The costs and benefits of elephants: communities and the CAMPFIRE programme in Zimbabwe

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Abstract

Community-based conservation programmes are rarely objectively assessed, particularly at the level of wildlife producers, who bear the costs of living with wildlife. In this thesis I investigated the coexistence of humans and elephants within the context of community-based conservation. I explored local support for elephant conservation, and how the interaction between costs and benefits from elephants influenced the nature of this support.

I researched human-elephant interactions in two CAMPFIRE districts in the mid-Zambezi Valley in northern Zimbabwe. Here, elephants generated the most revenues to the CAMPFIRE programme, but they also created intense conflict with rural farmers. Conversely, human activities affected elephant ranging patterns. Elephants avoided close contact with settlement, and avoided areas where human activity was great. Indeed, elephants no longer used riverine habitats because of heavy human settlement and resource collection activities.

Rural farmers perceived elephants as the worst of all problem animals because of the extensive damage they caused to wet season crops. Local perceptions closely matched with the amount of crop damage that each of the five worst problem animals caused. Human death was considered the second greatest conflict issue. Damage to dry season crops and additional forms of conflict were considered lesser issues.

Benefits from elephants were acknowledged, but only where they were substantial. The most mentioned benefit was CAMPFIRE revenues, followed by meat from hunted elephants. However, such benefits were inequitably distributed, and a few villages received investments that were many times more valuable than the rest. Furthermore, benefits did not reflect the pattern of costs incurred from wildlife among the communities.

Attitudes towards elephants were largely negative, but some attitudes were more positive. The explanatory variable that most influenced attitudes to elephants was CAMPFIRE revenues. Where there was a substantial investment, people were positive towards elephants. However, where investment was low, and did not reflect the costs, attitudes were strongly negative.

The results of this study indicate that it is possible to engender support for elephant conservation among rural communities. However in order to do so more widely, the amount of the benefits should be substantially raised. In addition, the means of disbursement should reflect the patterns of costs that occur at the village level.

This study has identified the critical interactions between rural communities and elephants, their key resource, within the CAMPFIRE programme. These findings are relevant to community-based conservation programmes throughout southern Africa, where economic benefits are used as incentives for the conservation of wildlife outside protected areas.

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Chapter 1 General Introduction

1.0 Introduction

In this thesis, I explore interactions between African elephants and people on communal land in the Middle Zambezi Valley, in the context of the costs and benefits set within Zimbabwe's CAMPFIRE programme. Humans and elephants have shared many of the same landscapes throughout Africa for thousands of years. But with increasing human populations and concurrently increasing demands for land and resources, conflict between elephants and people has become commonplace. Human activities compete with elephants to the point of exclusion. Conversely, elephants cause severe problems for rural communities. Elephants destroy crops and property, and endanger human life. Where community-based conservation (CBC) programmes such as CAMPFIRE operate, the benefits from wildlife aim to offset the costs of wildlife management for communities. Elephants have the potential to generate large revenues for such programmes. However, such programmes are rarely the subject of objective assessment, particularly at the level of the wildlife producer bearing the costs of living with wildlife.

In the rest of this chapter, I examine the general issues surrounding the conservation of wildlife where it coexists alongside people. First, I present the evolution of CBC from pre-colonial practices to the present day. I then describe the conceptual framework of CBC and explore incentives for conservation, including the generation of benefits, which may offset the costs of wildlife conservation. I then look at the interaction of costs and benefits in CBC, and how this affects local support for conservation. Finally I explore the specific costs and benefits that are associated with elephant conservation. These considerations in turn guide the aims of this project, which assesses the impact of community-based conservation upon the perpetuation of elephants in two CAMPFIRE districts in Northern Zimbabwe.

1.1 Community-based conservation

1.1.1 Conservation through history

Relations between communities and conservation in Africa have traditionally been poor, in part due to the preservationist approaches of colonial administrations across the continent, and to the ongoing policies of post-independence governments. The user rights of local people to natural resources have been attenuated by exclusionary laws which have in turn created animosity towards conservation. However, in the past thirty years conservation has undergone a major revolution, with the adoption of more inclusive, human-oriented approaches known collectively as community-based conservation. These broad and diverse approaches have been shaped by the social, political and economic conditions prevailing in Africa over the last two hundred years. This history must be acknowledged if the conditions in conservation today are to be fully understood.

1.1.2 Colonial conservation

From the early twentieth century, fears about natural resource depletion and loss of biodiversity have prompted policy makers to advocate the establishment of protected areas (Child, 1995). In British colonies in sub-Saharan Africa conservation focused upon the protection of large mammals. The Convention for the Preservation of African Flora and Fauna, signed in 1900, was the first international treaty to advocate the protection of large animals and their habitats through the provision of land for protected areas (IIED, 1994). Certain species of wildlife were afforded King's game status, and were only legally hunted by those in possession of a permit issued on behalf of the British Monarch. This legislation did not specifically prohibit Africans from hunting activities, but by nature local people were financially excluded from applying for a license (Child, 1995). Africans who hunted for the pot or for trade were reclassified as 'poachers' (Adams & Hulme, 2001).

In the pre-second world war period, conservation in Africa became even more exclusionary in nature. Africans were often forcibly relocated from areas which they had previously occupied (Brockington, 2002). Africa was partitioned into land units of forestry, wildlife and hunting areas to preserve selected species and landscapes: people had little place in this vision of conservation (Adams & Hulme, 2001). Protected areas were viewed as islands of wilderness, unpopulated by man. A common philosophy was that "A National Park must remain a primordial wilderness to be effective. No men, not even native ones, should live within its borders" (Grzimek, 1959; *cited in* Adams & McShane, 1992). Following World War Two the expansion of the protected areas system was driven by a colonial interest in hunting and a growing international consensus about wildlife conservation, based on conservation models in the US and UK (Adams & Hulme, 2001).

1.1.3 Conservation at Independence

As many African countries gained their independence in the latter half of the 20th Century, they retained the colonial conservation policies and legislation (Songorwa *et al.*, 2000). The centralised management model suited the aspirations of the newly-independent governments of the day, and the international bodies offering them assistance (Barrow & Murphree, 2001). In some countries, such as Zimbabwe, the Government increased the extent of protected areas post-independence, with financial support from western non-government organisations (NGOs). These NGOs focused their attentions upon the conservation of flagship species, which by default excluded local people (Hutton *et al.*, 1995).

Centralised ownership of wildlife ensured that the customary rights of use were removed from the citizens. In Tanzania the post-independence 1974 Wildlife Conservation Act prohibited human settlement in Game Reserves and limited all wildlife hunting to license, effectively nationalising all wildlife (Gillingham & Lee, 1999; Leader-Williams, 2000). Such centralised policies of wildlife management continued unabated until eventually challenged by the principles of community-based conservation.

1.1.4 The evolution of community-based conservation

In the 1980's the counter-narrative of community-based conservation (CBC) began to evolve (Adams & Hulme, 2001), as the role of the community as actors in natural resource management became better appreciated. The movement away from centralised, exclusionary conservation towards a decentralised and community-orientated approach was driven by economic reform, by increasing human population pressure on natural resources, and by ideological shifts in the world at large. These conditions are described in detail below.

1.1.4.1 Economic reform

Many newly independent African governments adopted economic structural adjustment packages which stipulated the decentralisation of State authority and gave rise to a shift to market-oriented economic reforms. The resulting decline in national budgets meant that Governments struggled to meet the rising demands of conservation. Law enforcement and monitoring declined, and this led to widespread poaching and the loss of biodiversity. For example, the nationalisation of wildlife in 1974 in Tanzania led to heavy commercial poaching and sharply declining wildlife populations through the late 1970's and 1980's (Leader-Williams, 2000). Continent-wide the black rhino population declined from 65,000 in 1970 to 3,800 by 1986 (Hillman, 1981; Cumming, du Toit & Stuart, 1990). A massive elephant decline that occurred in the same period was blamed upon the illegal ivory trade (Cobb, 1989 *cited in* Stiles, 2004). It was clear that the centralised conservation model was ineffective, and a change in strategy was required.

1.1.4.2 Sustainable utilisation of natural resources

Protected areas have a history of excluding people from using or managing natural resources. However, worldwide studies show that natural resources are a vital part of rural livelihood strategies, contributing to food security, economic development and cultural identities (IIED, 1994), especially for poorer people (Infield, 1988). Human societies have utilised wild living resources for most of their existences (Leakey, 1981). With increasing human populations, and their consequent reliance upon natural resources, a 'mosaic of biodiversity-friendly land-use' in which people's livelihoods are sustainably derived from natural resources, may be preferable to protected area 'islands' surrounded by agriculture (Hutton & Leader-Williams, 2003). Such islands would be valuable only to a privileged few and particularly unjust for the rural poor (Berkes & Folke, 1998). Therefore, developing a system of conservation which incorporates the sustainable use of such resources is considered a 'clear goal for which to strive' (Hutton & Leader-Williams, 2003).

1.1.4.3 Ideology

An ideological shift in thinking has taken place among the proponents of conservation in response to the 'dismal efforts' of State and other agency projects to protect biodiversity across the landscape (Barrow & Murphree, 2001). Increasingly it has been recognised that local communities must be actively involved, and their needs and aspirations considered, if biodiversity is to be conserved (Kellert, 1985). The 1980 World Conservation Strategy (IUCN, 1980), the 3rd and 4th World National Parks Congress (McNeeley, 1993), and the 1987 World Commission on Environmental Development (WCED, 1987) all emphasise the need to incorporate human dimensions into biodiversity conservation policies. This policy change first began in the development field, where it was recognised that the 'top down' practices of the 1970's were having little impact upon world poverty. An alternative agenda emerged which was decentralised and 'bottom up'. This people-oriented approach was considered both ethically and morally desirable (Adams & Hulme, 2001). Conservation practitioners rapidly adopted this approach, which formed the conceptual framework for CBC programmes.

Developing countries had neither the technical nor the financial resources to rely solely on centralised-regulatory control to protect biodiversity from an increase in human populations and their inevitable resource needs (Wells & Brandon, 1995). With the threat of species extinction, widespread illegal hunting and increasing conflicts between local people and protected areas, there was a powerful need for new approaches to natural resource management (Steiner & Rihoy, 1995). The community-based approach could be considered a pragmatic response to the complex problems arising from human pressures upon natural resources.

1.1.5 Sustainable use

The concept of 'sustainable use' is central to CBC theory. Sustainable use is defined as "the use of a component of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations" (Article 2, Convention on Biological Diversity). Sustainable use of wildlife resources may either be in a consumptive or a non-consumptive manner (Hutton & Leader-Williams, 2003). Issues of sustainability are discussed in the context of each of these models, below.

1.1.6 Consumptive and non-consumptive use

Consumptive use, also known as 'extractive use', involves the removal of individuals from the wild population, either through live capture or through some form of hunting (Hutton & Leader-Williams, 2003). Non-consumptive use involves the use of individuals that remain alive in the wild, either through the harvest of products such as wool or fruits, or through activities such as photo-tourism.

1.1.6.1 Consumptive use

The consumptive use of wildlife, especially through trophy hunting, can generate considerable revenues (Wilkie & Carpenter, 1999; Leader-Williams, 2000). Such revenues may benefit conservation: for example, trophy fees from elephant hunting have been ploughed back into elephant conservation programmes (Leader-Williams *et al.*, 2001). Consequently trophy hunting has been considered a viable means through which conservation can pay for itself (Kiss, 1990; Kock, 1995).

Despite the obvious economic benefits, the consumptive use of wildlife makes many conservationists nervous (Milner-Gulland & Mace, 1998), because overexploitation remains a constant threat. At particular risk are those long-lived wildlife species with low intrinsic rates of increase, and those with high economic value (Diamond, 1989). There are many examples of overexploitation, including the Southern Ocean whaling industry and the hunting of larger bodied animals for bush meat in the Amazon (Robinson & Bennett, 2000). However, while overexploitation has severely depleted these populations, such experiences have enabled the development of models of sustainable harvest which today govern more prudent practices, such as crocodile ranching (Hutton & Games, 1992) and well-managed trophy hunting operations (Caughley & Gunn, 1996). Indeed, these industries remain the mainstay of revenue generation for CBC programmes within southern Africa.

1.1.62 Non-consumptive use

Many CBC programmes rely upon the non-consumptive use of wildlife, in which tourism plays a principal role (Zube & Busch, 1990). Tourism has been one of the most consistent global industries over the past 50 years (WTO, 2002), with nature-based tourism enjoying rapid expansion. The shift towards more socially and environmentally responsible 'ecotourism' (Giannecchini, 1993) in theory provides tangible economic benefits to local communities from wildlife conservation (Goodwin, 1996).

Because tourism is non-consumptive, it is also assumed to be biologically sustainable. However, increasing numbers of tourists impact heavily upon natural ecosystems (Roe *et al.,* 1997), so sustainability cannot necessarily be assumed (Hutton & Leader-Williams, 2003). Most nature-based tourism occurs within protected areas, although recently there has been increased tourism development on private and communal land. However, unlike hunting, tourism requires greater accessibility and infrastructure (Leader-Williams *et al.,* 2001) and may therefore be less suitable for remote or undeveloped locations. Tourism can also be fickle and can react to national or global insecurity, and tourists' unwillingness to travel (Roe *et al.,* 2001).

1.1.7 Principles of CBC

All policies and programmes implemented under the CBC paradigm share a key assumption that biodiversity conservation will succeed only if local communities receive sufficient benefits, participate in the management, and therefore have a stake in conserving the resource (Gibson & Marks, 1995). The key principles of 'benefits' and 'participation' are defined below.

1.1.7.1 Benefits

In CBC financial benefits are returned to communities to provide an incentive for conservation. Benefits may accrue to individuals, through cash dividends, or they may be allocated to social projects, such as infrastructural improvements, community-identified projects, or capacity-building and training (Welford, 2001). Ideally, such benefits should seek to ensure that wildlife out-competes other forms of land use (Jones & Murphree, 2001). Equally, in areas of heavy conflict, benefits may simply attempt to balance the costs of living with wildlife (Leader-Williams & Hutton, 2005). Indeed, benefits may only be an effective incentive if viewed in relation to the costs that wildlife incur (Emerton, 2001).

1.1.7.2 Participation

The concept of participation underpins the normative theory of community-based conservation (IIED, 1994). Local involvement in CBC projects has been viewed as both a mean to achieving ecological sustainability and project efficiency, and as a democratic process that the more equitable involvement of individuals in decision-making about natural resources. By participating in conservation, local people are able to make decisions, manage resources, gain benefits and therefore have control over the activities that affect their lives (Slocum *et al.,* 1995). Participation is a highly desirable state. For example, in Maputo Elephant Reserve (MER) in Mozambique, the majority of community members interviewed expressed a desire to participate in the management of natural resources. This indicates that participation is indeed a major incentive for conservation at the community level.

1.1.8 The spectrum of CBC

Community-based conservation may be broadly defined as 'those principles and practices that argue that conservation goals should be pursued by strategies that emphasise the role of local residents in decision-making about natural resources' (Adams & Hulme, 2001). This definition encompasses a spectrum of strategies that engage communities and provide incentives for conservation to varying degrees.

At one end of the spectrum existing National Parks may be 'retrofitted' with a community outreach programme to achieve basic community requirements. The aims of such a programme could be described as biocentric; that is, primarily concerned with the protection of biodiversity (Adams & Hulme, 2001). Wildlife is viewed as having an intrinsic right to exist, and the scope for resource utilisation is low. Communities have little opportunity for involvement in wildlife management.

At the other end of the scale there are strategies that aim to devolve authority over natural resources and provide economic incentives to rural people (Adams & Hulme, 2001). Such programmes are described as anthropocentric, with sustainable development being their primary goal (Steiner & Rihoy, 1995). Natural resources are conserved for their utility value to people with the recognition that their sustainable use will benefit humans in the future. Communities have the opportunity to actively engage in the wildlife management process.

A whole range of programmes lie in the gradient between 'biocentric' and 'anthropocentric'. For example, the Selous Conservation Programme in Tanzania and Lake Mburo project in Uganda have emphasised joint management between protected areas and communities, granting quota systems for the sustainable use of plant and wildlife resources (Barrow *et al.,* 2001). Such programmes are designed to support traditional protected area conservation, whilst also providing local communities with the opportunity to utilise natural resources.

The Zimbabwean CAMPFIRE programme is an anthropocentric strategy which utilises wildlife resources for sustainable development. Accordingly it is this approach that will dominate the further discussion of CBC within this thesis. Now the principles of CBC have been discussed it is worth considering the costs and benefits of wildlife in greater detail.

1.2 The costs and benefits of wildlife

Human-wildlife interactions are commonly conceptualised in terms of costs and benefits. This balance between wildlife costs and benefits will determine the feasibility of a CBC programme. At the inception of the CAMPFIRE programme in Zimbabwe, only those rural districts with high 'benefit-cost ratio' were sought. This meant that any prospective district contained a broad resource base from which large benefits could be generated in order to offset costs, and thus improve the likelihood of success.

The costs and benefits associated with wildlife are diverse, and vary with the scale at which they are viewed, and the institution from which they are being viewed. The following overview of wildlife costs and benefits sets the scene for investigating how they influence local support for conservation.

1.2.1 Costs of wildlife conservation

In the broadest sense, the costs of conserving wildlife are diverse, ranging from the physical inputs required for conservation – staff, equipment and infrastructure – to the opportunity costs of conservation, which is defined as the lost opportunity of alternative land and resource uses, and the profits foregone because of wildlife conservation (Emerton, 2001). For example, land used for conservation may instead have been used for agriculture or building, and the cost of not pursuing these alternatives must be considered.

The severity of wildlife costs alters dramatically with the scale at which they are viewed. At a national scale the costs of wildlife are dominated by management expenditure: staff, equipment and running costs, and management activities such as enforcement and conflict mitigation (Emerton, 2001); and crop damage is a comparatively minor expense (Naughton *et al.*, 1999). However, at the community level the costs of crop damage to an individual may be enormous, and will certainly overshadow any other cost. In this research, I focus upon the impacts of costs and benefits of wildlife at the community level.

1.2.1.1 Wildlife costs at the community level

Wildlife costs incorporate both the direct and quantifiable, and the indirect, additional impacts at the community level. The 'direct' costs of wildlife incorporate physical and economic impacts of conflict (Hill, 1997; Naughton *et al.*, 1999), including crop and property damage, livestock losses, human injury and death. The indirect, or additional, costs include those energetic costs associated with crop guarding (Hill, 1997), restricted access to resources, the abandonment of fields (Naughton *et al.*, 1999), the disturbance of normal activities and travel, and the perceived risk of injury or death (Hoare, 2000).

1.2.2 The benefits of wildlife

Wildlife yields a wide range of economic goods and services (Emerton, 2001), such as the economic 'direct' values of live sales, meat, hides and trophies, tourism and education. Equally, wildlife is recognised by economists to support a range of ecological services, termed 'indirect' values, and these include carbon sequestration, population control and habitat maintenance. Many wildlife species hold cultural or religious significance to local people. There is also the potential or 'option' value which encompasses potential future benefits from tourism, pharmaceuticals and agricultural applications (Emerton, 2001). Finally there is the 'existence' value, which is their intrinsic value regardless of any other value or use (UN, 1982). The total benefit of wildlife is the sum of all these values which accrue at global, national and local levels (Emerton, 2001). However, CBC programmes tend to focus upon the direct values of wildlife, which are more readily quantifiable.

1.2.2.1 Wildlife benefits at the community level

While a range of cultural and existence benefits from wildlife may be in evidence at the community level, the most commonly acknowledged benefits are those with a strong utility value. In Tanzania, the primary benefit to communities around the Selous Game Reserve (SGR) was the annual allocation of wildlife meat quotas. Other benefits included land-use planning exercises, financial support for community development projects, and the establishment of Village Wildlife Committees, which were funded by wildlife revenues (Gillingham & Lee, 1999). In the CAMPFIRE districts of Zimbabwe benefits have taken the form of community programmes such as schools, water and health facilities, all of which have been funded with wildlife revenues (Jones & Murphree, 2001).

1.2.3 The influence of costs and benefits upon community support for conservation

People's attitudes towards a conservation programme are influenced by the benefits which they acquire from it, and the negative consequences of its conservation status (Parry & Campbell, 1992; Newmark *et al.,* 1993). CBC programmes provide economic and participatory benefits for conservation, but do benefits successfully engender support at the community level? Many researchers have investigated the attitudes of local communities towards conservation programmes, and the factors that influence these attitudes (e.g. de Boer & Baquete, 1998; Mehta & Kellert, 1998; Gillingham & Lee, 1999).

1.2.3.1 Negative attitudes towards conservation

If benefits from CBC programmes are perceived as small in relation to the costs or inequitably distributed, they may not achieve the desired effect. For example, people who responded negatively to the perceived benefits of wildlife in SGR complained that the primary benefit – wildlife meat – was too expensive and unfairly distributed (Gillingham & Lee, 1999).

Despite the best efforts of CBC programmes to meet the needs of rural communities, the costs of wildlife management are usually perceived to outweigh the benefits of living with wildlife (Naughton-Treves, 1998), resulting in widespread animosity towards wildlife. In Kenya, many people resent protected areas since they harbour potentially threatening wildlife (KWS, 1994; Low, 2001), while the protected areas in turn provide communities with no benefits. Long-standing aggressive disputes between farmers and conservationists have been documented around protected areas in Cameroon, Ghana, Namibia, Nepal, Tanzania, Uganda and Zimbabwe (Newmark *et al.,* 1993; Naughton-Treves, 1997; Mehta & Kellert, 1998; Naughton *et al.,* 1999; O'Connell-Rodwell, 2000; Hulme & Infield, 2001; Byers *et al.,* 2001; Barnes *et al.*, 2003; Parker, 2004).

Such negative interactions have the potential to undermine conservation efforts and long-term biodiversity goals (Mishra, 1984) and may threaten the viability of wild animal populations (Taylor, 1999) or wild land conservation (Hoare, 1995). Rural people may express their frustrations at unchecked crop loss through passive resistance to, or even sabotage of, rural development projects (Hill, 1998).

It is widely acknowledged that the costs associated with conflict must be reduced (Kangwana, 1995; de Boer & Baquete, 1999), while many have advocated the increase of benefits (Mehta & Kellert, 1998; Naughton *et al.,* 1999) as a means of increasing community support. However, where revenues are adequate and properly disbursed, they can engender community support for conservation (Archabald & Naughton-Treves, 2001).

1.2.3.3 Positive attitudes towards conservation

Access to conservation-related benefits can positively influence local attitudes (Infield, 1988; Lewis *et al.,* 1990). In communities around Selous Game Reserve (SGR) access to quota meat was a significant positive influence upon villagers' perceptions of wildlife benefits at the national and local level (Gillingham & Lee, 1999). Perceptions were markedly more positive than those reported by attitudinal surveys in other areas of Tanzania, where villagers had no access to such direct, wildlife-related benefits (Gillingham & Lee, 1999).

In Zimbabwe anecdotal evidence suggests that benefits from wildlife hunting has dramatically changed the views of rural people towards wild buffaloes. What had once been considered a major crop-raider is now viewed in more positive terms, with some villagers enthusiastically labelling the buffalo as 'their cattle' (Murphree, 2001). Furthermore, revenues distributed to communities around three national parks in Uganda not only improved peoples' perceptions of conservation, but reportedly encouraged conservation action in the form of increased community attendance at park meetings, and reduced poaching in and around the parks.

1.2.3.4 The influence of socioeconomic factors upon community support for conservation

A variety of socio-economic factors may influence people's attitudes towards conservation. In Nepal more positive attitudes towards wildlife conservation were harboured among the wealthier local people because they were in a financially better position to adjust to the loss created by wildlife (Mehta & Kellert, 1998). By contrast the poorest local people suffered a greater economic impact from wildlife crop damage, and their attitudes were consequently more negative.

In Tanzania, men were more predisposed to positive attitudes than women, reflecting the marginalisation of women in all decision-making activities in this predominantly Muslim area (Gillingham and Lee, 1999). In addition, an individual's involvement with local politics influenced their attitudes towards conservation: members of the local elite held economic and political power within their villages and obtained a disproportionate amount of quota meat from the project (Gillingham & Lee, 1999) and their views were consequently positive.

Socio-economic variables have effects upon attitudes that clearly vary from site to site. While socioeconomics have been shown to affect people's attitudes in Nepal and Tanzania, in Mozambique household size, ethnic group, religion, gender and education level had no significant influence upon the attitudes of individuals around Maputo Elephant Reserve (De Boer & Baquete, 1998).

1.2.3.5 Support in principle

Local support for conservation does not necessarily equate to support for the institutions responsible for the implementation of conservation strategies (Infield, 1988; Newmark *et al.*, 1993). For example, around Selous Game Reserve there was strong local support for conservation measures to protect wildlife and regulate hunting, but support for the wildlife management institutions was limited (Gillingham & Lee, 1999). Such mistrust of authority is widespread, and unless greater transparency and accountability can be displayed, threatens to undermine community and conservation relations (Mehta & Kellert, 1998).

In this section I have discussed the evolution and the guiding principles of CBC, the costs and benefits associated with living alongside wildlife, the balance between costs and benefits at the community level, and their effects upon attitudes towards conservation. In the next section I discuss the specific costs of human-elephant conflict that affect communities who live alongside elephants, and the current means of addressing such costs.

1.3 Human-elephant conflict

1.3.1 Human-wildlife conflict

Human-wildlife conflict is not a new phenomenon in Africa. The present situation echoes the traditional patterns of conflict on African agricultural frontiers that have occurred for centuries (Naughton-Treves, 1997). Human-wildlife conflict takes many forms, including competition for land and resources, physical damage to crops and property, threat to human lives, and numerous social costs. Often those affected are semi-subsistence farmers, whose livelihoods may be severely impaired as a result. In communities living along the boundaries of wildlife areas conflict with wildlife is the most persistent of all problems (Gillingham & Lee, 1999).

1.3.2 Human-elephant conflict

A wide variety of animals come into conflict with farming activities. These include birds, rodents, primates, antelopes, buffaloes, hippopotamus, bush pigs, and elephants (Bell, 1984). Whilst it is widely recognised that in most cases African elephants (*Loxodonta africana*) do not inflict the greatest damage to agriculture (Hawkes, 1991; Naughton *et al.*, 1999), they are regularly identified as the biggest threat. They elicit the greatest fear from rural communities because of the potential damage they can cause to crops, property, and human lives (KWS, 1994; Naughton-Treves, 1997).

Human-elephant conflict (HEC) has received considerable attention in recent years, and is now a severe management concern in elephant conservation in both Africa (Kangwana, 1995; Dublin, 1997) and Asia (Sukumar, 1989). HEC occurs throughout the elephant range (Hillman-Smith *et al.*, 1995; Tchamba, 1995; Lahm, 1996), and appears to be escalating (Bell & McShane-Caluzi, 1986; Mackie, 1992; Thouless, 1994), although this may also be attributable to increased publicity of conflict, political interest, and increased awareness of compensation (Hoare, 1999).

Increasing human populations and expanding agriculture have increased the potential for conflict between humans and elephants in many regions (Hoare, 1995). Elephants have been compressed into ever-smaller areas and their traditional migration routes have been cut off (Kangwana, 1995). As a result, humans and elephants compete directly for land that is becoming increasingly scarce (Thouless, 1994; Kiiru, 1995; Barnes, 1996).

1.3.3 Elephant crop damage

HEC takes many forms, including crop damage, human injury and death, damage to property and grain stores and livestock death. However, the most prevalent of these is crop damage. Elephant damage to crops has been cited as the foremost conflict issue in Kenya (Sitati *et al.*, 2003), Tanzania (Gillingham & Lee, 1999), Uganda (Naughton-Treves, 1998), and Zimbabwe (Parker & Osborn, 2001), among other places. Crop damage has a severe impact upon subsistence farmers in wildlife areas, reducing their ability to grow crops and feed their families.

Crop damage activity can be considered highly variable in space and time. A review of sixteen conflict studies across Africa revealed patchy or irregular spatial patterns of crop damage (Naughton *et al.*, 1999). There are few spatial trends, making it difficult to predict where conflict will take place (Sitati *et al.*, 2003). In addition crop damage displays broad inter-year variation (Taylor, 1999). But despite this variation, the following general patterns of activity have been identified.

1.3.3.1 Seasonality of crop damage

Crop damage is seasonal, exhibiting a peak of activity when the crops approach maturity (Kangwana, 1995; Tchamba, 1995), as they are most palatable during this phase (Bell, 1984). In the savanna habitats of Southern Africa this usually occurs towards the end of the rainy season. A dual-season peak of activity has been described in Zimbabwe (Parker & Osborn, 2001). The two periods of elephant crop damage reflect the different agricultural seasons; in Zimbabwe elephants raid rain-fed field crops during the late wet season, and small vegetable gardens along the beds of major rivers during the dry season. A similar pattern was discovered in India (Williams, Johnsingh & Krausman, 2001).

1.3.3.2 Spatial patterns of crop damage

Crop damage along the boundaries of protected areas has been observed in many countries (Bell, 1984; Harris, 1984; Naughton-Treves, 1997; Smith & Kasiki, 2000). The incidence of crop damage usually decreases with increasing distance from the PA (Naughton-Treves, 1997; Parker & Osborn, 2001; Barnes, 2003). Around Kibale N.P., Uganda, and Banyang-Mbo Wildlife Sanctuary, Cameroon the distance between a farm and the forest boundary was the single strongest predictor of crop damage in communities at the edge of these protected areas (Naughton *et al.,* 1999).

In Kenya, crop-raiding around the Maasai-Mara National Reserve was significantly correlated to the area of crops under cultivation (Sitati *et al.,* 2003), with the frequency of crop damage increasing with the total area of agriculture. In the Taita-Taveta region of Kenya, crop damage was positively correlated with migration patterns of elephants, and with permanent water points (Smith & Kasiki, 2000). Sources of permanent water are an obvious interface for conflict to occur, being a resource that both humans and elephants directly compete for.

Elephant crop damage may be influenced by vegetation type: in the Mid-Zambezi Valley, Zimbabwe, elephant damage to vegetable gardens along rivers during the dry season coincided with the fruiting of the *Masawu* (*Zisiphus macrunata*) tree, which produces sweet fruits that elephants eat (Parker & Osborn, 2001). In forest habitat secondary growth around agriculture was a factor in predicting conflict in Cameroon (Nchanji & Lawson, *cited in* Naughton *et al.,* 1999); elephants were attracted to the thick climbers and shrubs, which inevitably led to crop raiding in adjoining fields.

1.3.3.3 Crops vulnerable to damage

Elephants have been recorded damage a wide range of food and cash crops, including maize *Zea mays*, cotton *Gossypium hirsutum*, sunflower *Helianthus anus*, ground nut *Arachis hypogaea*, water melon *Curcubata* spp., millet *Eusine coracana*, onions *Alliun cepa*, beans *Phaseous vulgaris*, mangoes *Mangifera indica*, cassava *Manihot esculenta*, sugar cane *Saccherum officinarum*, pumpkin *Curcubita maxima*, potatoes *Ipomea patatas*, plantain *Musa paradisiacal*, okro *Hibiscus esculentus*, tomatoes *Lycopersicum esculentum* and cocoyam *Xamthosoma mafaffa*, among others (Osborn, 1997; Nahonyo, 2001; Barnes *et al.*, 2003; Sitati *et al.*, 2003).

Elephants have a natural preference for derivatives of plants from the *Gramineae, Leguminosae* and *Palmadae* families (Oliver 1978; Sukumar, 1989). A crop such as maize ripens uniformly and presents a super-rich patch of food for wildlife, and it is consequently highly vulnerable to wildlife predations (Naughton-Treves, 1997). Of twenty crops destroyed by elephants across Africa in sixteen different sites, maize was ranked the number one target crop (Naughton *et al.*, 1999). Such food crops are attractive to wild animals because the selective breeding of wild plants over centuries has reduced naturally-occurring defence chemicals, the loss of adaptations such as spines and thorns, and the reduction in fibrous tissues (Purseglove, 1972), making them more attractive to wild animals.

1.3.4 Elephant damage to food stores

Elephant damage to grain bins was a severe problem in Zimbabwe, particularly during drought conditions, where it constituted the major crop loss in communities around Sengwa Wildlife Research Area. The loss of this stored food was considered far more disruptive to farmers than the raiding of crops while they were still in the fields (Osborn, 1998) because the elephants could do a lot of damage to such a concentrated food source in a short space of time. Damage to field crops can be negated by planting replacements if the damage occurs early in the season, but food stores cannot be replaced until the following growing season. This type of damage has also been documented in Transmara District, Kenya, during drought conditions (Sitati *et al.*, 2003). In Luangwa

Valley, Zambia, elephants were reported to destroy stores of the fruit *Masawu*, which had been collected to supplement the diets of local farmers (Save the Elephants, 2005c).

1.3.5 Human death and injury

As a potential threat to human life elephants have a higher profile than other animals, and are consequently tolerated less by rural communities (Naughton *et al.,* 1999). Incidents of human injury and death caused by elephants affect both protected area staff and civilians. For example, in November 2005 a herd of elephants killed one game scout and seriously injured three others in Lake St Lucia, South Africa, while they drove along the lake shore (Save the Elephants, 2005a). In the same month elephants that had originated from the Maasai-Mara National Reserve killed four people in Narok, Kenya, (Save the Elephants, 2005b).

Some of the most revealing research has come from Transmara, Kenya, where 56 people have been killed by elephants in a period of 39 years between 1961 and 2000 (Kasiki, 1998). Most of these were men, and many of these incidents occurred during the night. Alcohol was a key factor in one third of the deaths; victims were drunk and returning home from the bar. Others died protecting their crops, herding cattle and walking at night between neighbouring villages (Kasiki, 1998). Human death, although less common than crop damage, is the most severe manifestation of HEC and is regarded as 'intolerable' (Naughton *et al.,* 1999).

1.3.6 Elephant damage to property

Elephants may also cause extensive damage to property. In Chobe National Park a tourist camp at Nogatsaa was eventually abandoned after elephants repeatedly dug up the water pipes to access the water in the dry season (M. Van de Walle, *pers. comm.*). In Malilangwe game ranch, Zimbabwe, a single bull elephant repeatedly destroyed fencing around a game capture boma during 1999 (D. de la Harpe, *pers. comm.*). Occasionally elephants will kill livestock: Dyson (2000) reported several cases in Muzarabani district, Zimbabwe, in which cattle were killed close to water sources during the night. Similarly in Kenya, elephants have been reported to chase or even kill cattle (Thouless, 1994).

1.3.7 Additional conflict

Additional conflicts are those which do not directly impact livelihoods. For example, the fear of running into elephants may restrict people's movements between villages, especially where attacks have recently occurred. Such fear among children may reduce school attendance, or interfere with the collection of fuel wood and thatch grass, or the collection of wild fruits. In the crop raiding season farmers and their families will be required to guard their crops and property, leading to loss of sleep and energy (Hill, 1997), poor employment opportunities, increased exposure to malaria and psychological stress (Sukumar, 1990; Tchamba, 1996; Naughton-Treves, 1998; Hoare, 2000; Williams *et al.,* 2001). Such indirect costs do not translate well to economic value and so are difficult to compare conventionally. While less-easily quantified than direct conflict, these indirect forms of conflict may outweigh the direct costs to local people (WWF, 1997).

1.3.8 Negative impacts of conflict

Where people and elephants share the same landscape, the relationship is frequently antagonistic: elephants have a serious impact upon their livelihoods which generates animosity and undermines support for elephant conservation across the continent. Very few, if any, species of wildlife can engender the extreme responses that the elephant can. Entire villages have been abandoned in response to conflict with elephants: Bell (1984) cites examples in Zambia and Malawi, and villages in central and West Africa have been abandoned due to the depredations of elephants (Barnes, 1990). Similarly, in Uganda in the early 20th century the "wanton destruction" of farms by elephants forced farmers to move elsewhere (GDA, 1924 *cited in* Naughton *et al.,* 1999).

There are many cases of communities killing elephants in retribution for crop damage. It is estimated that eighty three elephants were shot illegally between 1993 and 1996 around Banyang-Mbo Wildlife Sanctuary in Cameroon in response to continued conflict (Naughton *et al.,* 1999). In Kakum Conservation

Area, Ghana, communities surrounding the reserve organised the poaching of elephants in response to continued crop-raiding and the perceived inaction of the Government (Parker, 2004). Conflict presents a severe threat to the conservation of elephants, and casts an ominous shadow over the survival of elephant conservation (Naughton *et al.*, 1999).

1.3.9 Offsetting conflict

Conservationists and wildlife managers have been struggling to contain conflict for decades using crop protection measures such as fencing, which is technically effective (Taylor, 1999), but impractical for remote locations in developing countries (Osborn & Parker, 2003). Shooting problem animals is a common response to conflict, and while it provides free meat (Hoare, 1995) and reduces the number of problem animals (Leader-Williams & Hutton, 2005), it has little deterrent effect (Osborn, 1998). Rural farmers continue to rely upon traditional methods, including the beating of drums and the burning of fires, but these become less effective over time (Thouless, 1994; O'Connell-Rodwell *et al.*, 2000; Osborn & Parker, 2002).

In parallel with conflict mitigation, wildlife managers have more recently attempted to offset the costs of wildlife conflict through the generation of revenues and incentives. While elephants are undoubtedly the most problematic wildlife resource, they also are among the most valuable (Hoare, 1995), and can generate impressive benefits from trophy hunting. Such benefits can offset the costs incurred from living alongside wildlife, even if the revenues were not specifically designed for this purpose (Leader-Williams & Hutton, 2005).

In southern Africa the consumptive use of wildlife in CBC programmes is a common approach to conservation outside protected areas (e.g. BNRM[1] in Botswana; LIFE[2] in Namibia; LIRDP[3] in Zambia; CAMPFIRE[4] in Zimbabwe). There are many reports that portray a generalised picture of success. However, the CBC approach has been considered something of a 'privileged' solution to

1 Botswana Natural Resource Management programme
2 Living in a Finite Environment
3 Luangwa Integrated Rural Development Project
4 Communal Areas Management Programme For Indigenous Resources

date, which has been deemed 'self-evidently suited to dealing with the problem' (Adams & Hulme, 2001). As such it has undergone very little objective analysis to determine how effective it is at attaining conservation goals. It is currently unclear as to how successful such approaches have been in engendering support for wildlife conservation among rural communities, while also offsetting the costs of wildlife management.

1.4 Goal and objectives

1.4.1 Goal of this study

The overall goals of this study are: to determine the major threats to elephant conservation within the context of CBC; to establish the attitudes of rural communities towards elephant conservation; and, to determine the conditions of cost and benefit in which support for elephant conservation occurs.

I first investigate the effects of human activities upon the distribution of elephants across the study area in the Middle Zambezi Valley in Zimbabwe. I explore the effects of settlement and cultivation upon elephant habitat use. I then determine the impacts of ephemeral activities, such as firewood collection and hunting, upon elephant habitat use. The effects of such individual activities have not previously been determined. This research has been intentionally conducted at the sub-district scale in order to build upon previous research into human-elephant interactions which have been conducted at the national (Parker & Graham, 1988), and at the sub-national (Hoare & du Toit, 1999) scales, with divergent results. My investigation at the sub-district scale aims to reveal subtleties that may have been generalised at these larger scales.

While CBCs are often heralded as a success, rarely is there objective assessment of their effectiveness (Adams & Hulme, 2001), especially from the viewpoint of the communities that the programmes are designed to serve. In addition, it is rare for the specific issues of cost and benefit to be analysed in terms of community support for conservation. Within the mid-Zambezi Valley I investigate the costs and benefits that elephants present to communities. Costs include direct and indirect forms of human-elephant conflict. Benefits include revenues returned through the CAMPFIRE programme, and the wider benefits relating to elephants. I determine the relative influence of such costs and benefits upon people's attitudes towards conservation, and attempt to identify the conditions in which positive attitudes prevail.

1.4.2 Thesis structure

This thesis is divided into eleven chapters. There follows a brief description of the aims, methods and results of each chapter below.

In ***Chapter One*** I examine the evolution of CBC and the principles that guide CBC programmes. I investigate issues of costs and benefits in the context of community-based conservation, and how these affect local support for conservation. I explore the specific issues of human-elephant conflict which threaten to undermine CBC programmes.

Chapter Two places this research in the context of Zimbabwe, by defining the evolution and the conceptual roots of the national CAMPFIRE programme. I examine the current administrative structures and the means of revenue generation. Following this, I describe the ecology of the African elephant, with particular reference to the effects of human density and habitat transformation upon the elephant's ranging patterns.

In ***Chapter Three*** I describe the social and natural history of the mid-Zambezi Valley and detail the current political and administrative structures that are relevant to elephant conservation. I review current research into local attitudes towards the CAMPFIRE programme. I justify the scale at which I am working and the selection of my sample villages. I then introduce the general research methods employed in this study area, including sampling methodology, field methods, and a brief description of analytical tools and techniques. Detailed descriptions of methods are provided in each chapter.

Chapter Four investigates the patterns of elephant abundance across the study area. I determine the effects of environmental variables upon elephant abundance using elephant transect, stratified for vegetation type. The patterns of elephant abundance in relation to vegetation and season are determined through GIS analysis.

In ***Chapter Five*** I investigate the effects of human activities upon elephant distribution. Human activities are placed into two categories: permanent settlement and cultivation patterns; and ephemeral activities such as resource collection. I quantify settlement and cultivation through GIS analysis, and ephemeral activities through transect surveys, then determined their relative influence upon elephant abundance using multivariate analysis.

Chapter Six explores the rural farmers' perceptions of wildlife conflict through semi-structured interviews and focus group discussions. The full range of conflict issues are explored according to their impact upon the farmer's life. Elephant conflicts are prioritised in terms of the general problems facing the community, and in relation to other problem animals.

In ***Chapter Seven*** I quantify crop damage for all large mammals, using data collected in eight villages during 2003. I perform a comparative analysis between problem animals, using multiple means to assess the damage to crops. I then compare the crop damage caused by each mammal to farmer's perceptions of problem animals, as presented in Chapter Six.

In ***Chapter Eight*** I analyse human-elephant conflict, focusing upon crop damage and human death and injury. I define the temporal patterns of crop-raiding and investigate the crops most vulnerable to elephant damage. I then explore the effects of elephant group size upon the damage caused. Finally, I quantify the amount of crop damage that occurred in each village during 2003, and the number of incidents of human injury and death.

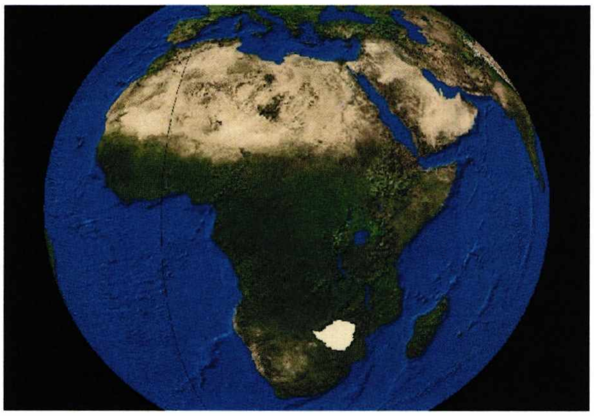
Chapter Nine investigates the benefits from elephants, commencing with farmer's perceptions of benefits. The most common benefits are then quantified using records from the Wildlife Offices in each Ward. I investigate how the size of the benefit influence people's perceptions of its worth. Finally, I analyse the disbursement of CAMPFIRE revenues by exploring the relationship between the costs of wildlife management, and the revenues returned to the communities across the study area.

In ***Chapter Ten*** attitudes towards elephants are determined from SSIs in which a combination of cost-benefit scores and fixed-response questions are combined to form an additive measure of attitude. I define the variables that affect people's attitudes from a review of literature and from SSI results. These include crop damage, death and injury by elephants, revenues from CAMPFIRE, and meat provided from hunted elephants. I also include a selection of socioeconomic variables. I determine the relative influence of each variable upon attitude using linear regression analysis.

Chapter Eleven reviews the salient findings of this research, and discusses them in the context of elephant management under the CBC paradigm.

In this chapter, by way of general introduction, I have discussed the conceptual framework of the CBC approach and have described the balance of costs and benefits that occur. In the following chapter I place this study in context by first presenting the CAMPFIRE programme in Zimbabwe, and then describing the ecology of the African elephant.

Chapter 2 Context of This Study



2.0 Introduction

Zimbabwe is viewed as something of a pioneer in the arena of community-based conservation (CBC). The national CAMPFIRE programme has been widely cited as a successful model for conservation outside protected areas. CAMPFIRE focuses upon development goals, where social and financial benefits are accrued through the sustainable management of natural resources (Jones & Murphree, 2001). Conservation benefits remain a secondary aim, but should follow if the management of natural resources provides appropriate incentives over other forms of land use. In the 19 years since its inception, CAMPFIRE has rapidly spread to 27 Rural Districts across the country, generating impressive foreign currency earnings, predominantly from safari hunting activities (Bond, 2001). Elephants are the key resource to CAMPFIRE, generating the majority of revenues nationally.

Such approaches to CBC have evolved from a history of colonial and independent government strategies in which all natural resources were firmly controlled by the State. The transformation from Statist conservation to CBC required not only a change in law, but a revolution in conservation policy. The evolution of CAMPFIRE reflects a complex history of political, social and economic change which is discussed in detail below. Following this, I examine the principles guiding CAMPFIRE, and the structures of administration that exist.

CAMPFIRE is heavily reliant upon elephant populations that occur outside protected areas. In order to persist, such populations must coexist alongside human populations, in a complex situation of habitat transformation and competition for resources. In the second part of this chapter I describe the general ecology of the African elephant, and then go on to explore the effects of human activities upon the ranging patterns of elephants.

2.1 The CAMPFIRE programme

2.1.1 A history of natural resource rights in Zimbabwe

In the past 100 years, the proprietorship over natural resources in Zimbabwe has switched from traditional leaderships to the State, and only recently has this power been partially restored to private land-owners, and to traditional leaders. Prior to colonisation, Chiefs and Headmen, through their connections with their ancestors, held ritual power over the land and its resources (Welford, 2003), reserving certain wildlife species and areas of land as their own hunting domains (Jones & Murphree, 2001). At this point in time, it is believed that the rules and institutions governing natural resources were weak. Human populations were sparse, natural resources were plentiful, hunting techniques were inefficient, and a combination of these factors ensured that environmental impacts were limited (Child, 1995).

European settlers arrived in the present day Zimbabwe from the turn of the 19^{th} Century. In the ensuing colonial period, the Europeans demarcated large tracts of land for commercial farming activities, protected areas and forestry enterprises, and seized the highest quality land for agriculture (see Appendix 1 for details of the distribution of land). Under colonial rule, natural resource management in southern Africa was preoccupied with nationalising and privatising resources, while communal property rights were largely ignored (Murphree, 1991). Africans were forced into "Native Reserves" on marginal agricultural land, which in 1936 took up just 20% of the entire country of the then Rhodesia. This compulsory relocation to reserves (now 'communal lands') undermined the traditional systems of land allocation and natural resource management (Masoka community, 1997). At the same time, during the last years of rule of pre-independence rule, in 1975 the government devolved control over wildlife on private land to private, predominantly white, landowners.

At independence in 1980, the Zimbabwe Government retained the Colonial style of centralised control, and authority over land and natural resources continued to be vested in the State (Scoones, 1996). The new Government embraced the protected area network and expanded the area of land under the National Parks and Wildlife Estate (NPWE). However, the new Government soon committed to the devolution of responsibility over wildlife from Government to communal landholder. This shift in conservation policy was precipitated by the country-wide decline in wildlife through illegal hunting, and the widespread conflict between people and protected areas.

2.1.2 Policy change

In order to adopt a community-based approach to conservation, substantial changes to the legal framework governing natural resources were required. Two key political decisions were instrumental in effecting this change: the first was the overhauling of the laws governing proprietorship of natural resources, and the second was the devolution of government power to the rural level.

Before Independence, the Parks and Wild Life Act (1975) had devolved proprietorship over natural resources to private landowners (Zimbabwe, 1975, 5), granting them custodianship over 'wild animals, fish and plants' upon their own land. This created incentives for wildlife management and precipitated an increase in the area of private land devoted to conservation across the country. Following the success of devolution on private land, it was believed the same incentives for conservation should operate in the communal lands. The 1975 Act was amended post-independence in 1982 to include natural resources in the communal lands. Under this amendment, Rural District Councils eventually attained Appropriate Authority to manage natural resources under the CAMPFIRE programme.

The Government then overhauled its laws governing the communal lands. The Communal Lands Act (1982) reassigned control over the Communal Lands (CLs) from traditional leaders to local government. District councils produced land-use plans that overrode customary land claims previously administered by Chiefs and Headmen. Ward Development Committees (WADCOs) and Village Development Committees (VIDCOs) were established as the political institutions at Ward and Village level. VIDCOs were considered the 'modern' system of local government, installed by the post-independence government to initiate and administer development at the local level.

The Rural District Councils Act (1988) devolved considerable central government power to the district level. This had several effects: first, central government had a greater presence in the CLs, and second, Rural District Councils (RDCs) were afforded greater power over planning and development. The Rural District Councils Act enabled the evolution of a nationwide scheme of CBC by creating the necessary administrative structures for the development of district-based conservation. Nevertheless, there was a distinct difference between the devolution offered to private and communal landowners, where that offered to private landowners remained with the unit of production, while that offered to communal landowners rested with a lower tier of government.

2.1.3 The evolution of community-based conservation in Zimbabwe

Two small-scale 'experiments' in the communal lands paved the way for the development of a national CBC programme. Both projects generated incentives from conservation for communities living with wildlife by providing tangible benefits. Operation Windfall[5] was developed by the Zimbabwean Department of National Parks and Wildlife Management (DNPWLM) as a pragmatic response to illegal hunting by local people who lived adjacent to Chirisa Safari Area in Zimbabwe's Midlands (Child, 1995). In Mahenye a partnership involving the community and a private sector safari hunter aimed to defuse the severe conflict between the community and Gonarezhou National Park in the south-east of the country.

2.1.3.1 Operation Windfall

In the late 1970's, the communal lands surrounding Chirisa Safari Area had one of the highest human population growth trajectories in the country. Poaching within the park was rife. Operation Windfall distributed meat and money from the proceeds of culling operations within the Safari Area, with the hope that the flow of benefits would provide incentives to rural people to stop illegal hunting practices. By the early 1980's there was a consensus within DNPWLM that technically, Operation Windfall had the potential to engage with wildlife

5 Wildlife Industry's New Development For All.

management problems in rural areas. But the major downfall of the operation was that it lacked institutional capacity (Martin, R.B. *cited in* Welford, 2003).

2.1.3.2 Mahenye

In Mahenye, a communal wildlife management system was developed in the early 1980's. The Mahenye community, marginalised from their land and property rights by the designation of Gonarezhou National Park in 1966, was resettled to an area of land bordering the new national park. In retaliation for widespread crop raiding from wildlife, and for the injustices of relocation, the community openly poached wildlife from the national park and communal lands (Murphree, 2001). Clashes with anti-poaching units fuelled a spiralling dialect of confrontation. In early 1982, the Mahenye leadership met with the national park authorities and a local safari operator to attempt to resolve the escalating conflict. The result was trial devolution of responsibility for wildlife to the community: they were permitted to appoint a safari operator to commercially hunt a quota of two elephants on their land, and would retain the proceeds from the hunt as an incentive for wildlife management. This agreement was approved by DNPWLM, and despite bureaucratic complications, was eventually deemed a success, leading to the community voluntarily designating a new wildlife area, and a marked reduction in poaching (Murphree, 2001).

2.1.3.3 CAMPFIRE

CAMPFIRE was formally initiated in October 1988 when NyamiNyami and Guruve Districts were granted Appropriate Authority (AA) status to manage their natural resources. Revenues from the 1988 hunting season spurred sceptical RDCs into action, and by the end of 1989 seven other districts had received AA status. The CAMPFIRE Association was established in 1991 as a national level institution that represented all Councils granted AA under the CAMPFIRE programme. By the end of 1991 twelve districts had signed up, amassing collective gross revenues of US $1.1 million (Jones & Murphree, 2001). Between 1989 and 1996, CAMPFIRE generated over US $10 million; and by 2001 there were 30 districts with appropriate authority status operating CAMPFIRE schemes, covering a total land area of 36,000km^2 (Bond, 2001).

2.1.4 Conceptual roots of CAMPFIRE

CAMPFIRE is the product of a radical change in policy, its economic motivations for sustainable use of natural resources, and the devolution of power over those resources, challenging the protectionist policies of Zimbabwe's recent past. These concepts form the foundations of the programme, and are somewhat unique to CBC in southern Africa (Jones & Murphree, 2001).

2.1.4.1 Economic instrumentalism

In 1989 the Zimbabwe Government published its Policy for Wildlife, which consolidated into official policy the thinking behind wildlife and incentives for sustainable use. Among the usual conservation rhetoric was a 'radical statement' concerning the fate of wildlife outside protected areas: all wildlife would have to compete economically with other forms of land use in order to survive, and would therefore be at the mercy of economic forces. This bold policy evolved from realisation that conservation based upon the intrinsic value of nature in the past had led to massive habitat loss through agriculture and the widespread elimination of wildlife in order to make way for livestock (Jones & Murphree, 2001). The proposed reform would enable conservation to compete economically with agriculture as a land-use. However such a policy was not without risk: conservation would either become economically viable, or wildlife would disappear (Jones & Murphree, 2001).

2.1.4.2 Devolution of responsibility

The devolution of responsibility for wildlife to communities was a principle fundamental to CAMPFIRE. This process would not only involve the devolution of management, but also control over the benefits from resources. Devolving such responsibility was not only considered a morally justifiable stance; it also provides a powerful incentive for the sustainable use of resources, by providing a strong sense of proprietorship over natural resources. This thinking is embodied in the 'producer community principle', which states that the unit of production should be the same as the unit of benefit (Murphree, 1999). Put simply, those people bearing the costs of living with wildlife should retain the full benefits.

2.1.5 Strategic compromises of CAMPFIRE

From its inception CAMPFIRE was compromised by strategic decisions which were considered necessary for its implementation. The first of these concerned devolution. The original intention was to identify and empower proprietary units at the community level (Jones & Murphree, 2001), in line with the producer community principle that had been achieved for private landowners. However, a combination of funding shortages and resistance from local government meant that these proprietorial units never evolved. Instead the existing local government structures, RDCs, were adopted as the management authority for wildlife.

This compromise meant that RDCs retained control over wildlife revenues. Communities argued they bore the primary costs of wildlife management, and so should be entitled to the revenues. But, keen not to loose control, the RDCs countered that they also bore some of the costs of wildlife production by providing roads and other infrastructure that made wildlife management possible, and they therefore should have a stake in the revenues generated. The resulting compromise saw the RDC retain up to half of all wildlife revenues generated in CAMPFIRE districts (Jones & Murphree, 2001).

Critics considered this a fundamental erosion of the principles of CAMPFIRE: the people who bore the primary costs of wildlife management would not have the authority to manage the wildlife, nor would they control the revenues. In fact, their participation in wildlife management has been reduced to the receipt of handouts from local government (Murombedzi, 2001). With the RDCs in charge, there are pervasive uncertainties for the producer communities regarding their investment in wildlife management (Jones & Murphree, 2001).

2.1.6 CAMPFIRE administration

As appropriate authorities, RDCs are required to devolve revenues and management responsibility to the community level. While there is no legal framework to structure this process, it is governed by the 'CAMPFIRE guidelines' (1991 and 1992), which aim to protect wildlife producer community interests in the absence of strong and well-defined property rights over wildlife (Bond, 2001).

The CAMPFIRE guidelines state that the community must receive 50% or more of the gross wildlife revenues, and must retain autonomy over the methods of expenditure. The community elects a Ward Wildlife Committee which receives the revenues on behalf of the community. The RDCs usually pay ward dividends annually in arrears. The wards allocate the revenues to wildlife management (resource monitors, game scouts, meetings and fence repairs), ward projects that generate income (grinding mills, cooperative goat rearing), or social facilities (school buildings and clinics), and occasionally direct cash dividends to households (Bond, 2001).

The RDC may retain up to 50% of the gross revenues, 15% of which may be considered an administrative fee or 'council levy', and as much as 35% which may be used for direct wildlife management costs, including enforcement, problem animal management and wildlife monitoring. The retention of up to half of the revenues from wildlife may be described as a taxation of wildlife, which provides a reliable stream of revenue to RDCs whose tax base is otherwise irregular (Bond, 2001).

2.1.7 Revenue generation

Between 1989 and 1995 the gross revenue retained by RDCs with AA exceeded US $9.3 million. Nationally, 93% of this was generated through lease of sport-hunting rights to commercial safari operators (Bond, 2001). The balance was generated through the lease of tourism rights, the sale of hides and ivory and other minor resources (Table 2.1). Just 2% of revenues were derived from tourism in the same period.

Table 2.1: Sources of wildlife revenue to district councils with appropriate authority between 1989 and 1995 (from Cumming & Lynam, 1997).

	Sport hunting	Tourism	Hides and ivory	Other
Total (Z$)	45,083,094	1,108,420	465,612	1,885,548
Total %	93	2	1	4

The success of the safari industry in CAMPFIRE districts has been attributed to its flexibility and low requirements for infrastructure. There is little dependence upon conventional transport and energy, little need for capital investment in accommodation, and no requirement for the photogenic landscapes required for tourism (Murphree, 2001). In recent times, the safari industry has suffered less disruption from the political instability and economic crisis than has the game-viewing tourism industry.

2.1.7.1 Elephants and CAMPFIRE

Elephants provide the greatest revenue of all natural resources to CAMPFIRE, contributing a countrywide mean of 64% in 1992 (Bond, 1994). Elephants represent the key resource to the CAMPFIRE programme, which are hunted according to careful quota setting, and the stringent monitoring of hunting activities. Elephants form the mainstay of revenue generation for the national CAMPFIRE programme, and it is essential that people and elephants continue to share the same landscapes if CAMPFIRE is to persist. In the following section I describe the ecology African elephants, with specific reference to their habitat requirements.

2.2 Elephant ecology

Elephants are generalists, and can adapt to a wide range of habitats and exploit a large variety of food sources. Through history, their ancestors have successfully inhabited the tropical, sub-tropical and temperate zones of the world. In the present day, the distribution of elephants has been limited by human activities which convert their natural habitat and disturb their natural distribution. Such effects are later described, but in order to place them in context I first describe the ecology, feeding behaviour and habitat preference of African elephants.

2.2.1 The evolution of African elephants

The African elephant (*Loxodonta africana* Blumenbach 1797) and the Asian elephant (*Elephas maximus* Linnaeus 1758) belong to the family Elephantideae, which originally evolved in Africa during the Pleistocene era. The forerunners of the Asian elephant later migrated to Asia. African elephants appeared in the fossil records around 750,000 years before present (b.p.), and are believed to have taken their current form around 40,000 years b.p.

Two sub-species of African elephant are recognised: the savanna elephant (*Loxodonta africana africana*), and the forest elephant (*Loxodonta africana cyclotis*). There is speculation that all African elephants evolved from the forest sub-species, and that up to 40,000 b.p. *L. africana* was confined to the forest by other elephant species, and was unable to emerge until they became extinct (Parker & Graham, 1989). The larger savanna elephant (5-7.5 tons, 3-4m at the shoulder) is distributed throughout Eastern and Southern Africa, and the smaller forest sub-species (2-4 tons, 2-3m at the shoulder; Grizmek, 1975) is found in Central and West African tropical forests (Laws, 1970). There are currently estimated to be 402,067 African elephants scattered in fragmented populations across the continent (Blanc *et al.*, 2002).

2.2.2 Elephant distribution

Elephants occupy a diverse range of habitats, from closed-canopy forest to deciduous woodland to bush-grassland. Elephants are not territorial, although they use specific areas during particular times of the year (Moss & Poole, 1983). Elephants exhibit a variety of home range sizes, which vary in relation to the environmental conditions: some appear to be sedentary for example, in Lake Manyara N.P., where home ranges vary between 15 and 52 km^2 (Douglas-Hamilton, 1971); while others are nomadic or disperse in the wet season (Leuthold, 1977; Lindeque & Lindeque, 1991; Viljoen, 1989). In Tsavo National Park, Kenya elephant home ranges extend from 350 to 1580 km^2 (Leuthold & Sale, 1973). In poorer habitats such as the semi-desert Kaokoveld in north western Namibia, home ranges vary between 2,851 and 18,681km^2 (Lindeque & Lindeque, 1991). The largest recorded home range for African elephants occurs in Mali, where elephants utilise between 11,600 and 24,300 km^2 (Save the Elephants, 2004).

2.2.2.1 Elephant distribution in relation to water

Elephant ranging patterns are determined by water availability, which in turn is dictated by rainfall (Leuthold, 1977; Afolayan & Ajayi, 1980; Western & Lindsay, 1984). Adult elephants have a water requirement of about 160 litres per day (Dougall, 1964), and in regions where water availability is highly seasonal elephant range is restricted to the location of permanent water. Elephants may congregate at water points during the dry season and disperse during the wet season, as noted by Taylor (1983) in the Sebungwe, and Connybeare (1991) in Hwange National Park. In the South Luangwa National Park, Zambia, bull elephants exhibit a strong 'site tenacity' to the Luangwa river during the dry season. In Chobe National Park, Botswana, family herds rarely travel more than 3.5km from permanent water during the dry season because of the high turnover of water in juveniles and lactating cows, and the reduced mobility of neonates (Stokke & du Toit, 2002).

2.2.2.2 Elephant distribution in relation to food

Seasonal variations in food availability and quality affect elephant ranging patterns and migration (Leuthold, 1977; Sukumar, 1989; Viljoen & Bothma, 1990). Trees influence movements of elephants in Transmara, Kenya, where elephants move up the escarpment to feed upon *Acacia spp.* trees not found elsewhere (Sitati, 2004). Similarly in the South Luangwa Valley, elephants move to higher slopes to feed upon *Musuku* (wild fruits) during December (Melland, 1938; *cited in* Sitati, 2003). Elephants conduct short-distance movements to feed upon the *Masawu* fruits that grow along the banks of the major rivers during the dry season in Zimbabwe's Zambezi Valley (Parker & Osborn, 2001). Forage quality may be greater in riparian woodland: in Chobe N.P. the forage on alluvial clays is nutritionally superior to the dystrophic sands further inland and the elephants accordingly spend more time feeding there (Stokke & du Toit, 2002).

2.2.2.3 Further factors influencing elephant distribution

In addition to water and food, elephant distribution is influenced by the availability of shade trees during the hot dry season, in Wankie N.P., Zimbabwe (Williams, 1975). Riverine woodland provides a combination of water and shade which makes it attractive to elephants. Elephants take refuge in the riverine woodland of the Transmara, Kenya during the day (Sitati *et al.*, 2003), and similarly utilise the riverine thickets of the Zambezi Valley (Dyson, 2000).

Elephants may travel long distances in search of salts otherwise lacking in their diet. Sodium is much sought after (Weir, 1969; Henshaw & Ayeni, 1971), and reproductive females may require additional minerals. In the later part of the dry season, elephant movements are determined by salt licks in Kasungu National Park, Malawi (Jackman, 1973). In Chobe N.P. bulls and cows spend considerable time feeding along the salt-rich alkaline flats in order to fulfil their mineral requirements (Stokke & du Toit, 2002).

2.2.3 Elephant diet

Elephants spend 70-90% of their time foraging for food, and consume between 100kg and 300kg (wet mass) of vegetation per day (Wyatt & Eltringham, 1974). Their diet is varied and consists of grasses, foliage, bamboo, roots, barks, wood and fruits of specific plants (Grzimek, 1975). As generalist feeders elephants will exploit the vegetation that is available to them. In the Zambezi Valley of Zimbabwe elephants were observed eating a total of 140 species of woody plants, including introduced fruit and ornamental trees (Dudley, 1997).

Savanna elephants are both browsers and grazers, feeding on grass during the wet season and switching to browse during the dry season (Guy, 1976; Hanks, 1979; Lewis, 1986; Wyatt & Eltringham, 1974). When grass is in its early growth cycle elephants tend to graze more and consume less browse. As grasses dry and become more fibrous and less nutritious, they consume more browse (Vesey-Fitzgerald, 1973).

2.2.4 Ecological role

As a keystone species elephants are important to the functioning of their ecosystem, performing the roles of seed dispersal (Lieberman *et al.,* 1979), vegetation change and water hole maintenance (Simberloff, 1998). Elephants have long been recognised for their potential to modify the environment (Leuthold & Leuthold, 1972; Laws *et al.,* 1975). Their bulk feeding can result in damage to trees and habitat (Eltringham, 1980; Barnes, 1983) and can cause woodland degradation (Douglas-Hamilton, 1973; Vesey-FitzGerald, 1973; Barnes, 1983; 1985; Jachman & Bell, 1985).

High utilisation rates of plants by elephants may result in alteration of vegetation structure (Caughley, 1976). Elephants are believed to be responsible for converting dry forest to thicket in the Zambezi Valley, Zimbabwe, by destroying large trees and encouraging a dense shrub layer to develop (Timberlake & Cunliffe, 1997). In riverine areas in Sengwa Wildlife Research Area, several tree species were markedly reduced in response to elephant damage, being replaced over time by *Combretum* spp. (Anderson & Walker, 1974). Around Queen Elizabeth National Park, Uganda, a 96% reduction in large trees was recorded over a 14-year period as a result of elephant activity. Such a decline in structural diversity can precipitate a decline in species diversity: in northern Zimbabwe, where the canopy had been removed from *Miombo* woodland by persistent elephant feeding, the species richness of birds and wood ants has declined (Cumming *et al.*, 1997).

2.2.5 Social structure

African elephants live in a 'fluid and dynamic social system in which males and females live in separate but overlapping spheres' (Poole, 1996). Female elephants live in small cohesive groups of close relatives with their immature offspring (Laws *et al.*, 1975). Females born into a group remain with the family, while the males are ejected on reaching sexual maturity (Douglas-Hamilton, 1972). Young males leave their natal groups at about the age of 14 (Poole, 1996), and may briefly join up with other family groups or bull groups. Bull groups are usually smaller than family groups, with a mean size of 2.4 elephants (Eltringham, 1982). Bull groups have long been described as loose associations of unrelated animals with weak social bonds (Douglas-Hamilton, 1972), but more recent research suggests that the social structure may be more complex than previously thought (Barnes, 1982; Poole, 1989).

Bull elephants generally travel greater distances than cows, reflecting the different social structure that characterises each sex. Bulls may travel large distances in search of oestrus females, who may be in short supply as a result of the high investment, long-term reproductive strategy of the species (Barnes, 1982). Mating tends to occur during the rains (Hanks, 1972; Guy, 1976; Martin; 1978) and this is considered a stimulus for large-scale movements among bulls.

2.2.6 Movements

Migrations are considered to be regular animal movements with predictable patterns both in space and time (Leuthold, 1977). In Taita-Taveta, Kenya, elephants follow traditional movement routes (Low, 2000) despite the extensive changes in land use that has occurred (Smith & Kasiki, 2000). Long-distance movements have been recorded in Amboseli (Western & Lindsay, 1984), Cameroon (Tchamba *et al.*, 1995), and Tsavo NP, Kenya, in 'fairly direct response' to localised rainfall (Leuthold & Sale, 1973). In Mali elephants traverse an annual migration route of 450km in length, linking up a series of ephemeral water points in the largest known migration route of any African elephants (Save the Elephants, 2004).

2.3 Human activities

2.3.1 Human and elephant distribution

The distribution of elephants in Africa is inextricably linked to that of humans (Hanks, 1979; Parker & Graham, 1989; Barnes *et al.*, 1991; Hoare & du Toit, 1997), not least because they share similar habitat requirements. An analysis of rainfall and soil fertility in Kenya and Zimbabwe concluded that elephants and humans both 'prefer fertile wetter areas' and that competition for land between the two species was inevitable (Parker & Graham, 1989). However, few attempts have been forthcoming to produce a model by which the interaction of people and elephants may predict the viability of elephants (Hoare & du Toit, 1997). This interaction is critical to elephant conservation outside protected areas, where community-based conservation programmes seek to balance the development requirements of local people with long-term conservation objectives.

2.3.2 Human density and competitive exclusion

Where humans exist at high density, they can displace elephants to the point of local extinction. An unpublished study in 1970 of human and elephant densities in Kenya deduced that 'elephant densities were zero or low where human densities were high and vice-versa' (Parker & Graham, 1989). Between 1950 and 1980 in the south-east quadrant of Kenya the contraction of elephant range mapped as the negative of rising human populations (Ecosystems, 1982). Such discoveries led to a more detailed analysis of the relationship between people and elephants.

2.3.2.1 Linear relationship between humans and elephants

Parker & Graham (1989) produced the first prevailing model from their research into human and elephant densities at a sub-continental scale. They proposed a simple linear relationship in which elephant density declined with increasing human density. This relationship was derived from two case studies; the first being in fertile soil areas of Kenya, and the second being in the semi-arid districts of northern Zimbabwe.

Parker & Graham (1989) postulated that elephant distribution was the inverse of human distribution, and took this as evidence that humans and elephants existed in a state of competitive exclusion, whereby both species simultaneously sought resources that were in limited supply. This form of competition 'becomes more acute as the population of either species increases' (Hardin, 1960 *cited in* Parker & Graham, 1989), leading to either the extinction of one, or a significant zone of no-overlap between the two species. By this theory elephants are competitively excluded from areas of high human density, and can therefore only exist in substantial numbers where human presence is inhibited (Burrill & Douglas-Hamilton, 1987). This theory of competitive exclusion was believed to account for 'most elephant decline in East Africa and continentally' (Parker & Graham, 1989).

Although it has received considerable support in the literature (Eltringham, 1990; Newmark *et al.*, 1994), the model of Parker & Graham (1989) has also been criticised on methodological grounds. Hoare & du Toit (1998) observed that

Zimbabwean elephant densities were estimated from a relationship between rainfall and elephant population density that was calculated in Kenya. But Kenyan elephant populations have been subject to very different environmental conditions, including drastic ivory-related declines, and the suitability of this relationship for Zimbabwe has been called into question.

2.3.2.2 Threshold relationship between humans and elephants

Investigating human-elephant interactions at a finer scale, Hoare & du Toit (1998) surveyed 25 census wards in unprotected elephant range within the Sebungwe region of Zimbabwe. Their findings suggested not a linear relationship, but rather that human density exerts an influence upon elephants according to a threshold above which elephants can no longer survive. Elephant density was unaffected by human density below 15.6 persons/km^2; but above this level elephants effectively disappeared from the landscape. Interestingly this critical value is not far removed from the figure of 18.9 persons/km^2 predicted by the linear model of Parker & Graham (1989). Research conducted around Garamba National Park, Democratic Republic of Congo, corroborates these findings: at low density the presence of subsistence farmers did not appear to impact significantly upon the distributions of wildlife (Merode *et al.*, 2000).

2.3.2.3 Land transformation

Rather than being a direct consequence of human density, Hoare and Du Toit (1999) hypothesised that elephants were affected by the transformation of natural elephant habitat to agricultural land. By this model, people and elephants could coexist in relatively high densities within the same ecosystem if human land-use did not involve the widespread transformation of land cover. But if land transformation exceeded 40-50%, then elephants may be extirpated from the environment. However, the precise details of this relationship remain unclear and there is a call for further research in this field (Hoare & du Toit, 1999).

2.3.3 Human disturbance

Habitat transformation is one of many ways in which humans affect elephant distributions. Elephants may also modify their distribution in response to human activities, either by avoiding areas of disturbance (Barnes *et al.*, 1996; Lewis,

1986) or by taking refuge. In Zambia, Lewis (1986) observed that human pressures disrupted elephant dispersal patterns and altered their feeding habits. In densely populated communal lands in Zimbabwe, elephants avoided people by utilising riverine thickets as refuges in the day time and only venturing out into open land under cover of darkness (Dyson, 2000; Parker & Osborn, 2001). In Sumatra, Nyhus *et al*., (2000) noted that Asian elephants avoided open areas around settlement during the day. Similarly in the Greater Ruaha Ecosystem, Tanzania, the distribution of elephants increased with increasing distance from villages (Nahonyo, 2001), indicating an active avoidance of settlement.

A similar situation exists with forest elephants in the Central African Republic, where human activity and elephant dung piles display a negative relationship, indicating that elephants avoided the areas that people frequent (Blom *et al.*, 2004). The avoidance of roads by elephants is well documented (Barnes & Jensen, 1987; Barnes *et al.*, 1991), with elephant densities only becoming greater with increasing distance from the road (Blom *et al.*, 2004).

2.3.4 Bull behaviour

Bull elephants may have a greater tolerance to human disturbance than do cows, this being attributed to a cow herd's reluctance to expose their young to danger. The 'male behaviour hypothesis' explains the greater likelihood of male elephants taking risks for the higher nutrition rewards of mature food crops in Asia (Sukumar & Gadgil, 1998), and in Kenya (Sitati *et al.*, 2003), where bulls raided crops closer to settlement than did cows.

It is clear that human activities dramatically affect the distribution and behaviour of elephants. But while generalised patterns of interaction have been identified at the macro scale, little is known about specific activities at the local level. Where people and elephants coexist within the context of CBC it is critical that the physical effects of human activities are better understood. This is particularly important if the relationships that govern interaction are thresholds rather than linear: defining the point at which elephants are displaced is essential for their perpetuation outside protected areas. Identifying which activities influence elephant distribution, and to what extent, will be critical to elephant management under the community-based conservation paradigm.

In this chapter I have explored the framework of CBC within Zimbabwe and have described the establishment of CAMPFIRE. I have identified the human-habitat interactions which affect elephants within CAMPFIRE districts. In the following chapter I introduce the study area, describe the social and economic activities of rural communities, and present the general methods employed during this research.

Chapter 3 Study Area and General Methods

3.0 Introduction

This research takes place in the two CAMPFIRE districts of Guruve and Muzarabani, which lie in the mid-Zambezi Valley in northern Zimbabwe. There follows a general description of the physical and human geography of the area. I then describe the process of selection of the wards and the villages in which the research was undertaken. Finally, I outline the general field methods and analytical techniques that have been used in this research.

3.1. Study area

3.1.1 Physical geography of the mid-Zambezi Valley

The Zambezi Valley is an ancient landscape that has changed little in the last 2-3 million years (Cumming & Lynam, 1997). The valley itself is a trench fault consisting of a flat valley floor bordered by escarpment mountains to the north and south. Geologically, the mid-Zambezi valley is dominated by Karoo sediments of the Permian and Triassic. In terms of geomorphology, the area is part of the Quaternary erosion cycle of the late Pleistocene, which extends from about 3 million years ago to the present.

The Zambezi Valley is a low-lying (350-500m above sea level) and semi-arid landscape (600-800mm rainfall per anum). There are three seasons: a rainy season from December to March (mean daytime temperature 26-34^{o}C); a cool dry season from April to July (mean daytime temperature 24-28^{o}C); and a hot dry season from August to November (mean daytime temperature >35^{o}C). The vegetation is composed of dry deciduous woodland dominated by *Mopane-Terminalia* spp. and *Mopane-Combretum* spp. woodlands, with dense riverine thicket of mixed species along the major rivers.

3.1.2 Wildlife in the mid-Zambezi Valley

The Zambezi Valley has been typified historically by large populations of wildlife, which persist today in a mosaic of woodland habitat and agriculture. There exist populations of elephants, buffaloes (*Syncerus caffer*), kudus

Tragelaphus strepsiceros, eland *Tragelapus oryx,* zebras *Equus burchelli*, impalas *Aepyceros melampus*, vervet monkeys *Cercopithecus aethiops*, chacma baboons *Papio ursinus*, bush pigs *Potamochoerus porcus* and wart hogs *Phacochoerus aethiopicus*, as well as significant populations of leopards *Panthera pardus*, spotted hyenas *Crocuta crocuta*, hippopotamus *Hippopotamus amphibious* and crocodiles *Crocodylus niloticus*. Lions *Panthera leo* and wild dogs *Lycaon pictus* are seasonal visitors to the study area (Mackie, 2001; CIRAD, 2001).

Over the past 100 years or so wildlife in the Zambezi Valley has been subjected to three major disturbances: first, the rinderpest epidemic of 1896, which reduced cloven-hoofed animals to extremely low levels; second, the game eliminations that formed a part of Tsetse control up to the late 1960's which were designed to protect the expanding livestock industry (Child & Riney, 1987); and third, the recent expansion of agricultural activities, which has displaced wildlife populations from their preferred habitats. In the past 20 years intensive settlement along river systems has effectively excluded wildlife from key dry season riparian habitats and water (Cumming & Lynam, 1997).

3.1.3 Elephants in the mid-Zambezi Valley

During the late 19th century elephants were heavily hunted for ivory, as the Zambezi Valley formed an integral part of ancient trade in gold and ivory which was centred on the East African coast (Cumming *et al.*, 1997). The elephant population was reduced to near extinction, but recovered significantly during the mid-20th century. Today, *circa*. 3000 elephants exist in the Mid-Zambezi Valley (Davies, 1997), at a mean density of 0.51 elephants per km^2 (Mackie, 2001). The population appears to be stable and contiguous throughout this range.

Elephant density varies both spatially and temporally across the study area, with large-scale movements occurring on a seasonal basis. During the rainy season, when water is readily available, elephants disperse widely across the landscape, but in the late dry season they move south into the Escarpment Mountains and north to Mozambique where perennial water supplies exist (Osborn & Parker, 2003a).

3.1.4 Human geography of the mid-Zambezi Valley

For 35,000 years the Mid-Zambezi Valley has been occupied by stone-age hunter-gatherers, who have existed at very low densities. Small-scale arable farmers have only inhabited the Mid-Zambezi Valley region in small numbers for the past 400 years in scattered farming settlements. Intensive settlement and agricultural development is less than 50 years old (Cumming & Lynam, 1997).

Pre-independence, the Zambezi valley was viewed as 'frontier' land by the colonial government, and only scattered settlements existed (Cunliffe, 1992). Poor soils and widespread tse tse fly distribution made the region unsuitable for human settlement and agriculture. However, overcrowding in the Tribal Trust Lands (TTLs) to the south prompted the government to resettle people to districts within the mid-Zambezi Valley. The introduction of irrigation schemes and a tse tse fly eradication programme during the mid-1960's enabled agricultural development to begin in earnest.

The mid-Zambezi Valley is classified as natural region IV and V (Appendix 2), typified by low rainfall, with poor, generally sandy soils (Lopes, 1996). Such regions are best suited to livestock production, and intensive arable agriculture is not recommended. Despite this, 97% of people within the mid-Zambezi Valley engage in rain-fed crop production (Cumming & Lynam, 1997). Only five percent of the land in the mid-Zambezi is considered suitable for arable farming, yet the total cultivated area in 2000 was predicted to exceed 18% (Cumming & Lynam, 1997), indicating that most farming occurs upon marginal soils.

Agriculture forms a continuous band along the major rivers and at the base of the escarpment mountains, along the southern borders of the study area. Some scattered settlements exist in the dry mopane woodland (Byers *et al.*, 2001). Agricultural activities have expanded rapidly due to the suitability of growing cotton, a lucrative cash crop, and to continued resettlement of small-scale farmers from the highveld. Between 1983 and 1993 land clearance reached a rate of 9% per annum as a result of large-scale immigration (Cumming & Lynam, 1997). Despite being the planning authority for all land within their boundaries, the RDCs have lost control of resettlement, which is conducted informally in order for prospective settlers to avoid the restrictions of the official system (Murombedzi, 2001).

3.1.5 Livelihood strategies of rural communities within the mid-Zambezi Valley

Most households in the mid-Zambezi valley rely upon agriculture as their main source of subsistence. Farming is small-scale dry land cultivation in which crops are grown between December and May. The main subsistence crops include maize *Zea mays,* groundnuts *Arapis hypogaea*, sorghum *Sorghum vulgare* and millet *Eusine coracana*. Cotton *Gossypium hirsutum* represents the most widely cultivated cash crop. Fifty nine percent of farmers within the Mid-Zambezi cultivate irrigated vegetable gardens during the dry season (Cumming & Lynam, 1997). Dry season cultivation is limited to gardens in the beds of the major rivers, where green maize, rape, tomatoes *Lycopersicon esculentum*, cabbage *Brassica oleracea*, onions *Allium cepa* and okra *Abelmoschus esculentus* are grown in small plots that are bucket-watered from wells. These plots are maintained from June through to September.

Maize is dried and stored through the dry season as the primary subsistence crop. This is supplemented with pumpkins and vegetables from the dry season gardens, and wild fruits and vegetables collected from the surrounding woodland (Welford, 2002). To generate income, farmers sell cotton as their principle cash crop, but surplus maize, ground nuts and vegetables may also be sold at local markets. Households may engage in income-generating activities such as brewing beer, making pots, rush mats or baskets, selling thatch grass, fish, bush meat or medicines. Men may work as labourers locally on farms, or on building sites, or may travel to other parts of Zimbabwe to find formal employment. Livestock may be sold or traded (Welford, 2002; Table 3.1).

Table 3.1: Income-generating activities within the mid-Zambezi Valley (from Cumming & Lynam, 1997).

Income-generating Activity	Percentage of income
Crop sales	35
Wages from employment	24
Livestock sales	14
Crafts	12
Remittances	11
Beer sales	9
Wildlife revenues	4
Vegetable sales	3

3.1.5.1 Natural resources

Communities within the mid-Zambezi Valley are heavily dependent upon natural resources, which contribute to most of their income-generating activities (Table 3.1). Virtually all nutrients used in vegetable and crop production are derived from soil stocks. All livestock feeds and most material in craft production and raw materials for beer production were derived from woodland resources (Table 3.2). In addition, gold panning activities have increased dramatically across the Zambezi valley in the past few years (Shoko, *unpubl.*). Therefore, natural resources play a critical part in the generation of household cash income (Cumming & Lynam, 1997).

3.1.5.2 Livestock

As key components of the communal lands production system in Zimbabwe, cattle provide households with a wide range of goods and services. These include cultural services, meat, insurance against crop failure and draught power (Cumming & Lynam, 1997). Fifty one percent of people own cattle within the study area. People own between one and 25 cattle, with the mean number being 5.13. In contrast 57% of people own goats, their herd size ranging from one to 110, with a mean size of 6.39. Only 4% of people own donkeys and they own between one and four animals, with a mean number of 2.14 animals (from interview survey, this study).

Table 3.2: Resources used by rural villagers within the study area (sourced from interview survey, this study: see *General Methods* in Chapter Three).

Resource type	Use of resource	% of people
Poles	Building, yokes, carpentry, other	90
Thatch	Building	84
Firewood	Domestic cooking	77
Grazing	Livestock fodder	39
Food stuffs	Fruits, vegetables, herbs, honey	30
Fibre	Building	24
Soil	Building	7
Brooms	Domestic cleaning	4
Gold panning	Income generation	2
Stones	Building	1
Bark	Construction of bee hives	1
Reeds	Income generation	1
Sticks	Building	1

3.1.6 Delineation of the study area

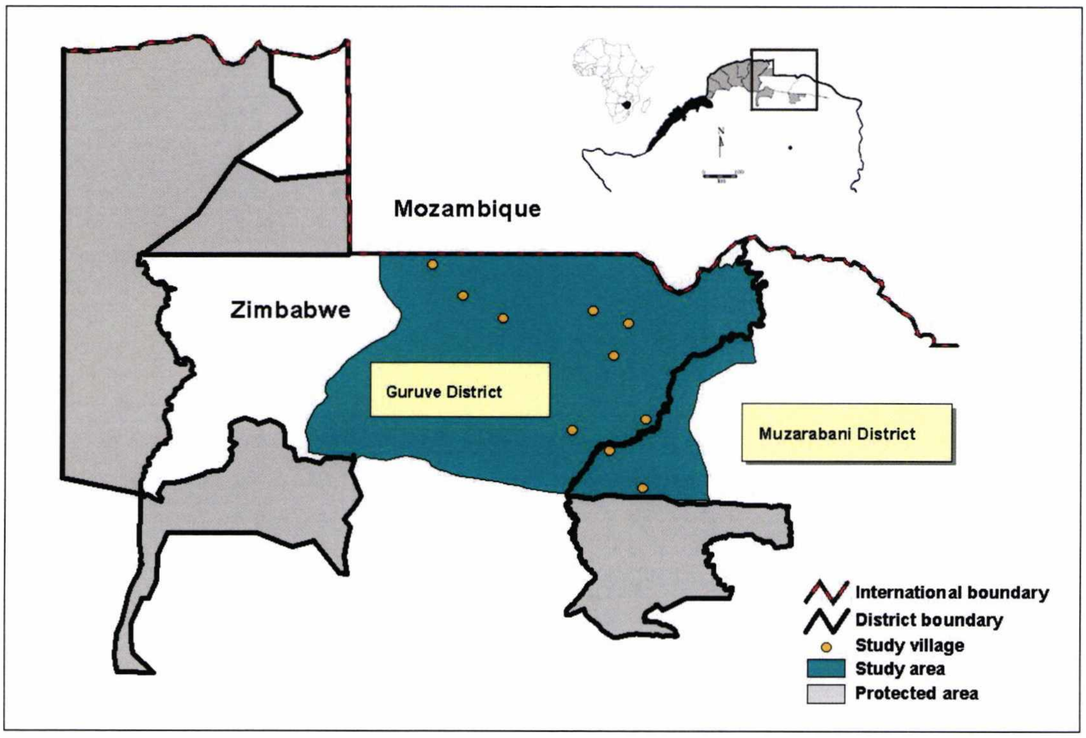
The study area encompasses 2,895 km^2 of the Zambezi valley, extending across Muzarabani and Guruve districts in north-eastern Zimbabwe (Figure 3.1). Muzarabani town, in the south eastern corner of the study area (31° 05' E, 16° 25' S), is approximately 200km directly north of Harare. The study area is bordered to the north by the international boundary between Zimbabwe and Mozambique, to the east by the Musengezi River, to the south by the Zambezi escarpment mountains, and to the west by the Manyame River. The project area extends 10km either side of the eastern and western river boundaries in order to include the riverine vegetation associated with either river system.

3.1.7 Administrative structures within the study area

The RDCs are the local government authority empowered by law to control, regulate and direct the development within each of the districts, as well as governing matters relating to common property management and the conservation of natural resources (Sibanda, 2001 *cited in* Welford, 2002). Guruve RDC administers eleven wards in Lower Guruve, three of which are within the study area. Muzarabani RDC controls fourteen wards, two of which fall within the study area. Guruve District was among the first RDCs to gain AA under CAMPFIRE in 1988. Muzarabani District followed three years later in 1991.

Although separate management entities, Guruve and Muzarabani RDCs manage their natural resources in collaboration. It is recognised by the respective CAMPFIRE committees that the elephants within each district are a shared resource, and management is conducted accordingly, even to the point of sharing revenues across the district boundary.

Figure 3.1: Location of study area within the mid-Zambezi Valley of northern Zimbabwe.



Wards are designated as 'producers' and non-producers', according to the density of wildlife within the boundaries. Producer wards contain high densities of commercially valuable wildlife and are permitted to set quotas for the hunting of these species, the revenue from which is retained by the ward. In contrast, non-producer wards are considered to have insufficient resources to support commercial hunting, and as such will receive only a base amount of revenue from CAMPFIRE. These designations embody the 'producer community principle' (Chapter Two), through which the wards bearing the costs of wildlife production retain the benefits. Hunting quotas are set by the DNPWLM at annual workshops in which representatives from the RDCs, the community and the CAMPFIRE service providers are present. Quotas are based upon survey data from aerial and ground surveys of large mammals carried out by RDC wildlife staff and service providers.

3.1.7.1 CAMPFIRE revenues in Guruve district

CAMPFIRE has generated substantial revenues in Guruve district: between 1989 and 2001 US$ 4,150,454 has been earned, of which 96% was generated through sport hunting activities, 2% was generated from the sale of problem animal control (PAC) hides and ivory, and 2% was generated from other activities (Table 3.3).

Table 3.3: Gross revenues from CAMPFIRE activities in Guruve district between 1989 and 2001 (sourced from WWF SARPO).

	Sport hunting	Tourism	PAC hides and ivory	Other
Total US$	3,971,812.00	0.00	95,232.00	83,410.00
Mean annual	305,524.00	0.00	7,325.53	6,416.15
Percentage	96	0	2	2

Of the gross revenues earned, 52% has been disbursed to communities in lower Guruve district (Table 3.4), and the remaining 48% has been retained by the RDC for wildlife management, administration and other activities.

Table 3.4: Allocation of CAMPFIRE revenues in Guruve district between 1989 and 2001 (sourced from WWF SARPO).

	Disbursed to communities	Wildlife management	Council levy	Other	Unallocated
Percentage of gross revenues	52	16	26	2	4

3.1.7.2 CAMPFIRE revenues in Muzarabani district

The gross earnings for Muzarabani district were substantially lower than for Guruve, and US$1,986,087 was earned over the same 13-year period. In Muzarabani, safari hunting contributed 70% of revenues, considerably less that in Guruve district, but still the majority share. Eight percent of revenues were generated through tourism, 7% through the sale of hides and ivory and 15% through other activities (Table 3.5).

Table 3.5: Gross revenues from CAMPFIRE activities in Muzarabani district between 1989 and 2001 (sourced from WWF SARPO).

	Sport hunting	Tourism	PAC hides and ivory	Other
Total US$	245,597.00	26,455.00	24,477.00	54,859.00
Mean annual	18,892.08	2,035.00	1,882.85	4,219.92
Percentage	70	8	7	15

Of the gross revenues earned, only 39% was disbursed to communities across the district (Table 3.6). The majority was retained by the RDC for wildlife management, administration and other activities.

Table 3.6: Allocation of CAMPFIRE revenues in Muzarabani district between 1989 and 2001 (sourced from WWF SARPO).

	Disbursed to communities	Wildlife management	Council levy	Other	Unallocated
Percentage of gross revenues	39	25	9	3	24

3.1.8 Community attitudes towards CAMPFIRE

Substantial revenues have been earned by both districts and these in turn have been reinvested in community projects across the study area. But the question remains as to whether the CAMPFIRE programme has generated support for conservation at the local level. As a national programme, and as an approach to conservation, CAMPFIRE has been deemed an unmitigated success in the absence of critical analysis (Adams & Hulme, 2001). However, little information exists as to its effects among the target communities. The few examples of current research are detailed below.

3.1.8.1 Negative attitudes

In Angwa ward, Lower Guruve district, several localised interview surveys have revealed intensely negative attitudes towards wildlife, which is seen to compromise the agricultural potential of the area. In Angwa ward 66% of respondents to an attitudes survey stated that wildlife had no value to them (Cutshall & Hasler, 1991). Angwa residents not only viewed wildlife as a major impediment to agricultural development, but also as dangerous pests that raid crops, take livestock and occasionally kill or injure people. Community members decided that 'the removal or eradication of wildlife' was second, on the list of the primary development needs for their ward. In a separate survey Welford (2002) found that 57% of community members in the same area believed CAMPFIRE should cease altogether.

A survey of community attitudes in Gutsa ward, Muzarabani district in 1999 also revealed predominantly negative opinions of the elephant. Despite the generation of revenues for community projects, local people viewed the CAMPFIRE scheme with scepticism. A common sentiment among community members in Gutsa was that agriculture, not CAMPFIRE, had developed the ward. Elephants were considered to impede agriculture, and therefore development, through their damage of crops (Dyson, 2000).

3.1.8.2 The negative impact of conflict

Crop damage engenders very negative attitudes towards CAMPFIRE among communities. HEC has become a high-profile national issue, attracting the attention of numerous newspaper reports. Often couched in emotive language, reports sport headlines such as: "Elephants and leopards wreak havoc in Muzarabani" (The Herald, 1998a) and "Authorities must act to end animal menace" (The Herald, 1998b). These reports call for government action to control the wild animals, and state that otherwise drought relief will be needed to enable people to survive the dry season.

In Muzarabani farmers have stated that they are willing to kill elephants in retaliation for crop damage, because the benefits of CAMPFIRE are meagre in comparison. One farmer said: "If nothing is done we are going to start killing these animals. We cannot let our crops be destroyed for the $300 we get from CAMPFIRE activities" (Herald, 1998a).

HEC within the study area takes many forms, including crop damage, the destruction of property, and competition for water and natural resources. However, crop damage is the most prevalent form of conflict across Muzarabani and Guruve districts; in Muzarabani during 1998 93% of all conflict incidents involved crops, while only 7% involved damage to property (n=155; Parker, 1998).

Human deaths from elephants, while not common, are high profile events that generate fear among rural communities. People in Angwa ward, Guruve district, view elephants not only as an impediment to agricultural development, but also as dangerous pests that raid crops and occasionally kill or injure people (Cutshall and Hasler, 1991). Such problems have also attracted the attention of the national press. A report from the Herald newspaper states that "living in wildlife-infested areas has become costly and risky as people get maimed or are killed by wild animals" (The Herald, 2003).

In Muzarabani district elephants have damaged grain stores during the dry season. Huts and fencing have also been destroyed (MZEP, 1999), and elephants have also killed cattle and goats (Dyson, 2000). In addition, elephant presence in woodland has restricts people's movements in the dry season, making fruit harvesting and the collection of other resources, including fire wood and water, difficult for local residents (Dyson, 2000).

3.1.8.3 Positive attitudes

While attitudes appear to be predominantly negative, in several locations there has been a very different response. Masoka is an isolated village in Kanurira ward, Guruve District. Kanurira is characterised by a low human population and high density of wildlife. In 1988 a CASS[6] study showed community attitudes towards wildlife that were generally negative; local residents were concerned mostly with gaining more community services from government, controlling tsetse fly, and encouraging new settlers. However, following distribution of revenues to the Kanyurira community through CAMPFIRE, wildlife came to be seen as a community endowment and something of economic benefit. "We see now," said one elder," that these buffalo are our cattle." The process of benefit disbursement had rekindled a proprietorial attitude toward the ward's wildlife.

3.1.9 Conflict mitigation

Conflict between wildlife and people is clearly a severe management issue for the RDCs, who attempt to mitigate conflict in a number of ways. First, revenues disbursed to communities are intended to offset such costs, and in the example above there is an indication of some success. In addition to revenue disbursement, RDCs also engage in conflict mitigation, and focus their efforts upon crop protection. The RDCs manage Anti-Poaching Units (APUs) who travel from village to village in reaction to reports of crop damage. Ward CAMPFIRE revenues fund APU units in each ward. Additionally there is a central unit which is centrally funded and supports the efforts of the ward units.

These units face considerable logistical problems in order to reach remote locations, especially during peak crop-raiding periods when the condition of the roads deteriorates from the rains. Disturbance shooting is the most common method of elephant control, despite the evidence to suggest that it has little deterrent effect upon crop-raiding elephants (Osborn, 1998; Thouless, 1994). In severe cases where elephants continually raid the same fields the APUs will be authorised to shoot an elephant, a strategy that reduces the number of problem animals, but has little deterrent effect on the behaviour of associated animals

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(Osborn, 1998). This methodology may also be considered a waste of a potential trophy animal.

Electric fencing projects have been initiated, both as ‘hard edge’ barriers along the edge of the MWA, and as individual fences encompassing a single farmer’s fields, but neither strategy has met with long-term success. One such barrier fence along the south-eastern edge of the MWA was designed to keep elephants out of the fields of Chawarura Communal Lands. The constant theft of solar panels and the high costs of repairing the fence led to its abandonment in 2002 (A. Mapfunga, *pers. comm.*).

Communal farmers commonly resort to their own methods of PAC, including burning fires around the fields, beating drums, and throwing stones at approaching elephants. However, elephants are able to habituate to such methods rapidly (Thouless, 1994; O’Connell-Rodwell *et al.,* 2000).

3.1.10 Conclusions

The mid-Zambezi Valley is an agriculturally poor area whose resources are stretched to the limits by an increasing human population. Following the government’s efforts to resettle farmers to the area, and the recent political unrest, immigration to the area has increased beyond the arable capacity. The clearance of natural habitat for farmland has increased concurrently, especially along the fringes of the major rivers.

Elephants are the key resource to both the Muzarabani and the Guruve CAMPFIRE programmes, providing the bulk of revenues through sport hunting. This revenue has been invested in community projects over the past 17 years. But elephants also cause crop damage and kill people, and as a result are widely regarded as competitors with agriculture rather than agents of development.

The circumstances of elephant conflict and of revenue distribution vary greatly across the study area. While previous research has indicated negative attitudes, and the national press portrays severe conditions of conflict, there do seem to be positive responses where benefits occur. There is a need to objectively assess peoples' attitudes towards the elephant, and to identify those components of human-elephant interaction that determine such attitudes.

3.2 General research methods

This section presents an overview of the methods of field data collection employed during this study. I begin by justifying the scale at which this research was conducted, and go on to describe the selection of the ten study villages which operate as centres for multiple data collection. I then introduce the methods used to collect data in the field, specifically describing training undergone for each type of data collection. The software packages used in analysis are described at the end of this chapter. Specific descriptions of data collection and analysis techniques are presented the relevant chapters.

3.2.1 Selection of study area

I selected the location of the study area on the basis of three criteria: first, the varied densities of humans and elephants; second, the existence of producer and non-producer wards; and third, the existence of data from previous research into elephant movements and conflict, which provides a baseline of information for this study, and serves to reinforce its findings. Each of these criteria is described in detail below.

3.2.1.1. Human and elephant densities

Within the mid-Zambezi Valley, both humans and elephants occur at varying densities. Human density within the study area in 1993 was recorded at 24.4 people per km^2 (Cumming & Lynam, 1997). This density is significantly higher than the critical values set by Hoare & du Toit (1999), who identified a human density of 15.6 people per km^2 as being critical to human-elephant interactions. However, this density is a mean value for the entire area and settlement patterns and densities vary enormously depending upon location. While settlement is concentrated along major rivers, there are extensive areas of mopane woodland in which virtually no-one exists. Therefore, humans occur at a density both above and below the threshold set by Hoare & du Toit (1999). In addition, the study area exhibits a broad range of elephant density, from 0-0.99 elephants per km^2 (Mackie, 2002).

3.2.1.2 Producer and non-producer wards

The study area encompassed both producer and non-producer wards, in which differing wildlife densities, and their associated costs, occurred. I selected three wards on the basis of their wildlife production status. The three wards selected were: Chikafa ward (3), Chiriwo ward (4), and Masomo ward (6) within Guruve district, and Gutsa and Hwata wards in Muzarabani district.

3.2.1.3 Previous research

The three selected wards were of specific interest because data from previous research conducted by the Mid-Zambezi Elephant Project was available for them. Elephant radio-tracking locations and crop damage reports from 1998-2002 provide a valuable baseline on elephant movements and conflict patterns for this current research.

3.2.2 Selection of study villages

I selected study villages from the three study wards which would act as foci for multidisciplinary research. Forty one villages fell within the study area, and I selected a random sample of 10 in the following way. First, I classified all the villages within the study area according to the broad habitat type in which they were located (Table 3.7). Villages in riverine habitat were within 1km of a major river; villages in jesse thicket habitat lay within 1km of the Gonono sand ridge; and, villages in mopane woodland were situated within either mopane woodland, or mopane-*Combretum* woodland. Each village was additionally classified according to whether it was in a producer or non-producer ward. I selected villages from each habitat classification using random numbers generated in Excel. I ensured that the resulting sample reflected the distribution of villages occurring within each habitat type, and within producer and non-producer wards.

In making my selection I ensured that villages were more than 5 km apart (direct line distance) in order to minimise the influence between selected villages. Because my research investigated the influence of revenues in each village, and their effect upon people's attitudes, it would have been difficult to differentiate this effect in villages in close proximity to each other. Originally there were twelve villages, but they were reduced to ten because in two villages, Chitsungo and Mupedzapasi, the access was difficult during the wet season and I consequently removed them from the analysis.

Table 3.7: Selection criteria for research communities.

Village	Vegetation type	Ward	Wildlife production
Chikafa	Riverine / jesse & Gonono	3	No
Bwazi	Riverine	3/4	Yes
Kapururira	Jesse thicket	4	Yes
Jowa	Jesse thicket	4	Yes
Majinga	Mopane / jesse & Gonono	4	Yes
Bonga	Riverine	4	Yes
Kasuo	Riverine	6	No
Gera	Mopane	6	No
Soka	Mopane	G	Yes
Warambwa	Mopane	G	Yes

3.2.3 Description of methods

3.2.3.1 Training enumerators

I selected an enumerator in each study village to collect ecological and sociological information within their own locality. I trained each enumerator to collect research data on a number of different issues. The tasks included both quantitative and qualitative research, which required very specific and intensive training. All ten enumerators were trained together in order to benefit from peer learning, but also in order to establish standard procedures. The specific forms of training are described below.

3.2.3.2 Crop damage reporting

Enumerators were trained to carry out crop damage assessments within their own villages. I exposed the enumerators to the procedures of reporting crop damage by wild animals (see Chapter Seven). The enumerators were trained to measure the area of damage, assess the intensity of damage, and accurately record elephant and wildlife spoor. I emphasised the importance of standard procedure, and demonstrating the dangers of inaccurate reporting. Following this initial training I employed the enumerators for a month trial period during September 2002, before signing them for the entire year.

I initially tested inter-observed reliability using blind tests in which the accuracy and reliability of each enumerator was compared from their reports on known events of known origin. During the entire period of contract I subjected each enumerator to spot-checks every month, where I would arrive unannounced and cross-check the recent crop-damage reports with the evidence in the fields. This conflict reporting scheme provided comparable quantitative data that was unbiased by human emotion.

3.2.3.3 Elephant dung surveys

Enumerators were trained to undertake elephant dung surveys according to the Distance sampling methodology. The initial training session involved 3 days of practical training in which transect protocols, data recording and measuring were covered. This was followed by a day of theory training in which the purposes of dung collection, and the importance of accurate measurements, was covered. As with crop damage reporting, enumerators were checked regularly in the field and individuals were rotated between teams.

3.2.3.4 Semi-structured interviews

My qualitative research took the form of a semi-structured interview survey and focus group discussions which were carried out in each of the study villages. These were designed to explore the perceptions of local community members of the costs and the benefits of living with elephants. I began with a baseline survey of farming activities and resource use which was used to determine each individual's socioeconomic status. I then explored the range of issues of human-elephant conflict that people faced, which were prioritised in terms of their impacts upon people. I then carried out a similar exercise for elephant benefits, identifying the key benefits and prioritising them in order of their importance. Finally, I assessed peoples' attitudes towards the elephant using a comparison between costs and benefits, and a series of fixed response questions to gauge peoples' support for elephant conservation.

Semi-structured interviews were guided by a pre-determined set of questions that were explored during an interview. This guide served as a checklist and ensured that basically the same information was obtained from every respondent. Yet there was a great deal of flexibility: the order and actual working of the questions was not determined in advance. Moreover, within the list of topics the interviewer was free to pursue certain questions in depth (World Bank, 2004).

3.2.3.5 Training for interview and focus group discussion methods

Five field enumerators and I underwent a four-day course trained in participatory field techniques, held at MWA headquarters camp in July 2002. The course was conducted by Mwaramba Associates, Harare, who specialise in training extension officers in social science research methods. The course detailed the theory and concept of participatory research, presented a 'toolbox' of potential methods to be used, and trained participants to use the methods in a field environment.

The field methods for this research were developed and field-tested at a pilot study held at Chief Hwata's homestead in Muzarabani District. The pilot lasted two days during which we invited 42 members of the local community to engage in group discussions, mapping exercises and individual interviews. The pilot tested each of the interviewer's facilitatory techniques and enabled the evaluation and modification of research questions.

Interviews were carried out by myself, with the help of an enumerator in each village. In addition, I trained Mary Matambanadzo, a Shona woman from Muzarabani district, to assist with the interviews, because with only limited Shona language skills at my disposal I would have been unable to conduct complex discussions in Shona myself. English literacy varies greatly in the Zambezi Valley, and conducting interviews purely in English may have led to confusion by misinterpretation of the questions, and loss of information through difficulty in articulating precise meanings in an unfamiliar language. In addition, as a woman Mary presented less of a threat to female interviewees, and was therefore able to access information unavailable to myself or other male enumerators. Mary was assisted by one of four male researchers from the project who had undertaken the same training in participatory techniques, and whose job was to record the interviews in detail.

3.2.3.6 Focus group discussions

I conducted focus group discussions in each study village, assisted by Mary Matambanadzo and one enumerator. The purpose of focus groups was to cross-check the results of the SSI survey, and to further explore the conflict issues raised by the interviews. FGs are a research method that enables the researcher to explore the experiences, opinions and concerns of a group of people. They draw together people from similar backgrounds or experiences in order to discuss specific topics through inter-and intra-personal debate. This approach is valuable in its capacity to reveal both the individual and the collective opinions, and how meanings are negotiated among group members (Cook & Crang, 1995).

The FGs were composed of groups of 7-10 people. Before the FG began it was explained that the proceedings were not political in any sense, and were for wildlife research purposes only. People's identities would not be disclosed if they preferred to remain anonymous. All present were encouraged to discuss and comment on the questions raised, and it was made clear that everyone's views would be welcomed equally. The discussions lasted up to one hour, and were guided by a series of issues similar to those employed for the SSIs (Appendix 3). The discussions were flexible in nature and often followed related topics of interest as they arose.

3.2.4 Secondary data

In addition to the data collected through field research a great deal of secondary data was accessed from institutions within Zimbabwe. The Government Statistics office in Bindura provided accurate population figures for the study area from the National census carried out in 1992 and 2002. Elephant population and density figures for the study area were gained from WWF SARPO[7]'s elephant census which was conducted in 2001. WWF SARPO also provided details of the gross revenues earned by Guruve and Muzarabani districts. CIRAD[8] provided the base map of vegetation for the study area, which included patterns of settlement and cultivation.

3.2.5 Analytical tools

This research required the employment of a variety of analytical tools, from mapping programmes to statistical packages. There follows a brief description of the analytical tools employed during the data analysis.

3.2.5.1 Geographical Information Systems

In this study a Geographical Information System (GIS) was used to map elephant distribution, and human variables on elephant habitat use. GIS is defined as a "computer programme and hardware designed to store, manipulate and display data recorded according to geographical location" (Marble, 1990). The data it contains can be thought of as a series of digital maps (coverages), which describe different information about the same study area (Smith & Kasiki, 2000). GIS studies have been used on elephants in three ways: i) to plot movements and calculate home range (Thouless, 1996); ii) to plot population numbers and distribution (Gibson *et al.,* 1998); and, iii) to explore habitat preferences (Omullo *et al.,* 1998).

The GIS system selected for the analysis was Arc View 3.2 (ESRI Inc., Redlands, CA). The Arc View software served as a data storage and display mechanism in addition to being an analytical tool. The base map for the study area included vegetation and settlement, derived from the CIRAD (2002) digital map, roads and rivers digitised from SPOT 4 remote sensing coverage, and transect locations and water sources from GPS locations in the field.

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8 Centre de coopération internationale en recherche agronomique pour le développement.

3.2.5.2 SPSS

I used Statistical Package for the Social Sciences (SPSS) for Windows version 12.0, which provides a broad range of capabilities for the entire analytical process. For bivariate analysis, where my data conformed to a normal distribution, I used parametric statistical tests. However, where my data did not conform to a normal distribution I used the equivalent non-parametric test. For example, to test the significance of a directional relationship between two variables I either used the parametric Pearson correlation, or the non-parametric Spearman's Rho correlation test. For multivariate analysis I used the multiple linear regression model in SPSS.

3.2.5.3 Genstat

I used Genstat for Windows version 7.1 (Lawes Agricultural Associates, 2003) to analyse elephant distribution data, which displayed a strong poisson distribution. I selected the Generalised Linear Interactive Model (GLIM) to investigate the influence of multiple variables upon elephant distribution (Crawley, 1993). GLIMs are increasingly used in biological and ecological studies and are well-reviewed, particularly in the fields of environmental control of species distribution (Augustin *et al.*, 1998; Miller & Franklin, 2002). More recently they have been used in the analysis of elephant habitat preference (Vanleeuwe, 2004).

In this chapter I have defined the study area and have described the conditions that persist within the context of the CAMPFIRE districts. I have additionally presented the general methods employed in this research. In the following chapter I investigate the distribution of elephants across the study area according to season and vegetation type.

Chapter 4 Assessing the Distribution of Elephants

4.0 Introduction

African elephants are among the most studied of all the undomesticated African mammals (Poole, 1996). Elephants have been censused in forest and savanna environments in order to determine their population sizes (Barnes, 2001). Researchers have investigated the distribution (e.g. Vanleeuwe, 2004), the use of habitat (de Boer *et al.*, 2000), the movement routes (e.g. Low, 2001; Osborn & Parker, 2003) and the effects of human disturbance upon elephants (e.g. Blom *et al.*, 2004). All such investigations require a survey of the elephant population in question, either by direct counts, in which the elephants themselves are quantified, or indirect counts, in which elephant signs such as dung and spoor are quantified.

If implemented correctly, dung counts are an effective and reliable method for estimating the relative abundance of elephants (Barnes, 1983). While dung counts have been used primarily in West and Central African rainforests to survey areas with low visibility (e.g. Eggert *et al.*, 2003), they can also be used in savanna areas where vegetation cover is thick, or where the landscape is inaccessible (Vanleeuwe, 2004), and additionally where precise information is required at a local scale (Nahonyo, 2001).

It is not always necessary to estimate the size of elephant populations in order to answer some research questions. In many cases, it is only necessary to determine the relative distribution of elephants. Indeed, much relevant management information can be derived from patterns of elephant distribution and relative abundance (Barnes, 1996). An index of relative abundance can be calculated from dung counts, and its calculation is relatively straightforward and does not necessitate the estimation of defecation rate, which is a potential source of error (Barnes, 2001). However, the one limitation to measures of relative abundance is that the ensuing results are not necessarily comparable other to studies.

The distribution of elephants in savanna ecosystems is dictated by the availability of water and food resources (Leuthold, 1977; Afolayan & Ayaji, 1980; Western

& Lindsay, 1984). In highly seasonal environments, elephants will stay close to perennial water especially during the dry season (Taylor, 1983; Connybeare, 1991; Stokke & du Toit, 2002). As generalist feeders, elephants will exploit the vegetation available to them, including grasses, foliage, bamboo, roots, bark, wood and fruits (Grzimek, 1975). Elephants may also show a preference for certain habitats. For example, forest patches were selected over the grassy plains in Maputo Elephant Reserve (de Boer *et al.*, 2000). Vegetation growing in areas of fertile soil may be selected over that growing on sandy soils (Stokke & du Toit, 2002; Holdo, 2003).

Previous research in the mid-Zambezi Valley has disclosed patterns of elephant movement that occur seasonally. A study of 20 radio-collared elephants has revealed that bull elephants moved regularly between the Zambezi escarpment mountains and the national border with Mozambique to the north (Osborn & Parker, 2003a). Elephants tend to disperse across the valley floor during the rains, and return to the escarpment mountains during the dry seasons, when water becomes scarce (ZamSoc & MZEP, 2000). However, while large scale seasonal movements have been tracked, little is known about the use of habitats by elephants, or by their interaction with humans.

With this in mind this chapter aims to increase our understanding of elephant distribution across the study area by:

- establishing the means of describing elephant relative abundance; and,
- investigating elephant relative abundance in relation to season and vegetation type within the mid-Zambezi study area.

4.1 Methods

4.1.1 Relative abundance of elephants

I determined the relative abundance of elephants across the study area using stratified dung surveys conducted during each of the three major seasons in 2003. They were carried out at the mid-point of each season: for the wet season, this was the second week of February; for the cool dry season, this was the second week of June; and, for the hot dry season, this was the second week of October. Each survey provided a snapshot of the relative abundance of elephants within that season.

4.1.1.1 Stratification of the study area

Elephants are known to have preferences for certain habitats, which will be reflected in their distribution. When surveying areas composed of different vegetation types elephant densities will be expected to be high in certain vegetation and low in others. This creates sampling problems, as the differences among vegetation type lead to high variance in the overall estimate of elephants (Barnes, 1996). To limit variation, the sampling effort must be stratified in proportion to the estimated density of elephants within each stratum. Thus there will be greater sampling effort in a stratum where elephant density is estimated to be high, and less sampling effort where elephant density is estimated to be low (Barnes, 1996). The initial estimate of elephant density is made from a pilot survey conducted within each stratum.

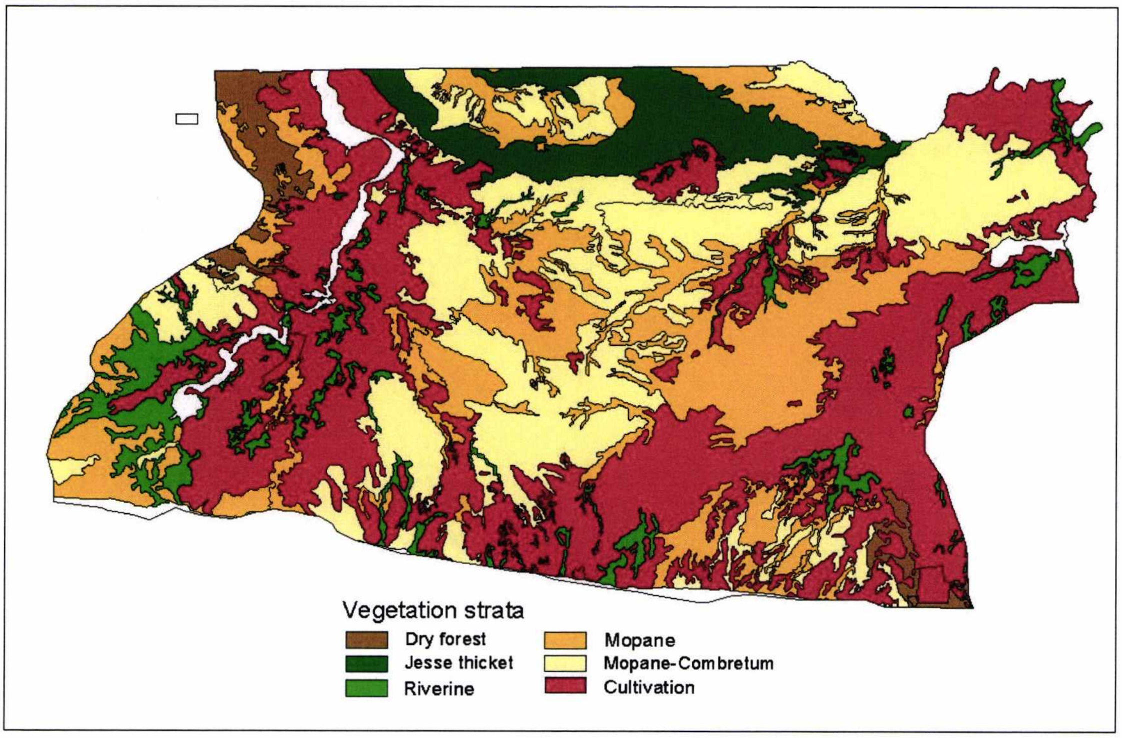
The vegetation in the mid-Zambezi Valley study area was categorised into five broad types, based upon the predominant species that occur, according to a classification system developed by CIRAD (2002) and Timberlake & Cunliffe (1997) (Table 4.1; Figure 4.1). Each of the vegetation types represented a sampling stratum in which elephant density was determined. Cultivation was not sampled because elephants would not treat this as natural habitat. In addition elephant dung has many uses to local people and it may be removed for fertilizer or medicine, so compromising any dung survey results.

To estimate elephant dung density within each stratum, a pilot study was conducted in September 2002 in which short transect sections were surveyed in each vegetation type. Transects ranged between 1 and 5 km in length. The number of elephant dung piles observed one metre to each side of the transect line was recorded, and the total was converted to a kilometric index of abundance (kmA) by dividing the number of observations by the kilometre distance travelled. The riverine pilot contained no elephant dung (Table 4.2).

Table 4.1: Vegetation strata within the study area

Vegetation Stratum	Area km^2	Area (%)	Species composition
Dry forest	77.2	2.7	*Xylia torreana, Diospyros quiloensis, Pterocarpus lucense antunesii*
Jesse thicket	186.3	6.4	*Baphia massaiensis, Terminalia brachystemma, Digitaria milanjiana*
Mopane woodland	620.4	21.4	*Colophospermum mopane, Combretum eleanoides, Combretum apiculatum*
Mopane-Combretum woodland	710.6	24.5	*Diospyros kirkii, Terminalia brachystemma, Combretum apiculatum*
Riverine thicket	163.7	5.7	*Colophospermum mopane, Commiphora caerulea, Gyrocarpus americanus,*
Cultivation	1076.9	37.9	

Figure 4.1: Vegetation strata within the study area.



4.1.1.2 Survey effort

Survey effort was limited by manpower and vehicle availability to a total transect length of 200km for each season. This total length was sub-divided among the five vegetation strata according to the density of elephants within each stratum. The density values were converted to a ratio which was then used to apportion target transect lengths to each vegetation stratum (Table 4.2). For the riverine stratum, the transect length was re-apportioned according to the area of the stratum, as displayed in the column marked 'Adjusted ratio'.

Table 4.2: Transect sampling intensity per vegetation stratum.

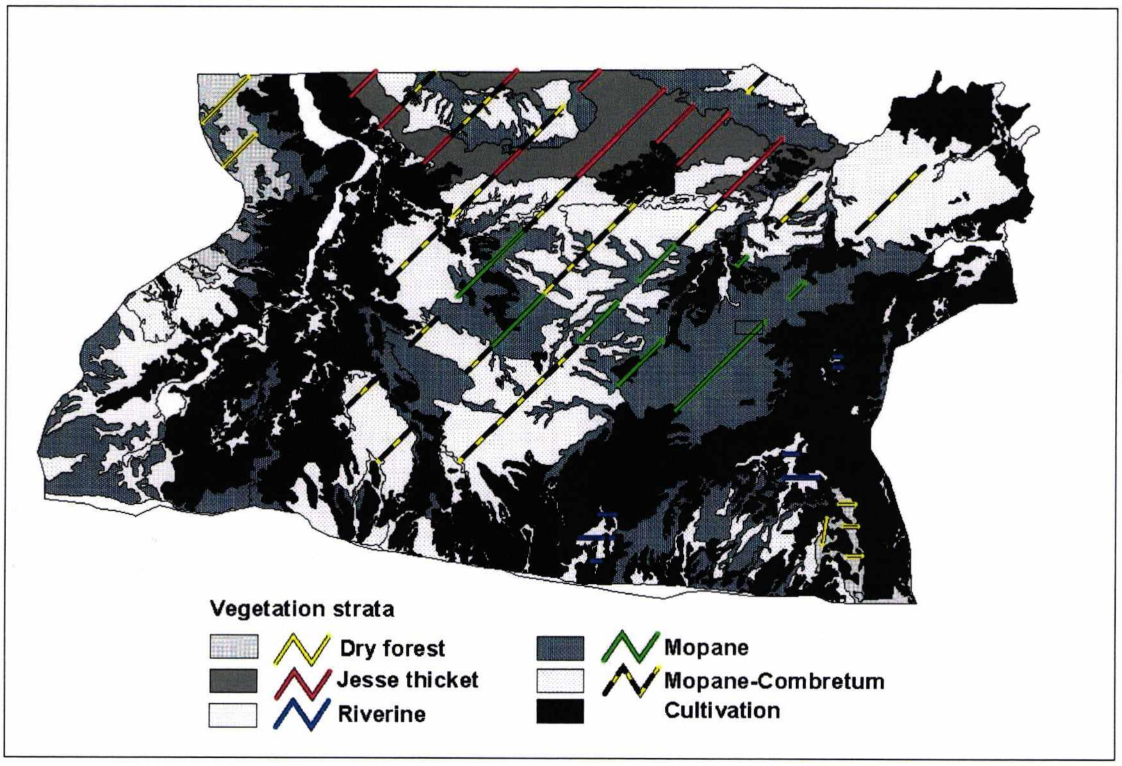
Vegetation stratum	Length of pilot (km)	Elephant kmA	Ratio	Adjusted ratio	Target transect length (km)
Dry forest	3	0.33	0.07	0.07	14.61
Jesse thicket	5	1.20	0.24	0.22	43.95
Mopane-Combretum	5	2.40	0.49	0.46	92.64
Mopane	5	1.00	0.20	0.20	40.18
Riverine	1	0.00	0.00	0.04	8.62

4.1.1.3 Survey design

The surveys were individually tailored to each stratum's specific size and shape. Transects were laid out using a randomised systematic design, the starting point of which was randomly selected using a grid overlaying the stratum map. Transects were placed in parallel at regular intervals (0.9-5.6 km apart depending upon the stratum), orientated North-east to South-west to take advantage of the prevailing North-easterly wind (Figure 4.2). The only exception to this occurred in the small riverine and dry forest patches, where transects were orientated North-south and East-west to maximise the coverage of the patches.

Each individual transect was approximately 5km long (range: 0.24km – 10.87km), this being a balance between effort required to reach each transect, and the concentration span of the observers. Once the design was completed, several transects were moved to ensure their start point was more than 500m from a road in order to avoid undue disturbance. The transect design was repeated in each season using the same locations, and minor adjustments were made where necessary (Appendix 4).

Figure 4.2: Transect design for the study area, showing individual transect designs for each vegetation stratum.



Each transect was surveyed by trained teams who used the standardised transect data sheet (Appendix 5). A GPS accurate to within 15m was used to locate the start points of each transect. In most cases transects ran along a north-easterly compass bearing, which the team followed until their specified distance had been achieved.

As each team moved along the transect base line, they noted any elephant dung. They recorded the distance along the base line at which it occurred, and measured the perpendicular distance from the base line to the centre of the dung pile using a measuring string. Where dung boli were scattered an assessment of the exact centre of the pile took into account all boli. The approximate age of the dung pile was noted using the five age categories devised by Barnes & Jensen (1987).

4.1.1.4 Actual transect distance

The transect lengths completed in each season did not perfectly match the idealised target distances displayed in Table 4.2. There were minor deviations from the targets in the wet and hot dry seasons (total deviation 0.5 and 2.4 km respectively; Table 4.3). However, the transect lengths displayed a substantial departure from the targets in the cold dry season because of staff shortages and vehicle problems (total deviation: 47km). Two field staff were dismissed in June 2003 due to misconduct and replacements were not identified and trained in time for the survey. In addition, only one vehicle was available for the entire month due to a breakdown of the second vehicle. As a result, transects were below target by: 13km in jesse thicket; 24km for mopane-*Combretum* woodland; and, 11km for mopane woodland.

Nevertheless, these inconsistencies in survey effort between seasons did not affect the precision of the survey results, because during analysis the dung counts were converted to an index of relative abundance in which the length of each transect was accounted for, thus negating any differences between the seasons.

Table 4.3: Overview of survey effort per vegetation stratum in each season.

Stratum	Target transect length (km)	Actual transect distance		
		WS (km)	CDS (km)	HDS (km)
Dry forest	15	13	13	14.7
Jesse thicket	44	44	34	45
Mopane-Combretum	93	92	71	95
Mopane woodland	40	43.5	28	40.7
Riverine	9	8	8	8
Total	**201**	**200.5**	**154**	**203.4**

4.2 Analysis

A total of 122 transects were carried out in 2003. Once completed, transects were divided into approximately 1km sections in order to increase the total sample size to 626 transect sections. Increasing the number of transects improved the efficiency of statistical analysis, which is maximised where there are many short transects rather than a few long ones (Norton-Griffiths, 1978). A larger sample size also enabled a greater number of independent variables to be included in the multivariate analysis of factors affecting elephant relative abundance, which is described in Chapter Five. From this point onwards, any mention of 'transect' in the text will refer to the c. 1km sections and not the original transect lengths.

4.2.1 Dung density

4.2.1.1 Detectability and distance analysis

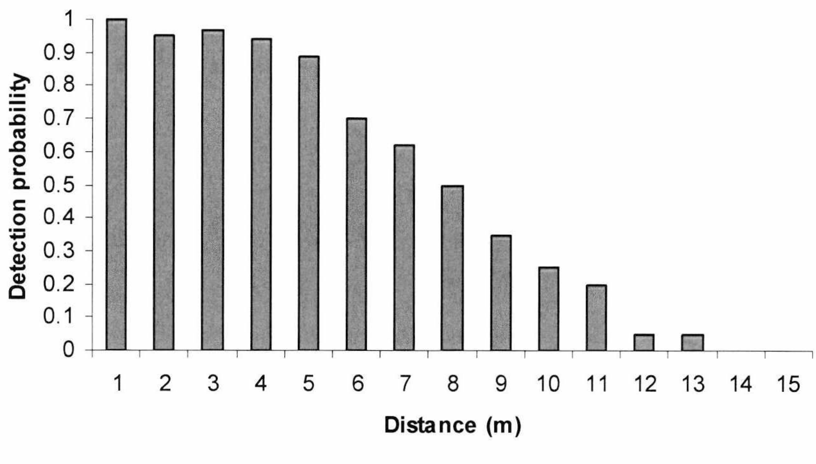
The data on numbers of dung piles and their distance from the transect base line did not account for any differences in detectability between vegetation strata. Variation in the detectability of objects is a common problem because vegetation structure influences the ability of an observer to detect the target object (Smith *et al.,* 1997). In thicker vegetation, the distance at which dung can be detected is lower than in less dense vegetation, where the dung is more visible. This difference in detectability determines the number of dung boli that will be recorded, and must be accounted for if comparisons are to be made between different vegetation strata.

The Distance programme Ver. 4.1 (Thomas *et al.,* 2003) enables comparisons of dung density between different types of vegetation. The programme models the probability of detection of objects within a vegetation type from the number of observed objects and their distance from the transect line. From this information, the model estimates the detectability of the objects and calculates their density for the area of interest.

Distance requires a minimum of 60-80 individual observations for each stratum in order to calculate density with accuracy. Where data fall below the minimum requirement there is a danger that the detection model will not fit the data and this renders the density estimate inaccurate. However, if the data are of good quality, it may be possible to fit a model to a data set that is small, and still generate an accurate density value (Buckland *et al.,* 1993). What is required is a broad shoulder, which indicates that the probability of detecting objects stays close to 1 for some distance from the base line (Figure 4.3).

Both jesse thicket and mopane-*Combretum* woodland contained a substantial number of observations, with 77 and 74 dung piles, respectively. Forty seven observations were made in mopane woodland, while only 27 observations were made in dry forest. While the sample size was small for dry forest and mopane woodland, these strata were still considered suitable for analysis because they exhibited the requisite broad shoulder (S. Strindberg, *pers. comm.*). However, no dung piles were observed in the riverine stratum, which was dropped from this analysis.

Figure 4.3: Data from a distance-sampled transect displaying a 'broad shoulder' in which the detection probability remains high for some distance from the line.

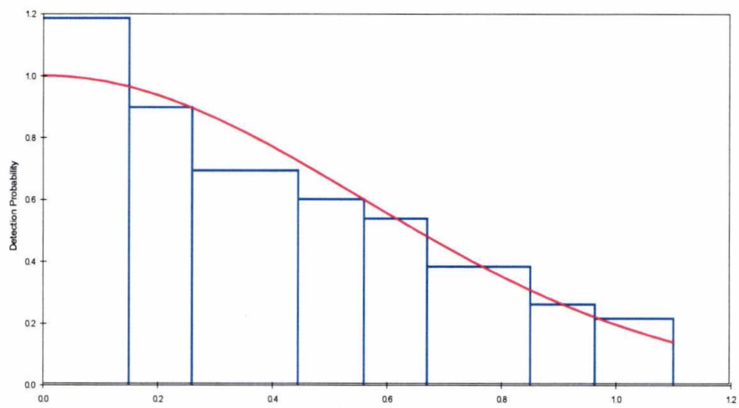


Distance provides a range of detection curves that can be fitted to transect data. These models are known as hazard rate, uniform and half-normal, and each one describes a different shape. The accuracy of the analysis depends upon the closeness of fit between the dung data and the model curve (Figure 4.4). Where there are outliers, the model may require adjustment parameters to fit these values. However, it is advisable to truncate the data and remove the outlying 5% of points, so increasing the goodness of fit of the model (Buckland *et al.*, 1993). In the above example a truncation distance of 9m would be acceptable.

4.2.1.2 Goodness of fit

The goodness of fit of a model is indicated through the Akaike's Information Criterion (AIC), which is an objective, quantitative method for selecting the most appropriate model (Buckland *et al.,* 1993). The AIC describes the goodness of fit of a model to a data set, and a lower value indicates a closer fit. A visual inspection of the model graph will confirm the closeness of the fit to the data (Figure 4.4).

Figure 4.4: Fitting the Distance model curve to elephant dung data.



The Chi square test is an additional goodness of fit analysis. It establishes categories within the detection curve and generates expected values for observations within each category. The observed data are then compared to the expected values, and the model fits well if the Chi square test is not significant. In contrast, when the data depart from the model expectations, the Chi-square will be significant, and the analysis should be rejected (Buckland *et al.,* 1993).

4.2.2 Calculating the index of dung abundance

For each transect, the data on dung density were converted to an index of dung abundance that enabled observations to be compared across vegetation strata (c.f.

Jenkins *et al.*, 2001). The index of dung abundance was calculated in two stages. First, I calculated the proportional contribution made by each transect line to the total number of observations in each stratum. Second, I multiplied this value by the density of dung within each stratum, as computed by Distance.

Number of individual dung piles on transect *x* * Dung density per stratum (km^2)
Sum of dung piles within vegetation stratum

The resulting index of dung abundance controlled for the differences in detectability between the different habitats, because it included the density estimate in its calculation (Jenkins *et al.*, 2001). This single index made each transect comparable between vegetation strata and between seasons. From this point forward this index of dung abundance will be employed in all graphical and statistical analyses. The index of dung abundance can be considered a measure of elephant relative abundance, if one accepts the assumption that elephants defecate at the same rate across the study area.

4.2.2.1 Spatial autocorrelation

When analysing spatial data, there is a risk that spatial autocorrelation will create a situation of non-independence (Koenig, 1999), in which adjacent cells have similar values for the dependent variable. This effect can increase the apparent significance of correlation coefficients, thus increasing the risk of committing a type-1 error.

CrimeStat® is a spatial statistics programme for the analysis of crime incident locations, developed by Ned Levine & Associates, Annadale, VA. It calculates Moran's *I* statistic, which measures over-clustering or over-dispersal in a spatial data set. *CrimeStat*® is Windows-based and interfaces with most desktop GIS programmes. I tested the elephant abundance data along *c.* 1-km transects for autocorrelation using *CrimeStat*®. Moran's *I* statistic is an index of co-variation between different point locations and is similar to a product moment correlation coefficient. If the value of *I* exceeds expected values then clustering has occurred. The test statistic Z indicates significant clustering where it exceeds ±1.96.

4.2.2.2 Index of dung abundance by season and vegetation type

Changes in the index of elephant dung abundance were compared between season and vegetation type using the arithmetic mean of the abundance index. Differences were investigated using bar charts and non-parametric bivariate and multivariate statistical tests in SPSS (ver. 12.0).

4.3 Results

4.3.1 Dung density

Dung density was estimated for each stratum using each of the three different detection curves (Table 4.4). Each model closely conformed to the shape of the data and density estimates for each individual stratum were similar regardless of the model employed, which indicated that the analysis was robust. The final model for each stratum was selected primarily on the basis of its AIC value, with the χ^2 goodness of fit test also being considered. The uniform detection curve provided the best results for dry forest and mopane woodland, while the half-normal detection curve provided the strongest analysis for jesse thicket and the hazard-rate model was most appropriate for mopane-*Combretum* woodland (Table 4.4).

Table 4.4: Distance analysis of four vegetation strata in which elephant dung was present during 2003.

Stratum	N	Detection curve	X^2	d.f.	p	AIC	Density km^2
Dry forest	22	Hazard rate	0.69	4	0.942	77.97	563.80
Dry forest	22	Uniform	0.48	5	0.992	75.57	623.83
Dry forest	22	Half-normal	0.41	5	0.995	75.60	638.52
Jesse thicket	67	Hazard rate	0.61	5	0.987	262.07	406.97
Jesse thicket	67	Uniform	0.98	6	0.986	260.43	352.13
Jesse thicket	67	Half-normal	1.13	6	0.980	260.20	350.18
Mopane-Combretum	45	Hazard rate	0.77	7	0.997	186.12	118.38
Mopane-Combretum	45	Uniform	2.34	7	0.938	187.77	86.90
Mopane-Combretum	45	Half-normal	1.16	7	0.992	186.50	101.89
Mopane woodland	39	Hazard rate	0.59	3	0.899	130.7	325.18
Mopane woodland	39	Uniform	1.06	4	0.899	129.22	306.54
Mopane woodland	39	Half-normal	1.13	4	0.889	129.29	309.43

4.3.1.1 Spatial autocorrelation

None of the elephant dung data sets displayed the characteristics of significant spatial autocorrelation (Table 4.5). The Z statistics in each case fell below the prescribed statistical threshold of ±1.96.

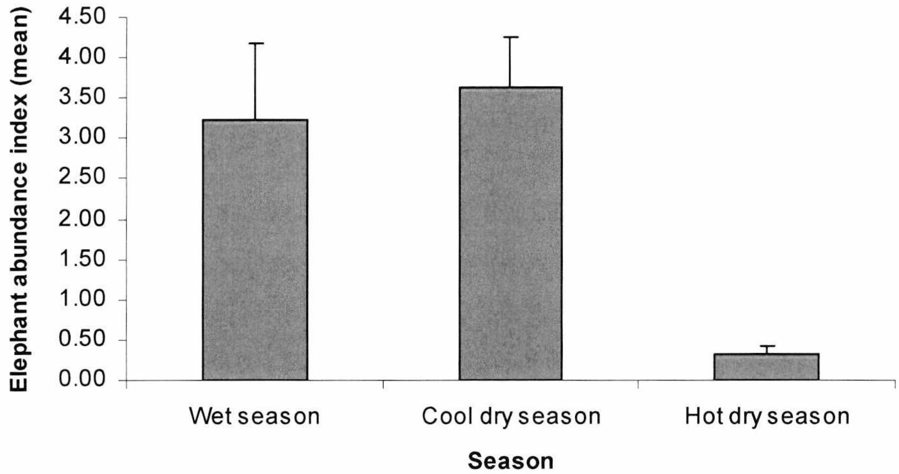
Table 4.5: Moran's *I* test for spatial autocorrelation.

Season	Moran's I	Normality significance (Z)
Wet season	0.025	1.324
Cool dry season	0.050	1.779
Hot dry season	0.0058	0.485

4.3.2 Index of dung abundance by season

The index of dung abundance differed by season (χ^2=45.06, p=<0.001, d.f.=2, Kruskal-Wallis test). The index differed between the wet season and the cool dry season (z=-3.68, p=<0.001, Mann-Whitney *U* Test), and between the cool dry and the hot dry season (z=-6.59, p=<0.001, Mann-Whitney *U* Test). However, the greatest difference was between the cool dry season and the hot dry season (Figure 4.5).

Figure 4.5: Mean ±SE index of dung abundance per season in 2003.



4.3.3 Dung abundance index by vegetation stratum

To compare the index of dung abundance between vegetation strata, data from all three seasons were first combined, and then displayed individually. With all seasons combined, there were no elephants detected in riverine woodland and this stratum was consequently excluded from the analysis. The index of dung abundance differed across the four vegetation strata (χ^2=17.39, p=0.001, d.f.=3, Kruskal-Wallis test). The index was much greater in dry forest than for other strata (Figure 4.6). The index did not differ between jesse thicket and mopane woodland (z=0.53; P=0.60; Mann-Whitney *U* test); but was much lower in mopane-*Combretum* (χ^2=11.09, p=<0.05, d.f. =2, Kruskal-Wallis test).

The pattern of dung abundance remained similar for individual seasons. In the wet season, the index of dung abundance differed across the four vegetation strata, and the index was highest in dry forest habitats (χ^2=22.54, p=<0.001, d.f.=3, Kruskal-Wallis test). The index of dung abundance was much lower in, but similar across jesse thicket and mopane woodland (z=0.53; P=0.60; Mann-Whitney *U* test), while abundance was lowest in mopane-*Combretum* habitats (Figure 4.7).

Figure 4.6: Mean ±SE of dung abundance index per vegetation stratum for all seasons combined in 2003.

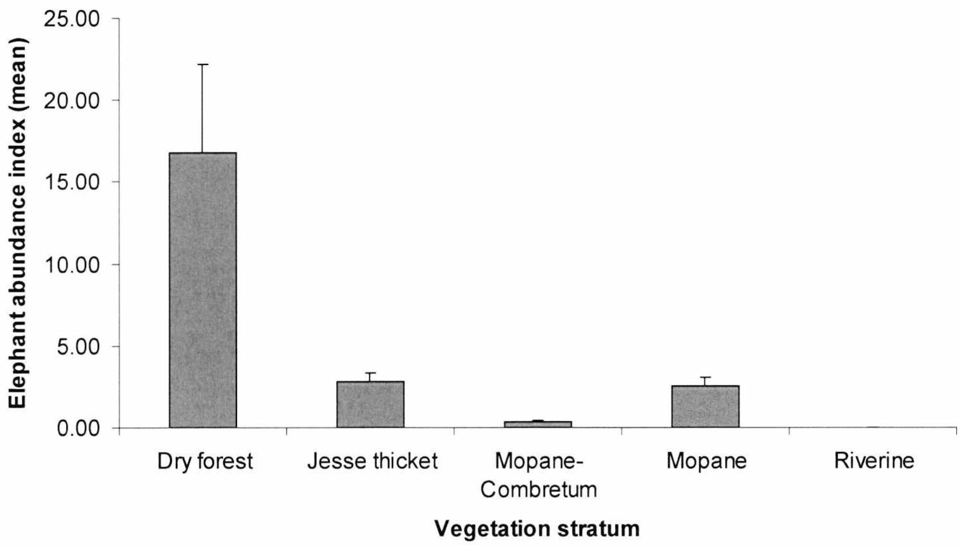
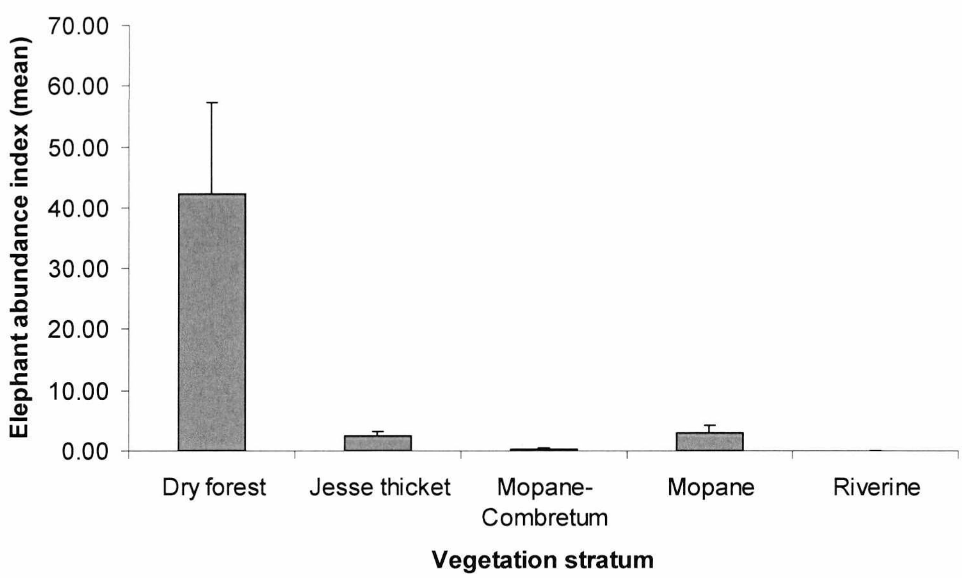


Figure 4.7: Mean ± SE index of dung abundance across the five vegetation strata in the wet season of 2003.



The index of dung abundance retained a similar pattern in the cool dry season, with significant differences between the strata (χ^2=18.07, p=<0.001, d.f.=3, Kruskal-Wallis test (Figure 4.8). Dry forest harboured the highest abundance of elephants, although the difference was not as great as in the wet season. The index of dung abundance was similar in jesse thicket and mopane woodland ($z=0.73$; $P=0.47$; Mann-Whitney *U* test), and the index remained lowest in mopane-*Combretum* woodland.

In the hot dry season, elephants disappeared from the dry forest and were only found in jesse thicket, mopane woodland and mopane-*Combretum* habitats (Figure 4.9). There was no difference in the index of dung abundance between these three vegetation types ($\chi^2=2.50$, $p=<0.29$, d.f.=2, Kruskal-Wallis test). The mean abundance exhibited high variance due to the high number of zeros and only a few large values, indicating that the elephant distribution was highly clumped.

Figure 4.8: Mean ±SE index of dung abundance across the five vegetation strata in the cool dry season of 2003.

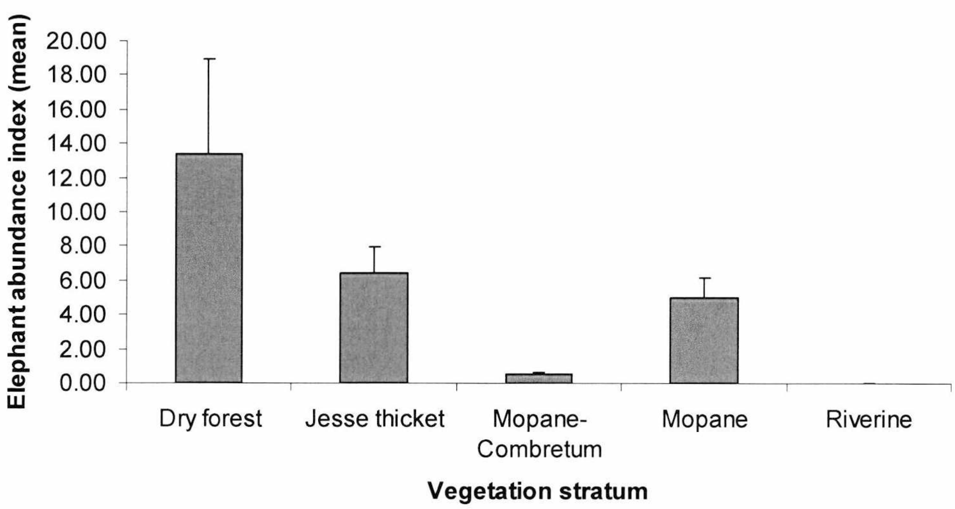
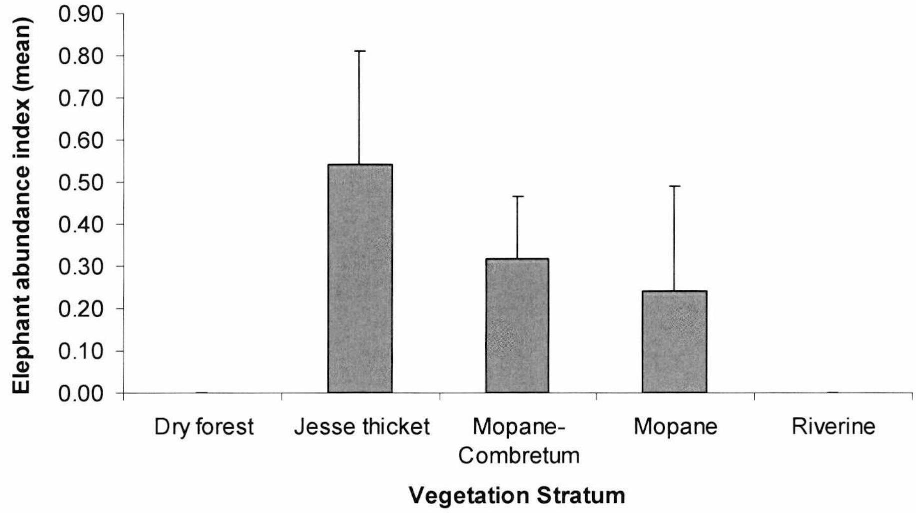


Figure 4.9: Mean ±SE index of dung abundance across the five vegetation strata in the hot dry season of 2003.



4.4 Discussion

In this chapter I have established the patterns of elephant relative abundance across the mid-Zambezi Valley study area. Elephant relative abundance differed markedly according both to seasons and to vegetation types.

4.4.1 Seasonal changes in relative abundance

Elephants exhibited considerable variation in their relative abundances through the seasons. Elephants were abundant across the study area in the wet season and cool dry seasons, but there was a substantial decline in their relative abundance during the hot dry season. These seasonal changes in the distribution of elephants were related to the availability of water. The mid-Zambezi Valley is semi arid, receiving between 600-800mm rainfall per annum (Cumming & Lynam, 1997). In highly seasonal areas, the range of elephants is restricted to sources of permanent water at which they will congregate in the dry season (Taylor, 1983; Connybeare, 1991). With perennial water limited to a few sites during the hot dry season, it is likely that elephants move away from the study area at this time of year.

A seasonal movement of collared elephants northwards towards lake Carbora Bassa in Mozambique has previously been documented (Osborn & Parker, 2003), suggesting that elephants move to the lake shore during the hot dry season. In the same season, bull elephants have been observed moving south from the Zambezi Valley floor to the escarpment mountains (ZamSoc & MZEP, 2000), where water is more readily available throughout the year. A substantial movement of elephants from the valley floor would explain the reduction in the relative abundance of elephants in the study area during the hot dry season.

4.4.2 Relative abundance and vegetation type

The relative abundance of elephants was highest in dry forest habitats, whereas they were absent from riverine thickets. Other research has described elephants preferentially using certain habitats. For example, in Maputo Elephant Reserve (MER) elephants were found predominantly in the riverine forests rather than the grassy plains (de Boer *et al.,* 2000). In Bwindi Impenetrable National Park, Uganda, elephants preferentially selected bamboo forests and swamp forest, and generally avoided other habitat types (Babaasa, 2000).

Such habitat selection was based upon the availability of food, and water during the dry season, as has been found in other studies (Mertz, 1986; Tchamba & Seme, 1993). In the late dry season, forage is characterised by an absence of green herbaceous species, and elephant diet may be restricted to a limited number of browse species with young leaves (Jarman, 1977; Coetzee *et al.,* 1979; Sukumar, 1990). The elephant's distribution thus reflects the availability of such browse species.

Elephants, in their selection of vegetation type, may also be influenced by soil type. Trees on sandy soils may be less favoured than those on more fertile soils, where higher concentrations of nutrients such as calcium, magnesium and potassium are found (Holdo, 2003). In Hwange National Park, Zimbabwe, there were greater concentrations of elephants on deeper soils, in which tubers and roots were widely available, and large trees provided better shade than was available on shallow soils (Williamson, 1975).

The vegetation structure may also have influenced the elephant's use of habitat. The relative abundance of elephants was highest within the dry forest habitats in the wet and cool dry seasons. As a dense vegetation type, dry forest offered concealment and shade. Elephants may move into dense vegetation, especially where human disturbance occurs (de Boer & Baquete, 1998). This may have motivated elephants to occupy riverine forest patches in MER, even though highly nutritious grassland covers much of the MER. However, in the hot dry season, elephants disappeared from the dry forest vegetation type altogether.

Jesse and Gonono woodland harboured the next-highest relative abundance of elephants. This vegetation type existed in a single crescent-shaped band across the north of the study area. Being dense vegetation, this habitat type also provided concealment and shade.

No signs of elephants were found in riverine forest during the entire year of 2003. This is surprising, as elephants may preferentially select riverine woodland for fruiting trees, minerals, refuge and water (Parker & Osborn, 2001; Stokke & du Toit, 2002; Fritz *et al.*, 2003; Sitati *et al.*, 2003). Indeed, in the recent past, elephants have been observed using riverine forest patches along the Musengezi in Gutsa (Dyson, 2000; *Personal Observations*, 2001). The absence of elephants may be explained through the expansion of agriculture along the rivers, which at higher levels of disturbance can cause a rapid decline in elephants and other ungulates (Fritz *et al.*, 2003). The possible effects of human activities are investigated fully in the following chapter.

In this chapter I have established the patterns of elephant relative abundance across the study area, and have described the influence of both season and vegetation type upon these patterns of abundance. This information forms a baseline from which to investigate the effects of human activities upon elephant relative abundance, which is the subject of the following chapter.

Chapter 5 Investigating the Variables that Influence Elephant Abundance

5.0 Introduction

The distribution of elephants in savanna ecosystems is largely dictated by the availability of water and food resources (Leuthold, 1977; Afolayan & Ayaji, 1980, Western & Lindsay, 1984; Sukumar, 1989; Sitati *et al.*, 2003). Elephant distribution is further influenced by habitat structure, with elephants showing a preference for denser vegetation, especially where human disturbance has occurred (de Boer *et al.*, 2000; Sitati *et al.*, 2003).

Human activities have a profound effect upon elephant distributions. In savannahs, land transformation affects the distribution of elephants, and when a critical threshold of cultivation is exceeded, elephants will be displaced from the landscape (Hoare & du Toit, 1999). In the rain forest, humans exert an 'overwhelming' influence upon elephant distributions, where elephants avoid settlements and roads (Barnes *et al.*, 1997; Fay & Agnagna, 2001; Blom *et al.*, 2004). Elephants may additionally be affected by ephemeral activities such as hunting, resource collection and human footprints (Blom *et al.*, 2001), although the impact of such activities is less well understood.

Geographical Information Systems (GIS) are increasingly used to identify and monitor biodiversity-rich environments (Sanderson *et al.*, 2002). GIS has been applied to elephant research as a descriptive tool to plot movements (Thouless, 1996), distribution (Gibson *et al.*, 1998), to explore habitat preferences (Omullo *et al.*, 1998), as a predictive tool for conflict (Sitati *et al.*, 2003) and to determine the effects of human disturbance (Vanleeuwe, 2004). In the mid-Zambezi Valley GIS has been used to identify and site an elephant movement corridor (Osborn & Parker, 2003a), which was developed on the basis of elephant movements and remaining natural habitat. However, as yet there has been no analysis of the effects of human activities upon elephant distributions.

In the previous chapter I established patterns of elephant relative abundance across the study area. In this chapter I will employ GIS to measure human activities, and investigate their effects upon the relative abundance of elephants.

Specifically I aim to:

- quantify variables of human activity;
- determine the influence of environmental and human activity variables upon elephant relative abundance; and,
- identify the critical thresholds of human activities above which elephants no longer occur.

5.1 Methods

I investigated those environmental factors and human activities considered most likely to influence elephant distributions. A broad range of potential explanatory variables was identified from a review of current research and from a pilot survey conducted within the study area. These variables were quantified, and their influence upon elephants determined by comparing them to the indices of elephant dung abundance that have been calculated in Chapter Four.

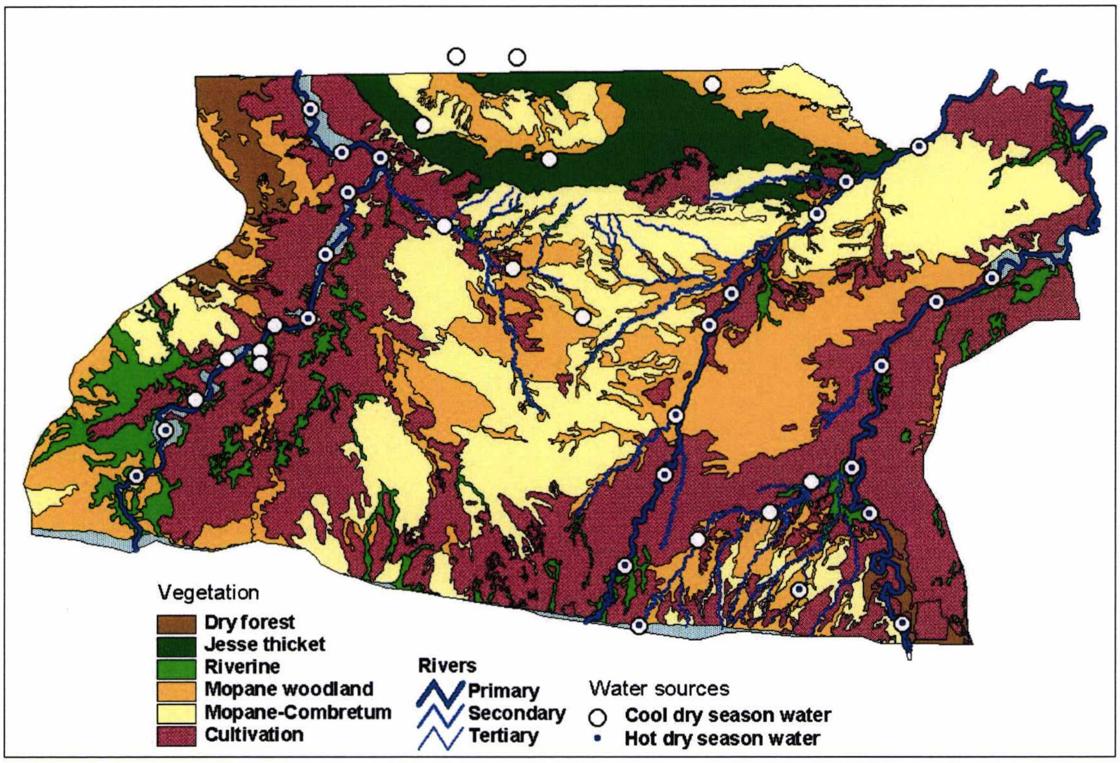
5.1.1 Environmental variables

The environmental variables included in this study comprised: season, vegetation type and water availability. Both season and vegetation were incorporated into the transect survey design. Surveys took place in each season, and were stratified according to vegetation strata, as described in Chapter Four. The quantification of water availability is described below.

5.1.1.1 Distance to water

I mapped all the sources of water that occurred during the cool dry and hot dry seasons. I ignored water during the wet season because it was ubiquitous and therefore unlikely to affect elephant abundance. To identify the positions of the water sources, I conducted a mapping exercise with my field staff, who marked all known sources of water on a printed satellite map. I located each site on the ground with a GPS and monitored the status of the water monthly, recording the point in the year in which it dried up. Field staff recorded any further sources of water they came across during their field work (Figure 5.1).

Figure 5.1: Water sources across the mid-Zambezi Valley study area.

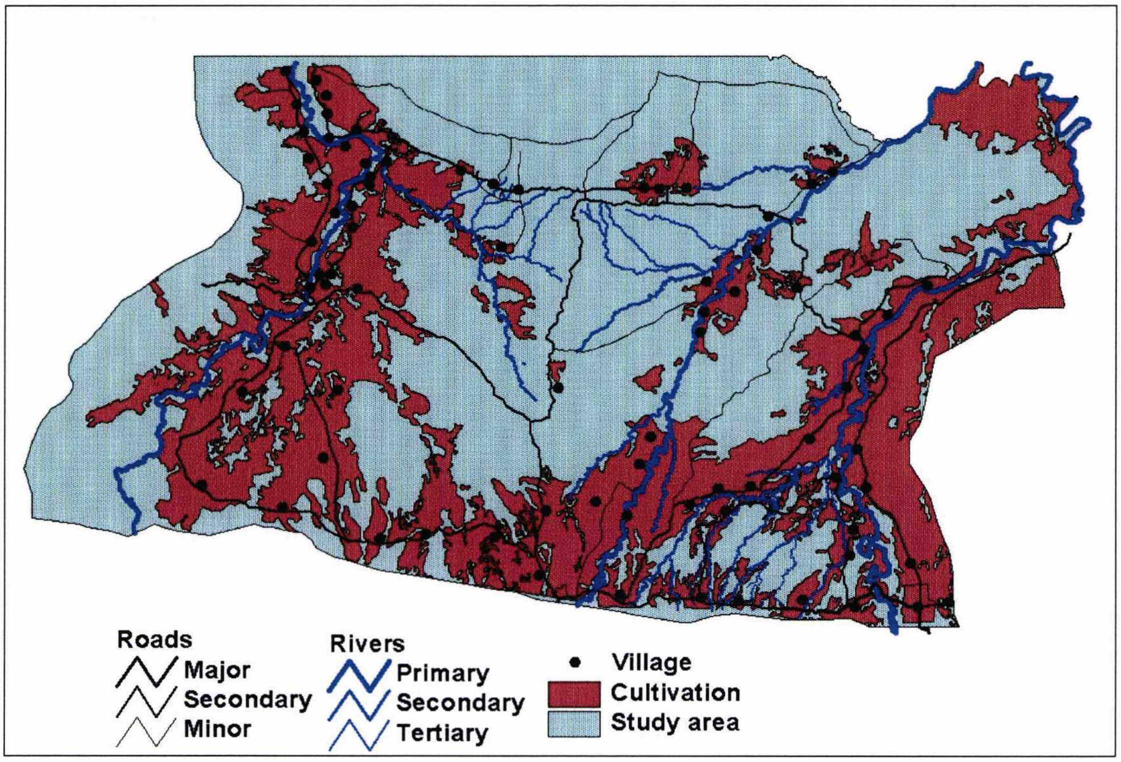


All water locations were downloaded to Arc View GIS. I calculated the distance to water for each transect in the cool dry season and the hot dry season, selecting only those water sources that still contained water on the date of the transect surveys. In Arc View, I created concentric distance buffers around each water source using the *Find distance* function in the *Analysis* menu. To find the distance between the water and transect sections I used the *Analysis, summarise zones* command, which created a summary table of the mean distance to water for every transect section.

5.1.2 Human activity variables

I categorised human activity variables into permanent and ephemeral groupings. Permanent activities included settlements and areas of agriculture. Ephemeral activities described those human activities carried out in the natural woodland surrounding settlement, including resource collection and cattle grazing.

Figure 5.2: Human settlement and cultivation within the mid-Zambezi Valley study area.



5.1.2.1 Permanent human activity

Previous studies have measured permanent human activities such as settlement and roads using remote sensing and GIS (e.g. Merode *et al.,* 2000; Blom *et al.,* 2004). In this study, I considered two forms of permanent human activity: settlement, and cultivation, which were both identified using Arc View.

I defined 'settlement' as any village recognised by the Rural District Council. I located each individual village using a hand-held GPS and imported these coordinates to Arc View direct from GPS (Figure 5.2). The villages were displayed as point data because they were spatially limited and distinct from the cultivation areas. I used Arc View to calculate distance to settlement for each transect section using the same methodology as described above for distance to water.

I determined human cultivation patterns from the CIRAD vegetation map (CIRAD, 2002) for wards 3, 4 & 6 in Guruve district, and Gutsa and Hwata wards in Muzarabani district. I imported the vegetation map to Arc View and isolated the *cultivation* component, which was used as the definitive location of cultivation within the study area (Figure 5.2). I measured the distance to cultivation and the percentage of cultivation surrounding each transect.

To calculate the distance between each transect and the nearest cultivation, I used the same methods as described previously for settlement and water. In Arc View, I created distance buffers that expanded outwards from every cultivation polygon. I used the *Analysis, summarise zones* command to calculate the mean distance to cultivation for each transect.

A simple measure of 'distance to cultivation' does not capture the spatial complexity of the cultivation surrounding a particular transect. For example, a transect completely surrounded by large expanses of cultivation at a mean distance of 2km would have the same 'distance' value as a transect that neighbours just one small field 2km away, despite the fact that the first transect is effectively surrounded by cultivation, but the second is not. Therefore, it is important to calculate the percentage of cultivation surrounding each transect. I buffered each transect at a distance of 1km using the *buffer* tool in the *Theme* pull-down menu. I then isolated all the areas of cultivation within each buffer using the *clip* function in the *Geoprocessing wizard.* I used the *X-tools* extension to calculate the area of these fragments and from these figures I calculated the percentage of cultivated land within 1km of each transect section.

5.1.2.2 Ephemeral human activity

Ephemeral activities have been quantified only a few times in relation to elephants. In his study of compression in South Luangwa, Lewis (1996) used gunshots and fire as indicators of human disturbance. Similarly, Blom *et al.,* (2004) measured a range of human activities including gun cartridges, snares, footprints and honey collection. In this section, I discuss a wide range of ephemeral human activities and describe their measurement.

Ephemeral human activities were recorded as part of the elephant dung surveys described in Chapter Four. In September 2002 I conducted a pilot transect survey to identify those human activities that could be detected in the field. From the pilot I selected only those activities that were: a) easily measurable; and b) abundant, to ensure that reasonable sample sizes could be attained. These activities were then recorded along every dung transect according to distance methodology. The following human activities were measured:

- tree cutting, defined as the stumps of felled trees;
- honey collection, where tree trunks had been cut to harvest honey;
- tsetse traps established by Tsetse Control;
- vehicle tracks and sightings of motor vehicles;
- grass cutting;
- hunting, where obvious signs of snaring or trapping were observed;
- livestock herding, where sightings, spoor or dung of cattle were observed;
- domestic dog sightings and spoor, and,
- human presence, characterised by sightings or footprints.

These human activity signs exhibited very different characteristics. Some lasted only a short period and were difficult to detect, for example footprints, whereas others remained for a long time and were highly visible, for example cut tree stumps. The longevity and detectability of the signs affected the frequency at which they were observed, and both these factors had to be adjusted for before the signs could be analysed.

5.1.2.3 Longevity of ephemeral signs of human activity

The signs were categorised into two groups according to their longevity. In the first group, all those signs that were of short duration, such as human footprints, cattle spoor and dog tracks, were grouped together. These signs were assumed to be visible for no more than seven days. The second group included all those long-duration signs such as tree cutting, honey collection and tsetse traps, which could remain visible from one month to more than a year. The short-lived signs were not directly comparable with the long-lasting signs because the longer lasting signs had a greater probability of being observed and would therefore be over-represented in relation to the short-lived signs. This necessitated me analysing short-duration and long-duration data sets separately.

Because long-duration signs varied greatly in their lifespan, I limited the data set to those signs estimated to be less than one month old. This enabled comparisons between activities such as grass cutting, which may last a month, and tree cutting, which can potentially be visible for multiple years. This also ensured that only recent human activity was included in the analysis.

5.1.2.4 Detectability of ephemeral signs of human activity

Before comparisons of human activity can be made between vegetation types, the detectability of the vegetation must first be accounted for. As with elephant dung surveys, the density of the vegetation affects the number of signs of human activity that are observed. While distance analysis can correct for the detectability of dung, it is not suitable for ephemeral signs such as footprints because they are not evenly distributed throughout the landscape, but instead tend to be clustered. Therefore, instead of modelling detectability, I decided to truncate the ephemeral signs to a distance at which the probability of detection would be close to 1 in every vegetation type. For short-duration observations I selected a strip width of 1m, and for long duration activities I selected a strip width of 5m. I made the assumption that within the prescribed distances every object would be detected, regardless of the vegetation type. These truncation distances were identified from frequency charts, and represented the point after which the detection of observations started to decline. All human activities were adjusted for transect length and presented as an index per km that could be compared across vegetation strata and across seasons.

5.2 Analysis

I conducted the data analysis in several stages. Firstly, I integrated all variables into a multivariate statistical analysis. Secondly, I investigated the relationship between individual variables using bivariate statistical analysis and scatter plots, which served to verify the results of the multivariate analysis and enable the exploration of non-linear relationships.

5.2.1 Multivariate analysis

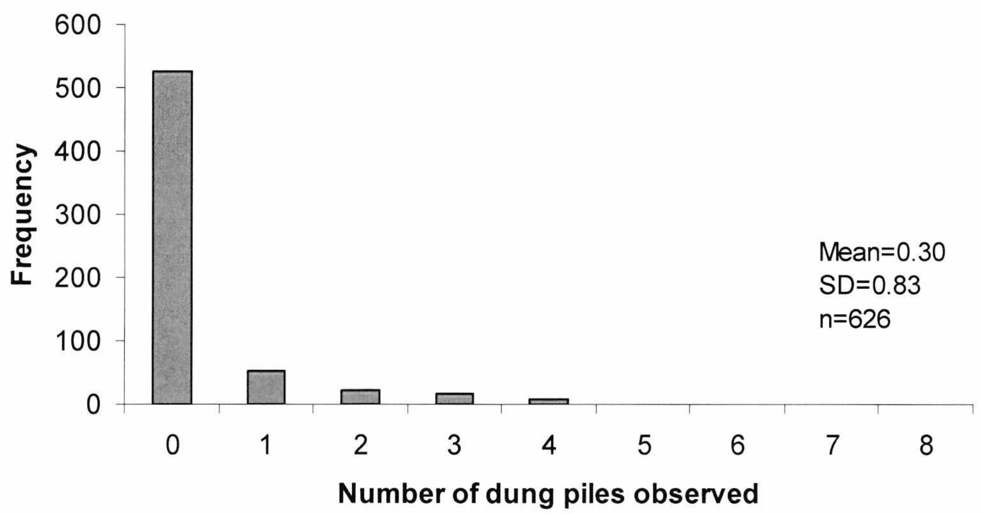
5.2.1.1 GLIM

I selected GLIM to conduct multivariate analysis on the effects of human activities upon elephant dung abundance. GLIMs have several advantages over multivariate regression analysis. First, they allow a wider range of assumptions to underlie the linear relationship between the response variable and the possible explanatory variables. Second, they have been designed to deal with, among other things, poisson-distributed response variables, that preclude the need for data transformation (McCullagh & Nelder, 1983; Nicholls, 1991; Crawley, 1993). Third, the dependent variable may be continuous. This is important as elephant dung data covers a broad spread of values, and reducing it to binary code would result in a loss of valuable information. Finally, the programme can analyse data sets that contain many zero values, as is the case for the elephant abundance data set.

5.2.1.2 Poisson distribution

GLIM tests the distribution of the response variable and generates a dispersion parameter. Where the poisson model has been selected, a dispersion parameter value of 1 equates to a perfect poisson distribution. If the value is lower than one, then the data set contains less variation than would be expected, and if it is greater than one then it contains more variation than expected from a poisson distribution. An example of poisson-distributed data, taken from the elephant dung surveys, is displayed below (Figure 5.3). Note the high proportion of zero values and the bias towards small numbers of dung piles.

Figure 5.3: Frequency of elephant dung piles observed in all transects in each of three seasons across the mid-Zambezi Valley study area.



5.2.1.3 Deviance

GLIM generates a deviance value, which varies according to the number of variables and the robustness of the data set (Table 5.1). The greater the change in deviance, the greater the effect of the explanatory variable upon the response variable. The deviance output can be used to judge the goodness of fit of the model. The regression deviance indicates the portion of the total deviance that is explained by the model, and the residual deviance is that which is unaccounted for by the model (Table 5.1). A portion of the total deviance that is approximately equal to the residual degrees of freedom remains inexplicable. This is characteristic of poisson-distributed data.

Table 5.1: Example of GLIM model output.

	d.f.	deviance
Regression	10	417.90
Residual	472	878.10
Total	482	1296.00

GLIM tests the robustness of individual variables by estimating their effect and calculating their standard error (SE) (Table 5.2). The smaller the SE in relation to the estimate, the more robust the parameter. Parameters that contain few data points typically produce large SEs. Ideally the SE should be three times smaller than the estimate.

Table 5.2: Example of GLIM parameter output.

Parameter	Estimate	SE	t
Constant	0.271	0.277	0.98
Season2	0.950	0.177	5.37
Season3	-1.340	0.330	-4.06
People	-0.474	0.103	-4.59
Tree	-0.621	0.152	-4.09
Cattle	-0.361	0.062	-5.86
Vegetation2	0.850	0.219	3.89
Vegetation3	-0.660	0.245	-2.69
% cultivation	-0.012	0.004	-2.77
Distance to settlement	-0.186	0.046	-4.04

5.2.1.4 Goodness of fit

A goodness of fit (GOF) test may be calculated using the estimates to generate expected values for the response variable. These are then compared to the observed values. For the output displayed in Table 5.2 the estimated index of elephant dung abundance would be calculated as follows:

Expected elephant dung abundance = *EXP(0.271+(0.950*Season2)-(1.34*Season3)-(0.474*People)-(0.621*Tree)-(0.361*Cattle)+(0.850* Vegetation2)-(0.660*Vegetation3)-(0.012*%Cultivation)-(0.186*Distance to settlement))*

The strength of the model is then gauged by calculating the number of observed values that are correctly predicted as expected values. While the observed values are whole numbers, the expected values are not. Therefore, to make them comparable, expected values are categorised into five classes: 0-0.5 = 0; 0.51-1.5 = 1; 1.51-2.5 = 2; 2.51-3.5 = 3; and >3. The number of expected values correctly predicted is expressed as a percentage of the total. A model that correctly predicts more than 50% of the expected values is considered acceptable.

5.2.1.5 Data in GLIM

Indices of elephant dung abundance from three vegetation strata were included in the GLIM analysis. These data were from jesse thicket, mopane woodland and mopane-*Combretum* woodland. The riverine stratum was excluded from the GLIM analysis because no signs of elephant dung were recorded, while the dry forest stratum was excluded because the data set did not conform to the poisson model, returning a dispersion parameter that was much lower than one. This was most likely due to the small number of observations of elephant dung within this stratum.

The variables 'season' and 'vegetation' contained independent classes and were treated as factor variables with 3 levels each. GLIM tests the effect of each level upon the response variable separately. Continuous variables such as 'people' and 'hunting' were log-transformed to increase linearity. Short-duration human variables were entered individually, and were also pooled as a summary variable called 'HD short' to investigate their combined effect. Long-duration human variables were individually entered and also pooled as 'HD long'. I removed Tsetse traps from the long-duration data set, as there were too few observations for meaningful analysis.

5.2.2 Bivariate analysis

5.2.2.1 Spearman's Rho correlation test

Bivariate relationships between continuous variables were explored using the Spearman's Rho correlation test in SPSS version 12.0. This served two purposes: first, it verified the results of the multivariate analysis; and second, it investigated co-linearity between the independent variables.

5.2.3 Non-linear analysis

Elephant responses to human disturbance are likely to be non-linear (c.f. Hoare & du Toit, 1999; Parker & Osborn, 2001). In order to investigate this possibility the continuous variables were plotted as scatter plots, whose shape can be meaningful when investigating a potential threshold relationship. Indeed, it may be more revealing to examine the outermost response surface than to examine a regression line through a cloud of data points (Hoare & du Toit, 1999). Such non-linear relationships were statistically tested by dividing the data into categories and comparing the index of elephant dung abundance between categories using the non-parametric Mann-Whitney *U* test and the Kruskal-Wallis test. The categories for each variable were selected by eye from an examination of the scatterplots.

5.3 Results

5.3.1 Multivariate analysis

5.3.1.1 GLIM

The response variable, index of dung abundance, conformed to a poisson distribution, returning a dispersion parameter of 1.04, making it suitable for analysis using the poisson model in GLIM. The final model returned a deviance value of 101.5 from a total of 676.4 (p=<0.01) (Table 5.3) and incorporated six variables (Table 5.4).

Table 5.3: Model deviance for GLIM analysis of the influence of environmental and human variables upon the index of dung abundance.

	d.f.	Deviance
Regression	7	101.5
Residual	551	574.9
Total	558	676.4

The final model included the following variables: season, distance to settlement, distance to water, people, dogs and cattle (Table 5.4). Season had a strong influence upon the index of elephant dung abundance, which further confirms the results of Chapter Four. However, the type of vegetation did not significantly affect the index of elephant abundance. The difference between jesse thicket, mopane woodland and mopane-*Combretum* woodland displayed in Chapter Four was found to be negligible in this more powerful and encompassing analysis. On the strength of this result, indices of dung abundance were pooled for these three vegetation strata for the remainder of the analysis.

Table 5.4: Model output from GLIM analysis

Variable	Estimate	S.E.	T
Constant	-0.411	0.242	-1.70
Cool dry season	0.959	0.182	5.28
Hot dry season	-0.214	0.262	-0.82
Distance to settlement	-0.00012	0.00004	-2.90
Distance to water	-0.00009	0.00003	-2.99
People	-1.202	0.487	-2.47
Dogs	1.493	0.523	2.85
Cattle	-0.636	0.282	-2.26

5.3.1.2 Goodness of fit

The expected values for the index of dung abundance were calculated from the estimated values (Table 5.4) and compared with the observed values. The model was able to correctly predict 67.1% of observed elephant dung abundance (Table 5.5), indicating a robust analysis.

Table 5.5: Goodness of fit of expected values for indices of dung abundance as compared to observed values.

		Observed				
		0	**1**	**2**	**3**	**>3**
Expected	**0**	**355**	23	10	2	3
	1	107	**20**	11	11	4
	2	7	3	**0**	0	2
	3	1	0	0	**0**	0
	>3	0	0	0	0	**0**
		Percentage correct				**67.1%**

5.3.2 Bivariate analysis

While the index of dung abundance varied dramatically between seasons (see Chapter Four), the effects of human activity upon dung abundance remained constant. This was confirmed through a graphical analysis displayed in Appendix

6. On the strength of these findings, the index of elephant abundance was pooled for all three seasons in the following bivariate analysis.

5.3.2.1 Spearman's Rho

The Spearman's Rho correlation tests between all variables indicated that with the exception of distance to water (r_s=-0.17; p=<0.01), there were no significant linear correlations between the index of dung abundance and any of the explanatory variables (Table 5.6). However, significant co-linearity existed between many of the explanatory variables. There was a strong correlation (r_s=0.68; p=<0.01) between distance to settlement and distance to cultivation, because settlement was surrounded by cultivation in all cases (see Figure 5.2). Distance to cultivation was weakly and positively related (r_s=0.27; p=<0.01) with distance to dry season water, while settlement was more strongly related (r_s=0.41; p=<0.01) with distance to water, indicating that both settlement and cultivation were located close to permanent water sources. The percentage of cultivation was strongly and negatively related to distance to cultivation (r_s=-0.73; p=<0.01), and was negatively correlated with distance to settlement and distance to water, for the reasons highlighted above.

Negative and significant relationships existed between human activities and their distance from cultivation. When pooled, short duration activities were moderately and negatively correlated with the distance to cultivation (r_s=-0.40; p=<0.01). When activities were viewed individually, correlations were weak and negative for cattle (r_s=-0.37; p=<0.01), people (r_s=-0.31; p=<0.01), dogs (r_s=-0.12; p=<0.01) and vehicles (r_s=-0.11; p=<0.05). This indicates a reduction in these activities with increasing distance from cultivation. The relationship between long duration activities and distance to cultivation was weak (r_s=-0.18; p=<0.01). Individually, hunting (r_s=-0.12; p=<0.01) 'other' activities (r_s=-0.13; p=<0.01) and tree damage (r_s=-0.09; p=<0.05) were weakly and negatively correlated to cultivation.

Signs of human activities were inter-related: for example, signs of people were moderately correlated with cattle (r_s=0.47; p<0.01); with dogs (r_s=0.40 p=<0.01); were weakly correlated with vehicles (r_s=0.32; p<0.01); and were very weakly correlated with tree damage (r_s=0.16; p<0.01); hunting r_s=0.13; p=<0.01), and other activities (r_s=0.09; p=<0.05). Cattle exhibited a very weak positive correlation with dogs (r_s=0.16; p=<0.01), with vehicles (r_s=0.15; p=<0.01) and with other activities (r_s=0.15; p=<0.01) and tree damage exhibited a weak positive correlation with other activities (r_s=0.30; p=<0.01). This indicates that some human activities were either carried out in association with each other, or they occurred in similar areas.

Table 5.6: Spearman's rho correlations between the dependent variable and all independent variables.

	Ele	dtc	dts	dtw	% cult	people	dog	Cattle	vehicle	short	Hunt	tree	other	road	long
ele	**1.00**			-0.17**											
dtc	-0.04	**1.00**	0.68**	0.27**	-0.73**	-0.31**	-0.12**	-0.37**	-0.11*	-0.40**	-0.12**	-0.09*	-0.13**		-0.18**
dts	-0.07		**1.00**	0.41**	-0.49**	-0.34**	-0.12**	-0.34**	-0.11**	-0.39**	-0.09*	-0.14**	-0.10*	0.12**	-0.12**
dtw				**1.00**	-0.24**	-0.20**	-0.14**	-0.17**		-0.21**		-0.10*		0.15**	
cult	0.02				**1.00**	0.30**	0.11*	0.40**	0.09**	0.43**	0.15**	0.11*			0.16**
people	-0.04					**1.00**	0.40**	0.47**	0.32**	0.79**	0.13**	0.16**	0.09*		0.19**
dogs	0.01						**1.00**	0.16**		0.39**	0.09*	0.09*			
cattle	-0.07							**1.00**	0.15**	0.78**			0.15**		0.16**
veh	0.03						0.02		**1.00**	0.37**		0.12*			0.15**
short	-0.05									**1.00**	0.11*	0.16*	0.19**		0.25**
hunt	-0.03			-0.06				0.01	0.03		**1.00**				0.30**
tree	0.03							0.08			0.07	**1.00**	0.30**		0.69**
other	0.01			-0.02	0.05		0.05		0.08		-0.04		**1.00**	0.24**	0.72**
road	0.00	-0.06			0.03	-0.04	-0.03	0.03	-0.03	0.00	-0.02	0.05		**1.00**	0.34**
long	0.02			-0.02			0.06								**1.00**

Ele = elephant dung abundance index; dtc = distance to cultivation; dts = distance to settlement; dtw = distance to water; % cult = % cultivation; short = sum of all short duration activities; long = sum of all long duration activities; *=p<0.05; **=p<0.01.

5.3.3 Non-linear analysis of permanent human activities

In the following section, non-linear relationships are investigated through a combination of scatter plots and bivariate statistical tests.

5.3.3.1 Distance to water

The index of elephant dung abundance exhibited strong non-linear patterns with distance to water. Dung abundance was highly variable between 0 and 7km, with values ranging from 0-33 (Figure 5.4). However, dung abundance was low between 7km and 17km from water sources. The data were categorised into <7km and >7km, and the index of dung abundance was found to be higher in the first category (z=-3.60; p<0.001; Mann-Whitney *U* test) than in the second, more distant category (Figure 5.5).

Figure 5.4: The relationship between the index of dung abundance and distance to water.

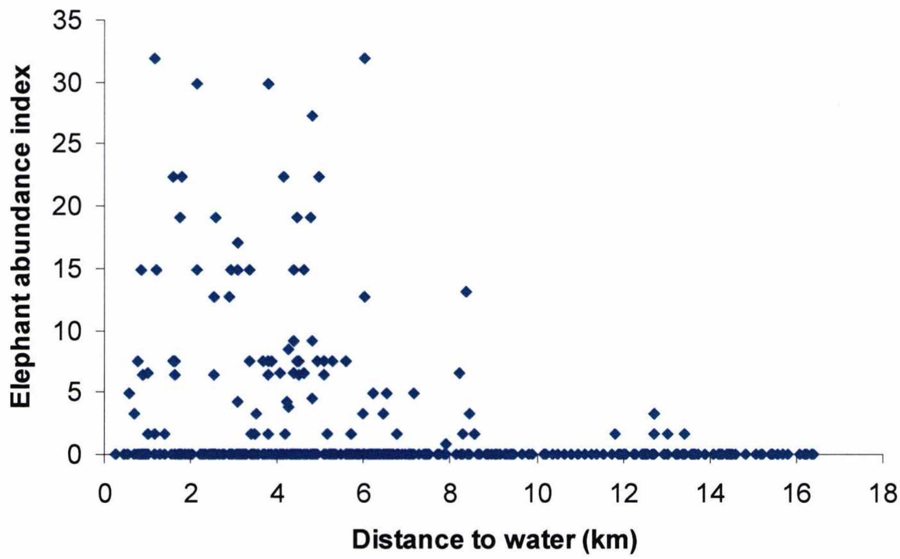
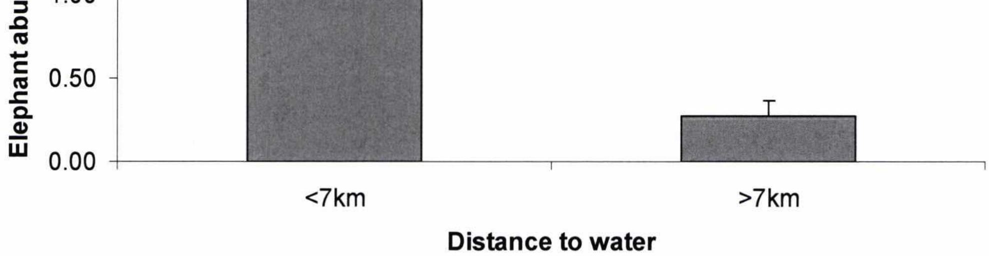


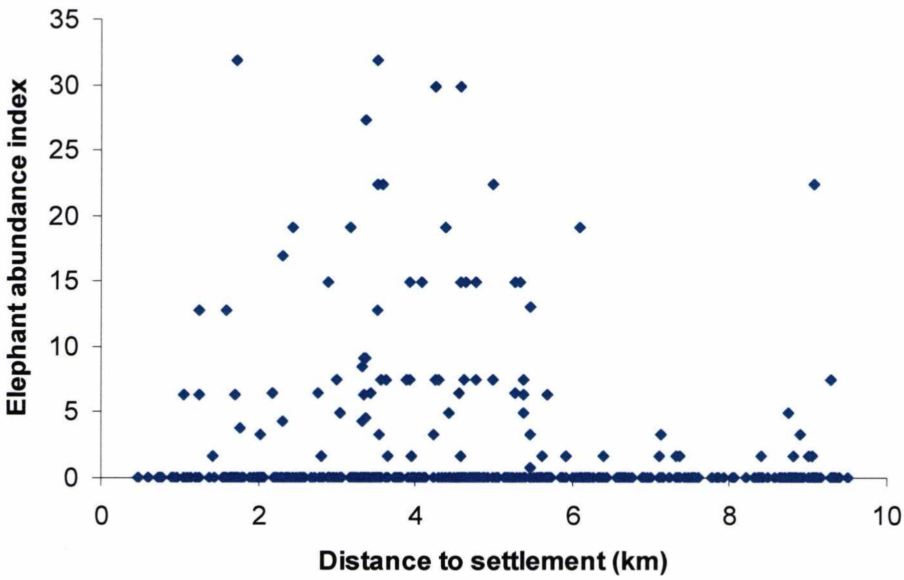
Figure 5.5: The mean ±SE of the index of dung abundance relative to different distance categories to water.



5.3.3.2 Distance to settlement

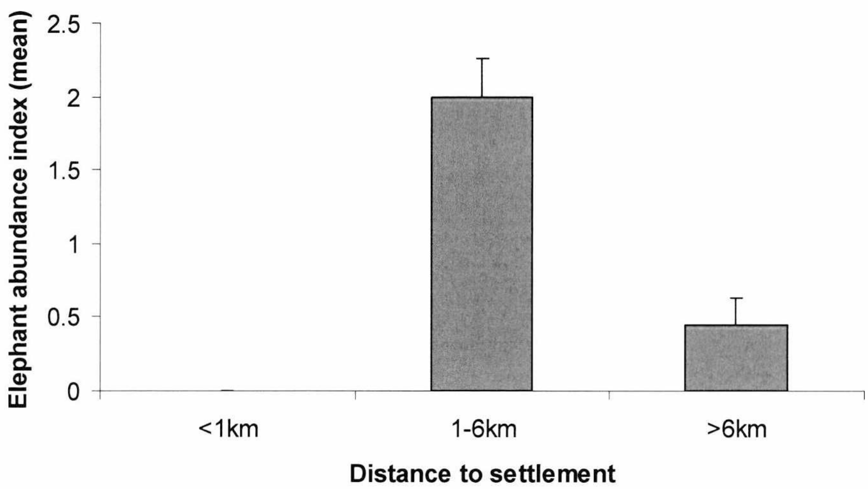
Elephants avoided settlements and the index of dung abundance was zero within 1km of any village across the study area (Figure 5.6). In contrast, the index of dung abundance was high between one and six kilometres from settlement, but tailed off beyond this point.

Figure 5.6: The relationship between the index of dung abundance and distance to settlement.



When categorised into three groups of less than 1km, 1-6km and greater than 6km (Figure 5.7), there was a large difference in the index of dung abundance with increasing distance from settlement (χ^2=36.87; p<0.001; Kruskal-Wallis test). The drop in the index of dung abundance at 6km may be caused by the co-variation between settlements and water, which are positively correlated (r_s=0.41; p=<0.01; Spearman's Rho correlation coefficient) (Table 5.6).

Figure 5.7: Mean ±SE of the index of dung abundance relative to different distance categories to settlement.



5.3.3.3 Distance to cultivation

Elephants did not avoid cultivation and dung was present in transects right up to the edge of cultivated areas (Figure 5.8). However, there was a difference in the index of elephant dung abundance between 0-3km from cultivation and beyond this distance ($z=-2.26$; $p<0.05$; Mann-Whitney *U* test), indicating that the relative abundance of dung was significantly higher close to cultivation than at distance (Figure 5.9). The drop in the index of dung abundance at 3km may be caused by the co-variation between cultivation and water, which are positively correlated ($r_s=0.27$; $p=<0.01$; Spearman's Rho correlation coefficient) (Table 5.6).

Figure 5.8: The relationship between the index of dung abundance and distance to cultivation.

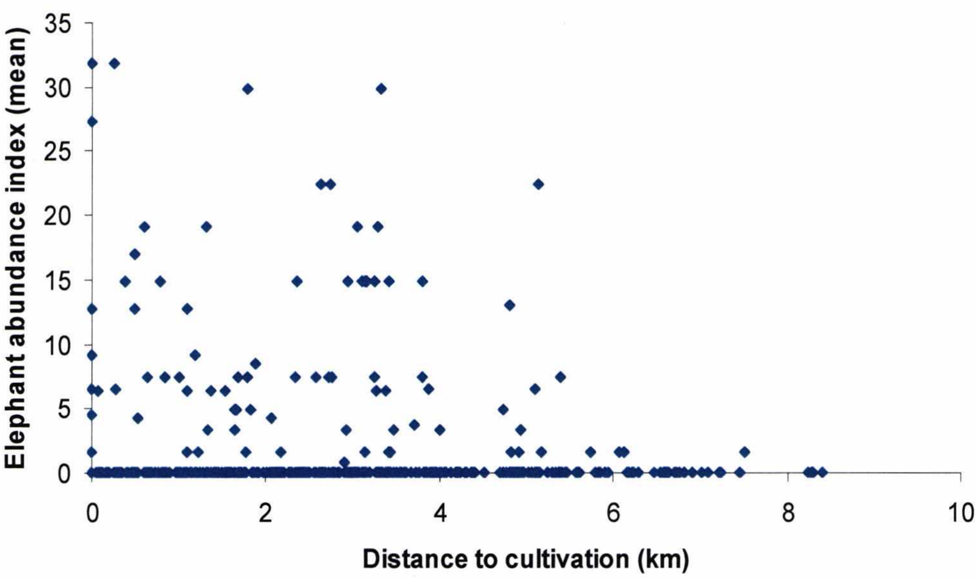
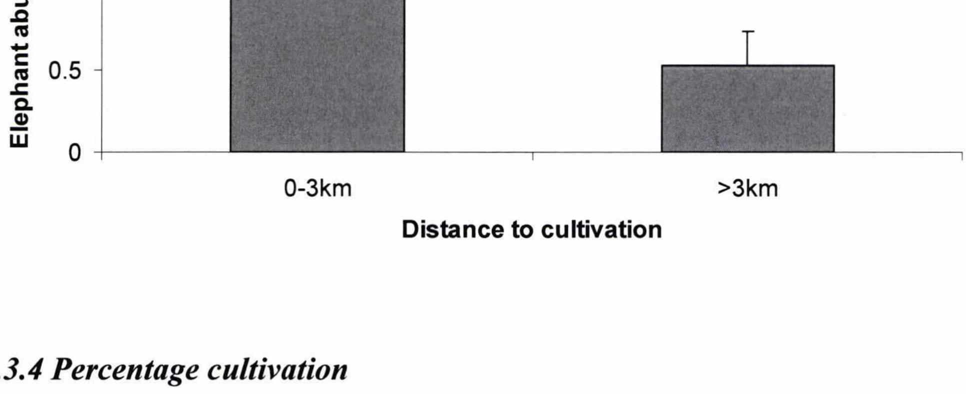


Figure 5.9: Mean ±SE of the index of dung abundance relative to different distance categories to cultivation.

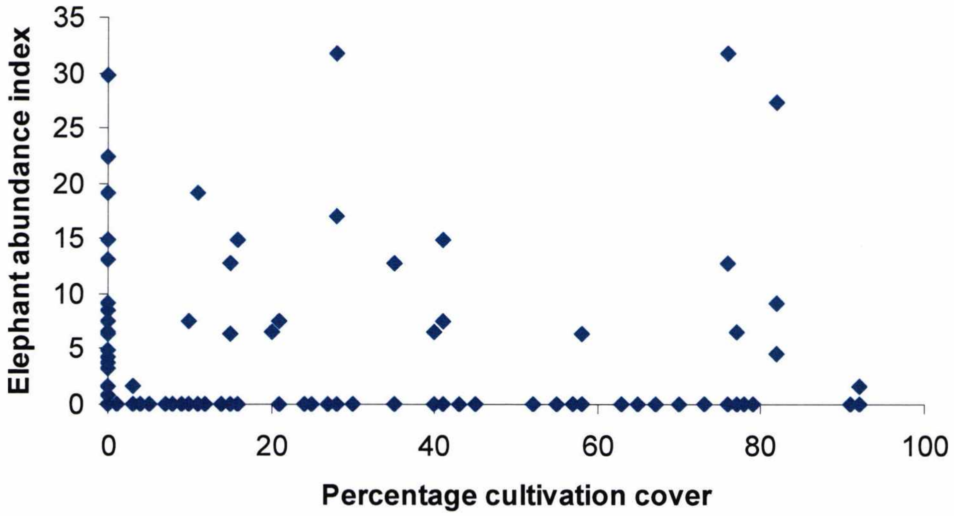


5.3.3.4 Percentage cultivation

There was no discernible pattern of elephant dung abundance in relation to the percentage of cultivated land surrounding transects. The index of elephant dung abundance was high in transects surrounded by between 0% and 92% cultivation

(Figure 5.10).

Figure 5.10: The relationship between the index of dung abundance and percentage cultivation cover.

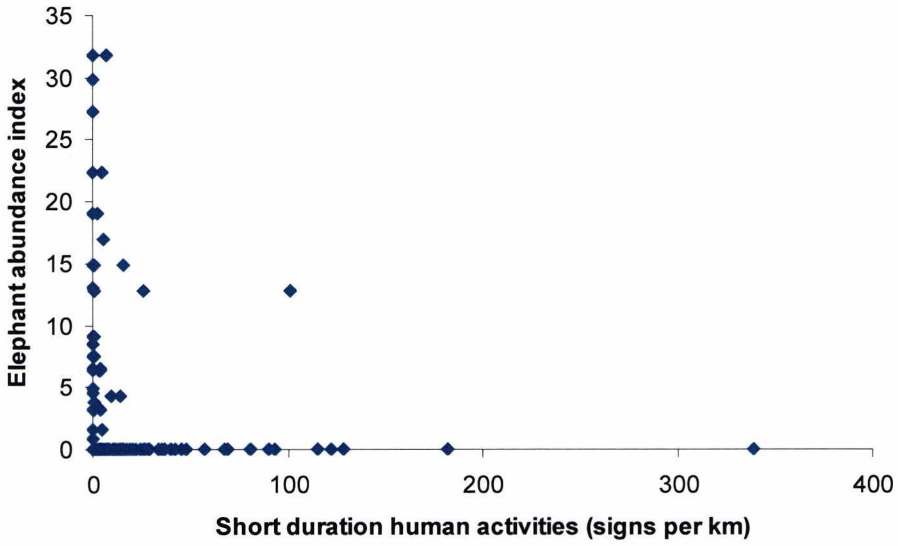


5.3.4 Non-linear analysis of ephemeral human activities

5.3.4.1 Short duration human activities

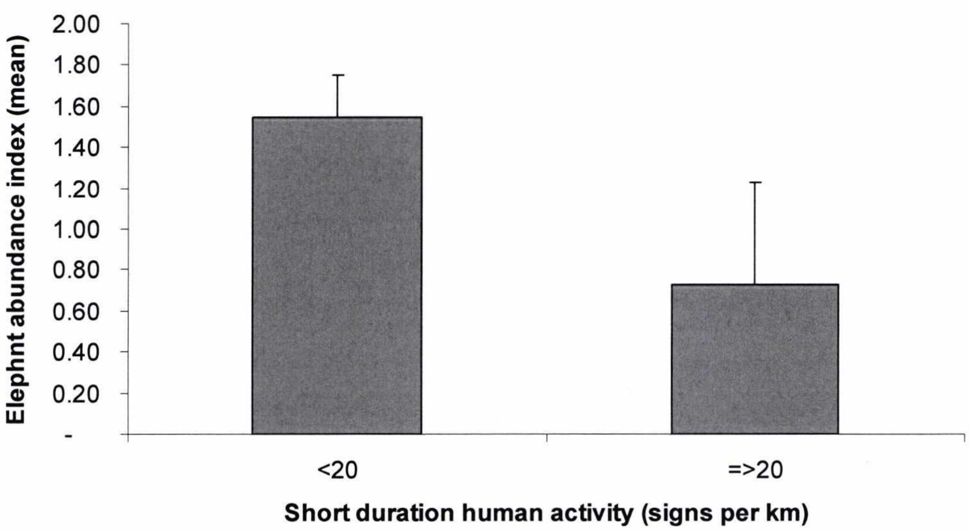
The index of dung abundance displayed a strong negative non-linear relationship with short-duration human disturbance variables when they were combined as a single variable (Figure 5.11). The index of dung abundance exhibited a broad range of values (0-33) where human disturbance was below 20 observations per km. However, beyond this threshold, the index of dung abundance fell to zero, except in one isolated case. This indicates that the relative abundance of elephants is high where human disturbance is low, but that elephant dung is not found in areas where this activity exceeds 20 observations per km.

Figure 5.11: Relationship between the index of dung abundance and short-duration human disturbance.



To explore this further, I divided the data set into two categories of 20 signs per km and less, and more than 20 signs per km (Figure 5.12), but any difference in the index of elephant dung abundance only tended towards significance (z=-1.67; p=0.09; Mann-Whitney *U* test) because of the high number of zeros in both of the categories.

Figure 5.12: Mean ±SE of the index of dung abundance relative to different categories of short-duration human disturbance.



Short duration human activities were considered as individual variables and each was categorised into 'low' and 'high' activity classes. There was no relationship between the index of elephant abundance and the activity levels of 'people', 'dogs', 'cattle' and 'vehicles' (Table 5.7). However, when 'people' and 'cattle' were combined, they produced a significant difference (z=-1.98; p=0.048; Mann-Whitney *U* test), indicating that the index of elephant dung abundance dropped significantly with the increasing activity of people and cattle. This verifies the findings of the GLIM analysis. However, dogs appeared to have no effect upon elephant distribution.

Table 5.7: The relationships between the index of dung abundance and short duration human disturbance.

Activity	Z	P
People	-1.408	0.159
Dogs	-0.258	0.796
Cattle	-1.822	0.068
People + cattle	-1.980	0.048*
People + cattle + dogs	-1.62	0.105

5.3.4.2 Long duration human activities

The index of elephant dung abundance exhibited a non-linear relationship with long-duration human disturbance variables, similar to that displayed with short duration human disturbance (Figure 5.13).

The index of dung abundance varied widely where human disturbance was below three observations per km, but the abundance index was much lower above this threshold. However, there were few data points for the high disturbance category. Human disturbance was separated into two categories of three signs per kilometre and below, and above three signs per kilometre (Figure 5.14), but the difference in the index of dung abundance and these two categories was insignificant (z=-0.24; p>0.05; Mann-Whitney U test).

Figure 5.13: The relationship between the index of dung abundance and long-duration human disturbance.

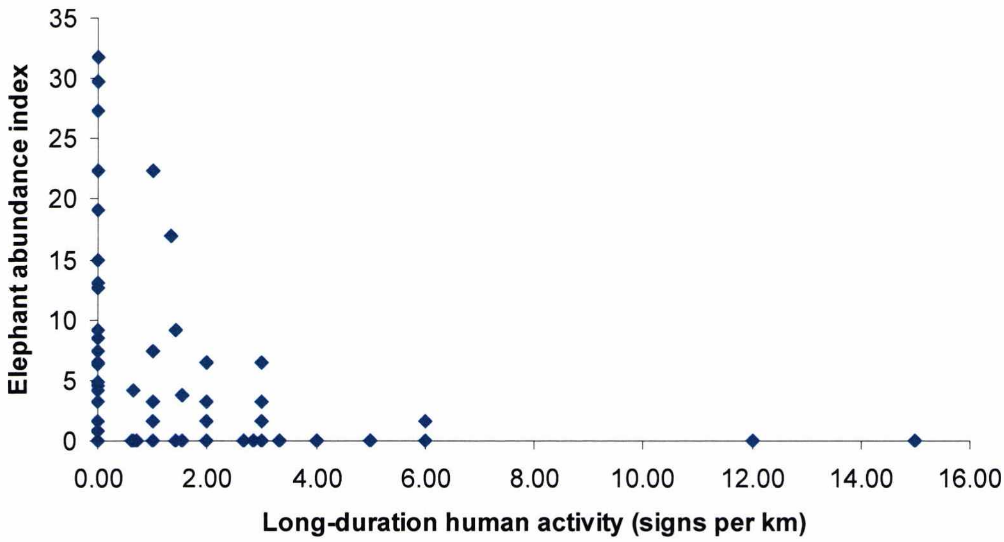
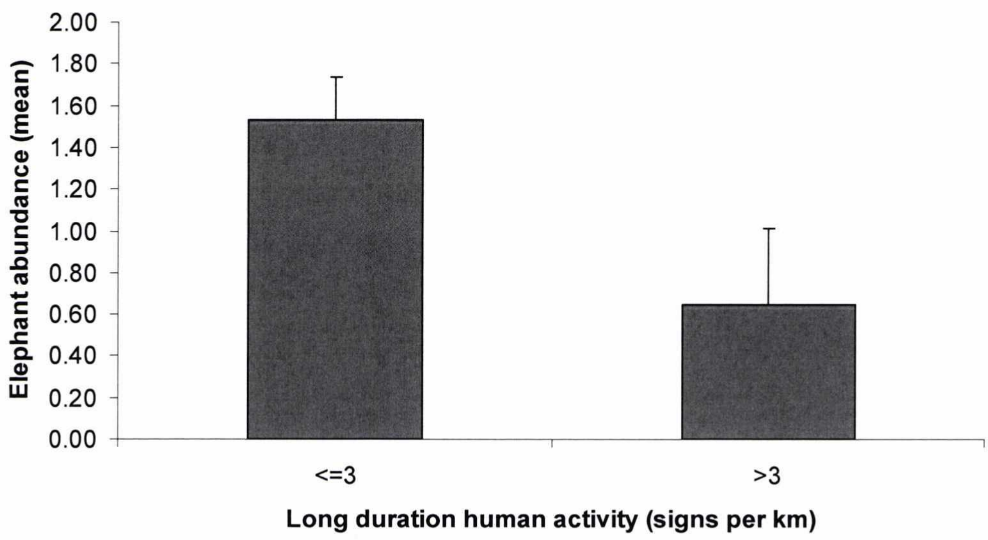


Figure 5.14: Mean ±SE of the index of dung abundance relative to different categories of long duration human disturbance.



The effects of long-duration human activities upon the index of elephant dung abundance were tested individually (Table 5.8). There were no differences in the index of dung abundance with increasing long-duration human activity of any kind. This was probably due to the high variation, stemming from the lack of data points above three signs per km for long-duration human activity.

Table 5.8: The relationships between the index of dung abundance and long duration human disturbance.

Activity	Z	P
Hunting	-0.596	0.55
Tree damage	-0.442	0.67
Roads	-0.004	0.99
Other	-0.239	0.81

5.4 Discussion

In this chapter I have investigated the effects of both environmental and human variables upon the relevant abundance of elephants within the mid-Zambezi Valley. Elephants displayed a strong relationship with water, as expected, and their dung was not commonly recorded more than 8km from permanent water. Equally, both permanent and ephemeral activities affected the relative abundance of elephants. They avoided settlement, but were able to tolerate areas that were predominantly cultivation. The presence of people and cattle affected elephants when the activity was at high levels. Other activities appeared to have a similar effect, although their non-linear nature made it difficult to determine such patterns. Certainly this is the first time that the effects of individual human activities upon elephants have been defined.

5.4.1 Environmental variables and elephants

Season was found to exert a significant influence upon elephant relative abundance. This confirms the findings of Chapter Four, namely that the relative abundance of elephants falls dramatically between the cool dry and the hot dry seasons as sources of permanent water become scarce.

Elephant relative abundance was greater closer to sources of water in the cool dry and hot dry seasons. In the mid-Zambezi valley, signs of elephants were not generally found further than 8km from water. Elephants are water-dependent and in semi-arid environments will remain close to sources of permanent water

(Taylor, 1983; Connybeare, 1991; Stokke & du Toit; 2002). In Chobe National Park, cow elephants rarely travel more than 3.5 km from permanent water during the dry season, but bulls are able to roam more than 10km.

5.4.2 Permanent human activity

No signs of elephants were found within 1km of settlement, indicating that they avoid being in close proximity to settlement. This was most likely due to the permanent human presence and high levels of activity. In addition, trees and shrubs had been removed close to settlement, creating an open habitat that provided no food or cover for elephants. Elephants similarly avoided settlement in the forests of north-eastern Gabon (Barnes *et al.*, 1991), and in the savanna habitats of Tanzania (Nahonyo, 2001).

Elephant relative abundance in relation to settlement bore similarities to elephant abundance in relation to permanent water. While avoiding settlement at close quarters, elephant abundance remained high at intermediate distances of between 1km and 7km from settlement. Beyond 7km there was less elephant activity, which was most likely explained by the close physical relationship between settlement and water. Settlement was usually sited at sources of permanent water, and the two variables were therefore closely correlated. Therefore the pattern of elephant relative abundance with distance to settlement may have more closely reflected the elephant's relationship with water than with settlement.

Elephants continued to use water sources that were surrounded by settlement during the dry season. For example, at Bonga village the residents of the village dug temporary wells in the bed of the Kadzi river at a place called Uchawachawa (FG notes, Bonga). This location was surrounded by dense settlement, yet elephants in large groups visited there in the hot dry season to drink water from the wells. A similar situation occurred in Kasuo village, where elephant spoor was regularly found around the village's temporary wells (FG notes, Kasuo). Such use of water brings elephants into close contact with people and their dry season gardens, leading to conflict, which is discussed further in Chapter Eight.

Distance to cultivation did not emerge as a significant in the GLIM analysis. However, on examining the graphical plot, the index of elephant dung abundance appeared to be higher closer to cultivation. After 6 km, the index of abundance fell to zero, probably as a result of the correlation between cultivation and dry season water sources. Elephants may not have avoided cultivation in the same way as settlement because a) there was less human activity than in settlement, except in the cropping season; b) there was more natural habitat at the edge of cultivation than settlement, because fields bordered natural woodland, whereas settlements tended to be cleared of vegetation; and c) cultivation may have been consistently over-exaggerated on the CIRAD vegetation map (G. Mazamba, *pers. comm.*).

There was no clear relationship between elephant relative abundance and the percentage of land that was under cultivation. The relative abundance of elephants was high at nearly every level of cultivation surveyed. Elephants are known to survive in a variety of human-transformed landscapes, including fragmented woodland landscape in a mosaic of agriculture (Williams *et al.,* 2001). From research in Zimbabwe, it has been suggested that elephants may not tolerate landscapes that are more than 50% transformed to agriculture. While this threshold was exceeded in localised areas, this was not the case for the landscape as a whole. If the mid-Zambezi Valley study area is considered as a whole, 38% of the overall land area has been converted to cultivation and settlement (CIRAD, 2002). This figure falls below that suggested by Hoare & du Toit (1999), indicating that elephants would be able to survive in the overall landscape, even if the level of transformation was greater in certain localities.

At this scale of analysis it is clear that elephants utilised habitats that were heavily transformed. Elephants utilised even those habitats that were up to 90% transformed, but because the overall landscape was less than 50% transformed, they were able to persist there. In the Sebungwe, elephants could persist in highly transformed landscape, as long as there was adequate undisturbed refuge nearby (Hoare, 1999).

5.4.3 Ephemeral human activities

Human activities affected elephant relative abundance in the three woodland habitats included in this analysis. In particular, signs of people and cattle herding affected elephant abundance significantly. Above a certain threshold elephants did not seem to tolerate these human activities in woodland habitats. This is a similar relationship to that found in the forests of the Central African Republic, where elephant numbers appeared to decline with increasing levels of human activity (Blom *et al.*, 2004).

In this study, it was possible to identify the effects of specific human activities, which has not previously been achieved. Blom *et al.* (2004) measured separate human activities, but they only discerned an effect upon elephants when these activities were combined. In this study, people and cattle exerted the greatest influence upon elephant relative abundance. This suggests that areas that people habitually used, and areas that were used for cattle grazing, were avoided by elephants, especially where usage was regular and heavy. Grazing activity was likely to be among the most common resource collection activities, bearing in mind that over half of all respondents throughout the study area owned cattle (Chapter Three).

It stands to reason that elephants would avoid the physical presence of people, as has been documented widely (e.g. Blom *et al.*, 2004; Nahonyo, 2001). However, it is less obvious why cattle would elicit an avoidance response. In Kenya, elephants retreated from recordings of cattle noises, because of an association between the cattle and the danger posed by the Maasai (Kangwana, 1993). If elephants associated cattle with humans in the mid-Zambezi, then it is possible the same avoidance would be observed.

Elephants appeared to react to short duration human activities in response to a threshold above which they no longer occurred. This pattern suggests that at low levels, human activities may be tolerated, and elephants may persist at even high abundances. However, when the threshold is reached elephants most probably move away to other areas. A similar pattern of elephant response was noted by Hoare & du Toit (1999) in relation to habitat transformation. This indicates that the elephant's response to human activity is governed by a threshold relationship, which has serious implications for elephant management; as such relationships are more difficult to interpret.

Short duration human activities were far more widespread than long duration activities, despite these signs being harder to spot, and lasting only a few days. They affected elephants significantly, whereas long-duration activities had no discernible effect. Short duration activities may represent more of a threat to elephants because the types of activity included may be habitually conducted in an area. For example, cattle grazing may occur in the same patch of woodland for several months, so representing a higher level of disturbance than an activity that occurs infrequently. Signs of short duration activities were far more numerous than long duration activities. Bearing in mind that long duration activities are more visible, and they last for a longer period, this suggests that short duration activities are many times more common.

The elephant's response to human activities described in this chapter may provide an insight into the lack of elephant activity within riverine vegetation. Until recently, elephants had been regular visitors to riverine thickets along the Musengezi and Utete rivers that define the boundary between Muzarabani and Guruve districts (Hoare, 1998). These thickets were used by bull elephants as they travelled between the Mavuradona mountains in the south and Guruve district to the north (G Parker, *cited in* Byers *et al.,* 2001). However, since 2001, and during the course of this research, no such sightings of elephants have occurred.

Guruve and Muzarabani districts have been subject to widespread resettlement in the last few years, as farm workers and their families were displaced by the government's land redistribution programme (Interview: Ward 6 councillor). As a result, large numbers of people have resettled and started cultivating new land. Many of the riverine thickets are surrounded by people at very high densities (Byers *et al.,* 2001). While cultivation exhibited no discernible effect upon elephants within this study, high levels of cultivation has been observed to have a negative effect upon elephant's usage of rivers within the study area (Cumming

& Lynam, 1997; Fritz *et al.,* 2003). High levels of cultivation along the major rivers may prevent access to riverine woodland and water for many species of large mammal.

In addition to agricultural activities, riverine thickets would be under intense pressure for resource extraction, bearing in mind the reliance of rural farmers upon natural resources (Cumming & Lynam, 1997). As has been observed in other habitat types, elephants do not tolerate high levels of human activity. Therefore, it is likely that the increase in the human population, and their associated demands for land and resources, have rendered the riverine thickets unusable to elephants.

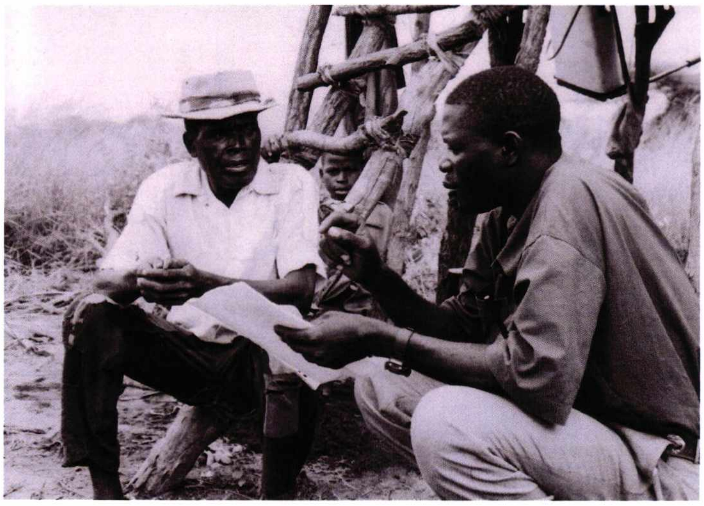
This has serious implications for the CAMPFIRE programme within Muzarabani district, whose elephant population centres upon the Mavuradona Wilderness Area (MWA). Elephant movements between MWA and Guruve district may be important for the genetic fitness of this small population of elephants (Osborn & Parker, 2003a), and if such a movement ceases, the viability of the CAMPFIRE programme in Muzarabani district may be weakened. It has been demonstrated that the revenue potential of a district declines rapidly as the human population increases (Bond, 1994), and if resettlement continues unchecked then it is likely that the potential for earning revenues through sport hunting will be compromised.

Land zonation is considered a key component of conflict resolution (Hoare, 2000), and careful land-use planning has been identified as crucial in avoiding or mitigating HEC in the future (Newmark, 1994). In addition to this, land-use planning could be used to create elephant refuge areas in which human activities were limited. In an increasingly fragmented and transformed environment, the prioritisation of key habitats based upon elephant requirements may be essential to their perpetuation. Creating or preserving landscape structures, such as corridors and stepping stones, may be an effective means of mediating the effects of habitat fragmentation on populations (Harris, 1984).

However, if elephants are to persist within designated areas of natural habitat, such areas would need to have little or no resource extraction. This would require the communities surrounding such areas to limit their resource collecting activities. For such a system to be feasible, the benefits that accrue from elephants must provide a sufficient incentive for people to willingly change their patterns of behaviour.

In this chapter I have shown that human activities affect elephants, which avoid settlement and areas of high human activity. In the next chapter I explore people's perceptions of human-wildlife conflict, in order to identify the major issues of conflict, and to determine the effects of elephants in relation to other wild animals.

Chapter 6 Perceptions of Human-Wildlife Conflict



6.0 Introduction

Human-wildlife conflict is a critical issue in conservation, as it creates intense animosity between rural communities and the wild animals that threaten their livelihoods (Adams & McShane, 1992; Naughton-Treves, 1997). Such negative interactions have the potential to undermine long-term biodiversity goals, as local people express their anger through encroachment on protected areas, poaching, and excessive resource use (Mehta & Kellert, 1998).

Conflict may be categorised as 'direct' and 'indirect' according to its impact upon people. Conflict can impact directly upon the physical and economic wellbeing of rural communities (Hill, 1997; Naughton *et al.,* 1999), through causing damage to crops, livestock and property, as well as human injury and death. Conflict can also cause broader and indirect social impacts upon people, for example through the effort required to protect crops and property, the disturbance of normal activities such as walking at night, and the fear of injury or death (Hoare, 2000). Such indirect costs may outweigh the direct costs of conflict, and may be a major component of the conflict perceived by local people (WWF, 1997).

Studies of human-elephant conflict have assessed both direct and indirect conflict issues through qualitative research (e.g. Hawkes, 1991; Newmark *et al.,* 1994; Hill, 1997; Naughton-Treves, 1997; de Boer & Baquete, 1998). Such qualitative approaches have been used to identify problem animals, and to rank the damage they cause (Naughton-Treves, 1997; Hill, 1997). Qualitative studies have also explored the wider, indirect issues of conflict, for which they are particularly suited. For example, strong emotions such as anger (Naughton-Treves, 1998) and fear (Hoare 2000; Naughton-Treves, 1997) are common responses to conflict, but may only be captured through qualitative research. In addition, it is possible to explore conflict over a time scale that is beyond the scope of quantitative research (Naughton-Treves *et al.*, 1999), because perceptions draw upon experiences that span many years.

Qualitative studies offer insights into the human perceptions of risk. Farmers may feel more vulnerable to large dangerous animals that can both inflict infrequent but potentially catastrophic losses to their crops or livestock (Naughton-Treves, 1997), and that can kill or injure (de Boer & Baquete, 1998; Naughton-Treves, 1997). In contrast, small frequent crop-raiders may be ignored (Hill, 1997).

Equally, interview-based research does carry the risk of inaccuracy, with farmers regularly exaggerating the amount of crops they loose to wildlife (Bell, 1984; Mwathe, 1992 *cited in* Naughton-Treves, 1998). In addition there may be a bias towards large animals, which may be unjustly blamed for the damage caused by smaller animals (Hawkes, 1991). However, such inaccuracies can be balanced out through parallel quantitative studies, which may serve to verify the qualitative findings (Naughton *et al.,* 1999).

Investigating conflict though qualitative means enables the identification of a broad range of issues, incorporating physical damage, the fear of injury or death, perceptions of risk, and wider social impacts. Such an approach provides a comprehensive review of wildlife conflicts, from which issues may be prioritised, and further research directed. To date, while crop damage studies have quantified elephant conflicts within the study area (e.g. Parker & Osborn, 2001), there has been no assessment of people's perceptions of conflict with wildlife. In this chapter I investigate the perceptions of human-wildlife conflict among rural communities in order to:

- determine the prominence of wildlife conflicts in the context of general problems faced by communities within the study area;
- Identify and prioritise the most problematic species of large mammal;
- identify and prioritise issues of human-elephant conflict; and,
- determine the relative impacts of direct and indirect elephant conflicts upon rural communities.

6.1 Methods

6.1.1 Semi-structured interviews

Farmer's perceptions of human-wildlife conflict were investigated through Semi-Structured Interviews (SSIs), as described in the *General Methods* section of Chapter Three. I conducted interviews in 10 study villages which had been selected as the focus of this research (Chapter Three). The questions asked in the interview were developed and refined during a pilot interview survey conducted at Chief Hwata's homestead in July 2002. The actual interviews were conducted between June and October 2003, a period of the year in which farmers tended to be less busy with agricultural work.

6.1.1.1 Selection of interviewees

Interviewees were selected in each village using a randomly placed compass bearing. The geometric centre of each village was located on a 1:25,000 orthophoto map. A bearing between 1 and 360 degrees was selected using the random number generator in Excel. The first three digits that corresponded to a bearing were selected and this bearing was drawn as a line outwards from the centre point. Every homestead encountered on the ground along the bearing was selected for interviews. Where respondents were not available, the next nearest homestead was selected. To ensure an equitable sex ratio, men and women were selected alternately. On occasion, women were reluctant to be interviewed or were refused permission by their husbands, who took their place. Inevitably, this cultural norm created a bias towards men in the sample (Table 6.1).

6.1.1.2 Interview questions

Interviews were conducted by myself, with two field assistants who acted as interpreters. Each interview took approximately one hour to complete, and began with questions to determine the respondent's origins, age, wealth and farming practices. The interview then moved to a series of questions that sought to first, understand the significance of human-wildlife conflicts in relation to the other general everyday problems they faced; second, prioritise elephant conflicts in relation to human-wildlife conflicts; and third, investigate the specific issues of elephant conflict.

Table 6.1: Sample size and gender of interviewees.

Village	Male	Female	Total
Chikafa	15	10	25
Bwazi	1	9	10
Kapururira	16	8	24
Jowa	16	0	16
Majinga	9	3	12
Bonga	18	1	19
Kasuo	10	8	18
Gera	15	14	29
Soka	10	8	18
Warambwa	6	6	12
Total:	**116**	**67**	**183**

Questions were open-ended and designed to promote discussion. Each question was worded carefully throughout to avoid leading questions that primed respondents towards making certain responses in that, or later, questions (Hill, 1997). For example, elephant crop damage was only discussed if the respondent mentioned it first. Respondents were free to mention any issues and were not guided by lists or pre-determined categories. Farmers were asked to rank the issues they raised in order of importance, as ranking has been used to great effect in other conflict research (e.g. Hill, 1997; Naughton-Treves, 1997).

The questions were as follows:

1. What are the general problems you face in daily life?
    a. Rank the problems, greatest first and smallest last.
2. Do you experience problems with wildlife?
    a. If so, which animals cause you problems?
    b. What type of problem does each animal cause?
    c. Rank the animals in terms of the problems they cause, greatest first and smallest last.

3. (If elephants have been mentioned above) What are the specific problems caused by elephants?
    a. How do elephant problems differ from other animals?
    b. Rank the problems they cause, greatest first and smallest last.

6.2 Analysis

6.2.1 'Mentioned' and 'worst'

I used two indicators to prioritise the conflict issues raised in each question. First, I tallied the number of times that each issue was mentioned, which highlighted its prominence in local perceptions. Second, I summed the number of times that each issue was identified as the 'worst', which highlighted only the most serious issues. Both measures were complimentary, and provided different perspectives on each issue discussed. Both measures were used to prioritise the importance of different problem animals, and further used to prioritise issues of elephant conflict.

6.2.2 General problems

General, or everyday, problems were identified by farmers in the first question of the SSI. Of interest was whether problems with wildlife were mentioned, and if so, where they fell in the context of other general problems. Every issue raised as a problem was prioritised using 'mentioned' and 'worst' scores. Several issues were pooled into common categories for simplification: 'lack of agri inputs' encompassed shortages of agricultural equipment, such as ploughs, as well as agricultural inputs such as fertiliser; 'lack of transport' incorporated the lack of buses, the lack of bridges and the poor state of the roads; and, 'livestock conflict' incorporated damage to crops by cattle, goats and sheep.

6.2.3 Problem species

Problem species were prioritised in the second question, using the same two indicators of 'mentioned' and 'worst'. The category 'wild pig' incorporated both bush pigs (*Potamochoerus porcus*) and warthogs (*Phacochoerus aethiopicus*), as interviewees did not differentiate between these species. In addition, the number of conflict issues associated with each species was investigated.

6.2.4 Elephant conflicts

The issues of elephant conflict were then explored in greater detail through question three. Again, issues were prioritised in terms of the number of times 'mentioned' and the number of times identified as 'worst'.

6.3 Results

6.3.1 General problems

The general problems mentioned by respondents were dominated by critical agricultural issues, such as the lack of food security and a lack of agricultural inputs (Figure 6.1). These were followed by mentions of development-related issues, including lack of transport and clinics, and the lack of drinking water. Conflicts with elephants received the seventh most mentions overall, a similar number to such fundamental issues as poor drinking water, and lack of rainfall. This ranked elephants higher than diseases such as malaria, and money problems. Elephant conflicts were distinguished from other species of wildlife that cause conflicts, which were ranked 11th, while conflicts involving livestock were ranked 14th (Figure 6.1).

The general problems that respondents considered as the 'worst' followed a very similar pattern (Figure 6.2) to the number of times each problem was mentioned (Figure 6.1). Food shortages and lack of agricultural inputs, followed by poor drinking water and lack of transport, predominated as the 'worst' issues among respondents. However, conflicts with elephant were ranked in sixth place alongside poor drinking water and rainfall. Conflicts with other wildlife fell to fourteenth place, indicating that they were rarely perceived as the worst problem (Figure 6.2).

Figure 6.1: The frequency with which general problems were mentioned by respondents from ten study villages in the mid-Zambezi Valley.

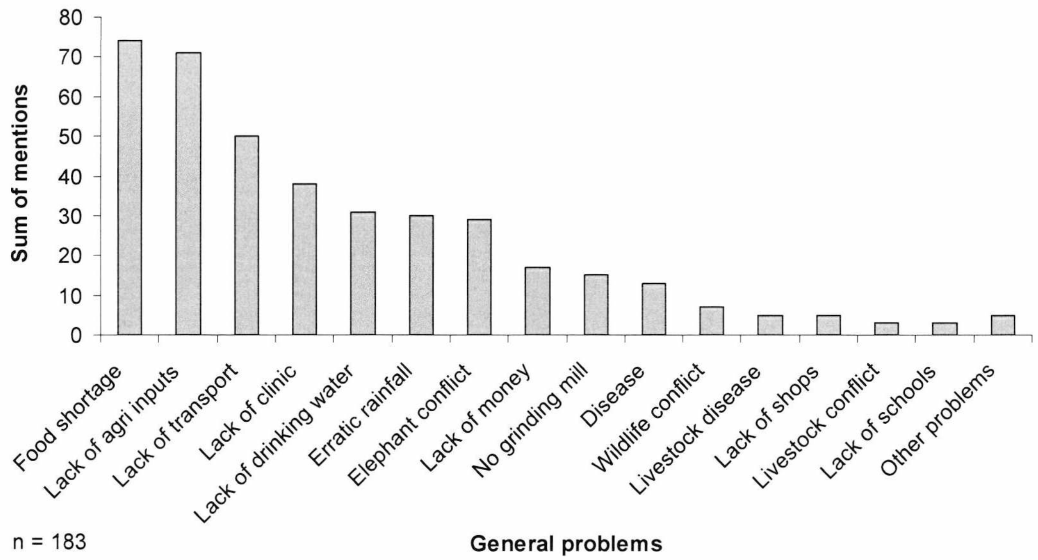
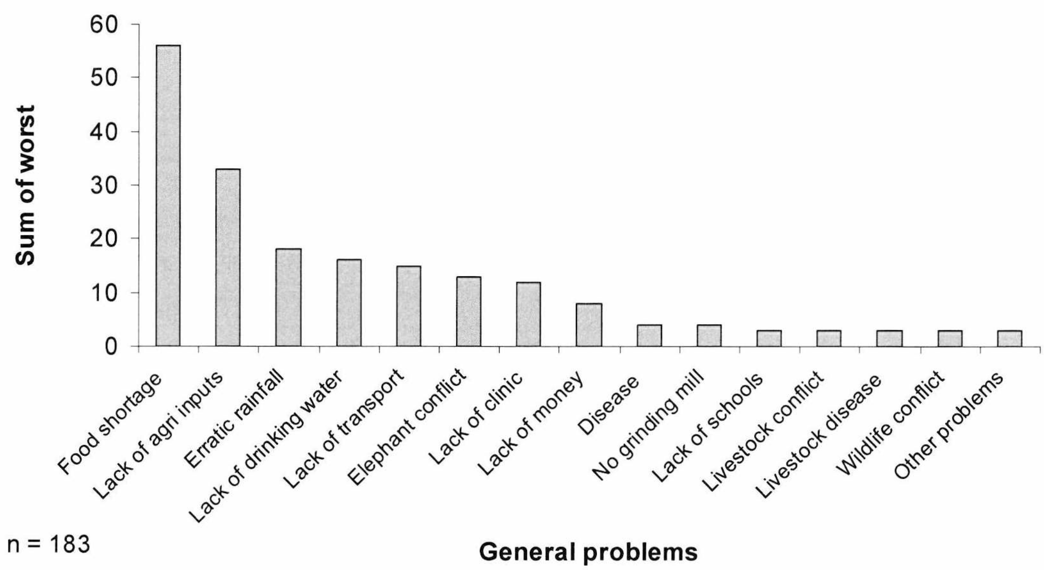


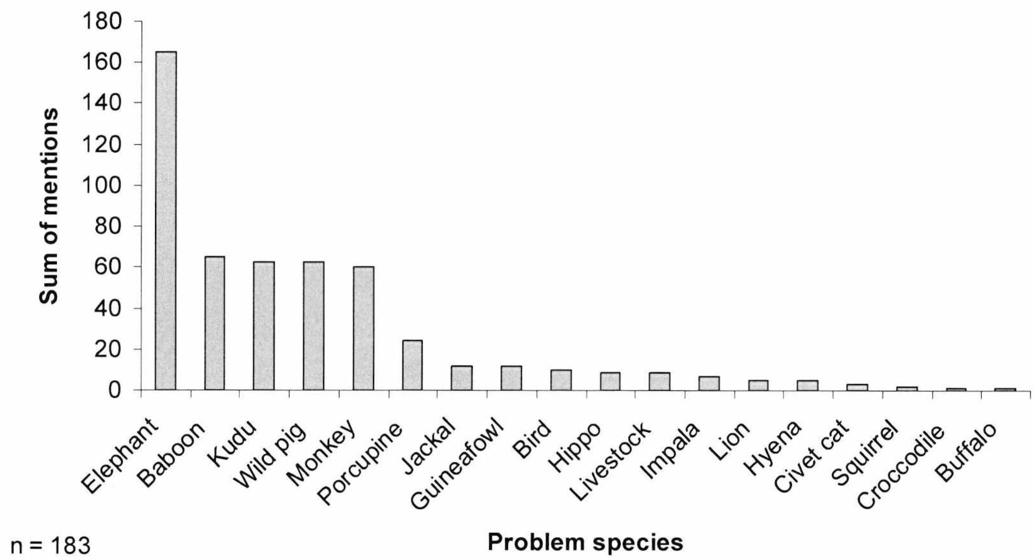
Figure 6.2: The frequency with which general problems were considered the 'worst' by respondents from ten study villages in the mid-Zambezi Valley.



6.3.2 Problem species

A total of 18 species of animal were considered to be a problem. Elephants were perceived as the most important problem species across the study area (Figure 6.3), and were mentioned by 165 (90%) of respondents. Chacma baboons (*Papio* *cynocephalus*), greater kudus (*Trangelaphus strepsiceros*), wild pigs and vervet monkeys (*Cercopithecus aethiops*) were the next-most mentioned problem species, and each was mentioned by between 60 (33%) and 65 (36%) of respondents. These four species formed a distinct group that were mentioned twice as frequently as the next most important problem species. Porcupines (*Hystrix cristata*) were mentioned 24 times (13%), and black-backed jackals (*Canis mesomelas*) and guinea fowl (*Numida meleagris*) were both mentioned 12 times (7%). The remaining species or species groups were mentioned by 10 or fewer respondents, and included a diverse range of birds, mammals and domestic livestock.

Figure 6.3: The frequency with which problem species were mentioned by respondents from ten study villages in the mid-Zambezi Valley.

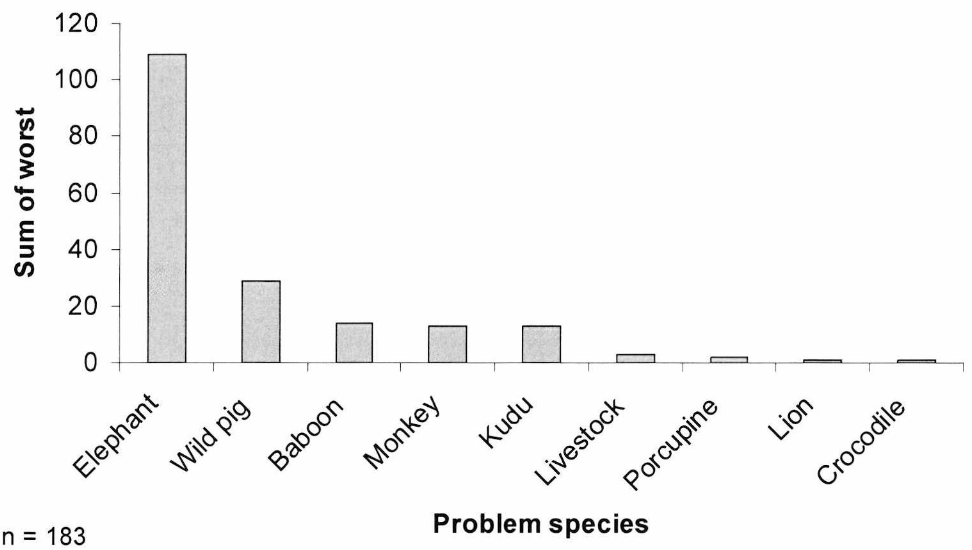


Many fewer species were identified as the 'worst' problem, than were mentioned as problem species (9 vs. 21). This suggested that farmers recognised many species as causing problems, but fewer were considered as serious problems. Nevertheless, the five problem species that were identified as the 'worst' (Figure 6.4) were the same as those 'mentioned' most often (Figure 6.3). These five species formed a distinct group, the least important of which scored several times more highly than those species and species groups that followed (Figures 6.3 and

6.4). However, the top five problem species were ranked in a different order in each scoring system.

Elephants remained the most important problem species which ever way they were scored, and were identified as the worst problem animal by 109 (60%) respondents. Bush pigs were identified as the next worst problem by just 29 (16%) of respondents, while baboons, monkeys and kudus were considered as the worst by 14, 13 and 13 respondents, respectively. Livestock, porcupines, lions and crocodiles were considered as the worst by less than five respondents each.

Figure 6.4: The frequency with which problem species were considered the 'worst' by respondents from ten study villages in the mid-Zambezi Valley.



The problem species identified caused a range of problems. The four most mentioned issues were wet season crop damage, killing people, injuring people and killing livestock (Table 6.2). Wet season crop damage dominated the conflict issues, being the primary form of conflict for 14 species or species groups of animals. Wet season crop damage was the primary conflict issue for all five of the most prominent problem species.

Six species of animal were considered to be dangerous to humans, either causing injury or death, or both. Of these, four were ranked as the top five problem animals. Elephants were considered the most dangerous of all, being identified as being able to kill people by 27 respondents, and injure people by a single respondent. Hippos and hyenas were considered to kill people by five and two respondents, respectively. Wild pigs and buffaloes were considered to kill and injure people, by three and two people respectively. Baboons were considered capable of injuring people by two respondents. Five species of animals were considered to be a threat to livestock, including jackals, lions and crocodiles, which were not considered to be harmful to people.

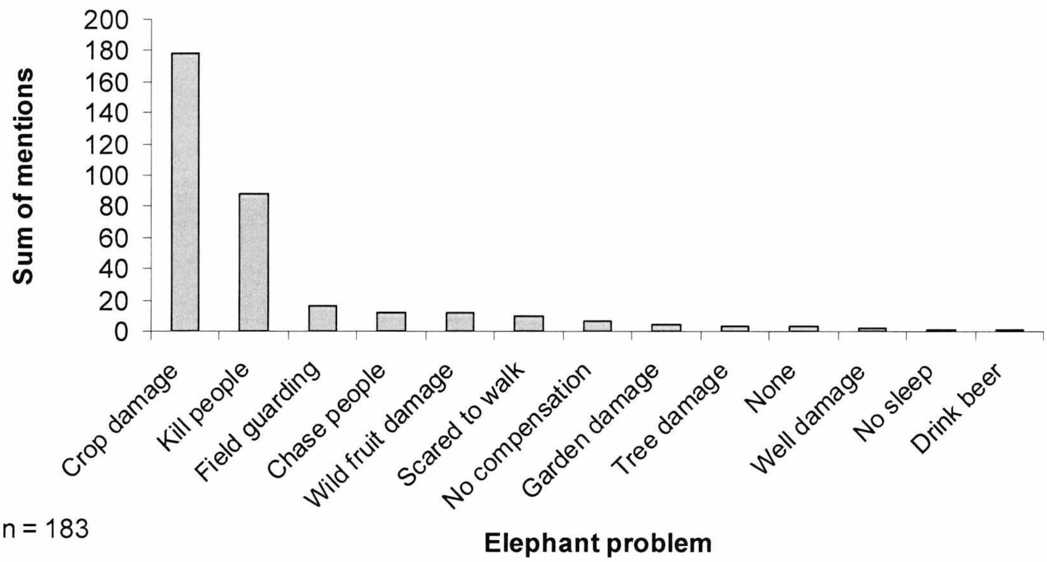
Table 6.2: The four most mentioned conflict issues caused by eighteen problem species identified by farmers in the mid-Zambezi Valley.

Problem species	Wet season crop damage	Kill people	Injure people	Kill livestock
Elephant	58	27	1	-
Wild pig	38	1	2	-
Monkey	39	-	-	-
Baboon	27	-	2	3
Hippo	13	5	-	-
Kudu	17	-	-	-
Porcupine	11	-	-	-
Jackal	10	-	-	1
Guinea fowl	10	-	-	-
Bird	8	-	-	-
Impala	7	-	-	-
Hyena	-	2	-	4
Livestock	6	-	-	-
Lion	-	-	-	4
Buffalo	1	1	-	-
Crocodile	-	-	-	1
Squirrel	1	-	-	-

6.3.3 Elephant conflicts

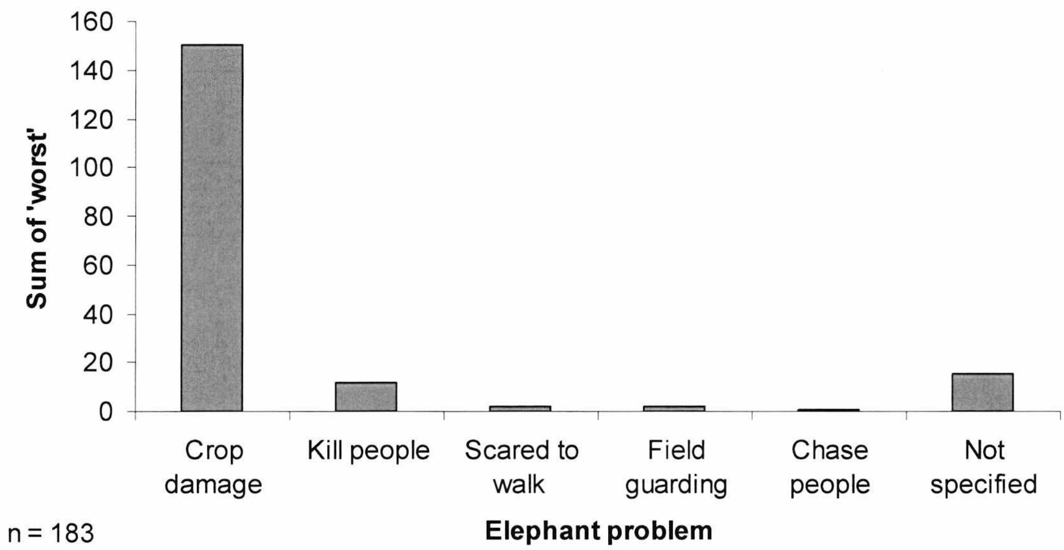
When considered in detail in question three, interviewees identified thirteen distinct problems caused by elephants. The majority of respondents (178; 98%) 'mentioned' wet season crop damage (Figure 6.5), while nearly one half (88; 48%) of respondents mentioned elephants killing people. The remaining issues were far less common: 16 respondents (9%) mentioned field guarding; 12 different respondents (7%) each mentioned elephants chasing people, and elephant damaging wild fruits, respectively. Ten respondents (5%) mentioned fear of walking in the bush at night. Damage to dry season gardens was considered a separate issue to crop damage, and was mentioned by four respondents (2%). Three respondents (2%) stated that there were no problems from elephants; two (1%) mentioned that elephants damaged the wells dug in rivers and one complained of a lack of sleep when guarding his fields from elephants. A further respondent protested that elephants had drunk a drum of his home-made beer

Figure 6.5: The frequency with which elephants conflict issues were mentioned by respondents from ten study villages in the mid-Zambezi Valley.



Only five of the 13 issues raised were considered to be 'worst' problems (Figure 6.6), although 15 respondents did not specify which of the conflict issues they raised was worst. A total of 150 (82%) of respondents considered wet season crop damage as the worst conflict issue, whereas only 12 (7%) of respondents considered elephants killing people as the 'worst' issue. Only two respondents (1%) considered guarding fields and fear of walking at night as the worst issue. One respondent considered that elephants chasing people as the worst issue.

Figure 6.6: The frequency with which elephant conflict issues were ranked as 'worst' by respondents from ten villages across the mid-Zambezi valley.



6.4 Discussion

In this chapter I have investigated the issues human-wildlife conflict according to the rural communities of the mid-Zambezi Valley. I have identified the five species of large mammal considered to be the greatest problem due to their damage to wet season crops. Elephants were considered to be the most serious problem species. In addition to wet season crop damage, they also killed and injured people and caused a multitude of other problems. Direct conflict issues, namely crop damage and human death, were considered problems of a far greater magnitude than indirect costs, such as resource collection and field guarding.

6.4.1 General problems

Elephants were ranked seventh of all general problems, and considered to be of similar gravity to drinking water, rainfall and transport. Water issues are high profile in the Zambezi Valley, which is classified as semi-arid. For those communities who do not have boreholes, water must be collected from rivers. In the wet season, flooded rivers provide poor quality water and those collecting water are at the mercy of the activities of those upstream. In the dry season, water is obtained from wells dug in the river bed. Water supply is therefore a problem in many villages, and the fact that elephants are considered to cause a similar level of problems indicates that these animals severely impact people's lives. It is noteworthy that elephant conflicts were considered separately to wildlife and livestock conflicts, and they were the only problem animal identified as an individual species.

6.4.2 Problem species

Elephants, bush pigs, baboons, kudus and monkeys were identified as the most problematic animals in the Mid-Zambezi Valley. The results fit closely with those of other areas: in a review of wildlife conflict studies across the continent baboons, monkeys, bush pigs and elephants dominated the list of problem animals (Naughton-Treves, 1998).

The identification of the worst problem animals may have been reinforced by the natural tendency to identify large animals as the greatest problem. The strong bias towards large animals (Litsinger *et al.*, 1982; Hill, 1997) occurs because farmers feel a heightened sense of vulnerability towards them. The five identified mammals are either large bodied, or form large groups, which makes them capable of destroying large areas of crops in a single sitting. Farmer's perceptions tend to reflect rare, extreme damage events rather than persistent small losses (Naughton-Treves, 1997), and as a result large animals with the potential to inflict extensive damage have a high profile. More frequent crop-raiders such as bush buck and birds may be more easily tolerated, even if the losses they cause are substantial in total (Hill, 1997).

All five of these animals were predominantly crop-raiders. Crop damage is a major issue for rural African farmers because it damages their livelihoods and reduces the capacity for farmers to subsist. The impact of crop damage is intensified by poor agricultural production, which in the mid-Zambezi Valley is severely limited by the environmental conditions (Cumming & Lynam, 1997). In the past two years agriculture has not been adequate to feed the communities of the Zambezi Valley. Poor rainfall and the shortage of food dominated the general problems, indicating the gravity of these issues in people's lives. The sporadic rains and drought conditions of the 2001-2002 and 2002-2003 growing seasons compounded food production problems, leading to the distribution of food aid throughout Guruve and Muzarabani districts. In such conditions, wildlife crop damage forms a further constraint on farmers who are already severely limited by climate and soils.

In addition to damaging crops, the three animals identified as most problematic, elephants, wild pigs and baboons, were perceived to present some threat to human life. Elephants and wild pigs were described as potential killers, and baboons were believed to have the potential to injure people. The perceived threat of an animal may increase its profile among local people (Hoare, 2001). In Mozambique, animals such as hippos and elephants were feared because they were aggressive and nocturnal, making them more difficult for farmers to deal with (de Boer & Baquete, 1998). The same applied to baboons and bush pigs in Uganda (Hill, 1997).

However, the fear of death was considered a lesser problem than crop damage for all the main problem species. This means the ability for an animal to kill or injure did not automatically elevate it to a higher status in people's minds. In addition, dangerous wild animals only appeared to be considered a serious problem if they were common. Both hyenas and buffaloes were considered a threat to human life, yet overall they were ranked among the lowest of the problematic species. These species were rare within the study area, being only occasional visitors.

6.4.3 Elephant conflicts

Wet season crop damage was considered to be both the most common and the worst form of conflict caused by elephants. As the largest of all crop-raiding animals elephants have the potential to cause extensive damage to crops, which has made them the number one problem animal in Uganda (Naughton-Treves, 1997). Crop damage has been identified as the most prevalent form of human-elephant conflict in many locations across the African continent (e.g. Hoare & Mackie, 1993; Hill, 1997; Gillingham & Lee, 1999; Sitati *et al.*, 2003).

6.4.3.1 Seasonal patterns of crop damage

Wet season and dry season crop damage incidents were raised as separate issues by those interviewed. Dry season or 'garden damage' was ranked a far lesser problem than wet season crop damage and was not considered the 'worst' form of conflict by any respondent. The emphasis placed upon the damage to each season's crops reflects their importance to the livelihood of the farmer. Maize is an important staple (Purseglove, 1972) which is cultivated during the wet season and stored to provide the bulk staple for the rest of the year. In contrast, vegetables grown in the dry season tend to provide supplementary nutrition (Welford, 2002) rather than staple food. Consequently, farmers viewed garden damage is an 'irritation' and a 'waste of effort' rather than a serious threat to livelihoods (FG notes, Bonga).

6.4.3.2 Human death and injury

The ability for elephants to take human life was the second most frequent problem and was considered the second greatest threat. Elephant killings, although intolerable (Naughton *et al.*, 1999), were considered a lesser issue than crop damage because they occurred infrequently. There was a high probability that one's farm would be damaged by animals, but a very low chance that one will be killed or injured by elephants. Interviewees specifically used the word 'sometimes' to preface human deaths, i.e. 'elephants sometimes kill people'. This gives clear reference to the fact that it is an occasional occurrence (FG notes, Jowa).

6.4.3.3 Indirect conflict

Elephants caused a range of indirect conflicts including damaging fruit trees, damaging temporary wells and presenting a risk to people who were walking at night. These issues were not afforded the same importance as was conferred to crop damage. This is probably a reflection of the fact that the additional forms of conflict did not affect the supply of staple food, as did crop damage. In addition, while presenting an inconvenience, such conflicts could also be avoided. For example, it would be possible to avoid walking at night, or to collect fruits from areas other than those where elephants were present.

Such diverse additional conflict issues were exclusive to elephants, and were not generally recognised for other problem animals, which were blamed almost entirely for their ability to destroy crops. It has been hypothesised that such indirect conflicts may outweigh the direct costs of agricultural damage in rural Zimbabwe (WWF, 1997). However, in this site this is not the case. People's perceptions of conflicts were dominated by crop damage and human death, and all indirect conflict issues were insignificant in comparison. However, while wider elephant conflict issues may be considered less important that crop damage, the fact that these issues exist may still serve to elevate elephants above other problem animals.

In this chapter I have established that farmers considered elephants to be the greatest problem of all large mammals. Damage to wet season crops was considered the greatest of all elephant impacts, with human death and injury as the next greatest problem. In contrast, indirect conflict issues, while numerous, were not afforded the same significance. Four other species of large mammals were identified as being problematic, causing damage to crops, and also representing a threat to human life.

This chapter has identified and prioritised conflict issues in terms of people's perceptions. In the following chapter, I investigate crop damage by wild animals in villages across the study area, using quantified crop damage reports to determine the relative damage caused by each animal. I compare farmer's perceptions of crop damage to the actual damage recorded, to determine the level of agreement between the two.

Chapter 7 Crop Damage by Large Mammals

7.0 Introduction

Crop damage is the most widespread form of direct conflict with large mammals, and has been identified as the primary conflict issue in many developing countries (e.g. Gillingham & Lee, 1999; Naughton-Treves, 1998; Newmark *et al.,* 1994). Crop damage is a severe problem for rural African farmers, whose crops are their primary source of income and subsistence. Communities in wildlife areas may already be economically marginalised, and so be in a poor position to bear the costs of escalating wildlife conflict (Naughton-Treves, 1998).

A wide variety of large mammals conflict with farming activities, including primates, antelopes, buffaloes, hippopotamus, bush pigs and elephants (Bell, 1984). Studies conducted around protected areas across the African continent identify baboons, monkeys, bush pigs and elephants as the predominant problem animals (Naughton-Treves, 1998; Chapter Six). Equally, livestock are often overlooked in conflict research, despite being frequent crop predators. However, their impacts may be lessened by local measures of restitution, which compensate for the damage they cause (Naughton-Treves, 1998).

Current research indicates that problem animals inflict damage in different ways. For example, monkeys cause widespread crop damage in many locations, but each event is predictably small. In contrast, baboons are not the most frequent raiders, but they can cause the largest total area of crop damage across many locations (Naughton-Treves, 1997). Elephants cause extensive damage to just a few locations, yet they do not necessarily damage the most crops overall (Hawkes, 1991; Naughton *et al.,* 1999).

While spatial elements of conflict remain difficult to predict (Sitati *et al.,* 2003), it is possible to identify broad patterns of crop-raiding activity. Mammals target mature crops which are at their most nutritious during their fruiting phase (Bell, 1984). In African savannas, a peak of elephant crop damage activity occurs during the late wet season, which coincides with the maturing of rain-fed field crops (Hoare, 1995; Kangwana, 1995; Parker & Osborn, 2001). In Zimbabwe, a dry season peak of crop-raiding corresponds to the maturing of vegetables, which are cultivated in gardens along the beds of major rivers (Parker & Osborn, 2001).

Crop damage must be rigorously quantified if the impacts of wild animals are to be considered objectively. Measuring damage to crops is not easy, as there is a great deal of variability in the timing, distribution and extent of incidents (Naughton-Treves, 1998; Taylor, 1999). Therefore, a systematic approach to monitoring is required (Hoare & Mackie, 1993), for which independent enumerators are considered essential (Taylor, 1999) if impartiality is to be achieved.

In previous research the spatial and temporal patterns of human-elephant conflict have been described in Muzarabani district (Parker & Osborn, 2001). However, to date there has been no comparative study of the damage caused by large mammals. In Chapter Six, farmers in the mid-Zambezi Valley prioritised five species of problem animal, and identified damage to wet season crops to be the worst form of human-wildlife conflict. In this chapter I aim to quantify large mammal crop damage in order to:

- identify the species of large mammal responsible for crop damage, and describe the patterns of damage they cause;
- prioritise problem species in terms of their impact upon farming in the Mid-Zambezi Valley; and,
- compare the perceptions of problem species with the levels of crop damage caused.

7.1 Methods

7.1.1 Crop damage assessment scheme

A crop damage assessment scheme measured crop damage in every study village across the study area. Crop damage information was recorded only for large mammals >3kg. Damage caused by rodents, birds and insects was ignored, despite them being significant crop predators in some areas (Naughton-Treves, 1998). Damage to crops was measured between December 2002 and November 2003. This 12-month period encompassed the two main agricultural seasons, which spanned December-May for wet season crops, and June-October for dry season crops.

Originally, I aimed to implement the data collection scheme in all 10 study villages, whose selection is detailed in the General Methods section of Chapter Three. However, it was only possible to use wildlife reports from eight villages, while the crop damage data from two villages were inconsistent and therefore discarded. Consequently, the analysis of large mammal conflicts featured in this chapter used the information from eight villages only.

I trained enumerators to record every incident of crop damage by large mammals within their own villages. Each enumerator patrolled the fields of their village twice per week searching for crop damage. Additionally, they relied upon farmers to report any damage to them. On encountering crop damage, the enumerator recorded information according to a standard format, which was modified from that used by Osborn (1998), and Parker & Osborn (2001) (Appendix 7).

7.1.1.1 Details of crop damage report

In each report, the details of the farmer, and the location and the timing of the incident, were recorded. This was followed by a description of the crop age and type. The area of the damage was measured by pacing the long and the short axis of the damaged patch and multiplying the dimensions to achieve the total area. Where multiple patches of damage occurred the enumerator calculated the area of each patch individually, and then added them together to generate the total. The total size of each field affected by crop damage was measured using the same methodology.

Enumerators recorded the severity of each incident, which assessed how much destruction had occurred within the area of damage. In low severity incidents, the damage was restricted and the majority of the crop within the damage area may have recovered to bear fruit. In high severity incidents, the damage to the crop plants was severe and the potential for recovery was seriously compromised for the entire damage area. Severity was categorised as follows:

- low: <25% of the crop in the damaged area is destroyed;
- medium: 25-50% destroyed; and,
- high: >50% destroyed.

The above measure incorporates a level of subjectivity into its assessment, in that each incident has to be placed in discrete categories, based upon the observations of the enumerator. A number of steps were taken to ensue the variability between enumerators was reduced to a minimum: first, there were only three broad categories; second, the enumerators were all trained together, so the parameters of each category were standardised; third, all enumerators undertook blind testing of the same crop-raiding incidents before duties commenced; and fourth, each enumerator was spot-checked once per month during the peak crop-raiding season.

The identity and group size of the problem animals were determined from spoor. Incidents caused by two species of wild pig, comprising bush pig *Potamochoerus porcus* and warthog *Phacochoerus aethiopicus*, and the two species of small antelope, comprising grey duiker *Sylvicapra grimmia* and steenbock *Raphicerus campestris*, were each combined because the damage they caused could not be reliably differentiated. For a number of dry season crop damage incidents, it was not possible to identify whether elephants or livestock, or a combination of the two, had caused damage, and these were classified as 'elephant and livestock' damage.

7.1.1.2 Definition of crop damage incidents

Crop damage was recorded by individual incident. However, the definition of an incident can vary depending upon whether it is viewed from the animal's or the farmer's perspective. If animal-oriented, then multiple raids on different farms by the same animals in a single night could be considered a single incident. If farmer-oriented, then the same pattern of raids would be considered as separate incidents on each of the farms on which they occur. While biologists generally prefer the former, and social scientists generally prefer the latter, both definitions of an incident are equally valid (Naughton *et al.,* 1999), providing the definitions are consistently applied.

I selected the farmer-oriented approach for this study. Therefore, an incident was defined as each occasion when a large mammal, or group of large mammals, caused damage to the crops of a single farmer. I followed this definition because my research investigates the impacts of elephants upon farmers, and in later chapters I relate these impacts to the farmer's attitudes towards elephants. In addition, many of the crop damage reports were made several days after the incident had occurred, and by this time it was difficult to determine whether the damage was caused by the same individuals, or by a different group of animals.

7.2 Analysis

7.2.1 Crop damage indicators

I analysed crop damage using three main indicators. First, I observed the frequency of incidents. Second, I studied the area of crops damaged in each incident. Third, I examined the severity of the crop damage for each incident.

7.2.1.1 Frequency of crop damage incidents

Frequency of incidents is the most commonly measured index for assessing crop damage, and is easily compared across different studies providing incidents are defined the same way. The limitation lies in the fact that each incident is treated as being of equal importance, and so there are no allowances for the extent of damage of different incidents.

7.2.1.2 Area of crop damage incidents

Measuring the area of crop damage better reflects the extent of damage to crops than measuring the frequency of incidents (Naughton *et al.,* 1999). There are several ways to calculate area. *Total area* describes the sum of all damage for a problem species for the year, and indicates its overall impact within the sociopolitical unit chosen for the study. However, this method does not specify the amount of damage that is caused per incident. Thus, a large total area of damage at one village could result from many small incidents, or a few extensive ones. The *mean area* of damage indicates whether the species mainly causes small or extensive areas of damage. Some problem species are capable of destroying large areas of crops in a single incident. Comparing the *maximum area* of damage will give an indication of the potential for a species to inflict extensive damage to crops in a single incident (e.g. Naughton *et al.,* 1999).

7.2.1.3 Severity of crop damage incidents

The severity of crop damage incidents has rarely been assessed in previous studies. Measuring the severity of an incident provided a further level of information regarding the effect of crop damage upon the crop.

7.2.2 Crop damage analysis

The above indicators were first used to compare crop damage between seasons, and then used to compare the damage between the main problem mammals. The five indicators were then combined to form an overall scoring system for these problem animals. This score was then compared to people's perception ranks of problem animals, as described in Chapter Six. Each analysis is explained in detail below.

7.2.2.1 Crop damage per season

Throughout this thesis, season has been defined in terms of the three climatic periods of the year. However, in the following analysis season has been defined in terms of the two distinct cropping periods of the year. Wet season crops were planted in fields in December and were rain-irrigated. They were harvested between March and June. Dry season crops were planted in gardens in June and were bucket-irrigated, being harvested up until October.

Wet season and dry season crops differed in terms of their growing period, the crop types, the cultivation techniques and the area under cultivation, and for this reason, I considered the damage done to each season's crops separately (Parker & Osborn, 2001). I pooled the results from all eight villages, and compared the frequency, total area, mean area and severity of crop damage between wet season and dry season crops. I then examined which of the mammals caused damage in each season. The Mann-Whitney *U* test was used to compare areas between seasons, because the area of damage values exhibited a strong positive bias, and conditions of normality could not be met.

7.2.2.2 Crop damage per mammal

In order to determine which large mammal was the greatest problem animal, I compared crop damage between each species or species group using five different measures. These were the frequency, total area, mean area, maximum area and the severity of crop damage. Comparisons were made using the Mann-Whitney *U* test and the Kruskal-Wallis test for the same reasons as stated above. Only wet season crop damage was considered in this analysis, as it was considered of greater importance than dry season damage by farmers (see Chapter Six). In addition, major differences in the agricultural patterns between the two seasons precluded any direct comparison between them.

7.2.2.3 Problem animals prioritised

Problem species of large mammals were ranked using all five measures of crop damage. The measures were combined to form a total rank for each mammal. The internal consistency of the overall rank was tested using Cronbach's Alpha (Cronbach, 1951). Cronbach's lies between zero and one, with higher values indicating higher internal consistency.

7.2.3 Perceptions vs. crop damage

The total ranking for problem animals described above was compared to people's perceptions of problem animals. Problem animals had been ranked according to peoples' perceptions in Chapter Six. For perceptions I used both the 'mentioned' and the 'worst' rankings. The perceptions rankings were compared directly to the crop damage rankings in order to explore a) whether the same problem animals were identified; and b) whether they were ranked in the same order. Ranks were compared using the Spearman's Rho correlation test in SPSS ver 12.0.

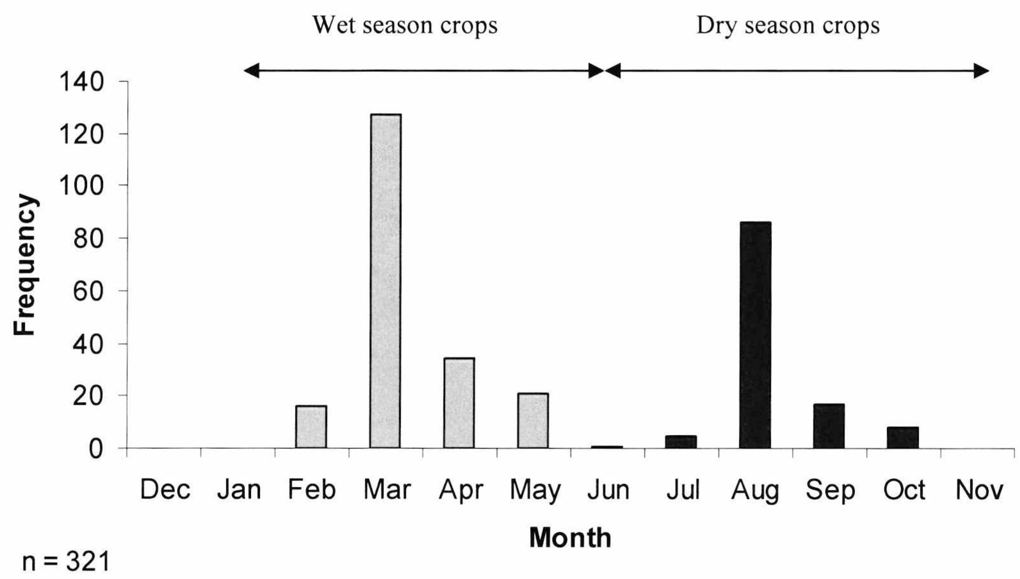
7.3 Results

7.3.1 Crop damage per season

7.3.1.1 Frequency per season

A total of 321 crop damage incidents were caused by large mammals in the eight study villages during the 12-month study period. A total of 207 incidents affected wet season crops, while 114 incidents affected dry season crops. The crop damage occurred in two distinct peaks. Wet season crop incidents mainly occurred between February and May, while dry season crop incidents mainly occurred between July and October (Figure 7.1).

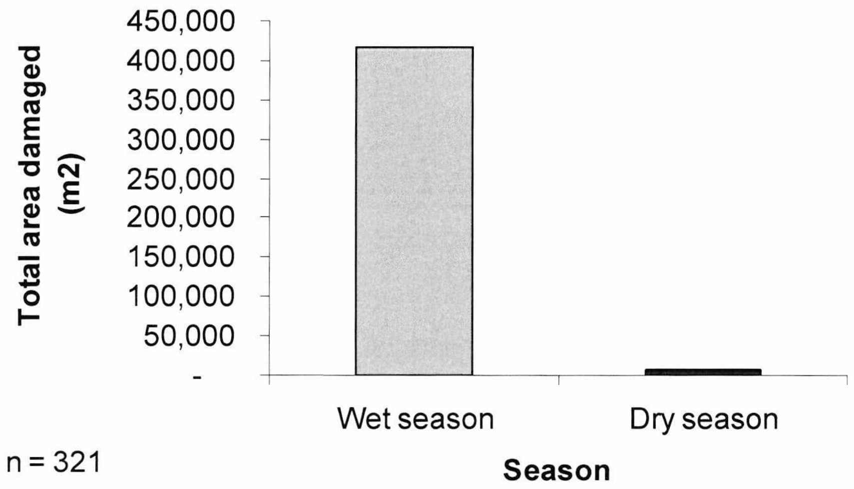
Figure 7.1: Frequency of crop-raiding incidents by all large mammals per month across eight study villages in 2003.



7.3.1.2 Area per season

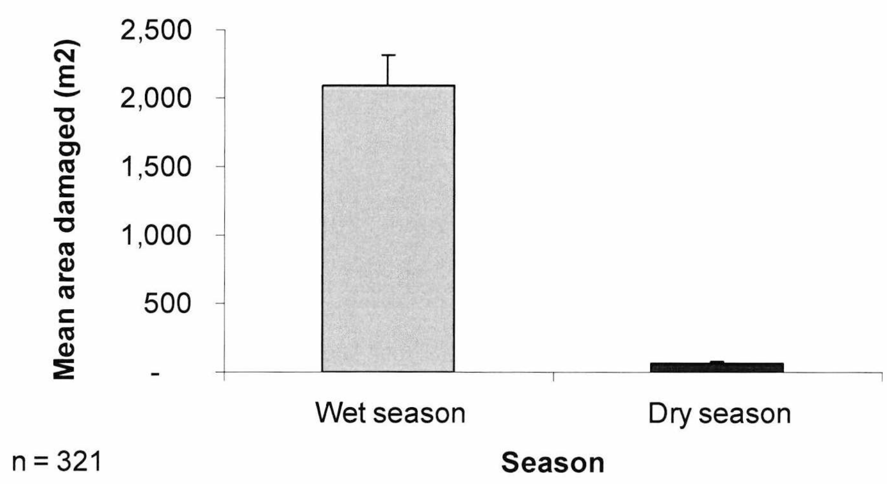
Large mammals caused more extensive damage to wet season crops than to dry season crops within the eight study villages. They caused damage to a total area of 415,354m^2 of wet season crops, compared with an area of just 7,872m^2 of dry season crops (Figure 7.2). The area of damage data set was highly skewed, with many small values and few large values (skewness = 4.29; SE = 0.17), indicating a departure from the normal distribution.

Figure 7.2: Total area of crop damage by large mammals in each season across eight study villages during 2003.



The mean area of damage in the wet season was 2,087m^2 per incident, and this was much larger ($z = -11.13$; $p = <0.001$; Mann-Whitney U test) than the mean of 68m^2 per incident for the dry season (Figure 7.3).

Figure 7.3: Mean ±SE area of crop damage by all large mammals across eight study villages during 2003.



The disparity in the mean area damaged per season reflects the size of the fields in each season. Fields that were damaged in the wet season were far larger (mean area 15,670m^2) than those damaged in the dry season (mean area 227m^2) (z = -14.39; p = <0.01; Mann-Whitney *U* test) (Table 7.1).

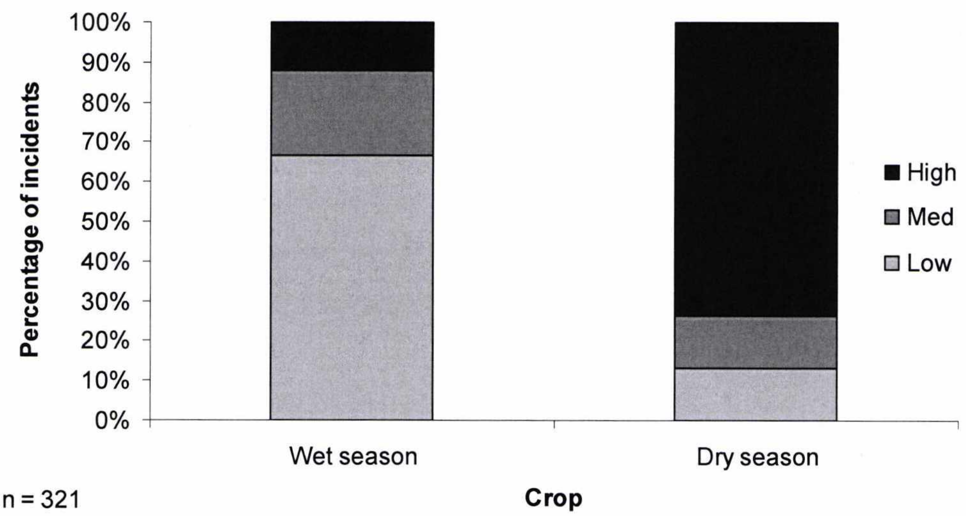
Table 7.1: Mean ±SE field size and damage area for wet season and dry season crops across eight study villages in 2003.

	Wet season	Dry season
Mean ±SE field size (m^2)	15,670 ±1,294	227 ±77
Mean ±SE damage area (m^2)	2,087 ±233	68 ±8

7.3.1.3 Severity

Crop damage was of greater severity in the dry than the wet season (χ^2=134; df=2; p=<0.01). A total of 73% incidents fell into the high severity category in the dry season, compared with only 12% of incidents in the wet season, when most (66%) incidents fell into the low severity category (Figure 7.4).

Figure 7.4: Severity of crop damage incidents by large mammals by seasons across eight study villages in 2003.

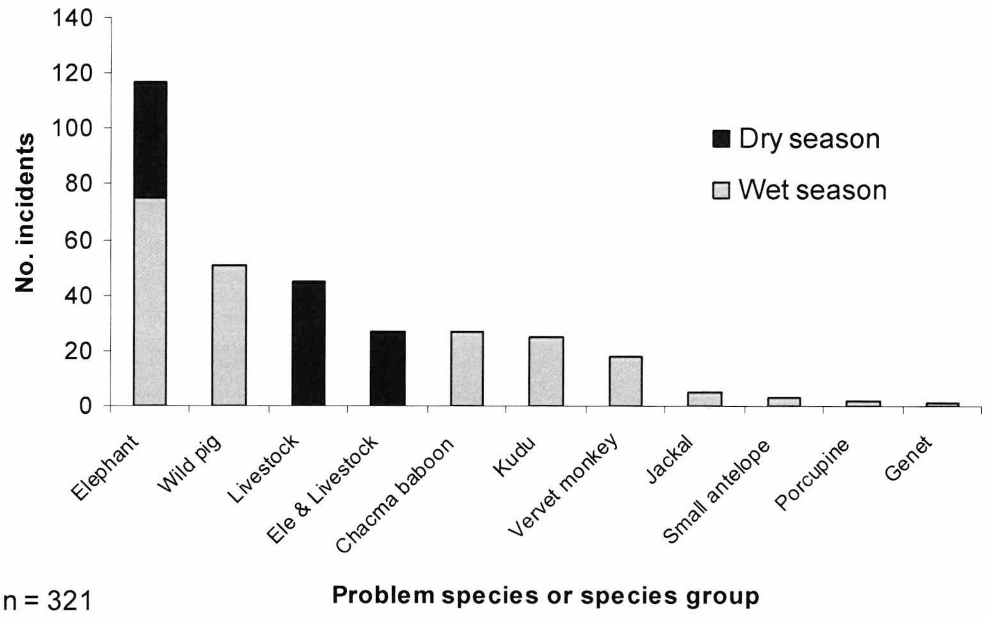


7.3.2 Problem animals per season

The 321 incidents of crop damage were caused by 10 species, or species groups, of large mammal (Figure 7.5). There is a clear distinction between the species and species groups responsible for wet season crop damage and those responsible for dry season damage. Elephants (*Loxodonta africana*) were the only mammals that raided crops in both seasons. Wild pigs, Chacma baboons (*Papio cynocephalus*), greater kudus (*Trangelaphus strepsiceros*), vervet monkeys (*Cercopithecus aethiops*), black-backed jackals (*Canis mesomelas*), small antelopes, porcupines (*Hystrix cristata*) and common genets (*Genetta genetta*) raided wet season crops exclusively. Livestock, comprising cattle, sheep and goats combined, only damaged dry season crops.

Elephants were responsible for 117 crop damage incidents, and caused over twice as many incidents as wild pigs (51), which were the second most frequent species group of crop raiders. Livestock were responsible for 45 incidents. The role of elephants and livestock in causing crop damage could not be differentiated in 27 incidents. Chacma baboons, greater kudu and vervet monkeys were responsible for 27, 25 and 18 incidents, respectively. Jackals, small antelope, porcupine, and common genet were responsible for five, three, two and one incidents, respectively.

Figure 7.5: Frequency of crop damage incidents by species or species group, and season across eight study villages in 2003.



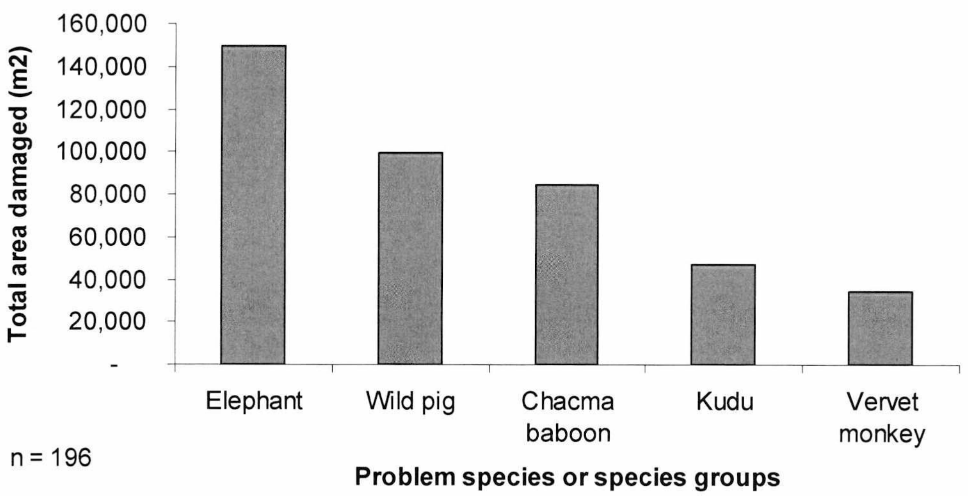
7.3.3 Crop damage per problem animal

In the following analysis, the five major wet season problem animals were compared. Jackals, small antelopes, porcupines and genets were omitted from further analysis because their sample sizes were too small to be meaningful.

7.3.3.1 Area of crop damage per animal

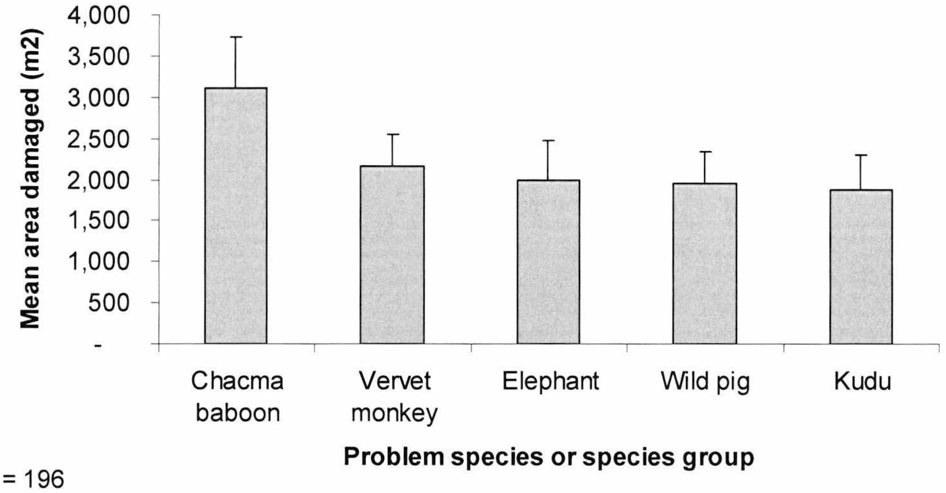
Elephants caused the most damage to wet season crops, damaging a total area of 149,898m^2, which was more than 1.5 times the extent of damage by the next problem species group. Wild pigs, baboons, kudus and monkeys damaged total areas of 99,346m^2, 84,259m^2, 47,062m^2 and 34,494m^2, respectively (Figure 7.6).

Figure 7.6: Total area of wet season crop damage by large mammals across eight study villages in 2003.



Baboons caused more than 3,000m^2 of damage per wet season raid, a much larger mean area of damage than that caused by other problem animals (χ^2 = 15.37; P = <0.01; Kruskal-Wallis test). However, there was a surprising similarity in the mean area damaged by the remaining four crop-raiding species or species groups. Monkeys, elephants, wild pigs and kudus each caused between 2,156 and 1,882 m^2 of damage per raid to wet season crops (Figure 7.7).

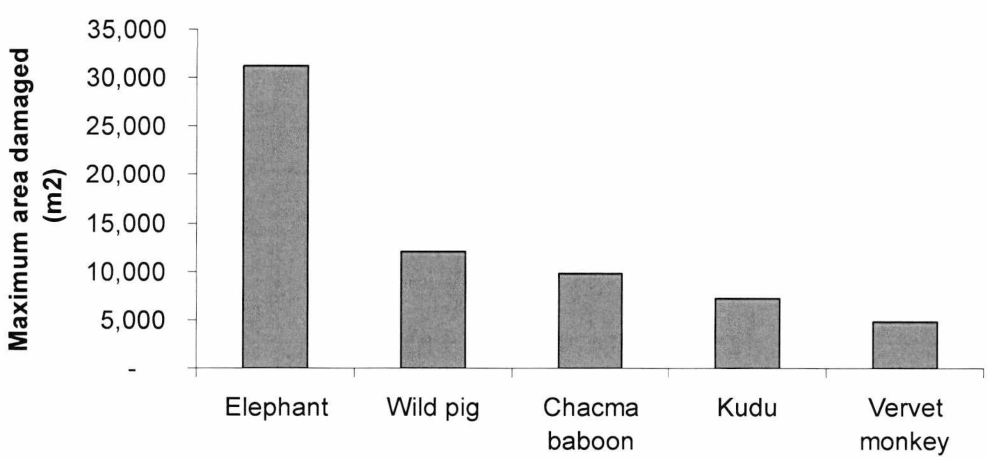
Figure 7.7: Mean ±SE area of wet season crop damage by large mammals across eight study villages in 2003.



n = 196

The maximum areas damaged by each species or species in one crop-raiding incident were largest for elephants, which destroyed 31,160m^2 in a single incident. This was nearly three times larger than the maximum area of 12,000m^2 destroyed by wild pigs. For chacma baboons, kudu and vervet monkeys, the maximum areas of wet season crops destroyed in a single incident were 9,800m^2, 7,280 m^2, and 4,900 m^2, respectively (Figure 7.8).

Figure 7.8: Maximum area of wet season crop damage by large mammals across eight study villages in 2003.

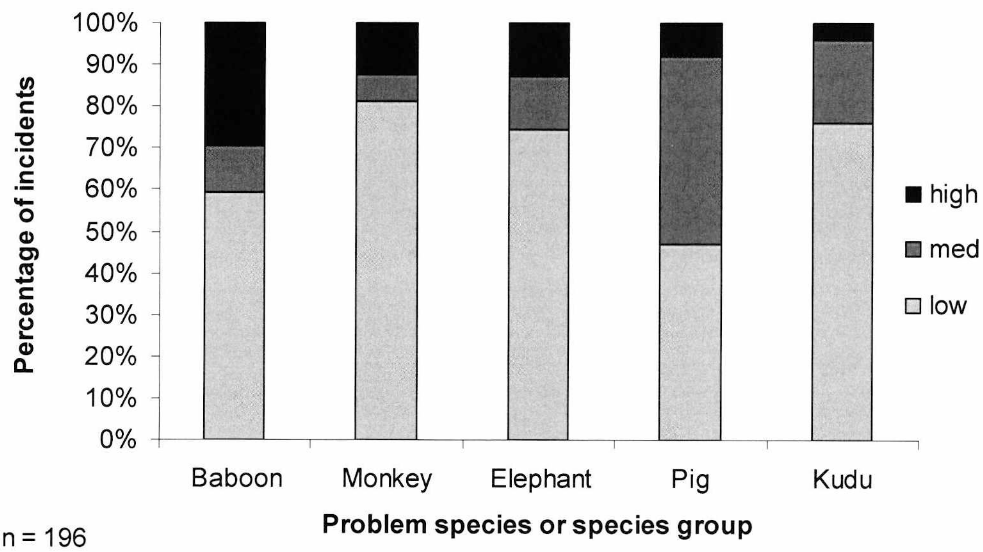


n = 196

7.3.3.2 Severity of crop damage per animal

The level of severity of the damage caused by each crop-raiding mammal exhibited large differences (χ^2 =145.15; P=<0.001). One third of baboon crop-raiding incidents in the wet season were ranked as being of high severity, compared with many fewer vervet monkey (13%) and elephant (12%) crop-raiding incidents (Figure 7.9). For wild pigs, only 8% of incidents were high severity, but nearly half the wild pig crop-raiding incidents (45%) were ranked as being of medium severity. With kudu, 4% of incidents were ranked as being of high severity

Figure 7.9: Severity of damage to wet season crops by large mammals across eight study villages in 2003.



7.3.4 Problem animals compared

The five most important crop-raiding mammals could be broadly grouped into two categories according to the nature of the damage they caused. First, elephants and wild pigs were the most frequent crop-raiders, and caused the greatest total area of crop damage throughout the wet season (Table 7.2). In addition, both these mammals were able to destroy the most extensive area of crops in a single incident. Second, baboons and monkeys were less frequent crop-raiders, but consistently raided the largest area of crops per incident, and the damage they caused was of high severity. Kudus displayed a pattern of damage that was more consistent with the first group, but as the lowest ranking animal, the pattern they displayed was not so distinctive.

All five measures of crop damage were used to determine which species or species groups cause the most serious damage to wet season crops. Each species or species group was ranked according to the frequency, total area, mean area, maximum area and severity of crop damage it caused, and a total rank was calculated from the sum of these measures. A rank of one signified the greatest impact and a rank of five indicated the least impact.

There was perfect agreement between frequency, maximum area and total area measures, but the order was somewhat different for the mean area and for the severity of damage, which agreed with each other perfectly (Table 7.2). As a result, the total rank displayed a high level of internal consistency (Cronbach's Alpha = 0.83), which represents a powerful result when compared to other research (c.f. Walpole & Goodwin, 2001). Based on this analysis, elephants were the most important problem species, followed in order by baboons, wild pigs, monkeys and kudus.

Table 7.2: Problem animal ranking for wet season crop damage across eight study villages in 2003.

Crop damage measure	Elephant	Baboon	Wild pig	Monkey	Kudu
Frequency	1	3	2	5	4
Total area	1	3	2	5	4
Mean area	3	1	4	2	5
Maximum area	1	3	2	5	4
Severity	3	1	4	2	5
Total	**9**	**11**	**14**	**19**	**22**
Rank	**1**	**2**	**3**	**4**	**5**

7.3.5 Perceptions vs. crop damage

Local perceptions of problem species were compared to the crop damage they actually caused. The same five species of elephants, wild pigs, baboons, kudus and monkeys dominated both the perceptions and the crop damage rankings. However, there was no correlation between the rank order of problem species according to the total crop damage rank, and the rank order according to either the 'mentioned' (r_s=0.7; p=0.19; Spearman's Rho test), or the 'worst' (r_s=0.87; p=0.054; Spearman's Rho test) perceptions rankings (Table 7.3).

The rank of 'worst' problem animals was compared to each individual crop damage measure. Three measures of crop damage - frequency, total area and maximum area of crop damage - returned the same ranking sequence, and are represented as 'frequency' in Table 7.3 below. The 'worst' perceptions ranking correlated strongly with these three crop damage measures (r_s=0.98; p=<0.01; Spearman's Rho test). However, there was no agreement between the 'worst' ranking and either the ranking according to the mean area of damage, or according to the severity of damage caused.

Table 7.3: Comparing perceptions of problem animals to actual crop damage.

	Perceptions ranks		Crop damage ranks		
Problem animal	**No. of times mentioned**	**No. of times worst**	**Total crop damage**	**Frequency of incidents**	**Mean area damaged**
Elephant	1	1	1	1	3
Wild pig	5	2	3	2	4
Baboon	2	3	2	3	1
Kudu	3	4	5	4	5
Monkey	3	4	4	5	2

7.4 Discussion

In this chapter I have established that five major problem species cause the greatest overall damage to wet season crops. Elephants were the greatest problem animal overall. These results agree strongly with the perceptions of local farmers, whose perceptions of the five worst animals reflected the most frequent and the most extensive crop-raiders. Wet season crop damage was far more extensive than dry season damage, largely due to the different cultivation practices in each season.

7.4.1 Problem animals

Elephants were the most serious problem animal, as calculated using five different measures of crop damage. The four next-most significant mammalian crop raiders were wild pigs, baboons, monkeys and kudus. These five animals have dominated the list of problem animals in many countries across Africa (e.g. Hill, 1997; Naughton-Treves, 1998).

The worst problem animals can be separated into two categories based upon the nature of the damage they cause. The similarity of crop-raiding patterns between elephants and bush pigs, and baboons and monkeys, may be explained as follows. First, the fact that elephants and wild pigs were the most frequent crop-raiders may have reflected their ubiquity across the study area. Unfortunately there are no figures to support this finding, as neither wild pigs, nor baboons or monkeys, have been censused within the study area. Both elephants and bush pigs were responsible for the largest area of damage in a single incident. As nocturnal creatures they would be able on occasion to damage extensive areas of crops without being disturbed. In addition, as large bodied animals that forage in groups, they have the ability to cause extensive damage in a short space of time. This characteristics doubtlessly led to their destruction of the largest area of crops overall.

Baboons and monkeys did not raid crops with the same frequency as did elephants or bush pigs. As smaller bodied daytime raiders, they also did not have the same capacity to inflict the same maximum area of damage to a field in a single incident, because crop-raiding forays during the day are more likely to be detected than those during the night. However, baboons and monkeys consistently caused damage to crops that was both extensive and severe. Such an ability is probably the result of cooperative behaviour between group members, who operate to rapidly consume as much of the crop as possible before being detected.

7.4.2 Elephants

As the largest of all crop-raiding animals, elephants have the potential to cause extensive damage to crops. Elephants damaged a total area of crops that was two and a half times greater than the next problem animal. This scenario has been noted elsewhere: around Kibale National Park elephants caused 77% of all crop damage by wildlife (Naughton *et al.,* 1999).

Elephants have the greatest propensity for calamitous damage, and can destroy the largest area of crops in a single incident, a finding in close agreement with those of Naughton-Treves (1998). The elephant's large body size and its tendency to move in groups enable it to cause extensive damage in a very short space of time. In Uganda, elephant crop damage was characterised by rare and extreme events which were consistently larger and less frequent than damage by other animals (Naughton-Treves, 1998). Elephants destroyed a mean of 60% area of the fields they entered in communities around BMWS, Cameroon (Naughton *et al.,* 1999). Their ability to cause catastrophic loss of crops has made them the number one problem animal elsewhere (Naughton-Treves, 1997).

In addition, elephants frequently caused small areas of damage, as evidenced by their small mean size of damage, and the fact that they were the most frequent crop-raiding animal. This pattern of damage is not consistent with results from other areas, but suggests that in the mid-Zambezi Valley, elephants may make regular forays in small groups. In addition, such small, frequent areas of damage may be due to damage caused by elephants passing through the fields without actually feeding. Unfortunately it was not possible to distinguish trampling and feeding incidents to a degree where meaningful analysis could be conducted.

7.4.3 Wild pigs

Wild pigs, like elephants, were frequent crop-raiders that caused extensive overall damage to crops. Pigs were the second most frequent crop-raider across the study area. They also created the second largest total area of damage, indicating that they were a common crop-raider with high overall impact. Like elephants, they had the ability to cause calamitous events, destroying the second largest area of crops in a single incident. Nonetheless such incidents were rare and the amount of damage they caused per incident was usually low.

7.4.4 Baboons

Baboons consistently caused both the largest mean area of damage and the greatest severity of crop damage. The high severity and large mean area of damage reflected the baboon's cooperative behaviour: they are considered to be cunning crop-raiders which work as a team to distract a farmer (Hill, 1997).

Baboons were infrequent raiders but they consistently destroyed a greater mean area of crops per incident than any other animal, including elephants. This pattern departs from that found around Kibale National Park, where baboons were frequent pests that damaged small areas of crops (Naughton-Treves, 1998). Primate losses were tolerated as low and constant as compared to catastrophic and sporadic, even though they could account for the greater area of crops overall (Naughton *et al.,* 1999). This difference may reflect the group size of baboons, which may be higher in the savannas than in the forest.

7.4.5 Monkeys

Monkeys were low frequency raiders that caused a low total area of damage. They did not have the propensity to cause calamitous events as wild pigs and elephants did. Monkeys were like baboons in that they caused large areas of damage in each incident. The damage they caused tended to be high severity, probably due to their large group size and their cooperative behaviour.

7.4.6 Kudus

Kudus were low frequency raiders that caused the smallest total area of damage. They did not have the propensity to cause calamitous events as the other problem animals did. The damage caused per incident tended to be small and low severity. Consequently they caused the lowest damage of all the worst five problem animals.

7.4.7 Perceptions vs. crop damage

People's perceptions of problem animal agreed closely with the crop damage evidence. The top five problem animals identified by farmers also caused the greatest damage to crops. However, the level of agreement between perceptions and actual crop damage was dependent upon the measures used.

The prioritisation of the 'worst' problem animals by farmers closely agreed with the frequency, the total area and the maximum area of damage caused by problem animals. Each of these measures agreed with each other perfectly, so it was difficult to identify which held the greatest importance. However, farmers known to be sensitive to extreme crop damage events (Naughton-Treves, 1997), whereas they may ignore damage by smaller or more frequent animals. Such a fear of calamitous events suggests that it is the maximum area of damage that is most important. Equally, the frequency of events may also affect farmer's perceptions, as those large animals that habitually raid crops would be constantly upon the farmer's mind. It is possible that a farmer will incorporate all three measures into his assessment of crop-raiding animals.

Identifying the most common problem animals was less accurate than identifying the worst: besides ranking elephants first, there was little consensus between perceptions and actual crop damage. This is most likely because farmers mentioned a wider range of animals, which included animals that had not caused damage to their crops in the current year. There was evidence for this at the village level: in Chikafa village kudus were identified by farmers as crop-raiders even though no damage was recorded for them during 2003. In addition, the lack of consensus between 'mentioned' scores and crop damage may reflect the closeness of the scores for perceptions ranking of baboons, kudus, monkeys and bush pigs, which may have been too close for any meaningful analysis of the difference (see Chapter Six).

7.4.8 Seasonality

Crop-raiding in the Mid-Zambezi Valley exhibited distinct seasonal peaks of activity, which have been noted elsewhere across the continent (e.g. Kangwana, 1995; Tchamba, 1995). This crop raiding activity corresponded to the main growing periods of wet season and dry season crops. There was little crop raiding activity in June, when the field crops had been completely harvested and the vegetable gardens had yet to be planted. In October, there were very few incidents, this being a time of year when the maximum temperature regularly exceeds 35°C, which is too hot for crop cultivation (Espere, 2004).

Dual season peaks of activity have been documented in Parker & Osborn's (2001) analysis of crop damage in the Eastern Zambezi Valley; and have also been observed in India (Williams *et al.,* 2001). The first peak of crop-raiding activity coincided with the maturing of field crops at the end of the wet season. The second peak corresponded to the maturing of irrigated vegetables cultivated along the banks of the major rivers.

The majority of crop damage incidents in both seasons affected mature crops. Wild animals target mature crops because they are at their most nutritious stage (Bell, 1984), in fitting with the optimal forage theory to maximise the rate of nutrient intake (Stephens & Krebs, 1986). The availability of such highly nutritious plants in cultivated areas is a major factor in explaining why elephants leave the safety of forest areas to raid crops (Sukumar, 1989; Santiapillai & Widodo, 1993).

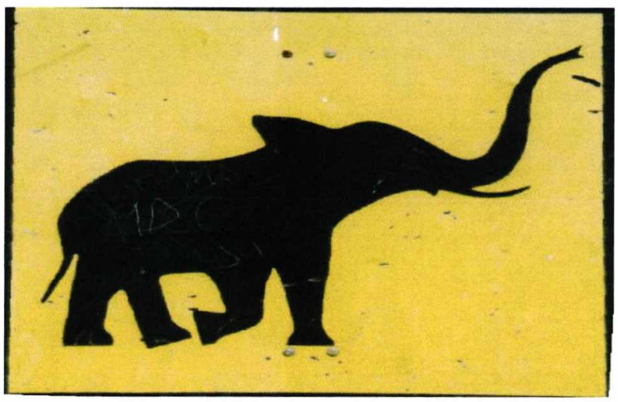
Crop damage may be triggered by changes in the nutritive quality of natural forage. In semi-arid areas with one rainy season, a fall in the nutritional value of natural forage may trigger the search for more nutritious food, leading to crop-raiding activities (Osborn, 1998). This may be exacerbated in the late dry season, when the forage quality is poor, and diet may be limited to a small number of browse species (Jarman, 1977; Coetze *et al.,* 1979). Dry season crops represent a nutritious source of food at a time of year when natural forage is scarce. Dry season damage to vegetable gardens by elephants and livestock may be exacerbated by the proximity of gardens to water sources and fruiting trees, as both resources are in high demand during the hot dry season.

The predominant differences in the area and severity of crop damage between the wet and dry season crops reflected the different cultivation practices. The total area of damage to wet season crops was over fifty times greater than for dry season crops, because wet season crops are grown in large fields, and dry season crops are grown in small gardens. Equally, the severity of crop damage was greater in the dry season, as the small size of the plots enabled crop-raiders to inflict proportionately greater damage.

Dry season crop damage was dominated by elephant and livestock damage. Elephants frequently damaged dry season gardens in conjunction with drinking from wells in the beds of the major rivers (see Chapter Five). Livestock were only a problem in the dry season because at this time of year they were left to roam freely during the day. In the wet season livestock were tended by herders to ensure they did not damage field crops. Dry season crops were only damaged by large mammals that could break through the fencing. Usually gardens were barricaded with thorn fences which smaller animals were unable to penetrate. For those incidents in which livestock and elephants were both involved it was the elephants that invariably broke into the gardens at night, which then allowed the cattle access (*Personal Observation*). Livestock have been identified as major crop-raiders elsewhere. Around Kibale National Park livestock damage was comparable to, and exceeded wildlife damage, but was less complained about because local means of remuneration existed (Naughton-Treves, 1998).

In this chapter I have identified the five greatest problem animals, based on quantification of the total crop damage they have caused. People's perceptions of the worst problem animals agreed closely with the crop damage data, indicating that perceptions are based upon extreme damage events. Elephants were identified as the greatest problem species overall. In the next chapter I shall explore elephant crop damage in detail in order to determine patterns of damage and to determine the impacts of elephant conflicts at the individual village level.

Chapter 8 Human-Elephant Conflict



8.0 Introduction

Human-Elephant Conflict (HEC) occurs wherever people and elephants coincide (Lahm, 1994; Barnes, 1996; Hoare, 1999), and poses a serious challenge to wildlife managers, local communities and elephants alike. HEC creates animosity towards elephants (de Boer & Baquete, 1998; Gillingham & Lee, 1999; Naughton *et al.,* 1999) and has lead to the retaliatory killing of elephants in Cameroon and Ghana (Naughton *et al.,* 1999; Parker, 2004). Conflict casts an ominous shadow over the future of elephant conservation outside protected areas (Naughton *et al,*. 1999), and poses important livelihood problems for African farmers who are poor.

Crop damage is perhaps the most prevalent form of conflict by elephants (Nyhus *et al.,* 2000; Sitati *et al.,* 2003), occurring throughout the African continent (Naughton *et al.,* 1999). In Kenya and Zimbabwe elephant crop damage accounted for 75-90% of all conflict incidents by large mammal pest species annually (Hoare & Mackie, 1993). Elephant crop raiding activity is highly variable in space and time. Spatially the distribution of incidents is described as 'patchy' and highly localised (Naughton *et al.,* 1999), but such patterns can still result in catastrophic losses to the farmer (Naughton-Treves, 1997). Crop-raiding is an almost exclusively nocturnal activity (Bell, 1984; Thouless, 1994; Sitati *et al.,* 2003). In the savanna seasonal patterns of crop-raiding activity coincide with the maturing of crops (Hoare, 2000; Parker & Osborn, 2001).

Elephants feed preferentially upon food crops from the family *Gramminea* (Oliver, 1978). Maize is highly vulnerable, being ranked the number one target crop for elephants across some sixteen sites in Africa (Naughton *et al.,* 1999). However, elephants have evolved as catholic feeders (Sukumar, 2003) and are therefore attracted to a variety of crops. In Cameroon, elephants primarily raided maize and millet, but also damaged cotton, ground nuts and yams (Weladji & Tchamba, 1999). Around Kibale National Park, Uganda, elephants expressed a preference for bananas and sweet potatoes (Naughton-Treves, 1997).

In addition to damaging crops, elephants also present a threat to human life. Although less common than crop damage, human death by elephants is the most severe manifestation of HEC and is considered to be 'intolerable' by rural communities living alongside elephants (Naughton *et al.*, 1999). People may be killed while defending their crops and property, or while going about their daily business. In Kenya, people were most likely to be killed by elephants when walking near roads at night (Sitati *et al.*, 2003). The potential for elephants to injure or kill people raises their profile and means they are less tolerated by rural communities (Naughton *et al.*, 1999; Hoare, 2001).

Previous research into elephant crop damage in the mid-Zambezi Valley has focused upon the seasonal and spatial patterns that occur (Parker & Osborn, 2001), but has not investigated the specific impacts of elephants upon crops. In addition, there has to date been no published quantification of incidents of human injury and death within the study area. In Chapter Six farmers across the study area identified wet season crop damage and human death as the worst forms of elephant conflict. Therefore, in this chapter I will investigate elephant conflict in detail in order to:

- define the temporal patterns of elephant crop damage across the study area;
- identify the crops most vulnerable to elephant damage;
- perform a comparative analysis of crop damage within each study village; and,
- quantify human death and injury for each village across the study area.

8.1 Methods

8.1.1 Crop damage

8.1.1.1 Crop type

The elephant crop damage incidents presented in this chapter are derived from the crop damage assessment scheme described in Chapter Seven. Data from 10 study villages have been considered in this analysis. Whereas in the previous chapter data for wildlife crop damage were only available in eight villages, for elephant crop damage the data were available for all ten study villages.

Crop damage was assessed according to the type and the age of the crops damaged by elephants. Crop type was recorded as the common English name, agreed at the outset of this research. Tomatoes (*Lycoposicon esculentum*) and rape (*Brassica campestris*) were combined because they were not always differentiated between the crop damage reports, as a result of their close association in small river gardens. Crop age was categorised into three classes based upon the life stage of the plant:

- seedling - denoting crops in their early growth phase, with shoots less than 10cm in height;
- intermediate - where the crop is in its main growth phase, with shoots more than 10cm in height; and,
- mature - where the crop is producing fruiting bodies (melons and tomatoes), cobs (maize), seeding heads (sorghum and millet), or tubers (sweet potatoes).

8.1.1.2 Problem elephant profile

Elephant group size was determined from spoor evidence in the fields. Each enumerator was trained to identify and count spoor, using evidence at the entry and exit points of the fields to gain the most accurate assessment. Additional evidence was collected from any farmers who may have witnessed the incident. It was difficult to determine the age or the sex of elephants, even on the rare occasions they were observed directly, because of the great variation in the size of males and females. With spoor, only the very largest and the very smallest footprints allowed classification: the largest belonging to large bulls, and the smallest belonging to calves that would almost certainly be a part of a breeding herd.

8.1.2 Human death and injury

Information on human death and injury was obtained from the Wildlife Offices of each Ward. I interviewed each councillor at their Ward offices in the presence of the Wildlife Committee. I requested specific details as to the location, timing and circumstances of all incidents of human death and injury caused by elephants between 1996 and 2002. This information was later verified through Semi-Structured Interviews (SSI) and focus group discussions in each of the study villages.

8.2 Analysis

8.2.1 Crop damage

8.2.1.1 Crop type

In order to compare crop damage between crop types I used the frequency and total area of damage measures described fully in Chapter Seven. I then investigated the relationship between crop damage and the age of the crop using the same two measures.

8.2.2 Problem elephant profile

I determined the group size of those animals involved in wet season crop damage. I examined the effect of the group size of elephants upon the amount of damage caused to crops using all five measures of crop damage detailed in Chapter Seven. These were: the frequency, the total, the mean and the maximum area, and the severity of crop damage. Only wet season incidents were considered in this analysis because major differences in the nature of the crop damage between the wet and dry seasons prevented the two data sets from being combined.

8.2.3 Crop damage per village

I then compared crop raiding among individual villages using the five measures of frequency, total area, mean area, maximum area and severity of damage per incident. I included only wet season crop damage incidents in this analysis because wet season crop damage was considered a far greater problem than dry season damage by farmers across the study area (see Chapter Six). In addition, the wet season and dry season data could not be combined for the reasons stated above.

8.2.3.1 Total rank of crop damage per village

I combined the five measures of crop damage to yield a total rank of elephant crop damage per village. Each village was ranked according to each measure in turn, with a rank of one indicating the greatest damage, and a rank of ten indicating the least. The ranks were then summed to create a total rank for each village. This total rank will be drawn upon in Chapter Ten as part of an investigation into the factors affecting farmer's attitudes towards elephants.

8.2.4 Cultivated area and crop damage

I then explored the relationship between the total area of crops damaged and the total area of land under cultivation in each village. It was not possible to measure the exact crop area of each village, due to the extensive and fragmented spatial arrangement of the crops. Instead, I estimated the total area of cultivation for each village using the mean area of cultivation per household, and census information from the National Census conducted in 2002. I calculated mean field size per household from a randomised sample of 64 householders from five villages across the study area, and accessed census information from the Central Statistics Department in Bindura (GOZ, 2002[9]). I tested the relationship between the area under cultivation and the total area of crops damaged using the Spearman's Rho correlation test.

8.2.5 Elephant group size and crop damage

I then investigated the relationship the mean elephant group size and the total area of crop damage within each village. I log-transformed the variables to increase linearity, and excluded villages in which no crop damage had occurred. I tested the relationship between the elephant group size and the total area of crops damaged using the Spearman's Rho correlation test.

8.2.6 Human injury and death

I compared the incidence of human injury and death by elephants between the study villages. I ranked each village in terms of the number of incidents that had

9 Government of Zimbabwe National Census 2002.

occurred between 1996 and 2002. This information will also be drawn upon in Chapter Ten, when investigating farmer's attitudes towards elephants.

8.3 Results

8.3.1 Crop damage

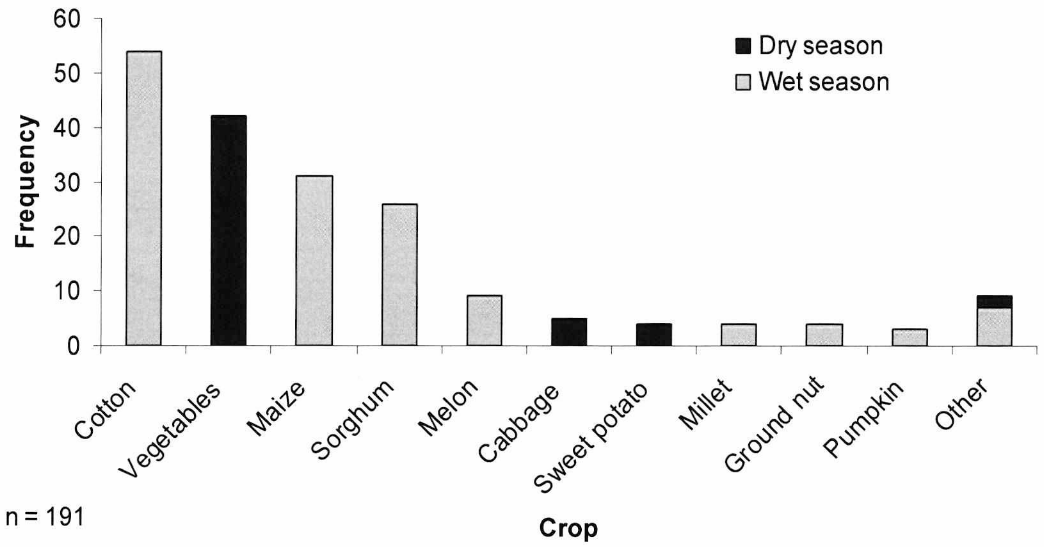
8.3.1.1 Crop type

A total of 191 elephant crop-raiding incidents were recorded in ten study villages. One hundred and thirty eight incidents (72%) affected wet season crops and 53 incidents (28%) affected dry season crops.

Ten different crop types were raided by elephants. Elephants most commonly raided cotton (*Gossypium hirsutum*), which accounted for 54 incidents of wet season crop damage. Vegetables (tomatoes and rape) were the next most raided, involving 42 incidents of dry season crop damage. Maize (*Zea mays*) and sorghum (*Sorghum vulgare*) followed with 31 and 26 incidents of wet season crop damage, respectively. For water melons (*Citrullis lanatus*) there were nine incidents, and for cabbages (*Brassica oleracea*) there were five incidents. For sweet potatoes (*Ipomoea batatas*), millet (*Eleusine coracana*) and ground nuts (*Arachis hypogaea*) there were four incidents each, and for pumpkins (*Curcubita maxima*) there were three incidents. Other crops, including beans (*Phaseolus vulgaris*), cucumbers (*Echinocystis lobata*), okra (*Abelmoschus esculentus*), cassava (*Manihot esculenta*), chilli (*Capsicum fruitescens*), onions (*Allium spp.*) and green maize (*Zea mays*) contributed to the seven incidents categorised as 'other' (Figure 8.1).

Seventy two percent of all the incidents affected food crops, whereas 28% of incidents affected cotton, which is grown as a cash crop. Sixty one percent of all incidents affected crops of the family *Gramminea*, which included maize, sorghum and millet.

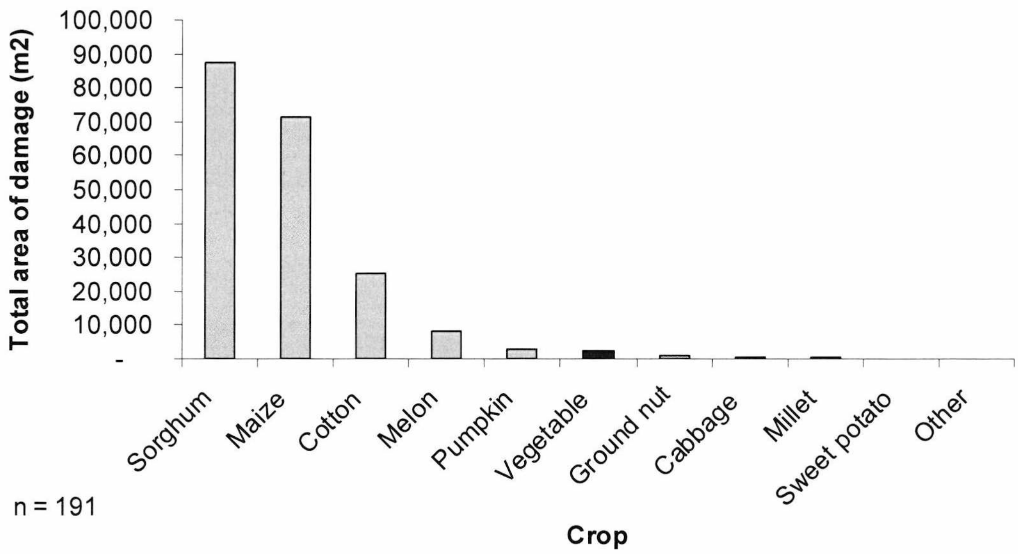
Figure 8.1: Frequency of elephant crop-raiding incidents per crop across ten study villages in 2003.



In terms of total area of damage, 99% of crop damage occurred to wet season crops, and just 1% affected dry season crops. The order of crops affected changed considerably when considering area of damage as opposed to number of incidents. The greatest total area of elephant crop damage occurred to sorghum (87,171m^2) (Figure 8.2). The next most damaged crop was maize, of which 71,415m^2 was damaged in total. Cotton came next with 25,313m^2 of damage. Much smaller total areas of melons (8,439m^2), pumpkins (3000m^2), dry season vegetables (2,481m^2), ground nuts (1,004m^2), cabbage (712m^2), millet (430m^2), sweet potatoes (42m^2) and other crops (24m^2) were damaged.

Food crops accounted for 87% of the total area of damage, while the cash crop cotton accounted for 13% of the total damaged area. Nearly 80% of the total area of crop damage affected crops from the family *Gramminea.*

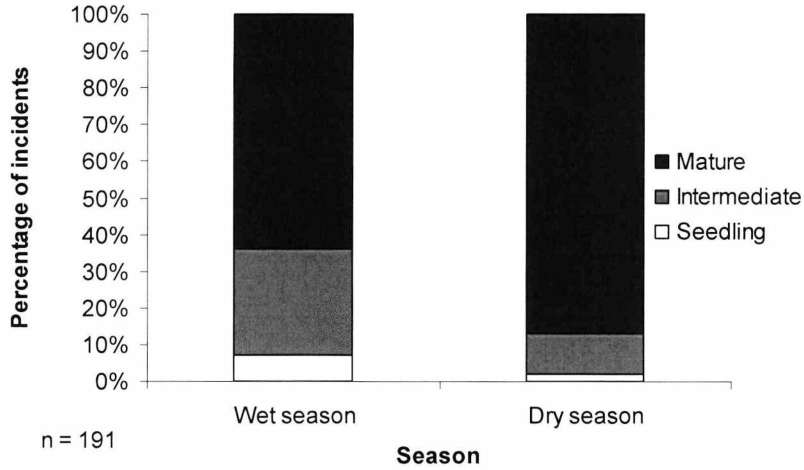
Figure 8.2: Total area of elephant crop damage to each crop type across ten study villages in 2003.



8.3.1.2 Maturity of crops

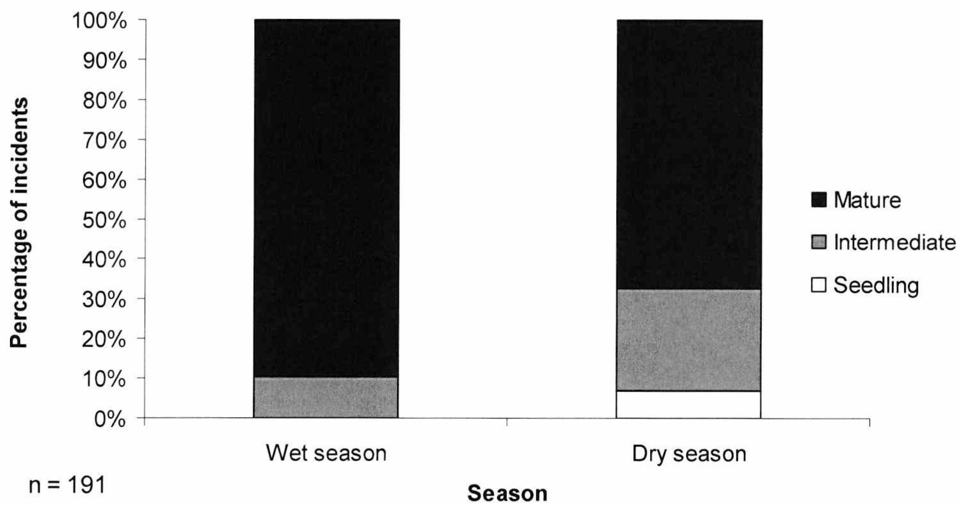
Most crop damage incidents affected crops at the mature stage. A total of 64% of wet season crops damaged were mature, 29% of incidents involved intermediate crops in their growing phase, and only 7% of incidents affected crops at the seedling phase (Figure 8.3). With dry season crops, the pattern was even more defined: 87% of incidents involved mature crops; 11% affected intermediate crops; and just 2% involved crops at the seedling stage. The frequency of high severity damage was greater for dry season than for wet season crops (χ^2=9.76; p=<0.01; Chi Square test).

Figure 8.3: Frequency of crop damage for each age class of wet and dry season crops damaged by elephants in 2003.



In terms of the total area of damage to each age class, 90% of wet season crops damaged by elephants were mature crops, and 10% were crops at the intermediate stage. Only 0.1% of damage occurred to seedlings. For dry season crops a similar pattern prevailed: 68% of the total damage area affected mature crops, 26% occurred to intermediate crops and just 7% affected seedlings (Figure 8.4).

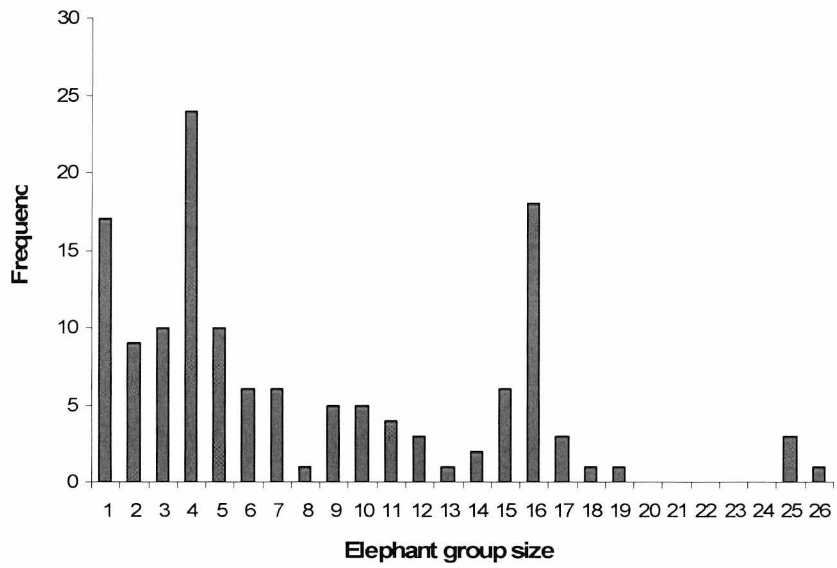
Figure 8.4: Total area of crop damage for each age class, for all wet and dry season crops damaged by elephants in 2003.



8.3.2 Problem elephant profile

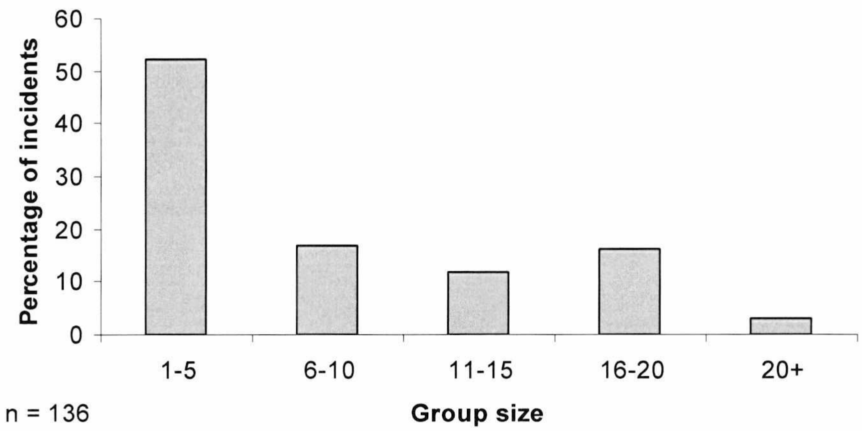
The group sizes of elephants that raided wet season crops ranged from one to 26. However, the distribution of group sizes was heavily skewed towards smaller groups, with a median group size of four elephants (Figure 8.5). Examination of this pattern of distribution suggested that elephant group size should be partitioned into five equal-sized categories of 1-5, 6-10, 11-15, 16-20 and a final category of 20+.

Figure 8.5: Frequency of crop-raiding elephants and group size for wet season crop damage in 2003.



Nearly one half of all crop-raiding incidents (52%) were perpetrated by elephants in groups of 1-5. Elephants in groups of 6-10 caused 17% of incidents; those in groups of 11-15 caused 12% of incidents; groups of 16-20 caused 16% of incidents; and, groups of more than 20 caused just 3% of all incidents (Figure 8.6). In only four instances were elephants recorded in a group size of 20 or more. This sample size was considered too small for statistical analysis, so this category was merged with the 16-20 category for the remainder of this analysis.

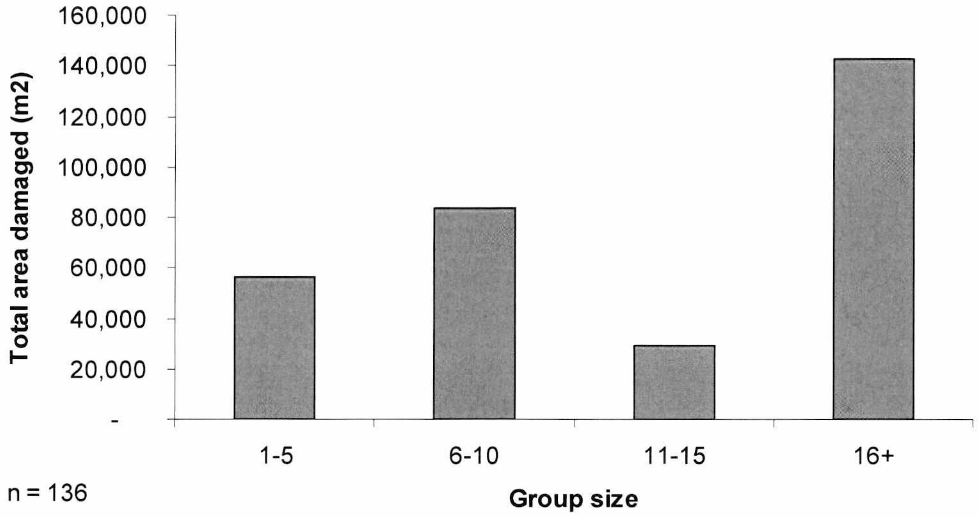
Figure 8.6: Frequency of crop-raiding elephants per group size category for wet season crop damage in 2003.



8.3.2.2 Group size and area of crop damage

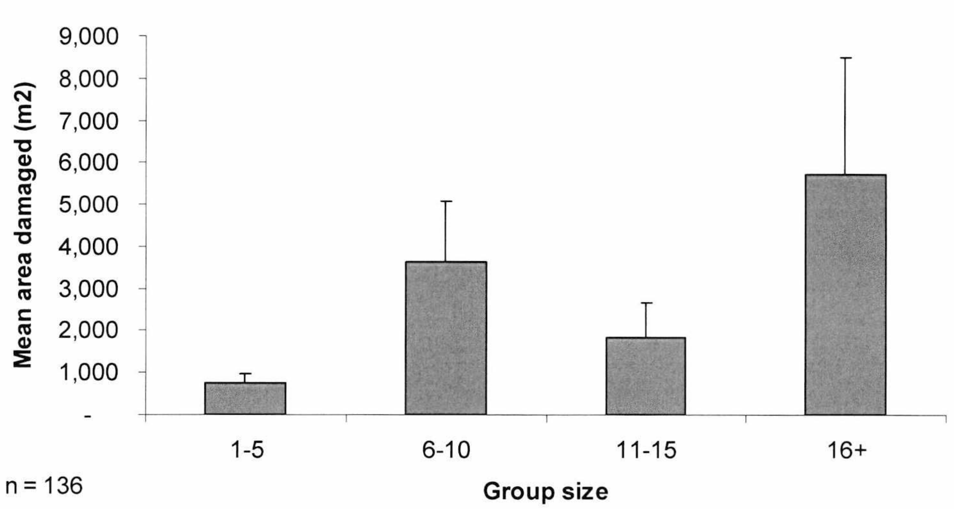
In contrast to the frequency of crop damage, the total area of crops damaged increased with the increasing group size of crop raiding elephants (Figure 8.7). Elephants in groups of 16 or more individuals were responsible for 142,835m^2, or 46% of the total damage caused by elephants. Elephants in groups of 6-10 caused 83,815m^2, or 27% of the total damage, followed by the 1-5 group size, which caused 56,183 m^2 or 18% of the damage. The smallest area of damage (29,333m^2) was perpetrated by elephants in the 11-15 group size.

Figure 8.7: Total area of crop damage per elephant group size category, for wet season crops damaged in 2003.



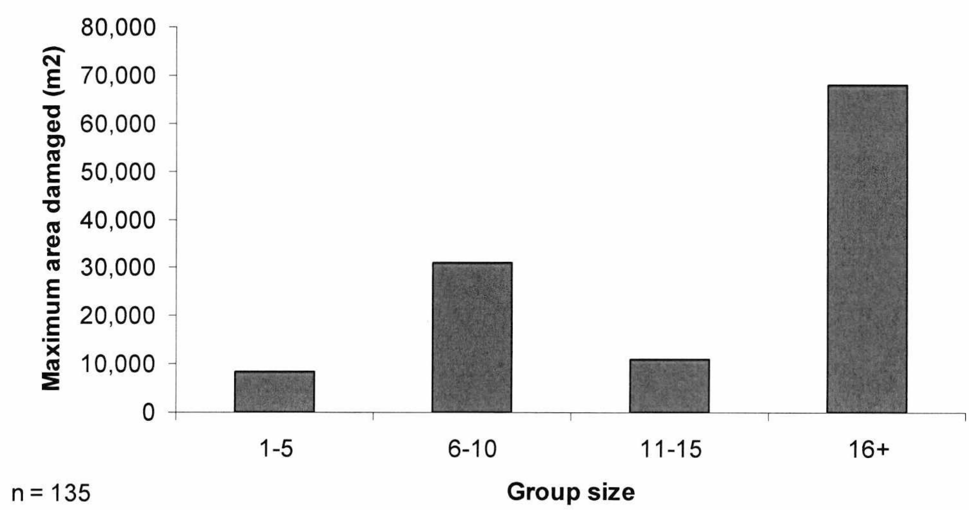
The mean area of crops damaged increased with the increasing group size of crop raiding elephants. The mean area of damage was 5,707m^2 for elephants in groups of 16 or more individuals, as compared to 774m^2 for elephants in groups of 1-5 (Figure 8.8). The area of crops destroyed was greater in larger groups of elephants than in small groups (χ^2=23.64; df=3; p=<0.01; Kruskal-Wallis test).

Figure 8.8: Mean ±SE area of crop damage per elephant group size category for wet season crops damaged in 2003.



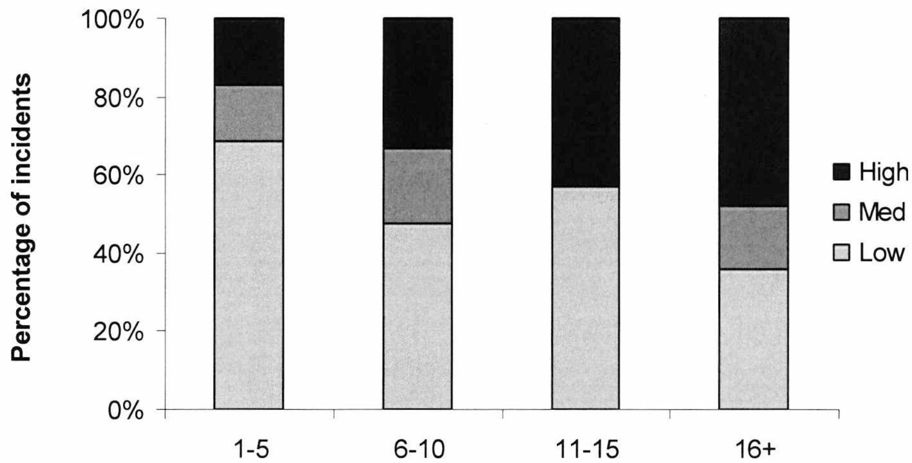
The maximum area of crop damage caused by elephants in a single incident was greatest for elephants in the 16+ group size category (Figure 8.9). Elephants in this group size category destroyed 68,100m^2 of crops, more than twice the area damage than any other group size. The smallest maximum area of crop damage (8,400m^2) was caused by elephants in the smallest group size category.

Figure 8.9: Maximum area of crop damage per elephant group size category for wet season crops damaged in 2003.



The severity of crop damage incidents in the wet season increased with the increasing group size of crop raiding elephants (Figure 8.10), indicating that larger groups of elephants caused more severe damage to crops than did small groups. When group size was tested as a continuous variable against the frequency of high severity incidents, there was a moderate positive relationship between the two variables (r_s=0.406; p=<0.001; Spearman's Rho test).

Figure 8.10: Severity of incidents and elephant group size for wet season crops damaged in 2003.



n = 130

8.3.3 Crop damage per village

The greatest number of elephant crop damage incidents occurred in Kasuo village (35), followed by Bwazi (27), Kapururira (21) and Bonga (18). Fewer incidents occurred in Chikafa (15), Gonono (12) and Gera (9), and no incidents occurred at all in Soka, Warambwa or Majinga villages (Table 8.1).

In terms of area of damage, results were fairly consistent between the total, the mean and the maximum areas of crop damage. For example, Kasuo village exhibited the greatest total area of damage and the largest single incident of crop damage. In Bonga village the second greatest total area of damage occurred, along with the second greatest maximum area of damage. Bwazi village exhibited the third-greatest total area of damage, and the fourth-greatest mean and maximum areas of damage (Table 8.1).

The severity of crop damage differed greatly between villages. Over sixty percent of crop damage incidents in Kapururira village were classed as high severity, as compared to 40% in Kasuo and 22% in Gera village. Seventeen percent of incidents in Bonga and Jowa villages, and 7% in Chikafa and Bwazi villages, were classed as high severity (Table 8.1).

Table 8.1: Ten villages ranked according to five measures of wet season elephant crop damage.

Crop damage measure	Village									
	Kasuo	Bonga	Kapirurira	Bwazi	Jowa	Chikafa	Gera	Soka	Majinga	Warambwa
Frequency	35 (1)	18 (4)	21 (3)	27 (2)	12 (6)	15 (5)	9 (7)	0 (8)	0 (8)	0 (8)
Total area	142,160 (1)	74,028 (2)	17,573 (5)	39,086 (3)	18,045 (4)	13,131 (6)	6,431 (7)	0 (8)	0 (8)	0 (8)
Mean area	4,062 (2)	4,113 (1)	837 (6)	1,448 (4)	1,504 (3)	875 (5)	715 (7)	0 (8)	0 (8)	0 (8)
Max area	68,100 (1)	31,160 (2)	12,800 (3)	8,400 (4)	4,200 (6)	4,200 (6)	4,900 (5)	0 (8)	0 (8)	0 (8)
Severity (%)	33 (2)	17 (4)	70 (1)	7 (7)	17 (4)	10 (6)	22 (3)	0 (8)	0 (8)	0 (8)
Sum of ranks	**7**	**13**	**18**	**20**	**23**	**28**	**29**	**40**	**40**	**40**
Total rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**=8**	**=8**	**=8**

8.3.3.1 Total rank of crop damage per village

Each of the ten study villages was ranked according to each of the five measures of crop damage. These ranks were combined to generate a total rank for each village (Table 8.1). While crop damage varied greatly between villages, the different measures of crop damage for each village were highly consistent, returning a Cronbach's Alpha value of 0.960, indicating that the total rank was representative of all five measures of crop damage.

8.3.4 Cultivated area and crop damage

8.3.4.1 Cultivated area per village

Field size per household was measured during 64 interviews with randomly selected farmers from five villages across the study area. The mean field size for each village did not differ between the five villages (χ^2=3.38; df=4; p=0.34; Kruskal-Wallis test), and so the sample was pooled. The mean field size per household was 4.58 ha, or 0.46 km^2 (+/-0.09 km^2). The total cultivated area for each village was calculated by multiplying the mean field size per household with the number of households per village (Table 8.2).

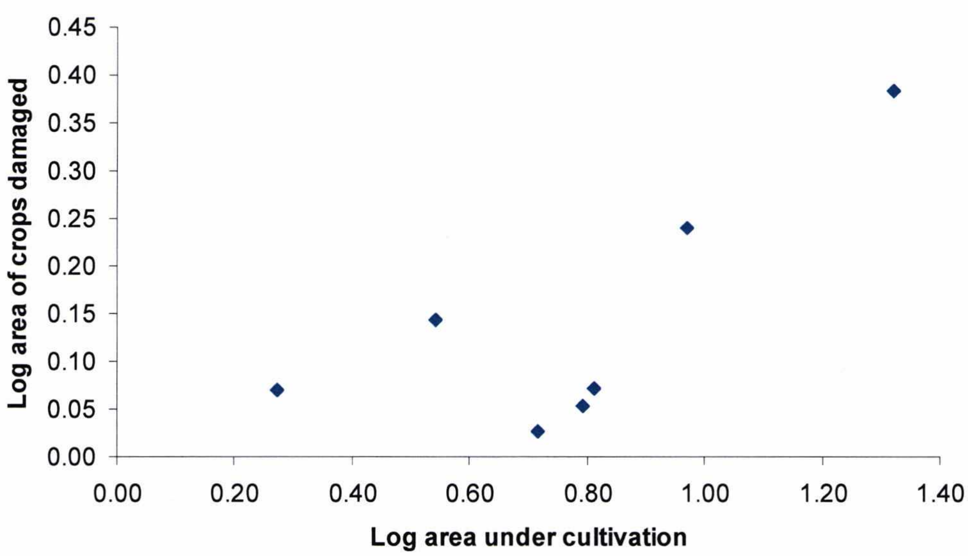
Table 8.2: Estimated area under cultivation for each of ten study villages.

Village	Population	No. households	Total cultivated area (km)
Chikafa	514	112	5.22
Bwazi	299	54	2.47
Kapururira	89	19	0.87
Bonga	861	182	8.34
Kasuo	2029	443	19.92
Majinga	608	148	6.78
Jowa	495	120	5.50
Gera	421	92	4.21
Soka	422	83	3.80
Warambwa	368	84	3.85

8.3.4.2 Cultivated area and crop damage

The area of crops under cultivation in each village did not correlate with the total rank of crop damage within each village (r^2= -0.28; p=0.43; Pearson correlation). However, the total area of crop damage caused by elephants in each village exhibited a strong positive correlation (r^2=0.74; p=0.056; Pearson correlation) with the total cultivated area in each village, which tended towards significance (Figure 8.11). In this analysis the villages in which no crop damage occurred have been omitted.

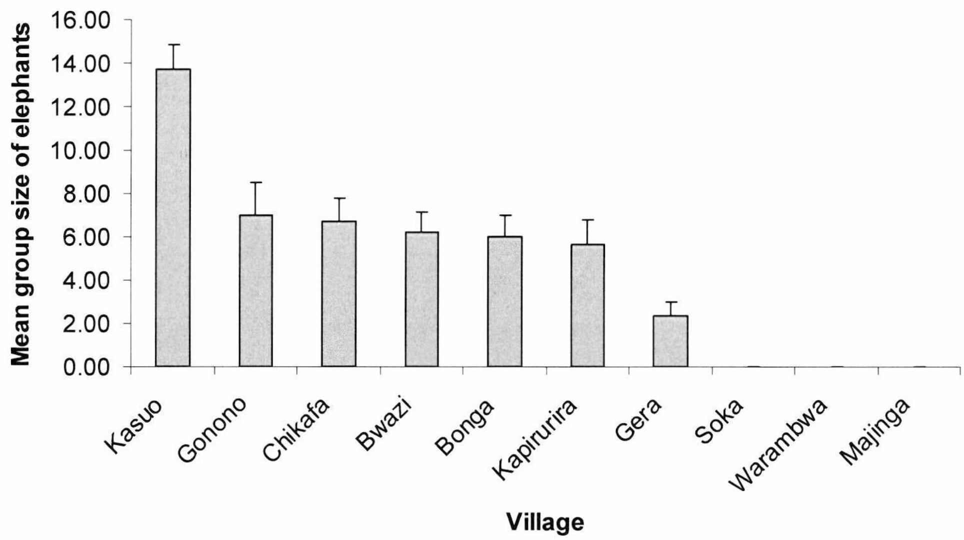
Figure 8.11: Relationship between total area of wet season crop damage and area under cultivation for each of seven villages in which elephant crop damage occurred in 2003, based on log transformed values.



8.3.5 Elephant group size and crop damage

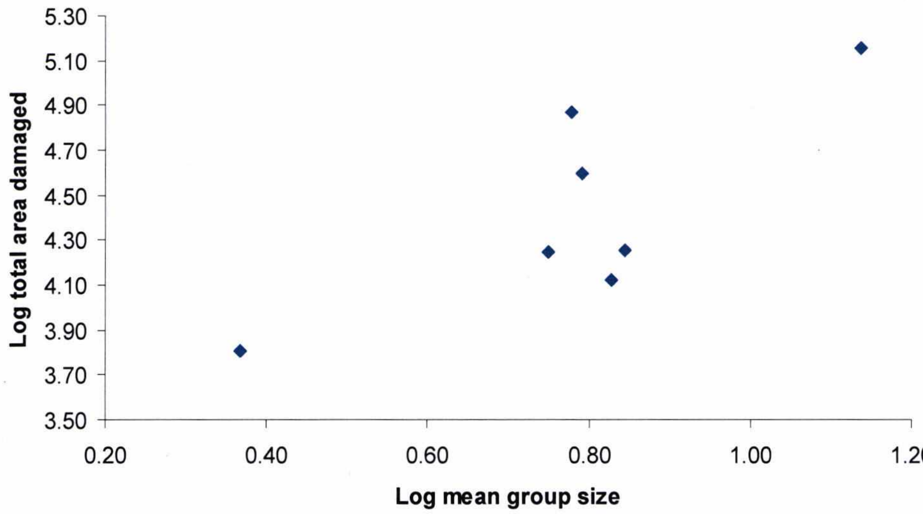
The mean group size of elephants displayed marked differences between villages (χ^2=40.19; p=<0.01; Kruskal-Wallis test), with Kasuo demonstrating much greater group sizes and Gera demonstrating much smaller group sizes than the other villages. There was a marked consistency between five of the seven villages in which elephants crop-raided in the wet season (Figure 8.12).

Figure 8.12: Mean ±SE group size of elephants in each village in the wet season of 2003.



There was no correlation between the overall rank of crop damage and the mean group size of elephants within each village (r^2=0.72; p=0.07; Pearson correlation). However, there was a strong positive relationship between the mean group size of elephants at each village and the total area of damage they caused (r^2= -0.79; p=<0.05; Pearson correlation) (Figure 8.13).

Figure 8.13: Mean group size of elephants and total area of damage in each village in the wet season of 2003.



8.3.6 Human death and injury

Five people were killed and two people were injured by elephants during six separate incidents across the study area between the years 1996 and 2002. Five of the six incidents occurred in Guruve district and just one occurred in Muzarabani district. (Table 8.3).

Table 8.3: Incidents of injury and death occurring between 1996 and 2002 in ten villages across the study area.

Incident	Village									
	Kasuo	Kapururira	Jowa	Soka	Bonga	Bwazi	Chikafa	Majinga	Gera	Warambwa
Injury	0	1	0	1	0	0	0	0	0	0
Death	2	1	1	0	0	0	0	0	0	0
Rank	1	2	3	4	=5	=5	=5	=5	=5	=5

8.4 Discussion

In this chapter I have defined the patterns of crop damage caused by elephants within the mid-Zambezi Valley. I have identified that graniverous food crops are the most vulnerable to crop damage when they are at the mature phase. I have determined that large groups of elephants, though rare, cause the greatest damage to crops. Using multiple measures I have prioritised each of ten villages according to overall crop damage. For these villages I have established that the area of crop damage increases with the increasing area of crops under cultivation. In addition, the mean group size of elephants varies between villages and this accounts in part for the pattern of crop damage observed. Finally I have ranked all ten villages according to incidents of injury and death caused by elephants.

8.4.1 Crop damage incidents

Of the 191 crop damage incidents described, nearly three quarters involved damage to food crops. Only two cash crops were affected by elephants: cotton, accounting for one quarter of all incidents and chilli, accounting for just one incident. When considered as damage area, nearly 90% of the damage affected food crops, with the remaining 10% affecting cash crops.

This selection of food crops is unsurprising, as selective breeding of crops over thousands of years has made food crops more palatable both to people and wildlife (Purseglove, 1972). Grass species such as maize, sorghum and millet accounted for nearly a third of all incidents (n=67; 29%), and 79% of crop damage by area, in keeping with the findings of other studies (e.g. Sukumar, 1989; Osborn, 1998). Elephants are known to preferentially select food crops from the *Gramminea* or grass family (Oliver, 1978).

Maize is the preferred staple food crop for many rural communities, grown for its high yields and relatively low inputs (Purseglove, 1998). It is widely grown in vulnerable places despite the risks from wildlife (Hill, 1997; Naughton *et al.*, 1999). When ripe, maize represents a super-rich patch of food that is highly attractive to wild animals (Naughton-Treves, 1997). As a result it is ranked the number one crop destroyed by elephants across Africa (Naughton *et al.*, 1999).

Elephants also damaged the cash crops cotton and chilli. While less documented than for food crops, elephant damage to cash crops has been recorded elsewhere. For example, in Ghana elephants ate cocoa pods around Kakum Conservation Area (Barnes *et al.*, 2003; Parker, 2004). Similarly, cotton was predated by elephants around Benoue Wildlife Conservation Area in Cameroon (Weladji & Tchamba, 2003).

Without measurements of the area of each crop type available to elephants, it is impossible to say whether the selection of crops was due to preference on the part of the elephant, or simply a result of the amount of each crop that was available. It is possible that the patterns of damage to each crop reflected the area of that crop which was under cultivation.

Most of the damage to wet season and dry season crops affected them at the mature stage, as found in other research (Tchamba, 1995; Kangwana, 1995; Hoare, 1995). This is because crops are more palatable at their fruiting stage (Bell, 1984).

8.4.2 Elephant profile

The most common group size of crop-raiding elephants was 1-5, which caused forty percent of all wet season incidents. This bias towards small elephant groups was similar to Kenya, where Sitati *et al.* (2003) described crop-raiding elephants in groups of between one and forty, with 80% of incidents being perpetrated by between 1-10 elephants. In Zimbabwe Hoare (1999) found most incidents were due to small groups of elephants. They raided crops in groups of between 1 and 47 elephants, with 89% of incidents being caused by between 1-10 animals.

In most previous research, elephants in small herds have been identified as the most frequent crop-raiding groups (e.g. Hoare, 2000; Nyhus *et al.,* 2000; Sitati *et al.,* 2003). However, no indication has been given as to the extent of the damage they caused. In the mid-Zambezi Valley large groups of elephants caused the greatest area of crop damage overall, despite being infrequent crop-raiders. In contrast, the area of crop damage caused by small groups of elephants was comparatively small, their impact being characterising as frequent but low.

Large groups of elephants consistently damaged greater areas of crops than did smaller groups. In addition, larger groups were also able to cause extensive damage, destroying the largest area of crops in a single incident. However, because large groups of elephants were infrequent, the potential for such extensive crop damage was rare. This pattern fits closely with those in Uganda, where elephants around Kibale National Park were considered infrequent, but extensive crop-raiders who were capable of causing calamitous damage in a single incident (Naughton-Treves, 1997).

Despite the rarity of the events, large groups of elephants can exert a profound influence upon farmers, who fear the extensive damage they cause (Chapter Six). If it were possible to reduce the frequency of such raids, the strong emotive responses they inspire may be reduced. It may be possible to direct the activities of the APUs towards incidents which involve large groups of elephants. This would be especially effective if large groups of elephants habitually raided the same fields, as has been indicated elsewhere (Hoare, 1999).

8.4.3 Conflict per village

There was a great variation in the amount of crop damage between the study villages, both in terms of the frequency of incidents, and in terms of the area of crops damaged. Such a pattern is unsurprising as spatial patterns of elephant crop damage have been described as 'patchy' and 'irregular' in other research, referencing the sporadic and infrequent nature of crop damage (Naughton *et al.*, 1999). Around Kibale National Park, Uganda, crop damage by elephants exhibited marked variation between villages, despite sites being in close proximity to each other. Ultimately, the explanation for such localised damage remains something of a mystery (Naughton-Treves, 1998). Other studies have found similarly persistent patterns of localised elephant damage (Bell, 1984; Hawkes, 1991; Lahm, 1994; Tchamba, 1996).

However, there are several variables that help to explain the total amount of crop damage that occurred in each study village. First, the area of crops damaged in each village increased with the area of crops under cultivation, and second, the mean group size of elephants in each village affected the area of crops damaged in total.

8.4.4 Cultivated area and crop damage

The area of cultivation has been a significant predictor of crop damage in other research (Sitati *et al.*, 2003; Sam *et al.*, 2005). In addition, elephants appeared to be attracted to larger farms around Kakum Conservation Area, Ghana (Barnes *et al.*, 2003).

While the area under cultivation was not accurately measured in each location, the calculations of field size were based upon a sample from across the study area that displayed high consistency. That the field sizes exhibited high consistency in every village is a result of the apportioning of fields by Agritex, the State agricultural extension authority. They allowed a maximum of 12 acres (4.8ha) per person and pegged the perimeter of fields in every village.

8.4.5 Elephant group size and crop damage

The mean group size of elephants in each village affected the total area of crops damaged. However, group size bore no significant relationship with the overall rank of crop damage. In Kasuo village, where the largest groups of elephants occurred, they caused the greatest total damage to crops, which fits neatly with the findings above, that larger groups of elephants cause more extensive damage. However, the reason for elephant group size varying between sites remains unclear.

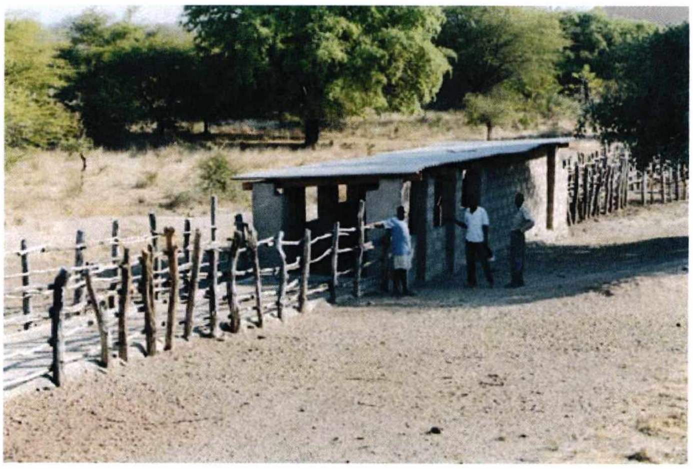
8.4.6 Human death and injury

There were only six incidents human death and injury from ten study villages over the seven year period. In comparison to crop damage, deaths and injuries were extremely rare events. A total of 191 incidents of crop damage occurred in one year as compared to just six deaths and injuries over a six-year period, indicating that the ratio of crop-raiding incidents to human injury and death was 200:1. By contrast, in Transmara District, Kenya Sitati *et al.* (2003) recorded 329 crop damage incidents in a 17-month period and 35 deaths and injuries in a 14-year period. In this case, the ratio of crop damage incidents to deaths and injuries was around 90:1. This suggests that the relative incidence of deaths was lower in the mid-Zambezi Valley than in Transmara. This finding fits well with the results of Chapter Six, in which human death and injury were considered a severe, but occasional problem.

Injuries and deaths tended to be clumped around several villages, with the majority of villages experiencing no incidents. The two most affected villages – Kasuo and Kapururira – were also ranked first and third for crop damage during 2003. It stands to reason that villages in which crop damage is common would also be at the highest risk from elephant attacks on people.

In this chapter, I have explored in detail the two major issues of human-elephant conflict - crop damage, and human death and injury – facing the farmers of the mid-Zambezi Valley. In the following chapter I turn attention to the benefits that rural farmers perceive to come from elephants in the mid-Zambezi Valley.

Chapter 9 Benefits from Elephants



9.0 Introduction

A key assumption of community-based conservation (CBC) is that success in conservation will only be achieved if local communities living close to the resource, and thus bearing many of the costs of its conservation, receive sufficient benefits to compensate, or over-compensate for these costs (Gibson & Marks, 1995; Emerton 2001). Consequently, CBC must aim to provide economic benefits from wildlife as an incentive for people to manage it sustainably. Ideally, such benefits should seek to ensure that wildlife out-competes other forms of land use (Jones & Murphree, 2001). Equally, in areas of heavy conflict, benefits may simply attempt to balance the costs of living with wildlife (Leader-Williams & Hutton, 2005).

Wildlife and natural habitats yield a wide range of economic goods and services, including the direct economic value of live sales, meat, hides and trophies, tourism opportunities and education (Emerton, 2001). There is also a range of indirect ecological services including population control and habitat maintenance; option values for potential future uses (Emerton, 2001); cultural values; and, the intrinsic 'existence' value (UN, 1982). However, the micro-economics of local benefits from conservation tends to focus upon the more tangible, direct values of wildlife, which can more readily appreciated by local communities than the less tangible indirect values.

In terms of direct values, CBC can rely either upon consumptive or non-consumptive forms of wildlife utilisation, or on a combination of both. Wildlife tourism and trophy hunting are the primary means of generating benefits for community-based conservation schemes in southern Africa, exemplified by the LIFE [10] programme in Namibia, the BNRM [11] programme in Botswana, ADMADE [12] and LIRDP [13] in Zambia, *Tchuma Tchatu* in Mozambique and CAMPFIRE in Zimbabwe (Steiner & Rihoy, 1995; Gibson & Marks, 1995; Taylor, 1995; Anstey, 2001).

10 Living in a Finite Environment
11 Botswana Natural Resource Management Programme
12 Administrative Management Design for Game Management Areas
13 Luangwa Integrated Resource Development Project

Wildlife benefits may be disbursed to communities in many forms, from cash dividends allocated to individuals and wildlife meat quotas allocated to villages (Gillingham & Lee, 1999), to infrastructural improvements and social projects such as schools and clinics, roads and bridges that serve wider groups (Archabald & Naughton-Treves, 2001). Benefits may support local income-generating projects, such as ecotourism and community forestry (Mehta & Kellert, 1998), or they may improve local capacity through land-use planning, the establishment of village wildlife committees (Gillingham & Lee, 1999) and community training (Welford, 2001).

Zimbabwe's CAMPFIRE programme incorporates the principles of economic incentives for conservation with the devolution of rights over natural resources. The strong economic principles of CAMPFIRE dictate that wildlife outside protected areas is expected to compete economically with other forms of land-use (GOZ, 1989). Revenues are generated primarily through the consumptive use of wildlife. Between 1989 and 1996, CAMPFIRE districts in Zimbabwe generated US $9.3 million, 93% of which was from trophy hunting (Bond, 2001). Elephants contributed nearly two thirds of this revenue in 1992 (Bond, 1994), making them the primary contributing species.

CAMPFIRE revenues are administered by the Rural District Councils (RDCs). The revenues are apportioned to communities according to the 'producer community principle', which states that those living with wildlife and bearing the costs should receive the benefits (Murphree, 1993). According to this principle, each ward within a CAMPFIRE district is designated as either a 'producer' or a 'non-producer' depending upon its wildlife status. A producer ward is considered to have sufficient game populations to support hunting quotas, and a high proportion of the hunting revenues are returned to the Ward in order to offset the costs of wildlife production. In a non-producer ward, the game populations are considered negligible and no hunting occurs. Non-producer wards receive a nominal annual payment of CAMPFIRE revenue from the RDCs.

While up to a half of the gross CAMPFIRE revenues may be retained by the RDCs, a minimum of 50% of the gross earnings are apportioned to the ward level, as stipulated in the CAMPFIRE Guidelines. This revenue is disbursed to wildlife management activities and community projects (Bond, 2001). Communities submit project proposals to their Ward Wildlife Committee (WWC), which allots revenue to the village projects considered most worthy. To date, most CAMPFIRE revenues have been invested in social projects such as schools, water supplies and health facilities (Jones & Murphree, 2001). Between 1989 and 1993, approximately 10% of the total revenue disbursed to sub-district level was paid in the form of individual household dividends (Bond, 1999), but since 1996 this practice has diminished.

The disbursement of broad social benefits such as development and education can improve community welfare and lead to short-term improvements in attitudes towards wildlife. However, doubts have been raised about the appropriateness of social projects in engendering community support for conservation (e.g. Stocking & Perkin, 1992). It is feared that such benefits may not adequately address the costs of wildlife to rural communities (Emerton, 2001). The costs of living with wildlife are not evenly distributed across the areas where social benefits apply, so those suffering the heaviest costs of living with wildlife are disproportionately worse off. Furthermore, it could be argued that social projects such as schools and roads should be the responsibility of national and local government to provide out of general funds, rather than through earnings made from wildlife.

Previous analyses of CAMPFIRE revenues have concluded that the revenues generated are insufficient to effect institutional change at the community level (Bond, 1994). The revenues have been insufficient to compete with agriculture as a land use at the household level, despite the programme's strict economic targets (Bond, 2001). However, while economic targets may have not been met, CAMPFIRE endeavours to return the benefits from wildlife management back to the communities who bear the cost of production.

CAMPFIRE benefits have been assessed at the national scale (Bond, 1994), and for several isolated villages (Maveneke *et al.,* 1998). However, benefits have not been studied comparably across multiple village sites, and neither have the specific benefits of elephants been investigated. In this chapter, I investigate the benefits from elephants as perceived by local people across a range of 10 villages in which the types and the values of the different benefits vary considerably. Specifically I aim to:

- identify and prioritise the benefits that derive from elephants as perceived by rural farmers;
- quantify the value of the key benefits identified for each village across the study area;
- investigate what factors influence the perceptions of benefits; and,
- investigate the relationship between revenues at the village level, and the costs incurred from wildlife.

9.1 Methods

9.1.1 Perceptions of benefits

I determined people's perceptions of the benefits that derive from elephants, using the SSI methodology that has been described fully in Chapter Six. The following questions formed a part of the same interview used earlier to explore issues of human-elephant conflict. Here, the purpose was to identify the most important benefits that derive from elephants, as perceived by rural farmers. Each respondent was asked:

1. Do you experience any benefits from elephants?
2. *If yes to the answer above*, name the benefits you receive from elephants.
3. Rank the benefits in order of importance, greatest first and smallest last.

9.1.2 Quantifying benefits

During the SSIs, respondents identified CAMPFIRE revenues, and meat from elephant hunting, as the two most important benefits from elephants (see this chapter: Results, Figure 9.2). Based upon these results, these two issues were quantified in each study village.

9.1.2.1 Revenues

The value of CAMPFIRE revenues in each village was assessed. This could potentially be achieved at a number of different levels: either as gross earnings to the RDC; as the amount disbursed to each ward; or as the amount expended on community projects within each village. In consideration of the fact that I will be focusing upon community attitudes to elephants at the village level (see Chapter Ten), I decided that assessing investment in community projects was more appropriate than considering the gross earnings to the RDC, because the projects would be more likely to influence community members. I therefore measured the amount of revenue spent by the Wildlife Committees in each ward on social projects within each of the ten study villages.

I collected information on CAMPFIRE-funded projects at the Ward Wildlife Offices of each ward. There I interviewed the ward councilor and the wildlife clerk, accessing the records of the type of project (e.g. borehole), its location (village), the total expenditure (in Zimbabwean dollars) and date of completion.

In the revenue analysis, I included all projects that were situated within the boundary of one of the 10 study villages. Where projects benefited multiple locations, then the value was apportioned across the recipient villages, on the assumption that they all accessed the benefits of the project equally. To give two examples: the Ward 4 APU was shared among all the villages within the ward equally. Hence, the value of the APU was apportioned equally to each of the recipient villages. Where CAMPFIRE projects were accessed equally by neighboring villages, the full value of such a project was included for all such villages. Thus the secondary school in Jowa was accessed by the inhabitants of both Bonga and Majinga villages, and the total value of this project was therefore incorporated into the revenue calculations of both these villages.

Only projects within the time period 1996-2002 were selected because the information on community projects prior to 1996 was unreliable in several locations, while projects that started after 2002 were still in the process of implementation at the time of data collection. In this time period revenues were spent purely upon social projects within the community, and no direct household payments were made.

9.1.2.2 Meat availability

Meat was the second most important benefit identified by respondents as coming from elephants. Every time safari hunters killed an elephant, the meat was made available to communities. News of the location of the carcass was passed by word of mouth, and people traveled to the carcass from the surrounding communities. Meat was distributed largely on a first-come, first-served basis. The numbers and locations of elephants shot in each year was on record at the Wildlife Offices for each of the four wards in Lower Guruve and Muzarabani districts. This information was accessed during interviews conducted at the Wildlife Offices of each ward, as described above.

9.2 Analysis

9.2.1 Perceptions of benefits

I used two measures to prioritise the benefits raised by farmers in the SSI questions. First, I tallied the number of times that each benefit issue was 'mentioned', which highlighted its prominence in local perceptions. Second, I summed the number of times each issue had been identified as 'best', which highlighted only the most important issues.

9.2.2 Quantifying benefits

9.2.2.1 Revenues

Each project's value in Zimbabwean dollars (ZW$) was corrected for inflation to a base date of July 2002, using the Zimbabwe Building Society Deposit 12-month Middle Rate. Each value was then converted to US dollars using the appropriate rate of exchange (Appendix 8). The total US$ expenditure, corrected to a July 2002 baseline, was log-transformed and displayed for each village for the period 1996-2002. These data on benefits received by each village are drawn upon later in Chapter Ten, when attitudes towards elephants are explored.

9.2.2.2 Meat

I entered the location of all elephant carcasses that had been trophy-hunted into Arc View, for the period of 1996-2002. This time period was consistent with that used for the revenue analysis. I considered that any village within 10 km of a carcass would potentially have access to the meat. This distance was identified during focus group discussions as being the maximum distance that farmers would be willing to travel to collect meat. I buffered each of the ten study villages at 10 km distance, and counted the number of elephant carcass locations that fell within each buffer. The number of carcasses within 10km of each village over the 7-year period was recorded as the meat 'score' for that village. These results will also be drawn upon in Chapter Ten.

9.2.3 Factors that influence people's perceptions of benefits

9.2.3.1 Value of revenues

During the SSIs, many respondents perceived there to be no benefits from elephants (see later in this chapter: Results, Figure 9.1). I explored the relationship between the frequency of 'no benefit' views, and the value of CAMPFIRE revenues within each study village, in order to determine whether the quantity of revenue that has been invested affected people's acknowledgement of the benefits. I calculated the percentage of respondents in each village who perceived there to be no benefits from elephants, and correlated this with the amount of CAMPFIRE revenues invested in each village from 1996-2002, using Spearman's Rho correlation test.

9.2.3.2 Crop damage and perceptions of benefits

I then investigated the incidence of elephant crop damage within each village, to establish whether it affected people's perceptions of the benefits received from CAMPFIRE. Elephant crop damage had been identified as the greatest form of all human-wildlife conflict across the study area (see Chapter Six), and therefore made a suitable indicator of wildlife cost. I correlated the percentage of 'no benefits' with the overall amount of elephant crop damage within each village, as previously quantified in Chapter Eight, using Spearman's Rho correlation test.

9.2.4 Benefits in relation to costs

I explored the relationship between the CAMPFIRE revenues and the costs of wildlife accruing in each of the ten villages, to see if revenue disbursement reflected wildlife costs. Again, I used elephant crop damage as an indicator of wildlife costs, and investigated its relationship with CAMPFIRE revenues in each village using scatter plots and Spearman's Rho correlation tests.

I then compared the amount of meat provided to each village against the amount of elephant crop damage that had occurred. As above, I used scatter plots and Spearman's Rho correlation tests to examine the relationship.

However, bearing in mind that this analysis is based upon a sample of villages from three wards, these results should only be viewed as indicative of the pattern of revenue disbursement. In order to accurately determine the disbursement of benefits in relation to costs, crop damage and revenue and meat disbursement would need to be quantified in every village of each ward.

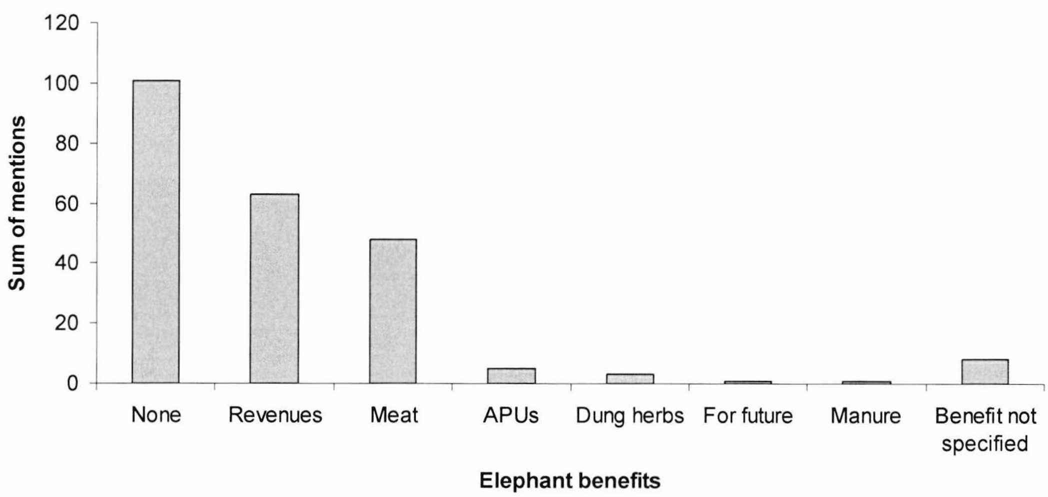
9.3 Results

9.3.1 Perceptions of benefits

A total of eight categories of benefits were identified by the 183 interviewees. The majority (56%) of respondents recognize benefits, while the remaining (44%) respondents mentioned that there were no benefits from elephants. Of those who recognized benefits, 27% of respondents mentioned revenues, and 21% mentioned meat from elephant hunts.

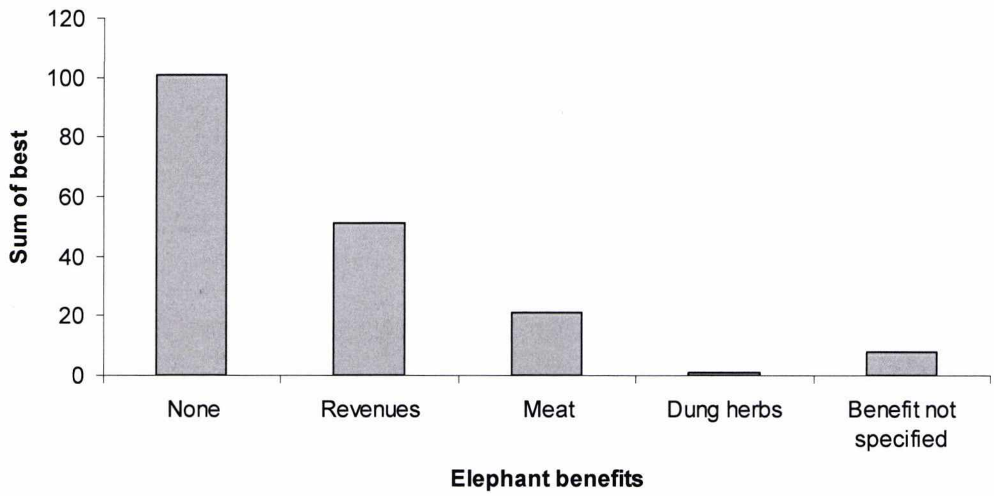
The remaining benefits were mentioned by far fewer respondents: the employment of APUs, who also protected fields from wild animals, was considered a benefit by 2% of respondents; elephant dung being used for herbal medicine was mentioned by three people (1%); the value of elephants for future generations to see, and the use of elephant dung for manure, were both mentioned by one person each (0.4%). Eight people (3%) acknowledged there were benefits from elephants, but did not specify what they were (Figure 9.1).

Figure 9.1: The frequency with which elephant benefits were mentioned by respondents from 10 study villages in the mid-Zambezi Valley.



Only four of the issues identified as elephant benefits, were considered the 'best' of the benefits. Fifty one people (63%) considered revenues from elephants to be the best benefit, and 21 people (26%) considered meat to be the best benefit. Just one person considered the herbal properties of dung to be the greatest benefit (1%), and 8 people (10%) recognized that there were benefits from elephants, but they were not able to specify what they were (Figure 9.2).

Figure 9.2: The frequency with which elephant benefits were considered the best by respondents from ten study villages in the mid-Zambezi Valley.



9.3.2 Quantifying benefits

9.3.2.1 Revenues

CAMPFIRE expenditure amounted to an equivalent of US$ 127,184.30, corrected to a base of July 2002, in the 10 study villages in the period 1996-2002. These revenues were primarily spent upon social projects, consisting of constructing and improving school buildings, employing ward wildlife staff, supporting income-generating projects such as cattle fattening projects, constructing dip tanks, improving clinic facilities, building infrastructure such as community toilets and fencing, and supporting local football clubs and celebrations (Table 9.1).

Table 9.1: Breakdown of CAMPFIRE revenue expenditure on community projects between 1996 and 2002 in ten study villages within the mid-Zambezi Valley.

Project	Total expenditure
School building	72,703.18
Ward staff	20,520.00
School improvements	7,730.96
Income generation	7,706.34
Wildlife staff (W4)	7,260.00
Dip tanks	4,666.66
Infrastructure	3,857.81
Clinic	1,515.84
Community events	1,223.51
Total	**127,184.30**

Of the total revenue spent upon all community projects among the study villages between 1996 and 2002, there was a 70-fold variation in the spending across villages, ranging from US $1,679 in Kasuo village to $119,885 in Jowa village (Table 9.2). The 10 villages could be placed into three broad groups, on the basis of the amount of revenues spent:

- less than US$ 5000 was invested in Kasuo, Gera and Chikafa villages;
- between US$ 7,500-15,500 was invested in Kapururira, Warambwa, Bwazi and Soka villages; and
- more than US$ 100,000 was invested in Bonga, Majinga and Jowa villages..

It should be noted that the sum of investment per village displayed in Table 9.2 exceeds the total value of all projects, as displayed in Table 9.1. This is because many of the projects were available to multiple villages, and their value was therefore duplicated.

Table 9.2: Total value of community projects funded by CAMPFIRE revenues within each of ten villages in the mid-Zambezi Valley between 1996 and 2002.

	Village									
	Kasuo	Gera	Chikafa	Kapururira	Warambwa	Bwazi	Soka	Bonga	Majinga	Jowa
Revenue $USD	1,679	1,943	4,895	7,532	8,306	9,078	15,279	101,169	105,265	119,885
Log	3.23	3.29	3.69	3.88	3.92	3.96	4.18	5.01	5.02	5.08
Mean revenue per annum $USD	239	278	699	1,076	1,187	1,297	2,183	14,453	15,038	17,126

9.3.2.2 Meat availability

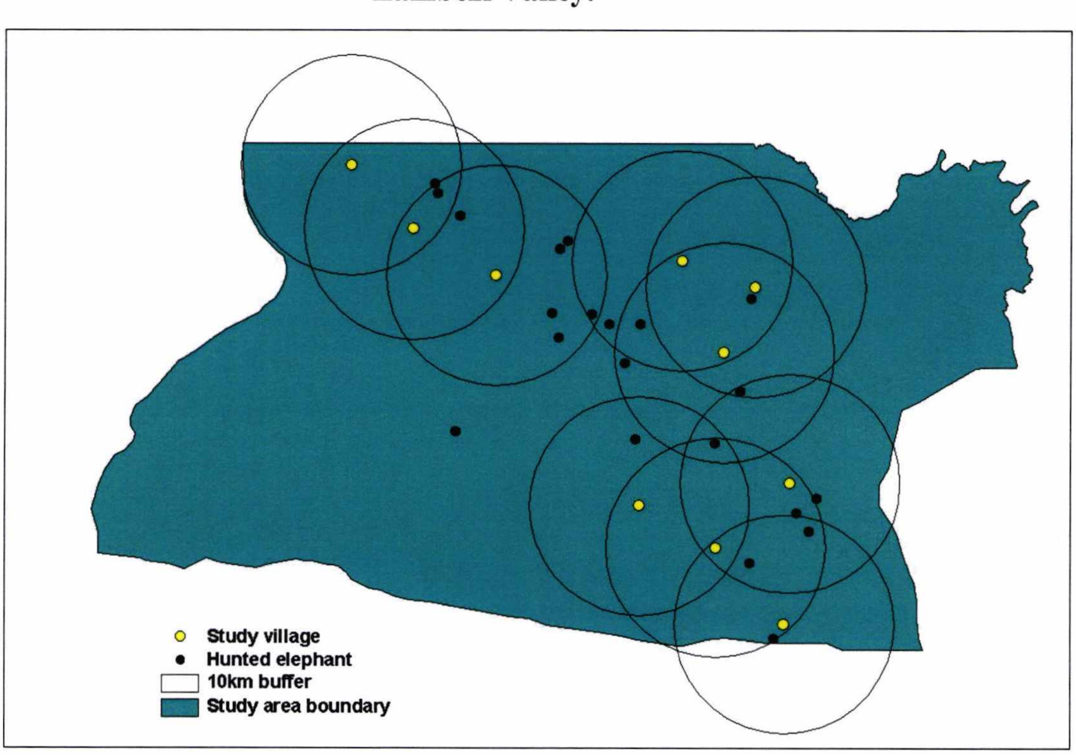
Elephant meat was available in each of the ten study villages between 1996 and 2002. However, there was a four-fold difference in the numbers of elephants hunted within each village, ranging from eight elephants shot within a 10km radius of Kapururira village, to just two elephants shot within 10km of Chikafa, Kasuo and Majinga villages (Table 9.3).

Table 9.3: Number of meat events within 10km of each of ten study villages across the mid-Zambezi Valley between 1996 and 2002.

	Village									
	Chikafa	Kasuo	Majinga	Bwazi	Soka	Warambwa	Jowa	Bonga	Gera	Kapururira
No. meat events	2	2	2	3	3	3	4	5	6	8

For two villages, nearly 50% of their 10km radius fell outside the study area (Figure 9.3). However, there was little possibility of their accessing further meat from these areas. For the northernmost village of Chikafa, the area outside the study area was a little-inhabited area of Mozambique; and for the southernmost village of Soka, the area extended into the steep and uninhabited northern slopes of the Zambezi escarpment.

Figure 9.3: Locations of hunted elephants between 1996 and 2002, and 10km distance buffers surrounding each of ten study villages within the mid-Zambezi Valley.

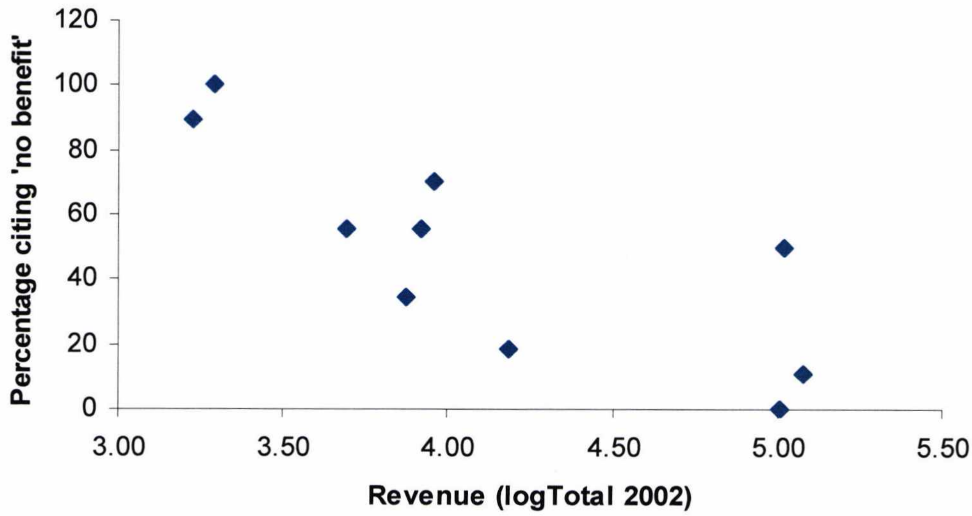


9.3.3 Factors that influence people's perceptions of benefits

9.3.3.1 Value of revenues

The percentage of respondents in different villages who said that 'no benefits' derived from elephants was strongly and negatively related (r_s= -0.77; p=<0.01; Spearman's Rho correlation test) to the amount of revenue invested in each village (Figure 9.4). This relationship indicates that respondents are more likely to acknowledge benefits as the overall levels of investment in benefits from social projects increases.

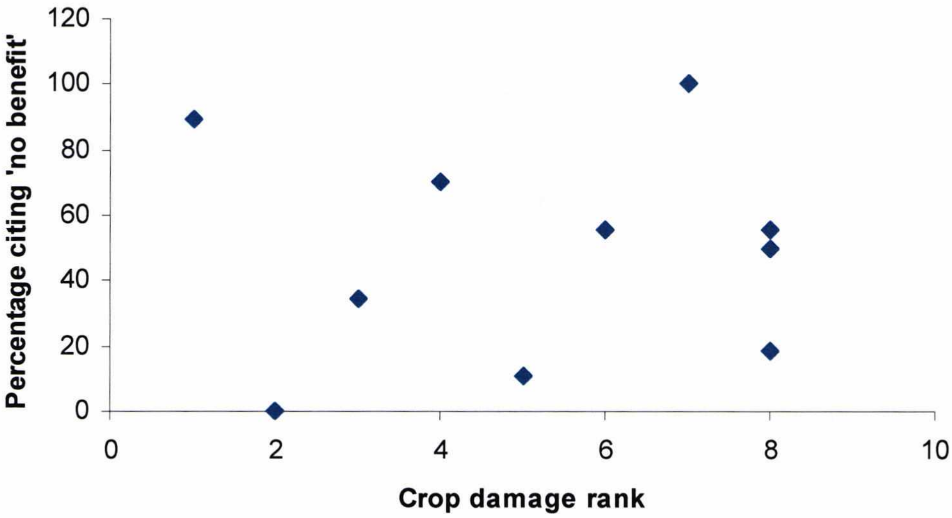
Figure 9.4: Percentage of SSI respondents from each village who stated that 'no benefits' derived from elephants, compared with log transformed CAMPFIRE revenues invested in ten villages between 1996 and 2002.



9.3.3.2 Crop damage and perceptions of benefits

The percentage of people citing 'no benefits' from elephants in each village bore no relationship (r_s=-0.03; p=0.94; Spearman's Rho correlation test) with the overall elephant crop damage that occurred in each village, indicating that the acknowledgement of elephant benefits is independent of the amount of crop damage that occurs (Figure 9.5).

Figure 9.5: Percentage of SSI respondents citing 'no benefits' from elephants, compared with the overall rank of elephant crop damage in ten villages in 2003.

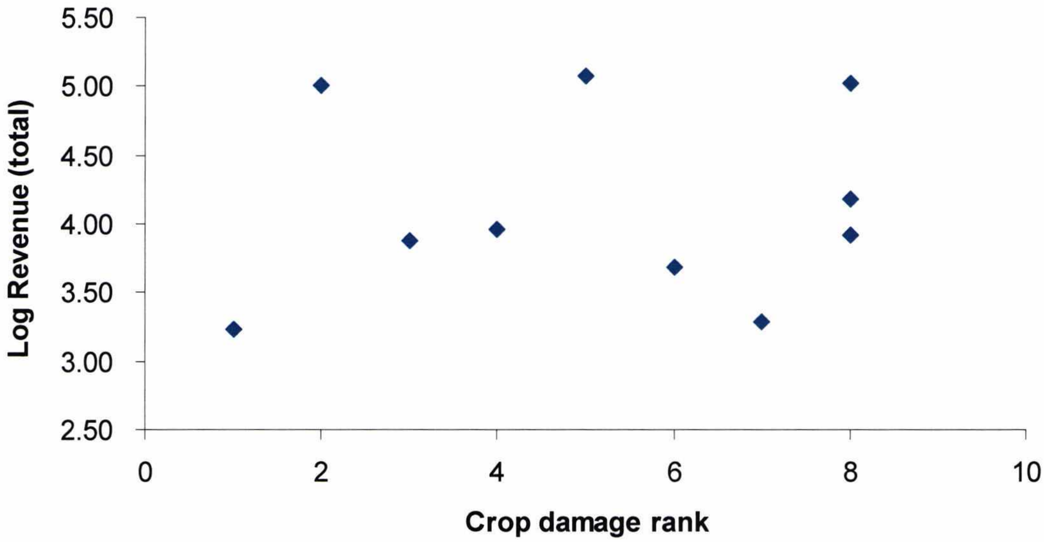


9.3.4 Benefits in relation to costs

9.3.4.1 Revenues and crop damage

The amount of CAMPFIRE revenue invested in each village was not correlated (r_s=0.26; p=0.46; Spearman's Rho test) with the overall amount of elephant crop damage that occurred in that village (Figure 9.6). Neither was revenue correlated with the frequency of crop damage (r_s=0.39; p=0.25; Spearman's Rho test), nor the total area of crops damaged (r_s=0.16; p=0.65; Spearman's Rho test). This indicates that the CAMPFIRE revenues invested did not reflect the amount of crop damage occurring among sample villages. In other words, the benefits that accrue to different villages bore no relation to the way that the costs of conservation were distributed.

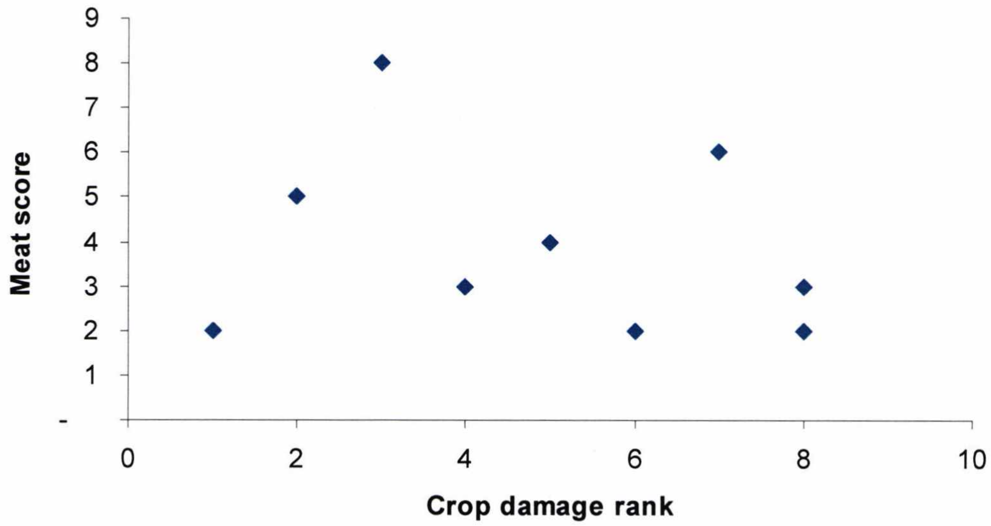
Figure 9.6: The relationship between the amount of revenues invested in community projects, transformed logarithmically, and the rank of crop damage by elephants in ten villages across the mid-Zambezi Valley.



9.3.4.2 Meat and crop damage

The amount of meat available to each village was not correlated (r_s=-0.21; p=0.57; Spearman's Rho test) with the overall amount of elephant crop damage that occurred in that village (Figure 9.7). Neither was the amount of meat related to the frequency of crop damage (r_s=-0.36; p=0.43; Spearman's Rho test), nor the total area of crops damaged by elephants in each village (r_s=-0.38; p=0.40; Spearman's Rho test).

Figure 9.7: The relationship between the amount of meat from elephants available in each village, and the rank of crop damage by elephants in ten villages across the mid-Zambezi Valley.



9.4 Discussion

In this chapter I have identified the benefits from elephants that farmers in the mid-Zambezi Valley considered to be most important to them. Many (44%) respondents believed that no actual benefits derived from elephants, and their views directly reflected the small amounts of investment made in their own villages. The two most important benefits accruing from elephants were first, CAMPFIRE revenues and second, meat from hunted elephants. The acknowledgement of benefits increased with the value of the investment. However, the CAMPFIRE revenues did not appear to be distributed in proportion to the amount of crop damage caused by elephants in each village. This suggests that one of the key pillars of CAMPFIRE was not fulfilled, namely that benefits received by each 'producer community' should relate to the costs of conservation borne by that community (Murphree 1993, Child, 1996).

9.4.1 The distribution of benefits

Many (44%) farmers perceived there to be no benefits from elephants. This may be due to a number of different factors. First, the benefits may have been insufficient; second, distributing benefits through social projects rather than household dividends may not have reached to the poorest members of society; and third, the divide between which villages bear the costs of conflict from wildlife, and which villages receive most benefits, may have reduced people's willingness to acknowledge benefits. These arguments are discussed further below.

9.4.1.1 The quality of the benefit

People's perceptions of the benefits from elephants were strongly and directly influenced by the investment of CAMPFIRE revenues within their village. The proportion of people citing 'no benefits' in interviews increased as the revenues invested decreased. In villages where revenues were lowest, everyone interviewed stated there were no benefits at all. In Kasuo and Gera villages, both in Ward Six, the mean revenues invested per annum from 1996-2002 was less than US $240 and US $280, respectively, which may have been insufficient to be acknowledged. Hence, if the benefits received are perceived to be small or inequitably distributed, they may not achieve the desired effect (Homewood *et al.,* 1997). However, in those villages receiving large investments, such as Jowa, in which a mean of US$ 17,130 per annum was invested, the recognition of benefits was greater, with only a small proportion of respondents citing 'no benefits'.

This disparity in revenue distribution between the study villages also reflects the designation of wards according to their wildlife production. Both Kasuo and Gera villages lie in Ward 6, which is deemed to be a non-producer ward with low wildlife populations and low associated costs. Therefore, this ward receives only a base payment from the RDC each year. In contrast, the three villages with the greatest investment all fall within Ward 4, a producer ward with large annual revenues.

9.4.1.2 The type of benefit

The type of project funded by CAMPFIRE revenues may also have influenced people's perceptions of benefits. Revenues were disbursed mainly social projects that seek improvements in infrastructural developments, which provided benefits to society in general, rather than those who suffer the costs of conservation. However, the poorest members of society may not be able to gain much from social projects that improve infrastructure, because associated costs are too expensive (Mehta & Kellert, 1998). For example, in focus group discussions, several farmers commented that the cost of medicines at the newly improved clinic were too high, and that the fees at the new built or improved schools prevented them from sending their children there (FG notes, Majinga). Such issues might in part explain why many people claimed there were no realisable benefits from social projects undertaken for their supposed benefit. Hence, those who could not afford to send their children to schools or to buy medicines from clinics were unlikely to recognise such social projects as a benefit.

9.4.1.3 The costs in relation to the benefits

People's perceptions of elephant benefits were not directly linked to the amount of elephant crop damage occurring in each village. The percentage of people citing 'no benefits' ranged from low to high in villages where there was no crop damage, and in villages where there was the most crop damage. In other research, the high incidence of crop damage has been found to cause people to ignore the benefits that they may receive from conservation (de Boer & Baquete, 1998; Gillingham & Lee, 1999). In such a situation the benefits from conservation are overlooked, and the influence of benefit system is undermined.

9.4.2 Tangible benefits

The benefits from elephants that were identified by farmers, such as revenues, meat and dung, may be considered direct and tangible benefits. Tangible benefits such as revenue and access to game meat were the most commonly acknowledged in Tanzania (Gillingham & Lee, 1999). Similarly in Uganda, revenues were identified as the greatest benefit from three national parks, where hunting and the provision of meat are not legal options (Archabald & Naughton-Treves, 2001).

9.4.2.1 Infrastructural developments

Infrastructural developments, such as schools and clinics, were well-recognised across the study area. The mid-Zambezi Valley has been considered something of a ‘frontier’ (Cumming & Lynam, 1997), and only recently has development occurred. In these circumstances it is not surprising that the provision of schools and clinics has been welcomed. Elsewhere, local support for infrastructural development funded by conservation revenues has been high (Mehta & Kellert, 1998; Archabald & Naughton-Treves, 2001). It stands to reason that such projects would engender local support, given that they are available to all but the poorest people in society, and therefore have a broad influence. In addition, the benefits are high profile, and would be expected to function for a long period of time.

However, several authors have questioned whether development goals are compatible with conservation objectives (Stocking & Perkin, 1992). The implementing authority may not have the mandate to fulfil local development needs, and there may be a gulf of difference between the views of the organisation and the expectations of the community (Mehta & Kellert, 1998). ICDPs have been accused of not fulfilling both their development and conservation roles (Stocking & Perrin, 1992); with environmental objectives being met, but at the expense of economic benefits (Ferraro & Kramer, 1997), and vice versa.

9.4.2.2 Meat

Meat was heralded as the second-most important elephant benefit. In reality the amount of meat disbursed to villages was small, considering the distances that needed to be covered and the number of people who were usually present at each carcass. During focal group discussions, many people complained that “you wait all day and all you get is a small piece of meat” (FG notes, Bwazi). However, despite the meagre offerings, the meat was free, and such benefits have been well-received elsewhere (Gillingham & Lee, 1999).

9.4.3 Wider benefits

In addition to revenues and meat, a number of wider benefits from elephants were also mentioned. Elephant dung has several uses, including as a medicine, and as manure. A single farmer recognised the intrinsic value of elephants, stating they should be there for future generations to see. This value was recognised in focus group discussions, even in those areas where people recognised few benefits from elephants. During focal group discussions, many farmers supported the concept of saving elephants for future generations, and others deemed that it was not man's place to decide the fate of the elephants: they were "God's creation and He alone had the right to determine their future" (FG notes, Bonga). This intrinsic right for wildlife to exist was also recognised in communities around Maputo Elephant Reserve in Mozambique (de Boer & Baquete, 1999) and among communities in Guassa, Ethiopia (Ashenafi, 2001).

9.4.4 The linkage between awareness of benefits and conservation

Communities must be aware of the source of benefits, and the direct linkages to the species or ecosystem in question, if they are to have maximum influence upon conservation. Where communities are unaware of the source of the benefits, the purpose of a benefits programme will be undermined (Archabald & Naughton-Treves, 2001). In the mid-Zambezi Valley communities were well aware that revenues were generated by elephant hunting, and indeed, that elephants contributed most of the revenues to CAMPFIRE. In fact, during focal group discussions, many people considered CAMPFIRE revenues and elephant revenues to be the same thing (FG notes Bwazi, Jowa & Majinga). This awareness is unsurprising in light of the intensive and sustained outreach campaign that has occurred in CAMPFIRE districts across Zimbabwe.

Such a linkage between benefit and conservation concern is critical to incentive-based conservation (Wells & Brandon, 1992; Hutton & Leader-Williams, 2003; Walpole & Thouless, 2005). Indeed, the fact that hunting is the major source of revenue generation may contribute to heightened awareness. The consumptive use of wildlife may generate more direct linkages, with a greater sense of ownership, than the non-consumptive alternatives (Leader-Williams *et al.*, 2001), because the benefits they provide are more obviously recognised as coming from a certain species.

9.4.5 CAMPFIRE and offsetting costs

In the Zambezi Valley, safari hunting has provided benefits that are widely recognised. Hunting provides reliable income for areas that may be less-suited to game-viewing tourism (Leader-Williams, 2000; Murphree, 2001), and can be a highly lucrative form of wildlife utilisation (Leader-Williams, 2000; Wilkie & Carpenter, 2001). However, the key with all benefit systems lies with the equity of disbursement: they must generate a net benefit; and, they should take into account the variations in the costs associated with living among wildlife (Murphree, 1993; Child 1995; Walpole & Thouless, 2005).

A pillar of the CAMPFIRE programme was its aim to disburse revenues to the communities bearing the costs of wildlife production, according to the 'producer community principle' (Murphree 1993). However, this study has shown at the village level that the revenues accrued did not reflect the level of costs incurred. In Kasuo village, which was affected by the greatest area of crop damage overall, the smallest amount of revenue had been invested because the village was within a non-producer ward in which the costs of wildlife management were assumed to be negligible. Furthermore, Jowa village received the greatest amount of revenue of all the villages, yet it suffered relatively low amounts of elephant crop damage during 2002. In terms of elephant crop damage it was ranked fifth overall (see Chapter Eight), despite being a 'producer' ward in which the costs of wildlife management were assumed to be high.

The disparity between cost and benefit at the village level arises from the designation of wards as either wildlife producer or non-producer. But the assumptions made about wildlife costs at the ward level do not apply at the village level. Elephants can move large distances in short periods of time, and have been observed performing seasonal movements across the mid-Zambezi Valley (Osborn & Parker, 2003). Therefore, a non-producer ward with no detectable resident population of elephants may be visited by herds of transient elephants on a regular basis. Indeed the Kadzi River, which flows through Kasuo Village, is a regular watering point for elephants during the dry season (*personal observation*).

In addition, elephants may make brief forays from neighbouring wards where resident populations exist. In the Sebungwe, Northern Zimbabwe, Hoare (1999) observed that elephant conflict commonly occurred in wards where there were no resident elephants. This is the case in Kasuo village, where the enumerator identified several woodland areas favoured by elephants, which were locally known as elephant 'bases'. It was believed that the elephants would occupy these bases during the crop-raiding season and conduct crop-raiding forays from them during the night. Two of the bases he showed me were across the ward boundary in the neighbouring Ward 4, just 5 km from Kasuo village. This is an example of why ward-level designation becomes inappropriate at the village level.

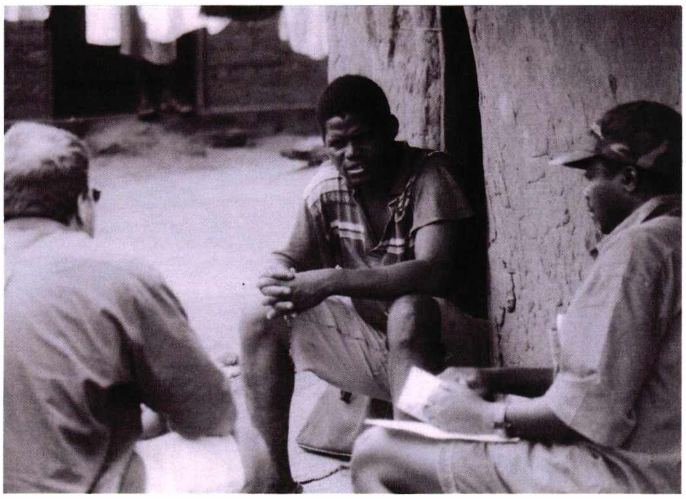
The disparity in revenue disbursement that occurs at ward level is also apparent within wards. Within Ward 4, the greatest revenues were invested in Jowa village, which received the second-lowest ranking of crop damage within the ward. In contrast, Kapururira and Bwazi villages were second-and third-most affected by elephant crop damage, but they received the least revenues. It is clear, even in the absence of records for every village in Ward 4, that the revenue disbursement does not fulfil the requirements of the producer community principle, either at the ward level, or at the village level.

While the current system of producer and non-producer wards acknowledges the different status of wards and their contribution to wildlife production (Bond, 2001), it does not cater for the heavy costs that occur at the boundaries of producer wards, or where transient wildlife passes through villages in non-producing wards. In such cases, a more flexible mechanism of revenue disbursement is required, which can react to the patterns of conflict that occur at the village level. This system would not need to be exclusive of the current system; rather it could augment it by providing payments to communities in relation to the costs they bear.

It is recognised that the ten study villages at the focus of this research represent a small sample of the total number of villages within the study area. Therefore, the amounts of revenue invested in each village do not take into account the amount of revenues disbursed to other villages throughout the area. In addition, this analysis can only be considered as indicative, because it has only been possible to compare the revenue invested over seven years with the crop damage from just a single year. Therefore, it must be borne in mind that the pattern of crop damage described for one year may not represent the long-term patterns of conflict. However, the negative relationship between revenues and costs at the village level indicates that the method of benefit disbursement does not adequately deal with the annual costs of conflict at the village level. As a result, the conditions of the producer community principle do not appear to be met (Murphree, 1993).

In this chapter I have established that while many people perceive there to be no benefits from elephants, the small majority of people acknowledge several direct benefits. However, these benefits were not evenly distributed, nor did they appear to be disbursed in proportion to the costs of living with wildlife. In the following chapter I describe people's attitudes towards elephants, and investigate how such factors as elephant conflicts and benefits influence these attitudes.

Chapter 10 Attitudes towards Elephants



10.0 Introduction

The relationship between rural communities and conservation in Africa has been traditionally poor, in part as a result of the protectionist approaches of colonial and post-colonial administrations. With the more recent shift of conservation narrative from 'fines and fences' to a community-based conservation approach (Adams & Hulme, 1999; Songorwa, 1999), local communities have increasingly sought economic benefits from conserving wildlife, and have been encouraged to participate in the management of natural resources. Consequently, the support of local communities has become central to achieving conservation goals.

Measuring local responses to conservation forms a critical component of CBC research (Mehta & Kellert, 1998), and can guide the design, implementation and evaluation of conservation programmes (Parry & Campbell, 1992). Attitudes may be assessed through a variety of qualitative methods, including interviews (e.g. Naughton-Treves, 1997; Hill, 1998) and questionnaires (e.g. Newmark *et al.,* 1992; Walpole & Goodwin, 2001), or a combination of the two (e.g. de Boer & Baquete, 1998; Hill, 1998). Ranks and scores are commonly used to determine the preference rating of issues, for example measuring the importance of the resource to the individual (de Boer & Baquete, 1998), or grading wild animals according to the problems they cause (Hill, 1997; Naughton-Treves, 1997). Fixed-response questions may be used to gauge attitudes to conservation issues (Mehta & Kellert, 1998; Walpole & Goodwin, 2002). Using multiple methods will increase the reliability of qualitative methods, and enable verification of the response (after Infield, 1988).

Peoples' attitudes towards conservation may be influenced by the benefits that they acquire from it, and the negative consequences of conserving wildlife that conflicts with local interests (Parry & Campbell, 1992; Newmark *et al.,* 1993). There are many examples of benefits influencing attitude. In Uganda, tourism revenue from three national parks was shared among communities at their border, resulting in improved attitudes, reduced illegal activities and increased local participation in national parks meetings (Archabald & Naughton-Treves, 2001). In Tanzania, meat distributed to communities around Selous Game

Reserve stimulated support for conservation (Gillingham and Lee, 1999). The negative influence of conflicts with wildlife is also well documented. Elephant crop damage causes a loss of livelihoods that is potentially catastrophic to the farmer (Naughton-Treves, 1997), engendering negative attitudes towards elephants across the continent (e.g. de Boer & Baquete, 1998; Naughton *et al.*, 1999; Gillingham & Lee, 1999). Incidents of injury and death caused by elephants create fear and raise the profile of elephants among local communities (Hoare, 2001).

Social factors such as ethnic group, religion and education can also influence attitudes towards PAs (Infield, 1998; Heinen, 1993), including gender (Mehta & Kellert, 1998; Hill, 1998), wealth (Gillingham & Lee, 1999), origins (de Boer & Baquete, 1998) and age (Mehta & Kellert, 1998). Personal experience may also influence attitude. In Uganda, for example, the effects of prior experience of elephants upon people's attitudes was explored (Hill, 1998).

Only limited research exists on the attitudes of rural communities towards CAMPFIRE in Zimbabwe. In Mahenye, Murphree (2001) found a positive improvement of attitudes towards wildlife conservation with the establishment of a safari hunting operation, a precursor to the CAMPFIRE programme itself. In Angwa ward, the mid-Zambezi Valley, Welford (2002) documented intensely negative attitudes towards CAMPFIRE, and Dyson (2000) found that local attitudes towards elephants were largely negative, as a response to ongoing crop damage. However, despite the fact that elephants represent both the greatest problems and the greatest benefits to communities, to date community attitudes towards the elephant are little understood. In this chapter I aim to:

- investigate the perceptions of rural farmers towards elephant conservation; and,
- determine the influence of benefits, costs and socioeconomic variables upon people's attitudes towards the elephant.

10.1 Methods

The methodology follows two approaches. First, I undertake a qualitative assessment of people's attitudes towards elephants. Second, I undertake an investigation into factors that influence these attitudes. In the following section I describe the qualitative techniques for assessing and verifying attitudes.

10.1.1 Attitudes

I interviewed a sample of 177 farmers in nine villages using the semi-structured interview methodology (SSI) described in the General Methods section of Chapter Three. I assessed the attitudes of farmers towards elephants using a problem-benefit scoring exercise and two fixed-response questions, which were then combined to form an additive score. This exercise was conducted as a part of the interview survey described in previous chapters.

10.1.1.1 Problem-benefit score

Individual attitudes towards elephants were first investigated through a scoring exercise that measured respondent's perceptions of the problems and benefits caused by elephants. Elephant problems and benefits had been earlier discussed with respondents (see Chapters Six and Nine respectively). Each respondent compared elephant-related problems directly to elephant-related benefits. They were invited to apportion a total of ten points between the problems and the benefits, with a greater number of points indicating a greater strength of attitude. The reliability of this score was cross-checked with an independent problem-benefit exercise carried out during focus group discussions in each village.

10.1.1.2 Fixed response questions

Respondent's attitudes towards elephants were further assessed using two fixed-response questions. The questions explored the participant's views on the importance of the elephant in the mid-Zambezi Valley. Farmers were asked to select the response that most closely matched their views. There were five responses ranging from 1 = strongly positive, 2 = positive, 3 = neutral, 4 = negative and 5 = strongly negative (*c.f.* Mehta & Kellert, 1998; Walpole & Goodwin, 2002). The questions, with the possible responses, were:

Do you think it is important for elephants to exist in the future?

1- Very important
2- Important
3- Neither important nor unimportant
4- Unimportant
5- Very unimportant

To what extent are elephants important to development in the Mid-Zambezi Valley?

1- Very important
2- Important
3- Neither important nor unimportant
4- Unimportant
5- Very unimportant

10.1.1.3 Additive score

The answers from the fixed-response questions and the problem-benefit balance were combined to form a single additive score. In order to give each component equal weighting in the final score, each was converted to a 10-point scale. The problem-benefit score was converted to a scale from 0-10, with zero denoting an entirely positive response, and ten denoting an entirely negative response. The fixed-response question scores were increased from a 5-point to a 10-point scores by multiplying them by two. Each score now ranged from 2-10, with 2 being the most positive and 10 being the most negative.

These question scores were combined with the problem-benefit score to create an additive score ranging from 5-30, with lower scores denoting more positive responses across all questions, and higher scores indicating more negative responses. The internal consistency of this score was examined using Cronbach's alpha (Cronbach, 1951). Cronbach's lies between 0 and 1, with higher values indicating higher consistency.

10.1.2 Variables affecting attitudes

The variables that potentially influence people's attitudes were identified by reviewing current research and from the results of the semi-structured interviews displayed in previous chapters. These variables included elephant-related benefits, issues of human-elephant conflict, and socioeconomic factors. The measurement of each is described in detail below.

10.1.2.1 Benefits

10.1.2.1.1 Revenues

CAMPFIRE revenues had previously been calculated for each village in Chapter Nine. All CAMPFIRE-funded projects that had been undertaken within each of the ten villages over the period 1996-2002 were included in the calculation of 'revenues' (see Chapter Nine). In addition, the number and the type of projects that were implemented using these revenues were also noted.

10.1.2.1.2 Meat availability

In Chapter Nine the number of times meat was available to communities from safari hunting was measured. The number of carcasses within 10km of each village over the period 1996-2002 was recorded as the meat 'score' for that village.

10.1.2.2 Conflict

10.1.2.2.1 Crop damage

Crop damage was identified as the major human-elephant conflict issues by interviewees (see Chapter Six), and were therefore considered likely to influence attitudes. Each of the ten villages had been ranked according to crop damage, based upon the results of a crop damage reporting scheme carried out during 2003 (see Chapter Eight). This overall rank incorporated measures of frequency, area and severity of crop damage incidents, with a rank of one denoting the most crop damage, and a rank of ten denoting the least.

10.1.2.2.2 Human injury and death

Human injury and death was considered the second most important conflict issue (Chapter Six). In order to measure it, each village was categorised according to the number of incidents of human injuries and deaths that had occurred between 1996 and 2002 (Chapter Eight). There were five categories: 1=no death or injury; 2=single injury; 3=single death; 4= multiple deaths; 5=multiple death and injury.

10.1.2.3 Socioeconomic variables

The gender, age, origins and relative wealth of each respondent were determined during each interview. Gender was recorded as a dichotomous variable (0=male; 1=female). Respondents were initially placed into five age categories of <20, 21-30, 31-40, 41-50 and >50. A farmer's origins were described as local (having being born within either Muzarabani or Guruve districts), national (originating from another region of Zimbabwe), or foreign (having emigrated from a neighbouring country).

Wealth was determined from the summed value of agricultural implements and livestock declared by each respondent. Being a predominantly agrarian society, farmers invest in livestock and agricultural implements, and the sum of these items acts as a comparative measure of a family's wealth. The value of implements was adjusted for inflation using the Zimbabwe Building Society Middle Rate to July 2002, and converted to US$ using the appropriate exchange rate (Appendix 9). The wealth categories were: <$100; $100-$500; $501-$1,000; $1,001-2,000; $2,001-$3,000; and >$3,000. The width of the categories varied between $100 and $1000 to ensure an adequate sample size was obtained in each category.

10.2 Analysis

10.2.1 Multivariate analysis

The relative influence of all the above variables upon attitudes was tested using Multiple Linear Regression. A total of eight variables were entered into the regression. In addition to the described variables I entered a new variable called 'village'. Each village was assigned a code in order to investigate the influence of site-related variables that may not otherwise have been identified in this research.

Linear regression is a multivariate technique that assumes linearity and is used to predict a dependent variable from a set of independent variables. Linear regression estimates the coefficients of the linear equation, involving one or more independent variables that best predict the value of the dependent variable (SPSS 12.0). Regression was used to determine which of the identified factors were significant in predicting attitude responses, while controlling for the effect of the others (Mascie-Taylor, 1994).

The model summary table (Table 10.1) shows an example of a regression output. New variables are added in each successive model until the final model is reached. R-square, the coefficient of determination, is the squared value of the linear correlation between the observed and model-predicted values of the dependent variable. The change in R-square between models indicates the amount of change in the dependent variable that is attributable to each additional variable. For example, the variable 'village' is accountable for a change of 0.03 (Table 10.1).

Table 10.1: Example of model summary of linear regression.

Model	Predictors	R-square	Change
1	Revenue	0.244	0.244
2	Revenue + village	0.274	0.03
3	Revenue + village + gender	0.292	0.018

The critical model diagnostics include: the overall R-square value (e.g. 0.292; Table 10.1), the degrees of freedom and the significance value, which in this example were 165 and p=<0.001 respectively. A further priority for analysis is to ensure that the residuals are normally distributed in order to meet the assumptions of the model. There should be no relationship between the residuals and the predicted variables.

10.2.2 Bivariate analysis

Bivariate analysis was conducted between all the independent variables in order to: first, verify the results of the regression analysis; and second, investigate any co-variation between independent variables. Categorical variables such as age were individually tested using the non-parametric Mann-Whitney *U* test for two independent samples and the Kruskal-Wallis test for multiple independent samples. Continuous variables such as wildlife revenues were tested for a directional relationship using the non-parametric Spearman's Rho correlation test. All analyses were conducted in SPSS 12.0.

Any unexpected relationships that resulted from the regression analysis were investigated by plotting the variable of interest against the residuals of a regression conducted with that variable excluded. If the relationship was found to be heavily dependent upon the leverage of a few outliers, it was discounted as spurious.

10.3 Results

10.3.1 Attitudes

10.3.1.1 Problem-benefit score

The scores resulting from the problem-benefit exercise were skewed towards negative attitudes, indicating that overall, problems exceeded benefits. These scores correlated strongly with an identical exercise conducted during the focus group discussions, indicating that the scoring system was a robust and reliable means of measuring attitude across villages.

10.3.1.2 Fixed-response questions

Farmer attitudes were further determined from the responses of participants to two fixed-response questions. The scores displayed a negative skew similar to the problem-benefit score.

10.3.1.3 Additive score

The problem-benefit score and the scores for questions 1 and 2 were combined into a single additive score. This score displayed a high level of internal consistency (Cronbach's Alpha = 0.83), which exceeded previously accepted scores (0.61 in Walpole & Goodwin, 2001; 0.63 and 0.68 in Mehta & Kellert, 1998). This indicates there was close agreement between the three components of the score.

The additive attitude score displayed a strong negative skew, indicating a bias towards negative attitudes (Figure 10.1). One hundred and thirty two respondents (75%) held predominantly negative attitudes towards elephants. Of these, 39 (22%) were strongly negative and 88 (50%) were negative. Twenty three respondents (13%) were neutral in their views towards elephants. Forty five (25%) respondents held views that were predominantly positive, of which 23 (13%) were positive and four (2%) were strongly positive (Table 10.2). From this point forward discussions of 'attitude' will refer to this additive attitude score.

Figure 10.1: Distribution of additive attitude score.

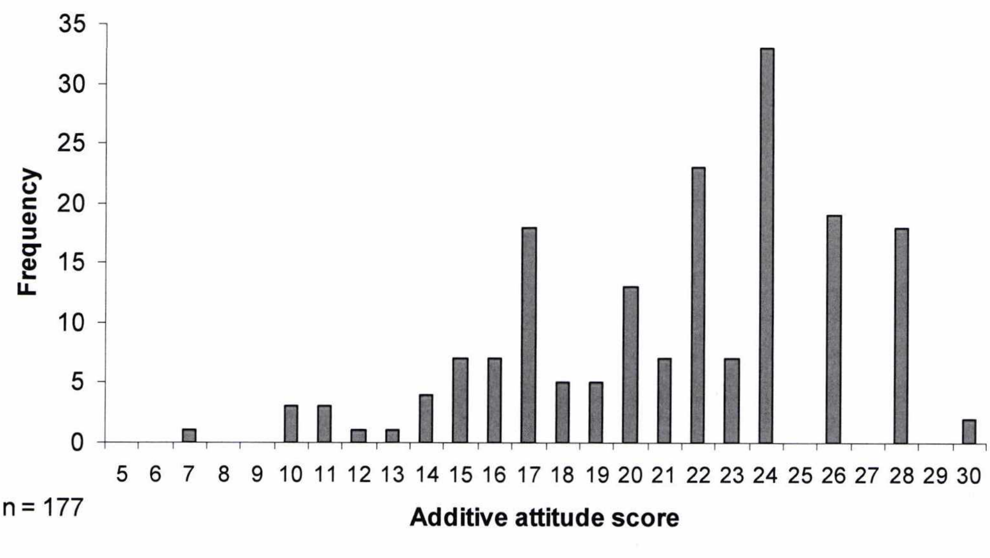


Table 10.2: Additive attitude score responses.

	Very positive	Positive	Neutral	Negative	Very negative
Score	**5-10**	**11-16**	**17-18**	**19-24**	**25-30**
Frequency	4	23	23	88	39
Percent	2	13	13	50	22

10.3.2 Variables affecting attitude

In the following section elephant benefits, human-elephant conflict and socioeconomic variables are described in turn prior to their inclusion in the multivariate statistical analysis.

10.3.2.1 Benefits

Both revenues and meat have been quantified as benefits from elephants for each study village in Chapter Nine. Total revenues for each village for the period 1996-2002 are displayed in Table 9.2, and log-transformed values were entered to the regression as they appear in this table. Meat availability in each village for the same period is displayed in Table 9.3. The meat 'score' for each village was added to the regression analysis.

10.3.2.2 Conflict

Both elephant crop damage and incidents of human death and injury have been quantified for each study village in Chapter Eight. Crop damage for each village during 2003 is displayed in Table 8.1, and these were entered into the regression as the overall rank score for each village. The number of incidents of human death and injury that occurred during 1996-2002 in each village are displayed in Table 8.3, and these too were entered into the regression.

10.3.2.3 Socioeconomic variables

One hundred and thirteen respondents were male (64%) and 64 were female (36%). Only two respondents were under twenty years of age, so this category was merged with the with the 20-30 year category to create a single category of <30 years, which comprised 59 (33%) respondents. Forty two (24%) respondents were in their thirties and 29 (16%) were in their forties. Thirty nine (22%) respondents were >50 years of age. The majority of respondents originated from within the mid-Zambezi Valley: 99 (56%) respondents were classified as local, whereas 64 (36%) respondents were Zimbabwean from another province, and 10 (6%) respondents were from another country.

Seventy three (41%) respondents fell into the lowest wealth category, owning livestock and farming implements to a total value <US$100. Twenty two (12%) respondents owned between US$100 and $500 of assets; while 29 (16%) owned between US$500 and $1000; 24 (14%) owned between US$1000 and $2000; and 20 (11%) owned between US$2000 and $3000 of assets. Nine people (5%) owned livestock and equipment worth more than US$3000.

10.3.3 Multivariate analysis

The multivariate analysis identified four factors as being significant in predicting the attitudes of 177 respondents towards elephants. The model explained much of the variation in people's attitudes towards elephants (r^2=0.567; df = 176; p=<0.001). The residuals were normally distributed and did not display any pattern with the predicted variables. The significant variables were: revenues spent on community projects within each village; the incidence of human death; investment in clinics, and finally, the overall rank of crop damage by elephants (Table 10.7).

Table 10.3: Model summary of linear regression.

Model	Predictors	R-square	Change
1	Revenue	0.449	0.449
2	Revenue + human death	0.493	0.044
3	Revenue + human death + clinic	0.547	0.054
4	Revenue + human death + clinic + crop damage	0.567	0.020

Revenue was the strongest predictor of attitude, displaying an R-square value of 0.449. This negative relationship indicated that as revenues increased, so the attitude score decreased and attitudes became more positive. Human death displayed an R-square value of 0.044; the positive relationship indicating that as the number of incidents of death and injury rose, so the attitudes towards elephants worsened. The variable 'clinic' displayed an R-square value of 0.054. This negative relationship indicates that villages in which CAMPFIRE-funded clinics occurred harboured more positive attitudes. Finally, the total area of crop damage in each village caused an R-square value of 0.020. Somewhat counter-intuitively, the negative relationship indicated that as the area of crop damage across villages increased, so the attitudes towards elephants improved.

10.3.4 Bivariate analysis

The bivariate analyses corroborated the results of the regression analysis, except in the case of crop damage, which did not correlate with attitude scores (r_s=0.08; p=0.29; Spearman's Rho correlation test). Crop damage rank was plotted against residuals, which confirmed the positive relationship between crop damage and attitude. Gender was found to significantly influence attitude, even though it was not a significant factor in the regression analysis. The weak positive correlation (r_s=0.20; p=<0.01; Spearman's Rho correlation coefficient) indicated that women held more negative attitudes towards elephants than did men.

10.4 Discussion

In this chapter I have completed the first analysis of the attitudes of rural communities towards elephant conservation within a CAMPFIRE district in Zimbabwe. I have demonstrated that attitudes towards elephants are largely negative, but that some respondents hold positive attitudes towards elephants. Attitudes towards elephants were mainly influenced by the amount of CAMPFIRE revenues invested in community projects around each village. They were also affected by the incidence of human death and injury, and the specific funding of clinics by CAMPFIRE. Finally, attitudes were also affected by the total area of crop damage within each village.

10.4.1 Attitudes towards elephants

Attitudes towards elephants were predominantly negative across the study area. The 177 respondents displayed the full spectrum of attitudes, from strongly negative to strongly positive, but the majority fell within the negative range. Negative attitudes towards elephants are common among rural communities, and have been documented across the African continent (Naughton-Treves, 1997; Naughton *et al.,* 1999; Hoare, 2000), and also within the Zambezi Valley (Dyson, 2000). The reason for such attitudes lies in the distribution of costs and benefits from elephants, which have been found to be out of balance elsewhere (Kangwana, 1995). The major issues influencing attitude are discussed below.

10.4.2 Revenues and attitude

The strong positive correlation between revenue and attitude indicates that revenues disbursed for social projects at the village level have a strong influence upon attitude within the mid-Zambezi Valley study area. People harboured more negative attitudes where revenues were low, and more positive attitudes where revenues were high. Revenue was the single greatest variable affecting people's attitudes towards elephants, a result that fits with the findings of previous research. Revenues have been identified as the most important benefit in Tanzania (Gillingham & Lee, 1999) Uganda (Archabald & Naughton-Treves, 2001), and Ethiopia (Zelealem, 2001), among other places.

10.4.2.1 Positive influence of revenues

There are several reasons why communal revenues positively influence attitude within the mid-Zambezi Valley. First, the investment in several locations has been substantial. For three villages in Ward 4, the total investment amounted to over US$100,000 each for the period 1996-2002. Such large sums are sufficient to make a difference to rural communities. Adequate funding has been identified as a pre-requisite for successful benefit schemes elsewhere (Archabald & Naughton-Treves, 2001).

Furthermore, the investment has financed some major infrastructural projects. These projects improve the services of an area that has historically suffered from poor infrastructure (Cumming & Lynam, 1997). Revenues have been invested in schools and clinics (Chapter Nine), and such community projects have a broad influence upon a community because all but the very poorest community members will have access to the projects (e.g. Archabald & Naughton-Treves, 2001). Infrastructural improvements have been identified as the most desired output for communities in Nepal (Mehta & Kellert, 1998).

Clinics were the only project type that was individually identified by community members in the mid-Zambezi Valley. In an area with poor infrastructure in which diseases such as malaria are commonplace, clinics may be perceived as a critical service with the potential to save lives.

A large proportion of CAMPFIRE revenues went to the employment of local staff, who were employed as game scouts, anti-poaching unit personnel and camp guards for the safari hunters. The mid-Zambezi Valley has low potential for formal employment (Welford, 2002), and such local jobs can constitute a major benefit of community-based conservation to local communities (Walpole & Thouless, 2005).

While it is recognised that the calculation of 'total' revenue in this analysis may inflate the value of the overall investment, and indeed, duplicate the investment of some projects, this means of calculating CAMPFIRE expenditure is robust. If revenues are reduced to ranks, instead of actual US$ values, the pattern of influence upon attitudes remains the same, indicating that this means of revenue calculation is reliable.

10.4.2.2 Negative influence of revenues

While high revenues exerted a positive influence upon attitudes, at the other end of the scale low revenues generated a negative influence. Negative attitudes arose for several reasons: first, there was inequitable distribution of revenues among villages; second, in some areas the wildlife revenues had been terminated due to a change in policy; and third, the revenues disbursed did not relate to the costs of wildlife at the community level (see Chapter Nine). These issues are discussed in full below.

10.4.2.2.1 Inequitable distribution of revenues

The inequitable distribution of revenues created negative attitudes in communities with lesser investment. In this study the residents of Jowa were considered by other villages to be the 'privileged' party to which the highest amount of revenues was distributed. Farmers in other villages within Ward 4, such as Bwazi, had their crops damaged every day, yet the benefits all ended up in Jowa village at the other end of the ward (FG notes, Bwazi). In Tanzania, a similar situation was documented. Benefits from wildlife in Selous that were distributed to communities were shared mainly among the privileged and this caused resentment among the majority of the community members (Gillingham & Lee, 1999), and created mistrust of the authorities.

10.4.2.2.2 Producer and non-producer Wards

The Guruve and Muzarabani RDCs designated each ward as either a wildlife producer, or a non-producer. However, the designation has changed in the recent past, causing intense resentment. Ward 6 used to be a producer ward with wildlife revenues flowing to community projects, but have since been terminated. A change in policy in 1996 designated Ward Six as a non-producing ward. The councillor was angry that his ward no longer received wildlife management benefits. His ward suffered from wildlife conflict from lions and elephants passing between Ward 4 and the escarpment mountains, but his people received precious little in the way of compensation (FG notes, Kasuo). The councillor intimated that people in his ward were more likely to shoot animals because of the conflict they suffered. Once communities have expectations of benefits and they are removed, park-community relations will be soured (Archabald & Naughton-Treves, 2001). A similar case occurred in Kenya: when the KWS failed to deliver the promised 25% of Park income to communities around Tsavo NP, community members threatened violence and mobilized to invade the park (Sindiga, 1999).

10.4.2.2.3 Revenues and conflict

As documented in Chapter Nine, the CAMPFIRE revenues did not appear to reflect the costs borne by communities living with wildlife. Instead of increasing with crop damage, revenues were found to decrease in areas where the crop damage was most severe. CAMPFIRE aims to provide economic incentives to those who bear the costs of wildlife production (Murphree, 1999). However, this result clearly illustrates the chasm between revenue distribution and wildlife conflict on the ground. Economic benefits from wildlife will only be viewed as an incentive for community wildlife conservation where they are distributed in relation to the costs incurred (Emerton, 2001).

The system of producer and non-producer Wards creates conditions for inequity, because the assumption that conflict will be negligible in non-producer wards is flawed. Elephants destroyed crops in both Masomo and Kasuo villages, both within the non-producer Ward 6 of Lower Guruve. With no quota for hunting and only limited access to shared revenues, farmers in Ward 6 faced a situation where the costs of elephants were not offset by any significant benefits. Under such circumstances, it is not surprising that rural communities engender negative attitudes towards elephants. In Angwa ward, Guruve district, residents considered wildlife as a major impediment to agricultural development. The benefits from wildlife were so trivial in comparison to the costs that the second-most important development need was the removal or eradication of wildlife (Cutshall & Hasler, 1991). Such sentiments represent the failure of the CBC system.

What is required is a system of disbursement that is able to address the high costs accruing in villages at the boundaries of productive wards. In villages such as Kasuo, which lies close to the boundary of Ward 4, a system along the lines of park outreach might be suitable. Recognising that the conflict is in fact a cost resulting from the producer ward, it could be argued that an isolated village at its boundary should be compensated from the producer ward. Addressing such conflicts would be a major step in balancing the costs of wildlife production, and influencing perceptions in areas where attitudes towards conservation are extremely negative.

10.4.2.2.4 The type of benefit

The provision of benefits to communities may not provide the incentives for conservation they intend to. Most CBC programmes assume that improving livelihoods of local people will inevitably lead to the adoption of externally-introduced conservation norms (Welford, 2002). However, the provision of economic benefits, while important, may not in itself be a sufficient condition for wildlife conservation (Emerton, 2001).

One reason for this is that the broad community benefits delivered from conservation projects do not address the underlying forces that motivate the destruction of wildlife and natural resources (Emerton, 2001). People suffer crop damage by wild animals, which impacts their livelihood security, yet the form in which benefits are shared rarely provide compensation for the loss of income suffered by the beneficiaries (Emerton, 2001). Therefore, such benefits do not address the costs to livelihood that the farmer suffers.

10.4.3 Crop damage and attitudes

There was an unexpected relationship between the amount of crop damage caused by elephants and people's attitudes towards elephants within each village. Community attitudes were more positive in villages in which crop damage was greater. This relationship is counter-intuitive, cannot be accounted for in any logical way.

Elephant crop damage is considered the most serious of wildlife conflict issue across the study area (Chapter Six). It is a cost that impacts upon farmer's livelihoods and it would be expected to give rise to negative feelings. In previous research crop damage engendered strongly negative attitudes towards CAMPFIRE and conservation in Angwa ward (Welford, 2002). In other studies across Africa crop damage has engendered negative attitudes towards wildlife and protected areas (e.g. Hill, 1997; de Boer & Baquete, 1999; Naughton *et al.*, 1999). So why is this not the case, at least with the current data set, in the mid-Zambezi Valley?

First, it is likely that attitudes are influenced by conflict that has occurred over a number of years. The crop damage reporting scheme only measured crop damage during 2003, and was not sufficient to capture the longer-term trends. Elephant crop-raiding patterns can be patchy and vary between years (Naughton *et al.*, 1999), and there are few spatial correlates with which to predict the location of conflict (Hoare, 1999). This means that the amount of crop damage an individual suffers may vary enormously between years. A farmer who experienced serious crop damage in the previous two years, but none in the current year, may express negative attitudes towards elephants based upon his previous years' experience. In light of this, measuring just the current year's crop damage was not sufficient to capture these longer-term trends.

Second, crop damage is a cost borne by the individual (Naughton-Treves, 1997), with most farmers loosing nothing, and only a few individuals suffering catastrophic loss (Ngure, 1995). Therefore, in contrast to the broad influence of revenues, crop damage may only influence a few people strongly.

10.4.4 Human death and attitudes

The incidence of human deaths and injuries caused by elephants had a significant upon attitudes, with increasing incidents creating more negative attitudes. Human death was considered by farmers to be the second greatest HEC issue within the mid-Zambezi Valley. In previous research, death and injury by any wild animal has elicited a strong response. Any animal taking human lives is considered to be 'intolerable' (Abound, 1986, *in* Naughton *et al.,* 1999). Elephants are less tolerated than other wildlife species for the very reason that they are dangerous to people (Naughton *et al.*, 1999; Hoare, 2001).

10.4.5 Meat and attitudes

The provision of meat did not affect peoples' attitudes towards the elephant. Although identified as the second greatest elephant benefit by the majority of respondents, it did not impact upon individual attitudes. Meat was considered an elephant benefit within the study area; however, it was heavily criticised for its rarity and the high competition. "You travel for 10km with a bucket and then when you get there nothing is left" one embittered farmer stated (FG notes, Bwazi). In most of the ten study villages an elephant was shot on average once per year or less. Even if an elephant was shot close to a village so many people would turn up to the carcass that the portions on offer were very small and many left empty-handed. In addition the majority of elephants were shot within reach of several villages and the competition for meat was therefore even more intense.

The provision of wildlife meat has positively influenced attitudes towards elephants in communities around SGR, Tanzania. Meat was the primary benefit from the Park and was supplied in large amounts direct to the villages (Gillingham & Lee, 1999). Each village received 6 wildebeest and 3 buffalo per year, far in excess of that received from elephants by villages in the mid-Zambezi valley.

It is acknowledged that the measure of meat used here: namely, the number of elephant carcasses within 10km of each village, may not be the most effective indicator of the meat benefit. This is because many of the carcasses may have fallen within 10km of several villages, and therefore the meat would have been potentially shared among the residents of all these villages. The greater the number of villages within walking distance, the lesser the benefit to each individual.

In addition, I assumed that meat would have been equally accessed by all members of a village. This is not likely to be the case: some individuals may have been informed of the hunting early in the day, and arrived at the carcass in good time to receive a large portion of meat, whereas others would have come later and received less. Still others would not hear the news until it was too late, and all the meat had been distributed. Therefore, the 'benefit' of meat would vary greatly according to the individual.

10.4.6 Socioeconomic variables

No socioeconomic variables significantly influenced attitude in the multivariate regression analysis. However, the bivariate analysis indicated that women did have more negative attitudes towards elephants than did men. Women may feel marginalised in the process of making decisions about revenue distribution. In a patrimonial society, such as that in MZV, community meetings are male-dominated and decisions about wildlife revenues will certainly be controlled by men. This was also the case in Nepal, where women were marginalised from the management of community forests and their lack of involvement meant they supported the programme significantly less than their male counterparts (Mehta & Kellert, 1998). By this same process women may be less aware of the benefits of elephants because they are less motivated to attend such meetings where decisions are made.

10.4.7 Participation and poor relations between community and authority

Participation underpins the normative theory of community-based conservation. It defines the shift in focus from centralised state-controlled resource management to devolved community-oriented programmes. In Zimbabwe the CAMPFIRE programme embodies this ideology, yet in practice it is not fulfilled. Originally it was envisaged that rural farmers would participate as community cooperatives in the management of natural resources. However, the management of natural resources remained with Local Government and devolution was left at the discretion of the Councils. Such sentiments have been voiced repeatedly in the mid-Zambezi: farmers complain of the problems caused by 'their' animals (FG notes, Soka) ('them' being the local government), and identify the RDCs as being responsible for the wildlife. In Soka Village one respondent claimed that all the animals, but especially the elephants, belonged to government, and they should come here to manage them properly (FG notes, Soka). This reflects the views of Murombedzi (2001), who claims that community participation has been reduced to the 'receipt of handouts'.

In some cases, the 'decentralisation' of CAMPFIRE has become a 'recentralisation' to district-level elite (Murombedzi, 1992). The result has been hostility towards the CAMPFIRE programme, mistrust of the Councils and increasing intolerance of wildlife (Jones & Murphree, 2001).

Participation is a highly desirable goal but if the potential is not realised, communities may be antagonised. In Botswana rural people held negative attitudes towards conservation despite a large income from safari hunting because they were not able to participate in decision-making (Parry & Campbell, 1992). Local participation in NGO projects is often limited to minor decision-making and the acceptance of material benefits rather than the active participation in wildlife management (Gillingham & Lee, 1999). While not the focus of this research, focus group discussions revealed discontent with the process of participation that agreed with the findings of Welford (2002). Participation in CAMPFIRE resource management and benefit decisions was perceived to be negligible, with all the major decisions being taken by the politicians. Such a situation could strongly influence affect attitudes towards conservation within the mid-Zambezi Valley, as well as in CAMPFIRE districts across the country.

10.4.8 Mistrust of authority

Many people expressed mistrust at the District Council's management of wildlife and revenues, which arose from suspicions of inequitable distribution of benefits. Several farmers from the Bwazi and Majinga areas complained that the Council workers were charging for elephant meat, when it should have been distributed for free. Farmers view this as a great injustice: "The animals take away our sadza (Maize), and then we have to pay for the meat" one farmer commented (FG notes, Majinga). Such perceived misuse of revenues by the relevant wildlife authority can increase tension between communities and conservation bodies (Archabald & Naughton-Treves, 2001). Strengthening the relations between community and wildlife management authority has been widely viewed as a critical activity for CBCs. Without such action, and increasing transparency and accountability, there is little chance of reaching conservation and development goals (Gillingham & Lee, 1999).

In this chapter I have shown that attitudes towards elephants are largely negative. I have demonstrated that the economic benefits of CAMPFIRE are the chief influence upon attitude: where they are plentiful they influence positive attitude; and where they are insubstantial and poorly distributed they engender strongly negative attitudes. In the following chapter I summarise the findings of this research in its entirety. I then discuss the future of elephant management in the mid-Zambezi Valley, drawing upon the findings of this research.

Chapter 11 Elephant Management and Community-based Conservation

11.1 Summary of findings

This thesis presents new research into the interaction between humans and elephants where they coexist within the context of community-based conservation. Through this research, I define the most important issues of conflict between rural farmers and elephants, and examine the characteristics of the benefits that are generated by the CAMPFIRE programme. Critically, I explore local support for elephant conservation, and how the interaction of costs and benefits influence the nature of this support. These findings are relevant to CBC programmes across southern Africa, where economic benefits are used as incentives for the conservation of wildlife outside protected areas. What follows is a summary of the main findings of this thesis, which are then discussed in the context of elephant management.

11.1.1 Community-based conservation

Community-based conservation programmes seek to redress the imbalance of the colonial and post-colonial preservationist style of conservation (Adams & Hulme, 2001), by actively involving local communities in biodiversity conservation (IUCN, 1980; WCED, 1987), and by providing economic benefits as an incentive for sustainable management (Gibson & Marks, 1995; Leader-Williams & Hutton, 2005). Such benefits can generate support for conservation locally (e.g. Archabald & Naughton-Treves, 2001). However, the performance of such programmes has been highly variable, while CBCs have only recently been the subject of objective assessment, having enjoyed the status of a 'privileged' solution until now (Adams & Hulme, 2001).

The CAMPFIRE programme encourages the sustainable use of wildlife through the provision of economic incentives (Steiner & Rihoy, 1995). Revenues from the trophy hunting of elephants and other large mammals has provided a wide range of social benefits to the communities of the mid-Zambezi Valley. Elephants represent the key resource to the CAMPFIRE programme in Guruve and Muzarabani districts, which are hunted according to careful quota setting. However, the perpetuation of elephants within these districts is threatened by the expanding human population and their inexorable activities of settlement, cultivation and resource collection.

11.1.2 Elephants and human activities

In this study, cultivation did not have a discernible effect upon elephants, probably because the overall transformation of habitat for the two districts remained below the 50% threshold identified by Hoare & du Toit (1999). However, elephants did avoid coming to within 1km of settlement, probably due to the intense activity of people and the lack of natural vegetation that is typical around settled areas. Beyond 1km from settlement, elephants were relatively abundant. Settlement was sited around locations of permanent water, a critical resource for elephants in the hot dry season. Such a situation creates likely conditions for conflict between people and elephants during this time of year, as elephants must pass close to settlement in order to access water (Chapter Five).

In addition to physical settlement, the resource collection activities of rural communities were also avoided by elephants. Most rural communities within the Zambezi Valley are reliant upon natural resources (Cumming & Lynam, 1997), which are collected from the woodland surrounding settlement. The elephant's tolerance to such activities appears to be governed by a threshold similar to that described by Hoare & du Toit (1999) for land transformation: at low levels elephants are able to abide such activities, but when they reach a certain level, elephants can no longer tolerate them and they are displaced (Chapter Five).

Intensive human activities may be responsible for the local extirpation of elephants in riverine woodland along the Musengezi River (Chapter Five). In recent years, elephants have stopped using riverine habitats, most probably in response to the increasing human population, and the consequent use of resources within such areas. This has implications for the future of CAMPFIRE within the study area: resettlement continues and is largely beyond the control of the RDCs (Murombedzi, 2001). Therefore, it is inevitable that increasing human populations will lead to diminishing returns from wildlife revenues (Bond, 1999).

11.1.3 Human-elephant conflict

11.1.3.1 Crop damage

Rural farmers in the mid-Zambezi Valley considered that of all large mammals elephants presented the greatest threat to their livelihoods. Elephant conflicts were considered on a par with such critical development issues as the lack of reliable water supply, which is of great importance in the semi-arid conditions of the study area (Chapter Six).

Farmer's perceptions of the five 'worst' problem animals reflected the frequency and the total area of crop damage that each animal inflicted (Chapter Seven). More importantly, the animals considered worst were those capable of inflicting the largest areas of damage in a single incident. This confirms the theory that farmers are sensitive to extreme damage events (Naughton-Treves, 1997), which can severely impact a farmer's livelihood in a single incident.

The greatest threat that elephants presented was through their damage to wet season crops. Elephants caused both the most extensive damage, and the greatest overall area of damage of any problem animal. The amount of damage caused in a single incident was dependent upon the number of elephants within a group. Large groups of elephants, though rare, were responsible for the extensive damage incidents that farmers so feared (Chapter Eight).

Damage to dry season crops was considered far less significant than damage to wet season crops, on account of the fact that dry season crops were supplementary to diet, as opposed to staples such as maize (Chapter Six). In addition, the area of crops damaged was far less in the dry season, on account of the discrete garden areas under cultivation at this time of year (Chapter Seven).

11.1.3.2 Human death

Human death and injury was considered the second greatest threat posed by elephants; a serious problem that influenced attitude (Chapter Ten), but one whose significance was reduced by the infrequency of occurrence (Chapter Six). In the absence of details of the circumstances in which people were injured, it is difficult to determine patterns of risk. However, it is likely that the situation would be similar to Kenya, where the majority of people killed or injured were walking at night under the influence of alcohol (Sitati *et al.*, 2003).

11.1.3.3 Additional conflict

The broad range of additional costs incurred by the presence of elephants was considered insignificant in comparison to the direct impacts of crop damage and human death. Such issues as damage to wild fruit trees, fear of walking at night and damage to temporary wells, although varied and numerous, were not afforded the same importance by communities (Chapter Six), most likely because such conflict issues did not directly affect the production of staple food. In addition, farmers could reduce the risk of such additional conflict situations by avoiding the activities that led to their occurrence.

11.1.4 Benefits from elephants

Benefits from conservation were predominantly disbursed to communities for the development and maintenance of social projects, such as schools, and the employment of wildlife staff. The source of revenues was widely acknowledged across the study area, with the link between elephant hunting and revenue disbursement being well established in people's minds (Chapter Nine).

The value of revenues, and the mechanism for their disbursement, had substantial effects upon people's attitudes towards elephant conservation. Where benefits were large, they were widely acknowledged (Chapter Nine). Conversely, where investment was low, community members tended not to acknowledge any benefits at all. The means of disbursement was inequitable, with large amounts of revenue being invested in just a few villages. The value of the investment in the three top villages was more than ten times higher than the investment in other villages (Chapter Nine).

11.1.5 Offsetting costs

It can be reasonably assumed that within the mid-Zambezi Valley crop damage is the greatest cost accruing to rural communities from wildlife (Chapter Six). The benefits of CBC programmes such as CAMPFIRE are intended to offset the costs of those living alongside wildlife (Leader-Williams & Hutton, 2003), as embodied in CAMPFIRE's producer community principle. In order to evaluate CAMPFIRE's success at offsetting costs it would be necessary to study the economic value of both the costs and the benefits that are derived from elephants.

11.1.5.1 A cost-benefit analysis

To successfully offset the costs of human-elephant conflict, any elephant-derived benefits must meet or exceed the value of the costs incurred. Comparing the costs and benefits directly necessitates a detailed economic assessment of both – something that is beyond the scope of this research. However, it is possible to generate a crude estimate of the financial value of crops damaged by elephants and compare this to the financial value of benefits for a single year. Such a calculation necessitates a number of assumptions to be drawn, and the use of estimated values, and as such should be considered nothing more than an indicator of the magnitude of the costs as compared to the magnitude of the benefits derived from elephants.

11.1.5.2 Calculating the value of elephant crop damage

The financial value of elephant crop damage was estimated from the crop damage data collected in 10 study villages during 2003 (Chapter Eight). The total area of crop damage (Figure 8.2) for each crop was converted to harvested weight using published yield values (FAO, 2003), with the assumptions that first, in every incident the area of crops damaged was totally destroyed, and second, yields did not vary with location.

Table 11.1: Crude financial value of crop damage per crop type, based upon crop damage recorded in the ten study villages during 2003.

Crop	Total area damaged Ha	Yield tonnes per Ha	Damage tonnes	Value US$ per tonne	Total value of damage US$
Sorghum	8.72	0.47	4.10	500	2,049.20
Maize	7.14	0.46	3.28	840	2,758.90
Cotton	2.53	0.47	1.19	710	844.26
Other	1.61	0.22	0.35	500	177.10
Total:					**5,829.46**

11.1.5.3 Calculating the value of elephant benefits

The financial value of elephant benefits was calculated for each of the ten study villages for the period 1996-2002 in Chapter Nine (Table 9.1). In order to compare favourably with the crop damage values for 2003, the mean financial value of benefits for all ten villages was calculated for a single year. This simply involved dividing the total benefits by seven years:

US$ 127,184.30 / 7 = US$ 18,169.19.

11.1.5.4 Comparing costs and benefits of elephants

The mean financial value of benefits for the ten study villages in a single year was US$ 18,169.19, more than three times the value of crop damage that was experienced in 2003, which was US$ 5,829.46. This indicates that investment from elephant revenues far exceeded the costs of crop damage across the study area.

However, it should be noted that crop damage values may be inflated because in many incidents of crop damage the crops within the area of damage may not have been entirely destroyed, as has been assumed in this calculation. In addition, the benefits figure is a mean value over ten years, whereas the crop damage figures represent the damage caused by elephants in a single year. Bearing in mind the huge variations exhibited spatially and temporally by elephant crop damage, the 2003 figures may not be representative of levels of crop damage occurring during the ten year period.

Despite these limitations, it is possible to tentatively conclude that the benefits of CAMPFIRE greatly exceed the costs of conflict, and therefore the programme provides a net benefit to the rural communities studied. Nevertheless, communities generally felt that the problems from elephants outweighed the costs (Chapter Ten). The many potential reasons for this imbalance are explored in turn below.

11.1.5.5 Benefits in different form to costs

The form that benefits take may not be suitable to offset the costs of living with elephants, for several key reasons. First, community projects provide general benefits, yet the costs of crop damage are borne by the individual farmer (Naughton-Treves, 1997; Walpole & Thouless, 2005). A few individuals are seriously affected by conflict, while the majority are impacted only in a minor way. In the mid-Zambezi Valley the benefits of improved infrastructure were well-recognised (Chapter Nine), especially in light of the 'frontier' status of the region (Cumming & Lynam, 1997). However, many farmers complained that the general benefits of social projects did nothing to compensate their personal loss.

Second, social projects such as those provided by CAMPFIRE undoubtedly improve community welfare. However, where farmers' crops are damaged, such incidents directly affect their ability to feed their families and generate income. In these circumstances social projects do nothing to compensate for this impact upon livelihood (Emerton, 2001), especially when the farmers are unable to afford school fees or medicines, and cannot therefore benefit from the social projects.

11.1.5.6 Benefits were not distributed in relation to the costs

Despite the high overall investment in community projects, benefits were not evenly spread among the villages studied. This created a situation where a few villages received benefits far in excess of the majority of villages. In these few villages, the investment was likely to generate support for conservation, but in the majority of villages the small investment was insufficient to engender community support.

The disbursement of benefits did not appear to reflect the level of wildlife costs. This was highlighted in the case of Kasuo village, which suffered the greatest crop damage but received the lowest revenues of all the study villages (Chapter 9). Jowa village on the other hand received the greatest investment whilst suffering only minimal crop damage.

This inequity was aggravated by the ward-level disbursement of benefits. Revenues were disbursed according to the wildlife designation of wards, as either a 'producer' or a 'non-producer'. While this system differentiates between wards that produce wildlife, and those that merely benefit from the opportunistic harvesting of wildlife from neighbouring wards (Bond, 2001), the ward-level designation is too crude to reflect the incidence of conflict at the village level. Villages in wards designated as non-producers suffered high levels of human-elephant conflict, yet received very little in the way of benefits (Chapter Nine).

11.1.5.7 Additional costs of living with elephants

In addition to crop damage, there were many other costs associated with elephants. These included: risk of death and injury, prioritised as the second most important issue; fear of moving at night; and, competition for a range of natural resources. Such conflicts have not been considered in this analysis, and indeed, many of them would prove difficult to value economically. But for communities they formed a component of the costs of living with elephants, which contributed to the perception that the costs of elephants exceed the benefits.

11.1.6 Community attitudes towards elephants

Most respondents within the mid-Zambezi Valley harboured negative attitudes towards elephants and their conservation (Chapter Ten). Such negativity stemmed from the inequitable disbursement of benefits and the high levels of conflict in several localities, which have been considered a major obstacle to community support for conservation initiatives elsewhere (Naughton *et al.*, 1999).

CAMPFIRE benefits, which are intended to provide incentives for conservation, were the greatest influence upon people's attitudes to conservation discovered in this research (Chapter Ten). Benefits in the form of social infrastructure did genuinely appear to improve attitudes towards conservation, as has been discovered elsewhere (Mehta & Kellert, 1998; Archabald & Naughton-Treves, 2001). However, their influence was dependent upon the value of the benefit provided. Where investment in community projects was high, attitudes towards elephants were positive (Chapter Ten), but where investment was low, attitudes were consequently negative. Of all the social projects, clinics appeared to make the greatest impact upon attitude, even though investment in these facilities was far lower than for schools.

While some positive effects of benefits may have been discerned, the poor disbursement of revenue also contributed to the negative attitudes so endemic to the area. Any positive impacts of benefits were eroded by their inequitable distribution and by their subsequent low value in many locations. Adequate funding is a pre-condition for the success of economic incentives for conservation (Archabald & Naughton-Treves, 2001). Previous research into CAMPFIRE has acknowledged that the revenues generated by the programme's activities are too small to create incentives for institutional change at the community level (Bond, 1994). The problem of insufficient revenues was further exacerbated by a distribution mechanism which did not account for the patterns of wildlife costs.

11.2 Summary of management issues

11.2.1. Reducing habitat loss

With a rapidly increasing human population relying upon farming and natural resources to subsist (Cumming & Lynam, 1997), there is a real risk that elephants will be driven from large areas of the mid-Zambezi Valley through settlement and resource collection activities. Needless to say, a reduction in the density of elephants within the study area would dramatically impact upon the generation of CAMPFIRE revenues.

It has been postulated that human densities affect wildlife revenues in a non-linear fashion: beyond a point of transition of approximately 9-10 people per km^2 the revenues earned from wildlife decreases dramatically (Bond, 1999). Therefore, increasing human settlement within the study area will inevitably lead to a reduction in the value of the benefits disbursed from CAMPFIRE. Such a threshold response difficult to manage for because there is no warning or gradual decline. There are also no guarantees elephants would return to an area if the levels of human activity returned to below the critical threshold.

11.2.1.1 Land-use planning

Land zonation is considered a key component of conflict resolution (Hoare, 2000; Barnes *et al.*, 2003), through which spatial competition between humans and elephants could be reduced at all scales. Equally, a land-planning approach would provide the means to reduce the effects of human activities upon elephants. In an increasingly fragmented and transformed environment, the prioritisation of key habitats based upon elephant requirements may be essential to their perpetuation. Planning elephant 'refuge' areas in which human activities are limited could present a highly effective means of retaining elephants within the mid-Zambezi Valley.

However, such refuge areas would need to have little or no resource extraction if elephant habitation were to be the prime goal. For such a system to be feasible, the benefits that accrue from elephants would need to provide a sufficient incentive for rural people to willingly change their patterns of behaviour. Currently, it is believed that the incentives provided by CAMPFIRE are not sufficient to institute change at the community level (Bond, 1994). If this is the case, then the system proposed will not work unless there are significant increases in the incentives produced by CAMPFIRE to balance the opportunity cost of elephant refuge areas.

11.2.2 Increasing the benefits from CAMPFIRE

The perception that revenues are insufficient is very complex to resolve, given that the primary means of revenue generation is unlikely to increase. Trophy hunting quotas are set according to the estimated population size of trophy animals, and unless there is a great increase in the population size of elephants, it is extremely unlikely that a quota increase will be sanctioned, or could be justified, by the DNPWLM. Indeed, enlarging the quotas would increase the chances of over-exploitation, one of the principle fears of conservationists with regard to consumptive use models (Milner-Gulland & Mace, 1998).

The opportunity for non-consumptive use remains severely limited. In light of the current political and economic instabilities, tourism in Zimbabwe is in decline and there exists virtually no opportunity for expanding current tourism-based activities within the mid Zambezi Valley.

If the amount of revenues cannot be increased, then the only option is to increase the efficiency with which the funds are disbursed. Potential areas of inefficiency are: first, the high proportion of wildlife revenue that is retained by the RDCs; and second, the provision of social projects such as schools and clinics, which arguably should be the responsibility of the State.

The revenues retained by RDCs are considered a 'taxation' of wildlife, which provide a reliable revenue stream in the absence of a secure tax base (Bond, 2001). Increasing the proportion of revenues that is disbursed to the community would be an obvious mechanism for increasing benefits; however, given the powerful argument the RDCs presented in order to secure one half of the revenues at the outset of CAMPFIRE (Jones & Murphree, 2001), it is unlikely that such a reduction in income would be sanctioned.

There is a powerful argument that social projects such as schools and clinics are the responsibility of central government (Walpole & Thouless, 2005), and should be funded from the central treasury rather than from CBCs. If such projects were covered by the treasury, wildlife benefits could be better directed to tailor community needs, including individual household dividends and other community-identified projects. Furthermore, revenues could be directed to crop protection and conflict mitigation (Walpole & Thouless, 2005), which would address the major cost of wildlife to rural communities. Additionally, this approach would reinforce the links between conservation activities and the benefits from wildlife. However, it is unlikely that the treasury will invest more heavily in social projects, as government seems to rely increasingly upon CAMPFIRE to provide the resources for infrastructural development in rural districts.

11.2.3 Disbursement of benefits

The current mechanism for the disbursement of revenues from CAMPFIRE does not adequately address the patterns of cost that occur at the village level. Currently a large proportion of the revenues are tied up in long-term social projects, which are beneficial, but which may not adequately reflect the annual patterns of conflict. What is required is a flexible revenue distribution that reflects the costs of wildlife management at the village level. In addition to the revenues invested in long-term social projects, a portion of the total funding disbursed to communities should be invested to reflect the levels of conflict that occur annually. This would address the sporadic distribution of crop damage, which is extremely difficult to predict (Hoare, 1999; Sitati *et al.*, 2003).

If benefits are to effectively offset the costs of wildlife management, then they should take a form that may directly compensate the farmer for their losses (Emerton, 2001). Crop damage was the major form of conflict within the study area, and in order to offset this impact upon a farmer's livelihood, the benefit must take a form that will improve livelihoods. Individual compensation schemes are fraught with problems (e.g. Hoare, 1995), and may encourage agricultural expansion, with negative effects upon rural farmers (Bulte & Rondeau, 2005). Furthermore, direct compensation would require careful quantification of each individual case of crop damage. However, establishing a community fund which responds wildlife costs at the village level could offset costs and aim to address livelihoods through agricultural support, without encountering the pitfalls of individual compensation.

While such a disbursement mechanism may address the imbalance of revenue disbursement within producer wards, there remains the problem of communities within non-producing wards who suffer crop damage. In such a situation revenues need to be transferred from producer to non-producer wards. An outreach-style programme such as that found in communities along the boundaries of national parks should be established, from which producer wards would provide economic assistance to selected villages at their boundaries.

Any scheme that attempts to offset the costs of conflict at the village level will require quantitative field data on which to base decisions of benefit disbursement upon. A conflict reporting system can be remarkably efficient to run (Hoare, 2001; Parker & Osborn, 2001), and while labour-intensive, would enable the objective assessment of wildlife costs.

11.2.4 Participation and the devolution of responsibility

The participation of rural communities in wildlife management is considered a key principle of CAMPFIRE. Incentives for conservation at the community level may be vastly improved by increased participation, which has demonstrably positive benefits elsewhere (Parry & Campbell, 1992; de Boer & Baquete, 1999). However, the management of resources under CAMPFIRE has remained in the hands of the RDCs and responsibility is largely centralised at the district level (Murombedzi, 1994).

The lack of devolution has left communities with little responsibility over wildlife; their participation constitutes little more than the receipt of benefit handouts (Murombedzi, 2001). There has been some evidence of devolution to the sub-district level (CAMPFIRE news, 1998: 8); however, in the absence of pervasive incentives from participation for rural farmers, incentives for conservation are currently derived entirely from economic benefits.

11.2.5 Reducing the impact of conflict

If benefits cannot feasibly be increased, then efforts should be centred upon reducing costs. Crop damage is the greatest problem facing rural communities, creating an imbalance between the problems and benefits from wildlife. The current means of mitigating conflict are unsatisfactory and many farmers resort to their own means of crop protection (Osborn & Parker, 2003b). This implies that the efforts of the APUs - funded by CAMPFIRE revenues - are not sufficient. Therefore, crop protection must be improved in order to reduce the costs of wildlife management to rural communities (e.g. O'Connell-Rodwell *et al.*, 2000).

To reduce the impact of crop damage, more APUs are required at the village level. In addition, APUs should prioritise incidents of crop damage involving large groups of elephants which cause the extreme events that engender such fear of elephants among farmers. This intervention should be especially effective if elephants engage in habitual raiding, as some bull groups appear to do (Hoare, 1999).

Centralised problem animal control suffers many logistical problems, and reaction times may be slow when demand is at its peak. In recent years there has been a call for the decentralisation of problem animal control, and the development of cheap, locally available interventions (Osborn & Parker, 2003b). In such schemes chilli has been found to successfully reduce crop damage in several locations (Osborn & Parker, 2002; Walpole & Sitati, *in press*). Community-based approaches show promise, and should form a component of wider conflict mitigation. Such systems would be suitable for CBC areas because they require minimal financial investment and reduce the emphasis upon the role of centralised units in reducing crop damage.

11.2.6 Conclusions

Community-based conservation programmes face the difficult challenge of meeting conservation targets whilst simultaneously providing for the development needs of rural communities. While programmes such as CAMPFIRE have been heralded as a success in ethical terms, and in financial terms at the district level (Bond, 1994), their effectiveness on the ground has been rarely assessed, but certainly not in terms of the attitudes of communities and their land use decisions (Leader-Williams & Hutton, 2005). This study has investigated the interaction between humans and elephants and has identified the key components of cost and benefit that drive people's attitudes. While the outlook may appear bleak, conditions for genuine support have been identified, and with key adjustments to benefit disbursement, this support could be greatly increased.

The principles of cost and benefit in incentive-based conservation addressed in this research relate to the operations of the CAMPFIRE programme in two districts in Northern Zimbabwe. However, the findings and their implications are neither confined to this programme, nor to this geographical location. Across the southern African sub-region, CBC programmes provide incentives for the sustainable use of natural resources, and in such programmes the results of this research will also apply.

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Appendices

Appendix I. Land tenure categories in Zimbabwe

Land tenure categories

State Land comprises 15.5% land area of Zimbabwe and consists of National Parks and other wildlife areas, gazetted forest reserves and State farms, which are on statutory allocation, freehold and leasehold tenure systems.

Communal Lands comprise 41.4% of the land area, and belong ultimately to the State. They are based upon a customary tenure system.

Resettlement Lands make up 9.1% o the country, and were introduced after independence in 1980 to relieve the increasing population pressure in the Communal Lands and to redress landlessness amongst households displaced during the independence war. These areas are based upon a leasehold tenure system.

Commercial Farming Areas comprise 34% o the country and consist of large-scale commercial farms and small-scale commercial farms which are on a freehold and leasehold tenure system.

The above categories were inherited from the colonial government at Independence. The descriptions relate to the situation as it was in 1997, before the fast track land redistribution which gazetted 2450 farms (6 million hectares) for compulsory purchase by the Government.

Appendix II. Natural Regions in Zimbabwe.

Natural Regions in Zimbabwe

Natural Regions, also known as agro-ecological regions, are based upon soil type, rainfall, and other climatic factors. These classifications have formed the basis of all land use planning by government agencies since 1960.

Natural Region I covers less than 2% of land area and is confined to the Eastern Highlands. The relatively low temperatures, high rainfall and high agricultural potential has led to intensive diversified agriculture including tea, coffee, forestry, deciduous fruit and livestock production.

Natural Region II covers 16% of the country, predominantly in the north east. The moderately high rainfall (750-1000mm) is suitable for intensive crop and livestock production. The dominant vegetation type is *miombo* woodland.

Natural Region III comprises 18% in the centre of the country, and is characterised by erratic rainfall (650-800mm) and severe mid-summer dry spells. This semi-intensive farming region provides marginal conditions for maize, tobacco and cotton. The natural vegetation is *miombo.*

Natural Region IV is the most extensive of the regions, covering 37% of the country. The region has low annual rainfall (450-650mm) and is subject to periodic seasonal droughts. The predominant farming practice is livestock production. The dominant vegetation is *miombo, Acacia-Terminalia-Combretum* and *mopane* woodlands.

Natural Region V covers 27% of the south, south-east and north of the country. This region experiences very low erratic rainfall (<500m) and is suited only to extensive farming, such as cattle production, and more recently, game ranching. The dominant vegetation is *mopane* woodland.

Appendix III. **Focus group discussion guiding questions.**

1. Do you experience problems from wildlife?
    - If so, which animals?
    - Rank the animals in order of the problem, greatest problem first.
    - Why are the animals in this order? Describe the problems associated with each.

2. (If elephants mentioned above): What are the specific problems caused by elephants?
    - Rank the problems, with the greatest problem first.

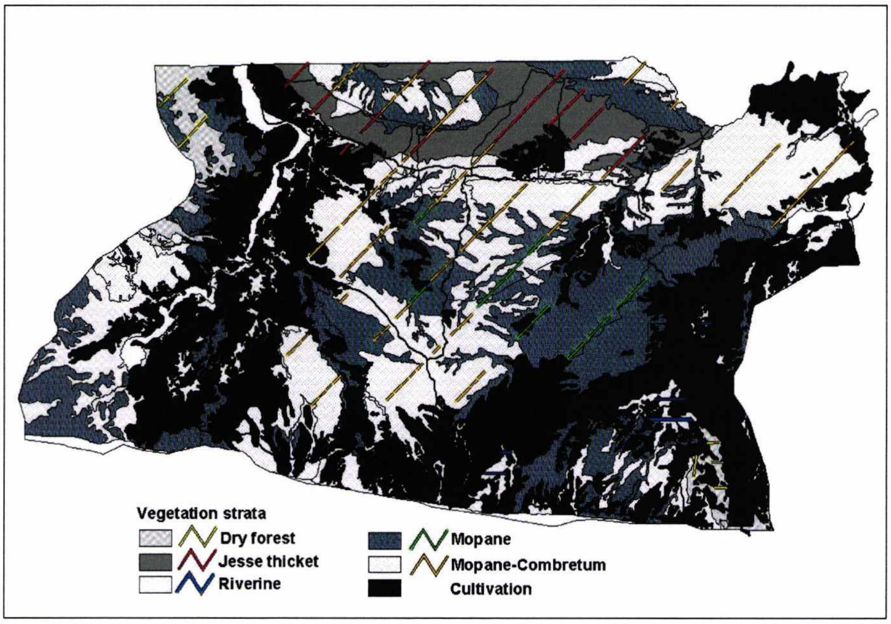
3. Are there any benefits from elephants?
    - List the benefits
    - Rank the benefits in order of importance
    - *Ask about community projects, PAC etc, here.*

4. How do the costs and benefits compare?
    - Describe which of problems and benefits is greatest.
    - Score the balance of costs and benefits out of 10.
    - Ask why the respondent has chosen the above score.

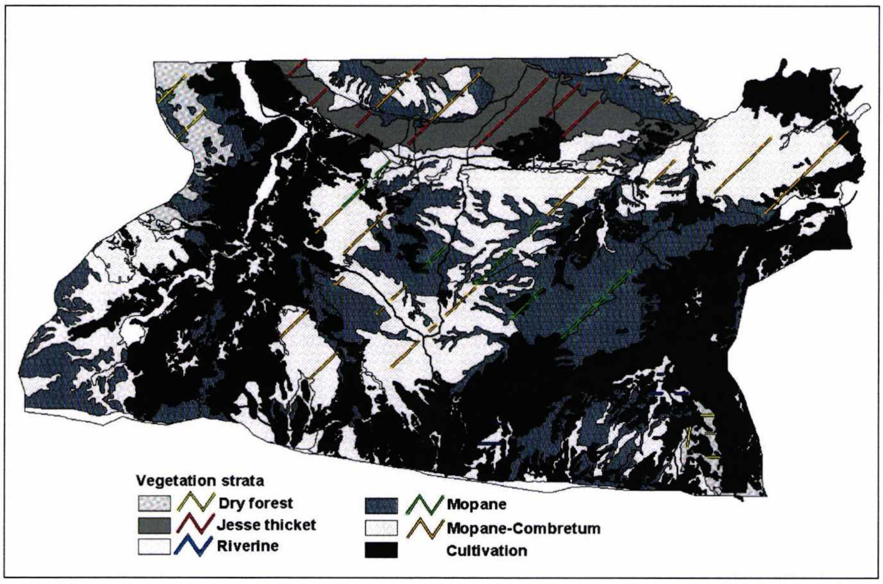
5. What would be needed to balance the costs and the benefits?
    - Probe for specific items/values.

Appendix IV. **Elephant dung transects carried out in each of the seasons during 2003: a) wet season; b) cool dry season; and, c) hot dry season.**

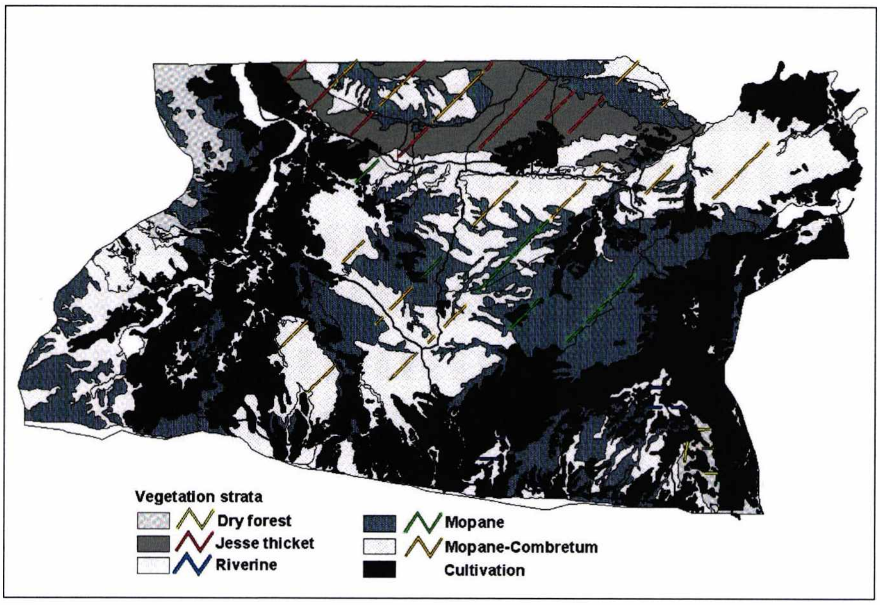
a)



b)



c)


Vegetation strata
Dry forest
Jesse thicket
Riverine
Mopane
Mopane-Combretum
Cultivation

Appendix V. Mid-Zambezi Elephant Project transect recording sheet.

Date: Habitat name:

Time: Transect ID:

Start point:

Distance along transect	**Animal species**	**Observation e.g. dung, spoor**	**Age of sign**	**Distance from transect**	**Human signs e.g. cattle, woodcutting**	**Observation e.g. dung, spoor**	**Distance from transect**	**Age of sign**	**Habitat type**

Appendix VI: **Comparing the proportion of elephant abundance in relation to human and ecological variables, for all three seasons during 2003.**

Figure a) Elephant abundance and distance to cultivation.

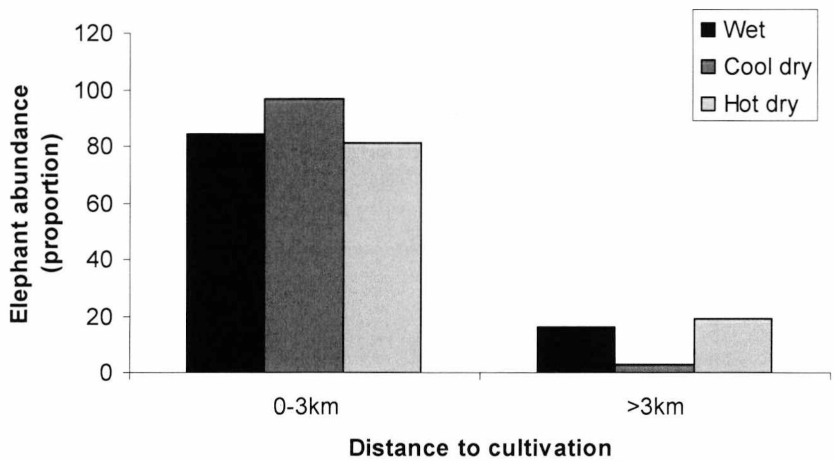


Figure b) Elephant abundance and distance to settlement.

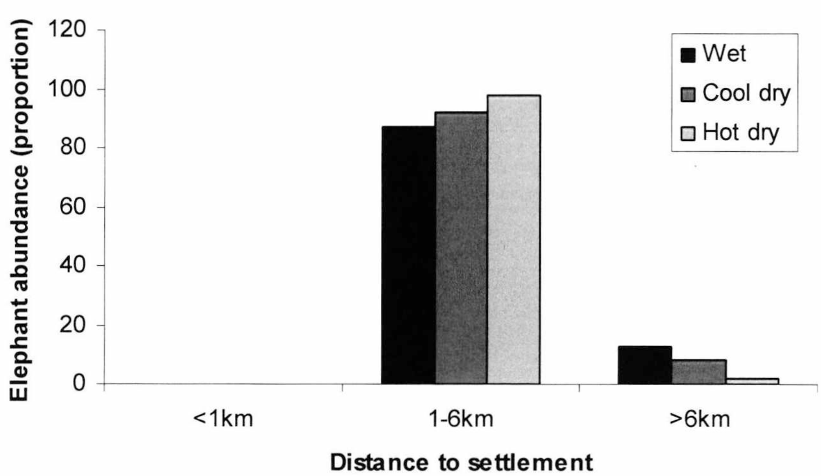


Figure c) Elephant abundance and distance to water.

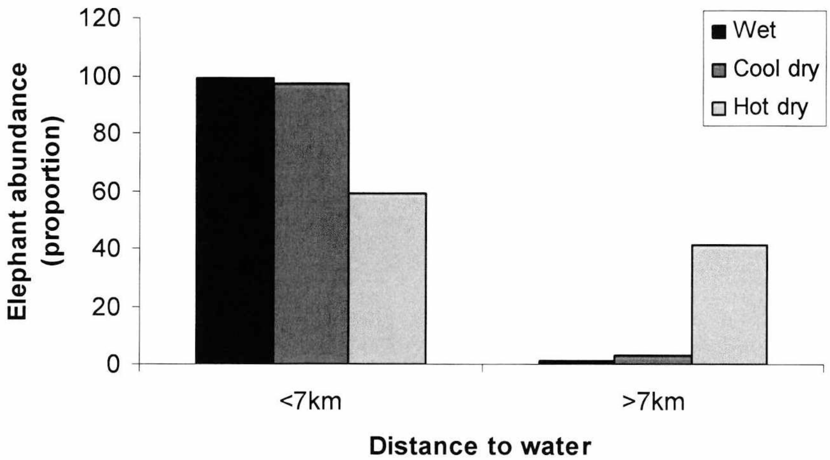


Figure d) Elephant abundance and short duration human activity.

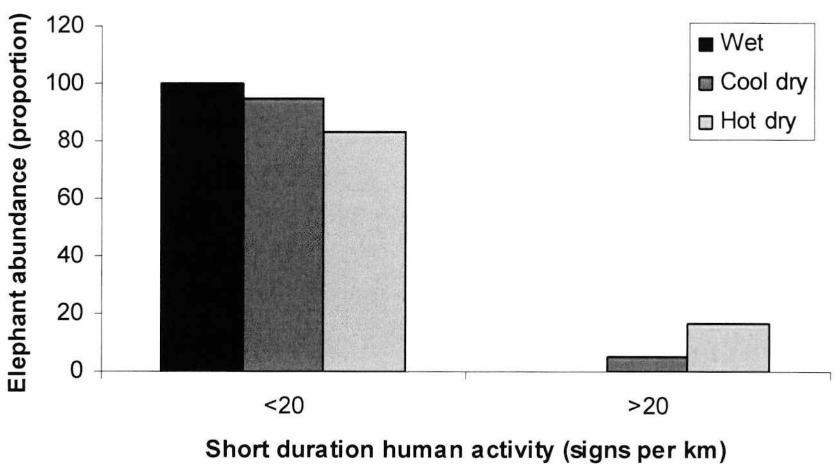
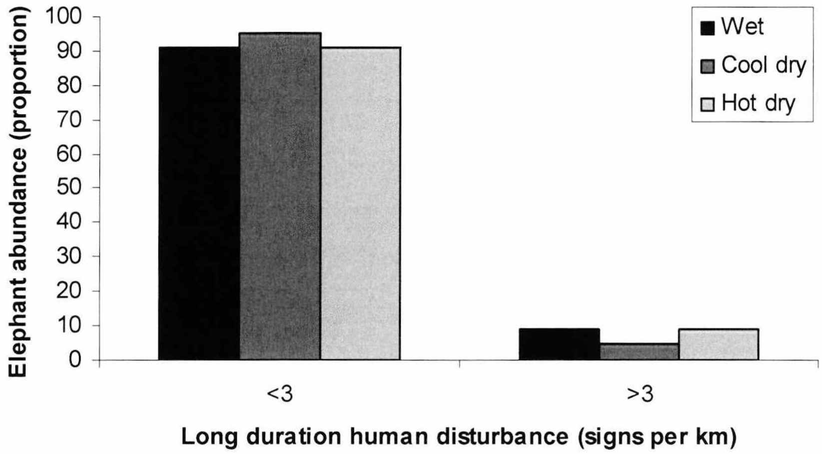


Figure e) Elephant abundance and long duration human activity.



Appendix VII. Wildlife Conflict Reporting Form.

1. Report Details

Report date
Incident date
Reporter

Ward
Village
Farmer

2. Details of Conflict

2a. Crop Damage

Crop	Age	Quality of crop	Total area of crop	Area damaged	Intensity of damage

2b. Damage to property

2c. Damage to Livestock

3. Problem Animals

Problem animal:
No. animals:
Sex of animals:
Information from:

Direction of entry
Direction of exit:

Visual	
Farmer	
Spoor	

4. Problem Animal Control

Method of PAC:
No. of persons:
ID of persons:
Reaction time of elephants:

Time PAC started:
Time PAC finished:

5. Comments:

Appendix VIII. **Tables displaying: a) official exchange rate from ZW$ to US$ between 1996 and 2002; and, b) interest rates for Zimbabwe 1996-2002, from Zimbabwe Building Society Middle Rate.**

a)

Year	Exchange rate
1996	10.00
1997	12.44
1998	24.78
1999	38.33
2000	44.61
2001	55.00
2002	55.00

b)

Name	ZIMBABWE BLDG.SOC. DEPOSIT 12 MONTH - MIDDLE RATE	ZIMBABWE BLDG.SOC. DEPOSIT 24 MONTH - MIDDLE RATE
Code	ZIDPB1Y	ZIDPB2Y
1991	10.12	10.38
1992	12.68	12.12
1993	14.85	15.00
1994	15.85	16.00
1995	15.85	16.00
1996	15.85	16.00
1997	15.85	16.00
1998	13.50	13.75
1999	14.55	14.88
2000	14.55	14.88
2001	14.55	14.88
2002	14.55	14.88
2003	14.55	14.88

Appendix IX. **Table displaying value of agricultural implements and livestock used in wealth ranking exercise, displaying adjustments for interest rates and USD conversion.**

Object	Value ZW$	Interest adjustment	Value US$
Plough	75,000	65,502	81.88
Scotch cart	140,000	122,270	152.83
Harrow	75,000	65,502	81.88
Wheelbarrow	22,500	19,650	28.13
Cow	250,000	218,340	272.93
Goat	25,000	21,834	27.29
Sheep	50,000	43,668	62.50
Donkey	50,000	43,668	62.50