HUMAN-ELEPHANT CONFLICT IN AREAS ADJACENT TO THE TSAVO NATIONAL PARKS, KENYA.

BY

SAMUEL M. KASIKI

Thesis submitted for the degree of
Doctor of Philosophy
University of Kent at Canterbury
November 1998

Summary

This thesis investigates the issue of human-elephant conflict in the Tsavo ecosystem, which has the largest single population of elephants in Kenya. In the Tsavo ecosystem elephants that move out of the Tsavo National Parks became 'problem elephants' as they damage crops, kill people and threaten human life. In addition the presence of elephants in settled areas causes fear and insecurity.

Many factors determined the intensity of human-elephant conflict in Tsavo, but five of these were the most significant. These were human population density, percentage of land under cultivation, type of land ownership, fencing and the type of natural vegetation. Conflict was highest on private ownership small holdings with permanent water and wooded bushland type of natural vegetation.

Acknowledgements

It is with great pleasure that I take this opportunity to thank the many people in Kenya and in England who helped to produce this thesis. I am especially grateful to Care for the Wild International (CFTWI) for providing full funding for the study. Special thanks to Dr. William Jordan, CFTWI Chairman; Chris Jordan, Managing Director; Vivien Craggs, Trustee; and Geoffrey Craggs, Finance and Administration Manager, for their support in more ways than can be mentioned here.

Other than the role they played in their official capacity, Chris, Vivien and Goeffrey extended a very warm hospitality to my wife and I during my stay in England. Their generosity made my stay in the country a very pleasant one.

I would also like to thank my supervisor, Professor Nigel Leader-Williams, of the Durrell Institute of Conservation and Ecology (DICE) for his thorough reading of my drafts, comments, advice, guidance, support and patience throughout the writing up process. His keen interest in my work kept me on the right track.

Professor Ian Swingland, Dr. Mike Walkey and Dr. Richard Griffiths all from DICE were always willing to help in many ways. Bob Smith, my office mate, was always more than willing to sort out my IT and computer problems, as well as advice on statistical analysis. Other staff members of DICE helped in many ways, ranging from sorting out my accommodation matters to handling of my correspondences while in England. Mrs. Joan England and Mrs. Catherine Pepler were ever helpful, and especially patient in handling difficult fax transmissions. To all, I am extremely grateful.

Many other people helped in many ways to make my stay in England enjoyable. I would like to mention, in no particular order, Mrs. Brenda Jordan, Lindsey Gillson, Carol & John Brown, Shirley & Peter Odling, Shelley Hills, Helen Scott and Alex Obara.

In KWS, I would like to thank the Director, Dr. Richard Leakey, and Deputy Director, Mr. Joe Kioko, for their support and permission to be away for my thesis write up. Dr. John Waithaka, KWS Elephant Programme Co-ordinator, and Mr. Wilber Ottichilo, Deputy Director Biodiversity, all provided advice and fieldwork logistics support.

In Tsavo I thank the park Wardens Mr. Gichangi, Senior Warden Tsavo East, and Mr. Muhanga, Regional Assistant Director Tsavo, who all supported and provided encouragement during my fieldwork. Dr. Barbara McKnight, elephant research scientist in Tsavo, was a source of great encouragement and support, and helped in many ways during my fieldwork and write up. Her help and advice are highly appreciated.

I would also like to thank all the staff of the Tsavo Research Station, and especially Jackson Kin'goo, Elkana Mwambacha, Jefferson Mnjala and Komu Muthiani, who all assisted in many aspects of my fieldwork, and persevered many hot days, dangerous situations and sometimes hostile receptions by the local people during field surveys.

Samuel Adanje, Stephen Maina and Sarah Kitema were ever willing to assist whenever called upon to do so.

Many more other people too numerous to mention helped in different ways during my field study in Kenya and my stay in England. To all I say a big thank you.

Finally, and by no means of least importance, special appreciation and gratitude to my wife Joyce and children Beatrice, Dan and David, as well as my parents, who all provided solid support, encouragement and inspiration in difficult times. I owe the success of my study to them.

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Chapter 1

General Introduction

1.1 Introduction

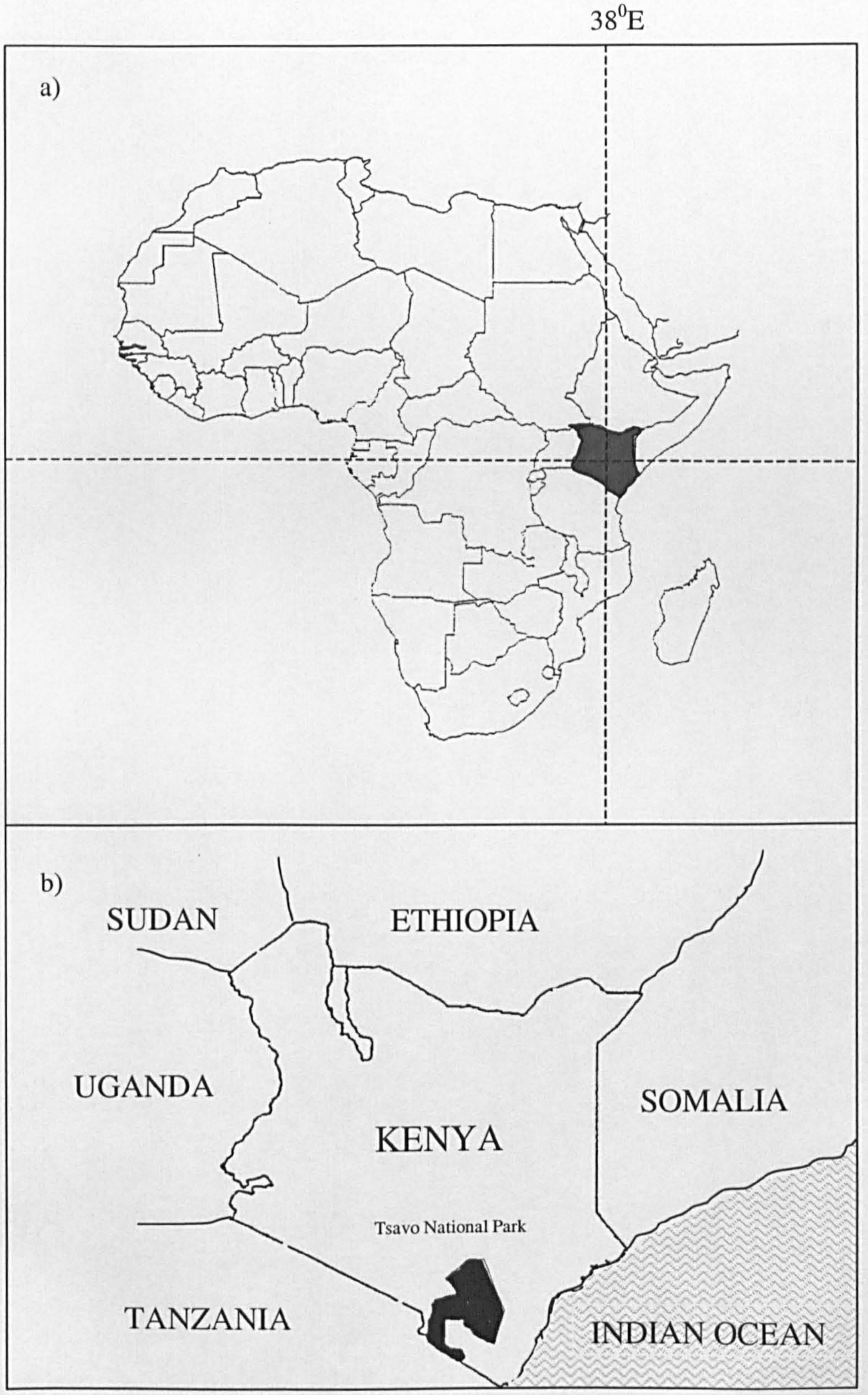
This thesis investigates the issue of human-elephant conflict in the Tsavo ecosystem, home to the largest single population of elephants in Kenya (Figures 1.1a and 1.1b). The conservation of the African elephant (*Loxodonta africana* Blumenbach 1797) is important because of the role the species plays in ecosystem function and its various values to humans. In recent years, human populations have increased in size and expanded their activities into the elephant's range, while some elephant populations have increased with better protection. This requires wildlife authorities to consider not only the welfare of the elephant and its habitat, but also the problems and conflicts that arise between neighbours competing for limited resources (Dublin *et al* 1997).

The conservation and management of the African elephant is a complex endeavour, requiring skills and strategies that deal with the species in both protected and unprotected areas (Dublin *et al* 1997). If elephants and man are to coexist outside protected areas, the levels of conflict must be reduced by decreasing the costs and increasing the benefits that come to the people from the presence of elephants. However, only by understanding the nature and extent of conflict under different circumstances, can it be determined if coexistence is possible, and at what cost (Thouless 1994). This study aims to provide such understanding for Tsavo.

1.2 The value of elephants

Elephants are central to promoting wildlife conservation and have compound values.

Figure 1.1 Map (a) showing the location of Kenya in Africa and (b) Tsavo National Park in Kenya.



These values range from the role they play in ecosystems to those that are intangible and hard to quantify, such as aesthetic, cultural and existence values, to more tangible economic benefits which can be quantified directly, largely through tourism (Kangwana 1996, Dublin *et al* 1997).

The African elephant is often referred to as one of the world's *flagship* species, which means it is a focal point of interest both for the general public and conservationists. By attracting attention to their future conservation, elephants also focus attention on the plight of the ecosystems of which they form an integral part. This attention often results in a multiplier effect that leads to the conservation of other species sharing the same habitat, helping to achieve the primary goal of biological conservation. Also being a *keystone* species in habitats where they live, elephants play a key role in the structuring of natural communities and thus the maintenance of biodiversity (Laws 1970, Laws *et al* 1975, Western 1989, Dublin *et al* 1997).

1.3 Elephant food and habitat requirements

The African elephant is the largest living land mammal, weighing several tonnes, and is a relatively unspecialised herbivore. Numerous studies in different parts of Africa have demonstrated the diversity of feeding behaviour that the species exhibits under different environmental conditions (Dougal *et al* 1964, Laws 1969b, Laws 1970, Wyatt *et al* 1974, Barnes 1982a, Eltrigham *et al* 1980, Ruggiero *et al* 1994). The African elephant is mainly found in forest, woodland or bushed grassland habitats. The species has an optimal daily food requirement of 6% of its live weight (Laws 1970).

1.4 Continental trend in African elephant numbers and possible causes

The African elephant once inhabited most of the African continent, from the Mediterranean coast down to its southern tip (Cumming *et al.* 1990). Today the range of the species comprises more scattered, fragmented populations south of the Sahara Desert (Said *et al* 1995). The continental decline of the African elephant population has received different explanations. On the one hand, models have suggested that the continental elephant population has declined since the 19th century because of killing the species for ivory (Milner-Gulland & Beddington 1993). On the other hand, it has been argued that recent disappearance and decline of elephant populations in some areas has often been due to the loss of essential habitats, as well as a result of complex historical processes between humans and elephants, not simply just as the result of rising human greed and the rising price of ivory (Parker & Graham 1989a, Child 1995). These authors point out that even in the absence of commercial poaching, elephant numbers, like those of other species that are unaffected by international trade, have declined in areas of increasing human density.

Other authors point out that elephants may change their range in response to disturbance, or there may be additional sources of mortality, such as control shooting by wildlife authorities, or snaring, which result in a gradual decline in numbers (Haigh *et al* 1979, Barnes *et al* 1991).

Throughout Africa, the elephant population has declined from about 1.3 million in the late 1970s to approximately 600,000 a decade later (Douglas-Hamilton 1987, Douglas-Hamilton *et al.* 1992). However, some small populations on the continent have apparently become locally over-abundant and have created intense conflict problems (Thouless 1992, Tchamba 1995, Daniba *et al* 1994, Taylor 1993, Osborn & Rasmussen 1995). Conservationists are therefore faced with the dilemma of managing a species in urgent need of protection over much of its range, yet which in certain limited areas is in need of population control or reduction (Caughley *et al* 1990).

1.5 Elephant conservation in Kenya

Kenya ranks high among nations that have reserved a substantial proportion of their land exclusively for wildlife conservation. The total land area under wildlife conservation is currently 44, 359 km^2, or about 7.5% of Kenya's total area (KWS 1990).

The country's legislation supports two main categories of protected areas (PAs). These are National Parks (NPs) and National Reserves (NRs), which include both terrestrial and marine areas, the latter being termed National Marine Parks (NMPs) and National Marine Reserves (NMRs). Both NPs and NRs are areas set aside exclusively for the preservation of wildlife, wild vegetation and objects of aesthetic, geological, prehistorical, archaeological, historical or other scientific interests. However, NPs allow no form of human interests other than tourism, while NRs allow for limited human interests and activities. NPs are owned by the central Government and managed by Kenya Wildlife Service (KWS), while NRs are gazetted areas owned and managed by local district councils. Kenya has 21 terrestrial NPs and 4 NMPs, 23 terrestrial NRs and 5 NMRs. Other areas are currently in the process of being designated as NPs, which will increase the proportion of land under wildlife conservation to about 8% (KWS 1990).

Wildlife also occurs outside the PAs and it is estimated that as much as 70% of Kenya's wild animals may be found on private and trust lands (KWS 1994).

KWS is the state corporation charged with conserving and managing Kenya's wildlife resources. It is a custodian of all the country's NPs and also has legal responsibility for wildlife on all NRs and on private lands. In all these areas, KWS is responsible for preserving ecosystems and biodiversity, and ensuring that these resources remain in optimum condition for the multiple activities the Government and the local people demand of them (Conservation and Management Amendment Act 1989).

KWS has produced a clear policy and action plans on the conservation of elephants in Kenya. These include law enforcement to stamp out poaching, establishment of an elephant data base on elephant population dynamics, investigating issues on human-elephant conflict in different parts of the country and implementing appropriate mitigation measures (KWS 1991a & b).

1.6 Human-elephant conflict in Kenya

Human-elephant conflict in Kenya is a real problem in practically the whole of the elephant's range (Kiiru 1995a & b). However, it is most intense where agriculture is involved, particularly when cropland borders NPs and NRs. The big losses, costs and fear that elephants cause by destroying property and killing people are the primary causes of conflict (KWS 1994). Loss of income from death and injury and material losses usually has devastating effects on victims and their dependants.

A survey of human–wildlife conflict conducted across the country in 1994 showed that the most notorious animal species were baboon and monkey (KWS 1994). However, it was also clear that elephants posed the most serious threat because they are the "most pervasive, voracious and powerful" animals. Between January 1989 and June 1994, wild animals in Kenya killed 230 people and injured a further 218 people, giving an average of 42 deaths and 40 injuries per year. Elephants were responsible for 173 of the 448 attacks (KWS 1994). A common view advanced by the people interviewed during this survey was that elephants, secure in their protected status, had increased in number and lost their fear of people, and had even become bold enough to invade homesteads and break into food stores and huts. A significant proportion of the respondents in this survey held the perception that the Government valued elephants more than people and was reluctant to kill problem elephants (KWS 1994).

1.7 Definition of human-elephant conflict and identified causes in Kenya

Human-elephant conflict in Kenya is defined as any and all disagreements or contentions relating to destruction, loss of life or property, and interference with rights of individuals or groups that are attributable directly or indirectly to elephants (KWS 1994). The same definition was adopted for this study.

In Kenya numerous factors that lead to human-elephant conflict have been identified but the following are the major ones (KWS 1994):-

1. Uncontrolled elephant movements and migrations, leading to invasion of human settlement areas, resulting in insecurity and curtailing human freedom of movement.
2. Loss and damage of agricultural crops.

3. Killing or injury of human beings by elephants.

4. Low compensation for people killed by elephants.

5. Competition for space with human communities.

6. Competition with livestock for pasture and water.

7. Loss of livestock killed by elephants.

8. Ineffective techniques for controlling problem elephants.

9. Destruction of infrastructure (e.g. fences, water supply systems, works, etc.).

10. Damage of natural forests, plantations and seedlings.

11. No compensation for destruction of property by elephants.

12. Inefficiency and abuse of compensation procedures.

13. Denial of share of revenue and other benefits to stakeholders.

14. Conflicts of interests over benefits accruing from wildlife.

15. Misconception of KWS as a donor agency, and resulting to over-expectations.

16. Behaviour of some KWS personnel towards the community – with claims of unwarranted harassment.

17. Land-use conflicts and inadequate policy for resolution.

18. Illegal hunting and trade in elephant products.

19. Policy weaknesses causing uncertainty in potential investors.

20. Competition and lack of involvement in tourism business.

21. Licensing problems among operators of wildlife related tourism activities.

22. Negative environmental impacts of tourism.

23. Negative social impacts of tourism.

24. Poverty.

The importance of each of the above factors may vary in different areas of the country and among different stakeholders. However, the most publicised are cases involving human death or injury and crop damage.

Human-elephant conflict in Kenya has become a topical issue. Other than the direct interactions between people and elephants, the problem is further complicated by what has been refereed to as "interpersonal conflicts", which involves stakeholders with divergent opinions or self-interests, which are often derived from competition between human groups for resources (KWS 1994).

1.8 Management of human-elephant conflict in Kenya

Before 1992 the issue of human-elephant conflict was never addressed seriously by the Government of Kenya or KWS. To a large extent, authorities managed human-wildlife conflict by avoidance and by force. It was generally perceived by affected communities that the former Wildlife Conservation and Management Department (WCMD) used provisions of the law to protect animals but turned to slow and inefficient administrative protocol, inaction and delay tactics when processing compensation for death, injury or damage to property. Over the years this has resulted in great discontent with the wildlife authority (KWS 1994).

Peoples' perceptions of benefits and costs further confound the issue. The view of many people is that Government needs wildlife because of revenue derived from tourism. The media usually reports the large sums of money accruing from tourism but does not explain what proportion of this money the Government actually receives. The majority of local people do not understand how this money is spent, for very little, if any, trickles down directly to affected landowners. This has led to most rural people having the understanding that the authorities ignore their wildlife-related losses, and at the same time deny them their true values and their need and right to use wildlife resources to supplement incomes and food supplies. Bitterness arises because of perceived view that the communities meet the high cost of wildlife, while the Government enjoys the benefits (KWS 1994).

1.9 Human-elephant conflict in the Tsavo ecosystem

The Tsavo NPs boundaries show an outstanding example of the map method of creating faunal sanctuaries, where no provision was made for the migration and dispersal of wild animals, especially the elephant, across PA boundaries (Laws 1969b). When the NPs were created in 1948 (see Chapter 2) the human population density was very low, at less than 5 per km^2 (Ecosystems 1982). Over the past five decades the number and distribution of people have expanded continuously and this has had a profound influence upon the ecology of the Tsavo ecosystem and patterns of land use within it. Elephants that move out of the NPs onto many of the neighbouring areas now come into conflict with legitimate human interests, whose outcome is intolerable to the poor neighbouring human community.

1.10 History of human-elephant conflict in Tsavo

The earliest records of human-elephant conflict in Tsavo are for 1916 when the District Commissioner of Voi (Figure 2.2) asked permission from the Government administration for the local people to kill elephants which were damaging crops (Visram 1987). However, it is not stated which crops were being damaged. Wray (1928) mentions that elephants "were often seen" at the foothills of Sagalla Hill

(Figure 2.2) but does not indicate whether or not these areas were then settled. From interviews during the present study, one old local man remembered having killed several elephants to defend his maize and other crops and to sell the ivory in the early 1940s.

An estate manager of a sisal plantation in Voi gives accounts of elephants raiding sisal plantations and cultivated areas adjacent to the Tsavo NPs in 1950s to the mid 1970s (Visram, 1987). The problem became so intense that growing of food crops and sisal was abandoned altogether in certain areas in the early 1970s. The years 1970 to 1972 were the worst, when large herds of elephants left the Tsavo NPs in search of food and water in the surrounding areas (Visram 1987), during a severe drought that occurred in Tsavo (Corfield 1973).

In the late 1980s it was reported that incidents of conflicts between man and elephants in Tsavo were on the increase (Ngure 1992, WCMD and KWS unpublished reports). The elephant population in the ecosystem was reduced at that time, first by the severe drought in the early 1970s and thereafter through poaching, from an estimated 42,000 in the 1960s to about 6,000 in 1980 (Ottichilo 1986, Poole *et al* 1992, Douglas-Hamilton *et al* 1994). Though the problem was talked about, no serious measures were taken to address the issue until 1992 when KWS formed a Problem Animal Control (PAC) unit within its Community Wildlife Service (CWS) department to deal specifically with human-wildlife conflict issues.

1.11 Aims of the study

The main aim of this study is to benefit wildlife managers and other stake holders in Tsavo, who have the task of resolving conflicts that arise from human-elephant interactions, with accurate information on which to base management decisions. Elephants will always range outside unfenced borders of PAs such as Tsavo and the maximum number of elephants that can be supported will depend on the tolerance of local human communities towards the species. Landowners disenchanted with elephants and other wildlife outside PAs could eliminate it perfectly legally by such means as land clearance, increased competition and disturbance from livestock, fencing or limiting access to water. The adverse effects of these measures may often be severe and long lasting (Child 1995).

The following were the main questions of the study:-

- What is the nature of human-elephant conflict in areas adjacent to Tsavo NPs?
- Does the intensity of conflict vary in different locations and seasons, and what are the likely causes?
- What is the group size, structure and composition of problem elephants?
- What is the impact of the conflict on the Tsavo elephant population?
- What is the economic impact of the conflict on the local human community?
- What intervention methods are employed and how effective are they?
- Which factors, or combination of factors, determine the intensity of human-elephant conflict in the Tsavo ecosystem?

1.12 Thesis organisation

The importance of elephants as a resource, the need to conserve the species, the developing problem of human-elephant conflict management in Kenya, and specifically in Tsavo, and the objectives of this study have already been outlined in Chapter 1. A description of the Tsavo ecosystem, past and present human occupation of the area, and the creation of the Tsavo NPs is described in Chapter 2. Chapter 3 deals with human demography and attitudes towards conservation, and wildlife utilisation and the main economic activities in the study area. In Chapter 4, trends in the Tsavo elephant population and factors influencing elephant numbers, distribution within and outside NPs, their seasonal distribution within NPs and causes of mortality are described. The major human-elephant conflict types, seasonal patterns and relation with rainfall, group composition of problem elephants, as well as other pest wild animals are described in Chapters 5. Chapter 6 explains traditional intervention methods by the local people and mitigation measures taken by KWS, while Chapter 7 gives an appraisal of electric fencing in Tsavo as a human-elephant conflict mitigation measure. In Chapter 8, a statistical analysis is undertaken to determine which factors, or combination of factors, determine the intensity of human elephant conflict in the Tsavo ecosystem. Finally a summary of the findings and recommendations are given in Chapter 9.

Chapter 2

Study Area and General Methods

2.1 Study area

This study was conducted in the Tsavo ecosystem in south eastern Kenya (Figures 11.b and 2.1). Detailed studies were carried out in areas outside the boundary of Tsavo NPs, one in Taita Taveta District where human-elephant conflicts are typical, and another in Kitui District where reports and complaints of problem elephants have been rare for many years (Figures 2.2 and 2.3).

2.2 The Tsavo ecosystem

The Tsavo ecosystem comprises approximately 43,000 km^2 and is located in south eastern Kenya and north-eastern Tanzania between 2^0 and 4^0S and $37^0$30' and $39^0$30'E (Figure 2.1). It ranges in altitude between 200 to 1,000 metres above sea level. Its slope is very even and gradual over most of the region, and only becomes steeper in the west. Isolated hills interrupt the general flat relief. To the north west is the densely populated parts of Ukambani, to the south west the Tsavo ecosystem is bound by Mts. Kilimanjaro, Pare and Usambara, and to the south east it is bordered by settled and fairly densely populated coastal hinterland. The ecosystem has more or less natural boundaries in these areas, which form a clear limit to the distribution of elephants (Wijngaarden 1985). However, the boundary to the north east is less clear and was chosen rather arbitrarily (Cobb 1976).

Figure 2.1 Map showing the Tsavo ecosystem.

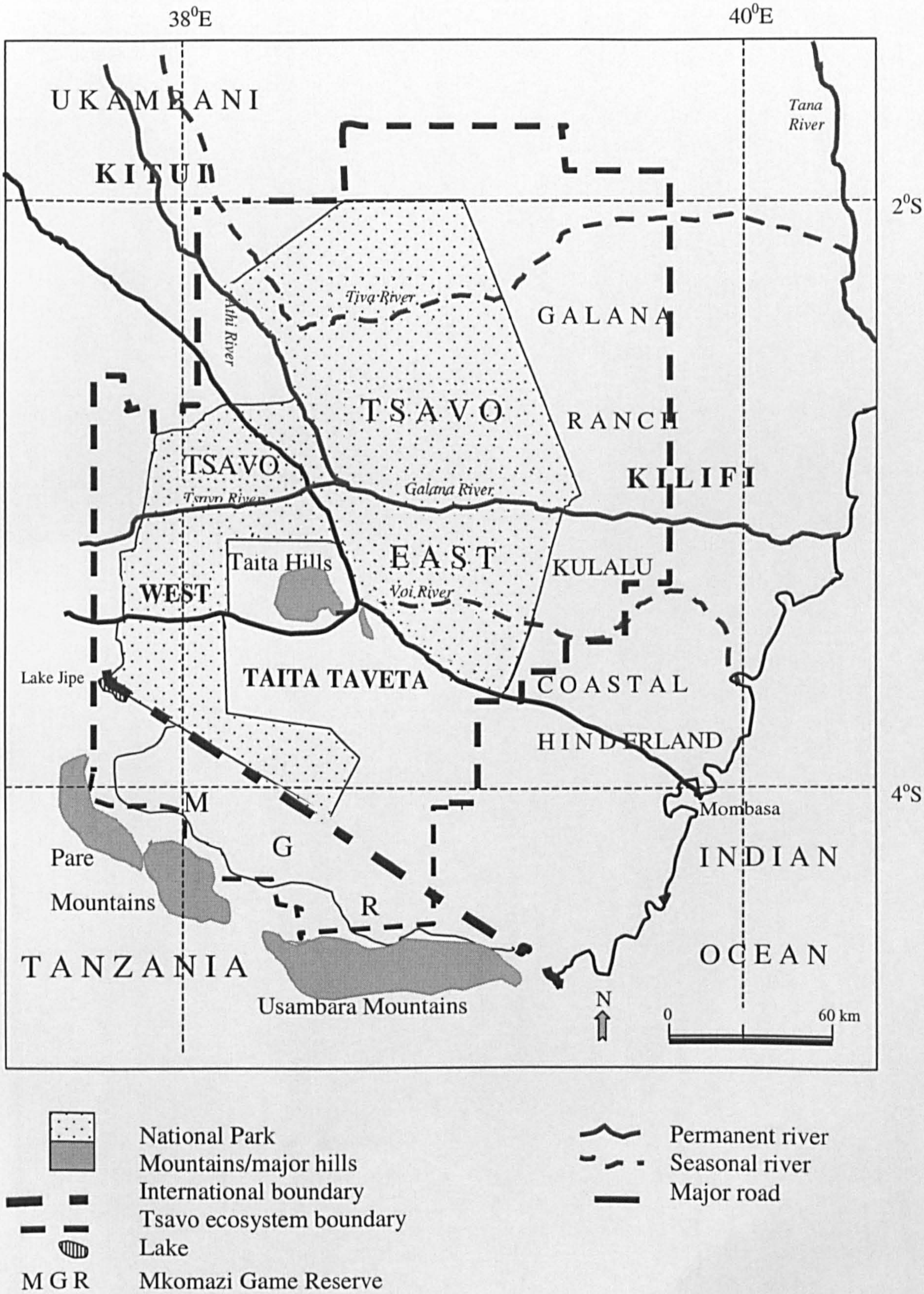


Figure 2.2 Study blocks in Taita Taveta District.

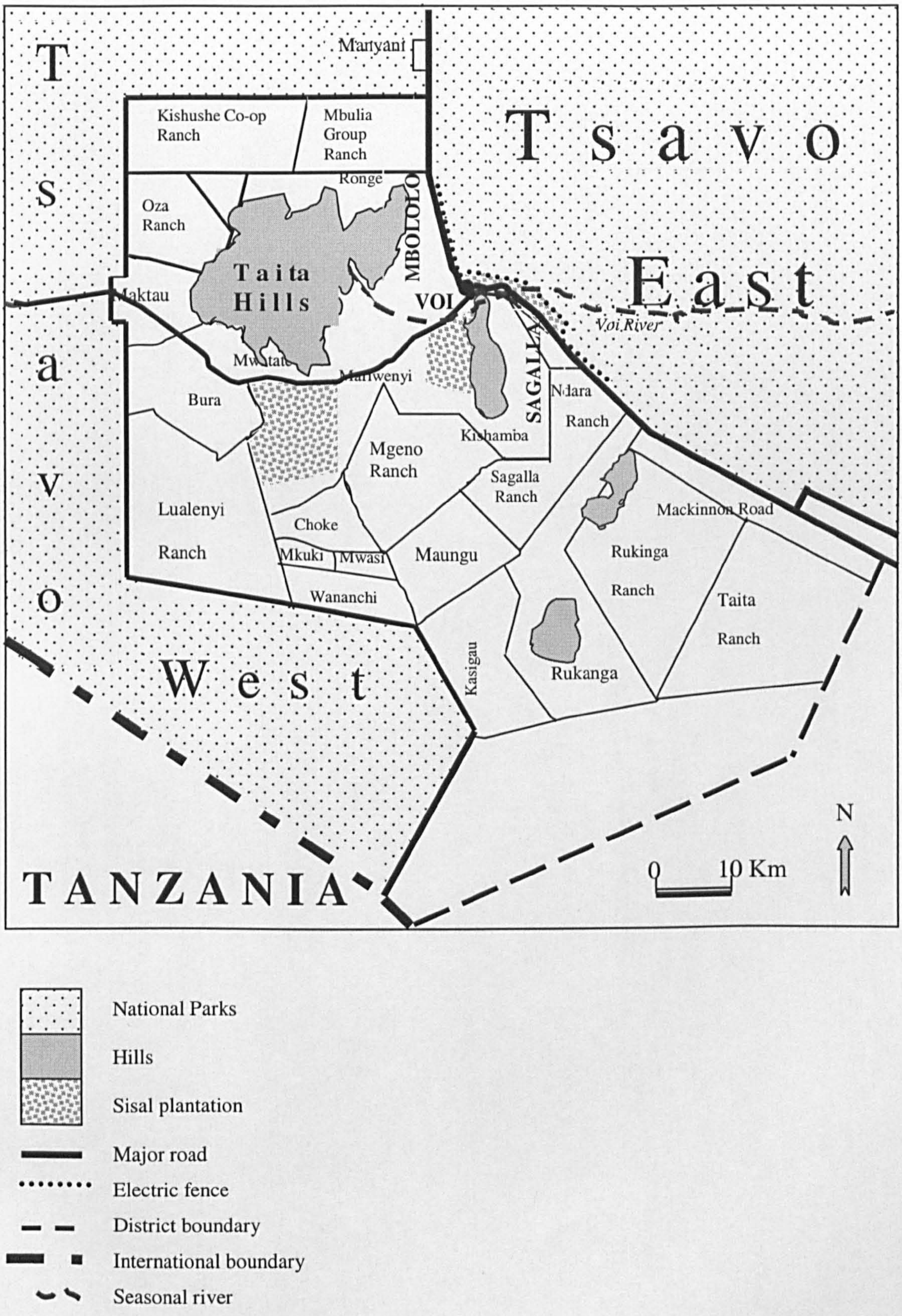
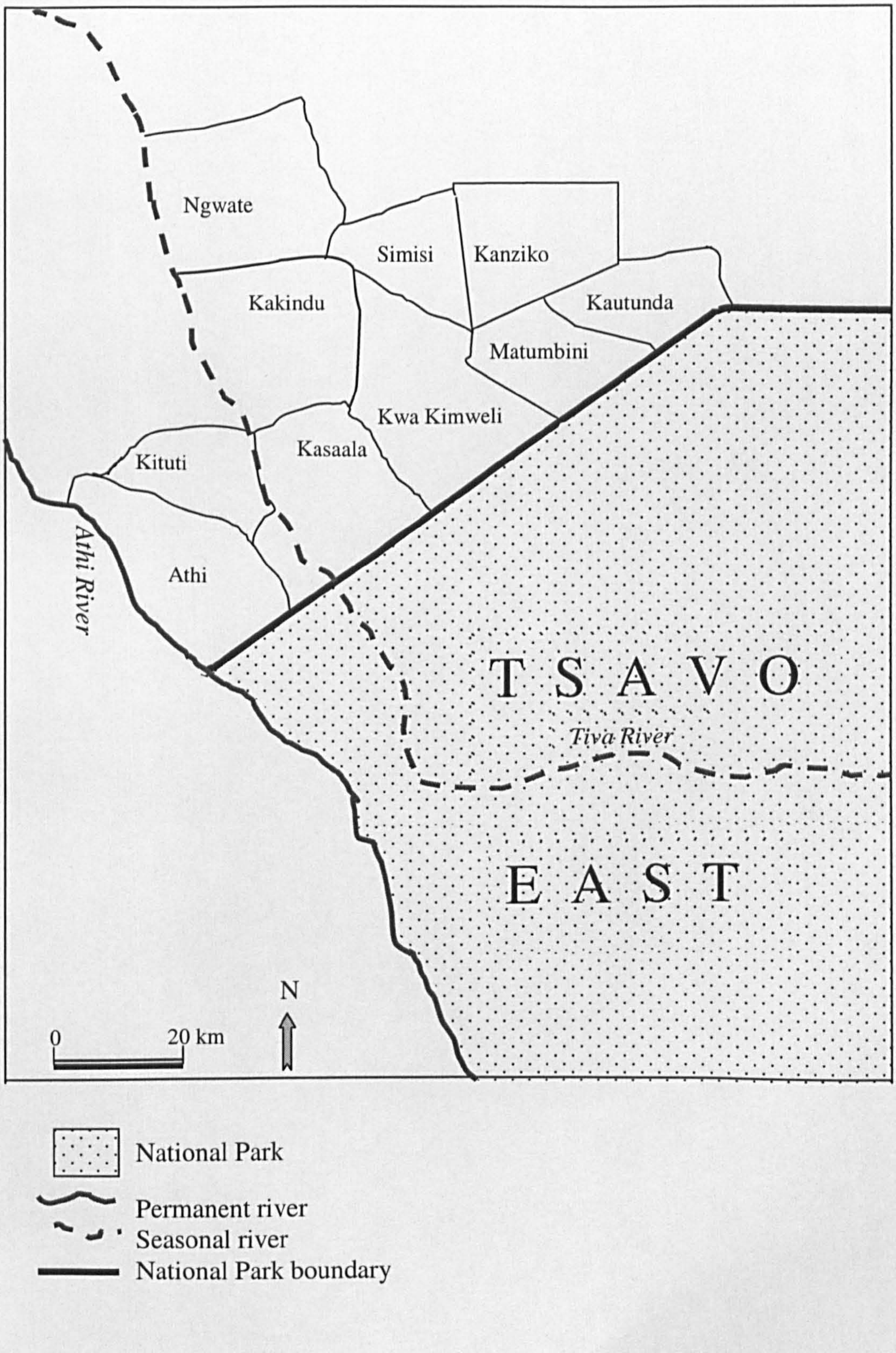


Figure 2.3 Study blocks in Kitui District.

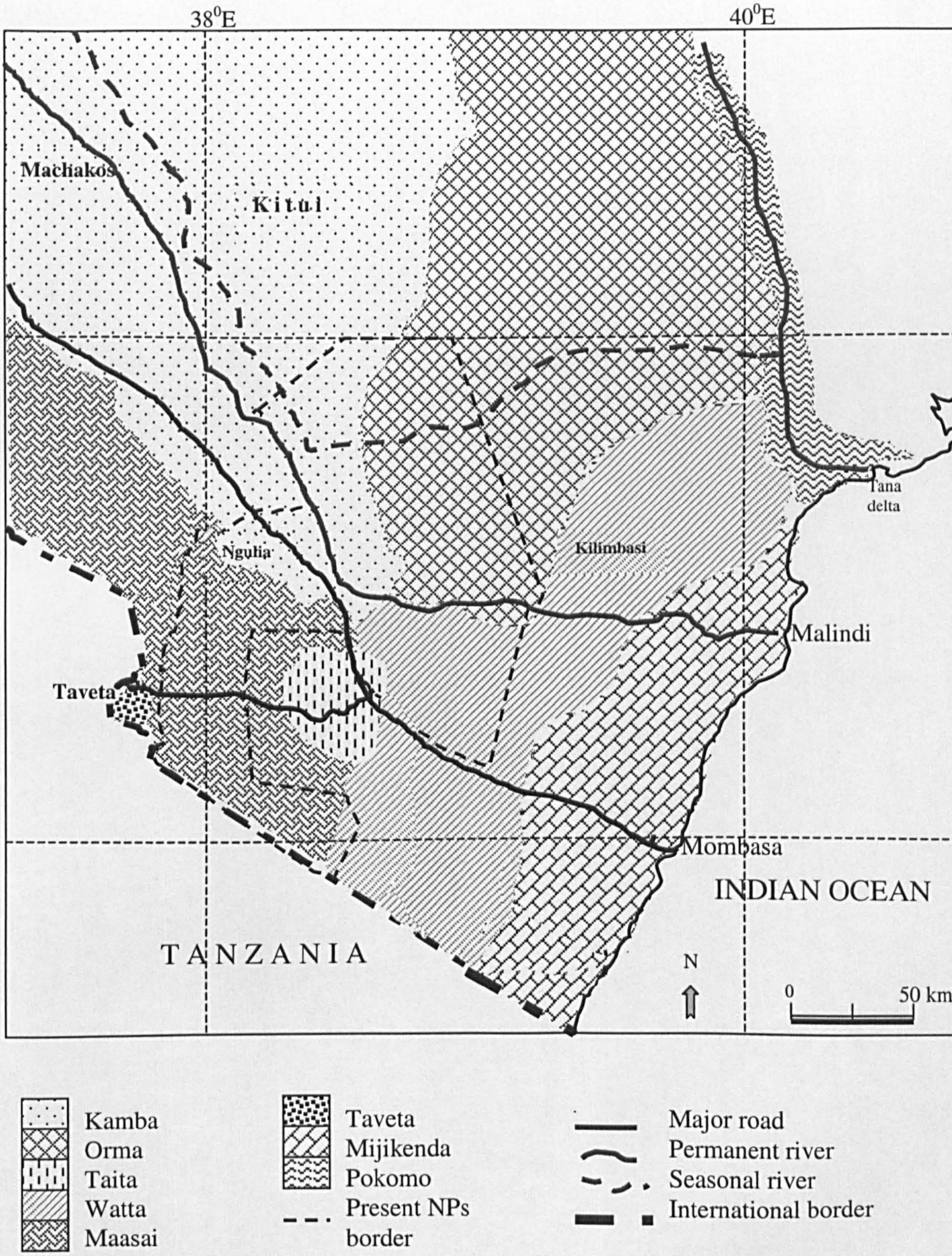


Cobb (1976) defined the Tsavo ecosystem as the total area used seasonally by the Tsavo elephant population. Wijngaarden (1985) revised this definition and described the Tsavo ecosystem as the area in which the major terrestrial animal populations find their home range on a yearly basis. The core of it is formed by Tsavo East (TsE) and Tsavo West (TsW) NPs in Kenya, which together occupy about 21,000 km^2, and the Mkomazi Game Reserve (MGR) which occupies about 5,000 km^2 in Tanzania. In the centre of the ecosystem, but outside the PAs, are the Taita Hills, which rise to 1,500m above the general landscape. These hills are densely populated due to their much higher rainfall and agricultural potential (Wijngaarden 1985).

2.3 Human occupation of the Tsavo ecosystem

The history of the Tsavo ecosystem remains speculative until the written records of the early missionaries (Krapf 1860). However, a great deal of information on the major patterns in land tenure and use before this date has been determined from oral history. Tribal groups have used the land in the Tsavo ecosystem for thousands of years before the creation of the NPs. These groups comprise the Watta (also known as the Waliangulu or Sonye), Taita, Taveta, Orma, Masai and Kamba (Sheldrick 1973, Patterson 1979, Ecosystems 1982, Wijngaarden 1985, Ville 1995). Their precise main areas of occupation and spheres of influence in this vast area have fluctuated throughout the centuries but their core areas of occupation were fairly constant (Figure 2.4). As past uses of the ecosystem by these people, who now live around the NPs, may well influence not only present attitudes to wildlife conservation but also future outlooks, this section provides a description of the main tribal groups.

Figure 2.4 Tribal land use before 1948 (adapted from Ecosystems 1982).



2.3.1 The Watta (Waliangulu or Sonye)

The Watta are the first and probably the oldest inhabitants of the central Tsavo ecosystem. The Watta once ranged from the Tana River to Kilimbasi and the Taita Hills (Figure 2.4). The Watta were hunters and specialised in elephant hunting, supplying the coastal traders with tonnes of ivory. Their main weapon were powerful bows and potent poisoned arrows, and their archery technology was reputed to be one of the best in East Africa (Sheldrick 1973, Parker & Amin 1983, Ville 1995). Their neighbours placed them in the same category as elephants, describing them as being powerful and dangerous, and often called them "animals" (Ville 1995).

The traditional way of life of the Watta revolved around the elephant. Camps were built next to an elephant that had been killed and dwellings were moved according to the kills. Elephant meat was their main food, supplemented by honey. Elephant fat was used for cosmetic purposes. The Watta attached great importance to the elephant through many of their myths and folklore (Ville 1995). They used elephants for ceremonial and initiation purposes. To become an adult, a young man had to kill a dangerous beast such as a rhino or a buffalo, but an elephant was even more precious, as the tusks were required for marriage. The first hunting success was greatly celebrated, the festivities lasting for many days before the hero was blessed in the hope that he would become a skilled hunter (Sharpe no date, Ville 1995).

For centuries before the creation of the NP the Watta may have contributed to the ecological balance by reducing pressure on woodland through hunting. It has been argued that the killing of elephants by the Watta actually preserved other important resources, such as trees (for example species of *Commiphora* and *Boswellia*) in whose hollows wild honey was found. The Watta also made use of other plant species, such as the fruits of the baobab (*Adansonia digitata*) for food and beer fermentation. Bark from *Sterculia africana* tree was used for making carrying straps, snuff and natural water storage containers. Products from *Grewia* spp. tree provided food and wood for making bows and arrows (Ville 1995). Most of these species also constituted a portion of elephant diet (Bax & Sheldrick 1963, Dougall & Sheldrick 1964).

The formation of the Tsavo NPs in 1948 led to an increase in elephant population in the NPs during the 1960s (see Chapter 4). This, coupled with the effects of fire, resulted in the destruction of many *Commiphora* and *Sterculia* species and baobab trees, thus depriving the Watta of essential resources, especially honey (Napier-Bax & Sheldrick 1963, Agnew 1968).

In later years, the failure by the authorities to accept the Watta's hunting as a lawful way of life after the creation of the Tsavo NPs made them 'outlaws'. They were not allocated any special rights to any land outside the NPs, and were expected to integrate peacefully with their neighbours. However, some Watta men did not give up hunting and turned to full time poaching, killing elephants for their tusks, and rhinos for their horn, and leaving the flesh to rot (Sheldrick 1973, Ville 1995). Together with other tribes, mainly the Kamba and Mijikenda, the Watta became a real threat to the survival of the Tsavo elephant population (Sheldrick 1973, Winjaarden 1985). Special measures had to be undertaken to curtail their extensive hunting in the newly created NPs. In 1956, the Government waged a massive anti-poaching campaign to suppress all traditional and tribal hunting throughout the Tsavo ecosystem (Sheldrick 1973).

This underscored the extensive, but hitherto unappreciated, use the local people made of the Tsavo ecosystem.

2.3.2 The Taita

The Taita are a tribe of diverse origin with elements from both coastal and mainland tribes (Mkangi 1975). Living in close proximity as agro-pastoralists in the Taita Hills, they developed linguistic and cultural ties which made them a homogenous tribe (Mkangi 1978). Records by explorers in the 19th century say that hunting was also an important way of life for the Taita (Ville 1995). While they did hunt in the areas about their hill strong-holds, they made no strong territorial claims to the Tsavo low lands. One method of hunting elephants for ivory was to dig game-pits covered with vegetation in the plains. However, this method was not very successful as most elephants learned to smell out the traps and avoid the plains (New 1873, Ville 1995).

In 1884 there was a severe famine in the Tsavo area and all the Taita had to survive by hunting. There are accounts of the Taita hunting rhino and buffalo for food, but not elephants (Ville 1995). Killing of elephants was taboo to the Taita, and the act was thought of as "murder". The Taita instead harnessed the strength of the elephant in other more acceptable ways for their own benefit. For example, the Taita sprinkled elephant dung around their fields to protect them from thieves, sorcerers and crop depredation by wild animals, including the elephant itself. They also burned the dung to cure a sick person through fumigation (Ville 1995). Some of these practices have survived to date and their applications in protecting their crops will be discussed in Chapter 6.

2.3.3 The Taveta

Linguistically related to the Taita, the Taveta are of mixed origin but predominatly Bantu (Ville 1995). They lived, rather as refugees from more powerful neighbours, cultivating in the ground-water forests in the present day Taveta (Figure 2.4). Their livestock made occasional use of the western fringes of the Tsavo ecosystem, though due to the presence of the Maasai (Section 2.3.5) this may have been only to a limited extent (Mkangi 1978, Ville 1995).

2.3.4 The Orma

The Orma are pastoralists believed to have entered the Tsavo ecosystem around the 15th century and are thought to have grazed their livestock as far south as the Tanzania border. Their livestock were badly hit by rinderpest in the last two decades of the 19th century, after which the Orma withdrew completely from the lands south of the Galana/Sabaki River (Patterson 1979, Ville 1995). The interests of the Orma in the Tsavo ecosystem clashed with those of the Maasai, another pastoral tribe (Section 2.3.5).

2.3.5 The Maasai

The Maasai are highland pastoralists who expanded into the Tsavo ecosystem in the 17th and 18th centuries and this brought them into conflict with Orma (Jacobs 1975, Saitoti 1980, Kipury 1983). At the height of their expansion, the Maasai grazed their livestock between Kilimanjaro and the Taita Hills, in what later became TsW, and regularly raided as far east as the Tana delta throughout the 19th century (Figure 2.4). As with the Orma, the rinderpest epidemics caused them to withdraw from their hinterland to the west (Krapf 1860, Johnston 1886, Ville 1995).

2.3.6 The Kamba

The Kamba are Bantu, who are believed to have arrived in the Machakos highlands from the south in the 15^{th} to 16^{th} centuries (Jackson 1976). The Kamba are thought to have later been augmented by the coastal tribes and they then radiated out from Machakos into Kitui, a lower and more arid region (Figure 2.4). To cope with the arid conditions, the Kitui Kamba relied more on pastoralism and hunting than the Machakos Kamba. This radiation proceeded until Kamba were established at Ngulia in what later became TsW (Jackson 1976). Through the evolution of a very lucrative ivory trade with the coastal people, Kamba influence in the Tsavo ecosystem became far more than that of mere subsistence hunters and pastoralists (Sheldrick 1973, Parker & Amin 1983, Ville 1995).

A major drought occurred in 1971 and there was a mass death of elephants in Tsavo (Corfield 1973). The neighbouring Kamba entered the NPs to profit from the ivory bonanza, and found that the park staff were unable to keep them out effectively (Ecosystems 1982). When the ivory from the elephant die-off became scarce, the Kamba took to poaching the surviving elephants. Their success became widely known and attracted numbers of aggressive Somali hunters (Sheldrick 1973, Parker & Amin 1983), which became a major factor in determining the fate of Tsavo elephants in later years.

2.4 Creation of the Tsavo National Parks

The main factors that led to the creation of the Tsavo NPs in their present location were based on environmental conditions and on the patterns of land use in the ecosystem in the early part of this century. The ecosystem lies in an area of low and erratic rainfall sandwiched between land of higher ecological potential and which supported widespread hunter gathering and traditional nomadic pastoralism. In contrast, the coastal zone to the east has high rainfall brought by the monsoons and the north west also has high rainfall due to an orographic influence. Consequently, high population densities and more settled forms of agricultural land-use also only occurred along the coastal strip and in highland areas.

In 1948 an area of 21,000 km^2 of the Tsavo ecosystem was set aside as NP (Legal Notices of Parks and Reserve Establishment, Tsavo National Parks, 1948). Once proclaimed, the only lawful use of the NPs by the public was tourism and recreation through game viewing, and also scientific research in wildlife ecology. The people who had occupied and used the area for centuries were evicted. This was a particularly severe infliction upon the tribes who had habitually used this land for grazing, hunting and other needs (see Section 2.3).

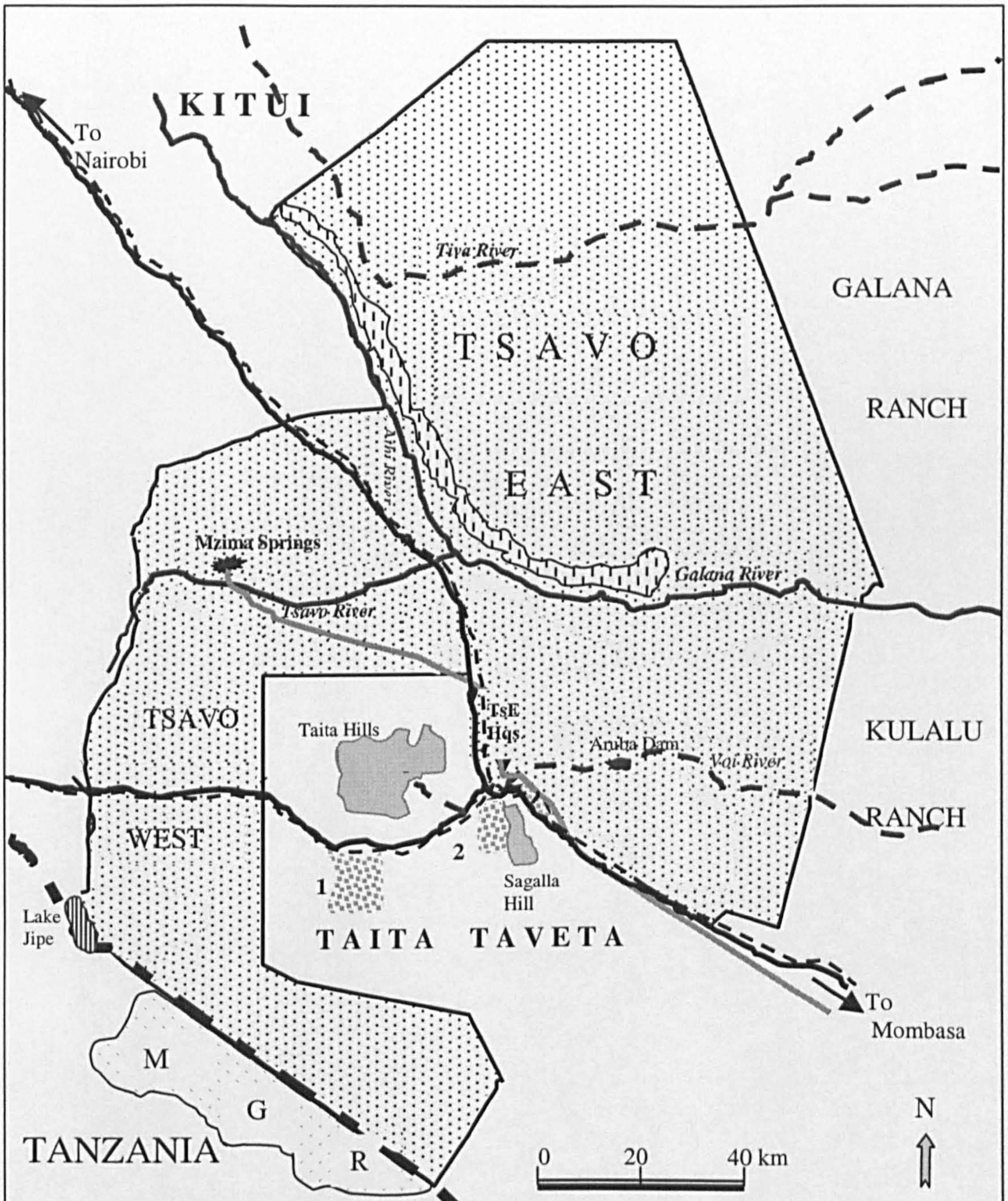
The available records do not show specific reasons for the creation of the Tsavo NPs in their present location other than that the land was relatively free to the gazetting agencies in terms of political and economic sacrifices, and that the land was considered useless for anything else. In the same period, other NPs were being created in Kenya and the general purpose of creating them was ".. for the preservation of wildlife, wild vegetation and objects of aesthetic, geological, prehitorical, archeological, historical or other scientific interest therein, and for incidental matters relating thereto .." (Preamble to Cap 377 of 1945, Laws of Kenya). This general purpose applied to the Tsavo NPs. The only factor of conservation planning in the delineating of the boundaries was the "boot" of TsW which was to abut onto the Mkomazi Game Reserve (MGR) in the neighbouring Tanzania (Ecosystems 1982) (Figure 2.5). For administrative purposes the park was divided into two sectors, TsE and TsW, the dividing line being the Nairobi-Mombasa railway (Figure 2.5). TsE, which lies between $2^0$00-$3^0$45' and $38^0$30'- $39^0$15'E, occupies an area of approximately 13,150 km^2. TsW lies between $2^0$41'-$4^0$08'S and $37^0$49'-$38^0$33'E and is the smaller of the two sectors occupying about 7,850 km^2. In the 1960s a large proportion of the remaining area of the ecosystem was developed into cattle ranches, to which wildlife from the NPs generally has free access (Wijngaarden 1985).

2.5 Climate

The rainfall regime in the Tsavo ecosystem is roughly related to the movement of the Inter-Tropical Convergence Zone (ITCZ) (Wijngaarden 1985). Rain usually falls in two rainy seasons. The main rains are usually from November to December, followed by a short but hot dry season in January to March. Another rainy season usually occurs in March-April/May and the period between June and October is generally dry and relatively cool, with temperatures rising again in September/October. This long dry season is the main period of stress for the elephant and other large herbivores in Tsavo, as strong southerly winds desiccate soil and vegetation, further exacerbating the lack of rainfall (Tyrrel & Coe 1974, Leuthold 1977a).

Although the seasons described above are usually well defined, rainfall varies considerably in its spatial and temporal distribution. The rains may fail to varying degrees in one season, or considerable rain may fall out of season. Also some areas in

Figure 2.5 The Tsavo National Parks.



- Permanent river
- Seasonal river
- Lake
- Major road
- Railway line
- Mzima pipeline
- International boundary
- MGR Mkomazi Game Reserve
- National Park
- Sisal plantation (1- Voi Sisal Estate, 2 -Teita Estate)
- Hills
- Yatta plateau

the ecosystem may receive substantial rain from isolated thunderstorms, while others remain completely dry (Wijngaarden 1985). Hence, it is difficult to make hard divisions of the seasons, as conditions may differ considerably between different areas at any one time. The combined length of the two dry seasons are longer than the two rainy seasons, 6-8 versus 4-6 months in most years (Leuthold 1977a).

The mean annual rainfall is 550 mm, but the amount is somewhat more in northern TsW and considerably less in southern TsW and most of TsE (Cobb 1976). TsE receives most of its rainfall from cloud formations moving inland from the Indian Ocean (Figure 2.1). As a result, the easternmost portions of the Tsavo ecosystem are often the first to receive substantial rain at the beginning of the wet season, or even out of season rains occasionally. Rainfall in TsW is generally higher and usually less erratic in spatial and temporal distribution than in TsE (Wijngaarden 1985). Thus environmental conditions can be characterised as being generally harsher and undergoing more fluctuations in TsE than in TsW (Cobb 1976, Wijngaarden, 1985).

Temperatures are fairly constant over the year, with a mean maxima of $33.3^{0}C$ in March and a minima of around $20^{0}C$ in July (Wijngaarden 1985).

2.6 Agro-climatic zones

An index of water availability reflecting variation in rainfall and evapotranspiration has been defined and a classification of agro-climatic zones worked out (Braun 1980). This index is based on the ratio of average annual rainfall (AR) to average annual evapotranspiration (AE), and presents variations in the water available for plant growth (Table 2.1). Zones with higher index value have both greater agricultural potential and more mesic natural vegetation than zones with lower index value.

Table 2.1 Braun's agro-climatic zones (Braun 1980)

Zone	AR/AE	Climatic designation	Characteristic natural vegetation	Agricultural potential
1	80%	Very humid	Moist forest	Very high
2	65-80%	Humid	Moist & dry forest	High
3	50-65%	Sub-humid	Dry forest & moist woodland	Medium to high
4	40-50%	Semi-humid to semi-arid	Dry woodland & bushland	Medium
5	25-40%	Semi-arid	Bushland	Marginal
6	15-25%	Arid	Bushland & scrubland	Low
7	15%	Very arid	Desert scrub	None

Reference will be made to this classification while discussing the agricultural potential of the Tsavo ecosystem. In general terms, most of the Tsavo ecosystem falls within agro-climatic zones 4 to 6, and only the Taita Hills and Sagalla Hills can be classified as falling into zones 1 to 3.

2.7 Soil fertility

Soil fertility and soil structure are second only to water availability in the importance of determining ecological and agricultural potential (Wijngaarden 1985). Based on a generalised soils fertility map, the broad picture in the Tsavo ecosystem is one of low fertility with isolated areas of better value (Sombroek 1980, Wijngaarden 1985).

2.8 Hydrology

People, their livestock and a wide variety of wild animals in the Tsavo ecosystem are dependent on regular and frequent intakes of water. The distribution of water, whether natural or artificial, is therefore of critical importance to the distribution of elephants, which are a water dependent species (Wijngaarden 1985).

2.8.1 Natural water supply in the Tsavo ecosystem

Natural permanent surface water sources are very limited in the Tsavo ecosystem (Figure 2.5). Only the Galana, Tsavo and Athi rivers flow all year round. Smaller seasonal rivers such as the Tiva and Voi retain stagnant pools and ground water long into the dry season. In southern TsW, permanent water is also available at Lake Jipe and in TsE small springs are found along the Yatta plateau and in some places on the dissected plains. Their discharge is small and the water often becomes saline by the end of the dry season. Because of intensive use, they also quickly become contaminated and the water undrinkable to elephants (Wijngaarden 1985, Pers. observ).

Numerous waterholes, which are usually shallow depressions in the landscape, hold water after the rains and may contain water for several months into the dry season. Elephants and other wallowing animals have probably played an important role in their formation and maintenance (Ayeni 1975).

2.8.2 Artificial water supply in the Tsavo ecosystem

The supplies of artificial water inside and outside the Tsavo NPs are described in some detail as they are likely to play a significant role in the movement and distribution of elephants within the ecosystem.

The need for an artificial water supply within the Tsavo NP was recognised in the early 1950s and plans for its development were started primarily for three reasons. These were to prevent wildlife from moving outside the NPs in search of water, to attempt to distribute wildlife evenly throughout the NPs, and to improve the touristic potential of the area (Sheldrick 1965, Ayeni 1975). In 1950 the first dam, Boka, was constructed along the Voi River near TsE park headquarters (Figure 2.5). Later in the same year another dam, Kandecha, was constructed further down river but it silted up the following year. Aruba Dam, which initially occupied an area of about 1.3 km^2 (Jenkins, pers. comm.), was then constructed a short distance down stream from Kandecha in 1951. This was the biggest dam ever constructed in the NPs and for many years it was a source of water throughout the year. However, due to heavy silting it no longer could hold much water, and from 1993 it became reduced to very swallow muddy puddles during the dry season, drying up completely in drought years.

The "elephant problem" became a major issue in Tsavo during the 1960s (see Chapter 4). A large water plan was initiated which included pumping water from Galana River to the northern area of TsE to supply water to wildlife, the main focus being on elephants. In 1962 Irima waterhole was constructed and in 1966 Mukwaju and Ndara boreholes were sunk, from which water was pumped at the peak of the long dry season in TsE (Figure 2.6). Other artificial waterholes were constructed in various other areas of southern TsE, most of them by widening and deepening natural pans in well drained soils expected to retain water for long after the natural waterholes and seasonal rivers had dried out. The boreholes and waterholes were expected to distribute game evenly and remove the pressure off the Voi River and Aruba Dam where over-utilisation of the vegetation and soil degradation had accelerated (Sheldrick 1965, Ayeni 1975). The water supply was well maintained till the late 1970's when the programme collapsed due to lack of funding (Jenkins, pers. comm). The boreholes worked well until 1977 when the pumps broke down and were neglected for many years. In 1994, Mkwaju borehole was rehabilitated by a private firm that operated a tourist tented campsite in the area. Water was pumped into a reservoir and was available to wildlife throughout the year. In mid 1995 Ndara borehole was also rehabilitated by the same firm and a mobile pumping unit used to provide water during the dry season.

Water development projects, primarily for cattle, were also carried out outside the NPs, which increased the availability of drinking water in the Tsavo ecosystem. Most ranches, such as Galana and Kulalu, developed their own water supply, either pumped from the Galana River (Galana and Kulalu Ranches) or supplied from a branch of a pipeline running from Mzima springs in TsW to Mombasa (Figure 2.5). Elephants seek access to most of the water supplies outside NPs, and this is a factor that has resulted in human-elephant conflict problems (Chapter 5).

Figure 2.6

2.9 Vegetation

Differences in vegetation types in the Tsavo ecosystem arise as a result of several interacting elements including climatic, geological and human induced factors (Wijngaarden 1985). The vegetation over most of the Tsavo ecosystem consists of mixed *Commiphora-Acacia* woodland with occasional large trees, the most frequent being *Delonix elata, Melia volkensii, Platycelyphium voense* and *Adansonia digitata* (Napier-Bax & Sheldrick 1963). Very common small trees are *Starculia rhynchocarpa, S. africana, Lannea elata,* and *Boswellia hildebrandtii.* Prominent bushes are *Cordia gharaf, Grewia* ssp., *Bauhinia taitensis, Terminalia orbicularis* and *Premna resinosa* (Greenway 1969, Wijngaarden 1985). *Sericocomopsis pallida* is a very common shrub, which forms a dense cover at or near ground level in many places (Leuthold 1994). The Galana and Tsavo rivers are fringed by *Populus ilicifolia, Acacia elatior, Hyphaene coriacea, Tamarindus indica, Newtonia* spp. and *Ficus* spp.

The important grasses include *Chloris myriostachya, C. gayana, Cenchrus ciliaris, Panicum deustum, P. meyerianum, P. maximum, Dactyloctenium gigariteum, Brachiaria deflexa, B. leersioides, B. serrifolia, Aristida* spp., *Eragrostis* spp. and *Tetrapogon* spp. The legumes *Indigofera* spp., *Tephrosia* spp. and *Crotalaria* spp. occur widely. In the rainy season creepers including *Ipomea* spp., *Thunbergia gurkeana, Cucumis* spp. and allied genera, cover much of the land while short-lived herbs including *Heliotropium steudneri, Commelina benghalensis, Digera alternifolia* and *Tribulus terristris* also occupy extensive areas of ground (Greenway 1969, Wijngaarden 1985).

In the past the vegetation was almost entirely *Commiphora-Acacia* bush. However, under the influence of elephant and fire, the bush was destroyed and thinned in large areas, where it was replaced by grassland (Agnew 1968, Laws 1969b, Wijngaarden 1985). However, in recent years there has been a slow reversal to bush (Leuthold 1994). In many places the riverine forest has been extensively thinned by elephants, fires and flooding. Small evergreen trees of the genus *Dobera*, and the evergreen shrub *Boscia coreacea*, *Thylachium thomasii* and *Salvadora persica* seem resistant and to be increasing in numbers, perhaps because they are unpalatable to elephants (Leuthold 1994).

2.10 Fauna

Over 32 species of the larger mammals (Glover *et a*l 1964, Cobb 1976) and 324 species of birds (Lack *et al* 1980) are found in the Tsavo ecosystem (Appendix III). Notably absent are some antelopes which dominate other ecosystems in East Africa, such as the wildebeest and Thomson's gazelle (Cobb 1976). Though the elephant is not the most numerous species, it is ecologically the dominant herbivore that has a profound effect on Tsavo ecosystem dynamics (Laws 1969b, Laws 1970, Leuthold 1977c, Wijngaarden 1985).

2.11 General methods

Data were collected using a multidisplinary approach. In Taita Taveta District, studies were carried out in the area between the southern sectors of TsE and TsW (Figure 2.2). In this area data gathered included human demography, land use, mode of livelihood, local peoples' attitudes towards conservation, types and frequency of human-elephant conflict incidents and intervention methods. Similar data were also gathered in Galana and Kulalu, which are two large-scale cattle ranches that lie adjacent to TsE and form part of the Tsavo ecosystem, but fall within Kilifi District (Figure 2.1). In Kitui District similar data were gathered in 10 blocks that were situated within 40 km of TsE boundary (Figure 2.3).

Rainfall records were gathered from the Kenya Meteorological Department and from 24 rain gauges installed to cover the study area. These were used to determine monthly rainfall totals, distribution and overall patterns throughout 1995 to 1997. The availability of surface water inside and outside the NPs was mapped and monitored on a monthly basis.

The main sources of information for human-elephant conflict incidents were KWS records. In each District there is central game station manned by KWS wardens and rangers, with substations and outposts in some villages. Each station or outpost has a Report Book (RB) and/or Occurrence Book (OB), in which information brought in by members of the public and actions taken are recorded on a daily basis.

To find out whether the KWS records were reliable, independent data on conflict incidents was collected over 6 months in three Locations adjacent to TsE (Mbololo, Voi and Sagalla). Both these independent data and records from KWS records were not significantly different ($\chi^2 = 0.279$, df = 2, $p > 0.10$).

Between 1995 and 1997, field studies were undertaken in conflict sites in Taita Taveta District where elephant visits and activities were verified. Data were collected on all incidents of human-elephant conflict. Notes were made of the following: the location; time and nature of conflict; action taken by the local people or the PAC unit of KWS; the sex and group composition of problem elephants; and, any other relevant information. Where elephants had left the scene, details were obtained by inspecting signs that could be attributed to elephants (footprints or dung), and the food crop or other plant species and parts consumed was noted.

Data on elephant trends were compiled using past census records and reports, while those on mortality were compiled from the TsE ivory store records, reports of sightings of carcasses by the TsE pilots and field rangers, CWS records and Tsavo KWS intelligence sources.

Data for the social part of the study were derived from questionnaire interviews in sample villages in the study sites in both districts. Efforts were made to elicit a wide range of information on interactions between the local people, elephants and other wildlife, including oral history. The interviews included both open-ended and fixed response questions, and were conducted with the help of KWS field assistants who spoke the local languages.

Villages were chosen at random, but efforts were made to visit at least 8 villages in each administrative Location (in administrative terms a few villages make a Sub-Location, Sub-Locations make a Location and Locations make a Division, then District and finally a Province, the largest administrative unit in Kenya). After reaching a village and informing the local administrator of our mission, respondents were selected from every third homestead along a path that seemed to cut across the village. The oldest member of a homestead present was chosen for interview, as he/she was likely to be most knowledgeable and able to give the most accurate information. However, in a few cases interviews were conducted on a chance encounter of suitable interviewees in scarcely populated areas.

Though all efforts were made to assure the respondents that all information provided was to be treated in strict confidence and no victimisation or any other action was to be taken against them, it was possible that some of the local people may have exaggerated some issues or did not express their opinions freely. Questions of historical nature were direct and the accuracy of the answers given in some instances depended on the memory and personal experience of the respondents. Only people aged 18 years or more were interviewed during the survey.

While it was very difficult to evaluate response bias, it was nevertheless felt that the results reflect the local situation and opinions accurately because of the nature of the response and consistency, which also matched the 11 years experience that the author has gained working in Tsavo. A total of 563 respondents were interviewed of which 312 were from Taita Taveta District and 251 from Kitui District. The questionnaire form used in this study is shown in Appendix I.

Details of specific methods are described in each chapter. Data were analysed using Microsoft Excel 97 and SPSS Version 8.0 for Windows statistical packages. Maps were produced using Microsoft Word 97 and Map Maker Version 1.0 for Windows, which is a simple Geographic Information System for creating and manipulating maps.

Chapter 3

Changes in Human Population in the Tsavo Ecosystem

3.1 Introduction

Expansion of the human population and its resulting activities have led to loss of elephant range in many parts of Africa, 'compressing' the species into sanctuary areas (Western 1989, Dublin *et al* 1997). Models have been presented which show that the distribution of elephants in Africa for the last 70 years has been inversely related to that of humans. This has been due to competitive exclusion of elephants where humans and elephants compete for the same resources (Parker & Graham 1989a & b, Hoare 1997).

The numbers and distribution of people in the Tsavo ecosystem have expanded continuously over the past five decades. This is likely to have had a profound influence upon the ecology of the ecosystem and the patterns of land use within it, resulting in a diminished range for the ecosystem's elephant population.

In this chapter, I provide a general description of changes in human population and distribution in the Tsavo ecosystem and a more detailed description of changes in some areas within 20 km of NP boundary (Section 3.3.1). The main economic activities and status of formal education of the local community are given in Sections 3.3.2 and 3.3.3, while Section 3.3.4 shows the period of residence in villages close to the NP boundary. Benefits from wildlife, both real and perceived, attitudes towards wildlife conservation, and various forms of wildlife utilisation in Tsavo are described in Sections 3.3.5 to 3.3.8, and these results are discussed in Section 3.4.

3.2 Methods

3.2.1 Human demography

Data on human population numbers and density were obtained from the Kenya Central Bureau of Statistics (KCBS). Data were available in the form of numbers of males and females, number of households in each census unit, area of census units and densities at the level of Sub-Location. A Sub-Location is the smallest administrative unit in Kenya and comprises of a few households which are usually in form of villages. Data were collected for 1948, 1962, 1979 and 1989, when the last national census was conducted. Figures were extrapolated for 1997 using the country's annual growth rate of 3.2 % (KCBS 1996). This approach yielded a run of actual and extrapolated figures from 1948 to 1997.

To show the general trend in human population changes in the Tsavo ecosystem, data for both Taita Taveta and Kitui Districts were pooled and the mean calculated for each of the 4 years. To further show an indication of human population changes and distribution over time within the ecosystem outside NPs, areas supporting different human densities were classified into four categories. These were high (>50 people per km^2), medium (20-50 people per km^2) and low (< 20 people per km^2) .

3.2.2 Surveys of socio-economic factors and attitudes towards conservation

Questionnaire surveys (Chapter 2, Appendix I) were used to gather information on the mode of livelihood, economic activities, status of formal education, period of residence, benefits from wildlife, wild resources utilisation and attitudes and perceptions towards wildlife conservation and KWS personnel among the Tsavo community.

3.2.3 Wildlife utilisation and tourism

Data on the harvesting of various species of wildlife were compiled from arrests of poachers found with wild meat, traps and snares found along the NP boundary and KWS intelligence reports.

Data on paying visitors and revenue collected for TsE was compiled from park records, for the years 1991 to 1995.

3.3 Results

3.3.1 Demographic patterns

Trends in human population in the whole of the Tsavo ecosystem outside NPs between 1948 and 1997 show a steady increase (Table 3.1). These data also show an increasingly higher proportion of the ecosystem supporting people at a higher density (Figure 3.1). In addition to the general intensification and expansion of the population throughout the ecosystem, the pressure in the immediate vicinity of the NPs has also increased. Data from five sample Locations within 20 km of TsE NP (Mbololo, Voi and Sagalla in Taita Taveta and Kasala and Simisi in Kitui, Figures 2 and 2.3) show that pockets of people living at medium and high density have established themselves near the NPs (Tables 3.2 and 3.3). This shows that these areas close to NPs are supporting an increasingly higher percentage of the human population in the Tsavo ecosystem (Table 3.2).

Table 3.1 Changes in human population and density in the Tsavo ecosystem 1948 to 1997. (The area within the ecosystem but outside NPs = 21,500 km^2).

Year	1948	1962	1979	1989	1997
Number of people	101,050	154,800	208,550	291,293	393,245
Density/km^2	4.7	7.2	9.7	13.6	18.3

Figure 3.1 Changes in the proportion of land supporting people at different densities within the Tsavo ecosystem (excluding NPs) 1948 to 1997.

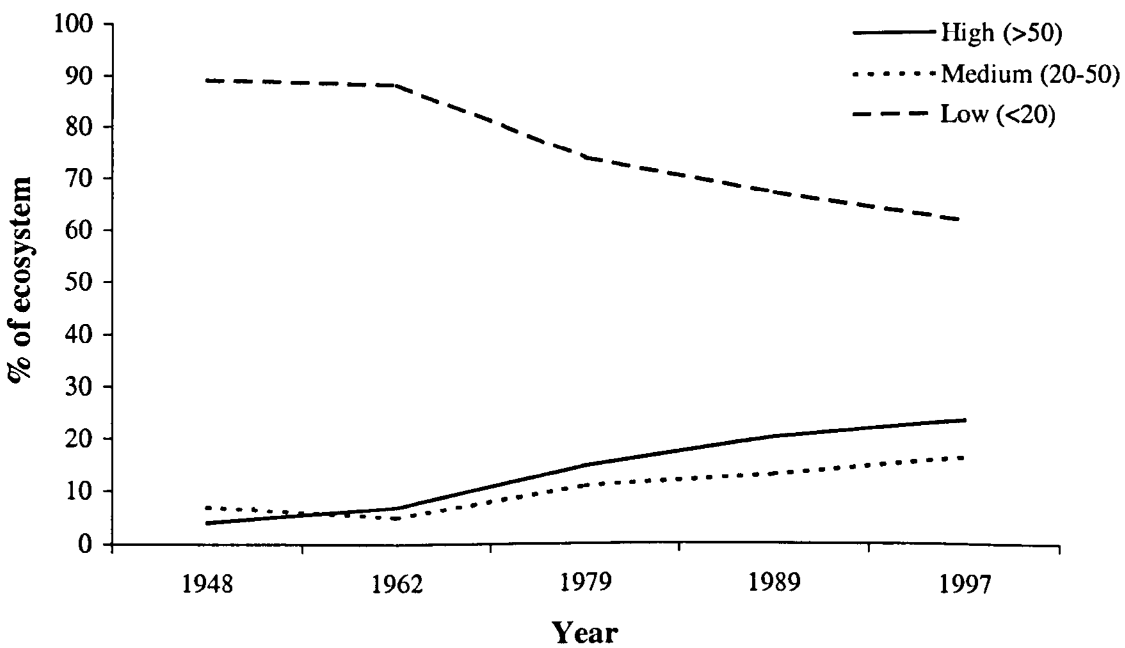


Table 3.2 Changes in human population density and number of households in three Locations adjacent to TsE in Taita Taveta District, 1979 to 1997.

Location	Year	Density (no./km^2)	No. of households
Mbololo	1979	3.4	5,512
	1989	12.2	8,166
	1997	34.7	-
Voi	1979	47.8	2,522
	1989	96.3	9,014
	1997	138.8	-
Sagalla	1979	11.5	3,308
	1989	15.6	4,539
	1997	21.4	-

Table 3.3 Changes in human population density and number of households in two Locations adjacent to TsE in Kitui District, 1979 to 1997.

Location	Year	Density (no./km^2)	No. of households
Kasala	1979	16	409
	1989	20	581
	1997	73.8	-
Simisi	1979	14.5	421
	1989	17.0	568
	1997	21.7	-

(Data on the number of households were available for 1979 and 1989 only).

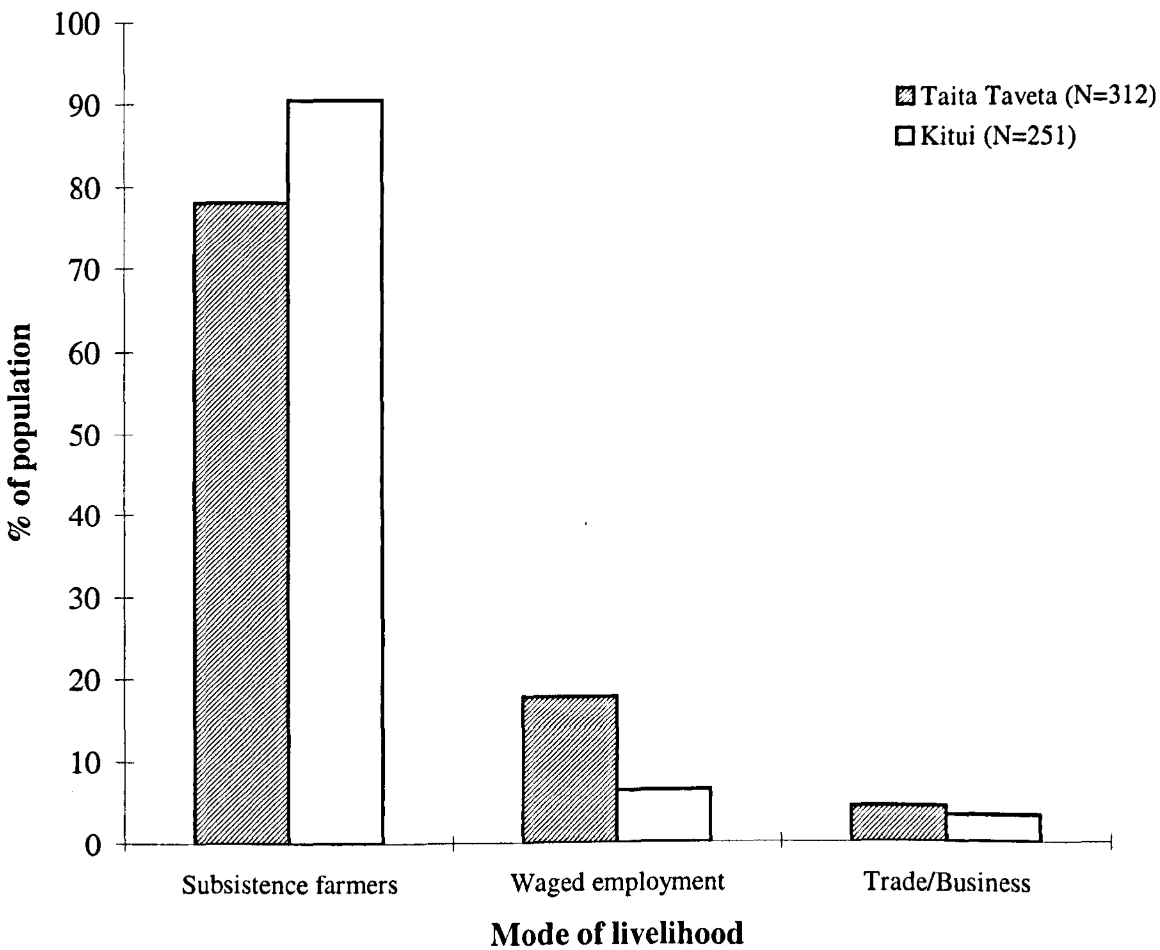
3.3.2 Main economic activities

There were 3 main modes of livelihood for both the Taita Taveta and Kitui people (Table 3.4). However, the proportions within each mode of livelihood differed between the two district (χ^2 =17.55, df = 2, p<0.01).

Table 3.4 Number of local people and main mode of livelihood in Taita Taveta and Kitui Districts.

	Taita Taveta	Kitui
Subsistence farmers	243	227
Waged employment	56	16
Trade/Business	13	8
Total	312	251

Figure 3.2 Mode of livelihood of the local Tsavo people.



In Taita Taveta District 8% of the people were peasant farmers while the proportion in Kitui District was 90% (Figure 3.2). The proportion of people in waged employment (teaching and other civil service jobs, working in urban areas, etc.) was 8% in Taita Taveta, whereas the percentage in Kitui was 6%. In Taita Taveta District 4% of the people were involved in trade and other businesses (running shops, provision stores, commercial poultry keeping, etc.) while in Kitui District 3 % fell in this category.

3.3.3 Formal education

The lack of, or differences in the level of, formal education is a factor that could influence attitudes towards wildlife conservation, and therefore the degree of tolerance towards coexistence with elephants. Data on formal education were classified into 4 categories based on level attained. Those who had no formal education at all were placed into 'None' category, while those who had some form of basic education of up to 7 years in primary school were classified as 'Primary' category. Respondents who had secondary school education were placed in 'Secondary' and anyone who had proceeded on to a tertiary professional training college or university was placed in 'College/University' category (Table 3.5, Figure 3.3).

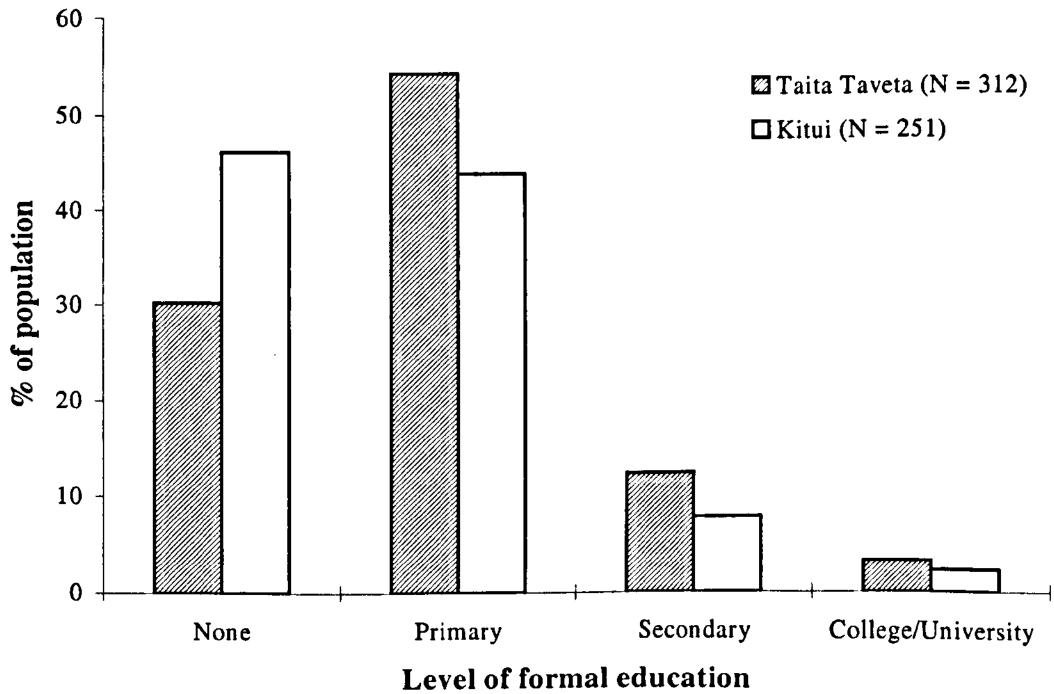
Table 3.5 Number of people who had attained different levels of formal education in Taita Taveta and Kitui Districts.

	Taita Taveta	Kitui
None	94	116
Primary	169	110
Secondary	39	19
College/University	10	6
Total	312	251

The data for each district were then pooled into 'None' for those who had no formal education at all and 'Educated' for all other categories and the difference was significant ($\chi^2 = 15.397$, df = 1, $p < 0.001$).

In Taita Taveta District 30% of the people had no formal education at all while the proportion in Kitui was 46% (Figure 3.3). In Taita Taveta, 54 % of the people had attained primary level education while 44% had done so in Kitui. A higher percentage, 13%, had attained secondary school education in Taita Taveta than in Kitui, 8%. A small percentage of people in both districts had received professional training in tertiary colleges or universities, 3% in Taita Taveta and 2% in Kitui.

Figure 3.3 Proportion of people who had attained various levels of formal education in Taita Taveta and Kitui Districts.

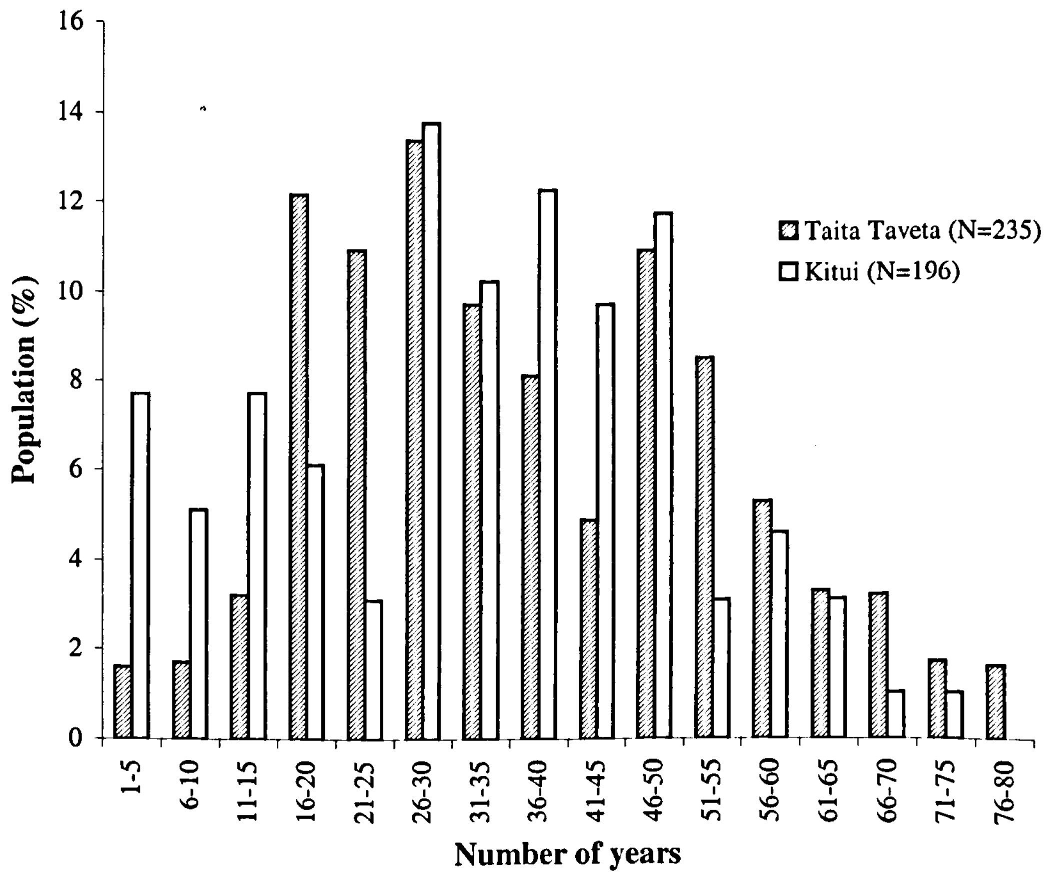


There is a possibility that these data show a bias against the more educated people and those in employment. A large proportion of people in these categories were working or seeking employment in areas outside the study sites. However, the findings were consistent with data obtained during the last national population census.

3.3.4 Period of residence

Overall periods of residence were different between the Taita Taveta and Kitui communities ($\chi^2 = 67.430$, df =5, $p < 0.001$).

Figure 3.4 Proportion of local people and their residence period in Taita Taveta and Kitui Districts.

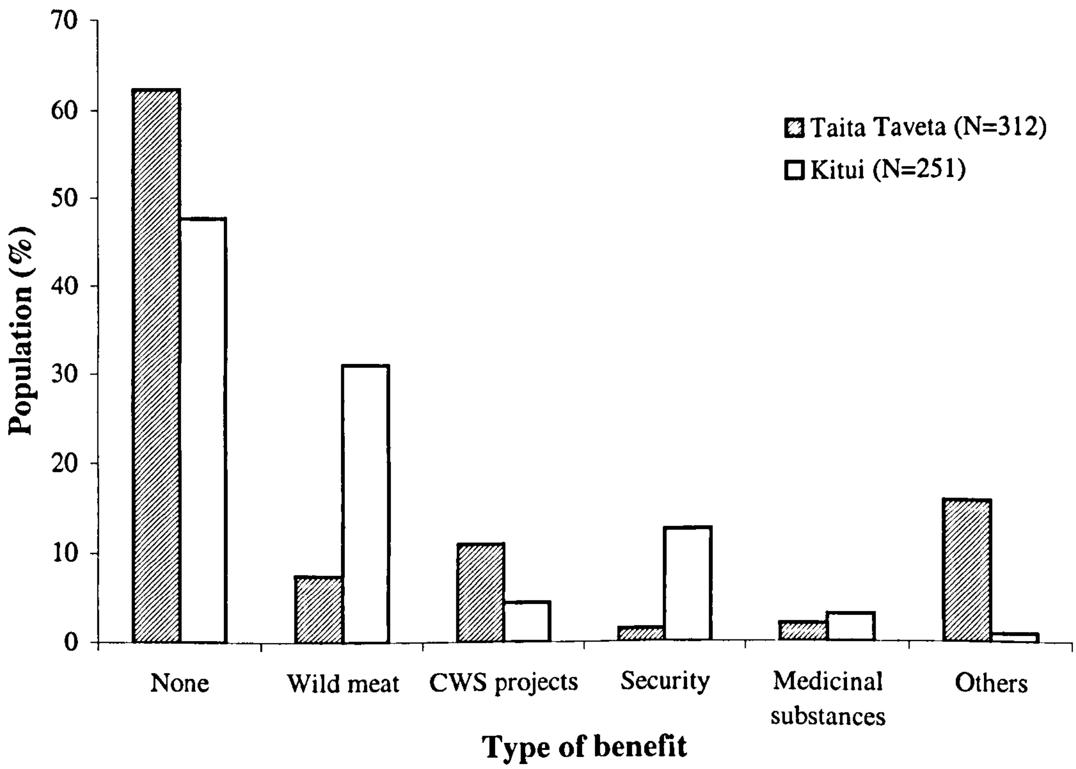


In Taita Taveta 93% of the people had lived for 20 or more years in their village by 1997 as compared to 74% in Kitui District. This may indicate that human population expansion towards the TsE park boundary has been accelerating faster in Kitui than in Taita Taveta District.

3.3.5 Real and perceived benefits from wildlife resources, KWS and Tsavo NPs

Asked what benefits they got from the presence of wildlife, NPs and KWS, the local people had different responses. Most of them gave multiple answers and the results were categorized using what each respondent considered to be the most important benefit (Figure 3.5).

Figure 3.5 Benefits from wildlife, NPs and KWS to the local people of Tsavo.



To find out whether there was any significant difference between the two districts in the proportion of people who got and did not get any benefits, the data for each district were pooled into 'None' for those who said they got no benefits and 'Benefits' for all benefit categories combined. This showed a difference between the two districts ($\chi^2 = 115.52$, df =5, p <0.001). In Taita Taveta District 62 % of the people said they got no benefits at all from elephants, other wildlife or KWS while 48% said so in Kitui District. In Kitui 31% of the people said they relied on wild animals for cheap meat, mainly through subsistence poaching, while the proportion in Taita Taveta was 8 %.

Projects funded by KWS (construction of school buildings, earth dams, etc) and aid given by the organisation (school fees bursaries, famine relief food, etc.) through its CWS programme benefited 11% of people in Taita Taveta District and 5% in Kitui District.

Robberies by gangs of bandits, who usually doubled up as elephant poachers, were more frequent in Kitui District where regular law enforcement personnel were few and widely spread out. In this district 12.6% of the people said they benefited from security offered by KWS anti-poaching personnel, who even at times assisted in the recovery of stolen livestock and other property. In contrast, only 1.5% of the people in Taita Taveta said that KWS played a vital role in the maintenance of security in the district.

In Kitui District 3% of the people said they benefited from wildlife culturally by obtaining medicinal substances in comparison with 2% in Taita Taveta. The proportion of the Tsavo people who got other direct and indirect benefits (tourism-based employment and enterprises, etc.) was higher in Taita Taveta District (16%) than in Kitui District (1%).

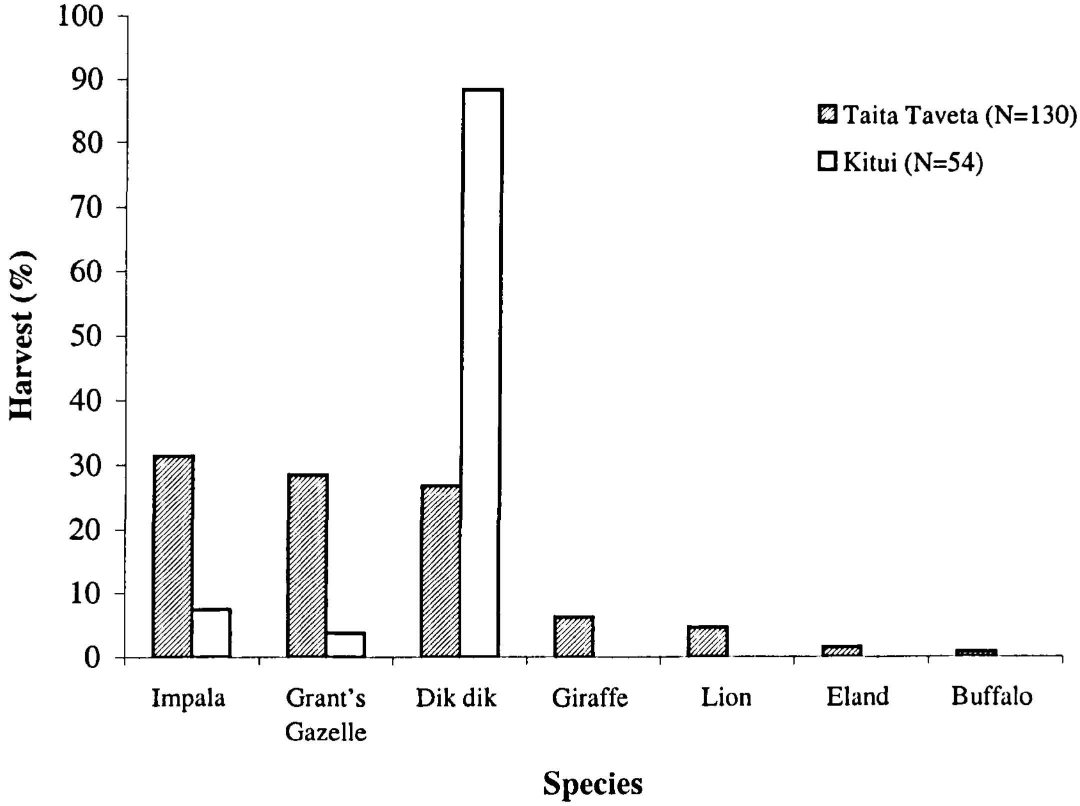
3.3.6 Wildlife utilisation by the local people

Hunting of game for subsistence has been a way of life for various tribal groups who occupied what is now Tsavo NPs and its environs (Chapter 2). Throughout 1995 to 1997, several species were harvested illegally, as evidenced by arrests of people in possession of wild meat (Table 3.6).

Table 3.6 Species and number of incidents of wild animal harvests, 1995-1997.

Animal species	Number of incidents	
	Taita Taveta	Kitui
Impala (*Aepyceros melampus*)	41	4
Grant's gazelle (*Gazella grantii)*	37	2
Dik dik (*Rhynchotragus kirkii*)	35	48
Girraffe (*Giraffa cameolopardus*)	8	0
Lion (*Panthera leo*)	6	0
Eland (*Taurotragus oryx*)	2	0
Buffalo (*Syncerus caffer*)	1	0
Total	130	54

Figure 3.6 Proportions of different species of wild animals harvested by the local people for meat and other products in Taita Taveta and Kitui Districts, 1995 to1997.



Most of the hunting was for the pot, but a few people killed large numbers of antelopes or larger wild mammals by using wire snares at night and traps. Another method used was "spotlighting" at night, whereby antelopes (usually impala, gazelle and dikdik) were dazzled by a powerful beam of light directed at their eyes, or stupefied with sound produced by a device modified from a car horn, while other people crept from behind the animals and chopped off their heads with heavy sharp machetes. The meat was then dried and sold locally at relatively cheap prices.

In Taita Taveta 7 species were harvested illegally while in Kitui only 3 were usually killed, with dikdiks comprising 89% of all recorded incidents (Figure 3.6). Though only 6% of the Taita Taveta people and 31% in Kitui admitted killing wild animals for subsistence, the percentage was likely to be higher as some of the respondents may not have accepted that they engaged in this illegal practice for fear of prosecution.

3.3.7 Use of other wild animal products

The Tsavo local people used a wide variety of wild animal products and derivatives for numerous other purposes (Table 3.7). A lot of the people believed that wild animals were immune to most common diseases and by eating wild meat or other products they could acquire the same immunity or get cured of deadly diseases. In Kitui 2.5% of the people said they used wild animal products for traditional medicine and cultural purposes while the proportion was 2% in Taita Taveta. Due to intermarriage and integration among the tribes in the Tsavo ecosystem over the years, it was not possible to separate the percentage use of each product by each tribe.

In addition to the animal parts and products, extracts from a wide variety of plant species were used in making herbal medicine for treatment of a wide variety of ailments.

Table 3.7 Wild animal products and their uses by the Tsavo community (Kamba, Taita, Watta).

Product	Use(s)
Elephant dung	Cure for measles and yellow fever. Rubbed on patient's body or added to bathing water
Elephant meat	Eaten to cure various allergies
Elephant blood	1.Cure for various skin diseases. Rubbed all over patient's body. 2. Drunk to cure diabetes
Tusk pulp	1.Believed to be a cure for breast cancer. 2. Given to children to lessen teething problems.
Elephant after-birth	1.Made into powder, mixed with water and given to women in labour to hasten delivery. 2. Buried in cattle kraals to make one wealthy.
Rhino horn	Used as an aphrodisiac.
Rhino skin	Roast and made into powder for treatment of whooping cough.
Lion fat	1. Rubbed on young male babies. Believed to make them to grow into strong and brave men. 2.Taken as medicine to cure a variety of ailments. 3. Used for treatment of asthma
Lion hair	Made into a ball then buried by a traditional medicine man in one's land or business premises. This is believed to bring good luck and prosperity, as well as being a powerful charm against witchcraft.
Zebra fat	For treatment of asthma
Oryx horns	Used by medicine men as charms stowage.
Eland blood	Sprinkled on flowering maize for improved yields.
Wild pig fat	Rubbed on body as a deterrent against witchcraft
Dikdik blood	From the liver - believed to cure eye ailments when rubbed directly around the affected part.
Dikdik hair	From the crest of the head, believed to cure tuberculosis. It is roasted and added to porridge or other drink.
Porcupine meat	Believed to give immunity to a wide variety of common diseases.
Tortoise liver	Roasted and made into powder for treatment of whooping cough.
Mongoose tail and hedgehog meat	Roast and powder mixed with water and drunk for treatment of yellow fever.
Ostrich fat	Asthma treatment

3.3.8 Tourism as a form of wildlife utilisation in Tsavo NPs

Since the creation of the Tsavo NPs, wildlife based tourism developed as a by-product of the imperative to preserve biodiversity. Wildlife tourism is becoming an increasingly important source of revenue for KWS and Kenya as a whole. Its importance is especially underlined because wildlife and PAs must be increasingly self-sufficient if they are to survive declining support from the central Government. Furthermore wildlife tourism is a marketing strategy, selling natural values and wilderness qualities which cannot be compromised if this form of utilisation is to be durable.

The number of paying tourists remained almost constant for the years 1991 to 1995, but the trend of revenue collected was upwards (Table 3.7). The changes in revenue collected was mainly due to increases in park entry fees and levies on hotel and camping businesses operating within the NP.

Table 3. 8 Number of tourist and revenue collected for TsE, 1991 to 1995.

Year	Number of visitors	Revenue (US$)
1991	136,949	589,953
1992	126,467	1,016,671
1993	136,804	1,742,677
1994	134,286	2,742,827
1995	132,595	2,556,910

(Source of data: TsE NP records, Accounts Department).

3. 4 Discussion

In 1948, when the Tsavo NPs were created, the human population was distributed largely according to the agro-climatic zones. The highest densities were found in the coastal zones and higher altitude areas in The Tsavo ecosystem, such as the Taita and Sagalla Hills, all which fall into Zones 1 to 3. In contrast the lower more arid Zones 4 to 6 supported the lowest human density. This relationship has become progressively weaker as population densities have build up within the ecosystem (Figure 3.1), including in the zones of low agricultural potential close to the NPs (Tables 3.2 and 3.3). Hence, the areas of the ecosystem formerly supporting low densities of less than 20 people per km^2 has fallen from 90% in 1948 to less than 65% in 1997, with noticeable change starting the early 1960s (Figure 3.1).

This build up has been due to both natural population increase and immigration of people into the ecosystem and closer to the NPs from the more densely populated surrounding areas (Ecosystems 1982, Ngure 1992). This trend is likely to continue as a result of the demographic structure of the community. About 51.4% of the people living in the ecosystem are under 15 years of age, and even if efforts to curb population growth are effective, demographic momentum will result in a higher population density in the near future (KCBS 1996).

The rapidly increasing human population is likely to result in further compression of the space available to elephants. With a significant proportion of the Tsavo elephant population still using ranges outside the NPs as seasonal dispersal areas (Chapter 4), conflict incidents are bound to increase.

The majority of the people in the Tsavo ecosystem are subsistence farmers (Figure 3.2) who depend on small plots of land for their livelihood. Few of the Tsavo population have other options or opportunities, a situation exacerbated by their having none or little formal education (Figure 3.3). Due to the poor climatic conditions in most of the Tsavo ecosystem, agriculture will not be able to support the majority of the people and innovative solutions will have to be found to enhance food production without further environmental damage. Depending on the decisions made, the outcome will affect the conservation of the elephant and other wild resources in Tsavo, either positively or negatively, depending on how the many inter-related issues will be addressed.

Knowledge on the attitudes that have developed toward the whole issue of elephant and other wildlife conservation and the factors influencing them is important in programme implementation to enable wildlife managers to tackle them in ways that attract support of the stakeholders and the general public. There are several levels at which the attitudes held by people towards the Tsavo NPs are important for their future. These can be placed in three main categories, village or grassroots level, district level and the central Government level.

Findings from this study showed that at the village level, the parks and the animals within and outside them were mainly perceived as a liability. Benefits received either directly or indirectly were only appreciated by a minority (Figure 3.5). Very few people received financial or other direct benefits from the money generated from wildlife through tourism, and none of the local people could legally generate wildlife revenues through hunting or other consumptive utilisation.

An interesting finding in areas where insecurity from poachers and bandits was prevalent was that most people held more positive attitudes towards the KWS anti-poaching personnel, whose presence kept bandits away and helped in retrieving stolen property, than to the NPs themselves or the animals within them. However, a significant proportion disapproved of some of the activities KWS rangers engaged in that were considered anti-social and culturally unacceptable (local administrators, pers. comm.). This suggests that attitudes of local communities may not only be strongly influenced by direct monetary benefits, but by the services and benefits they personally received. It would therefore seem that positive formal and informal contact is very important in breaking down mistrust between the local people and KWS personnel in Tsavo. Hough (1988) argues that formal and informal contacts may be critical in resolving conflict between potentially opposing parties.

More people in Taita Taveta District had lived for longer periods close to the NPs (Figure 3.4) and a higher proportion in the district said they got no benefits at all from wildlife, KWS and the NPs (Figure 3.5). This suggests that in Tsavo individuals who have lived for a longer period adjacent to NPs are more likely to hold negative attitudes than shorter-term residents. The reasons for this were not clear but could be related to the fact that more people in Taita Taveta have experienced greater resource utilisation restrictions than Kitui residents. Being closer to TsE headquarters law enforcement against all forms of illegal wildlife utilisation is more intensive in Taita Taveta District than in Kitui were there were fewer KWS personnel.

There was still widespread illegal harvesting of wild animals in the Tsavo ecosystem, with a wider variety of species killed in Taita Taveta District than in Kitui (Figure 3.6). Many subsistence poachers were arrested during the study period in areas adjacent to the NPs but the problem still persisted. Penalties for this kind of poaching were usually low, as courts of law were uncomfortable in handing down heavy penalties for the killing of animals whose value was not well defined in the national law. The low penalties given by magistrates served only to lower the poachers' input costs, and many people were willing to take the risks.

Where animals were hunted there was usually a powerful incentive to do so. The driving force in Kitui seemed to be for food and, if possible, to raise the meager annual family income. Hunting has always been a way of life for the local community and many people resented the park administration for denying them rights to kill some animals for subsistence. Arresting and prosecuting those who hunted for the pot did nothing to reduce their antagonism towards the NPs and conservation authority.

Utilisation of other wild resources within the NPs also shaped the attitudes of the local Tsavo people. Many could not understand why they were denied access to what used to be their grazing lands, traditional holy shrines, water sources and gathering and harvesting of honey and other products for food, house construction and cultural values. This resulted in apathy towards wildlife, and disobedience or downright antagonism to wildlife regulations imposed by KWS, which was probably a natural response to the discrimination, which impinged on their traditional lifestyles. In some occasions it was established that fires were deliberately started in the NPs by the local people during the dry season to destroy the resources which they had been denied.

Though the majority of the people had ill feelings towards the parks and conservation, a few people were still hopeful and showed some faith of getting benefits from wildlife, mainly through the KWS CWS programme (Figure 3.6). However, they expressed great dissatisfaction with unfulfilled promises and meager benefits that sometimes took years to percolate down through the various layers of central Government and KWS bureaucracy.

Wildlife based tourism in Tsavo satisfied the twin aims of commercial use of wild resources while at the same time helping to preserve biodiversity and natural landscapes. Most revenue from tourism emanated from motorised game viewing. According to figures released by the Ministry of Tourism and Wildlife (MTW), international tourism earned the country US$ 63 million while domestic tourism earned an extra US$ 16.5 million in 1996. In that year this accounted for 18% of all Kenya's foreign exchange earnings (MTW 1997).

The elephant is among the top five species that attract tourists to Tsavo (Tench *et al* 1995). The Tsavo elephant population is therefore an important asset for the whole country. The population trends, distribution and factors influencing the species survival in the Tsavo ecosystem will be described in the next chapter.

Chapter 4

Tsavo Elephant Population Trends and Distribution

4.1 Introduction

The Tsavo elephants are the largest single population in Kenya, and numerous studies have been carried out there since the early 1960s (Glover 1963, Napier-Bax and Sheldrick 1964, Glover *et al* 1964, Laws 1966a & b, Laws 1967a & b, Laws 1969a & b, Corfield 1973, Leuthold 1977a, Ottichilo 1981, Wijngaarden 1985, Douglas-Hamilton *et al* 1994, McKnight 1996). Early research was generated and directed towards solving the "elephant problem" caused by a concentration of elephants within the Tsavo PA after the creation of the NPs, leading to a modification of the vegetation from dense *Commiphora-Acaia* bush to open grassland (Napier-Bax & Sheldrick 1963, Laws 1969b).

More recently the main focus has been on changes in population numbers due to poaching (Douglas-Hamilton *et al*, 1994). Although recognised as a major problem in the conservation of the species, human-elephant conflict did not receive much attention until the last five years. This is the first comprehensive study of human-elephant conflict to be undertaken in the Tsavo ecosystem.

In this chapter, I give an overview of elephant population trends and factors influencing them in the Tsavo ecosystem, using data obtained from various sources (Section 4.3.1). The seasonal distribution of elephants in the Tsavo NPs in relation to rainfall and permanent water availability is discussed in Sections 4.3.2 and 4.3.3.

Elephant mortality from all causes throughout 1992 to 1997 is described in Section 4.3.4 and a discussion of the findings in Section 4.4.

4.2 Methods

4.2.1 Elephant population trends and factors influencing them

Data on elephant population trends in the Tsavo ecosystem since the 1960s were compiled from past counts, including WCMD, KWS and Department of Remote Sensing and Resource Surveys (DRSRS) records. Historical accounts of administrators, explorers and other travellers since the last century were reviewed to gather additional information on the species in the Tsavo ecosystem.

4.2.2 Elephant movements and distribution

Data on seasonal elephant distribution were gathered by aerial surveys with the assistance of pilots from TsE. The flight patterns were not systematic and no pre-calculated course was flown. Flights instead were organised so as to track the movements of elephant groups as closely as possible, essential for the deployment of security personnel and planning of law enforcement strategies. Most survey flights began at 06:00 hrs to 10:00 hrs in the morning and from 16:00 hrs to 18:30 hrs in the afternoon. The location of elephant groups in different seasons for the years 1995 and 1997 was plotted to produce a map of seasonal distribution.

Data sheets were designed on which details of the location of all elephants sighted inside and outside NPs, time of sighting, group size and, when possible, group composition were recorded. A Global Positioning System (GPS) was used to locate all elephants sighted. Any other relevant or incidental information such as rainfall distribution, state of vegetation, fires, poaching, carcasses, livestock in parks, charcoal burning, and other illegal activity was also recorded.

All data on elephant locations throughout 1995 to 1997 were plotted on the Tsavo map divided into 10x10 km grids. A map of seasonal distribution inside NPs was then generated using the mean densities for each grid for the three years.

4.2.3 Elephant mortality

4.2.3.1 Sex determination

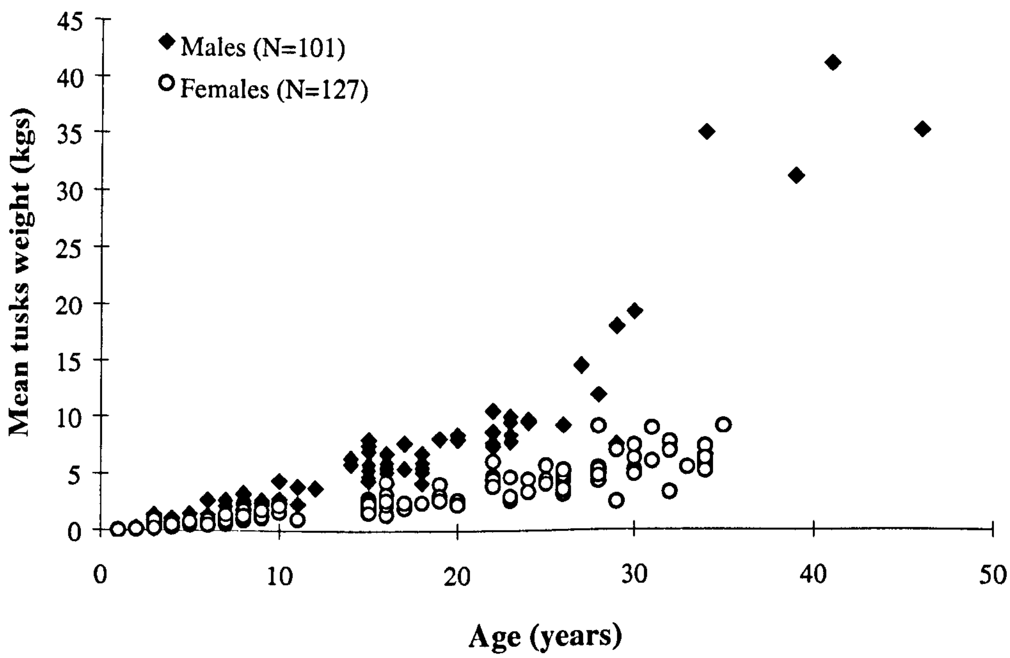
Efforts were made to obtain as much data as possible on all dead elephants within the Tsavo ecosystem, both inside and outside the NPs. Ideally, their sex was determined when the carcass was still fresh and genitalia identifiable. When this was not possible, for example with poached elephants whose recovered tusks were the only available source of data, Laws' method was used to determine sex (Laws 1966b). This method is based on the observations that male tusks of a given age have a larger basal circumference and taper more sharply than those of females. Male elephant tusks also tend to be longer at a given age, though this may not always be obvious due to wear and tear (Corfield 1973). Using this method approximately 92% of tusks can be correctly sexed and sex specific mortality determined (Laws 1969b).

4.2.3.2 Age determination

The age of dead elephants can be estimated by measuring the lower jaw, teeth width and length (Sikes 1966, Laws 1966b, Hanks 1972b). Tusk weight can also be used to estimate the approximate age of dead elephants (Laws 1966b).

All the tusks collected were weighed and the mean weight of each pair from one elephant used to estimate age at death. However, as with determining sex, wear and tear, as well as tusk abnormalities may result in wrong conclusions, and efforts were made to use as many complimentary methods as was possible. Where available, lower jaws were used to verify estimated age. A regression of tusk weight against age of 228 (101 male and 127 female) elephants cropped in TsE, whose sex and age were reliably determined (Laws 1966a) was used to predict the approximate age of dead elephants whose tusks were the only source of data (Figure 4.1).

Figure 4.1 Relationship between elephant age and tusk weight.



Source of data - raw data from elephants cropped in TsE NP, Tsavo Research Station (Laws 1966a).

However, in some instances, for example tusks confiscated from poachers, it was difficult to differentiate which tusks came from the same elephant. In such cases a qualitative assessment was made to determine the pair that was the best match.

After estimating age at death elephants were placed into five-year age classes up to 25 years old, after which they were grouped into 10 years age class up to 35 years, then 15 years age for elephants over 35 years old. Data were collected for the years 1992 to 1997.

4.3 Results

4.3.1 Elephant population trends

Elephant population data were available from 1962 to 1994, which are from both sample and total counts and are available from different parts of the ecosystem (Table 4.1, Figure 4.2). However, complete data on the distribution of the species inside and outside PAs within the Tsavo ecosystem were only available for the years 1972, 1988, 1989 and 1994 (Table 4.1, Figure 4.3).

Table 4.1 Tsavo ecosystem elephant counts 1962 to 1994.

Area	**1962**	**1965**	**1969**	**1972**	**1973**	**1978**	**1988**	**1989**	**1991**	**1994**
	Total	Total	Total	Sample	Sample	Sample	Total	Total	Total	Total
Inside Kenyan protected areas										
TsE (North)	5,224	8,056	6,619	6,435	9,011	n/d	770	134	450	399
TsE (South)	4,189	4,744	5,709	6,633	3,955	2,469	2,283	3,020	3,436	2,733
TsW	1,386	2,238	8,134	4,419	9,208	1,938	1,274	2,106	1,233	3,132
Total inside Tsavo NPs	**10,799**	**15,038**	**20,462**	**17,487**	**22,174**	-	**4,327**	**5,260**	**5,119**	**6,264**
Outside Kenyan protected areas										
Taita	n/d	n/d	500	1,235	n/d	79	853	642	1,413	287
Galana	n/d	n/d	2,964	4,379	500	1,076	90	74	50	46
Remainder	n/d	n/d	n/d	100	300	n/d	0	46	50	26
Rombo	n/d	n/d	n/d	0	n/d	n/d	0	193	n/d	446
Total outside Tsavo NPs	-	-	-	**5,714**	-	-	**943**	**955**	-	**805**
Mkomazi Game Reserve										
	n/d	n/d	n/d	2,067	n/d	667	93	11	131	302
Total ecosystem	-	-	-	**25,268**	-	-	**5,363**	**6,226**	-	**7,371**

Where data were not available the entry is given as "n/d". Sources: Glover 1963, Laws 1969b, Corfield 1973, Cobb 1976, Leuthold 1977a, KREMU 1978, Ottichilo 1981, Wijngaarden 1985, Ottichilo 1987, Olindo *et al* 1988, Poole *et al* 1992, Douglas-Hamilton *et al* 1994).

Figure 4.2 Tsavo ecosystem elephant population distribution inside and outside PAs, 1962 to 1994.

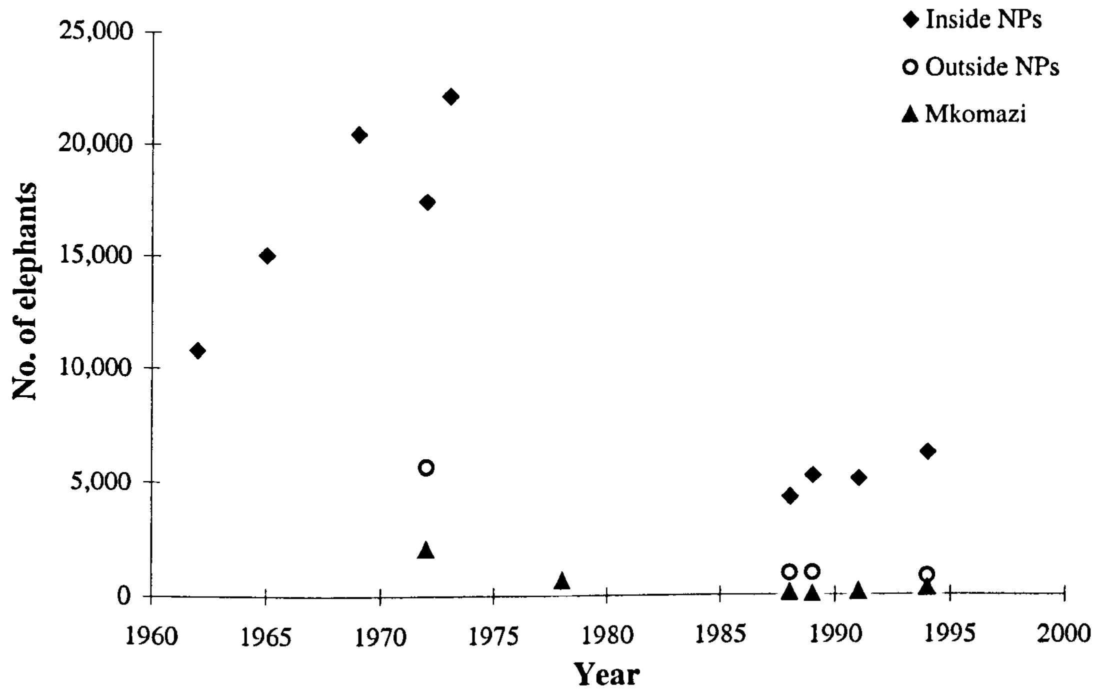
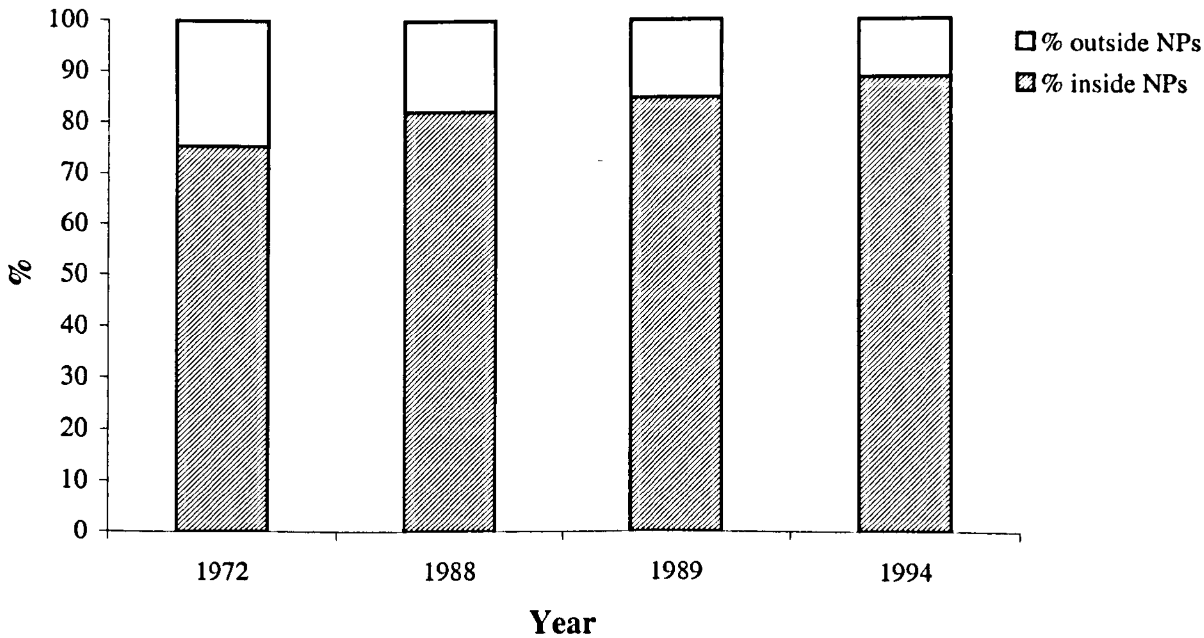


Figure 4.3 Changes in the proportion of elephants inside and outside PAs in the Tsavo ecosystem, 1972 to 1994.



There has been a decline of the proportion of elephants outside NPs between 1972 and 1994 ($r^2 = 0.915$, $p < 0.05$, $N = 4$). Whereas 25% of the Tsavo elephants were found outside Kenyan NPs in 1972, the percentage was 11% in 1994.

4.3.2 Elephant distribution and seasonal ranges in the Tsavo NPs

There was a major difference in the main seasonal ranges of elephants for the years 1995 to 1997 (Figures 4.4 and 4.5). During the dry season (June to October/early November), the highest concentration of elephants was along the Galana and Tsavo Rivers in both parks and to the south-west of TsE, near Voi, and the south west of TsW near Lake Jipe (Figure 4.4). In TsE, elephants tended to generally move westwards as the long dry season approached (late May/June) towards the south west boundary, where they stayed most of the dry season (June to October/early November). This is the area with the highest concentration of artificial water supplies within the NP (Figure 4.6). With the start of the rainy season (late October/early November) elephants moved into areas without permanent water, and their distribution was more widespread throughout the wet season (November-April) (Figure 4.5).

4.3.3 Water distribution

The distribution of water supplies and approximate distances to permanent water showed that the sources of permanent surface water were very limited within the Tsavo NPs (Figure 4.6). In TsE, only the Athi-Tsavo-Galana Rivers flow throughout the year. The Tiva and Voi are seasonal and in the dry season contain water only in the sandy riverbeds in a few locations. In TsW the Tsavo River, Mzima springs and

Figure 4.4 Dry season elephant distribution inside Tsavo NPs, 1995 to 1997 combined.

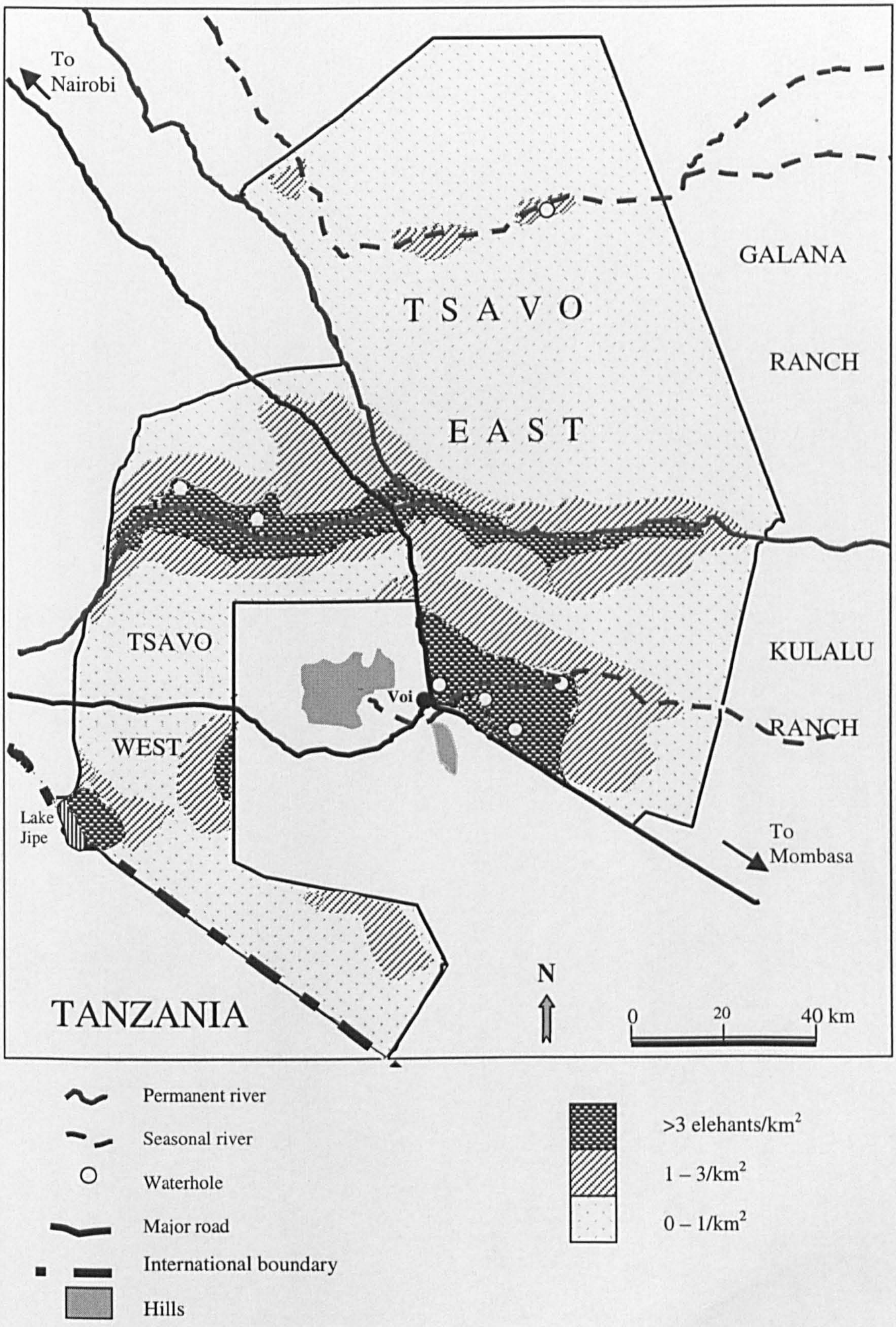


Figure 4.5 Wet season elephant distribution inside Tsavo NPs, 1995 to1997 combined.

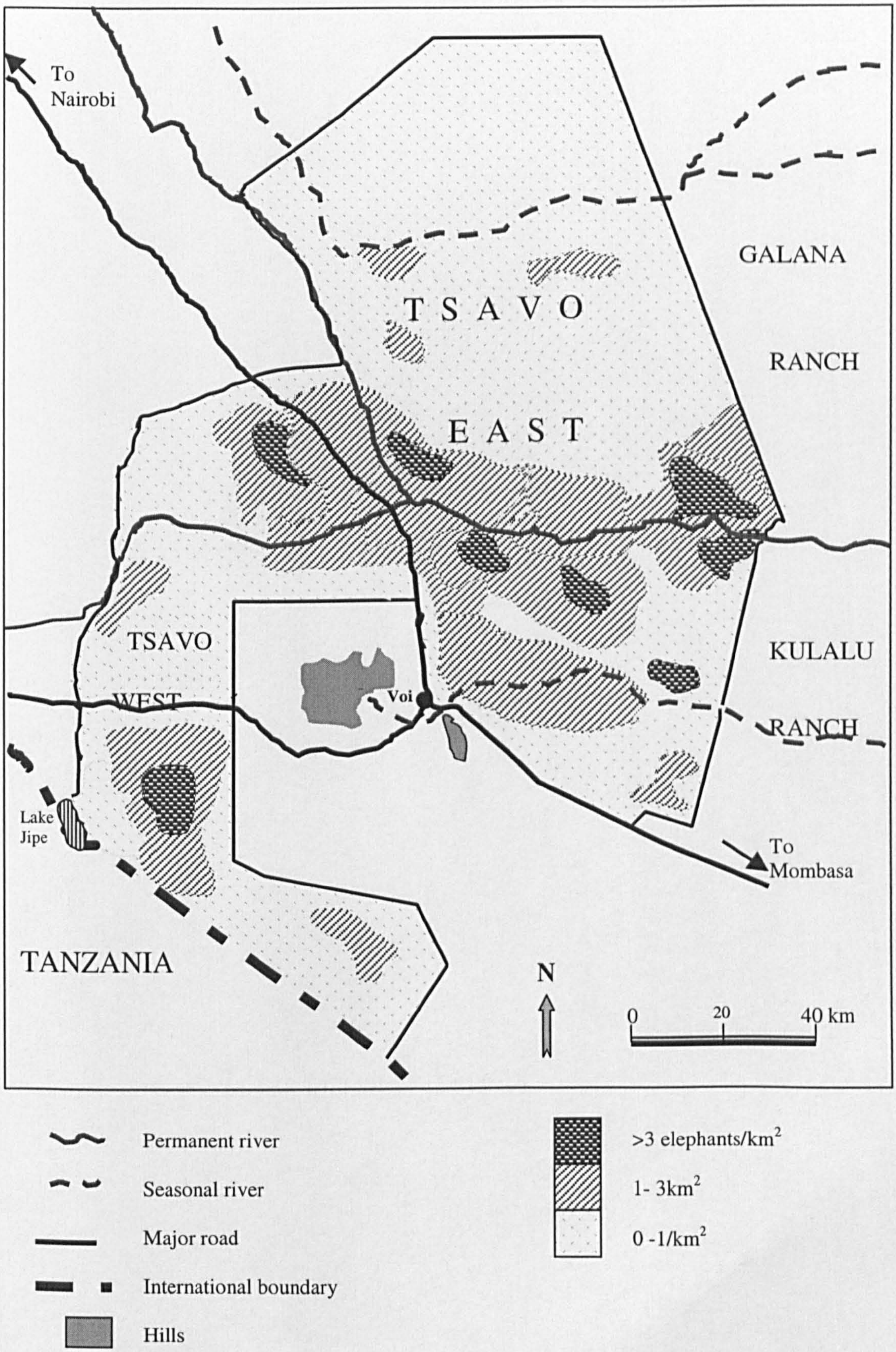
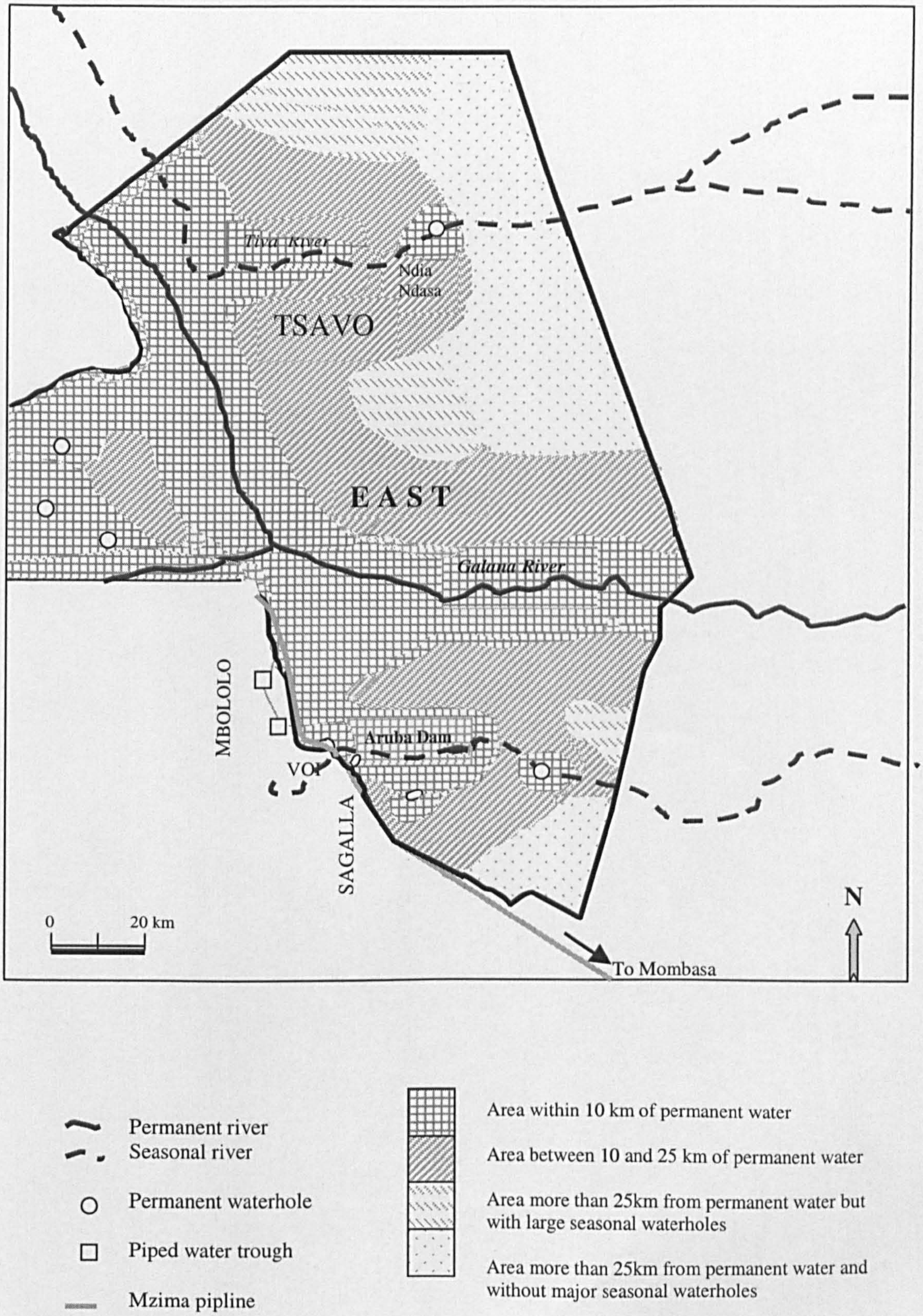


Figure 4.6 Estimated distance to permanent water supplies in TsE, 1997. (adapted from Wijngaarden 1985).



Lake Jipe are the only sources of permanent water. Lack of surface water in large parts of the Tsavo NPs therefore seemed to preclude their use by elephants during the dry seasons, restricting the species to within reach of permanent supplies.

Outside the NPs permanent water was available at cattle watering troughs supplied from branches of the water pipeline running from Mzima Springs in TsW to Mombasa (Figures 2.5 and 4.6). The largest trough was in Mbololo just outside the south-west boundary of TsE (Figure 4.6). Earth dams in Mbololo and Mwatate areas, natural springs in Mwatate and Bura and small-scale irrigation schemes along Voi River were other sources of permanent water outside NPs. Permanent water supplies were also found in some of the cattle ranches adjacent to the NPs (Chapter 2).

4.3.4 Elephant mortality

4.3.4.1 Causes of mortality

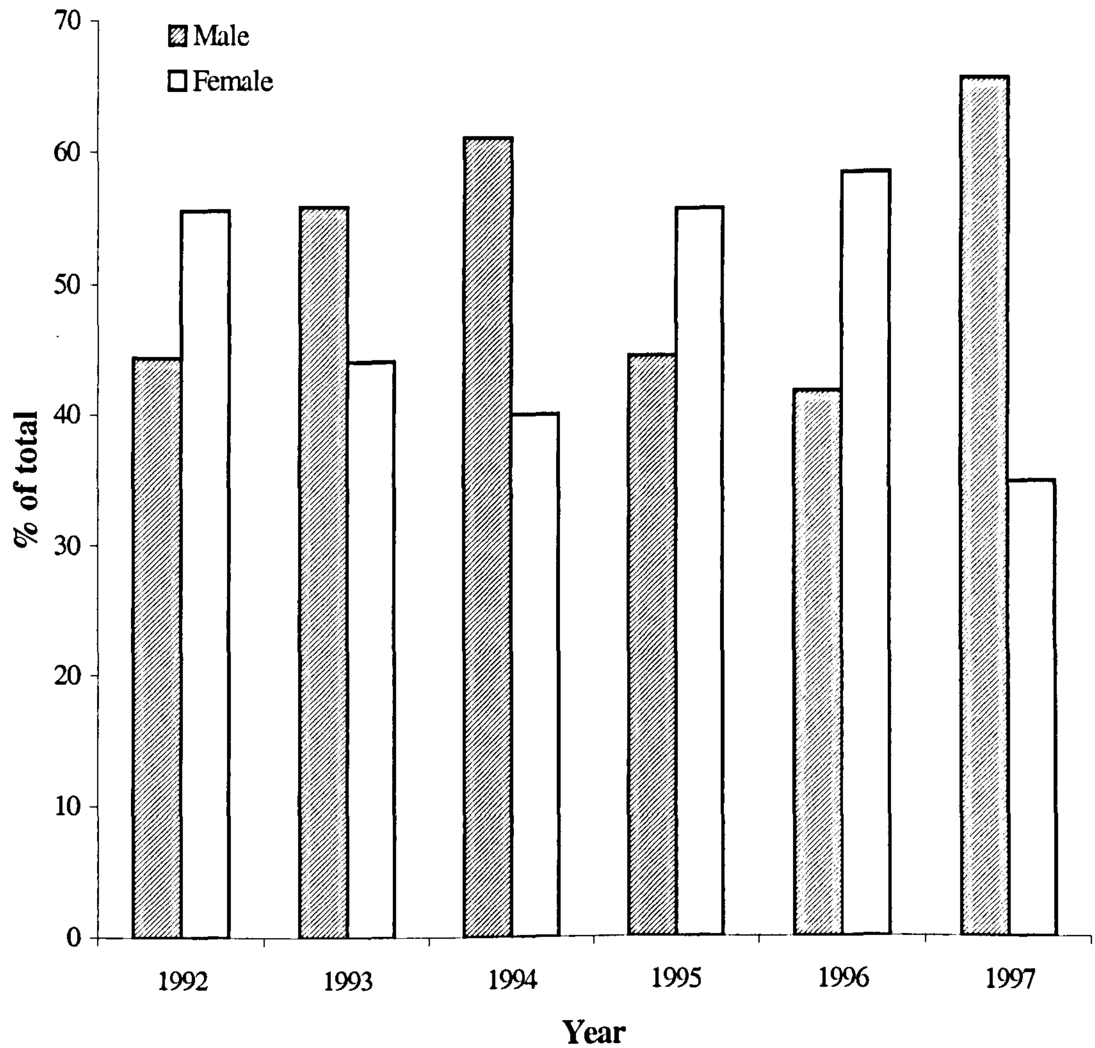
Throughout 1992 to 1997, 187 elephants were found dead in the Tsavo ecosystem from various causes (Table 4.2).

Table 4.2 Elephant mortality from all causes throughout 1992 and 1997 in the Tsavo ecosystem.

	1992		1993		1994		1995		1996		1997		Total
Cause	M	F	M	F	M	F	M	F	M	F	M	F	
Unknown/natural	4	12	11	6	8	2	8	7	0	4	11	3	76
Conflict	5	8	3	1	6	0	7	12	3	6	1	3	55
Poaching	8	4	1	3	2	1	4	6	7	3	7	3	49
Accidents	3	1	0	0	0	0	1	0	0	1	1	0	7
Total per sex	20	25	15	10	16	3	20	25	10	14	20	9	187
Total	45		25		19		45		24		29		187

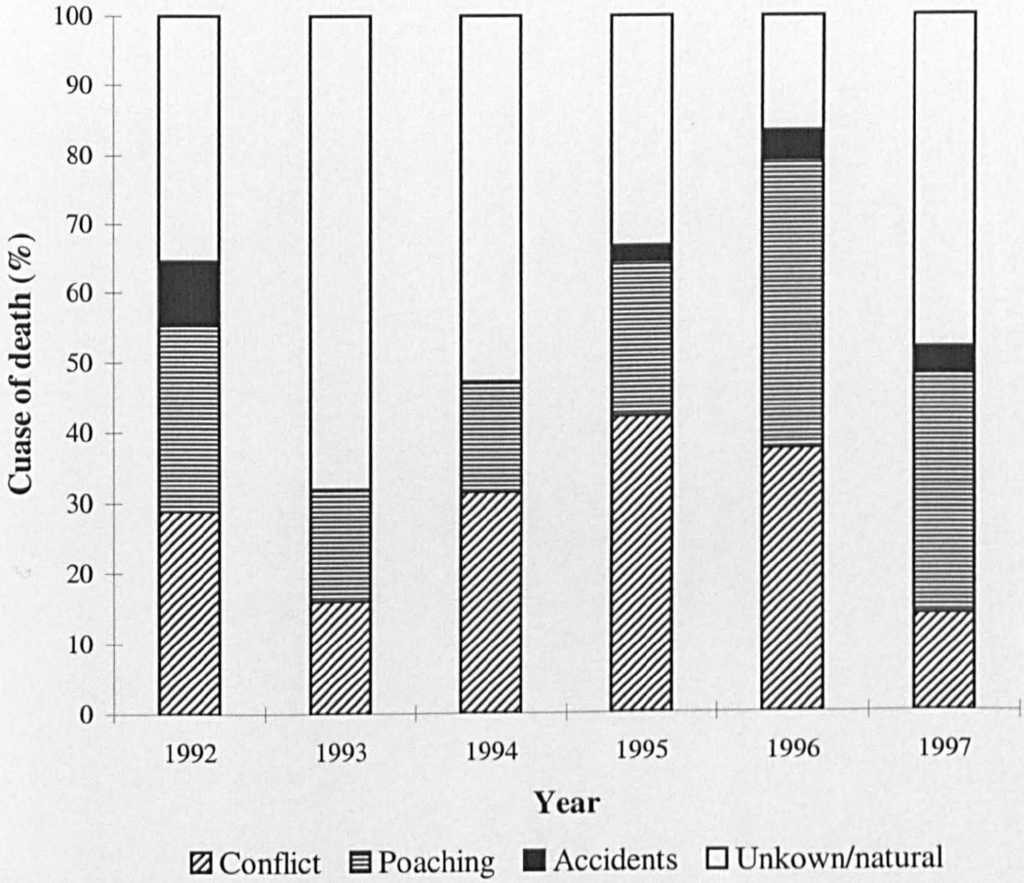
Of the recorded dead elephants, 54% (101) were males and 46% (84) were females, and there was no significant difference between the frequency of male and female deaths from all causes (χ^2 = 7.826, df =5, p> 0.10) (Figure 4.7).

Figure 4.7 Sex specific mortality from all causes, 1992 to 1997.



On a yearly basis, the percentage contribution to mortality by each cause varied between 1992 and 1997 (Figure 4.8).

Figure 4.8 Percentage contribution by each cause to mortality throughout 1992 to 1997.



From 1992 to 1994 deaths from unknown/natural causes contributed the highest percentage, while in 1995 deaths from human-elephant conflict incidents comprised 42% (19) of mortality. In 1996 the proportion of elephants that died from poaching increased and contributed 42% (10) of all elephant deaths in that year. In 1997 mortality from unknown/natural causes once again increased contributing 48% (14) of elephant deaths, with poaching still an important factor accounting for 35% (10) of all deaths in the same year.

Death through accidents contributed 4% of total mortality throughout 1992 to 1997, and this occurred when elephants got hit by trains or buses as they crossed the

Nairobi-Mombasa railway line or road, and when they got stuck in mud in drying riverbeds and dams inside NPs (Table 4.3).

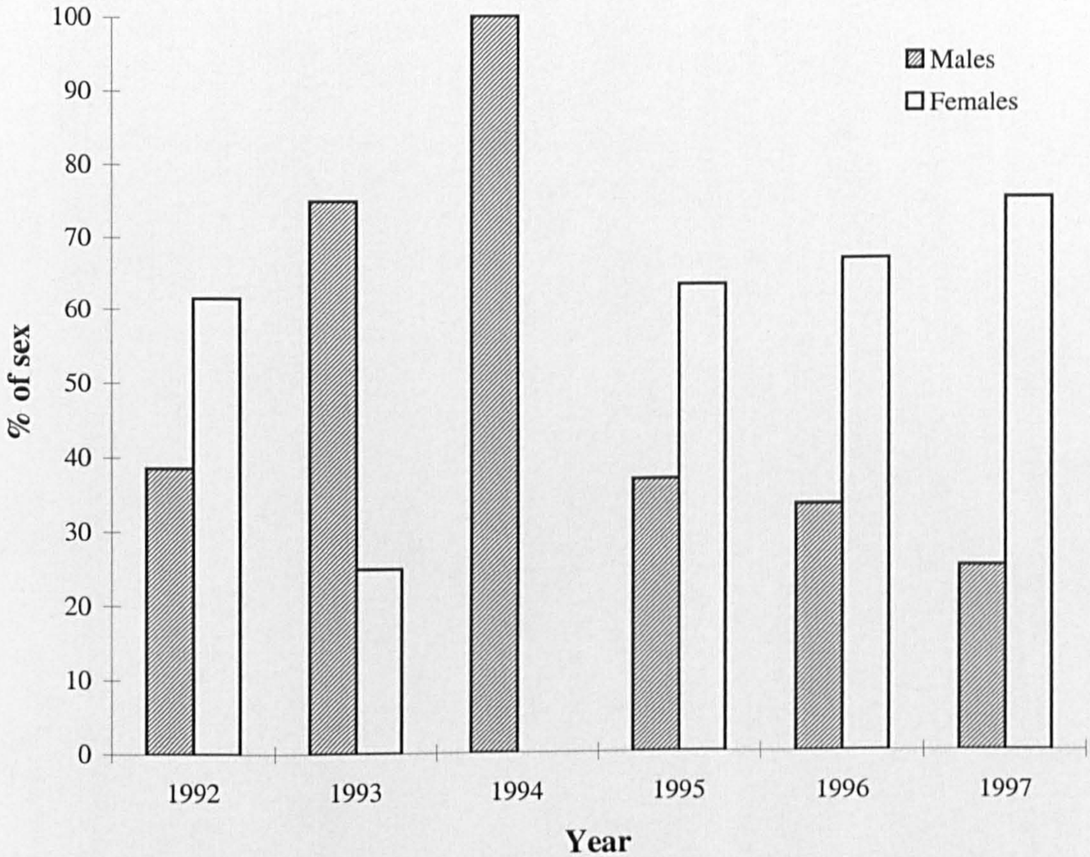
Table 4.3 Elephant deaths due to accidents, 1992 to 1997.

Cause of accident	**Year**						
	1992	1993	1994	1995	1996	1997	Total
Hit by train	1	0	0	0	1	1	3
Killed on highway	1	0	0	1	0	1	2
Stuck in mud	2	0	0	0	0	0	2
Total	4	0	0	1	1	1	7

Of the 55 elephants killed in conflict related incidents throughout 1992 to 1997, 44% (24) were males and 56 (31) were females, and there was no significant difference between the frequency of male and female deaths from conflict incidents (χ^2 = 1.910, df =2, p >0.10).

For each year 1992 to 1994 the total number of males shot on control was more than that of females but this reversed from 1995 to 1997 (Figure 4.9).

Figure 4.9 Sex specific mortality from conflict 1992 to 1997.



4.3.4.2 Elephant mortality in different age classes

The estimated ages of the elephants that died from all causes throughout 1992 to 1997 ranged from less than a year to over 50 years (Tables 4.4a to 4.4d). In order to find out whether there was any difference in sex ratios between deaths from conflict and other causes, and in age classes, data for each cause and sex were treated separately.

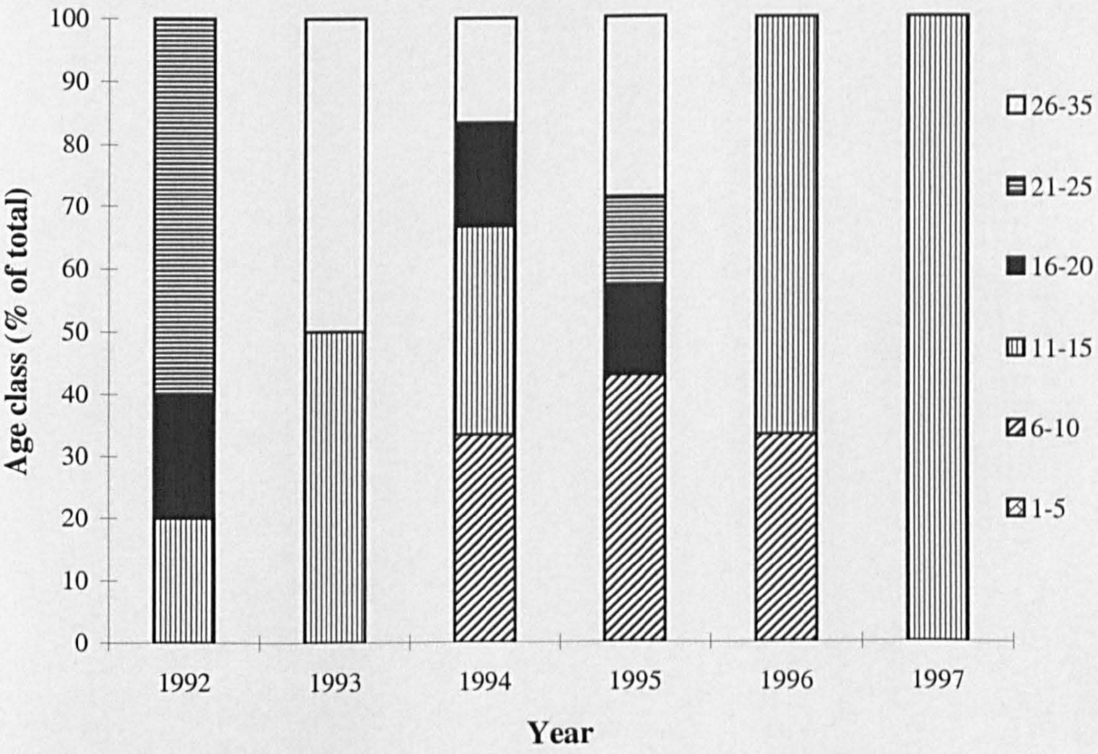
4.3.4.2.1 Mortality in different age classes as a result of conflict

Throughout 1992 to 1997, 24 male elephants of various age classes were killed as a result of human-elephant conflict in Tsavo (Table 4.4a, Figure 4.10a).

Table 4.4a Age class of dead male elephants killed during conflict,1992 to 1997.

Year	Age class							Total
	1-5	6-10	11-15	16-20	21-25	26-35	36-50	
1992	0	0	1	1	3	0	0	5
1993	0	0	1	0	0	1	0	2
1994	0	2	2	1	0	1	0	6
1995	0	3	0	1	1	2	0	7
1996	0	1	2	0	0	0	0	3
1997	0	0	1	0	0	0	0	1
Total	0	6	7	3	4	4	0	24

Figure 4.10a Males - mortality in different age classes from conflict, 1992 to 1997.

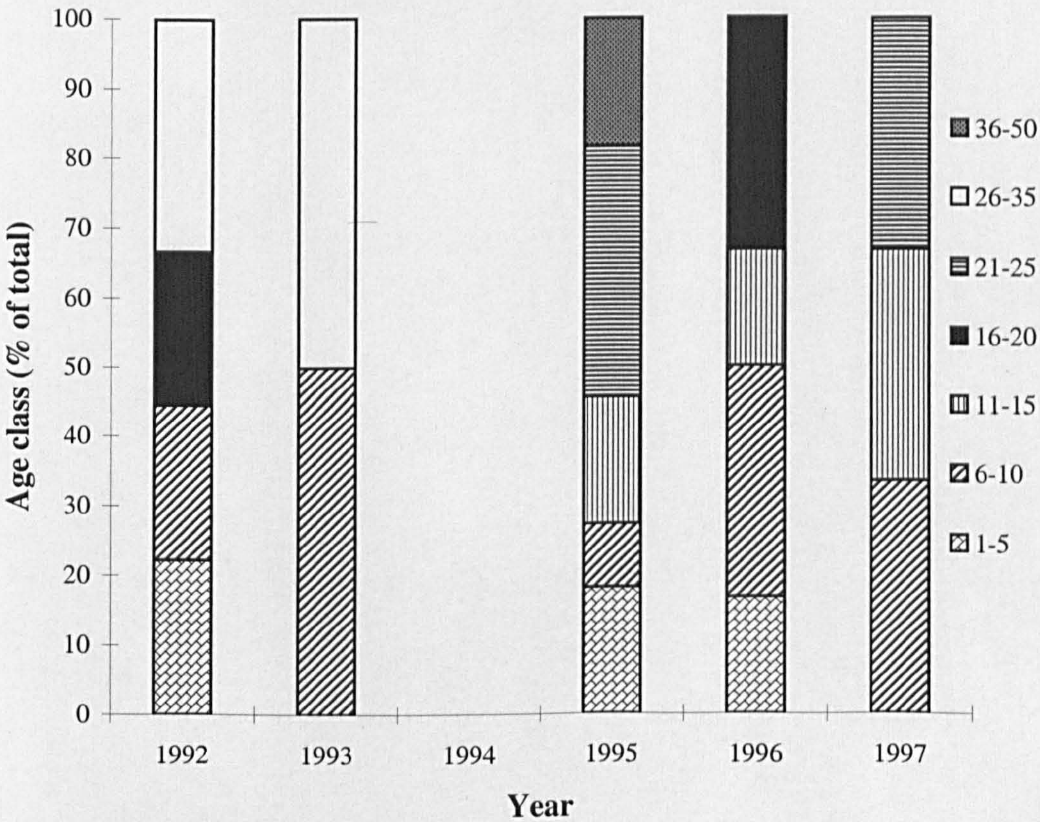


During the same period 31 females of various age classes were also killed as a result of conflict (Table 4.4b and Figure 4.10b).

Table 4.4b Age class of dead female elephants from conflict 1992 to 1997.

Year	Age class							Total
	1-5	6-10	11-15	16-20	21-25	26-35	36-50	
1992	2	2	0	2	0	3	0	9
1993	0	1	0	0	0	1	0	2
1994	0	0	0	0	0	0	0	0
1995	2	1	2	0	4	2	0	11
1996	1	2	1	2	0	0	0	6
1997	0	1	1	0	1	0	0	3
Total	5	7	4	4	5	6	0	31

Figure 4.10b Females - mortality in different age classes from conflict, 1992 to 1997.



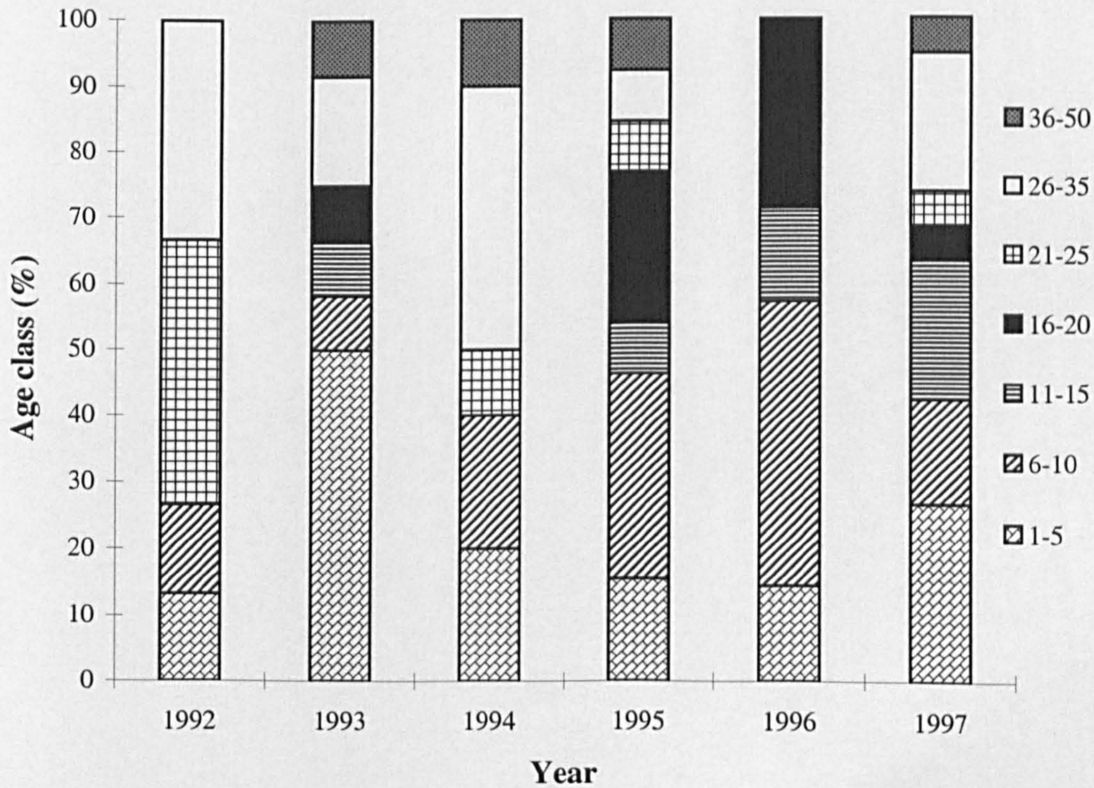
4.3.4.2.2 Male mortality in different age classes from all other causes excluding conflict

Throughout 1992 to 1997, 76 male elephants died from all other causes excluding conflict-related incidents (Table 4.5a and Figure 4.11a).

Table 4.5a Age class of dead male elephants from all other causes, 1992 to1997.

Year	Age class							Total
	1-5	6-10	11-15	16-20	21-25	26-35	36-50	
1992	2	2	0	0	6	5	0	15
1993	6	1	1	1	0	2	1	12
1994	2	2	0	0	1	4	1	10
1995	2	4	1	3	1	1	1	13
1996	1	3	1	2	0	0	0	7
1997	5	3	4	1	1	4	1	19
Total	18	15	7	7	9	16	4	76

Figure 4.11a Males - mortality in different age classes from all other causes, 1992 to1997.

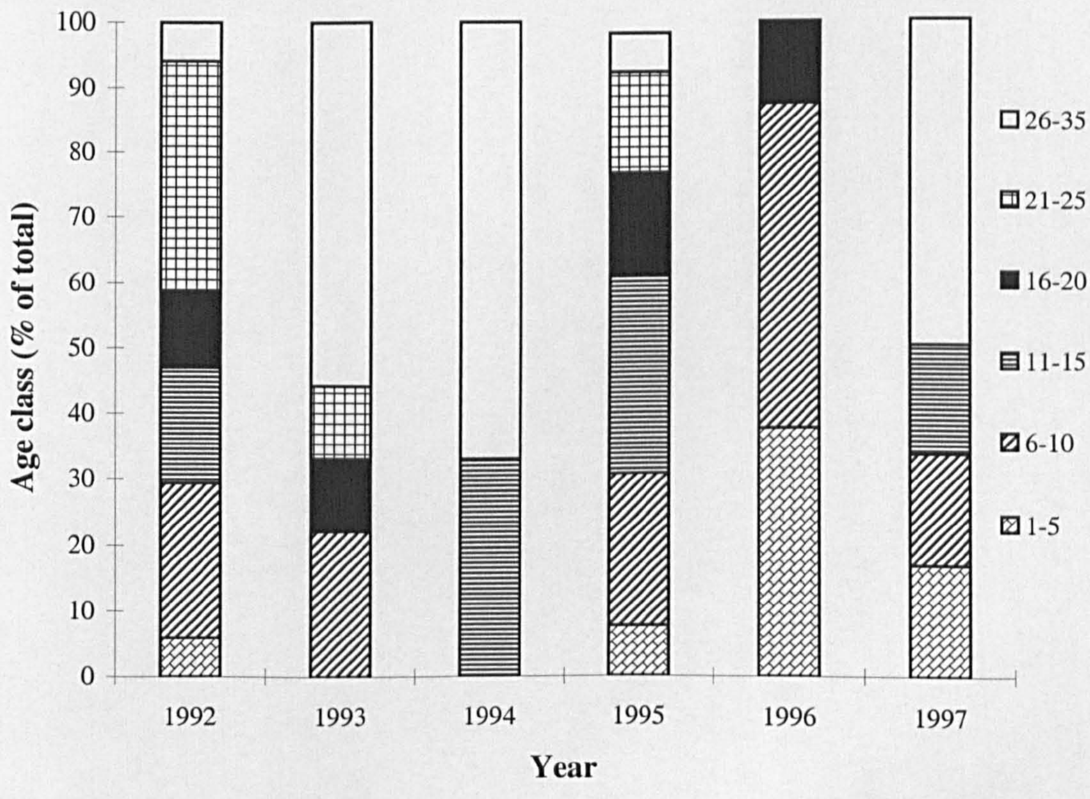


During the same period 56 female elephants died from all other causes excluding conflict (Table 4.5b and Figure 4.11b).

Table 4.5b Age class of dead female elephants from all other causes 1992 to 1997

Year	Age class							Total
	1-5	6-10	11-15	16-20	21-25	26-35	36-50	
1992	1	4	3	2	6	1	0	17
1993	0	2	0	1	1	5	0	9
1994	0	0	1	0	0	2	0	3
1995	1	3	4	2	2	1	0	13
1996	3	4	0	1	0	0	0	8
1997	1	1	1	0	0	3	0	6
Total	6	14	9	6	9	12	0	56

Figure 4.11b Females - mortality in different age classes from all other. causes, 1992 to 1997.



Of the male elephants that died from conflict throughout 1992 to 1997, 67% (16) were 20 years or less in age while the percentage of the same age class from all other causes for the same period was 62% (47). For the same age category for females 65% were killed in conflict incidents compared to 63% that died from all other causes. These findings suggest that elephant mortality from all causes in the Tsavo ecosystem was higher in younger elephants (< 20 years old) than in older ones.

4.4 Discussion

4.4.1 Elephant population trends and factors influencing them

Historical evidence suggests that uncontrolled exploitation of elephants for ivory in the latter half of the 19th century led to a substantial reduction of the Tsavo elephant population. Spinage (1973) suggests that intensive exploitation of elephants between 1840 and 1890 led to a sudden collapse of the ivory supply from over-exploitation. The large-scale introduction of firearms accelerated the decline, an occurrence documented in the accounts of early explorers in East Africa. Krapf (1860) comments that elephants were very sparse in Tsavo and along the Kenya coast. Reference is made of encounters with rhino and other big game during the construction of the Kenya-Uganda railway across Tsavo in 1898 to1900, but no mention is made of elephants (Patterson 1979).

At the turn of the century game laws that restricted the exploitation of elephants were introduced and there was a gradual recovery of the elephant population (Parker & Amin 1983, Douglas-Hamilton 1987, Poole *et al* 1992). The creation of the Tsavo NPs in 1948 led to the compression and rapid increase of elephants within the strictly protected areas in the 1950s and 1960s. As a consequence elephants increasingly sought refuge within the NPs and the 1950s and 60s saw the build up of elephant numbers in the protected area, leading to what was referred to as the "Tsavo elephant problem" (Glover 1963b, Glover & Sheldrick 1964, Sheldrick 1965, Laws 1969b).

Population estimates in early 1960s place the total elephant population in the Tsavo ecosystem in the range of 28,000 to 42,000 (Laws 1969b). Early total counts showed that, in the period 1962 to 1969, the elephant population within the Tsavo NPs varied from about 11,000 to 20,000 (Table 4.1). No data are available for the number of elephants outside the NPs for these years but estimates are placed at between 3,000 to 5,000 (Douglas-Hamilton *et al* 1994).

A population 'crash' occurred in 1970-1971, when a severe drought occurred in Tsavo, resulting in the death of about 6,000 elephants in TsE, and an estimated 9,000 in the entire ecosystem (Corfield 1973). This reduced the elephant population to about 25,000 in 1972. The main reason for these deaths was thought to be starvation as no evidence was found for increased poaching activities or disease (Corfield 1973). The population continued to decline in the early 1970s after the drought, a decrease thought to have been due to loss of a high percentage of breeding females (Corfield 1973, Leuthold 1976).

The unprecedented rise in the price of ivory in the mid 1970s, which also coincided with the breakdown of law enforcement of wildlife regulations in Kenya, led to increased legal hunting and poaching of elephants in Kenya (Poole *et al* 1992). Unlike most other elephant range areas in the country, there was some control over hunting and poaching in Tsavo. By using carcass counts Cobb (1976) concluded that in 1975 mortality rate was approximately 10% per year, largely attributed to poaching.

In 1976 poaching escalated in Tsavo, a period that coincided with the merger of Kenya National Parks (KNP) authority (an autonomous body that was responsible for running many of Kenya's NPs) with the Government Game Department (GD) to form Wildlife Conservation and Management Department (WCMD). WCMD, a Government department, became the custodian of all wildlife in Kenya. Being less funded and inefficient, the merger resulted in further loss of elephants in Tsavo through poaching.

After decimating elephants outside PAs, poachers armed with automatic firearms entered the Tsavo NPs in 1980s, which resulted in a sharp decline in elephant numbers. The Tsavo elephant population declined from an estimated 25,000 in 1972 to just more than 5,000 in 1988 (Ottichilo, 1981, Olindo *et al* 1988) (Table 4.1). This necessitated the taking of measures by the Kenya Government to prevent further decline in the species' numbers.

In 1989 the Tsavo population began to increase (Table 4.1), a recovery attributed to two main factors. These were the rehabilitation in 1989 of the former WCMD into KWS, a semi-autonomous agency that could operate more efficiently, and the listing of the African elephant on Appendix I by the Convention on International Trade in Endangered Species (CITES) in October 1989. This population increase continued to the end of 1997 (Douglas-Hamilton *et al* 1994, DRSRS, unpublished data).

4.4.2 Elephant distribution inside and outside the Tsavo NPs

In the 1970s it was established that large areas outside the NPs in the Tsavo ecosystem were also important for the elephants, and they occupied these areas seasonally or permanently (Cobb 1976, Leuthold 1977). Leuthold (1977) noted that elephant densities outside parks were usually higher during the wet season than during the dry season in the 1970s, although overall densities were considerably lower outside than inside the NPs throughout the year. Findings from studies conducted in the 1980s showed that, on the contrary, elephant densities outside the NPs were usually higher during the dry season than during the wet season (Wijngaarden 1985). Though no quantitative observations were made during this study, evidence from aerial counts suggests that elephant densities outside the NPs were usually higher during the dry season than during the wet season, and that overall proportion of the elephants population utilising areas outside NPs has been decreasing (Figure 4.3).

These conflicting results on seasonal distribution of elephants in the 1970s and 1980s to 1990s could probably be explained by the availability of permanent surface water inside the NPs during the two different periods of study. In the late 1960s to late 1970s, artificial water supplies were well developed and maintained inside the NPs, unlike the situation in the 1980s and 1990s (Chapter 2). Other factors that are likely to have influenced elephant distribution are poaching, diminishing range due to human population increase outside NPs, and other forms of disturbances by human activities.

4.4.3 Permanent water distribution and its effects on elephant distribution

The seasonal variations in the distribution of elephants suggest that seasonal changes in ecological factors influence the inter-seasonal movements in Tsavo. Both qualitative and quantitative observations since the 1960s have shown that the Tsavo elephants tended to concentrate near permanent water supplies during the dry season (Glover & Sheldrick 1964, Laws 1969b, Leuthold & Sale 1973, Cobb 1976). Leuthold (1977) concluded that there was a seasonal distribution of elephants related to rainfall and availability of surface water. McKnight (1996) noted the same distribution, and findings by aerial tracking during this study arrived at the same conclusion (Figures 4.4, 4.5 and 4.6).

Permanent water supplies are especially important during the long dry season, which is the most critical time of the year, and the extent to which water and food supplies are combined is critical for dry-season survival of the Tsavo elephants (Leuthold 1977). Qualitative observations since 1990 have indicated that loss of some dry season feeding ranges in southern TsE through uncontrolled fires induced more frequent movement of elephants out of the NP to the settled area, resulting in higher conflict incidents in Mbololo, Voi and Sagalla Locations. Conditions in TsE are less favourable and subject to greater fluctuations and irregularities than in TsW (Cobb 1976), hence perturbations in this sector of Tsavo are likely to have more marked effects on elephant distribution in the area. Abundant supply of piped water close to the NP is another factor that may encourage elephants to move out in periods of water scarcity.

During the wet season local food quality is probably the major determinant of elephant distribution and movement (Leuthold 1977). Localised rainstorms in some areas of the ecosystem result in substantial shifts of elephant movements and distribution. The ability of elephants to sense local rainstorms over considerable distances, even against prevailing wind, has never been explained (Leuthold 1977).

Though the pattern of rainfall in Tsavo is relatively regular in the long term, certain parts of the year being normally dry and others wet, in the short term it is highly irregular both in space and time, producing considerable and largely unpredictable fluctuations in food and temporary water supplies. Permanent water supplies, by contrast, are generally fixed in space and thus predictable. These ecological conditions require a strategy of habitat utilisation that is geared to the long term regularities on the one hand, yet flexible enough to accommodate the short term irregularities on the other hand. This highly flexible system of movements may enable the Tsavo elephants to make use of resources that are available only temporarily while at the same time reducing their impact on the areas on which they depend for dry season survival (Leuthold 1977).

The main features of the Tsavo elephants' long term strategy are likely to be the relatively small localised dry-season ranges near permanent water supplies and the apparent fidelity of individual elephants to them (Leuthold 1977). Long term radio tracking studies (Leuthold & Sale 1973) showed that radio collared elephants returned to the same dry-season ranges repeatedly after incursions into other areas during the wet seasons. McKnight (1996) noted that some individually recognised elephants did the same. These dry season ranges are likely to be relatively "stable" and knowledge on them could be maintained by tradition within the family groups (Leuthold 1977). Moss (1988) shows that the older female elephants, notably the matriarchs, are the main repository of this knowledge. Whether the same applies to males is still not clearly known, but studies in Tsavo have shown a similar behaviour (McKnight 1996). This implies that killing of matriarchs may deprive the rest of the family valuable knowledge on spatial and temporal utilisation of resource within the Tsavo ecosystem, essential for the elephants survival.

Although the general seasonal movement patterns have remained the same for many years, it was noted that there were local shifts and variations caused by fires within the NPs, disturbances from cattle incursions into the NPs and other forms of human disturbances inside or close to the NPs.

4.4.4 Elephant mortality in the Tsavo ecosystem

At the height of poaching during 1988, average elephant losses in the Tsavo ecosystem were calculated at 2 elephants per day (Douglas-Hamilton *et al* 1994). Though more males were initially preferred for their bigger tusks, the incentive for poachers to kill females and immature elephants increased as the big bulls became rare. This resulted in poaching of both male and female elephants throughout 1992 to 1997 (Table 4.2).

The formation of KWS and an international ban on ivory trade by CITES, resulted in a significant reduction in poaching in Tsavo in the early 1990s, and elephant mortality was down to 45 elephants per year by 1992, and reduced further to 19 elephants in 1994 (Table 4.2). However, starting 1995 the number of elephants that died from all causes per year went up. This could be attributed to a number of factors, some of which will be discussed below. However, it is likely that the figures used in this study do not represent total mortality as young elephants without tusks decompose faster and their skeletal remains would get scattered or removed all together by scavengers, which may have resulted in an under-representation of younger age classes.

In 1992 to 1994 deaths from unknown/natural causes contributed the highest percentage, while in 1995 deaths from human-elephant conflict incidents comprised 42% of total elephant mortality in Tsavo. This high proportion of mortality from conflict could be attributed to a change of policy on dealing with problem elephants in this year, when shooting of elephants involved in conflict incidents by KWS rangers was sanctioned in more cases than was the case throughout 1992 to 1993.

The proportion of males to females that were killed in conflict related incidents varied over the years. From 1992 to 1994 a higher proportion of males were shot on control but the trend reversed from 1995 to 1997 (Figure 4.9). This change could once again be attributed to a recommendation by KWS head office to its field staff that shooting of female elephants rather than males was more effective in minimising human-elephant conflict. Findings on this hypothesis from Tsavo are presented in Chapter 6.

Under natural conditions the adult sex ratios of elephant populations are slightly biased in favour of females (Laws 1969a & b, Parker 1979). In 1966 the sex ratio of the TsE elephant population was 53.8% male and 46.2% female (Laws 1966b). Due to heavy poaching in the ecosystem in the 1980s, the elephant population became highly skewed towards females (Poole 1989, McKnight 1996). During a Tsavo ecosystem elephant total count in 1988 it was reported that no adult males were seen (Olindo *et al* 1988). In 1989 the ratio was 13.8% male and 86.2% female, a factor attributed to heavy poaching (Poole 1989c).

Male elephant mortality in Tsavo, which has an even lower percentage of sexually mature bulls (McKnight 1996), may result in lower recruitment rate, and therefore a slower recovery of the population from the effects of poaching. Lewis (1984) suggests that a decline in calving rate in the Luangwa Valley, Zambia, could have been as a result of low availability of males. In Mikumi NP, Tanzania, low recruitment rate and low proportion of either pregnant or lactating adult females was attributed to an almost total absence of breeding males (Poole 1989). It is therefore important that elephant bulls in Tsavo should be highly protected and shooting of mature bulls in conflict incidents should be avoided.

The killing of females has also a significant impact on the Tsavo elephant population. Long term records collected in Amboseli indicate that the death of an adult female is likely to result in the death of at least one immature elephant (Poole 1989). These studies in Amboseli NP further show that calves under 2 years have no chance of surviving without their mother, while calves between the ages of 2 to 5 years old have a 30% chance of surviving two years following their mother's death. Juveniles between ages 6 and 10 years old have 48% chance of survival (Poole 1989).

The Tsavo elephants have been heavily poached and disturbed, and about 43% of the population live in fragmented families lacking in old and experienced matriarchs (McKnight 1996). Due to the nature of the elephants social structure the death of females, which play a critical role in the survival of other family members (Buss 1961, Moss & Poole 1983, Lee 1987, Moss 1988) is highly significant. Killing and disturbance of females during conflict incidents is likely to add further stress to the population and result in higher calf mortality. Death of many females through poaching and conflict incidents could be the reason for the high percentage of deaths from unknown/natural causes recorded for most years in the ecosystem (Figure 4.8). This calls for a more careful planning of human-elephant conflict mitigation measures in the Tsavo ecosystem.

In the next chapter I will describe conflict incidents and patterns, and how they relate to rainfall.

Chapter 5

Conflict Types and Patterns

5.1 Introduction

It is inevitable that people who share the same range and resources with wild animals such as elephants will incur costs. These may be direct such as human death and injury and loss of property, or indirect such as competition for resources and insecurity.

In this chapter data on human deaths and injuries caused by elephant, and livestock deaths from attacks by elephants and other wildlife throughout 1992 to 1997 will be presented (Sections 5.3.1 and 5.3.2). The crops cultivated and those destroyed by elephants will be described in Sections 5.3.3. The size and proportion of fields per household, which gives an indication of land transformation in the study sites, will be shown in Section 5.3.4. Yearly human elephant conflict patterns and their relation with rainfall will be presented in Section 5.3.5, while the group composition and structure of problem elephants will be described is Section 5.3.6. An overview of other problem wildlife in Taita Taveta and Kitui Districts will be given in Section 5.3.7, and a discussion of the results follows in Section 5.4.

5.2 Methods

5.2.1 Conflict reporting by the local people

Before the forming and setting up of a Problem Animals Control (PAC) unit by KWS in 1990, few people reported conflict incidents to the former WCMD, citing insensitivity and reluctance by the wildlife authority to take any action. During this study a questionnaire survey was conducted to determine the percentage of people who reported conflict incidents.

5.2.2 Deaths and injuries of humans and livestock

All human deaths and injuries caused by elephants in Tsavo throughout 1992 to 1997 were reported to KWS officials and recorded in Occurrence Books (OBs). Details of the location, victims' sex, age, details of circumstances of attack, and information on the elephants responsible were entered in some instances.

Similar records were available on livestock deaths and injuries from 1995 to 1997, although these contained fewer details. However, in all cases information was available on the location and number of animals killed by elephants and other wild animals. Data from these records were used for human and livestock deaths and injuries for the years 1992 to 1997.

5.2.3 Loss and damage of agricultural crops

Data on the crops grown, those damaged by elephants and whether damage by elephants had influence on the choice of crops grown by the local farmers were gathered by questionnaire surveys. Where crop raiding was reported field visits were made to confirm damage, noting the location, date and time of damage. However, no quantitative assessment was made on the damage caused to crops or other property.

5.2.4 Plot size per household and proportion under cultivation

The size of fields owned by individual households was determined by using records issued to landowners by the Survey of Kenya Department (SKD). In a few instances where SKD documents were not available, the landowner was asked the approximate size of the land he/she owned, which was thought to be a reliable method as most people knew the size of their fields.

To determine the proportion of fields in each household under cultivation, the landowners were asked to give, in terms of quarters, the proportion cleared for growing crops. The quarters given were then translated into the percentage of each households land used for growing crops. By using this simple approach, it was found that many farmers were able to provide fairly accurate information on the percentage of their land under cultivation. Data were obtained on a total of 163 household plots, 89 in Taita Taveta and 74 in Kitui.

5.2.5 Group composition of elephants involved in conflict

Where conflict incidents occurred when it was light enough to see the elephants, the group size and composition of elephants involved was determined by direct observation. Aging and sexing techniques were learned in two training sessions, at the Amboseli Elephant Research Project (AERP) in Amboseli NP and in TsE, conducted by Cynthia Moss, the AERP Director.

Individual elephants were sexed and placed into categories as singles, groups of 2-5, 6-10, 11-20 or > 20 elephants. Where incidents occurred at night, such as most cases of crop raiding, the elephants' footprints were used as an indirect method of determining group composition and approximate numbers. Though footprint length has been shown to be a reliable field method of estimating the age of elephants (Western *et al* 1983, Lee & Moss 1995), the nature of the soil in Tsavo (sandy and loose) made it difficult to collect quantitative data. However, it was possible to determine whether it was a case of a single or more elephants, and an estimate of numbers in cases of 5 or less elephants. Only those data obtained by direct observations and those reliably determined by footprint method were used for analysis.

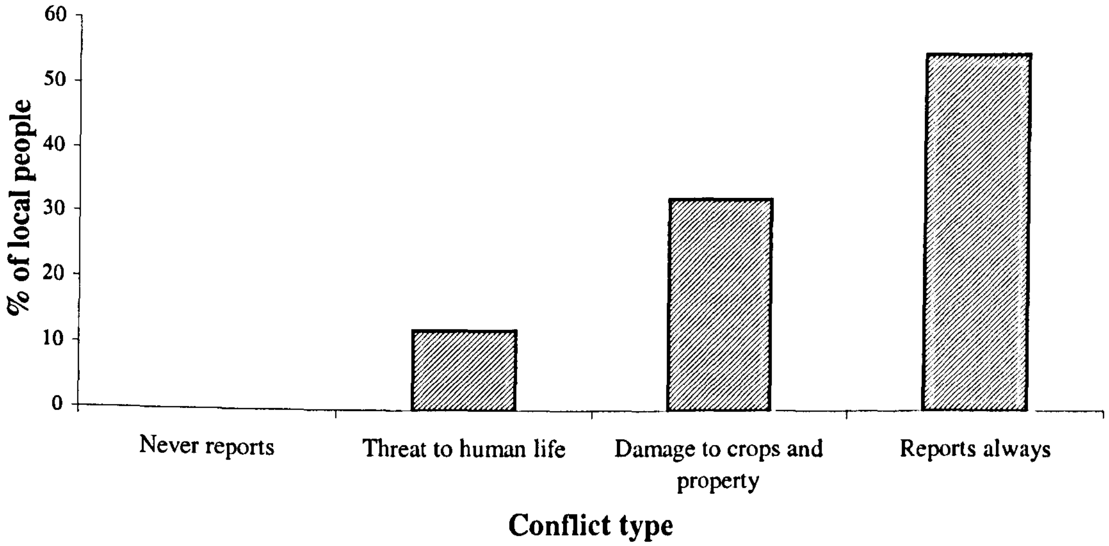
5.3 Results

In this study 4 major types of human-elephant conflict were identified in the Tsavo ecosystem. These were killing and injury of human beings by elephants, competition for resources with and killing of livestock, loss and damage of agricultural crops, and insecurity and curtailing human freedom of movement. Destruction of infrastructure, mainly water distribution piping, and storage and fences occurred to a lesser extent.

5.3.1 Conflict incident reporting by the local people

All human-elephant conflict incidents in Taita Taveta District were reported either directly to KWS personnel or through other Government authorities (village headmen, chiefs, district officers, etc.) who in turn passed on the information to KWS (Figure 5.1).

Figure 5.1 Human-elephant conflict incidents reporting to KWS by the local people in Taita Taveta District, 1995.



Of the total local community, 55% said they always reported all conflict incidents, 33% said they only reported damage to crops and other property, and 12% the presence of elephants in or close to villages thought to be a threat to human life.

5.3.2 Human deaths and injuries

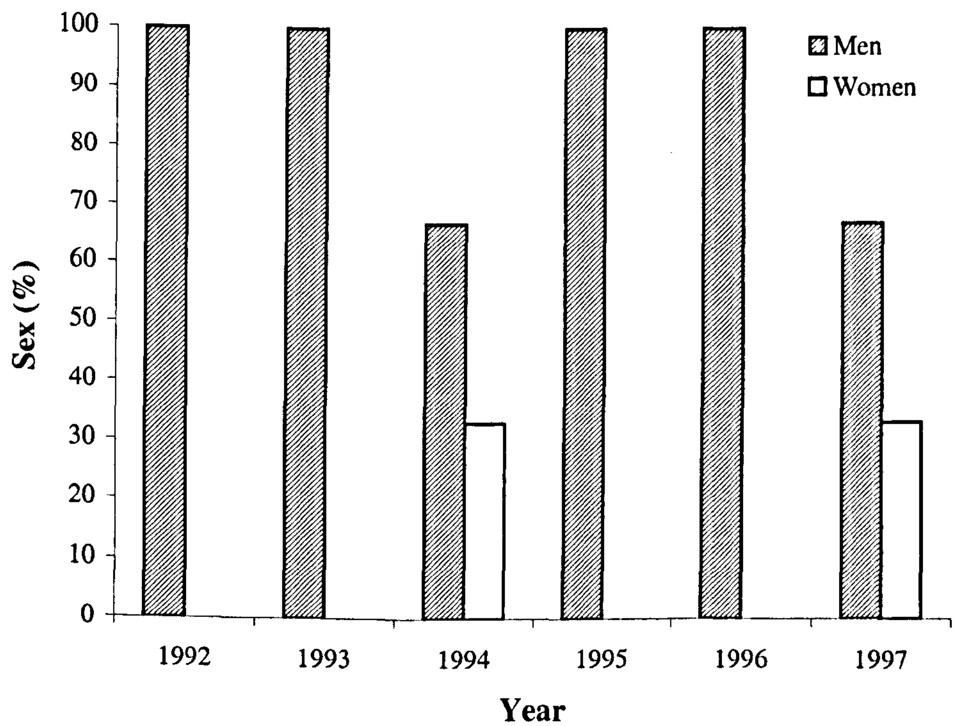
Throughout 1992 to 1997, 15 people were killed and 5 injured by elephants in Taita Taveta District (Table 5.1). No elephant related deaths occurred in Kitui District during this period.

More men than women were either killed or injured by elephants in the 6-year period (Figure 5.2). Of the people killed 87% (13) of them were adult men. In the same period 5 people were injured and 80% (3) were adult men and none were women. The explanation for this human mortality may be due to the higher frequency of contact between elephants and men during crop vigilance, herding of livestock or walking at night to and from leisure and other social functions.

Table 5.1 Human deaths and injuries throughout 1992 to1997.

Year	Deaths				Injuries			
	Men	Boys	Women	Total	Men	Boys	Women	Total
1992	6	0	0	6	0	1	0	1
1993	1	0	0	1	0	0	0	0
1994	2	0	1	3	0	0	0	0
1995	1	0	0	1	1	0	0	1
1996	1	0	0	1	2	0	0	2
1997	2	0	1	3	1	0	0	1
Total	13	0	2	15	4	1	0	5

Figure 5.2 Proportion of men and women killed by elephants, 1992 to 1997.



Of the 20 attacks when people were either killed or injured, 55% (11 incidents) occurred during crop vigilance. Elephants were known to respond aggressively to attempts to chase them away from the fields. Though a few people used relatively safe places such as platforms or sitting in trees, the majority used flimsy makeshift shelters which did not offer much protection from a charging elephant.

People attacked while walking or riding bicycles along paths or through the bush constituted 30% (6) of total incidents, while 10% (2) incidents occurred when the victims were herding livestock. A small proportion, 5% (1) incident occurred while the victim was fetching water from an earth dam.

Late evening beer drinking is a favourite pastime for many men in villages adjacent to the NPs. In some cases it was established that the victims were drunk and were probably unaware of the proximity of elephants along the paths while walking home or from one village to another. In some areas, remnant forests between villages provided hiding places for elephants, and owing to poor visibility, one was likely to encounter elephants at a close range. If an elephant's immediate reaction was to charge then there may have been no time or place for safety.

Little information was available (11 incidents) on the elephants responsible for attacks on humans, though they were known to include both bulls and cows. However, it was difficult for many victims or witnesses to tell the sex of the aggressive elephants, and most information was determined by whether there were young calves or not. Of all the attacks on humans by elephants, 82% (9 incidents) were thought to be by adult females. Interviews with 5 survivors and 6 witnesses accompanying victims indicated that females, particularly those with calves, were more aggressive.

5.3.3 Killing of livestock by elephants

During the rainy season there are many temporary pools and seasonal rivers, but once these dry up, livestock and wild animals have to share limited water supplies (Figures 5.3a and 5.3b). Contact of livestock with elephants at these places can result in death or injuries to the domestic stock. However, cases of elephants killing livestock were very rare in comparison to mortality caused by lions and other wildlife (Table 5.2). Livestock killing by elephants was insignificant throughout 1995 to 1997, accounting for 2 cattle as compared to predation by lions (*Panthera leo*), which were responsible for 98% of cattle deaths from wildlife. No cases of elephants killing shoats (sheep and goats) were reported while lions killed 203 shoats in the same period. Cheetah (*Acinonyx jubatus*), leopard (*Panthera pardus*) and two species of hyenas (*Hyena hyena* and *Crocuta crocuta*) were other wild animals that preyed on livestock.

Table 5.2 Livestock mortality caused by elephants and other wildlife in Taita Taveta District, 1995 to 1997.

Year	Killed by elephants		Killed by lion		Killed by other wildlife	
	Cattle	Shoats	Cattle	Shoats	Cattle	Shoats
1995	2	0	13	48	n/d	n/d
1996	0	0	57	79	n/d	2
1997	0	0	32	76	n/d	6
Total	2	0	102	203	-	-

Figure 5.3a Spring water point in Sagalla Location utilised by livestock as well as by elephants.

Figure 5.3b Earth dam within the Tsavo ecosystem for domestic water use. Such water points attracted elephants during the dry season.

5.3.4 Crops cultivated in Tsavo

The climate of the Tsavo ecosystem has been described previously in Chapter 2. Agriculture in the region is mainly traditional rain-fed cultivation, and a wide variety of food and cash crops are grown. There were 23 crops commonly cultivated, which were usually grown in mixed inter-cropping in small-scale holdings (Table 5.3).

Late March to late June/early July is the major crop season and planting is done after March/April rains. November to early March is the minor crop season and cultivation of the crops begins after the October/November showers. Other than pigeon peas, which is a biennial crop, maize and the other crops are ready for harvest in late February/early March in the first crop season and in late May/early June for the second season. Papaya fruits throughout the year whereas mango fruits ripen in late February and early March. Bananas, sugar cane and most vegetables are grown on a small plots, usually under irrigation along Voi River (Figures 5.4a and 5.b), while mango and citrus fruit trees are found in a few fields.

Sisal (*Agave sisalana*) is grown on large plantations as a cash crop. The two main plantations were Voi Sisal Estate adjacent to south-western boundary of TsE and Teita Sisal Estate mid way between TsE and TsW (Figure 2.2).

The proportion of people who cultivated each crop varied in the two districts (Figure 5.2). Maize, which is the stable food for the local people, was cultivated by a 100% of the

Figure 5.4a Diesel pumps used for crop irrigation along Voi River. Notice the pumps in the open among sugar cane plants.

Figure 5.4b Vegetables and fruits grown under irrigation along Voi River. Elephant raids in such fields are common and vigilance was kept for many hours.

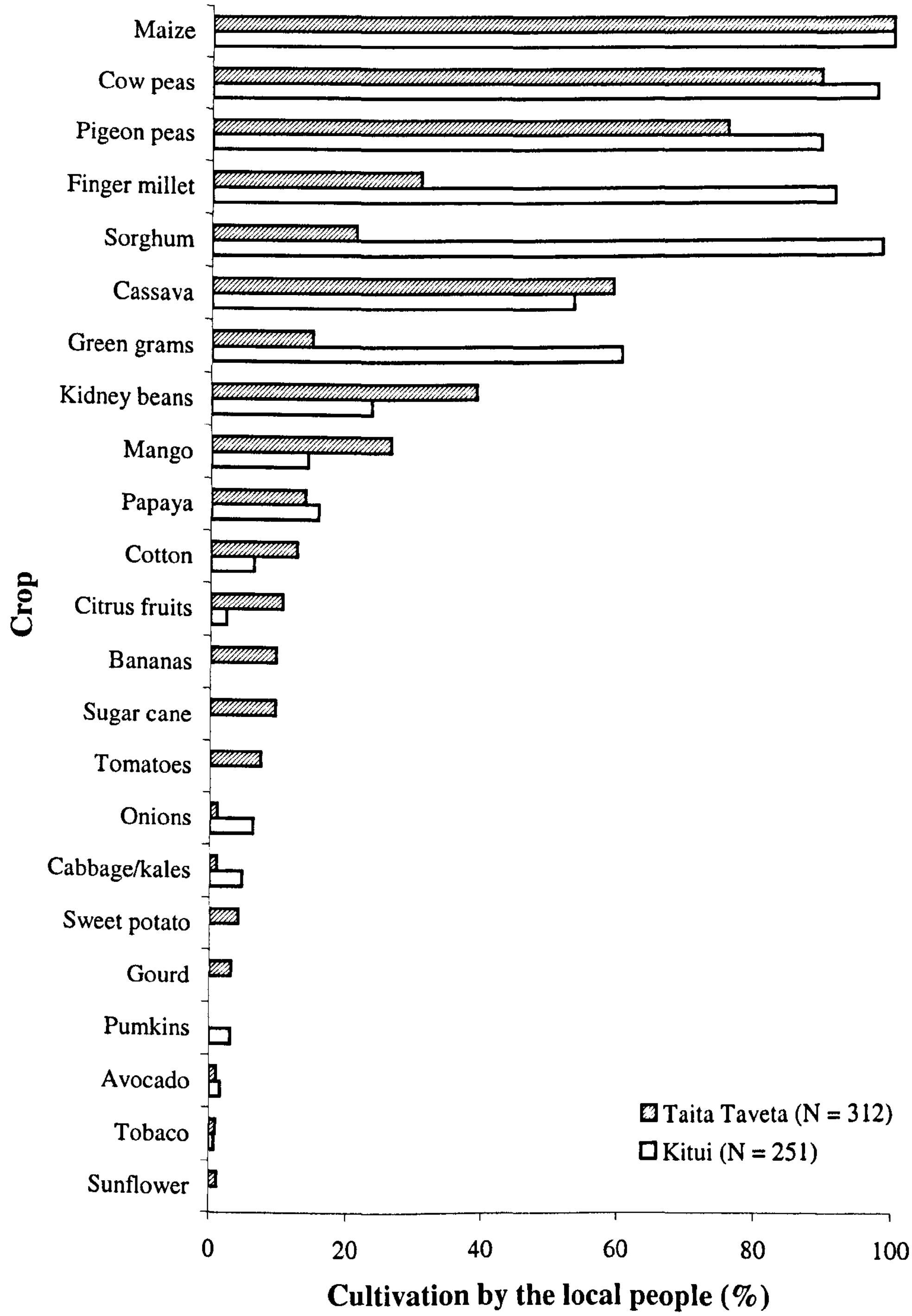
farmers in Taita Taveta and Kitui Districts. Cow peas, pigeon peas, sorghum and finger-millet were other important food crops, which were grown by many people. However, the effort required to keep out bird pests had discouraged many farmers from cultivating these crops.

Table 5.3 Major crops grown in Taita Taveta and Kitui Districts and their use, 1995 to 1997.

Crop	Scientific name	Main use
Maize	*Zea mays*	Food crop
Cow peas	*Vigna sinensis*	Food crop
Pigeon peas	*Cajanus cajan*	Food crop
Finger millet	*Eleusine coracana*	Food crop
Sorghum	*Sorghum vulgare*	Food crop
Cassava	*Manihot esculenta*	Food crop
Green grams	*Phaseorus aureus*	Food crop
Kidney beans	*Phaseolus vulgaris*	Food crop
Mangoes	*Mangifera indica*	Food/cash crop
Papaya	*Carica papaya*	Food/cash crop
Cotton	*Gossypium hirsutum*	Cash crop
Citrus fruits (oranges & lemons, etc.)		Food/cash crop
Bananas	*Musa domestica*	Food/cash crop
Sugarcane	*Saccharum officinarum*	Food/cash crop
Tomatoes	*Lycoposicon esculentum*	Food/cash crop
Onions	*Allium sepa*	Food/cash crop
Cabbages/kales	*Brasica* spp.	Food/cash crop
Sweet potatoes	*Ipomea batatas*	Food/cash crop
Gourd	*Lagenaria siceraria*	Food/making containers
Pumpkins	*Curcabita maxima*	Food
Avocado	*Persia americana*	Food/cash crop
Tobacco	*Nicotina tabacum*	Cash crop
Sunflower	*Helianthus annuus*	Cash crop

Though crop raiding by elephants was a major problem in Taita Taveta District, only 29.3% (110) of the local people said they had been forced to abandon the cultivation of some traditional crops they would like to grow (bananas and vegetables along Voi River, mangoes, sugar cane and papaya) due to fear of damage by elephants.

Figure 5.6 Crops grown and percentage cultivation by the local people in Taita Taveta and Kitui Districts, 1997.



5. 3.5 Percentage of land under cultivation

Households in Kitui District had larger fields (Mann-Whitney, $z = -6.652$, $p < 0.001$) and a lower percentage of their fields under cultivation (Mann-Whitney, $z = -7.652$, $p < 0.001$) than in Taita Taveta District (Table 5.4).

Table 5.4 Average field size (hectares) and percentage under cultivation in Taita Taveta and Kitui Districts.

District	Mean field size per household	Mean % under cultivation per household
Taita Taveta	8.9 (SD ± 9.185)	71.2 (SD ± 20.626)
Kitui	20.1 (SD ±14.877)	42.1 (SD ± 17.429)

This indicates that there has been more land transformation in Taita Taveta District than in Kitui District.

5.3.6 Conflict incidents and patterns

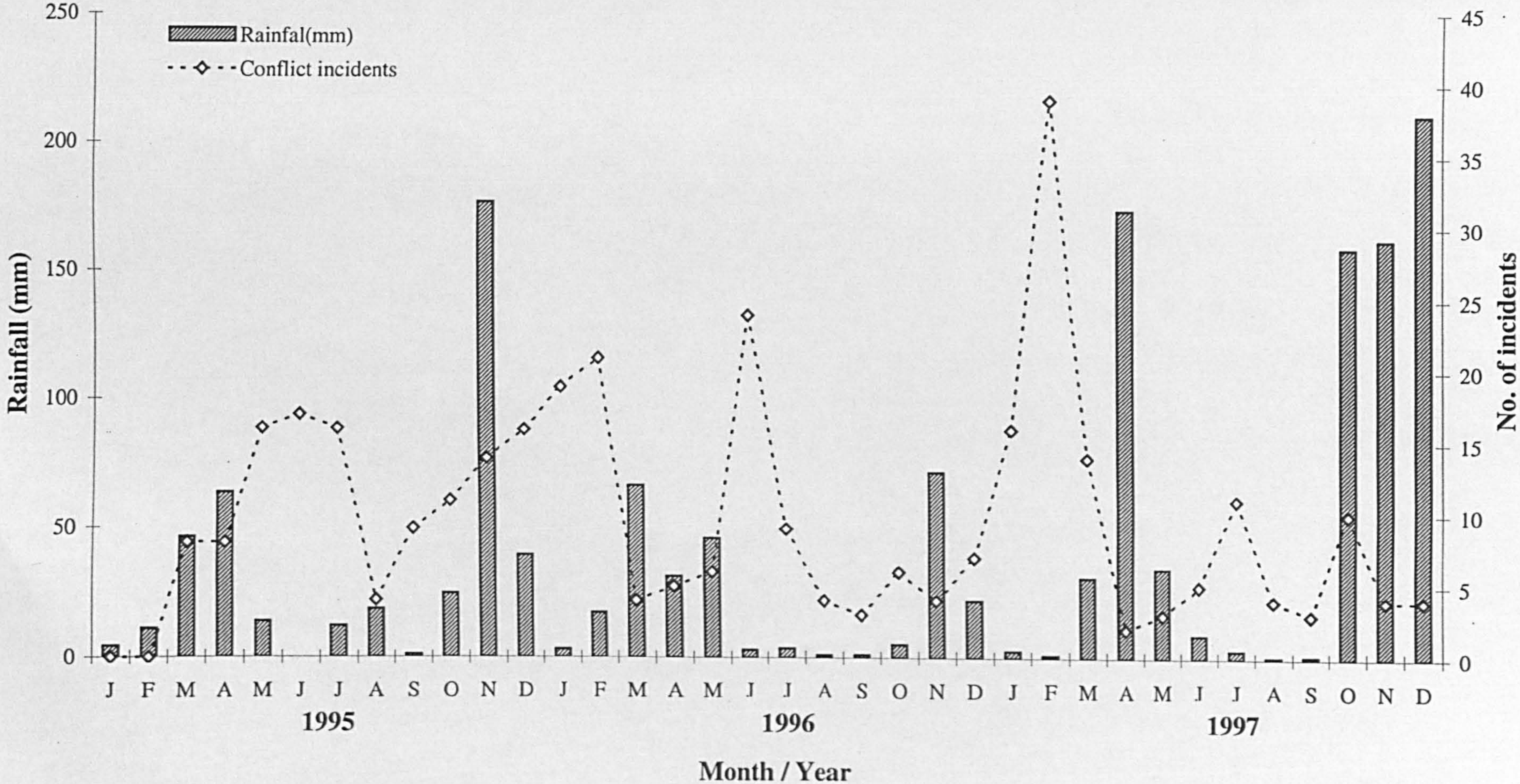
A total of 346 conflict incidents (crop damage, human attacks and reports of insecurity caused by presence of elephants, etc.) were recorded for the three years 1995 to 1997 (Table 5.5). The intensity of conflict incidents were different in dry and wet seasons (χ^2=16.435 df=4, $p<0.01$) with more incidents recorded during the dry season. In this study a wet season was defined as a rapid rise in rainfall to reach a peak of ≥ 50mm (Figure 5.6).

Table 5.5 Monthly conflict incidents and rainfall throughout 1995 to 1997.

	1995		1996		1997	
Month	Incidents	Rainfall (mm)	Incidents	Rainfall (mm)	Incidents	Rainfall (mm)
January	0	4.5	19	3.3	16	2.7
February	0	11.1	21	17.5	39	1.1
March	8	46.5	4	67.2	14	31.1
April	8	63.8	5	31.7	2	173.8
May	16	14.0	6	46.4	3	34.7
June	17	0.0	24	3.0	5	9.0
July	16	12.1	9	3.6	11	3.1
August	4	18.8	4	1.1	4	0.6
September	9	1.2	3	1.2	3	1.0
October	11	24.8	6	5.2	10	159.0
November	14	177.0	4	72.3	4	162.1
December	16	40.0	7	22.2	4	210.7
Total	119	413.8	112	274.7	115	788.9

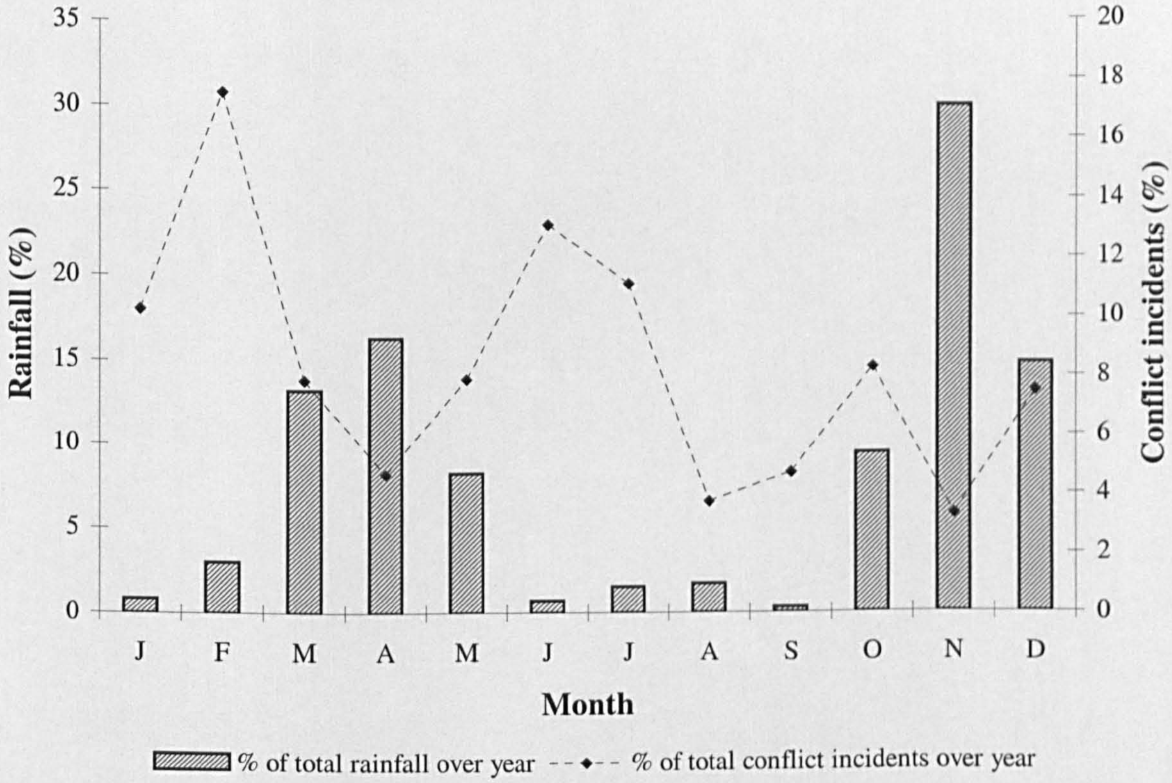
The seasonal pattern of conflict incidents showed peaks which were shifted about two months after the wet season. There was less rainfall in 1996, and in this year there was the highest number of conflict incidents, with peaks in February and June. In 1997 there were lower conflict peaks, a factor which could be related to the unusually heavy and prolonged rainfall in Tsavo, associated with the *El Nino* phenomena.

Figure 5.6 Relationship between rainfall and number of conflict incidents, 1995-1997.



The general annual conflict pattern is shown as a plot of the means of the total monthly rainfall and number of conflict incidents for the three years (Figure 5.7).

Figure 5.7 Mean monthly rainfall and conflict incidents throughout 1995 to 1997.



There were two main human-elephant conflict peaks, one in the beginning of the year (January-February) and another in the middle of the year (June-July), both displaced to about two months after the wet season. A total of 85% of conflict incident occurred during the dry season while 15% were recorded during the wet season.

Most (84%, N=290) crop raids occurred after dark. Elephant groups would move to the edge of the NPs in late afternoon and cross over into the settled areas between 19:00 hrs and 21:00 hrs. They would then feed in these areas and raid farms most of the night and return back into the NPs between 05:00 hrs and 06:00 hrs.

Maize, which was cultivated by 100% of the farmers, was the main crop eaten and damaged by elephants, accounting for 61% (N = 210) of all complaints in Taita Taveta District. Though no data were gathered in this study, anecdotal evidence suggested that elephants preferred larger fields with high density of standing crop at mature stage. In these fields serious damage was done by elephants plucking out the cobs. During raids in farms whose crops were at earlier growth stages the elephants mainly ate the terminal portion of the succulent stem and the leaves, or plucked the stalk bearing the inflorescence.

Though elephants could be attracted to a cultivated field by one crop, the damage caused by trampling of crops not consumed was enormous in most farms. Where papaya, mango and banana were grown extensive damage was caused to the whole plants. In addition to eating the inflorescence spike or fruit bunch, banana stems were split and the fibrous pith consumed as well. Sugar canes were uprooted, broken and eaten and entire crops were sometimes consumed in a single night.

5.3.7 Group size and composition of elephants involved in conflict

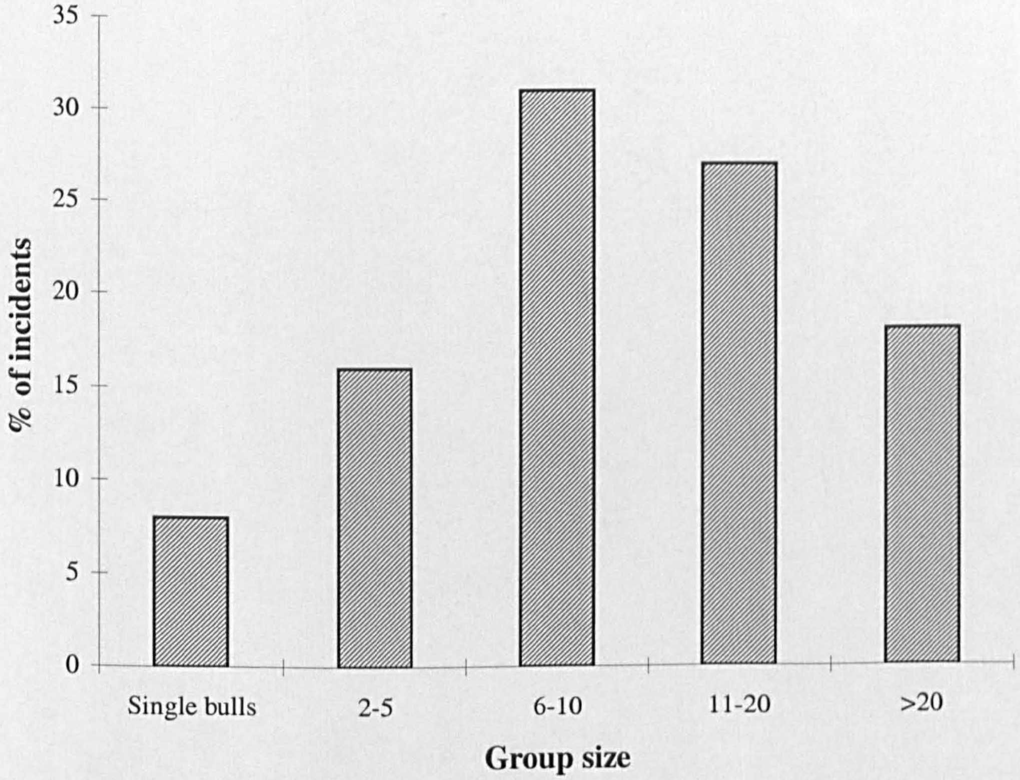
The term "group" is used to refer to any number of elephants that were closely associated in space and appeared to be co-ordinated in their activity at the time of observation (Leuthold 1976). The majority of elephant groups involved in conflict consisted of family groups with or without accompanying mature bulls (Table 5.6 and Figure 5.8).

Table 5.6 Group size and composition of elephants involved in conflict in Taita Taveta 1995 to 1997.

Group size	Number of incidents	Group composition
Singles	14	Always bulls only
2-5	16	Bulls or cow/calf groups
6-10	25	Bulls or cow/calf groups
11-20	21	Mixed groups
>20	2	Mixed groups, usually aggregations
Total incidents	78	

Conflict incidents involving bulls only formed 27% (N=21) of incidents, and the rest were cow-calf or mixed groups. No incidents of a single female or only a mother and calf doing crop aiding or venturing into the settled area were recorded.

Figure 5.8 Group size of elephants involved in conflict, 1995 to 1997.



Lack of radio tracking equipment made it impossible to establish the frequency of visits to the same areas by same individual or groups of elephants. It was also not possible to establish the distance traveled by elephants from the NPs into the settled area.

5.3.8 Other problem and pest wildlife

Though elephants were ranked top of problem wildlife species in Taita Taveta, this may not necessarily reflect their relative significance in terms of crop biomass consumed and destroyed, or destruction to other property. Other wild animals were also considered to be serious pests both in Taita Taveta and Kitui Districts, though they were not feared as

Figure 5.9 Other problem wildlife in three villages in Taita Taveta District, 1995 to 1996.

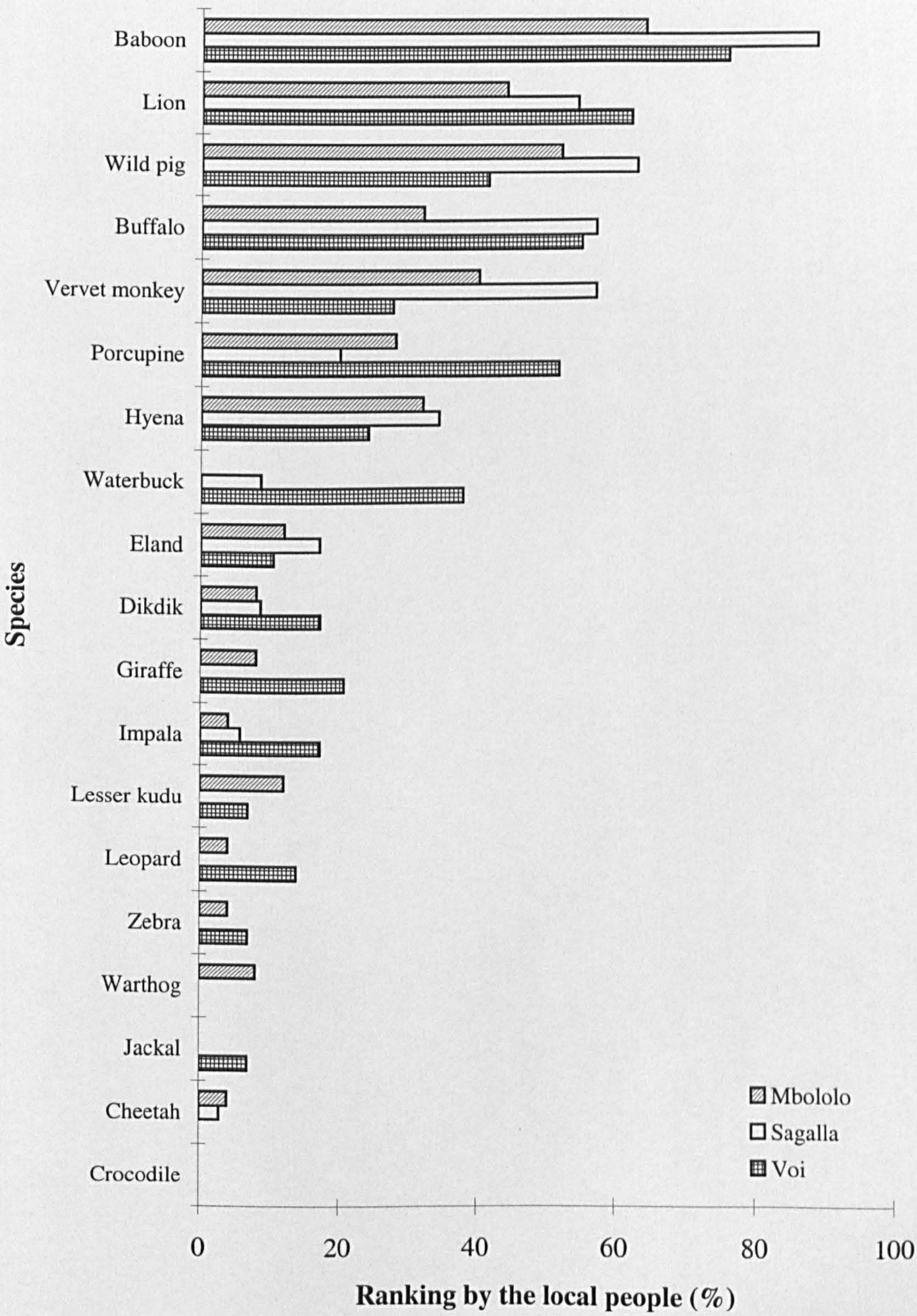
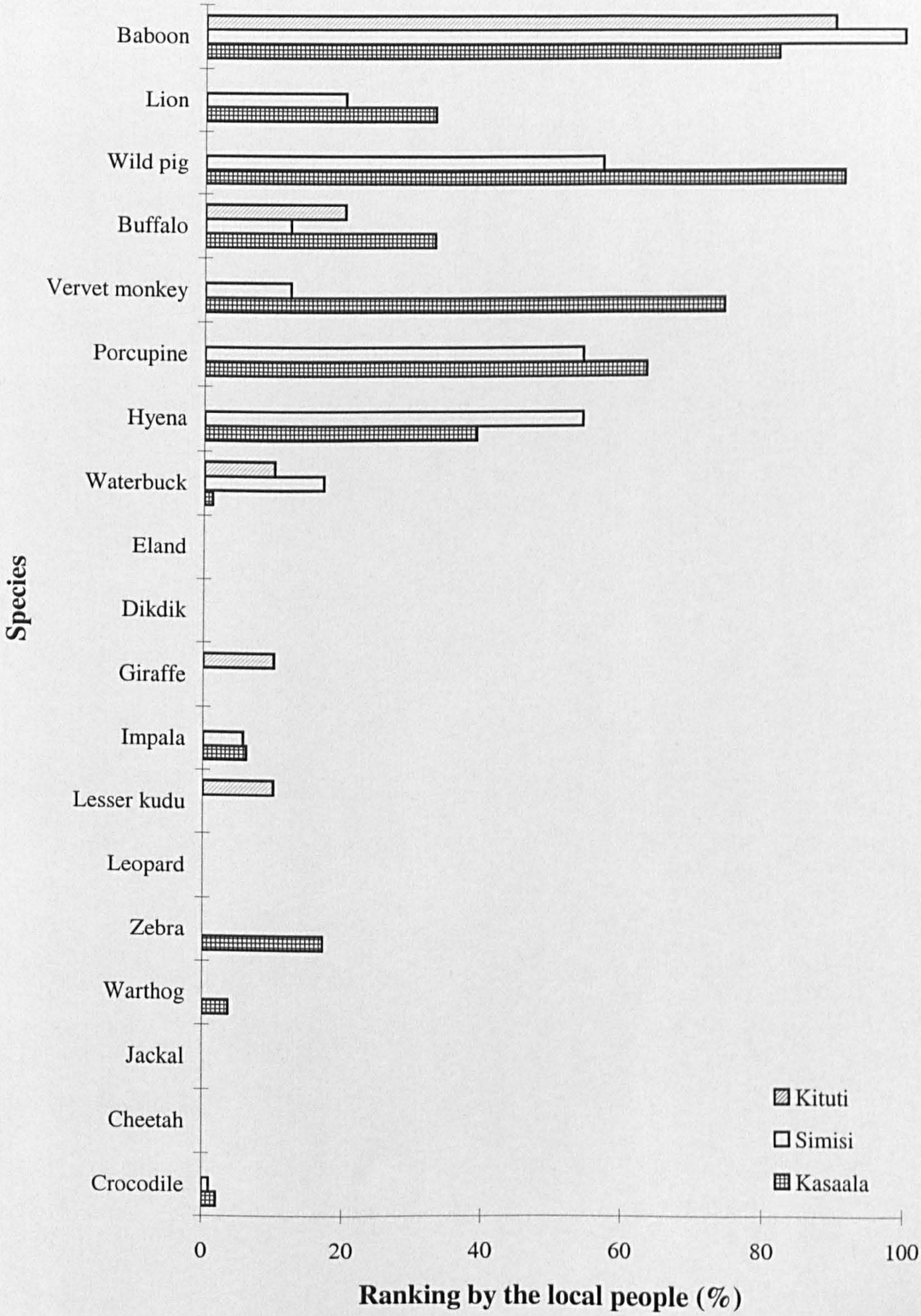


Figure 5.10 Other problem wildlife in 3 villages in Kitui District, 1995 to 1997.



much as elephants (Figures 5.9 and 5.10). More other wild animal species were regarded as pests in Taita Taveta District than in Kitui District (18 vs14). In Kitui district yellow baboon (*Papio cynocephalus*) and wild pig (*Potamochoerus pocus* or *P. larvatus*) were regarded as the most serious problem animals causing much damage to crops, while the damage caused by baboons to crops in Taita Taveta was regarded as being only second to that by elephants.

Ranking of different wild animal species varied in different villages in both Taita Taveta and Kitui districts, but no detailed studies were conducted to find out the reasons for this.

5.4 Discussion

Living in an area with high elephant numbers poses problems to human communities and their property. Close encounters with elephants pose the risk of death or injury and peoples' freedom of movement is interfered with (Kiiru 1995, Kangwana 1995). In areas with remnant thick bush elephants present danger to people walking about, herding livestock or performing other daily chores.

Throughout 1992 to 1997, 15 people were killed and a further 5 injured by elephants in Tsavo (Table 5.1). Though the number of people killed by elephants annually in the area was far less than that from other causes (malaria and other diseases, road accidents, etc.) the public outcry it generated was vociferous. And although other wildlife species contributed to human-wildlife conflict, and may have caused more crop and livestock losses, elephants were the most widely feared because of the difficulty of stopping them with any barrier and the danger they posed to human life. Mature elephant females were responsible for most of the attacks on humans (82%). This could be because female elephant mothers with calves are more likely to feel seriously threatened by the proximity of a human (Moss *et al* 1983, Lee 1987, Moss 1988, Sukumar 1989). No incidents of a single female or only a mother and calf doing crop raiding or being involved in other conflict incidents were recorded. This is similar to findings in Asia, a case explained by the fact that an adult female would not risk engaging in what may be 'high risk' activity with only her calf (Sukumar 1989).

Although human-elephant conflict incidents were recorded in almost all the months throughout the study period, conflict was most intense during the dry seasons (Figures 5.6 and 5.7). Elephants were noted to be attracted more to areas where permanent natural or artificial water supplies were available, especially livestock watering points and earth dams. Most visits to these water points were at night, but large groups (>10) were noted to spend more time in the vicinity of these water points to as late as 07:30 hours, after which they moved into nearby forest enclaves where they sometimes remained all day. Disturbing such elephant groups during the day by the local people or KWS rangers in an attempt to drive them back to the NPs usually resulted in their scattering over a wider area, making them more aggressive and hence increasing the risk of fatal encounters.

Crop depredation by elephants occurred in most areas where cultivation was done in lowland Taita Taveta. Due to scarcity of water in the NPs the need by elephants to utilise resources close to permanent water supplies near agricultural land increased the chances of elephants' contact with crops. Though elephants could be attracted to a cultivated field by one crop, the damage caused by trampling of crops not consumed was enormous in most farms. Where non-palatable crops were grown damage occurred as the elephants traversed the fields. In most of the fields visited by elephants yields from all cultivated crops was greatly reduced.

Other than maize and other grain crops, elephants seemed to relish papaya, mango and banana plants and fruits, which were all available during the dry season. In months when most of the land was under fallow small groups of elephants made incursions to feed on banana, mango, sugar cane and other crops grown under irrigation. Anecdotal evidence showed that small groups or individual elephants traveled long distances in search of these plants, which they consumed and destroyed extensively.

Cases of elephants demolishing stores or huts to reach for food and killing people in the process have been reported in some parts of Kenya (Waithaka 1993) and in south east Asia (Sukumar 1989), but none occurred in Tsavo during the study period.

In Tsavo 62% of elephants involved in human-elephant conflict were groups of 6 or more elephants and only 18% of the incidents were by 'bulls only' groups (Table 5.6, Figure 5.8). This is unlike findings from studies in south east Asia (Sukumar *et al* 1988, Sukumar 1989, Sukumar 1990, Sukumar 1991) and Zimbabwe (Hoare 1997, Osborn 1997). In south east Asia, Sukumar (1990) found that 82% of human deaths by elephants in the region involved sub-adult or adult male elephants. The same author also observed that bull elephants continued to raid a selected field or cluster of fields for a few consecutive nights before turning their attention to other locations. Osborn (1997) shows that only bulls were involved in conflict incidents in areas adjacent to the Sebugwe region of Zimbabwe. These authors advance the view that some bulls become habitual human killers or crop raiders. Data gathered in this study did not provide any evidence that some elephants become habitual raiders or human killers in Tsavo. However, some local people claimed that they could recognise some problem elephants that frequented their villages from physical characteristics (tusk shapes, ear notches and other body marks) but this could not be reliably corroborated.

In the large commercial cattle ranches, the presence of elephants was a hazard to stock and herdsmen, especially at water points. However, due to the very low human density in these areas the problem was not considered serious. As long as the ranches remain in this status conflict incidents within this form of land use will remain minimal.

An indirect insecurity problem due to the presence of elephants close to human habitation was that from heavily armed poachers, who sometimes doubled up as vicious robbers. Cases of violent robbery, rape and abducting of local men to carry food and ivory for the poachers occurred occasionally in some villages in Taita Taveta and Kitui Districts. Frustrated ivory poachers also at times stole livestock and other property. These robberies were sometimes carried out with extreme violence resulting in extensive damage to property and loss of human life.

The current legislature makes it illegal to graze or water livestock in the PAs, but cattle incursions occur especially during the dry season. In periods of extreme drought grazing of livestock in the PAs is sometimes sanctioned by the government for a limited period, but once it is allowed controlling the activity becomes difficult. Elephants and other wildlife, on the other hand, are free to roam in areas outside the parks where they feed on natural vegetation, crops and consume water on private land. The fact that the local people have been legally denied what they consider their dry season grazing range and are expected to support wildlife on their land without any form of compensation has resulted in hostile feelings towards the park authorities and the wildlife they protect, leading to a higher intolerance of the elephants' presence on private land and use of artificial water supply outside NPs.

In the next chapter I will describe conflict intervention methods by the local people and KWS and their direct cost.

Chapter 6

Intervention Methods and Costs

6.1 Introduction

Where humans and elephants share the same range, one of the unfortunate outcomes is the death and injury of either species, and destruction of human property by elephants. In Taita Taveta District, where elephants range into settled areas, the local people use a variety of methods to protect their crops and to discourage elephants and other wildlife from cultivated land and settled areas. Some of these methods have been used for decades but they have never been investigated in detail.

In order to reduce the cost of elephants to the local people, KWS also employs different conflict mitigation measures whose success varies from place to place. In this chapter, I will describe the common methods used by the local people in Taita Taveta and the extent of their use among the local community (Section 6.3.1), and the direct cost of protecting crops from elephants to Taita Taveta people (Section 6.3.2). Intervention methods by KWS, effectiveness and costs in Tsavo are given in some detail (Sections 6.3.4 and 6.3.5), and a discussion of these results follows (Section 6.4).

6.2 Methods

6.2.1 Intervention methods and costs

Questionnaire surveys were used to gather data on intervention methods used by the local people in Taita Taveta and Kitui Districts (Appendix II). Data were also gathered in both districts on the direct costs incurred by the local people while protecting their crops from elephants and other wildlife. These included the number of hours spent on vigilance per day/night (using a 24 hour cycle), and the cost of material used to deter and discourage elephants and other wildlife from cultivated fields per household per year. This made it possible to find out whether elephants had an influence on the costs and vigilance time to the local community's intervention efforts.

Data on the running and maintenance of PAC vehicles were compiled from KWS vehicle's daily Work Ticket (WT). The total mileage covered by each vehicle on elephant control missions was calculated and used to compute the cost of petrol and maintenance. Complete records were available for 1996, which was a typical conflict incidents year.

6.2.2 Effectiveness of shooting male or female elephants

Where elephants were shot and killed outside NPs in Taita Taveta District as a conflict mitigation measure, the sex of the elephant killed was determined and the period taken before elephants re-visited the same location monitored. This was expected to give an indication of whether killing of an elephant of one sex was more effective in keeping the rest away. Data were gathered throughout 1995 to 1997.

6.3 Results

6.3.1 Intervention methods by the local people

6.3.1.1 Traditional methods

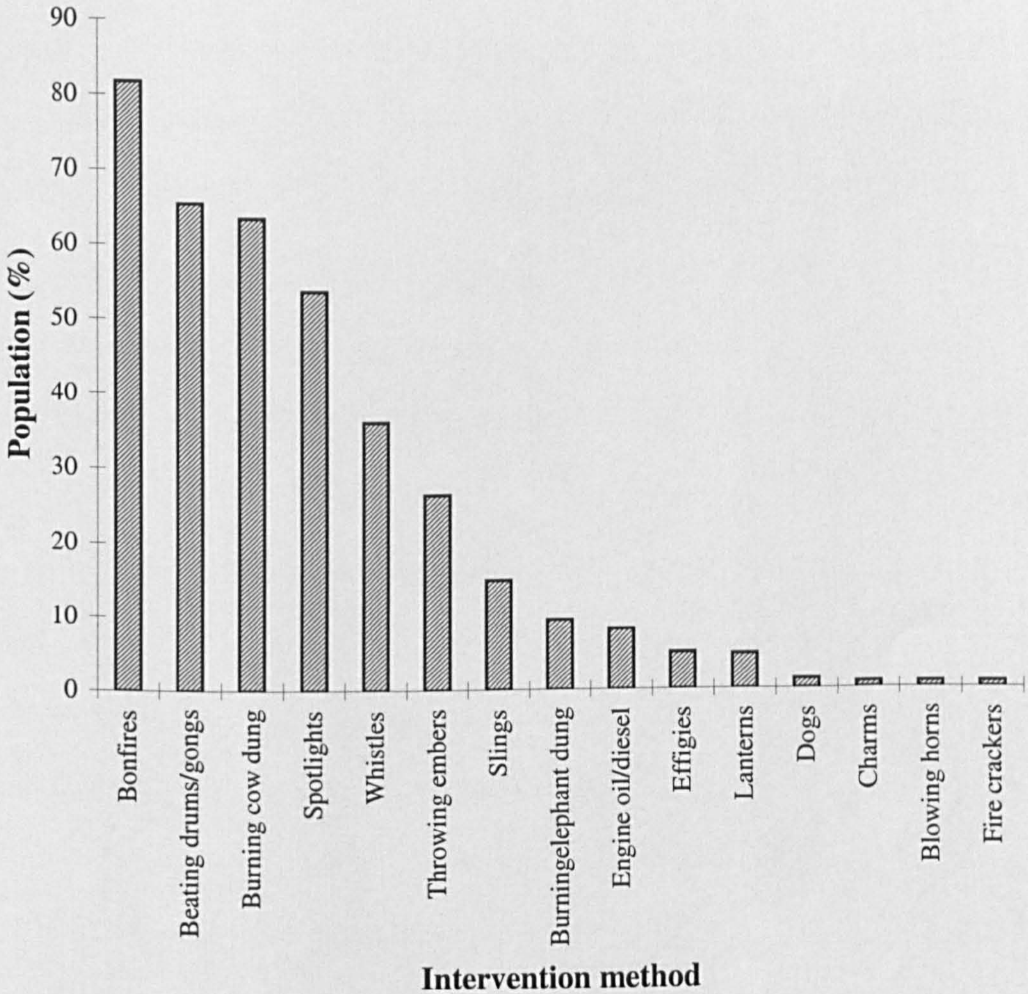
There were 15 commonly used traditional intervention methods in Taita Taveta District, the choice depending to a large extent on the cost and availability of the necessary manpower. The proportion of the local people who used a specific method varied, but the popularity of the methods was consistent in the three sample villages in Taita Taveta District (Table 6.1).

Table 6.1 Intervention method used by the local people in Taita Taveta District, 1995 to 1997. The 'Number of people' column is the total number of people who said they used a particular method, either separately or in combination with other methods. The total number of respondents was 375.

Method	Number of people
Bonfires	312
Beating metal drums and gongs	250
Burning cow dung	242
Spotlights	205
Blowing whistles	138
Throwing embers	101
Slings	57
Burning elephant dung	36
Engine oil/diesel	31
Erecting effigies	19
Pressure lamps/Lanterns	18
Dogs	5
Traditional charms	3
Blowing horns	3
Fire crackers	3

The most commonly used methods in Taita Taveta District were use of fires and production of noise by beating of metal drums and gongs (Figures 6.2 and 6.3). Of the total population 82%, used fires as an intervention method and 65% used noise. Other widely used methods were burning of cow dung (63%), spotlights (54%), blowing whistles (36%) and throwing burning embers at intruding elephants (26%).

Figure 6.1 Percentage use of various traditional intervention methods by the local people in Taita Taveta District.



Fires aiming to serve as a deterrent were kept alight throughout the night. Either one big fire was made at the centre of the farm or smaller ones were lit at intervals at the periphery of the cultivated field. Wood was the most commonly used fuel, but a few farmers used diesel or kerosene, old tires and other rubber or plastic material, which were thought to produce strong olfactory irritants that kept elephants away (Figure 6.3). Other methods of illuminating included use of pressure lanterns, which used liquefied gas or kerosene. These produced bright light that covered a wider area.

Burning of cow dung was thought to be effective through olfactory repulsion of elephants and other problem wildlife. Burning of elephant dung or wild sisal (*Sansevieria* spp.) chewed by elephants was thought to be more effective in keeping elephants away. However, suitable elephant dung was hard to find outside NPs and though many people would have liked to use it only 9% (N=28) of the local people in Taita Taveta said they could find sufficient quantities for burning. The explanation by the local people was that because elephants ate a wide range of plants, their dung contained many constituents which acted as efficient medicines or repellents to chase away intruders, including elephants themselves (see also Chapter 2 Section 2.3.2).

Use of dry cell powered spotlights was another method used by 54% of the Taita Taveta people. Use of six 1.5V cells or more to power a single spotlight was thought to be very effective in scaring away elephants by dazzling them with the powerful beam. However, the cost of cells, which needed replacing every two to three nights, was too high for most farmers and the majority (61%) of the people used 2 cell battery spotlights, which were only good for locating the elephants at night, after which they used other means to scare them off.

Slings made of sisal (*Agave sisalana*) or bark from *Sterculia africana*, were used for throwing missiles or cracked like whips to produce a sound similar to gun shots or thunder-flashes (Figures 6.3 and 6.4). However, this was physically strenuous and was

Figure 6.2 Vigilance shelter and metal gong. The gong is activated by wind and a rope pulled from the safety of the shelter.

Figure 6.3 Diesel fuelled fire and tree bark whip for scaring elephants off. Notice the man on the right holding a spotlight.

Figure 6.4 Cracking a sling to scare elephants off.

Figure 6.5 Diesel doused cloth hung at the periphery of a cultivated field to keep out wild animals.

only effective when used at close range to elephants. Of the people who used this method, 70% (N=57) said it was very effective in chasing away elephants, especially when used in combination with firecrackers or other explosives. However, acquiring of explosives legally to supplement use of slings was expensive and involved a length process and few farmers could afford the cost. To produce a similar sound, some farmers used ingenious ways of making their own crackers using powder from match stick heads, but this was done by a very small proportion, 0.006% (2).

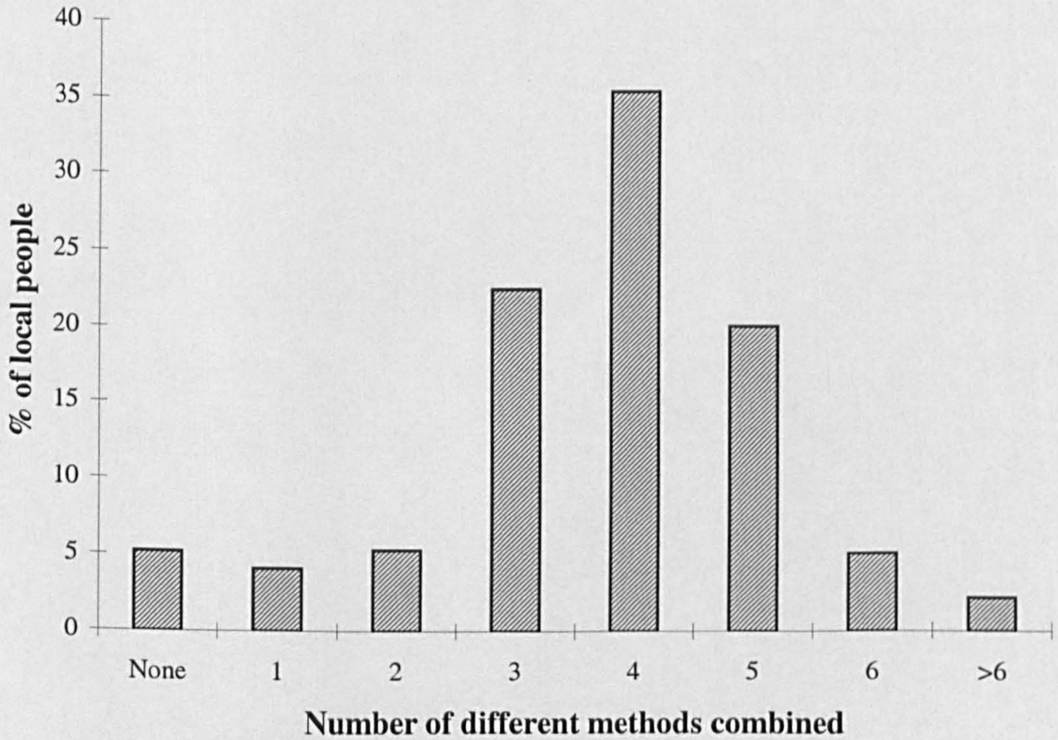
In their desperate attempts to keep out elephants from their property, farmers resorted to other kinds of affordable methods. Spraying of diesel or used engine oil at the edges of their cultivated fields was a practised by 10% of local people. Other forms of applying these substances was by dousing pieces of cloth or human effigies with used engine oil or diesel and hanging them round the fields (Figure 6.5). Those who used this method argued that the smell would discourage elephants from visiting their farms.

Dogs were used by 1% of the farmers to warn them of approaching elephants. Though trained dogs could be useful for this purpose, there was the danger that elephants could react aggressively to barks, and if an elephant chased the dog the latter would naturally tend to seek refuge from its master, exposing both to great risk.

Only a few people (0.9%), all from Mbololo Location, believed that using charms provided by traditional medicine men would be effective in keeping elephant away from crops and homesteads. In Sagalla Location, a similar proportion (0.9%) believed that blowing lesser kudu (*Strepsiceros imberbis*) horns as instructed by local medicine men during elephant raids would scare the elephants off.

The majority of the local people used a combination of methods to improve on effectiveness (Figure 6.6). However, a few people did not use any intervention methods at all. The reason given by all those who used no intervention methods was that the costs and risks involved during vigilance were not worth what they expected to harvest due to the low and unreliable rainfall in the Tsavo ecosystem.

Figure 6.6 Proportion of people who used different numbers of intervention methods in combination in Taita Taveta District, 1997.



No data were available or were collected on the effectiveness of the various traditional methods used by the local people in Taita Taveta District.

6.3.1.2 Other intervention methods

6.3.1.2.1 Fencing

Some 10% (30) of the farmers had attempted some form of fencing round cultivated fields and homesteads to prevent crop damage and elephants getting too close to their houses. However, the cost of barbed wire and fencing posts was too high for most of the peasant farmers.

The fences ranged from simple thorny branches to strong barbed wire (Figures 6.7a and 6.7b). Though the thorn bush fences could keep off most wildlife they were not an effective deterrent to elephants.

Qualitative observations on the effectiveness of the barbed or other wire fence were interesting. After their exposure to electric fences the Tsavo elephants seemed to respect any wire fences, even when the fences had no electric current. An even more interesting observation was that elephants did not raid 5 fields near TsE surrounded by upright posts without any wires (Figure 6.8a and 6.8b). However, insufficient data were available to test these observations and further investigations need to be carried out.

6.3.1.2.2 Audio playbacks

An attempt was made by the management of the Voi Sisal Estate to use playbacks of a jumble of noises recorded during a control shooting exercise in the same area in 1995. The sound was amplified from an ordinary cassette player to two large ordinary speakers and played during elephant raids of the plantation. When elephants entered the estate and the playback was done, the response by the elephants was that of an

Figure 6.7a Thorn bush fence around a homestead and cultivated field to keep out wild animals.

Figure 6.7b Barbed wire fence around a cultivated field

Figure 6.8a & b Post without wires around a maize field near TsE, 1997.

(a

(b

initial nervousness and confusion, but after about half an hour they ignored the sound and continued to feed on the sisal plants. The playbacks were done for two consecutive nights but the sound did not deter elephants from entering the plantation. No further trials were done after the two days trials throughout 1995 to 1997.

6.3.2 Cost of intervention methods to the local people

Assessing the direct economic costs of crop raiding by elephants is difficult in Tsavo because one has to calculate the projected crop yield in the absence of elephants among other factors. Often people will harvest maize early as they have learned from experience the rate of attack is highest on more mature cobs and they may lose everything, in addition to cutting intervention costs. This is likely to reduce the value of the harvest, even if elephants do not eat or destroy it. Another factor is the unreliable rainfall, which may fail or be insufficient in most seasons and the entire crops may wither and die. In such circumstances damage done early in the season by elephants would have no impact on the final harvest.

Another complication is that the value of subsistence agriculture cannot be measured in purely economic terms (Kangwana 1995). Often the crops destroyed are the only source of food for the affected families. The time spent defending crops and acquiring alternative food must also be considered in assessing costs. There are further indirect costs, for example the need for the people to spend sleepless nights during vigilance, and loss of school hours when some children stay home to assist their parents to defend their crops.

In this study an attempt was made to only assess the direct costs incurred by the local people while protecting their crops from elephants using methods discussed in Section 6.2.1. Costs included expenditures on wages for watchmen or other hired labour and services, purchase of fuels, spotlight cells, and other material directly related to human-elephant conflict intervention. Only 234 respondents in Taita Taveta and 69 in Kitui were able to give approximate figures on how much they spent to protect their crops from elephants and other wildlife.

The Taita Taveta people spent more time (Mann-Whitney, $z = -6.950$, $p < 0.001$) and more money (Mann-Whitney, $z = -5.121$, $p < 0.001$)) protecting their crops than did Kitui people (Table 6.2)

Table 6.2 Average annual expenditure and daily vigilance hours per household in Taita Taveta and Kitui Districts, 1996.

District	Mean hours per day	Mean expenditure per year (US$.)	
Taita Taveta	9.3 (SD ± 3.22)	1,218 (SD ± 831)	(N=234)
Kitui	6.6 (SD ± 2.12)	741 (SD ± 266.5)	(N=69)

In Taita Taveta District the average household expenditure was US$ 1,218 per year on materials and services and 9.3 hours of vigilance per day during crop seasons. In Kitui District, where elephants were not a problem, the average household expenditure was US$ 741 per year on materials and services and 6.6 hours of vigilance per day during crop season. This indicates that intervention costs are higher where elephants are a problem in addition to other wildlife. However, these figures should be treated with caution as no correction was made for KWS efforts in the two districts.

6.3. 3 Intervention methods by KWS

In an effort to reduce human-wildlife conflict in Tsavo, a PAC unit was formed by KWS in 1992 to deal with all cases related to human-wildlife conflict, with emphasis on elephants. A special team of rangers and an officer were assigned these duties and given an office in Voi town, which was easily accessible to most of the local community. Various non-fatal and fatal methods have been used by this team, either singly or in combination, to drive off elephants from areas where they were a problem to the people.

6.3.3.1 Non-fatal methods

The most commonly employed non-fatal method was the use of thunder-flashes and blank ammunition to drive off elephants from cultivated fields or settled areas. When thunder-flashes were not available, shots were fired in the air or over the elephant's heads.

In 1994 two helicopters were used to chase large herds of elephants which had invaded some areas of Bura 'block' (Figure 2.2) during the day back to TsW. Although the drive was successful, elephants went back to the same area the following night. The helicopter drive was repeated the following day and the elephants once again moved out of the NP at night. The exercise was called off due to the high cost involved and the pandemonium it created among the elephant herds in the settled area.

6.3.3.2 Fatal methods

It has been argued that shooting one of the group members while raiding could discourage the rest from making subsequent visits to the same place for a long time

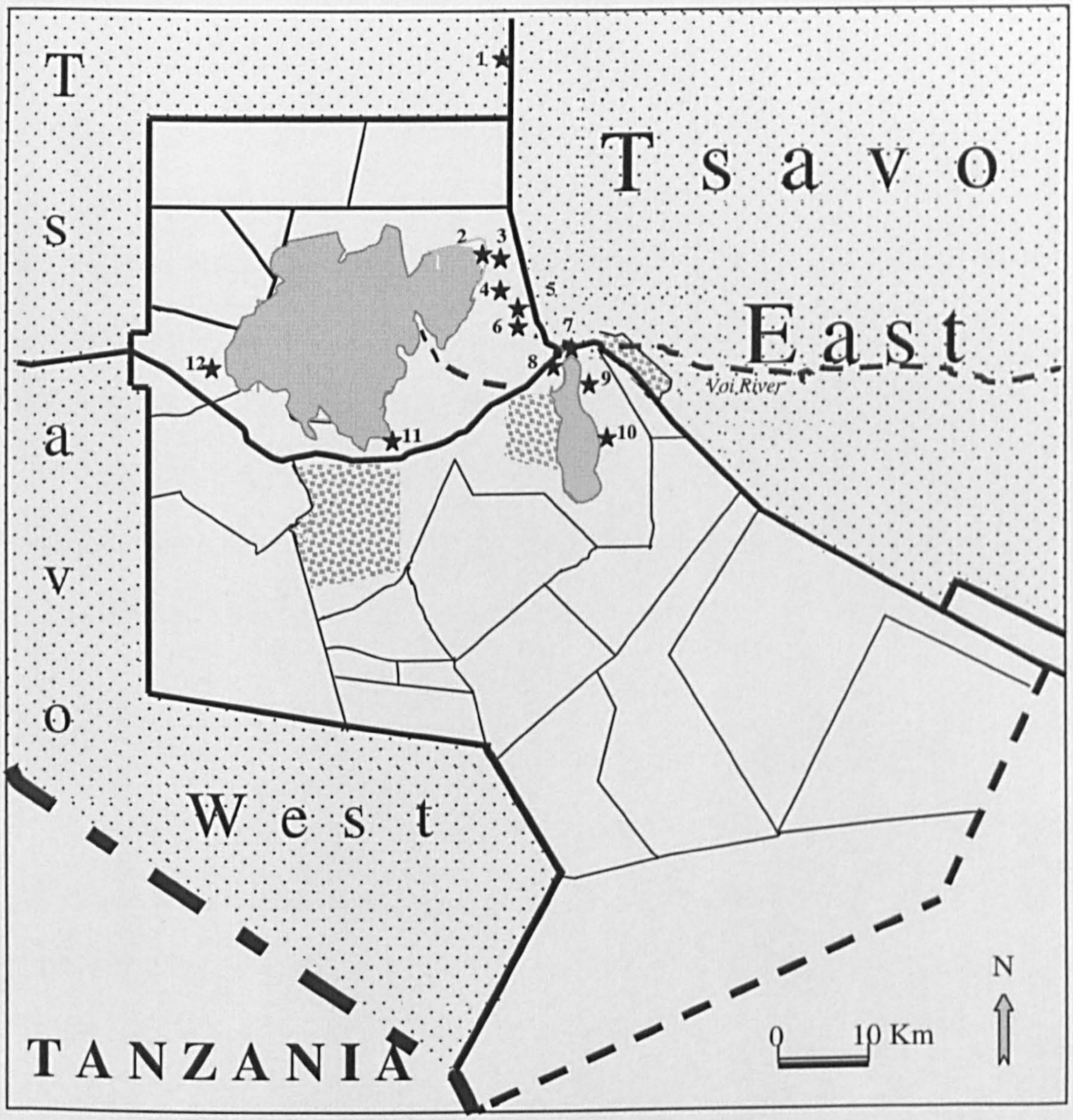
(Kiiru 1995, KWS unpublished reports). During this study shooting of elephants in 12 areas, 8 involving male and 4 involving female elephants, were monitored in locations outside NP throughout 1995 to 1997, to determine how long other elephants took before re-visiting the area. Elephants kept away for varying periods (Table 6.3, Figure 6.10) but it could not be established whether it was members of the victim's family or different groups which made the first re-visit.

Table 6.3 Period taken before elephants revisited an area where one was shot dead, based on 12 incidents from 1995 to 1997.

Area	Sex of elephant shot	Time before a revisit
Mbololo	Male	3 hours
Mraru	Male	1 day
Ikanga	Male	1 day
Ndi	Male	4 days
Mzinga	Female	6 days
Gimba	Male	9 days
Musorongo	Female	26 days
Manyani prison	Male	40 days
Mwakingali	Male	60 days
Irima	Female	85 days
Tausa	Male	120 days
Mariwenyi	Female	122 days
Total incidents	12	

The average revisit period after killing a male elephant was 29.4 days (SD ± 42.7) while the period for a female was 59.8 days (SD ± 53.4). However, there was no difference in the length of time taken before a revisit between the sexes (Mann-Whitney, $z = -1.360$, $p > 0.10$), although these incidents were very few and the conclusion reached in this test may therefore not be valid. Furthermore, other factors such as the seasons, presence or absence of crops, permanent water, etc., could influence the incentive of elephants to return to a particular area.

Figure 6.9 Locations where problem elephants were shot dead and revisiting by other elephants monitored, 1995 to 1997.



National Park
Hills
Sisal plantation
Major road
★ Locations where elephants were killed
Seasonal river
District boundary
International boundary

1- Manyani Prison
2- Tausa
3- Irima
4- Mbololo
5- Ndi
6- Ikanga
7- Mzinga
8- Mwakingali
9- Gimba
10- Mraru
11- Mariwenyi
12- Mosorongo

6.3.4 Cost of conflict to KWS

The cost incurred by KWS due to human-elephant conflict and the control of other problem wildlife ranges from the hiring of staff and purchase of equipment to the loss of the wildlife killed. Quantifying of the multiple losses was beyond the scope of this study and only transport costs were calculated.

A total of 35,200 kilometres were covered on human-elephants conflict assignments throughout 1996. At the standard maintenance and fuel cost of US$ 0.42 per kilometres (KWS Mechanical Department 1996), this amounted to US$ 14,583 for 1996. The total operational budget for running the Tsavo NPs (TsE & TsW) in that year (excluding staff salaries) was US$167,000. Thus about 8.7% of expenditure went to running PAC vehicles on elephant control missions.

6.4 Discussion

For decades the Taita Taveta people have used a wide variety of traditional methods to mitigate human-elephant conflict in the Tsavo ecosystem. Some of the methods are more effective than others and the choice has always depended on the availability of the necessary resources and manpower. The success of various methods also varied in different villages depending on the incentive of elephants to use these areas outside the NPs.

The local people would not normally kill an elephant for fear of being prosecuted and the risks involved. However, the death of 7 elephants in some villages between 1994 and 1997 could not be explained. All 7 elephants had no apparent external injuries and their tusks were intact. Thouless (1994) notes that it was possible that poisoning of problem elephants by the local people occurred in Laikipia District of Kenya by use of poisoned maize cobs. In Tsavo there was talk of poachers and dissatisfied farmers poisoning small water holes outside NPs where elephants were known to visit frequently, but this was never confirmed. Poisoning of water reservoirs by the local people in Tsavo was unlikely, as the same sources were important for their livestock and domestic use. Any poisoning would be by use of food items relished by elephants, but no cases of elephant poisoning were ever confirmed in Taita Taveta as no post-mortems were carried out.

A unique intervention method in Kitui district was the use of strong perfumed soaps and body sprays on pieces of cloth and effigies hung at the edges of cultivated fields. This was believed to put "human" smell to the material on which it was applied, and therefore enhanced their effectiveness as wild animal deterrents. Some of the perfumes used were relatively expensive and their use increased further the costs of intervention. Whether the same was effective on elephants was not known.

The use of powerful lights to dazzle raiding elephants has been tried in south east Asia (Sukumar 1989). In Asia, a car or tractor fitted with spotlight was found to be fairly effective in keeping out elephants provided the vehicle was taken close enough to the elephants. However, once the vehicle was withdrawn the elephants came back. This option may be tried in Tsavo in some irrigated farms by using KWS cars or generators.

Some of the intervention methods used by the local people are no longer sustainable and may lead to environmental degradation. The cutting down of trees to provide large volumes of firewood for night fires has already become a serious problem in some villages in Tsavo. Very little wood is left in areas near Voi town and most of the farmers in this area purchased their wood supply from other villages. This commercialisation of wood supply had resulted in illegal harvesting from the NPs, and KWS had to put in extra effort to minimise this illegal use of NP resources. Other methods pose the risk of pollution. The use of diesel and engine oil as elephant deterrents by farmers is likely to lead to contamination of the soils, the crops grown and water resources, which may become widespread when washed away by run off during the rainy season.

In addition to the wide variety of methods employed by the local people, efforts by KWS did not reduce the human-elephant conflict problem to tolerable level in Taita Taveta. Crop raiders quickly habituated to false threats and in some places persistent elephants were not deterred by gunfire, including shooting one of the group. Despite their being shot and killed in conflict areas the elephants showed no indication of avoiding these "high risk" areas. The availability of water outside NPs and crops grown under irrigation seemed to provide powerful incentives to the elephants especially during the dry season. No evidence was found to support the hypothesis that shooting a female was more likely to discourage elephants from raiding than shooting a male (Mann-Whitney, $z = -1.360$, $p > 0.10$). However, the data gathered were too few and further investigations need to be done.

Based on the social organisation of elephants (Buss 1961, Douglas-Hamilton 1972, Croze 1974a, Laws *et al* 1975, Poole 1987, Moss 1988) shooting a female elephant may be more likely to discourage other elephants from visiting the same area. Though bulls may be in association with the females, when family groups are frightened away the bulls will most likely follow. Since there are no bonds between males, or between males and females, shooting a male is less likely to have much influence on the behaviour of other males or of females. However, shooting a matriarchs or other large group leaders should be avoided as it is likely to leave the rest of the group leaderless, and they may then cause more problems, in addition to jeopardising the survival of the rest of the group (Moss 1988).

The attempt made by the management of the Voi Sisal Estate to use playbacks of a jumble of noises recorded during a control shooting exercise could be explored further as a potential non-lethal method for use in Tsavo. Sukumar (1989) cites an example in Asia where audio playbacks were effective in keeping away a raiding bull elephant. A number of studies on elephant communication have demonstrated possibilities for manipulating elephant behaviour with playbacks of vocalisations (Poole *et al* 1988, Poole & Moss 1989, Langbauer *et al* 1991). Kangwana (1993) played back recordings of Maasai cattle noises to elephants in Amboseli NP, Kenya, and she observed that elephants retreated from recordings because of an association made between the danger posed by the Maasai (who periodically speared them) and the sounds of their cattle. Whyte (1993) suggests that elephants may emit low frequency distress calls when being culled, which has the potential for use to repel elephants from cultivated fields. The problem with elephant sounds, as explained by these authors, is that most is of very low frequency and thus require expensive equipment to record and playback. Other shortcomings of this method are that a large repertoire of recordings would probably have to be used to avoid habituation, and a potential exists for disrupting normal elephant communication and social systems, especially if done close to NPs (Osborn *et al* 1995).

The direct cost of keeping out elephants from cultivated fields and the settled areas in Taita Taveta District was unsustainably high for the peasant farming community. This is likely to have increased further the impoverishment of the people. About 93% of the households in Taita-Taveta district fall within the income bracket of less than US$ 600 per household per year (Taita-Taveta District Development Plan 1989-1993). The average direct cost of intervention in Taita Taveta was US$1,218 per year, which was about double the yearly income of the majority of the households. This clearly shows that the relative effect of elephants on the lives of peasant farmers living adjacent to the Tsavo NPs was enormous. However, where farmers kept constant vigil during the crop season they were more likely to get better yields.

The cost of running the KWS PAC vehicles, which consumed about 9% of the Tsavo NPs annual budget, was also high. In addition to equipment depreciation costs, extra money was further spent on paying PAC rangers' allowances while on control missions. Despite this expenditure and efforts, there was no significant change in annual conflict incidents (Chapter 5, Table 5.3). A number of factors are likely to have affected the performance of the PAC team. Major among these were lack of adequate transport, trained staff and proper equipment.

Throughout 1995 to 1997 only one 4 x 4 light utility pick-up truck and 2 motor bikes were assigned full time PAC duties to cover an area of more than 11,000 km^2. This was clearly inadequate, especially during peak conflict seasons. There were three

PAC posts in Taita Taveta located in Voi town, Bura and Taveta (Figure 2.2). Voi was the main post and based here were the 4 x 4 vehicle and one motor bike. The other stations had no permanent means of transport and the rangers had to do patrols on foot or rely on transport borrowed from other Government departments.

The Voi station, which was also the command centre, was manned by one officer and 4 rangers. These were responsible for co-ordinating all matters related to human-wildlife conflict in Tsavo and taking appropriate short-term mitigation measures. Bura and Taveta outposts had two rangers each. With such vast areas to cover these rangers had at times to work both day and night shifts. The problem was exacerbated by lack of sufficient funds to pay their allowances, leading to low morale and hence poor performance of their duties. The PAC staff also lacked proper training on the appropriate methods to use when dealing with problem elephants.

Other than frequent shortages of appropriate firearms and ammunition, the rangers lacked adequate communication gear, suitable clothing, tents for overnight work and other basic necessities such as torches and anti-insect and snakebite supplies. There were numerous instances when rangers had to rely on the goodwill of villagers for food while out in the field. Where effective control was not achieved due these constraints the local people blamed KWS of being insensitive to the problems caused by elephants.

In the next chapter I will describe electric fencing as a human-elephant conflict measure in the Tsavo ecosystem.

Chapter 7

Electric Fencing as a Human-elephant Conflict Mitigation Measure in Tsavo

7.1 Introduction

Electric fencing projects for the separation of human settlements and wildlife areas have been proposed in areas where wildlife is still abundant and where potentially destructive animals come into contact with peoples' property. However, a fence creates a 'hard hedge' which may result in serious interference with certain animal populations (Child 1995).

Electric fencing as a human-elephant conflict mitigation measure was started in Tsavo in 1995. In this chapter I give an assessment of the effectiveness of a 30km solar powered electric fence constructed along the south east boundary of TsE NP. The fence design and construction is described in Section 7.3.1 and its effectiveness in achieving the set objectives is described in Sections 7.3.2 and 7.3.3. The effect of the fence on elephant and other wildlife movements are discussed in Sections 7.3.4 and 7.3.5, fence breakage in Section 7.3.5, and a discussion of the findings in Section 7.4.

7.2 Methods

7.2.1 Conflict incidents before and after fence construction

Data on conflict incidents were collected before and after the fence construction in three Locations, Mbololo, Voi and Sagalla, the main areas where the fence was constructed (Figure 7.1), as described in Chapter 5. Human-elephant conflict data throughout 1995 to 1996 in these Locations were used as 'pre-fence' incidents, while conflict incidents throughout 1997 were used as 'post-fence' incidents. In the statistical analysis conflict incidents throughout 1995 to 1996 for the three Locations were pooled together and a mean monthly 'pre-fence' conflict incidents calculated. The monthly conflict incidents throughout 1997 were used as they were recorded.

7.2.2 Local community's attitudes and perception towards the fence

Data on the local community's experiences before and after the fence construction, and whether the fence prevented them from accessing resources within the NP were obtained using questionnaire surveys in the three Locations.

7.2.3 Effects of the fence on the Tsavo elephant movements

Due to unavailability of radio tracking equipment, only qualitative data were collected on elephant movements across TsE NP boundaries. As most elephant movements across the NP boundaries were at night, tracking of elephant crossings was done indirectly by using footprints. Every morning, an inspection was made at the ends of the fence line for elephant footprints and the direction they were headed. Additional information on sighting of elephants was obtained from villagers in the three Locations adjacent to the fence, CWS rangers and TsE pilots.

7.2.4 Electric fence breakage

Data were collected on all incidents of fence breakage throughout 1997. Data collected included the date, location and animal species responsible whenever possible. Where no direct observations of animals actually breaking the fence were made, footprints or any other evidence at the point of breakage were used to determine the animal responsible. Throughout 1997 daily checks were made to ensure that the electric fence was functioning efficiently and any defects detected were repaired immediately. Therefore breakage was detected in all instances within 24 hours after happening, and evidence of animals that might have caused a breakage was usually available on the bare ground below and along the fence line.

7.3 Results

7.3.1 Fence design and construction

The TsE fence construction work started in September 1995 and by the end of December the same year the designated length of 30 km, running from Ndara to Ndi (Figure 7.1) had been cleared, graded and drainage channels constructed at the appropriate places to prevent flooding and soil erosion. Putting up of posts started in January 1996 and the whole stretch was completed by the end of the same year.

The fence consists of six strands of high tensile wire with an average vertical wire spacing of 28 cm (Figure 7.2a, Figure 7.3). Four of these are live, and a barbed wire runs at the bottom of all the other wires to prevent passage of smaller animals (Figure 7.3).

The posts are 2 metres high above the ground and spaced at an average interval of 8 metres. The voltage varied between 5.1 kV in the morning and 6.1 kV in the evening, though further voltage fluctuations occurred depending on the amount of sunshine received in different times of the day. In addition to being an elephant barrier, this fence was also made to restrict movement of other wild animals out of the NP and prevent people and livestock from entering TsE NP.

Figure 7.1 Map showing the location of the Tsavo East electric fence, 1997.

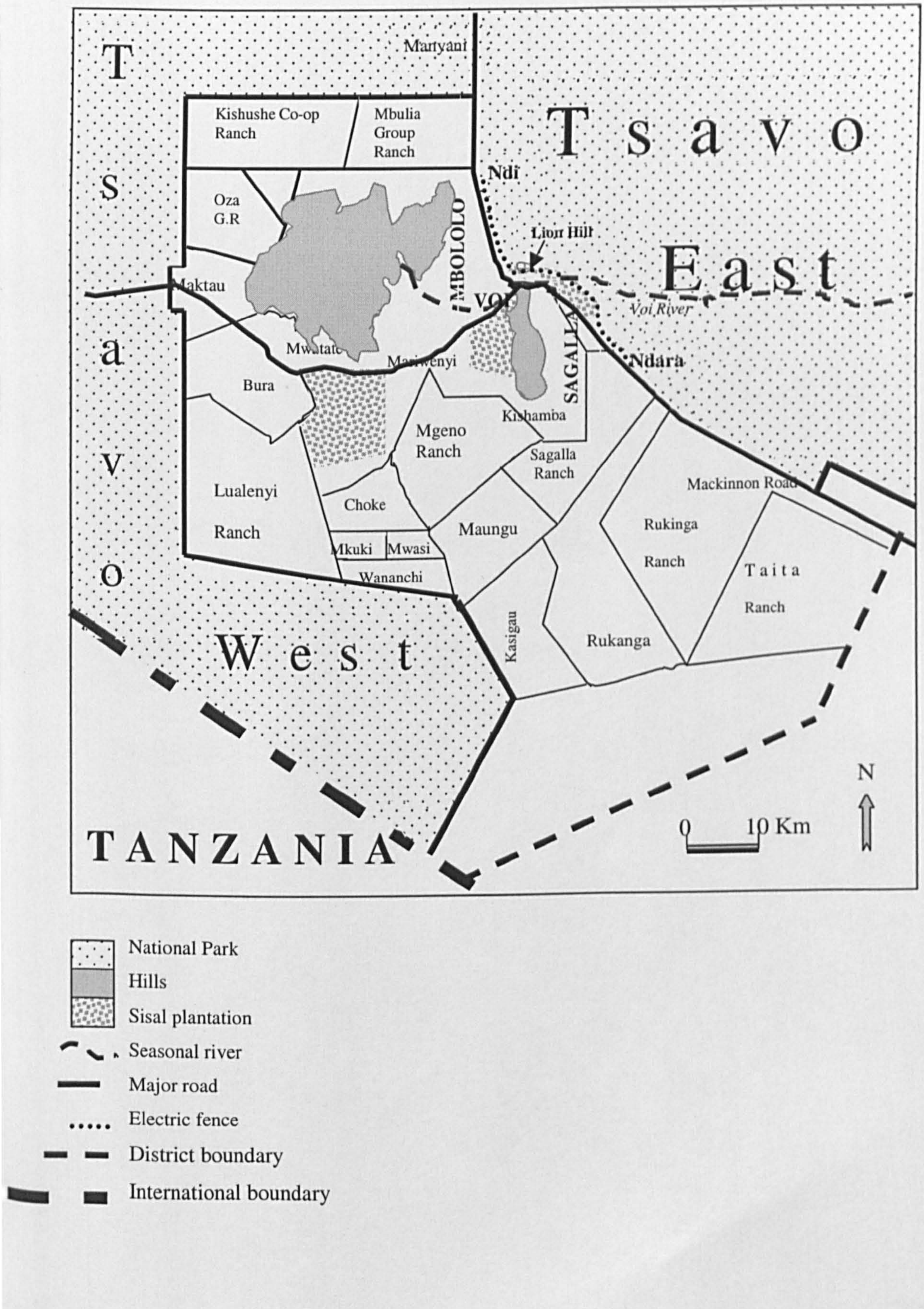
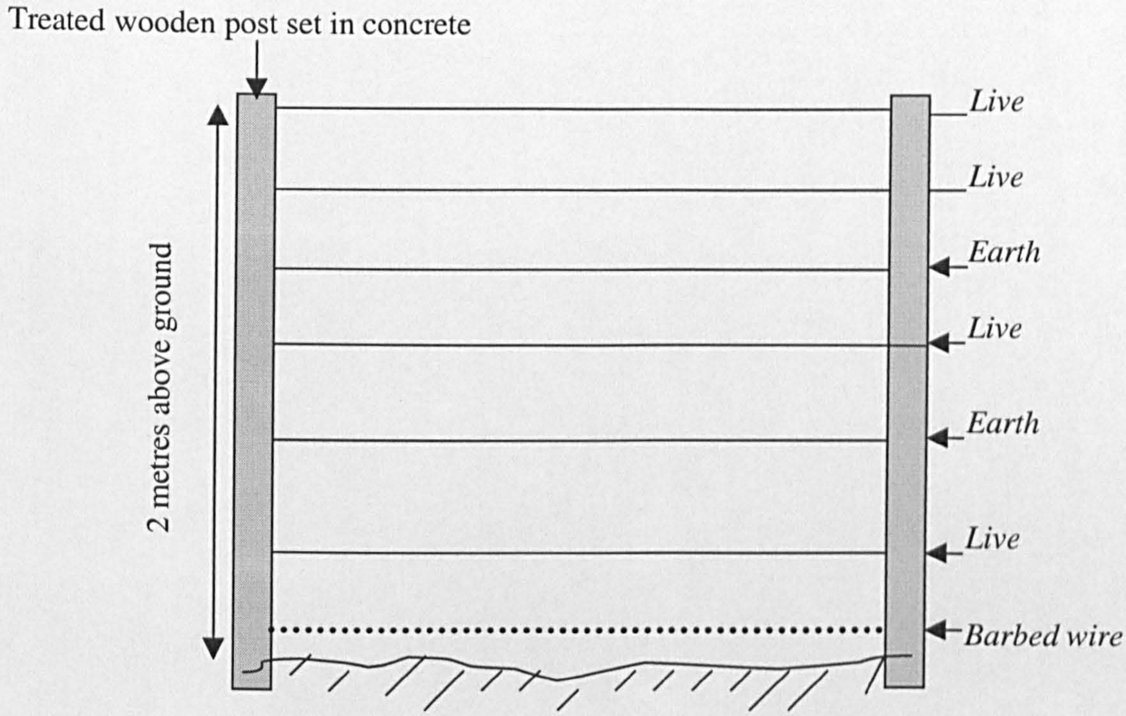


Figure 7.2a Electric fence along TsE park boundary, 1997.

Figure 7.2b Elephant grid barrier across the TsE hqs–Voi town road at Lion Hill, 1997.

Figure 7.3 The Tsavo electric fence design.

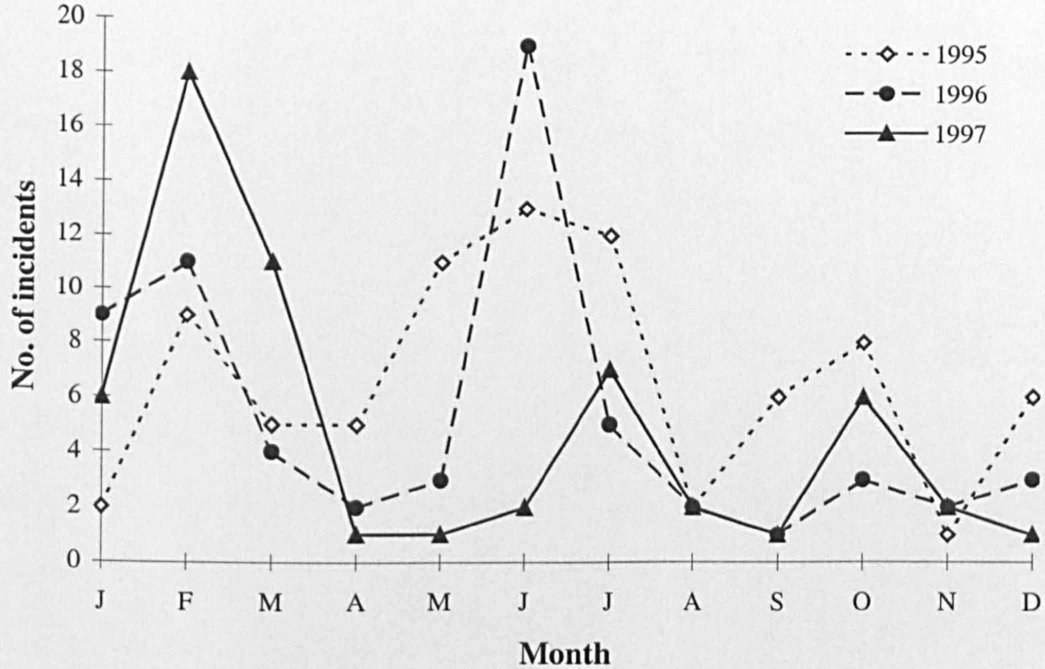


The estimated installation cost of the fence was US$10,800 per kilometre, and a calculated 10% maintenance cost per year. However, the annual maintenance cost was expected to go up as electrical components and fence posts needed replacing.

7.3.2 Effectiveness of the fence in reducing human-elephant conflict

There was no difference in the annual conflict incidents before and after the fence construction in the three Locations (χ^2=3.966, df=1, p>0.05). The 'pre-fence' and 'post fence' patterns showed the same three peaks in January to March, and May to July with lower peaks during September to November (Figure 7.4). However, the 'post-fence' peak in the months of January to March was higher, while the peak in the months of May to July was lower than that of the previous two years. However, there was no difference in the months of September to November between "pre-fence" and "post fence" years.

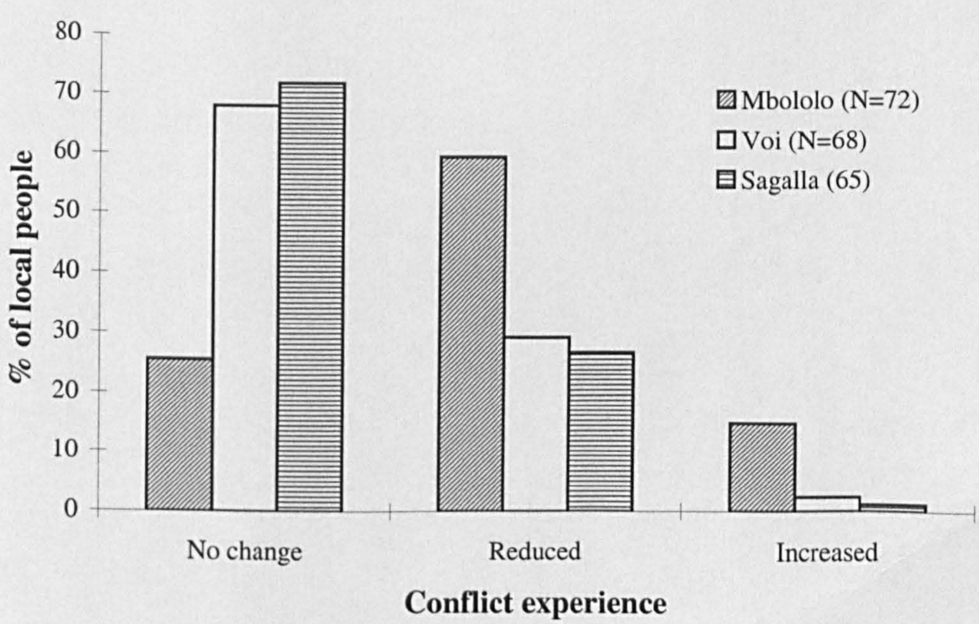
Figure 7.4 Monthly conflict patterns before and after fence construction, 1995 to 1997.



7.3.3 Local community's experiences before and after fence construction

The experiences of the local people on the intensity of human-elephant conflict after the fence construction varied in the three Locations (Figure 7.5).

Figure 7.5 Conflict experience by the local people after fence construction 1997.



In Mbololo Location 26% (N=72) said there was no change, 60% said there was a reduction in conflict incidents and 14% said the problem had increased since the fence was constructed. The 60% who said there was a reduction in conflict incidents were mainly people living in villages mid way along the fence, and those who said it had increased where mainly people from villages near the Ndi end of the fence.

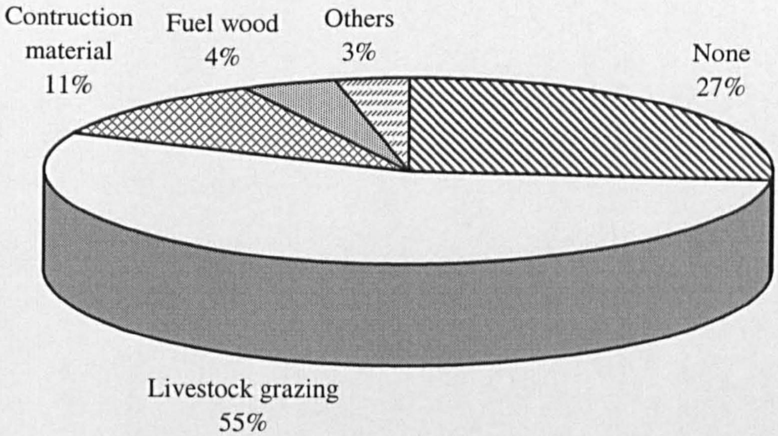
In Voi Location 68% (N=68) said there was no change in conflict incidents, 29% said the problem had reduced and 3% said conflict incidents had increased. In Sagalla Location 72% said they noticed no change in human elephant conflict incidents in the Location after the fence construction, 27% said the intensity had reduced and 1% said conflict incidents had increased.

When asked whether the fence prevented them from accessing some resources within TsE NP, many people gave multiple responses. They were then asked to give the most important resource the fence deterred them from accessing from the NP. Data for the three Locations were pooled (Table 7.1, Figure 7.6).

Table 7.1 Number of respondents who considered the fence as a deterrent to utilisation of resources in TsE NP, 1997.

Resource	Number of people
Livestock grazing and watering	117
None	57
House construction material	24
Firewood	9
Wild animal meat	7
Total	214

Figure 7.6 Proportion of the local people who said the fence was a deterrent to utilisation of resources inside TsE NP, 1997.



Of the respondents, 55% (N=117) said the fence prevented them from grazing and watering their livestock inside TsE, while 27% said the NP was too dangerous for them or their livestock to go into, and therefore the fence made no difference to them as far as utilisation of resources was concerned. High demand for house construction material (thatch grass, wood, rocks for crushing into gravel, sand, etc.) in Voi urban area created a lucrative business for supply of these resources, and 11% of the people said the fence prevented them from harvesting these resources in the NP, though done illegally. Timber from *Melia volkensii* tree species, used for making high quality furniture, fetched high prices both locally and in other areas outside the Tsavo ecosystem. Some people said the fence prevented them from easy poaching of logs of this tree species from the NP. Fuel wood for domestic and vigilance use, was another important resource for the local community, and 4% of the people said the fence prevented them from collecting wood in the NP for their own use as fuel or for sale to other villages. A minority, (3%) said the fence was a deterrent to use other resources.

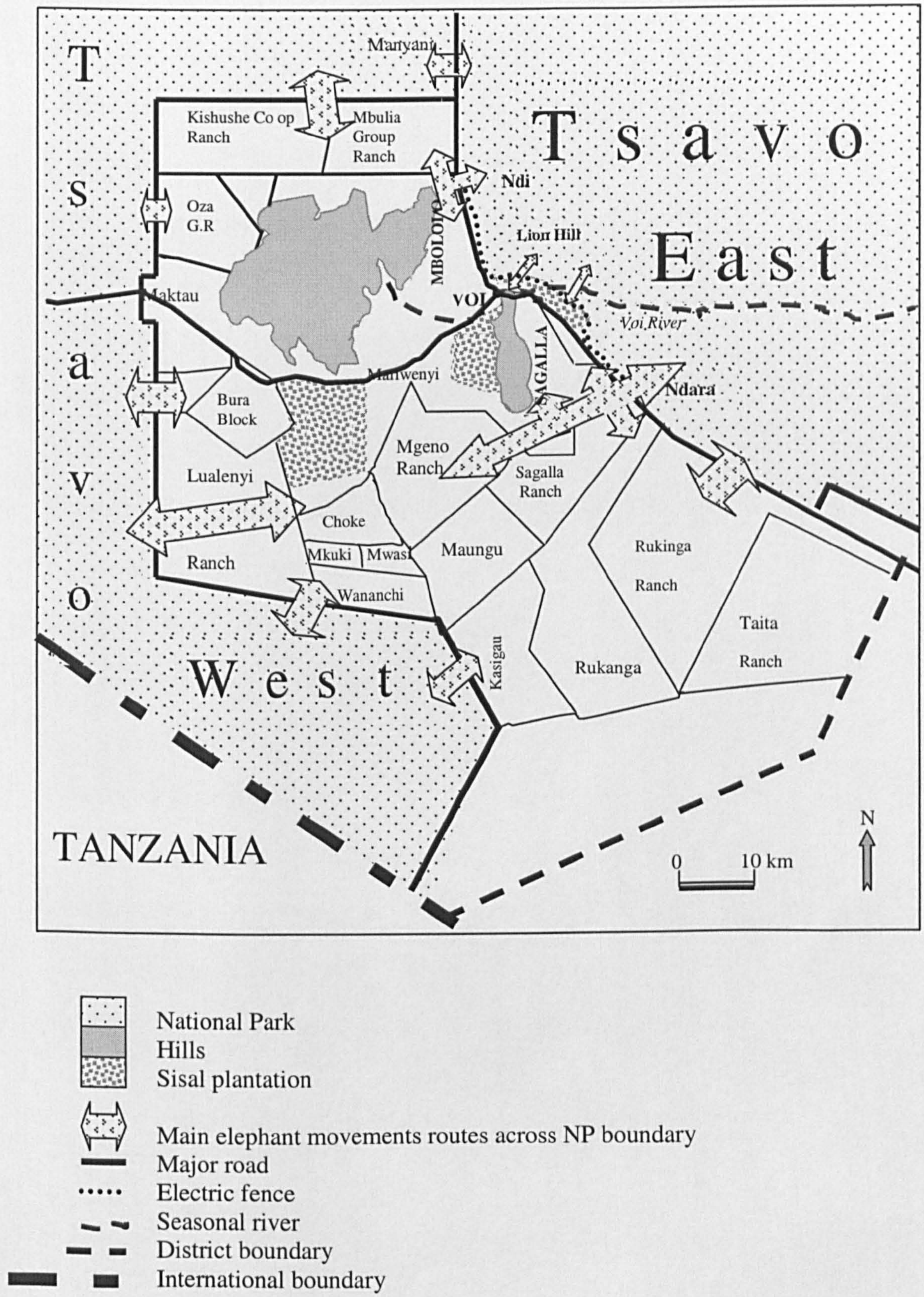
For example, some people said the electric fence prevented the dispersal of antelopes and other small game into the settled areas, which they hunted for meat and medicinal substances.

7.3.4 Effect of the fence on elephant movements

Data on elephant distribution in the Tsavo ecosystem show that a proportion of the Tsavo elephant population uses areas outside NPs either seasonally or permanently (Chapter 4). A fence could create a barrier that would deny elephants access to dispersal areas outside the Tsavo NPs. The findings given in this section are based on qualitative observations by KWS security and PAC rangers, TsE pilots, and anecdotal evidence from residents of Mbololo, Voi and Sagalla Locations of Taita Taveta District throughout 1995 to 1997.

Using information from the above sources and ground tracking by following footprints outside NPs, it was possible to get a picture of local movements across NPs boundaries, and in some areas outside NPs. Immediately after the fence construction some elephants were apparently unable to move out of TsE to Mbololo, Voi and Sagalla Locations using their direct traditional routes. After about 6 months they learned to get out at both ends of the fence at Ndi and Ndara and cross into the settled area. Some groups also moved out across an inappropriately constructed grid at Lion Hill and under electrically weak dangling wires across Voi River (Figure 7.7).

Figure 7.7 Main elephant movement routes and patterns across NPs boundary in Taita Taveta District, 1995 to 1997.



On leaving the park at the Ndi end of the fence, some of the elephants groups went into Mbulia Ranch and others moved south to villages in Mbololo. These were the areas where the residents complained that conflict incidents had increased. In Sagalla Location the majority of problem elephants seemed to emanate from the ranches, especially Mgeno Ranch (Figure 7.7). Therefore the fence had little effect on elephant movements and conflict incidents in this area.

7.3.5 Effect of the fence on other wildlife species

Very little information was available in Tsavo on wildlife movements, which made it difficult to monitor the effect of the fence on the movement of different wildlife species other than the elephant. However, qualitative observations indicated that there were more zebra (*Equus burchelli*), impala (*Aepyceros melampus*) and common waterbuck (*Kobus ellipsiprymnus*) outside the fence in the area between Lion Hill and Voi River, unlike the case before the fence construction.

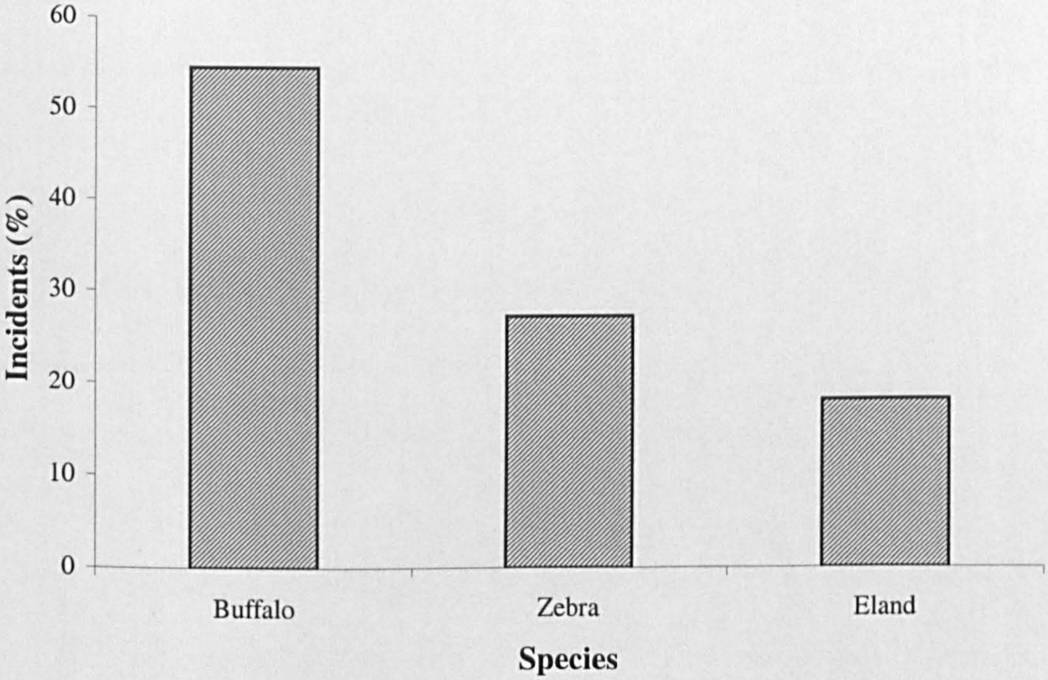
7.3.6 Fence breakage

A total of 22 confirmed incidents of fence breakage involving 3 species of wild animals were recorded throughout January to December 1997. None of these were by elephants (Table 7.2, Figure 7.8).

Table 7.2 TsE electric fence breakage incidents and wild animal species responsible, 1997.

Animal species involved	Number of incidents
Buffalo	12
Zebra	6
Eland	4
Total	22

Figure 7.8 TsE electric fence breakage incidents by wild animals, 1997.



Buffalo (*Syncerus caffer*) were involved in 56% of fence breakage incidents, while zebra were responsible for 25% of all incidents. Eland (*Taurotragus oryx*) accounted for 19% of the total incidents.

7.4 Discussion

Fences can lower conflict, but fencing projects are fraught with difficulties, ranging from capital costs to the many parties that need to be satisfied before the barriers can be created. In considering fencing as an option, a clear understanding of the affected elephants' movements, both large scale and local migrations in all areas surrounding human settlement, and their underlying causes, is essential (Douglas-Hamilton *et al* 1994). Also critical is the length and the routing of an elephant barrier, as well as the acceptance and support by the local people. Anything short of this may lead to ineffective placing of the fences and expensive mistakes (Ngure 1992, Douglas-Hamilton *et al* 1994).

Early trials and types of electric fencing in Tsavo in the early 1950s were failures (Jenkins & Hamilton 1982) and attention was turned to moats and ditches. Simple ditches, 2 metres wide and 2 metres in depth were constructed in Aruba and around experimental vegetation plots (elephant exclosures) in the early 1970s, but these needed constant maintenance because elephants learned how to break down the walls of the moats and climb through (Jenkins & Hamilton 1982).

In 1991, a simple solar powered 6 km fence was constructed to keep out elephants from Voi Sisal Estate (VSE), bordering TsE (Figure 7.1). This fence also failed due to a number of factors, major among them vandalism by people from the local community. The fence wire was stolen and some of it was used to make snares to trap wild animals (giraffe, lions, various antelopes, etc.). During the period it was functional (about 1 year) elephants continued to raid the sisal plantation by going round the barrier (pers. comm., VSE manager).

In 1995, with funding from the European Union, KWS decided put up a solar powered electric fence along TsE borderline from Ndi to Ndara (Figure 7.1) to reduce human elephant conflict in adjacent areas. Construction work was effectively completed at end of 1996, although some sections of the fence needed modification.

Immediately after the fence construction relatively few human-conflict incidents occurred in many parts of Mobolo and Voi Locations, leading to some local residents in these areas to think that the elephant problem had been solved (Figure 7.5). However, the elephants soon learned to go round both ends of the fence and to cross into the settled area. Some groups also discovered weak spots along the fence through which they could get out of the NP.

Though people in villages mid way along the fence said human-elephant conflicts incidents had reduced, many of those in villages at the northern end of the fence complained that the elephant problem had actually increased some months after the fence construction. It is likely that the deflecting effect of the fence had concentrated elephants into this area, where they probably spent more time, and as a consequence an increase in conflict incidents.

Evidence gathered during this study suggests that the TsE fence was not long enough to reduce human-elephant conflict in adjacent areas to a tolerable level by the local people, and it had not reduced conflict incidents by any significant level as by end of 1997 (Figure 7.7). The majority of the local residents have been disappointed for they expected the fence to be a panacea for human-elephants conflict in Tsavo. For residents of some villages the fence has even made the problem worse and perhaps their support for the programme has been waning, which may lead to acts of vandalism which could result in failure fencing programme.

Anecdotal evidence suggests that, before the fence was put up, there used to be a bi-directional movement of elephants between TsE and TsW through the ranches and settled areas. In one instance in October 1996 the movement of a bull elephant was tracked from Mgeno Ranch to Mbololo where it was unable to cross into TsE after getting to the fence (Figure 7.7). Trapped in the settled area this elephant had to be shot as it posed a great danger to the local residents. Though insufficient data were available to support this, it is likely that the fence interfered with traditional movement patterns of elephants between the two southern sectors of TsE and TsW. Using radio-tracking methods, Leuthold & Sale (1973) noted that elephants in the Tsavo area, particularly TsE, were highly mobile and sometimes undertook long distance movements across the NPs in response to localised rainfall and availability of other resources.

Information from the local residents and footprint tracking indicated that problem elephants in Sagalla came from the ranches, especially Mgeno Ranch. This indicates that the 30 km fence only reduced the problem in a few villages in Mbololo, mainly those that lie midway along the fence line. However, other than a generalised pattern, the effects of the TsE fence on elephant's movements, and local migration patterns were difficult to determine during this study. The fence did not seem long enough to cause major disruptions but more detailed studies need to be conducted to establish current movement patterns across the two parks before further extensions of the fence are made.

Fence breakage by elephants in TsE was not a major problem. This could be due to two main reasons. First, elephants in TsE have been exposed to a well-maintained electric fence since 1991, when a 6km perimeter fence was installed around the TsE headquarters buildings to keep elephants out of human habitation within the NP. Immediately after the completion of the TsE headquarters fence in 1991, there used to be numerous breakage incidents by elephants, but such incidences reduced with time and none occurred after about a year. It was also noticed that elephants that broke the fence and got inside would not go out through upright posts after the wires were removed, regardless of the amount of pressure applied (shooting over their heads, using motor trucks to drive them out, etc.) until the posts were pulled down. After their encounter with the fence while breaking in, the experience they got seemed to make them associate the posts with painful stimuli. This probably explains the observation that elephants avoided cultivated fields with upright fencing posts without wires put around fields in some areas adjacent to TsE (Chapter 6).

It is generally argued that the most important factors that determine the success of electric fences constructed to prevent the movement of elephants are fence design, voltage and the quality of maintenance. However, Thouless *et al* (1994) found no clear relationship between these and fence success in Laikipia, central Kenya. He cites examples of well-built and well maintained fences, with adequate power supplies but which were broken regularly by elephants. He suggests that effectiveness is probably related to elephant's previous experience to fences and the incentive to cross the barrier. He notes that it may be the case that once elephants learn to recognise the fence as a barrier between areas in which they are safe from areas where they may fall into danger they may reduce pressure on the fence.

A second factor that may have resulted in elephants not breaking the Tsavo boundary fence may be its entire length. Being only 30 km in length, and with several weak spots where elephants could go through, it was probably not necessary for the elephants to risk an electric shock while there were safer ways of getting out.

Buffaloes were responsible for more fence breakage than any other species in 1997 (Figure 7.8). Buffaloes were also the cause of major failures of the TsE headquarters perimeter fence, with an average 10 breakage incidents per year between 1991 and 1994, and average 4 breakage incidents per year between 1995 and 1997. Waterbuck were observed to move in and out by jumping across the grids built across roads (Figure 7.2b), and cases of zebra and eland interfering with the TsE perimeter fence were never observed throughout 1991 to 1997. The reasons for buffalo breaking both fences, and zebra and eland breaking only the boundary fence were not clear. Child (1995) noted that in Zimbabwe zebra broke fences because they could not tolerate the interruption of their natural movements, but there is no data on zebra movements in Tsavo.

Findings from this and other studies suggest strong reasons against electric fencing in the Tsavo ecosystem. First, for effective control of problem elephants, extensive fencing will be necessary along NPs boundaries and some ranches, whose capital and maintenance costs will be prohibitive. The installation cost of the Tsavo fence was US$ 10,800 per kilometre, with an estimated maintenance cost of 10% per year, the figure rising with time as electrical components and fence posts need to be replaced. Construction costs in other places for elephant barrier fences have been lower. In Laikipia, Kenya, multistrand fences cost approximately US$ 2,500 per kilometre in 1994, and the annual maintenance costs was estimated at US$ 150 per kilometre (Thouless *et al*, 1994). Hoare (1992) gives a figure of US$ 500 to $1,500 per kilometre for electric fencing schemes in Zimbabwe designed to keep out elephants from croplands. In comparison with these fences constructed elsewhere for spatial separation of elephant's range and human habitation, the cost of electric fencing is very high in Tsavo.

Thouless (1994) suggests that to enhance the effectiveness of an electric fence it may be necessary to shoot a few elephants, especially those that may be identified and noted to repeatedly break the fence. Use of various other methods both by the local people and KWS may further improve the success of the fence. The possibility that an elephant may associate a sound (beating of drums, whistle, horns, etc.) with punishment may encourage them to remain within the "safe" NPs. Using all these methods it may be possible to discourage elephants from crossing the barrier, and therefore reduce conflict incidents without having to kill many elephants. An efficient PAC programme implemented by appropriately trained rangers may result in significantly fewer elephants being shot over the long term.

A second factor against fencing in Tsavo is insufficient information on dispersal and movement patterns of many species, and the effect the fences might have on their survival. Thirdly, there is a possibility that many species of animals occur at higher densities in certain seasons close to human habitation than inside NPs. Qualitative observations indicated that in some areas at the edges of the Tsavo NPs had a higher plant and animal diversity. Leopold (1933) argues that edges of PAs are likely to have a greater animal species diversity due to either the variety of vegetation at edges compared to areas further away, or due to availability of two different habitats in close proximity. The availability of food rich successionary vegetation, which grows in abundance in these areas, may attract more animals (Leopold 1933).

Finally, the pattern of encroachment and growth in human population in the Tsavo ecosystem will exert more pressure on the land, leading to extensive degradation. It is important to note that most of the local people are poor subsistence farmers and agriculture in this zone is clearly unsustainable under the poor land husbandry practised by the people. People clear land and burn the vegetation as this guarantees ownership. Local wood and grass needs cannot be sustained and shortages are already being felt in many villages adjacent to the NPs. All these factors make a solution involving land use shift and integration more worthwhile to consider. Emphasis should be on land use forms that are compatible with elephant conservation, in which case there will not be much need of actual exclusion of either humans or elephants from particular areas.

In the next a statistical analysis of factors, or combination of factors, that determine the intensity of human-elephant conflict in the Tsavo ecosystem will be carried out.

Chapter 8

Determinants of Human-elephant Conflict in the Tsavo Ecosystem

8.1 Introduction

Foraging and water requirements by elephants in many of their range areas results in conflict with the local human population. While the number of conflict incidents may be on the increase due to increase in human population density and human activities closer to elephant's range, the contention that the intensity of conflict is increasing has not been reliably demonstrated in many places in Africa (Hoare 1997). It is therefore important that the determinants of human-elephant conflict be quantified and hypotheses tested as a prerequisite to making sound management recommendations on mitigation of the problem in different elephant range areas.

Resources to manage human-elephant conflict in many parts of Africa are limited by the scale of the problem and the remoteness of some of the areas where it occurs. An ability to anticipate potential conflict areas would greatly improve the distribution of the available resources to reduce the problem. Hence, this chapter presents a statistical analysis that aims to determine which factors, or combination of factors, that influence the intensity of human-elephant conflict using data gathered in the Tsavo ecosystem, a case study for savanna ecosystems.

8.2 Methods of analysis

8.2.1 Sample size

Data were recorded in a matrix for 38 blocks, each a discrete unit of different land use, from both Taita Taveta and Kitui Districts. The total sample data comprised 29 blocks in Taita Taveta District and 9 blocks in Kitui District (Figures 2.2, 2.3).

8.2.2 Dependent variable

The dependent variable was the total number of conflict incidents for 3 years in each block in Taita Taveta and Kitui districts throughout 1995 to 1997. To correct for area of each block, a 'conflict index' was calculated by dividing the total number of conflict incidents for the 3 years period by the area (km^2) of each block.

8.2.3 Explanatory variables included in the analysis

Many of the factors that were thought to have played a role in determining the intensity of human-elephant conflict in the Tsavo ecosystem provided the explanatory variables used in this analysis. Factors expected to play a role in determining the intensity of conflict and for which there were data across the blocks included the following: human population density; water supply (whether permanent or seasonal); presence or absence of crops; percentage of land under cultivation; elephant population density within 40 km inside nearest NP; distance of frontage of the block facing the nearest NP; fencing, whether completely fenced, partially fenced or no fencing along the frontage facing the nearest NP;

land ownership status; and the type of natural vegetation (open forest, wooded bushland, bushed grassland, or open grassland). The derivation of these explanatory variables is described below in some detail:

8.2.3.1 Human population density

The human population density for each block was derived as described in Chapter 3, Section 3.2.1. In the NPs and ranches, where no human settlement was allowed other than for the establishment's staff, the population density was given as zero.

8.2.3.2 Water supply

The status of water supply in each block, both natural and artificial, was categorised based on availability throughout the year. Where surface water was permanently available throughout the year the variable was categorised as (1) *water* and where water sources were seasonal as (2) *no water.*

8.2.3.3 Presence or absence of crops

Each block was categorised as having (1) *crops* or (2) *no crops.* No differentiation was made of the type of crops grown and by what proportion of the local community.

8.2.3.4 Percentage of land under cultivation

Using the method described in Chapter 5, Section 5.2.6 the proportion of each block under cultivation was estimated and given as *% under cultivation.*

8.2.3.5 Elephant population density inside NPs

It was likely that the density of elephants in adjacent area inside the NPs played a role in determining the intensity of conflict in the blocks. Using a mean of the 1995 and 1997 elephant distribution data, elephant density at various locations along a 40km band inside the NPs was calculated and used as *elephant density inside NP.*

8.2.3.6 Frontage to the NPs

The average parallel boundary distance of each block facing the nearest NP was measured and this distance given as *frontage* for the study block.

8.2.3.7 Fencing

Each block was categorised as being (1) *fully-fenced* if the TsE electric completely separated the block from the NP, (2) *partially- fenced* if the electric fence ran along only a portion of the boundary, and (3) *not-fenced* if there was no fence at all separating the block and the NP.

8.2.3.8 Land ownership status

The type of land ownership was categorised as (1) *small-holder* where the land was privately owned by small scale peasant farmers and (2) *ranch* were the land use was for large scale cattle ranching owned by one individual or a group of people.

8.2.3.9 Natural vegetation type

The classification of vegetation type for each block was based on a simplified method used by the Kenya Soil Survey (Weg and Mbuvi 1975). This classification is based on an estimation of the percentage cover by trees, shrubs and grass. Where trees were dominant, the vegetation was categorised as (1) *open-forest*; where the proportion of trees and shrubs was roughly the same as (2) *wooded-bushland*; where there were no trees but the proportion of shrubs was approximately the same as that of grass (3) *bushed- grassland*; and where the vegetation was dominated by open grassland areas as (4) *grassland.*

8.2.4 Explanatory variables not included in the analysis

A number of other factors that are also likely to affect the intensity of human-elephant conflict in the Tsavo ecosystem were not quantified for all blocks during this study and where not included in the analysis. Among these are the following:

- vegetation abundance and species composition inside and outside NPs;
- presence of salt licks;
- benefits, either tangible or perceived;
- period of residence;
- human-elephant conflict mitigation efforts by the local people;
- human-elephant conflict mitigation efforts by the PAC unit of KWS;
- formal education and literacy levels;
- effect of poaching on the distribution and movement of the Tsavo elephants;

- factors that are hard to define or quantify, for example local political manipulation which may influences people's attitudes and perceptions towards wildlife conservation, KWS and the NPs.

8.2.5 Statistical analysis

The possible determinants of the intensity of human-elephant conflict in Tsavo were examined using SPSS package (Version 8.0 for Windows). The statistical technique used was the General Linear Model (GLM) analysis. Each explanatory variable was examined to determine its possible effects on the number of conflict incidents in the Tsavo ecosystem. As percentage data cannot be used in GLM, an Arcsine transformation was undertaken on data on the percentage of land under cultivation.

8.3 Results

The number of conflict incidents showed a significant relationship with 5 explanatory variables, some of which were continuous (human population density and transformed percentage of land under cultivation), and others which were categorical (type of land ownership, fencing and natural vegetation type) (Table 8.1).

Table 8.1 Tests on explanatory variables in the Tsavo ecosystem, 1995-1997.

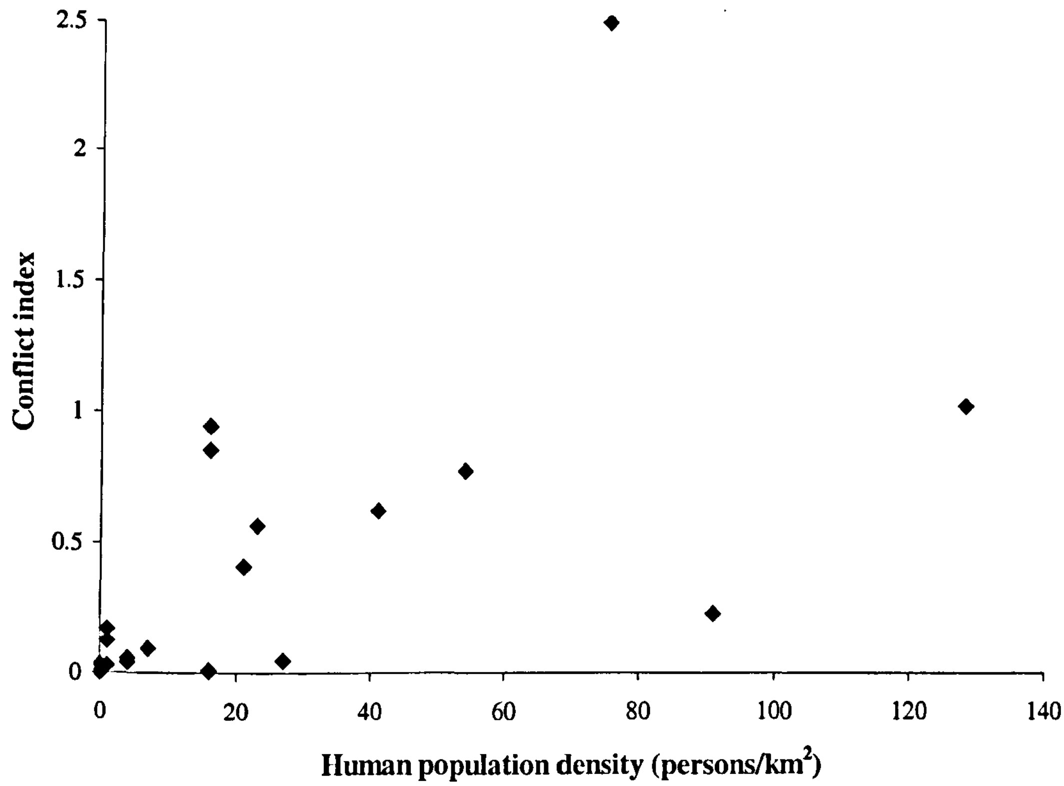
Explanatory variable	df	F-ratio	95% Sig.
Corrected Model	16	21.481	0.000
Human density	1	32.313	0.000
Transformed % land under cultivation	1	70.215	0.000
Land ownership type	1	25.866	0.000
Fencing	1	31.386	0.000
Water	1	18.953	0.333
Vegetation type	2	29.662	0.000
Water *vegetation type	1	37.110	0.000
Fenced *vegetation type	1	0.358	0.559
Land ownership * water	1	18.953	0.001
Land ownership * natural vegetation type	1	22.065	0.000
Water * land owner * vegetation type	2	22.065	0.000

(Adjusted $R^2 = 0.916$)

Permanent water as a single factor did not show a significant influence on the intensity of conflict. However, permanent water supply was a significant factor in combination with the type of land ownership and natural vegetation type.

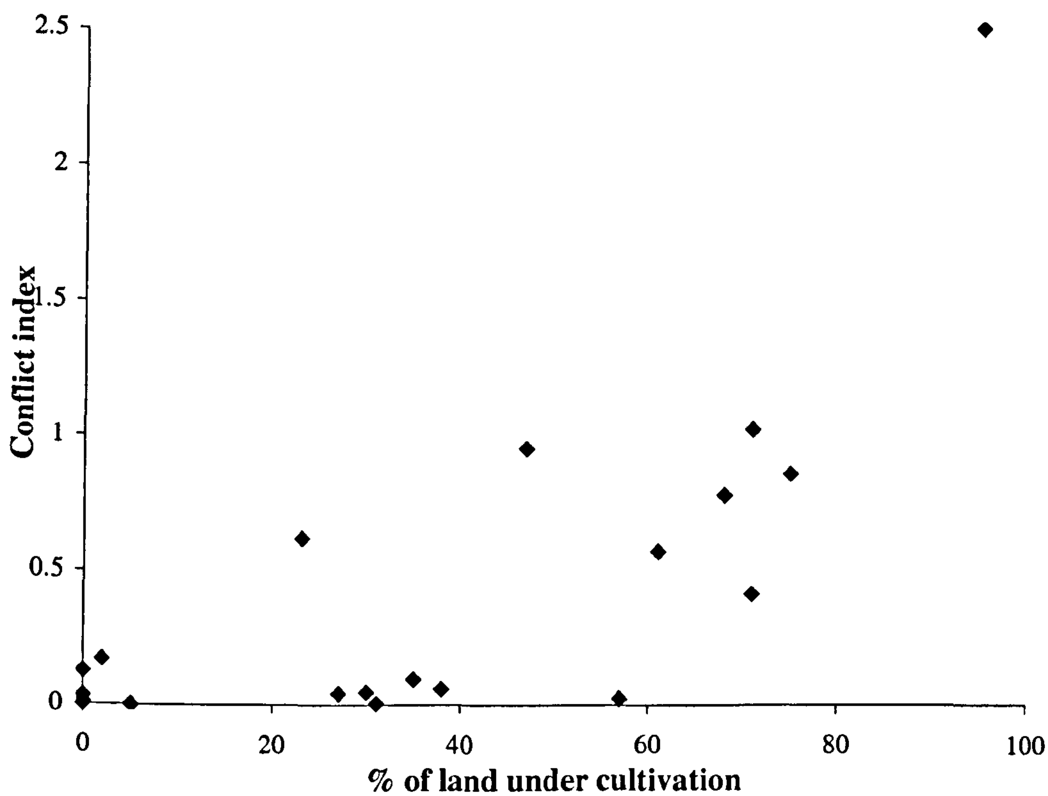
Generally there was an inverse relationship between conflict index and the human population density (Figure 8.1). However, as human density was not independent in determining the intensity of conflict in the Tsavo ecosystem, the relationship was not evident in all the blocks.

Figure 8.1 Conflict index vs human population density in the Tsavo ecosystem, 1995 to 1997.



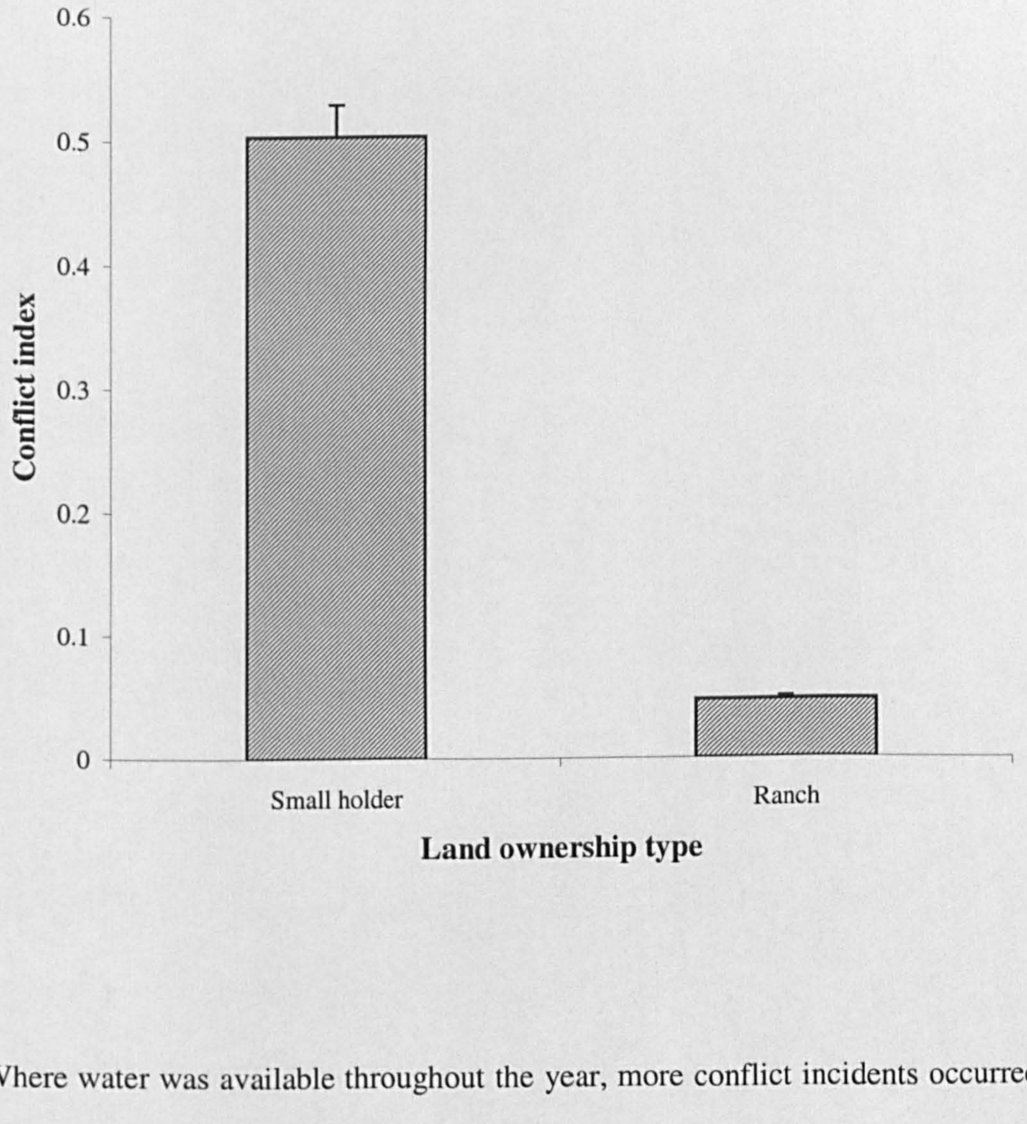
The relationship between conflict index and percentage of land under cultivation (Figure 8.2) was similar to that of conflict index and human population density (Figure 8.1). This could be the case that the proportion of land put under agriculture in the Tsavo ecosystem is interrelated to human population density.

Figure 8.2 Conflict index vs transformed % of land under cultivation in the Tsavo ecosystem, 1995 to 1997.



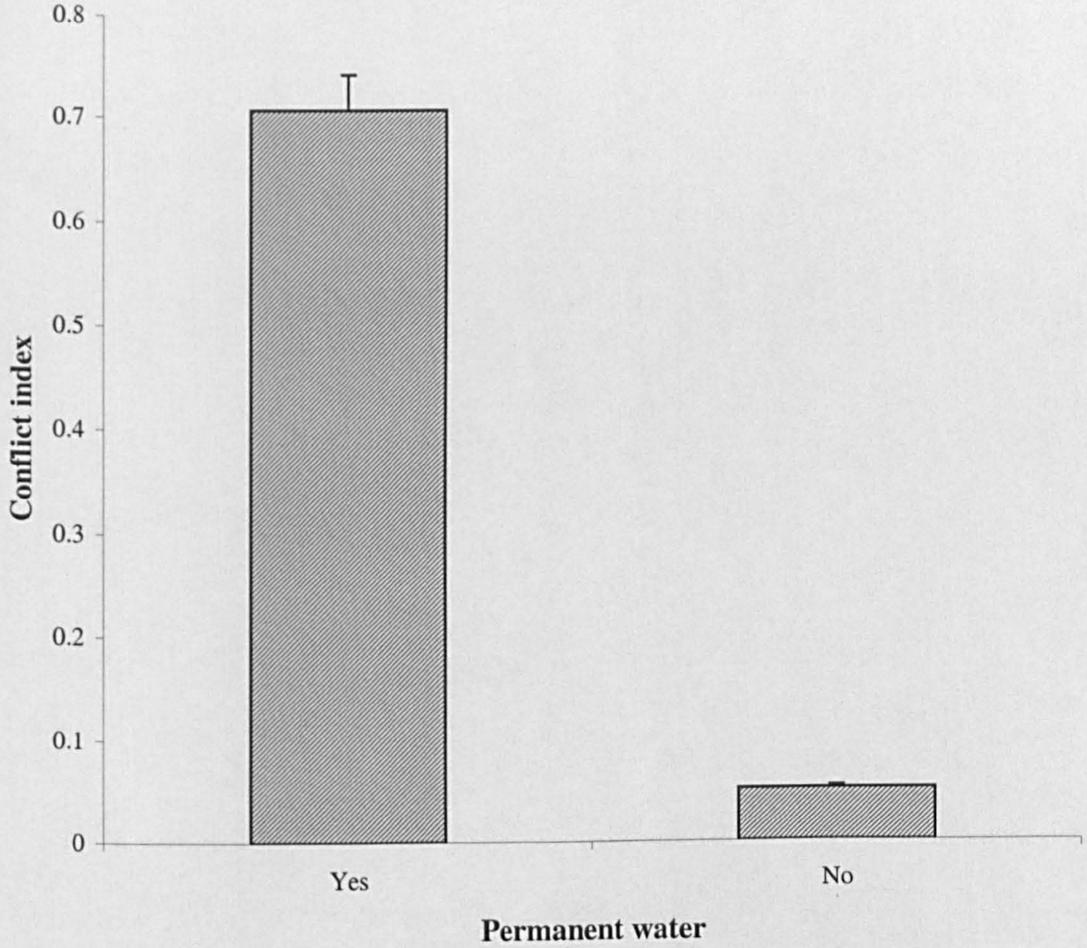
Human-elephant conflict was most intense on small holder type of land ownership and less in the ranches (Figure 8.3).

Figure 8.3 Conflict index vs type of land ownership in the Tsavo ecosystem, 1995 to 1997.



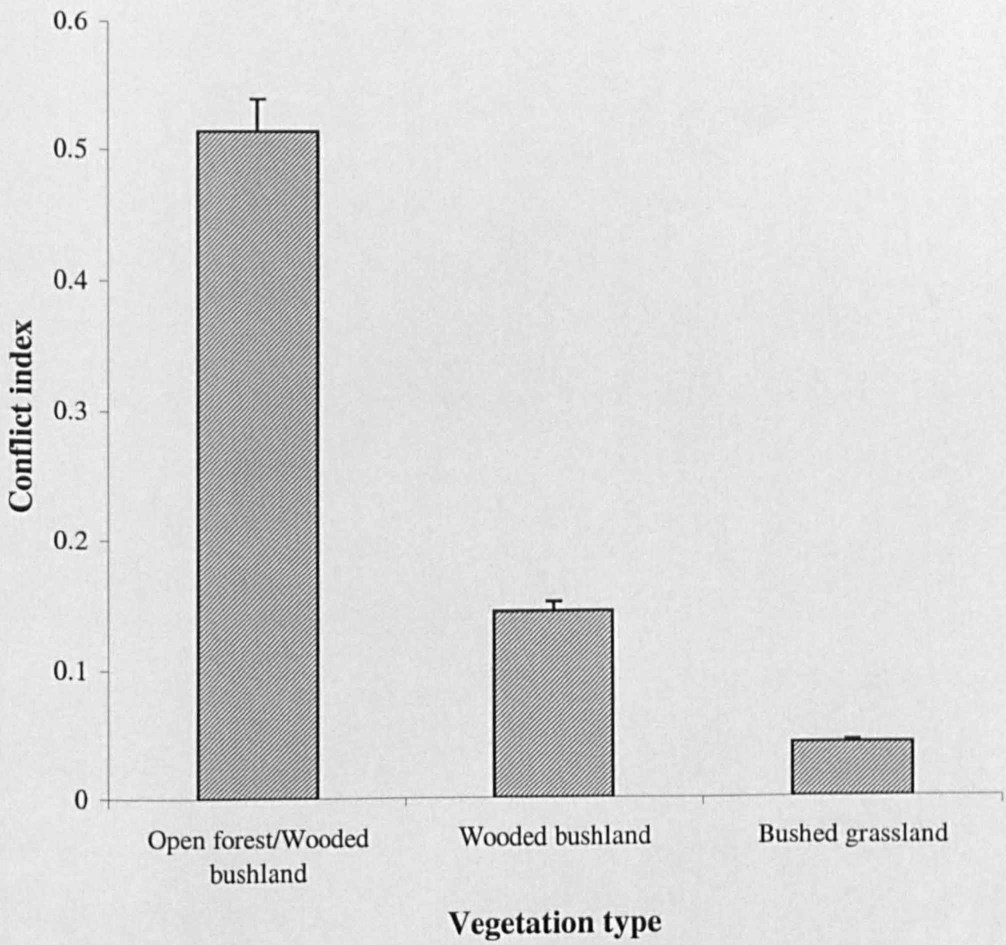
Where water was available throughout the year, more conflict incidents occurred than where the resource was only available seasonally (Figure 8.4).

Figure 8.4 Conflict incidents vs permanent water



The number of human-elephant conflict incidents was highest in areas whose vegetation comprised of open forest or wooded bushland and lowest in bushed grassland type of habitat (Figure 8.5).

Figure 8.5 Conflict index vs natural vegetation type



8.4 Discussion

The statistical analysis of the factors that appear to be important in determining human-elephant conflict in the Tsavo ecosystem throughout 1995 to 1997 has showed the importance of various determinants, which either singly or in combination, influence the intensity of the problem in various sites adjacent to the Tsavo NPs.

The most important factors that had significant influences were human population density, percentage of land under cultivation, type of land ownership, fencing, and natural vegetation type. Where the human population density was high there was also a high percentage of land under cultivation, and therefore these two factors were inter-linked in the Tsavo ecosystem.

Whereas owners of ranches tolerated the presence of elephants on their land, small-scale peasant farmers were less tolerant of the species on their property, leading to higher conflict incidents in the private small holder type of land ownership (Figure 8.3). Fencing was effective in villages where the barrier completely separated settled areas from the NP, and therefore the importance of this type of intervention method in certain areas. The significance of the type of vegetation was not investigated in detail, but the influence of this factor could be related to the abundance of plant species preferred by elephants in conflict areas relative to that inside the NPs, especially during the dry season. Shelter provided by trees to elephants outside the NPs during hot weather may also play a role in conflict intensity. This probably explains the high number of conflict incidents in areas with trees (Figure 8.5).

Permanent water was important in explaining conflict intensity through an interaction with the type of land ownership and vegetation type. Considered together, the highest number of conflict incidents occurred where there was permanent water on small holder type of land ownership, with open forest or wooded-bushland vegetation type (Table 8.1). Though permanent water in the ranches may have attracted elephants to these areas there were no complaints unless elephants damaged piping or storage bunkers. Where permanent water was available on private small holder land the damage and fear elephants caused was intolerable.

The present study did not find evidence for an association between human-elephant conflict intensity and elephant population density in adjacent NPs. Hoare (1997) made similar observations in the Sebugwe region of Zimbabwe. He suggests that elephant crop raiding incidents where opportunistic feeding forays by male elephants and the conflict intensity therefore was dependent on the behavioural ecology of individual elephant bulls.

In certain other parts of Kenya (Waithaka, 1993, Kiiru 1995), and areas of Zimbabwe (Hoare 1995, Hoare 1977, Osborn 1977) human-elephant conflict incidents were observed to show seasonal peaks corresponding to the late wet season, an occurrence attributed to raiding by elephants on maturing food crops. In the forest elephant range in Gabon, Lahm (1996) found that most conflict incidents, mainly crop raiding by elephants, occurred during the wet season.

In areas adjacent to the Tsavo NPs the presence of crops was not a significant factor on its own in determining the intensity of human-elephant conflict, supporting the view that crop raiding by elephants could be opportunistic.

Findings from this study have showed that settled areas adjacent to the Tsavo NPs, where the land ownership was by small scale peasant farmers, the dominant vegetation type was either an open forest or wooded-bushland, and permanent water (whether natural or artificially provided) was available, were likely to attract elephants and become human-elephant 'conflict hot spots'. Priority should therefore be given to such areas by KWS when implementing human-elephant conflict mitigation measures in the Tsavo ecosystem.

Chapter 9

Summary and Conclusions

9.1 Introduction

The protected area of Tsavo is very large by world standards. However, its present size does not cover the entire range needed by the elephant population in the ecosystem, especially in times of drought. Many studies have shown that the Tsavo elephants utilise areas outside the NP boundaries, which indicates that resources within the NPs are insufficient to sustain the year round needs of the elephants. It may also be the case that certain elephants still utilise or would like to utilise areas that they know through tradition, but which happen to be outside the NPs boundary or where people have moved in. In either case the future of the elephants involved may depend to a certain extent on the future land use in the areas concerned.

The adjacent human population is increasing at a high rate and any land not currently protected for wildlife conservation or a similar purpose is likely to come under increasing pressure to be used for agriculture or settlement. Since the interaction between elephants and people in the Tsavo ecosystem has proved to be largely incompatible in many areas adjacent to the NPs, the potential for conflict is considerable, and elephants may eventually be displaced from many areas outside the Tsavo NPs.

The Tsavo local human community use a wide range of methods to chase and discourage elephants from cultivated fields in an effort to reduce crop lose, damage to other property and insecurity caused by presence of elephants in settled areas. This is a particularly difficult task as elephants can be extremely dangerous to chase off or deter using 'traditional' methods employed by most people, and some farmers got killed while trying to defend their crops. Successful precautions to deter elephants required long hours of vigil during the crops growing season, which was a serious drain on a family's financial and labour resources. The problem was exacerbated by there being no provision for compensation to loss of food crops and property in the revised Wildlife Act, and very little for human death or injury.

Intervention methods and problem elephant control by KWS was also found to be ineffective and inefficient due to lack of necessary resources and trained manpower. Control shooting resulted in significant elephant mortality, which may increase the level of stress in the Tsavo elephant population that is still recovering from the effects of heavy poaching and disturbance. Loss of the species, which is a major attraction for tourists in Tsavo NPs has multiple economic implications. In addition KWS incurred considerable expenditure every year, when all too often there where no crops worth protecting. In a number of cases disappointment at the refusal to shoot problem elephants led to political abuse of the authority.

The perception of the local community Tsavo towards elephants and the NPs was mainly negative. To most people these highly mobile elephants were seen as government property that caused much damage, over which the local people could exert no authority, and for which they had no allegiance or pride of ownership. To the majority of the peasant farmers, having an elephant killed provided meat and simultaneously removed a pest. Few local people in Tsavo have reason to regret the disappearance of the elephant, and it may even be a psychological relief for some members of the community who have suffered or lost relatives, either killed by elephants or in the hands of poachers. Such attitudes are disastrous for the conservation of elephants in Tsavo. However, attitudes can be changed by enhancing the flow of sustainable benefits, thus converting a problem into an asset.

Survival of the people and the elephants they share some land with depends on resolving the twin objectives of increasing tangible benefits to the local communities and reducing the cost of living with the resource. This is likely to encourage and empower the local human community to play a more active role in the conservation of elephants and biodiversity in general.

9.2 Human-elephant conflict mitigation in the Tsavo ecosystem

9.2.1 Construction of barriers

The settled area in Taita Taveta District is like an 'island' of human habitation and cultivation in what is a 'sea' of PAs and ranches. Theoretically the ideal solution would be to seal in the people and their activities by use of barriers and let the elephants roam free outside. However, effective and complete spatial separation of elephants and people in Taita Taveta is not feasible, and in the absence of long term information, its ecological impacts cannot be anticipated. Large-scale land use shift or resettlement of the human population are also not feasible in the present land tenure system.

Spatial separation of elephants from humans and their activities by restricting movements of both through fencing or other forms of barriers may be used, as fencing was shown to be effective in some villages. However, prior knowledge of elephant movements will be necessary for effective placing of the barriers.

9.2.2 Conflict mitigation by habitat management

Findings from this and other studies show clearly that permanent water availability has a great influence on elephant distribution. In the dry season, daily water requirements by elephants impose an invisible barrier at 16-40 km from water (Leuthold 1977). It can therefore be argued that the provision of artificial water supply in the NPs, and away from the boundary, may reduce the proportion of elephants leaving the NP in search of the resource.

Artificial water supply is a useful tool in wildlife management but can lead to environmental disasters if not complemented by a good understanding of the ecological processes on which sustainable use of the habitat depends. Man-induced habitat changes can alter the composition and overall biomass of the indigenous fauna (Campell & Child 1971). Where water is a limiting factor and is then provided, most species are likely to increase, at least temporary, and animal movements patterns changed.

Studies in Tsavo (Glover 1963b, Glover *et al* 1964, Laws 1969, Corfield 1973, Cobb 1976, Leuthold 1977) have shown that elephant damage to the habitat tends to start at focal points, around waterholes and along rivers, because they act as centres of elephant concentration. Unplanned provision of artificial waterholes to confine elephants in the NP may almost invariably aggravate the degradation problem by providing new foci of damage. The effect on woody vegetation is much greater and longer lasting than the effect on grassland and herbs, because woody species have longer growth cycles (several hundred years in the extreme case of baobab) and therefore a longer replacement time. The same care should be taken in areas outside NPs where KWS plans to fund water development projects in pursuit of its CWS objectives.

However, there is an argument that provision of artificial water supply may not be an ecologically sound management strategy in Tsavo. Rain-fed water pans in the area behave differently from year to year because of the patchiness of rain showers, which results in the patterns of animals' pressures differing over a series of years. Moreover, since full waterholes and good plant growth are both associated with rainfall, animals are likely to use the areas where the vegetation is best able to accommodate heavy use. If use was excessive because of high numbers of animals, there is likely to be a feedback to the amount of water consumed and hence to the length of time that a pan can hold water and support grazing in the area around it.

The natural control mechanism on the distribution of elephants and other wildlife within the Tsavo NPs can be mimicked to prevent undesirable degradation effects. Boreholes may provide an easily managed artificial water supply option. Where accelerated damage is detected operations of the influencing boreholes can be shut down long enough to enable recovery. This requires setting up of rigorous monitoring programmes that would indicate when undesirable changes begin to take effect.

9.2.3 Changing local communities' attitudes towards conserving elephants

The majority of the local people living adjacent to Tsavo NPs had hostile feelings towards NP and elephants. Many saw the PAs and the elephants within them as a liability. This could have also been a reflection of the historical conflict between local people and the park managers since the creation of the NPs in 1948. Further, local climatic conditions, low economic development and level of formal education of the Tsavo ecosystem community may have played a role in influencing attitudes.

There is need for wildlife conservation education in order to activate group ethics and appeal to communities to participate in wildlife conservation programmes. A higher level of awareness may increase tolerance to elephant damage, resulting in fewer conflict problems. Few park values, other than those associated with tourism, have been quantified and explained, especially to the people who bear the opportunity cost of having the Tsavo NPs in close proximity.

The enhancing of benefits to the local people, either through sharing of money generated by the NPs through tourism, material support by KWS through its community service programmes, or increased employment and other income generating opportunities, would help in creating positive attitudes towards elephant conservation and better relations between wildlife managers and the local people. If, however, the elephants remain a liability to the Tsavo human community, people will not be able to afford to preserve it, except as a tourist curiosity within the NPs.

9.2.4 Land use planning

Promotion of land-use practices that maintain low human density on adjacent lands is probably the most desirable long-term strategy. Efforts should be made to maintain the present status of the large inhabited tracks of land designated as ranches, where conflict is minimal. Programmes linking the development of the ranches with wildlife conservation would be appropriate in the Tsavo ecosystem, which is mainly an area of low agricultural potential, with poor soils, low and unreliable rainfall and animals that destroy crops. This approach may also emerge as a valuable tool for redressing environmental degradation outside the NPs as well.

Implementation of most of the above mentioned conflict mitigation measures needs planning and huge funding, and may take time. Meanwhile interim measures requiring less funding would be necessary. One such measure is an effective communication means between the local people and PAC personnel on movements of problem elephants outside the NPs. The most efficient way would be the use of two-way radios. This would improve on the monitoring of elephant movement in settled areas and speed up intervention measures by KWS. In some instances reports of elephants in some villages were received by the PAC team days after raiding, and it served no purpose visiting an area long after the elephants had left. This resulted in unnecessary expenditure by KWS. Better still will be the training of community scouts who will be responsible for collecting and communicating elephant movement details outside NPs, and who may also be key people in gathering information on elephants and their activities in the settled area.

Clearly, the Tsavo NPs can never be too large for the elephant population, and the hope lies in extending the areas in which elephants can survive beyond the borders of the NPs, conservation areas beyond NPs. This in turn will be possible only if the people owning the land are prepared to tolerate the elephants and preserve their habitats.

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Appendix I

QUESTIONAIRE SURVEY ON HUMAN WILDLIFE CONFLICT IN AREAS ADJACENT TO THE TSAVO NATIONAL PARK.

No. ____

I am a scientist interested in the interaction between people and wildlife (especially elephants) in your area. I would like to get as much information as possible on how wildlife affects you in your day to day activities. This information will be used to make decisions towards solving human-wildlife conflict in your area and improve on benefits from conservation of wild resources. To ensure your anonymity you will not be required to give your name, and all information provided will be treated in strict confidence, and none will be used against you. It is important that you give accurate information otherwise the wrong decisions may be made.

1. Date: __/__/199_

2. Time: Start __________ End __________ Total minutes __________

3. Area: Division: ______________________________
Location: ______________________________
Sub-location: ______________________________
Village: ______________________________

Grid reference: ______________________________

4. Sex of respondent ( )M ( )F Age (yrs) _______

5. Family member ( )Wife ( )Husband ( ) child Other______________

6. Level of formal education:
( )None ( ) Primary ( ) Secondary ( ) Tertiary college ( ) University

7. What is your major occupation?
( )Peasant farmer.
( )Waged in area.
( )Waged in urban centre
( )Other (please specify)______________________________

8. For how long have you lived in this area? (No. of years) __________

9. Where did your household live before you moved here?
Sub-location ____________________
Location ____________________
Division ____________________
District ____________________

10. Why did you move to this area?

( ) More land here for farming.
( ) More land here for grazing
( ) Inheritance
( ) Other reason(s), please specify ____________________________
____

11. What crops do you cultivate (in order of importance).
i. ______________________________
ii. ______________________________
iii. ______________________________
iv. ______________________________
v. ______________________________
vi. ______________________________
viii. ______________________________
ix. ______________________________

12. What is the size of your land? ______ Acres, or _________hectares

13. How much of your land is under cultivation? (eg. 3/4, 1/2, 1/3,1/4 or actual area)______

14. What is the major use of the uncultivated land?

( ) Livestock grazing.
( ) Fuel wood collecting
( ) No particular use
( ) Other (specify)____

15. Do wild animals come to your land or neighbourhood? ( )Yes ( ) No.

16. If yes, which wild animals come to your land or neighbourhood?

(a) Wet season	(b)Dry season.	(c) All year round.
1. ______________	1. ______________	1. ______________
2. ______________	2. ______________	2. ______________
3. ______________	3. ______________	3. ______________
4. ______________	4. ______________	4. ______________
5. ______________	5. ______________	5. ______________

17. When did elephants last come to your area?
Month ____________
Year ____________

18. If elephants come to your area, how big are the groups?

( )singles ( ) 2-5 ( ) 5-10 ( )10-20 ( )>20

19. If elephants have not come to your area for a long time, what do you think are the reasons?____

____

20. As far as you can remember, has the frequency of problem wildlife increased or decreased? ( ) Increased
( ) Decreased

21. What do you think are the possible reasons for the observed increase/decrease.
i.____
ii.____
iii.____

22. When wild animals come to your land/farm/area do you always report of their presence to the relevant authorities (KWS, local administrative officer, etc.)?
( ) Reports always
( ) Reports only when they cause damage to crops, property, etc.
( ) Reports when they pose threat to human life or livestock
( ) Reports when they compete for resources with livestock stock
( ) Never reports

23. Have you been forced to change your main crops due to destruction and damage by elephants ( )Yes ( ).No.

24. If yes, which main crops did you change from and to?

Changed from	To
i. ________________	i. ________________
ii. ________________	ii. ________________
iii. ________________	iii. ________________
iv. ________________	iv. ________________

25. Are there any benefits you get from wildlife, the neighbouring National Park or Kenya Wildlife Service?
( ) None ( ) Meat ( ) Medicinal substances (please explain) ____________________

____

____

____

( ) Others (please explain)____

____

26. Are there some resources you would like to get from the National Park? Give in order of your priority?

i. ______________________
ii. ______________________
iii. ______________________
iv. ______________________
v. ______________________

27. How would you like KWS to help you to improve on your present living? (give in order of your priority)
i. ____
ii. ____
iii. ____
iv. ____
v. ____

Thank you for your time and co-operation.

Appendix II

INTERVENTION METHODS BY LOCAL PEOPLE AND COST OF CONFLICT

No _____

1. Date: __/__/199

2. Time: Start ___________ End __________ Total minutes _________

3. Area: Division:____
Location: ______________________________________
Sub-location: ___________________________________
Village: ____

4. Sex of respondent ( )M ( )F

5. Age (yrs) _______

6. Family member ( )Wife ( )Husband ( ) child Other______________

7.What methods do you use to discourage elephants from raiding your crops, or driving them out of your cultivated fields? Please list them in order of effectiveness.
i. ____
ii.____
iii____
iv ____
v. ____
vi____

8. How many hours do you spend on vigilance per day/night ? ________

9. What direct costs do you incur in relation to raiding intervention? Please list the items bought and hired services costs.
i ____
ii ____
iii____
iv____
v ____

10.Since the construction of the electric fence, have you noticed any change in the frequency of conflict incidents? ( ) increased
( ) decreased
( ) no change)

11. Does the fence deter you from utilising any resources within the National Park?
( ) Yes ( ) No

12. If yes, can you name the resources in order of importance?
i. ______________________________
ii. ______________________________
iii. ______________________________
iv. ______________________________

Thank you for your time and co-operation.

Appendix III

CHECKLIST OF MAJOR MAMMALS OF TSAVO

1. African elephant (*Loxodonta africana)*
2. Black rhinoceros (*Diceros bicornis*)
3. Cape buffalo (*Syncerus caffer*)
4. Lion (*Panthera leo)*
5. Leopard (*Panthera pardus)*
6. Cheetah (*Acinonyx jabatus)*
7. Spotted hyaena (*Crocuta crocuta)*
8. Striped hyaena (*Hyaena hyaena)*
9. Caracal (*Felis caracal)*
10. African wild cat (*Felis lybica)*
11. Serval cat (*Felis serval)*
12. Common zebra (*Equus burchelli)*
13. Grevy's zebra (*Equus grevy*i) (introduced into TsE in 1963).
14. Maasai giraffe (*Giraffa camelopardalis*)
15. Eland (*Taurotragus ory*x)
16. Common waterbuck *(Kobus ellipsiprymnu*s)
17. Impala (*Aepyceros melampus*)
18. Eland (*Taurotragus oryx*)
19. Oryx (fringe eared) (*Oryx beisa)*
20. Coke's hartebeest (Kongoni) (*Alcelaphus. cokii)*
21. Common waterbuck (*Kobus ellipsiprymnus)*
22. Lesser Kudu (*Strepsiceros imberbis*)
23. Hunter's hartebeest (Hirola) (D*amaliscus hunteri*) (introduced into TsE in 1963 and restocked 1996).
24. Grant Gazelle (*Gazella granti*)
25. Gerenuk (*Litocranius walleri*)
26. Warthog (*Phacochoerus aethiopicus*)

27 Bush pig (*Potamochoerus pocus or P. larvatus*)

28. Yellow Baboon (*Papio cynocephalus*)
29. Ant bear (O*rycteropus afer*)
30. Tree hyrax (*Denchrohyrax arborues*)
31. Rock hyrax (*Heterohyrax brucei)*
32. Red duiker (*Cephalophus harveyi*)
33. Blue duiker (*Cephalophus monticolor*)
34. Bush duiker (*Sylvicarpa grimmia)*
35. Klipspringer (*Oreotragus oreotragus*)
36. Suni (*Nesotragus moschatus*)
37. Steinbok (*Raphicerus campestris*)
38. Kirk's dik dik (*Rhynchotragus kirkii)*
39. Bolor reedbuck (*Redunca redunca*)
40. Bushbuck (*Tragelaphus scriptus*)
41. African Hare (*Lepus campensis*)
42. Cone rat (*Thryonomys swinderianus*)

43. Porcupine (*Hystric galeata*)
44. Striped ground squirrel (*Xerus erythropus*)
45. Unstriped ground squirrel (*Xerus rutilus*)
46. Bush squirrel (*Paraxerus ochraceus*)
47. East African Red Squirrel (*Paraxerus palliatus*)
48. Kenya Mole Rat (*Tachyoryctes ibeanus*)
49. Naked Mole Rat (*Heterocephalus glaber*)
50. Spectacled Elephant Shrew (*Elephantulus rufescens*)
51. East African Hedgehog (*Erinaceus pluneri*)
52. Giant white toothed shrew (*Crocidure occidentalis*)
53. Rousette fruit Bat (*Rousettus aegyptiacus*)
54. Epauletted fruit Bat (*Epomophorus wahlbergi*)
55. Pale bellied Fruit Bat *(Epomops frangueti*)
56. White bellied Tomb bat (*Tophozous mauritianus*)
57. Hollow faced bat *(Nyoteris hispida*)
58. False vampire Bat (*Magaderma cor*)
59. Yellow-winged Bat (*Lavia frons*)
60. Landeis Horseshoe Bat (*Rhinolophus landeri*)
61. Lesser leaf-nosed Bat (*Hipposideros caffer*)
62. Giant Leaf-nosed Bat (*Hipposideros commersoni*)
63. African Trident Bat (*Triaenops afer*)
64. Banana Bat (African Pipistrelle) *Pipistrellus nanus*
65. Yellow bellied Bat *Scotophilus nigrita*
66. Angola free bellied Bat *Tadarida condylura*
67. White bellied free-tailed Bat (*Tadarida limbata*)
68. Flat-headed free-tailed Bat *(Platymops barbatogularis*)
69. Greater Galago (*Galago crassicaudatus*)
70. BushBaby (*Galago senegalensis*)
71. Black faced vervet (*Cercopithecus aethiops*)
72. Blue or Sykes Monkeys *(Cercopithecus mitis*)
73. Lesser ground Pongolin (*Manis temminoki*)
74. Hunting dog *(Lycaon pictus*)
75. Golden Jackal (*Canis aureus*)
76. Black backed or silver backed Jackal (*Canis mesomelas*)
77. Side striped Jackal (*Canis adustus*)
78. Bat-eared fox (*Otocyon megalotis*)
79. Zorilla (*Ictonyx striatus*)
80. Ratel or Honey Badger (*Mellivora capensis*)
81. Clawless Otter (*Aonyx campensis*)
82. Africana Civet (*Civettictis civetta*)
83. Neumann's small-spotted Genet *(Genetta genetta*)
84. Bush or Large spotted Genet *(Genetta tigrina*)
85. African palm Civet (*Nandinia binotata*)
86. Marsh Mongoose (*Atilax paludinosus*)
87. Dwarf Mongoose *(Helogale undulata*)
88. Large Grey Mongoose (*Herpestes inchneumon*)
89. Slender or Black-tipped Mongoose (*Herpestes sangguineus*)
90. White tailed Mongoose (*Ichneumia albicauda*)

91. Banded Mongoose (*Mungos mungo*)
92. Aard-wolf (*Proteles cristatus*)

CHECK LIST OF THE BIRDS OF TSAVO

324 species of land birds have been recorded in Tsavo East (Lack *et al,* 1980). About half of these are seen too rarely and only the more common ones are listed below.

1. Yellow necked Spurfowl
2. Crested Francolin
3. Harlequin Quail
4. Helmeted Guineafowl
5. Quail Plover
6. Buff-Crested Bustard
7. White-bellied Bustard
8. Black-headed Plover
9. Crowned Plover
10. Caspian Plover
11. Spotted Thicknee
12. Heuglin's Courser
13. Black-faced Sandgrouse
14. Chestnut-bellied Sandgrouse
15. Red-eyed Dove
16. Ring-necked Dove
17. Laughing Dove
18. Namagua Dove
19. Emerald-spotted Wood Dove
20. Orange-bellied Parrot
21. White-bellied Go-away Bird
22. Great Spotted Cuckoo
23. Black and White Cuckoo
24. Eurasian/African Cuckoo
25. Didric Cuckoo
26. White-browed Coucal
27. Speckled Mousebird
28. Blue-naped Mousebird
29. Striped Kingfisher
30. Chestnut-bellied Kingfisher
31. Eurasian Bee-eater
32. Madagascar Bee-eater
33. White-throated Bee-eater
34. Little Bee-eater
35. Somali Bee-eater

36. Eurasian Roller
37. Lilac-breated Roller
38. Rufous-crowned Roller
39. Broad-billed Roller
40. Hoopoe
41. Green Wood Hoopoe
42. Abyssinian Scimitar-bill
43. Grey Hornbill
44. Red-billed Hornbill
45. Von der Decken's Horbill
46. Yellow-billed Hornbill
47. Brown-breasted Barbet
48. Black-throated Barbet
49. Spotted-flanked Barbet
50. Red-fronted Tinkerbird
51. d'Arnaud' Barbet
52. Red and Yellow Barbet
53. Greater Honeyguide
54. Lesser Honeyguide
55. Nubian woodpecker
56. Cardinal Woodpecker
57. Bearded Woodpecker
58. Chestnut-backed Sparrow
59. Chestnut-headed Sparrow
60. Singing Bush Lark
61. Red-winged Bush Lark
62. Pink-breasted Lark
63. Friedmann' Bush Lark
64. Drongo
65. Black-headed Oriole
66. Golden Oriole
67. Grey Tit
68. Scaly Chatterer
69. Rufous Chatterer
71. Zanzibar Sombre Greenbul
72. Northern Brownbul
73. Common Bulbul
74. Rufous Bush Chat
75. White-browed /Scrub Robin
76. Irania
77. Sprosser
78. Rock Thrush
79. Isabelline Wheatear
80. Northern Wheatear
81. Pied Wheatear
82. Capped Wheatear
83. Bare-eyed Thrush
84. Marsh Warbler
85. Upcher's Warbler
86. Olivaceous Warbler

87. Willow Warbler
88. Garden Warbler
89. Whitethroat
90. Barred Warbler
91. Yellow-breasted Apalis
92. Grey Wren Warbler
93. Desert cisticola
94. Ashy Cisticola
95. Tiny Cisticola
96. Yellow-vented Eremomela
98. Red-fronted Warbler
99. Northern crombec
100. Grey Flycatcher
101. Spotted Flycatcher
102. Black-headed Batis
103. Chin-spot Batis
104. Pygmy Batis
105. Paradise Flycatcher
106. Pangani Longclaw
107. Golden Pipit
108. Black-backed Puffback
109. Slate-coloured Boubou
110. Grey-headed Bush Shrike
111. Brubru
112. Rosy-patched Shrike
113. Three-streaked Tchargra
114. Black-headed Tchargra
115. Long-tailed Fiscal
116. Taita Fiscal
117. Red-backed Shrike
118. Red-tailed Shrike
119. Lesser Grey Shrike
120. White-crowned Shrike
121. Helmet Shrike
122. Retz's Helmet Shrike
123. Violet-backed Starling
124. Wattled Starling
125. Blue-eared Glossy Starling
126. Ruppell's Long-tailed Glossy Starling
127. Red-winged Starling
128. Magpie Starling
129. Golden-breasted Starling
130. Fisher's Starling
131. Hilderbrandt's Starling
132. Shelley's Starling
133. Superb Starling
134. Red-billed Oxpecker
135. Collared Sunbird
136. Eastern Violet-backed Sun bird
137. Amethyst Sunbird

138. Little Purple-banded Sun bird
139. Hunter's Sunbird
140. Abyssinian White-eye
141. Red-billed Buffalo Weaver
142. White-headed Buffalo Weaver
143. Parrot-billed Sparrow
144. Yellow-spotted Petronia
145. White-browed Sparrow Weaver
146. Black-capped Social Weaver
147. Red-headed Weaver
148. Black-necked Weaver
149. Masked Weaver
150. Back-headed weaver
151. Chestnut Weaver
152. Red-billed Quelea
153. White-winged Widowbird
154. Fire-fronted Bishop
155. Pin-tailed whydah
156. Paradise Whydah
157. Green-winged Pytilia
158. Red-Cheeked Cordon-bleu
159. Purple Grenadier
160. Crimson-rumped Waxbill
161. Grey-headed Silverbill
162. Cut-throat
163. Somali Golden-breasted Bunting
164. Yellow-rumped Seed-eater