Coexistence in a land use mosaic? Land use, risk and elephant ecology in Laikipia District, Kenya

This dissertation is submitted to the University of Cambridge for the degree of Doctor of Philosophy

Max Graham

King's College

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PREFACE

This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration except where specifically indicated in the text and acknowledgements. No part of this dissertation has been submitted for a degree or diploma or other qualification at any other University. The text does not exceed 80,000 words.

Abstract

This thesis is about the patterns, determinants and consequences of human-elephant interaction in Laikipia District in northern Kenya. Laikipia is located outside of formally protected areas, supports a range of land use types and harbours Kenya's second largest elephant population comprised of over 3,000 animals. I use interdisciplinary methods and multiple scales of spatial analysis to examine elephant distribution, persistence and interactions with people in this human landscape.

At a course scale, results from several data sources show that elephants occur across almost 50% of Laikipia District and, intriguingly, are relatively evenly distributed across locations under cultivation, settlement and livestock production. At a finer scale, however, results from over a 100 km of ground transects, show that the relative abundance of elephants varies in relation to specific forms of human activity, in particular the risk of mortality presented by human occupants to elephants.

Elephant use of areas where they are not tolerated by local people, such as smallholder farms, is determined by human population density and distance from daytime refuges. Elephant use of smallholder farms increases with the proportion of land under smallholder production within an elephant range. Male elephants use areas where human occupants are elephant-intolerant, and/or present a threat of mortality, more than female elephants.

Elephants use cover of darkness to exploit areas where they are not tolerated by local people. In addition, I show that elephants increase their speed of travel through such areas. I argue that these findings, together with some preliminary evidence for aggregation in response to risk, suggest that elephants demonstrate behavioural plasticity in response to risk and are resilient to human induced landscape change, to some degree.

Contact with elephants among local people in Laikipia varies with patterns of resource use by different households. Negative attitudes towards elephants were, however, not shaped by the likelihood of contact with elephants but rather by negative experiences

involving elephants, such as crop-raiding, and/or knowledge of incidents in which elephants had either injured or killed local people.

A district-wide electrified fence is currently being constructed in Laikipia to mitigate human-elephant conflict, in particular the damage to crops and human fatalities caused by elephants. While electrified fences can impede elephant movement if well maintained and ‘enforced’, they are also beset with maintenance problems. In addition, electrified fences may reinforce perceptions of who owns elephants, which is shown to be a determinant of negative attitudes towards elephants in this study. Electrified fences may also contribute to the emergence of a perceived ‘elephant problem’ in Laikipia, with declines in woodland and some wildlife species. Therefore, other options for the mitigation of human-elephant conflict should be explored, alongside electrified fences. In this thesis, I discuss these other options, including affordable community-based elephant deterrents, land-use planning and the promotion of conservation-based benefit streams to local people that live with elephants. A combination of these methods could assist with the future conservation and management of elephants in Laikipia and beyond.

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Chapter 1: Introduction

1.1 INTRODUCTION

This thesis presents a study of the way large terrestrial mammals and people coexist within shared landscapes. Currently our understanding of the ecology of large terrestrial mammals is largely based on observations made in places where human activity, other than perhaps tourism, is strictly prohibited, such as national parks. However, large mammals often live and range within the human-dominated matrix. There are several reasons for this:

1) Many national parks were created in areas which held little value in terms of economic potential (Adams, 2004) rather than with consideration for the distribution of wildlife and biodiversity so that in some countries, such as Kenya, the majority of wildlife is found outside of national parks (Western, 1989).

2) Many species of wildlife are ecologically compelled to range/migrate from protected to non- protected areas (Douglas-Hamilton et al., 2005, Forbes & Theberge, 1996).

3) Today there are several categories of 'protected area', other than national parks, which permit some level of human use and management (IUCN & Cardiff University 2002). In such places people and wildlife may share resources.

4) Human population growth and land pressure in developing nations is forcing people to move into non-protected wildlife areas.

For the reasons outlined above, it is clear that research into the ecology of large mammals cannot be carried out without consideration for the human landscapes within which large mammals live. Indeed, it is these very human landscapes on which the persistence of wildlife and biodiversity depends (Western, 1989). However, the mechanics of interaction between human and natural realms remain poorly understood. This thesis examines human-wildlife interactions across Laikipia District in north Kenya and uses the variability in human resource use and management across space to provide a 'natural experiment'. Because they range extensively within this landscape, African elephants (scientific names for animal species and cultivated plants mentioned in the text are provided in Appendix 1) are used as a common medium through which to measure and compare human and wildlife perspectives across different resource use and management zones. Laikipia District presents a unique setting within which to do this. Land in Laikipia exists under a range of property rights regimes (communal, private, government owned and open access), that are each in turn associated with specific land-user groups and their particular resource use and management regimes. Overlay on top of this diverse human landscape, the second highest density of wildlife in Kenya, including over 3,000 elephants, and the significance of Laikipia as a unique context for carrying out research into human-wildlife interaction becomes apparent.

The diagram below (Fig. 1.1) provides a conceptual framework that was used to guide the synthesis of this thesis and illustrates the complex nature of interaction between people and wildlife within landscapes. This framework suggests that background factors such as historical events, political transitions and environmental change contribute to the composition of landscape occupants. This composition may comprise distinct groups of human resource users that interact with wildlife in different ways based on factors such as their origins, experience, livelihoods, value systems, prevailing institutions, environmental conditions etc. While less clear, elephants occupying the same landscape could also be classified into distinct groups because long-lived animals, such as elephants, will have experiences and learned strategies for optimising their nutrient intake and negotiating risks in space and time (Moss, 1988). These factors will dictate the ways in which elephants interact with different human resource users and their associated land use and management regimes.

Life strategies of human and elephant occupants can be analysed and assessed independently, and at various scales. For example it would be possible to explore cultivation patterns across Laikipia district or within a specific settlement or at the individual farm level. It would also be possible to study elephant habitat use for an entire population or for a known ‘family unit’ (Douglas-Hamilton, 1971, Moss & Poole, 1983, Wittemyer et al., 2005) or for an individual female or male elephant. By developing a framework for conceptualising human and elephant ecology at different scales, it also becomes possible to consider the different scales at which people and elephants interact.

This thesis uses the conceptual framework illustrated below to try and unravel a complicated matrix of human-elephant interactions and their underlying determinants in the Laikipia landscape. Through this process the goal is to clarify how we currently study and understand human-wildlife interaction and to contribute to this field through the use of an interdisciplinary and landscape-orientated (or scale sensitive) approach.

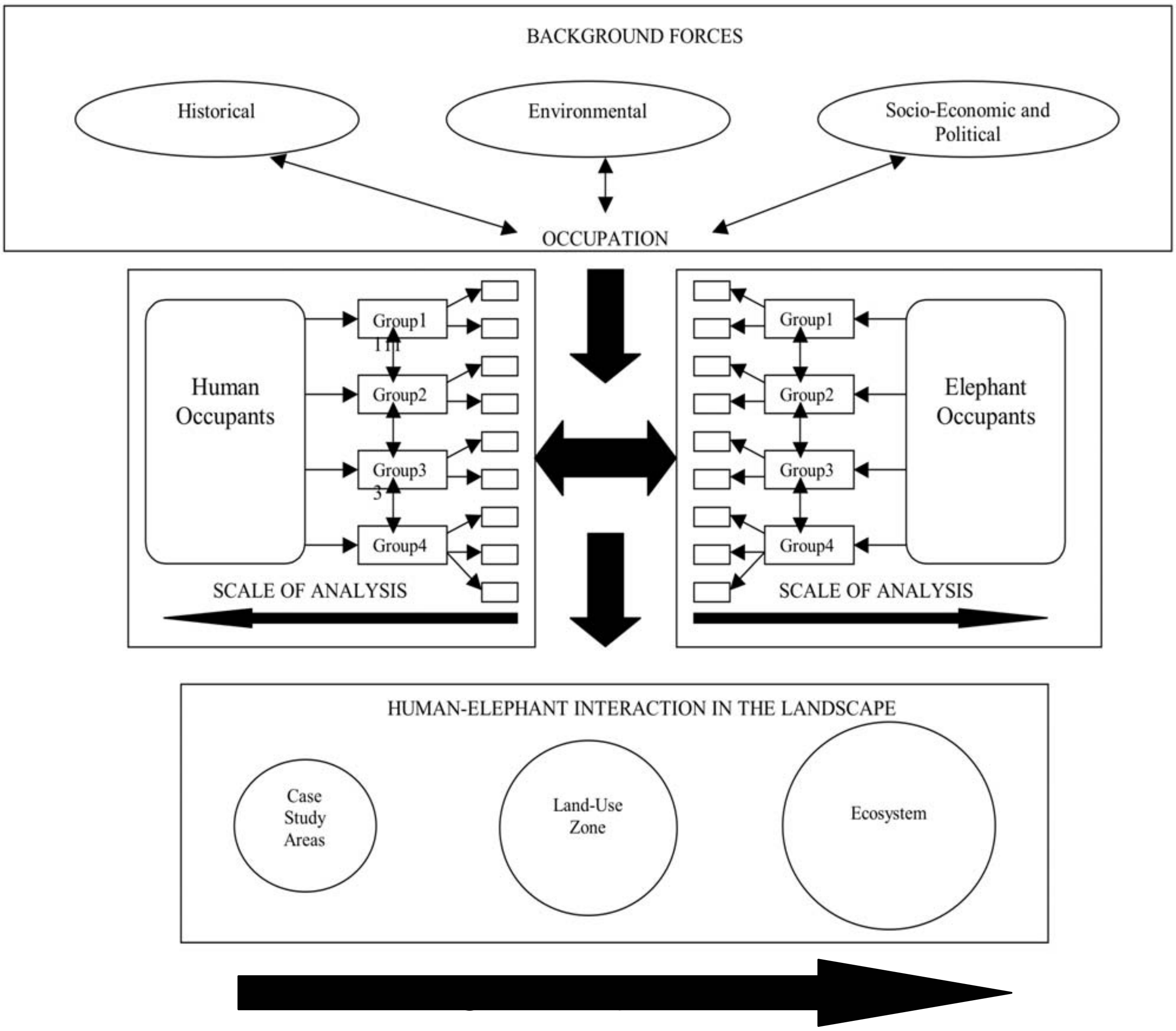


Fig. 1.1 Conceptual Framework

1.2 RESEARCH QUESTIONS

1.2.1 Question One

How does elephant distribution vary across and within different land-use types in Laikipia?

The conventional theory regarding the relationship between people and elephants is simply that they are mutually exclusive. This was supported by a model of human-elephant interaction produced by Parker and Graham (1989) that shows elephant density declines linearly as a function of the natural logarithm of human density. Their model was based on coarse national distribution data in Kenya and Zimbabwe and has received considerable support in the literature (Eltringham, 1990, Happold, 1995, Newmark et al., 1994). A further study carried out at a finer level of analysis showed that elephant density declines once a threshold of human density of approximately 15.6 persons/km^2 has been reached (Hoare & Du Toit, 1999).

Though both Parker and Graham's (1989) and Hoare and Du Toit's (1999) analyses may be representative at a coarse level, they do not provide insights into complex relationships between people and elephants at finer levels of resolution, nor do they identify the specific factors associated with people that lead to elephant declines. A small-scale farmer and a hunter-gatherer represent quite distinct independent variables as far as an elephant is concerned. In contrast, this study considers the role of human land use and the risk of mortality presented by human occupants in determining patterns of elephant distribution across a landscape.

1.2.2 Question two

Have elephants adapted their behaviour to negotiate the risk of being killed by human-resource users within the landscape?

Elephants are widely reported to crop raid exclusively at night (Hoare, 1999a, Naughton-Treves, 1997, Osborn, 1998, Sitati et al., 2003, Thouless, 1994). This suggests that elephants are deliberately avoiding confrontation with people. There is also anecdotal evidence of elephants travelling faster when moving through unprotected areas between distinct 'home sectors' in north Kenya (Douglas-Hamilton et al., 2005). These observations suggest that elephants may be adapting to conditions within shared landscapes. However, finding a reliable and systematic measure of this behavioural phenomenon is challenging. Aerial counts and diurnal surveys which provide the main basis for defining and assessing wildlife distribution do not accurately present the spatial extent of wildlife occupancy within landscapes. This is because most aerial counts are carried out during the day perhaps, at best, once in a year. Wildlife movement, particularly of large mammals, is likely to vary considerably depending on time of day and season. As a consequence this study considered diurnal and nocturnal distributions of elephants in an attempt to generate proxy indicators of elephant behaviour for measuring responses to the presence of risk in a land-use mosaic. Other proxy indicators for measuring behavioural responses to the presence of people (as represented by the presence or absence of risk) have been used in previous studies. These indicators include the sexual composition of elephant groups (Osborn, 1998, Sukumar, 1991), group size (Abe, 1995, Demmers & Bird, 1995, Kangwana, 1993) distances between elephants and human settlement or livestock (Thouless, 1995) and directly observed elephant reactions to various visual and oral stimuli associated with people (Barnes, 1983a, Kangwana, 1993). In this study similar proxy indicators for elephant behaviour in relation to 'risk' are considered within the context of Laikipia.

1.2.3 Question 3

How do responses to the presence of elephants vary among rural people in Laikipia District?

There has been a great deal of research into conservation attitudes among rural people. Much of this research has explored relationships between positive or negative attitudes towards wildlife and/or conservation against a range of independent variables such as wealth (Gillingham & Lee, 1999, Infield, 1988), access to project benefits (Gillingham & Lee, 1999, Infield, 1988, Lewis et al., 1990, Parry & Campbell, 1992), and ethnicity (Gadd, 2005, Kangwana, 1993). This body of research combined with economic analyses of the opportunity cost of conservation (Norton-

Griffiths & Southey, 1995) has greatly contributed to a paradigm shift from ‘fortress conservation’ (Brockington, 2002) to a more people-centred approach (Western et al., 1994). In practice the people centred approach to conservation in terms of both strict wildlife conservation goals (distribution and numbers of wildlife and the extent of natural habitat available) and social goals (improved access and distribution of wildlife benefits), has not been without its problems (Gibson & Marks, 1995, Murombedzi, 1999, Oates, 1999). A clear constraint among many of the recent integrated conservation and development projects is the absence of clear goals (Adams et al., 2004). In the wildlife sector this may stem from problems of scale, with little understanding of how specific livelihood activities (i.e. collecting firewood, tending crops, watering livestock) result in specific ‘bundles’ of experiences for local people that may define the ways in which they perceive and behave towards wildlife. It seems therefore that a more functional and ‘actor’ orientated approach is needed for understanding the linkage between human and wildlife ecology within a shared landscape. As such this study uses livelihood specific experiences as well as the socio-economic contexts within which local people live as a basis for exploring views of, and behaviour toward, wildlife.

1.3 INTRODUCTION TO LAIKIPIA

1.3.1 Geography

Laikipia District covers 9,700 km^2 in north central Kenya, encompassing a plateau of rolling low hills at an elevation of 1700-2000m above sea level, straddling the Equator, northwest of Mt. Kenya (5199 m) and northeast of the Aberdare highlands (3999 m). The eastern wall of the Rift Valley forms the western boundary of the district. Samburu District is to the north, below the Laikipia escarpment and is punctuated with forest clad mountains, most notably the Karissia Hills and Mathews Range (2241 m).

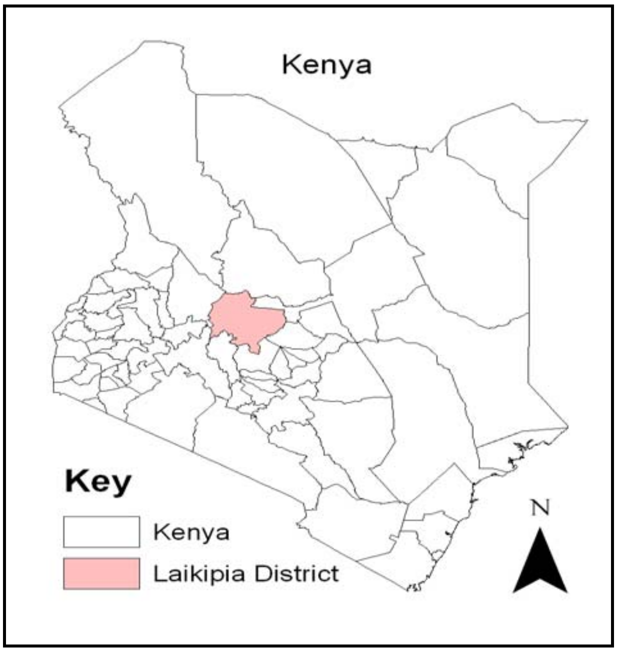


Fig. 1.2 Location of Laikipia District.

Around three quarters of the district consists of volcanic rock with a gentle and/or slightly undulating topography. The relief varies in the west, with the ridges and mountains that occur parallel with the Rift Valley-Ndundori (2870 m), Marmanet (2609 m) and Lariak (2283 m), and in the northeast, with the Loldaiga and Mukogodo hills (1700-2200 m). The northern part of Laikipia is characterised by low plains (800 to 1200 m) that extend into neighbouring Samburu and Isiolo Districts (Gichuki et al., 1998a).

Rainfall is typically bimodal, mostly falling in two seasons, the ‘long rains’, between April and June, and the ‘short rains’, between October and December, although rain is unpredictable, and may fall at any time of year. Annual rainfall is strongly influenced by the presence of Mt. Kenya and the Aberdares, falling along a steep gradient from between 750 mm in the southern part of the district to 300 mm in the lower, northern part of the district (Berger, 1989, Gichuki et al., 1998b).

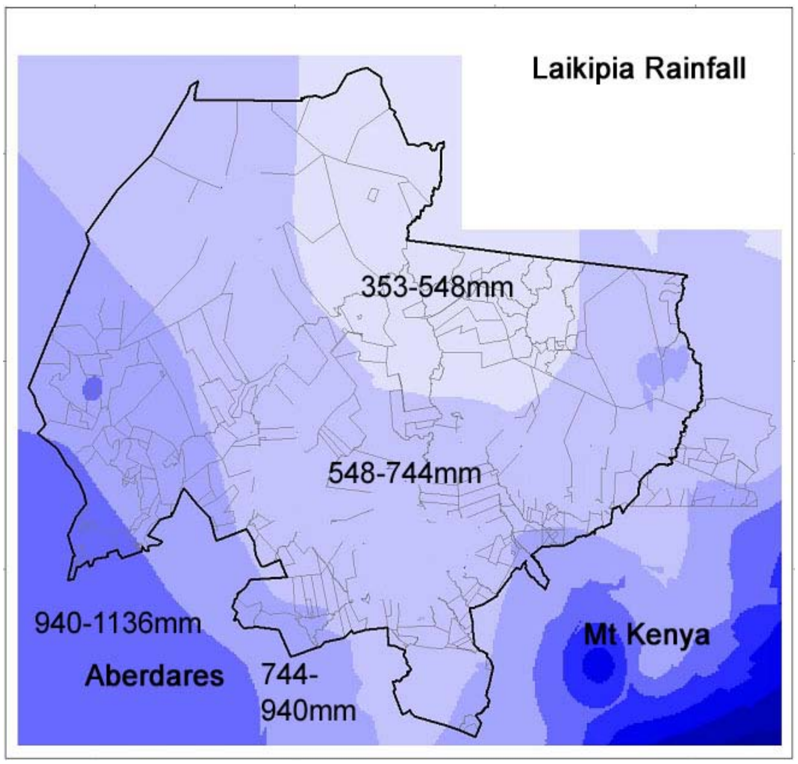


Fig. 1.3 Rainfall patterns in and around Laikipia District (adapted from a digital map generated by Nick Georgiadis and Nasser Olwero of Mpala Research Centre in 2002 and based on long term records from 58 rainfall gauging stations collected by the Natural Resource Monitoring, Modelling and Management Project (NRM3))

Most of Laikipia drains northwards through the Ewaso Ngiro and its main tributary, the Ewaso Narok, both of which are fed by perennial streams from Mt. Kenya and the Aberdares. There are additional sources of water available on the commercial ranches within the district in the form of dams and water tanks, the latter fed by boreholes. To the north, in the lowland areas of Samburu, however, the Ewaso Ngiro is the only permanent source of water (Thouless, 1995).

The variation in altitude and rainfall across the district is associated with marked changes in vegetation cover and land use from protected upland forest, a belt of moist cultivation to savannah under both commercial and subsistence livestock production, and where abundant, wildlife-based tourism.

Land in Laikipia exists under private, communal and government ownership. Large-scale ranches under mainly private ownership but also including several government owned properties and varying from 5000 to 100,000 acres in size, cover 42% of the district. Smallholder plots varying in size from one to five acres cover 37% of the district and where arable, are under cultivation and where not arable, have effectively been abandoned and are under opportunistic occupation and/or use by pastoralists. Communally owned group ranches, under traditional livestock production, cover about 8% of Laikipia and are located in the lower and relatively more arid northern part of the district. The remaining areas of Laikipia are covered by government forest reserves, swamps and urban areas.

The human population of Laikipia (310,000 in 1995-Kiteme et al., 1998) is mostly clustered into a southern belt of arable smallholder land, where population densities vary from between 200-300 people per km^2, compared with 50 people per km^2 on marginal smallholder land, one person per km^2 on large scale ranches and 10 per km^2 on the northern communally owned group ranches (Thouless, 1994).

Wildlife densities in Laikipia are the second highest in Kenya, after the well known Maasai Mara Game Reserve in Narok and Transmara Districts. Laikipia District hosts several globally endangered species of large mammal, including most of the world’s 2100 Grevy’s zebras, a recovering population of African wild dog, Jackson’s hartebeest and more than 200 black rhinos, most of Kenya’s total population. Laikipia, together with neighbouring Samburu and Isiolo Districts, is home to Kenya’s second largest elephant population. In 2002, 3,036 of the 5,189 elephants counted within this region, were recorded in Laikipia District (Omondi et al., 2002).

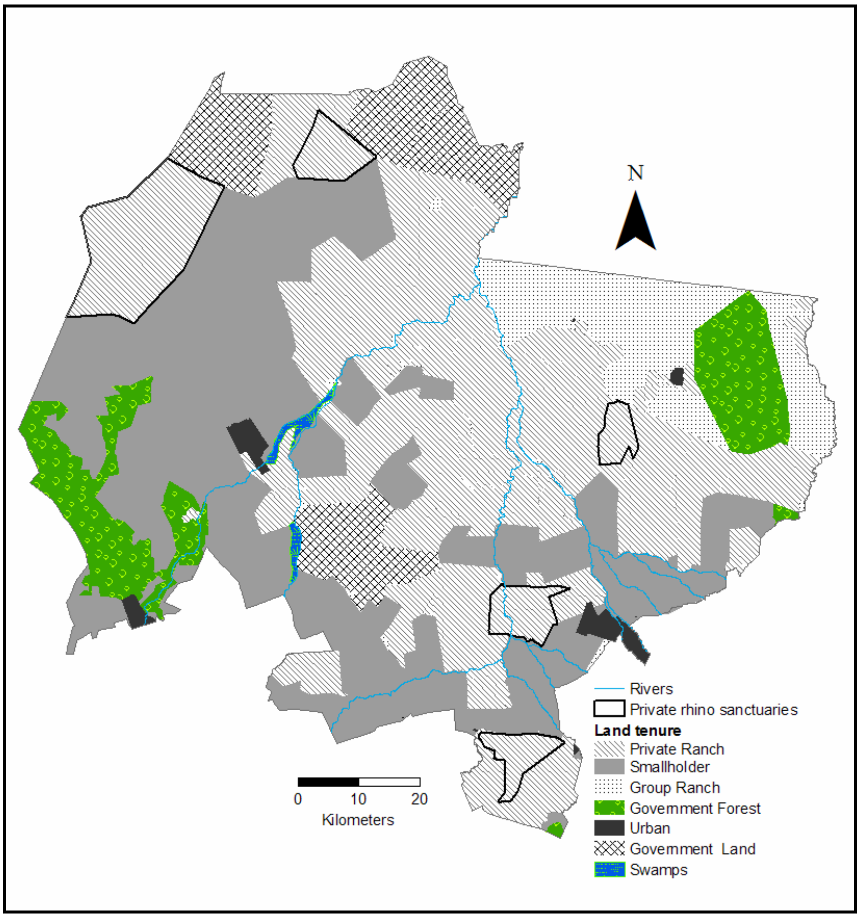


Fig. 1.4 Land tenure in Laikipia District

1.3.2 History

This section briefly presents several significant historical events that have shaped Laikipia into a unique and particularly interesting context for which to explore the interrelationship between people, land-use and elephant ecology. Each event is described and linked to relevant features within the current Laikipia landscape. Broader historical trends are explored in relation to the ivory trade in chapter two. By exploring significant events in Laikipia's history four major features in the contemporary landscape will emerge: 1) Political ecology; 2) Vegetation cover; 3) Elephant distribution and 4) Land use.

The Arrival of Pastoralists

The pre-colonial history of the Laikipia plateau and its surrounds is far from clear but it appears that there were two waves of 'pastoralisation'. According to the archaeological record some form of mixed cattle and goat/sheep pastoralism first appeared in the central highlands of Kenya by *c*. 3400-3000 BP (Marshall, 2000, Marshall & Hildebrand, 2002). This has been attributed to the movement of and local contact with herders from Sudan, Ethiopia and possibly Somalia (Bower, 1991, Marshall, 2000). However livestock husbandry was initially taken up slowly and it is likely that many early herding communities continued to rely on hunting and foraging both because of the availability of abundant wild foods and the incidence of livestock diseases such as Trypanosomiasis and Malignant Catarrhal Fever (Gifford-Gonzalez, 1998). The early occupants of Laikipia left an enduring imprint on the landscape including rock art, stone cairns, stone circles, flaked obsidian, pottery and iron slag (Taylor et al., 2005). In addition these early occupants left behind them a Cushitic language known as Yaaku (Heine, 1974) that is still spoken among a remnant group of hunter-gatherers living in north-eastern Laikipia (Cronk, 2004). This language has largely been replaced by Maa, and during the field work period, I met just two individuals who still spoke Yaaku. The former presence of these Cushitic speakers in Laikipia is confirmed by the oral traditions of the current occupants of Laikipia and Cushitic speakers living in north Kenya (Lemosa, 2005, Mutundu, 1999).

The original Cushitic occupants of present day Laikipia were either assimilated or displaced by Maa speaking pastoralists, possibly sometime prior to AD 1600 (Jacobs, 1972). The latter represented the product of a wider pastoral revolution among Nilotic people occupying the lower Turkana basin (Sutton, 1987) and may have differed from their Cushitic predecessors in that they were economically specialised, relying exclusively on livestock rather than practicing a mixed economy. They were also socially organised into ‘age sets’ so that young men could be mobilised for military purposes. This may have acted as a precursor for the parallel process of economic specialisation of hunter gathering by the remaining mixed economic units. Such a strategy would have reduced competition with their more powerful Maa-speaking neighbours and provided opportunities in terms of trade (Herron, 1991).

These historical processes of economic change are relevant to the current context for three reasons. Firstly, the emergence of pastoralism in the Laikipia region may have contributed to vegetation change alongside natural changes in moisture, through the combined activities of grazing and burning. Burning would have been carried out to both encourage pasture and reduce habitat available to the tsetse fly (Lamprey & Waller, 1990). Evidence for this burning activity and the transitions in vegetation cover to which it contributed were captured through recent analyses of sediments at a river floodplain on the Laikipia plateau (Taylor et al., 2005). These analyses indicate burning and the expansion of fire-adapted *Acacia* bushland *c*.1900 BP and grassland *c*.1700 BP, replacing Afromontane forest in this particular site. The most significant expansion of vegetation in the form of fire-resistant grassland occurred *c*.700 BP and coincided with local fires, possibly indicating the presence of substantial numbers of people with their livestock.

The process of land use and associated vegetation change captured by Taylor et al., (2005) is highly likely to have shaped the present day mosaic of grassland, *Acacia* bushland and Afromontane forest evident in Laikipia. It is possible that the existence of a vegetation mosaic in this area facilitated ethnically based divisions of labour through the parallel process of “pastoralisation”, “agriculturalisation” and “foragisation” (Herron, 1991). This spatial division of economies together with the emergent habitat mosaic would have, and probably still has, significant implications for the distribution of elephants and other species of wildlife.

The second reason that the process of pastoralisation is significant in terms of the contemporary Laikipia setting, is that it contributed to the emergence of elephant hunters. As specialised pastoralists consolidated into territorial-based ethnicities (such as the Turkana, Purko-Kisongo, Samburu and Laikipiak Maasai), their raiding power probably made it increasingly difficult for mixed-economy units to defend their livestock holdings. Mixed-economy units could therefore either become assimilated by the emerging pastoral ethnicities or revert to purely agricultural or foraging modes of subsistence (Herron, 1991). By the 18th Century, specialised foragers within Laikipia would have developed trade and patronage links with their pastoral neighbours. At this time, ivory may well have been exchanged for meat, skins, milk etc. In addition, a growing world demand for ivory and the increased presence of Swahili and European traders would have encouraged many ethnic groups to engage in the ivory trade (Hakansson, 2004) making ivory a local currency and providing an incentive for foragers and perhaps some pastoralists, whose descendents occupy the present day Laikipia region, to acquire elephants hunting skills.

The third reason that the arrival of pastoralists is significant for the current Laikipia context is that current knowledge of the identities of pre-colonial pastoral occupants has contributed to a set of ethnically based claims to ancestral resources that permeate the contemporary political economy. For example, the fact that a group of Maa speaking pastoralists, the Laikipiak Maasai, consolidated into a distinct ethnic unit and established the Laikipia plateau as their territory at some stage in the last 500 years, has encouraged many current occupants of Laikipia to claim ancestral association with the 'Il-Laikipiak' in a bid to secure access to resources and territory (Hughes, 2005). It is interesting to note that historians assert that the Il-Laikipiak Maasai section was in fact wiped out through internecine warfare at the end of the nineteenth century (Sobania, 1993). Another similar though less significant claim to territory and resources based on ethnic ancestry in present day Laikipia is that of the descendents of the ethnically consolidated foraging group known as the Yaaku who inhabit the forested hills of north-east Laikipia (Cronk, 2004). While a thorough discussion of these ancestral claims and their validity is beyond the scope of this thesis, what is important here is to bring to light that these claims may possibly contribute to changes in land-tenure in the future which could have implications for elephants and other wildlife species.

European Settlement

In the late 19th century, the British government took the decision to encourage European colonisation of the East African protectorate with the objective of creating an export-orientated, free-market economy (Pestalozzi, 1986). This decision was taken in light of administrative problems experienced in the protectorate and the need to recover some of the considerable costs involved in the construction of the Uganda railway. As a result, the highlands of Kenya were alienated for European colonisation with the African occupants relocated into reserves. As part of this process, an agreement was drawn up in 1904 between Maasai elders and the British government whereby the Maasai would vacate their lands in the Central Rift Valley in exchange for a Northern Maasai Reserve in the present day Laikipia region and a Southern Maasai Reserve in present day Kajiado and Narok Districts (Hughes, 2005). Another Maasai agreement in 1911 moved the Maasai from the Northern Reserve into an expanded Southern Reserve and paved the way for European settlement in Laikipia

(Hughes, 2005). By the 1920s, the soldier settler scheme, in which farming units of between 1,000 and 5,000 acres were made available on easy terms to retiring British soldiers, acted as a catalyst for increasing the number of European settlers within Laikipia (Kohler, 1987).

There were several significant processes that the arrival of European settlers instigated. The first of these was the creation of large estates. This occurred as successful pioneer farmers bought up smaller farm units and as a result of the colonial government policy that land units above 10,000 and in some cases even 30,000 acres were needed for profitable beef production in Laikipia. The process of land consolidation was further facilitated by the government's assertion that Europeans with local knowledge were better placed to farm land in Laikipia than newcomers and so were given preferential treatment when land was made available[1]. Land consolidation continued up until and even after independence resulting in the emergence of very large ranching estates (Kohler, 1987), some exceeding 90,000 acres in size, two of which, Ol Pejeta and Ol Ari Nyrio, still exist today. While not considered at the time, the emergence of large contiguous land units within Laikipia was to prove significant in allowing the area to support high populations of elephants and other wildlife in later years.

European settlement of the Laikipia plateau also affected the prevailing human-vegetation dynamics associated with Maasai occupation. The combined factors of destocking, land consolidation and a reduction in deliberate burning, resulted in an increase in *Acacia* bushland and woodland (Larsen & Lane, 2005). In addition European farm owners invested in boreholes and dams for their ranching operations making water readily available for both livestock and wildlife. These factors are likely to have encouraged elephants and other species of large mammals to establish territories in Laikipia after independence as is discussed further in the section below.

[1] DC/LKA/1/15, DAR 1929, p.233

Smallholder settlement

Smallholder settlement in Laikipia developed against a backdrop of massive population pressure in central Kenya, growing discontent over African land-rights that culminated in the armed 'Mau Mau' uprising, and the transfer of power from a colonial to an independent Kenyan government in 1963.

The 'million acre scheme', set up by the British government in 1961 with the objective of purchasing and sub-dividing European farms in the arable 'scheduled areas' gained momentum after independence in 1963. However these government settlement schemes played a relatively insignificant contribution to smallholder settlement in Laikipia. In fact the main means of land acquisition in Laikipia for settlement was through non-governmental land buying groups (cooperatives or companies). These self-help groups were typically comprised of many willing buyers and one or several influential personalities such as politicians. For example, among the chairmen of twenty selected land buying cooperatives that had bought land around Nanyuki, the administrative centre of Laikipia, seven were either senior government administrators or politicians (Kohler, 1987).

The involvement of both businessmen and politicians in these land buying schemes is likely to have played a significant role in the decline in both plot size and cultivation potential of land distributed among cooperative shareholders (Huber & Oponde, 1995). Campaign tactics encouraged (and still encourage) politicians to try and settle as many landless people as possible rather than consider the suitability of the land available. Businessmen may have been more concerned with the profits to be made through the resale of sub-divided large-scale farms to cooperative shareholders. In either case, as suitable arable farms became scarce, large-scale farms in more arid areas were purchased and subdivided. However, due to poor rainfall, plots here could barely be farmed and so were often abandoned (Huber & Oponde, 1995). These abandoned units attracted a range of different pastoralist groups struggling with similar problems of population pressure in addition to armed conflict in their home areas. Pokot, Turkana, Samburu and Mukogodo Maasai groups, previously restricted from grazing on the Laikipia plateau by the colonial administration, now occupy and graze their livestock on these abandoned smallholder land units. The presence of small-scale cultivated plots in Laikipia has precipitated widespread crop-raiding by elephants. This is now considered the single biggest issue relating to wildlife within the district and is often politicised as will be shown in parts of this thesis (Chapter Nine).

In summary the process of land sub-division and small-scale settlement in Laikipia is significant in the current context for three reasons:

1) It set a precedent for the use of land by political leaders to gain political support in Laikipia.

2) It created a patchwork of farms that became subject to wide-spread elephant crop-raiding.

3) It created a pattern of absentee properties held by landlords that became available for opportunistic pastoralists and other resource users.

The Arrival of the Elephants

In the context of the last two hundred years, records suggest that elephants in any numbers are relatively recent arrivals in Laikipia. Elephants do not appear to have been observed on the Laikipia plateau by early European explorers (Newmann, 1898; Hohnel, 1894). It is not entirely clear why this was the case though it may have been the result of the combined effects of high livestock densities, burning for pasture improvement and the then ivory trade and associated African elephant hunting that drove elephants into thicker cover to the north and within the region’s forests. These potential impacts are discussed further in Chapter Two with reference to recent discussions of the regional impact of the historical trade in ivory. During European settlement, elephants were shot by colonial game wardens in Laikipia’s forests in and to the west of the present day district boundaries, for the purpose of deterring crop-raiding (DC/LKA/1/115, 1928), but were absent or rarely seen on the savannah plains and woodlands covering the rest of Laikipia. From the 1960s elephants were occasional visitors to the Laikipia plains and by the late 1970s they were present in significant numbers (Thouless, 1994). It is likely that intense poaching in Samburu

District occurring into the 1980s prompted elephant immigration into Laikipia. An aerial count in 1977 estimated 2093 live elephants to 51 dead elephants in Laikipia, while in neighbouring Samburu there were an estimated 710 live elephants to 2793 dead (Thouless, 1992).

Elephant movement into Laikipia was originally resisted by Laikipia's large-scale ranches whose stock fencing, water pipes and other infrastructure were threatened with extensive damage. In addition, crop-raiding in the smallholder settlement areas became a problem. As a consequence there were several attempts to drive elephants to the north of the district (Mwenge International Ltd, 1979). However because Laikipia was relatively secure, with ample forage and permanent water from boreholes and dams, there was little incentive for elephants to leave, and inevitably these drives failed in their objective. Since the initial wave of elephant immigration, large-scale properties have learned to live with elephants and the management approach consistently proposed for managing human-elephant conflict in the district is to separate elephant tolerant from intolerant properties through the construction of a district-wide elephant fence (Jenkins & Hamilton, 1982, Thouless, 1993, Thouless et al., 2002). Over 3,000 elephants were counted in Laikipia in 2002 (Blanc et al., 2003).

Because of the diversity in land-tenure, use and management across Laikipia, the arrival of elephants has resulted in a range of interactions with people across time and space. These interactions and the patterns to which they contribute are the subject of this thesis.

1.4 THESIS STRUCTURE

1.4.1 The challenge of complexity

As was illustrated earlier in this chapter, Laikipia exists beyond the Kenyan protected area network, supporting a range of livelihoods and associated land use regimes while at the same time supporting a diverse range of wild animals and natural habitats. This context presents a unique research opportunity by providing a microcosm for the range of landscape and land management types under which wildlife exists across

Africa. The complexity of the Laikipia landscape, however, also presents a challenge for research into human-elephant interaction. This challenge could be divided into two categories:

1. The need to consider interaction at multiple scales: The conceptual model presented in this chapter suggests that the nature of the relationship between people and elephants varies depending on the temporal and spatial parameters under consideration.

2. The need for interdisciplinary methods: In Chapter Two, I will draw on the existing literature to demonstrate that human-elephant interaction is comprised of both ecological and social dimensions

Within the context of this thesis the 'scale problem' is best presented as a question: what is the appropriate scale for research into human-elephant interaction in Laikipia and the associated response in terms of elephant ecology? The complexity of ecosystems is now well established within the ecological literature (Gillson & Lindsay, 2003) and patterns within ecosystems are increasingly viewed as the result of a 'hierarchy of processes' (Wu, 1999, Wu & Loucks, 1995). For example, Gillson (2004) describes how different ecological processes determine tree densities in an East African savanna at micro, local and landscape scales and patterns of tree density identified at higher scales can only be fully explained by studying smaller scale processes. Given this emerging view of ecosystems, it would seem that human-elephant interaction in Laikipia could only be understood through investigations carried out at multiple scales.

The principal observation based on previous work that underpins the structure of this thesis is that human-elephant interaction is not a phenomenon that can be easily represented at different scales by a single variable such as crop-raiding incidents but instead requires different sorts of data and analyses to understand processes at different scales. Therefore, research into human-elephant interaction requires not only consideration of the 'scale issue' but also requires interdisciplinary methods. Similar conclusions have been reached by a number of researchers working towards understanding other sorts of environmental problems (Mascia et al., 2003, Stem et al., 2005).

Based on the discussion above I used several strategies for managing the complexity of the Laikipia landscape:

1. I focus on one particular component of the system as represented by human-elephant interaction and the associated response in terms of elephant ecology which for the purpose of this thesis is the distribution, abundance and movement of elephants across time and space. Because of their size, ecological adaptability and wide-ranging movement patterns elephants are, perhaps more than any other species of mammal in Laikipia, 'landscape' relevant, simultaneously occupying multiple zones of human land use and interacting with associated human occupants. Elephant ecology is measured in this thesis to identify patterns and describe ecosystem function.

2. I use an analytical framework that identifies patterns and assesses causal relationships on nested spatial scales. The ability to move between scales was facilitated both conceptually and in practice through the use of a Geographical Information System (GIS).

3. This thesis used a multidisciplinary approach, using research techniques from both the social and natural sciences to identify causal relationships through a process of triangulation.

While the overall research strategy I describe above helped create parameters for carrying out research within the Laikipia landscape, there were obviously practical limitations to what could be achieved in the time available. Firstly, investment of effort was allocated between different spatial scales providing a rather broad overview of nested interactions rather than a highly detailed analysis of interactions at any single scale. There were also trade offs that had to be made between the empirical identification of ecological pattern and the iterative process of identifying causal effects and illustrating the significance of context. Thus the final thesis structure represents a ‘mixed bag’ designed to provide insights into a complicated topic of research within the time that was available.

In the next chapter I will provide a review of the literature on human-wildlife conflict with the aim of contextualising this thesis. In Chapter Three I describe the sources of data used in each of the analytical chapters. Here I summarise each of these analytical chapters, together with the sources of data and analytical approaches used for identifying and analysing ecological and social dimensions of human-elephant interaction in Laikipia at nested scales.

1.4.2 Ecological patterns and land use

Chapters Four to Seven present ecological patterns in Laikipia across time and space at different spatial scales with the natural variation in ecological and socio-economic parameters providing a ‘natural experiment’(de Merode, 1998, Diamond & Case, 1986). Table 1.1 shows the sources of data used in relation to specific research questions within each of these four chapters.

Chapter Four presents ecological patterns across space and time at the landscape level through GIS based analyses using ArcGIS v. 9 (ESRI, 2004). The advantage of using a GIS is that multiple layers of information covering large areas can be integrated into a single database, facilitating the identification, description and analyses of ecological patterns at different scales. Three types of wildlife distribution data were used to identify and assess ecological patterns in the Laikipia ecosystem. The first of these data were aerial sample and total counts of wildlife, made available by the Government of Kenya Department of Resource Surveys and Remote Sensing (DRSRS) and the Kenya Wildlife Service (KWS), respectively. Wildlife and livestock population estimates for Laikipia were compared over time to identify trends. In addition, sample aerial count data were reanalysed to calculate densities for both wildlife and livestock within different land-use categories to identify explanatory effects. The second set of data used comprised the GPS positions of sixteen elephants I tracked using GPS collars. These collars were made available by Save the

Elephants[2] through a collaborative project carried out in 2004 (see chapters three and seven). The third and final data used were GPS locations of crop-raiding incidents collected through a network of local scouts that I recruited, trained and supervised throughout the fieldwork period with the financial support of the Centre for Training and Integrated Research and Training in the ASAL Development (CETRAD), a Government of Kenya research institution supported by the University of Berne, Switzerland, and based in Nanyuki town, Laikipia. The use of these multiple sources of data: 1) allows the limitations of aerial count data to be overcome; 2) provides data that better represent the biology of the animal under consideration and; 3) challenges preconceived notions of ecological patterns in human dominated landscapes.

Chapter Five moves down a notch in scale, identifying and assessing the relative abundance of elephants across discrete sample areas within which human livelihoods, land-tenure, land use and land management were relatively homogenous. This is achieved through analyses of direct observations of elephant dung, vegetation cover and human resource use, collected using standard transect sampling techniques (Buckland et al., 2001). I chose to use dung count methods, which can be more reliable than aerial counts for estimating the relative abundance of elephants and other large mammals (Barnes, 2001, Jachmann, 1991, Young et al., 2005) and are certainly more cost effective (Jachmann, 1991). Spatial data on the distribution of elephant carcasses and qualitative material drawn from informal interviews with resource users and land managers were used to both contextualise and inform the analysis of the ecological patterns identified. The transect survey provided higher resolution data that were used to both cross-check and explore determinants of, the broader spatial patterns identified in Chapter Four.

[2] Save the Elephants is a UK registered charity (www.savetheelephants.com), based in Kenya, with GPS tracking expertise. The collaborative project was entitled the 'Ewaso Ngiro Elephant Research and Conservation Project', that I designed and carried out with Save the Elephants between January and December 2004 through a grant provided by the United States Fish and Wildlife Service, Assistance Award No: 98210-4-G793 and the Safaricom Foundation. Use of GPS collaring data generated from this project is guided by a protocol agreed to with Save the Elephants. Under this protocol Save the Elephants own the GPS tracking data but I have complete freedom to analyse and present these data, subject to clear acknowledgement of ownership. In the event of a publication (journal or book chapter) using these data, co-authorship will in all cases be offered to Dr. Iain Douglas-Hamilton, the executive director of STE.

Chapter Six presents a spatial analysis of crop-raiding by elephants in Laikipia at different scales. As mentioned earlier, the data on crop-raiding used in this analysis were collected by trained local enumerators, 'scouts'. This approach was used to generate a reliable and consistent data series rather than the patchy or potentially exaggerated data sources that would have been available from government records and questionnaire surveys, respectively. Scouts were initially employed through funding from my ESRC/NERC studentship (award no: R42200134211). In August 2003 CETRAD provided funding to employ scouts through a grant from the Government of Switzerland. All of the independent variables used in this analysis were derived through manipulation of spatial data using GIS techniques. The statistical analysis was carried out using an approach adapted from a recent study of human-elephant conflict in Transmara District in southern Kenya (Sitati et al., 2003). This latter study represents the latest and most advanced attempt to analyse human-elephant conflict within a spatial framework.

Chapter Seven examines yet another scale of human-elephant interaction through analyses of individual elephant movement patterns based on the GPS tracking data mentioned above. The collection of these data necessitated an extra year of fieldwork and as was mentioned earlier, this was made possible through a U.S. Fish and Wildlife Service grant and the support of Save the Elephants. The technology for remotely downloading elephant location data at hourly intervals for extended periods of time has only become readily available within the last few years. The collars I deployed to collect the data used in this thesis were the first of their kind, using the local mobile phone network to transmit location data remotely (i.e. via text messages). Thus the GPS tracking data used in this thesis are unique both because hourly positions on elephant movement have not been available or analysed before and because this is the first time to my knowledge that such high resolution movement data has been available for elephants occupying a land-use mosaic. For these reasons I felt the collection of these data was justified despite the necessity of spending an extra year in the field. The collection of these data did however have further implications in terms of data processing and analyses. The tracking files were extremely large (up to 20,000 records for a single elephant) and therefore took considerable time to clean, prepare and analyse. Once again this was achieved largely through the use of GIS software and is described in detail in chapters four and seven.

1.4.3 Human livelihoods, land management and perceptions of elephants across a land use-mosaic

If one considers human-elephant interaction in Laikipia as a 'hierarchy of processes' then an understanding of the causal effects of the higher scale ecological patterns assessed in Chapters Four, Five, Six and Seven requires knowledge of the livelihood activities and associated interactions with elephants that occur at lower scales. These lower scale interactions are investigated in chapters four, eight and nine based largely on analyses of questionnaire survey data and qualitative material collected through informal interviews during the fieldwork period. There were of course other options that could have been used for carrying out research into local livelihoods and associated interaction with elephants. The selection of the methodology described is therefore further discussed in Chapter Three.

Over and above the questionnaire data and qualitative material analysed in Chapters Four, Eight and Nine, other types of data sources were used in these chapters. In chapter four I used remote sensing and aerial survey data to facilitate description-at a coarse scale-of the variation in the distribution and abundance of settlement, cultivation and livestock production across space and time. In Chapter Nine I use crop-raiding incident data to compare perceptions of loss against actual loss to elephants. Lastly, I update the base maps on land use and land-tenure produced by Kohler (1987) in a GIS to show coarse changes in land-tenure over the last 15 years and to better describe current land use. This is achieved by analysing data collected through my fieldwork, interviews with local ranch managers and conversations with other local informants.

Table 1.1 Research questions and data used for the analysis of ecological patterns.

Question	Scale	Data	Source
Temporal and spatial variation in wildlife distribution and density in relation to human land use (Chapter 4)	Landscape	Aerial sample counts 1985- 2003 (19.2% sampling intensity) Aerial total counts 1992 and 2002 Classified Landsat TM images 2002 3668 HEC reports 2003-2004 GPS collar data 2004-2005 Human Land use/Land tenure	GOK, DRSRS[3] KWS[4]& Thouless, 1992 MRC[5] PhD fieldwork PhD fieldwork/ STE[6] CETRAD[7]/ fieldwork
Relative abundance of elephants in relation to vegetation cover, human activity and land management (Chapter 5)	Land use zone	Dung density along 56 line transects (2 km each) 189 elephant mortality reports 16 informal interviews	PhD fieldwork PhD fieldwork /STE[8] PhD fieldwork
Distribution and intensity of crop-raiding by elephants (Chapter 6)	Land use zone	2420 crop raiding reports 2003-2004 GIS vector layers of rivers, roads and ranch boundaries Cultivation (Classified Landsat TM Scenes) Sample aerial count of human dwellings in 2004	PhD fieldwork CETRAD[7] MRC[5] DRSRS[3]
Elephant movement across a land-use mosaic (Chapter 7)	Landscape Land use zone Land unit	GPS collar data 2004-2006 Land use/land tenure Land cover (Classified Landsat TM images)	PhD fieldwork/ STE[6] CETRAD[7]/ PhD fieldwork MRC[5]

[3] GIS shape files of sample aerial counts of animals and dwellings, together with animal population estimates were made available through the Government of Kenya, Department of Resource Surveys and Remote Sensing, through a grant provided by the British Institute of East Africa.

[4] GIS shape files of 2002 elephant total count made available through the Kenya Wildlife Service (www.kws.org)

[5] Classified Landsat TM scenes made available through Mpala Research Centre (www.mpala.org)

[6] GPS collar data collected by me in collaboration with Save the Elephants (see footnote 2)

[7] GIS shape files of land-tenure/land use, road and rivers were made available through the Centre for Training and Integrated Research in ASAL Development, (CETRAD).

[8] 50 Elephant carcass reports were collected either by me or my field assistants. The remaining 127 reports were collected in the field by Onesmus Kahindi, a Save the Elephants employee, and made available to me through Save the Elephants. Where verified by me or my field assistants these reports were used in this thesis (see chapters 3 & 5).

Table 1.2 Research questions and data used for human land use and interactions with elephants

Question	Scale	Data	Source
Human land use across time and space (Chapter 4)	Landscape	Land-tenure/land use	CETRAD[7]/ PhD fieldwork
		Sample aerial counts of livestock & human dwellings (1987-2003)	DRSRS[3]
		Cultivation (classified Landsat TM scenes 2002)	MRC[5]
		356 household questionnaires	PhD fieldwork
Household activities and associated interaction with elephants (Chapter 8)	Land use zone	356 households questionnaires, 16 informal interviews, field observations	PhD fieldwork
	Land unit	356 households questionnaires, 16 informal interviews, field observations	PhD fieldwork
Perceptions of elephants (Chapter 9)	Land use zone	356 households questionnaires	PhD fieldwork
	Land unit	2420 crop-raiding reports (elephants) 2003-2004	PhD fieldwork
		361 crop-raiding reports (other species of wildlife) 2003-2004	PhD fieldwork

Chapter 2: Human-wildlife conflict and the persistence of large mammals

2.1 INTRODUCTION

In Chapter One I briefly presented a conceptual paradigm for exploring human-elephant interactions within Laikipia. The importance of considering wider historical and social processes and factors was stressed and illustrated within the Laikipia context. In addition the main research questions and hypotheses of this study were presented. In this Chapter, I present a review of the wider body of conservation literature to build a framework for the questions and hypotheses introduced in the last chapter. Some of the concepts and case studies presented in this chapter will be used to help inform analyses of data collected in Laikipia District between 2002 and 2005 and presented in subsequent chapters.

The topic of this thesis falls broadly within the field of human-wildlife conflict. To facilitate exploration of this complex field, it can be broken down into two main categories:

1) The impact people have on the ability of wild animals to persist in a given landscape. Such impacts include: a) direct mortality and injury; b) fragmentation of natural habitats through conversion into crop-fields, settlement and livestock pasture and; c) the creation of barriers to wildlife movement (fences or human activities that scare or deter animals). The latter can deprive wildlife populations of genetic exchange and access to seasonal food and water resources.

2) The deleterious impact that wild animals have on the well being of local-people. This category of human-wildlife conflict includes human deaths and injuries, crop-raiding, livestock predation and the constraints presented to general day to day human activities (e.g. collecting firewood, travelling to school)

Both of these categories of human-wildlife conflict are reviewed in this chapter. It is important to note, however, that not all interaction between people and elephants is negative. This will be explored further in Chapters Eight and Nine.

The first section of this chapter will explore the exploitation of elephants with a particular focus on the ivory trade over the pre-colonial, colonial and post-colonial periods. The next section will examine the changing narratives that describe the ecological impacts of land use and landscape change on elephant populations with a particular focus on wildlife persistence in human-dominated landscapes. The third and final section of this chapter will explore the available literature on human-wildlife conflict with a focus on case studies of human-elephant conflict, with both ecological and social dimensions of this phenomenon explored.

2.2 ELEPHANTS AND IVORY

The accounts of early European travellers and explorers in Africa indicated a conspicuous absence of elephants and other large mammals in some apparently suitable areas suggesting that hunting by indigenous Africans had contributed to localised extirpations (Neumann, 1898, Selous, 1881, Thomson, 1885, von Hohnel, 1894). Indeed such accounts might support the narrative of ‘competitive exclusion’ between people and elephants posited by a number of researchers and discussed further in subsequent sections of this chapter (Eltringham, 1990, Happold, 1995, Parker & Graham, 1989). The expansion of the ivory trade, however, had penetrated the African interior for several centuries and had existed for millennia, prior to the arrival of the first Europeans, and its influence on elephant distribution during the pre-colonial period is likely to have been highly significant (Surovell et al., 2005). Thus during that time, it is likely that trade, not competition for space, affected elephant distribution.

Ivory was in high demand in early Egypt. It was subsequently used by the Romans and in China and India. The historical demand for ivory among the early civilisations of Rome, Egypt, China and India is thought to have contributed to the extinction of elephants from Syria around the 4th Century A.D. and from the rest of North Africa by the 7th Century (Spinage, 1994). By the 15th Century profitable trade with the Middle East, China, India and subsequently Europe had precipitated extensive settlement by Swahili speakers along the East African coast (Hakansson, 2004). Between 1500-1700 Europe was importing between *c*. 100-200 tonnes of ivory per year and by the late 19th century, European ivory imports may have been as high as 700 tonnes per year (Spinage, 1994) representing tens of thousands of elephants killed per annum. The huge demand for ivory over the centuries is likely to have created an extensive and complex trading network within pre-colonial Africa. In addition it would have encouraged local people to hunt. Some of these groups, particularly those entirely dependent on hunting, would have become adept at killing elephants. This pattern is illustrated in Dalleo's (1979) exploration of early Somali trade and 'poaching' in northeast Kenya. Prior to British occupation, Somali camel caravans travelled into the interior to procure game trophies, slaves and gums, destined for the coast and export. The indigenous people living along these caravan routes supplied Somali traders with ivory, including the Turkana and Samburu of present day northwest Kenya; the pastoral Boran, Gabbra, and Sakuye who sometimes hunted elephants on horseback near Mt. Marsabit; and Kikuyu and Meru people living and farming around Mt Kenya. Some of these groups had 'client' hunters. An example of such a client group is the 'Wata', once believed to be the client hunters of Orma pastoralists and traders (Parker, 1983). The Wata became the main focus of anti-poaching operations in Tsavo National Park under the then Kenyan colonial administration. Another hunting group, the Boni, hunted elephants directly for Somalis as indentured servants (Dalleo, 1979). It is highly likely that the Yaaku and other hunting groups in and around the Laikipia region were involved in this trade prior to British occupation and had similar relationships with their pastoralist neighbours[9]

The British established game laws in East Africa as early as 1897 (Dalleo, 1979). These laws were originally designed with the intention of restraining opportunistic and unscrupulous European hunting in designated areas as much as, if not more than, indigenous hunting (Adams 2004: 30-36). In addition, much effort was made to secure revenue from the control of the ivory trade (Steinhart, 1989), principally through a strict licensing systems. This licensing system also intended to discourage trade of ivory among indigenous groups such as the Somalis, though was largely unsuccessful (Dalleo, 1979). During the 1950s in the then Kenya Colony, the Game and National Park Departments noted an increase in elephant poaching by indigenous

[9] Herron (1991) describes how the early hunter-gathering groups that occupied Laikipia and the surrounding region acquired livestock by trading tusks with coastal traders, Somalis and Europeans. However according to oral traditions these groups often gave their livestock to their 'patrons', dominant pastoral neighbours, for safe keeping as they were afraid of being attacked by raiders.

hunters in the east of the colony (Parker, 2004, Steinhart, 1994), leading to the first major large-scale anti-poaching operations of their kind as will be discussed further below.

The 'ivory crisis' describes the period between the early 1970s and the early 1990s when African elephant populations declined dramatically in response to intense poaching. Over this period Uganda's elephant numbers fell from an estimated 17,600 to 1,800, in Kenya from 130,00 to 19,000 and in Tanzania from 185,000 to 87,000 (Douglas-Hamilton, 1987). This surge in poaching has been linked with a number of factors. The first of these was growing prosperity in Asia, where the use of ivory for cultural, ornamental and ceremonial purposes has a long history. The second factor was political instability and war in many newly independent African countries, resulting in both a regional glut in modern firearms and an absence in administrative control inside and outside of protected areas. As a result, increasingly well-armed and dangerous poaching gangs infiltrated places such as Tsavo National Park in Kenya. In Uganda, political instability had deteriorated to the extent that the Ugandan military were directly involved in wide-scale elephant poaching within national parks. The third reason for the surge in ivory poaching was corruption within game departments and tacit support among higher levels of government.

The scale of the commercial poaching experienced in some parts of Africa had two main effects. The first was the militarization of wildlife authorities in response to the danger presented by well-armed poaching gangs. This was epitomised in Kenya, with the establishment of the paramilitary Kenya Wildlife Service and an infamous 'shoot to kill' policy for deterring poachers (Leakey & Morrely, 2001). The second was the CITES (Convention on the International Trade in Endangered Species of Wild Fauna and Flora) ban on the ivory trade, prompted by the hard and sometimes graphic evidence for the widespread poaching of elephant populations across Africa that was propagated by the media at the time.

The effect of the CITES ban on the trade in ivory is still debated (Stiles, 2004) but poaching pressure on savannah elephant populations has reduced and in some African range states, such as Kenya and Tanzania, elephant numbers have since increased though are still below pre-poaching levels (Blanc et al., 2005). There is pressure from

Southern African range states, where elephant populations are increasing in number due to effective protection and management, to lift the ban in the trade in ivory (Gillson & Lindsay, 2003). In contrast, the pervasive effects of continuing war and political instability in the Africa equatorial forest zone (Draulans & Krunkelsven, 2002) is thought to have placed forest elephant populations under intense poaching pressure (Blanc et al., 2003).

2.3 LAND USE CHANGE, PEOPLE AND ELEPHANT POPULATIONS

The pre-colonial African landscape has been characterised as small, scattered human settlements existing in a ‘sea of elephants’ (Parker & Graham, 1989). However the arrival of Europeans and the establishment of colonial administration in Africa marked the beginning of a new phase in human-elephant interaction.

Modern weapons used by early European hunters and their African servants facilitated the slaughter of large mammals in prodigious quantities (MacKenzie, 1988). Hunting of elephants by Europeans and the ivory trade more generally during the pre-colonial period is likely to have resulted in major transitions in the spatial occurrence of human-elephant conflict as elephants shifted their range beyond the intense hunting spheres of the European ivory market.

The creation of game laws and game departments effectively transferred responsibility for crop pest management from the local people living with large mammal pests such as elephants, buffalos and hippos, to the colonial authority. In some parts of British Africa where game was inimical to the commercial interests of European settlers, ‘African tribes’ and/or the ‘crown’, its elimination was sanctioned by colonial governments and as was mentioned earlier, became the principal activity of game departments, resulting in hundreds of elephants and rhinos killed on ‘control’ each year (Steinhart, 1989). The main objective of these game control exercises was to pave way for settlement and protect crops (Adams 2004: 73-75). In other parts of Africa game was exterminated in huge numbers in an attempt to control the spread of disease, particularly sleeping sickness (Adams 2004: 162-266). Where effective, the introduction of the combined system of game laws, a central wildlife authority and protected areas prevented Africans from carrying out traditional systems of wildlife control and management. This had implications for future vulnerability of small-scale farmers living with large mammal pests such as elephants (Naughten-Treves, 1997) as will be discussed later in this chapter.

Thirdly this period marked the first phase in the designation of protected areas for wildlife preservation in Africa. By the 1930s the ideology of game preservation had taken root in the western world. There was growing consensus among European colonial powers on the need for game reserves in Africa. However it wasn't until after the Second World War that a national park system became established in East Africa. These 'internal frontiers' profoundly altered the historical relationship between African people and elephants. The establishment of national parks in Africa often involved the removal of indigenous African groups and illegalised all usufruct use of the gazetted area (Anderson & Grove, 1987). In addition, perhaps for the first time, resources were made available to focus on the task of controlling elephant poaching and the ivory trade. This was highlighted in the case of Tsavo National Park, where an effective anti-poaching campaign practically eliminated elephant hunting by the indigenous Wakamba and Wata people (Parker, 2004, Steinhart, 1994). Where effective the process of creating protected areas contributed to localised vegetation changes. These apparent changes continue to shape much of the debate concerning elephant conservation and management in Africa today.

2.3.1 The 'elephant problem'

While African national parks attempted to create inviolate sanctuaries from which people were excluded, they also contributed to the emergence of a perceived new conservation crisis, commonly referred to as the "elephant problem"(Glover, 1963). In Tsavo National Park in Kenya the impact of conservation policies and effective protection from indigenous hunters resulted in a rapidly growing elephant population. While local people may have been excluded from the park so too were wildlife excluded from areas beyond the park. As a consequence, Tsavo's large and growing elephant population had a visible impact on the park's woodlands (Laws, 1970, Napier Bax & Sheldrick, 1963). This combined with a persistent drought created the appearance of a devastated landscape, leading to a debate among scientists and park managers as to the appropriate management measures that might be taken, including the option of an elephant cull (Laws, 1969). However this proposed intervention challenged the preservationist concept underpinning the creation of the national park as a natural wilderness. Consequently proposals for an elephant cull were rejected and shortly thereafter the elephant population crashed after a prolonged drought (Corfield, 1973). The elephant population in Tsavo decreased further still as a result of uncontrolled poaching for ivory in the mid-1970s from 17,487 to 5363 (Douglas-Hamilton et al., 1994). The Tsavo ‘elephant problem’ had a resounding impact on the scientific community at the time and soon there were a number of studies carried out in other national parks where other ‘elephant problems’ emerged (Barnes, 1983b, Russel, 1968).

The ‘elephant problem’ encouraged the emergence of systematic elephant culling as a management tool for various conservation areas in Africa. Examples of such operations include the cull of 2000 out of 14000 elephants in Murchison National Park, Uganda (Laws et al., 1975). In response to ethical arguments and uncertainty over the long-term impact of elephant-vegetation dynamics, culling was suspended in southern Africa in the mid 1990s. However, elephant populations have increased considerably in southern Africa (Botswana, Zimbabwe and Kruger National Park in South Africa) and with the localised decline in woodland cover the ‘elephant problem’ narrative has resurfaced. This narrative however is increasingly challenged as a result of the equilibrium to non-equilibrium paradigm shifts in ecology (Gillson & Lindsay, 2003, Scoones et al., 1993) and emerging models suggest that different ecological processes dominate tree abundance at micro, local and landscape scales so that:

“*to understand vegetation patterns in savannah landscapes, it is necessary to study vegetation dynamics at a range of spatial scales, using data which covers hundreds of years*” (Gillson, 2004).

This is expensive and difficult to achieve and therefore simplistic assumptions about elephant-vegetation interactions are unlikely to be reliable. The problem of elephant over-browsing in protected areas is a classic ‘environmental narrative’ (Leach & Mearns, 1996)

2.3.2 Elephants and people in competition

As was mentioned briefly in Chapter One, Parker and Graham (1989) presented a model of elephant populations suggesting that human population growth and settlement expansion were more significant threats to elephant populations over the long term than was the ivory trade. They suggest that because humans and elephants have common environmental requirements, competitive exclusion of elephants will occur in preferred habitats where human populations reach a certain density. Parker and Graham’s (1989) analyses show that in highly fertile regions of Kenya, elephants do not occur where human density is greater than 82 persons/ km^2. In some Zimbabwean regions, where soils are considerably less productive, they estimated the human density threshold for elephant occurrence to be considerably less at 18.5 persons /km^2. This model of competitive exclusion has been supported by a number of other studies. For example Barnes et al. (1991) found that densities of forest elephants decreased with linear distances from roads and/or villages. There is evidence to suggest that patterns of competitive exclusion also exist between people and other large mammals (Happold, 1995, Newmark et al., 1994).

The coarse scale at which Parker and Graham (1989) carried out their investigations may have overlooked important elements of the relationship between people and elephants at finer scales. Hoare and Du Toit (1999) carried out a similar analysis in the Sebungwe region in Zimbabwe. Data for the same region was used in Parker and Graham’s (1989) model. However, while Parker and Graham used data at the district level, Hoare and du Toit (1999) carried out their analysis at the ward level, representing the smallest unit of administration in Zimbabwe. Results from this finer level of analysis indicate that while elephant density and human density were inversely correlated, this relationship does not fit a linear model. Instead elephant density was shown to be unrelated to human density until a threshold of human density is reached at about 15.6 persons/ km^2, representing a transformation of land to agriculture of between 40 and 50%, at which point elephants vanish. Hoare and du Toit (1999) concluded that the sudden disappearance of elephants above this threshold could be attributed to elephants moving away to less disturbed habitats rather than dying *in situ*.

They also suggest that when the total area of land transformed by human settlement exceeds a critical level, "the size and connectivity of the remaining patches of elephant habitat are then the determinants of whether or not elephants remain as residents or move away," (Hoare & Du Toit, 1999). These conclusions bring to light the role of both habitat transformation and elephant ecology in determining the ability of elephants to persist in human landscapes.

2.4 EGGS AND BASKETS: HABITAT FRAGMENTATION AND WILDLIFE PERSISTENCE

Several studies have attributed declines and extinctions of large mammals directly and indirectly to human-induced habitat fragmentation (Newmark, 1995, Newmark, 1996, Western & Ssemakula, 1981). While habitat fragmentation may not be the ultimate cause of local extinctions of large mammals, the process of habitat fragmentation is thought to lead to isolation of small populations that are considered vulnerable to stochastic processes that may lead to extinction. Stochastic processes have been categorised as follows (Bennett, 2003, Shaffer, 1997):

- Genetic: Loss of genetic diversity and a reduced capacity for a population to resist recessive lethal alleles or respond to changing environmental conditions (can occur through genetic drift, inbreeding etc)

- Demographic: Factors affecting birth, immigration, death and emigration. For example if a small population, by chance, experiences low birth rates, the immediate survival of the population may be greatly reduced.

- Environmental: Seasonal change, which for example may affect food supply, rates of survival, fecundity etc.

- Natural catastrophes: Floods, fires, hurricanes etc

It is possible that these four processes may interact with a population simultaneously and their relative impact will vary depending on context. Given the threat these stochastic processes pose to isolated populations, conservation biologists have attempted to develop guidelines for establishing the requisite size of a population for it to be considered ‘viable’ (Gilpin & Soule, 1986, Soule, 1987). Estimates for the numbers required for populations to persist vary in relation to the temporal scale and particular situation under consideration. For example, while between 70 and 90 individuals are considered sufficient to ensure the persistence of a grizzly bear population for a century, a much larger population would be needed to ensure persistence for up to 200 years (Shaffer, 1997).

To determine the viability of populations of large mammals there are several population specific factors that are considered important. These include reproductive rate, survivorship, and genetic effective population size[10]. In large mammals, particularly carnivores, empirical evidence suggests that values for these characteristics can be low, increasing vulnerability to extinction (Noss et al., 1996). For example, wolves in the Rocky Mountains have relatively high reproductive rates but survivorship of pups in a female’s first year is low. In addition, only a single alpha female and alpha male in each pack breed. These and other character traits have led to suggestions that the genetically effective population (N_e) size for wolves may be as low as 33% of census size (Noss et al., 1996). In addition to genetic and demographic considerations in population viability assessments, there are other density-dependent factors that pose significant challenges for conservation planning.

The densities of large mammals are considered to be restricted by factors such as the availability of resources (mainly food and water) and/or intra or inter specific competition (Meffe & Carroll, 1997). For example densities of prey have shown to influence both densities and home ranges of large carnivores (Weaver et al., 1996) and elephant densities have been reported to vary with habitat quality (Parker & Graham, 1983, Parker & Graham, 1989). These factors have implications for the size of reserves needed to retain viable populations. Metzgar and Bader (1992) estimate that based on average grizzly bear density in the Rocky Mountains, 129, 500 km^2 of ‘wild lands’ would be needed to maintain an N_e of 500. Such spaces are “so large as to

[10] The concept of genetically effective population size (N_e) takes into account that in natural populations breeding sex ratios may be uneven, reproductive success among females may be uneven or the population has undergone a major reduction in size. As a consequence, N_e is always significantly smaller than the census population size.

strain credibility,"(Noss et al., 1996). Conceptually, however, the creation of such mega-reserves to ensure large mammal persistence may not be necessary if separate populations can be connected in space in what effectively would constitute a reserve network.

2.4.1 Metapopulations

While the focus on the dynamics and management of small populations is relevant to isolated patches, there is growing recognition that such fragments interact with the surrounding matrix. Indeed individuals may move from one patch to another. Within this context there are two concepts that have helped aid understanding of the dynamics of small populations. These are: 1) metapopulations; and 2) source-sink theory. A metapopulation has been defined as a:

"*network of semi-isolated populations with some level of regular or intermittent migration and gene flow among them, in which individual populations may go extinct but can then be recolonised from other populations*" (Meffe & Carroll, 1997).

The metapopulation framework has been used to explain the structure of a number of populations of large mammals in contemporary human landscapes. For example, Sweanor et al. (2000) show that cougars in the San Andres Mountains, New Mexico, exhibit characteristics consistent with the metapopulation concept. They estimated that on average 8.3 cougars successfully emigrated from, and 4.3 cougars immigrated to, the San Andres Mountains each year. Males were found to disperse significantly further than females and were more likely to traverse large expanses of 'non-cougar' habitat. They conclude that cougar dispersal between patches facilitates the persistence of the population. This may be because immigration of individuals into a population theoretically reduces the N_e required to ensure population persistence. Several researchers have concluded that one migrant per generation is a sufficient level of gene flow for maintaining genetic diversity and preventing inbreeding (Frankel & Soule, 1981, Mills & Allendorf, 1996). While empirically this may be difficult to prove and is unlikely to be sufficient for many species (Wang, 2003), particularly large mammals, the level of dispersal recorded in San Andres is still likely to be 'good' for maintaining population structure.

The concept of ‘sources’ and ‘sinks’, related to the concept of a metapopulation, also assumes a degree of ‘connectivity’ (see below for a definition) between distinct populations or patches. However, in contrast to the metapopulation concept, the source-sink framework conceptualises a network of good habitats, where local reproduction is greater than mortality, and bad habitats, where local mortality exceeds reproduction. Within this framework individuals from source habitats will disperse to sink habitats, maintaining or even causing sink populations to increase (Pulliam, 1988). Thus it is conceivable that most of the individuals in a local population may exist in habitat that cannot maintain the population (Meffe & Carroll, 1997). So as to take into account human-induced mortality within seemingly source like habitat, Naves et al. (2003) further elaborated on this concept by including 3 further categories. These include: matrix, with no reproduction and/or very high mortality; refuge, with low reproduction and low mortality; and attractive sink, with high reproduction and high mortality. They found this expanded framework better explained bear population dynamics, particularly sites of extinction and probabilities of extinction, in the Cantabrian Mountains, Spain.

Both metapopulation and source-sink conceptual frameworks assume that a specific type of movement, ‘dispersal’, is possible between populations or patches. Dispersal has been categorised into two forms (Colbert et al., 2001): natal dispersal: the movement between natal area or social group and the area or social group where breeding first takes place; and breeding dispersal, the movement between two successive breeding areas or social groups. However, while dispersal has been used to study and explain population dynamics in fragmented habitats (Palomares et al., 2000), the distinction between these and other types of movement is arbitrary and it is obvious that other forms of movement will serve the same function as dispersal. As such, a more useful framework for assessing the ability of a small population to resist the process of isolation through movement is found in the more flexible concept of ‘connectivity’. Connectivity has been defined as the “degree to which the landscape facilitates or impedes movement among resource patches” (Taylor *et al.* 1993 as cited in Bennett, 2003). Bennett (2003) suggests that there are two components influencing connectivity for a particular species:

- Structural component: The spatial arrangement of different types of habitats in the landscape. Features of relevance within the structural component would be for example the continuity of 'suitable habitat', the extent and length of gaps, the distance to be traversed etc.

- Behavioural component: This relates to the behavioural response of individuals and species to the physical structures in the landscape

The metapopulation and source-sink frameworks described above underpin the perceived need for connectivity between habitat patches within the field of conservation biology. In addition, connectivity may be considered desirable to ensure individuals in a population have access to resources that are seasonally distributed. For these reasons, the principle that 'connectivity' is good, albeit expressed in different ways, is often one of the main assumptions in studies of small populations. This is illustrated through several case studies on the existence, use and planning of wildlife 'corridors'.

2.4.2 Wildlife Corridors

In their assessment of the status of known elephant corridors in India, Johnsingh and Williams (1999) concluded that too little had been done too late. Their findings suggest that of the five corridors investigated, all had been transformed by human activity including settlement, cultivation, and construction of roads, railways and army camps. As a consequence at least three of these corridors were no longer used and the remaining two were likely to be severed in the near future. On the basis of these findings, it was suggested that the Indian experience should be used to guide other Asian nations in prioritising areas for conservation (Johnsingh & Williams, 1999).

Osborn and Parker (2003) used GIS analyses to identify an elephant corridor between two elephant refuges in Zimbabwe. They did this by assigning weights to each of four land-use types between the two refuges based on subjective judgements of the risk to traversing elephants. These land-use types were: 1) 'suitable habitat', which had not been settled or cultivated; 2) riverine woodland; 3) settlement areas; and 4) areas surrounding roads. They then used a least-cost function using GIS software (ArcView-ESRI, 1996) to identify a path that would incur the lowest risks to potentially traversing elephants. The output from this analysis was a corridor of 41.6 km in length with varying widths depending on the availability of suitable habitat. The total area of the identified corridor was 350 km^2. Radio-tracking data from five female and eighteen male elephants in the two refuges were used to assess elephant use of the corridor identified in their analysis. Results show that only male elephants used the corridor. Because of a range of human activities, most notably killing of elephants and expansion of settlement and agriculture, it is considered unlikely that this corridor will be used in the near future (Osborn & Parker, 2003).

The two case studies described above illustrate situations in which corridors have been accepted as management and conservation tools for elephants specifically. The latter case was insightful in that it investigated the extent to which a corridor identified based on theoretical elephant preference was actually used by elephants.

Hilty and Merenlender (2004) also measured 'use' of corridors and found that the structure of corridors played an important role in determining the extent of use by mammalian carnivores in Northern California. Specifically they concluded that corridors that were riparian and/or wide were more frequently used than corridors that were narrow and/or located in vineyards.

Despite the importance attributed to corridors in facilitating the persistence of wildlife populations (Armbuster & Lande, 1993, Beier, 1993, Simberloff & Cox, 1987), there are few empirical studies on the subject of corridor use, such as that provided by the two case studies mentioned above (Lindenmayer & Nix, 1993). Even less research has been carried out to compare persistence of wildlife populations in isolated areas with and without corridors (Newmark, 1993). This is probably a reflection of the practical constraints to landscape-scale experiments for testing the efficacy of corridors (Inglis & Underwood, 1992). As a consequence there has been much debate into the value of corridors (Noss, 1987, Simberloff & Cox, 1987). Indeed some have argued that the presence of corridors may even facilitate the decline in wildlife populations by facilitating the spread of contagious diseases (Hess, 1994). None-the-less, acceptance of wildlife corridors has “outpaced scientific understanding” (Bennett, 1999) and corridors often form a central component of conservation planning (Harris et al., 1996). For example dispersal corridors were considered the central component of a ‘conservation landscape’, generated in a GIS and designed for tigers living in isolated populations along the Himalayan foothills (Wikramanayake et al., 2004). Thus despite uncertainty over their value, corridors have emerged as a major tool for conservation biologists, landscape ecologists and wildlife managers.

Corridors are one particular type of landscape structure relevant to connectivity and the broader issue of wildlife population decline. Often corridors are considered as continuous linear strips of contiguous wildlife friendly habitat and the main movement of concern along such strips is dispersal. However, there are other types of connecting habitats (e.g. stepping stones, habitat mosaics) and other types of movement (daily foraging or migratory movements) that can facilitate connectivity and are sometimes ignored in the corridor debate (Bennett, 2003). In addition the behavioural component of connectivity briefly mentioned above can have significant implications for the persistence of wildlife populations. Lastly, as indicated in earlier sections, human impacts other than habitat fragmentation can have a significant influence on wildlife mortality and thus connectivity and persistence. While an assessment of the relative importance of all these factors is beyond the scope of this thesis, further exploration of some of these factors, as described through previous research, is merited on the basis of their potential significance in the Laikipia context.

2.4.3 Nature fights back: Resilience among large mammals

Newmark (1993) established a series of criteria for the successful design of wildlife corridors. He asserts that detailed knowledge of the target species is vital. Specifically, “ecological information on the habitat requirements, seasonal movements, dispersal, avoidance behaviour, and learning behaviour is required for the effective design of wildlife corridors,”(Newmark, 1993). Although only alluded to by Newmark (1993), the factors he mentioned constitute a major component in determining the ability of a species to persist in the face of direct and indirect human impacts (Weaver et al., 1996). ‘Resilience’ has been defined as the “degree to which an entity can be changed without altering its minimal structure” (Pickett et al., 1989).

Weaver at al. (1996) examined basic mechanisms of resilience to human disturbance at three hierarchical levels which I summarise in Table 2.1.

Table 2.1: Resilience mechanisms at different hierarchical levels (based on Weaver et al. (1996)

Level	Disturbance type	Resilience Mechanism
Individual	Habitat Loss	Behavioural plasticity
Population	Overexploitation	Demographic compensation
Metapopulation	Habitat fragmentation	Dispersal

Weaver et al. (1996) used this hierarchical framework to construct resilience profiles of large carnivores in the Rocky Mountains in the U.S.A. They suggest that wolves exhibit behavioural plasticity in food acquisition by killing prey of different species, though wolf density has also shown to be influenced by the density of large ungulates (moose, dall sheep). This latter trait may have a depressing impact on resilience. However wolves possess other attributes that improve their chances of persistence. For example empirical data show that wolf reproduction abilities can counter the impacts of human exploitation, depending on ungulate biomass, pack size and sex structure. In addition wolves have been documented to disperse as far as 917 km, though typically dispersing wolves move approximately 197 km with males dispersing further than females. This dispersing capability together with relatively high annual productivity represents a degree of ‘resilience’ to human disturbance. Grizzly bears, Weaver et al. (1996) argue, have lower dispersal capabilities and productivity than wolves. In addition grizzly bears require high quality forage in spring and autumn to ensure successful hibernation and reproduction. As a result, grizzly bears are considered less resilient than wolves.

There are other examples of individual behavioural attributes relevant to the concept of resilience. For example: 1) a number of East African understory birds are incapable of crossing forest clearings wider than a few hundred metres (Newmark, 1993); 2) North American black bears are known to avoid areas more than 25 metres from cover (Noss et al. 1996); 3) a wide range of ungulates are unable to cross veterinary fences in southern Africa (Mordi, 1989) and the movements of wolves and other large predators are impeded by roads in North America (Weaver et al., 1996). These examples illustrate the importance of flexibility in relation to habitat use. However, even where species possess attributes that have endowed them with a degree of resilience to environmental change and stochastic events, these same attributes may in fact increase vulnerability in the context of human landscapes. One example of such an attribute is the ability (and need) of large mammals to move long distances.

Woodroffe and Ginsberg (1998) used data from 22 intensive studies of large carnivores in protected areas to show that over 74% of 635 of deaths with known causes were directly attributable to people. Most of these deaths occurred outside of protected areas. In this same study, they also found that “in a reserve of given size, wide-ranging carnivores are more likely to become extinct than those with smaller home ranges, irrespective of population density.” They suggest that this is because, “ranging behaviour mediates contact with human activity which accounts for a very high proportion of adult mortality in all of these species,” (Woodroffe & Ginsberg, 1998). Therefore the identification of patterns and underlying determinants of animal movement is an important step for assessing the potential for those animals to persist in contemporary and future landscapes.

2.4.4 Big movers: Elephant movement across time and space

Elephants are some of the widest ranging terrestrial mammals on earth. Recent studies carried out in Namibia and Mali describe home ranges for individual elephants of up to 12,800 km^2 and 24,000 km^2, respectively (Legett, 2006)[11]. Elephant home ranges are thought to vary in size largely in response to habitat quality and/or rainfall. Where rainfall is relatively high and forage is abundant home ranges recorded for African elephants are relatively small. For example in the equatorial forests of Cameroon, where water and forage is abundant, home ranges (calculated as minimum convex polygons) for two female elephants were 203 and 329 km^2 (Powell, 1997). Similarly in Queen Elizabeth National Park, a savannah zone in which water and forage are also abundant, the mean home range size for 19 cow elephants was also relatively small at 364 km^2 (Abe, 1984). In arid regions extremely large ranges have been recorded as described for Namibia and Mali above. Large home ranges have also been recorded

[11] Figures for the home ranges of African elephants derived from studies carried out in different parts of Africa are presented in chapter 7.

for elephants living in other arid regions such as Tsavo East National Park (Leuthold & Sale, 1973) and northern Kenya (Thouless, 1995). Such wide ranging movements are thought to represent coping strategies in environments where food and water are spatially and temporally scarce. However the pattern of large-scale movement varies between regions. In Tsavo, for example, elephant movement in the wet season was random and opportunistic, probably in response to the random and localised distribution of rainfall events and subsequent availability of quality forage (Leuthold & Sale, 1973). In northern Kenya, however, movement among migratory female elephants seemed to be more consistent, with similar patterns of movement between dry season and wet season ranges across years (Thouless, 1995).

As I alluded to earlier, historically the mobility of elephants is likely to have facilitated the persistence of some elephant populations during times of intense human exploitation. In recent times evidence for this pattern of risk management is illustrated in cases where elephant populations have ‘appeared’ in areas where they were formerly absent such as the elephant population described by Tchamba (1996) in Cameroon. The ‘arrival’ of elephants in Laikipia described in this thesis and by Thouless (1994) is another example of this phenomenon. Accommodating the remarkable mobility of elephants is increasingly believed to be important for both ensuring that elephants can persist in the future, for example by enabling populations to respond to climatic change, while at the same time maintaining the ecological integrity of the places that elephants inhabit and is the main reason behind calls for ‘mega-parks’ (Van Aarde, 2005). However if the remarkable mobility of elephants is to be maintained or even engineered in the future then, given current trends, human occupied landscapes will, invariably, need to be included within conservation plans. The ability of elephants to use such human occupied landscapes will ultimately depend on the willingness of local people to accommodate elephants. Thus an understanding of the contexts within which coexistence between people and elephants occurs and the associated social impacts and implications of such coexistence is increasingly important for gauging the potential of elephant persistence in the landscapes of the future.

2.5 HUMAN-WILDLIFE CONFLICT

The deleterious impacts of wildlife on people can best be understood in terms of what Naughton-Treves (1997) terms vulnerability, defined as the “potential for loss,” (Cutter 1996). Historically local people have probably always been ‘vulnerable’ to the negative impacts associated with large mammals. Indeed there are millennia old records of crop-raiding by elephants in both the African and Asian continents (Osborn, 1998) and there is some evidence to suggest that large carnivores have predated on people in Africa ever since the two species co-occurred (Treves & Naughton-Treves, 1999). The presence of high densities of elephants in pre-colonial Africa is thought to have presented a major constraint to cultivation (Barnes, 1996, Hoare, 1999, Parker & Graham, 1989). There are early colonial records of small-scale farmers suffering extensive depredations by elephants in the equatorial forests (Schweitzer, 1922). It is probable that the shifting pattern of cultivation practised within Africa’s equatorial forests encouraged a mixture of secondary growth highly favourable for elephants (Barnes, 1991). The wide stone walls surrounding ancient villages in Zimbabwe may have been constructed to deter crop-raiding elephants (Clutton-Brock, 1999) indicating that crop-depredations by elephants has long been a significant problem in the African savannas. Certainly there are recent examples of subsistence farmers abandoning villages as a result of conflict with wildlife in parts of modern day Zambia and Malawi (Bell, 1984) providing further clues as to the extent to which pre-colonial African farmers may have been vulnerable to crop-depredation.

Thus human-wildlife conflict and conflict with elephants in particular is not a new problem for African communities. However, reported incidents of conflict between people and large mammals have increased in recent years (Kangwana, 1995) and human-wildlife conflict in general is perceived to be increasing (Kiiru, 1995; Treves and Karanth, 2003) and more widespread (Hoare, 1999). However, given the historical and more recent impacts of the ivory trade this perception is not entirely justified. For example in Uganda the elephant range has decreased from 70% to less than 7% of the country’s land area and there has obviously been a concomitant decline in the geographical extent of the problem of crop-raiding by elephants (Naughton-Treves, 1997). In reality therefore human-wildlife conflict in Africa is perhaps more accurately described as neither increasing nor decreasing but dynamic and dependent on the temporal and spatial dimensions under consideration. There are, however, elements within the human-wildlife conflict matrix in Africa that have changed since the pre-colonial era.

Local people were once able to offset the costs associated with co-existing with large mammals by hunting and scavenging for meat (Naughten-Treves, 1997, Treves & Naughton-Treves, 1999). Hunting once played an important economic, social and cultural role among pre-colonial African communities (Steinhart, 1989) and in some cases continues to do so today (Gibson & Marks, 1995). In addition, indigenous hunting provided a traditional system for wildlife management. For example, the Kikuyu tribe of the present day Kenyan highlands once had their own guild of hunters called upon to hunt and kill crop-raiding pests, including elephants (Leakey, 1977). Under European and, subsequently, post-colonial African administration the introduction of game laws, designation of protected areas and more general attempts to prevent ‘native hunting’ suppressed traditional systems of wildlife use and management in some parts of Africa (Naughten-Treves, 1997). Where effective the loss of knowledge of traditional pest management and/or fear of reprisals is likely to have resulted in local people becoming more vulnerable to wildlife depredations, particularly where the designated wildlife authority is under funded and understaffed and thus unable to deal with requests for help from vulnerable communities, as is often the case in many African countries today.

2.5.1 Measuring vulnerability

An important first step in understanding the social and ecological factors contributing to human-wildlife conflict is to establish the spatial and temporal patterns of such conflict. The most common approach used for measuring vulnerability has been to carry out interviews among households. These have been used to estimate economic losses to predators (Mishra, 1997) and crop pests (De Boer & D.Baquete, 1998). The problem with using household interviews is that respondents are inclined to exaggerate losses (Bell, 1984). In the third world context, the reasons for doing so often relate to expectations of compensation (De Boer & D.Baquete, 1998, Gesicho, 1991). This may in turn be related to the preconceptions of the interviewer’s wealth, status and motivations. Given that many rural development projects are often precipitated by field research, these perceptions are likely to be reinforced making interview-based methods for calculating the economic status of households more problematic in the future.

Government records and other secondary sources can also be useful sources for determining loss to wildlife depredation. However these secondary sources are not always reliable. In remote locations government administration is often limited and it is likely that many incidents of human-wildlife conflict go unreported (Kiiru, 1995, Thouless, 1994). Even in areas where wildlife authorities do exist, the absence of clear incentives, such as compensation schemes, may discourage local people from reporting incidents of human-wildlife conflict. In addition there is little consistency in record keeping by the wildlife authorities, making it difficult to make comparisons across space and time (Treves & Naughton-Treves, 1999). As such it is perhaps best to confine use of such records to exploring significant events that are less likely to go undocumented. Examples of such conspicuous events include incidents where people have been injured or killed and incidents where elephants or other wildlife have been shot on ‘control’.

The problems identified with using interviews and government records to establish spatial and temporal levels of loss to wildlife have encouraged the development of more reliable human-wildlife conflict enumeration systems (Hoare, 1999b). These systems rely on regular field visits by locally trained reporters to record the spatial location of events and in the case of crop-raiding, providing reliable estimates of the level of damage. If well implemented, the benefits of using such systems are that they can capture most, if not all, wildlife incidents in a focal area. The resulting data sets are not only useful for measuring actual loss but also for estimating relative loss to different species and in some cases, determining ecological factors underlying human-wildlife conflict.

Each of the approaches I have outlined above for measuring and understanding loss to wildlife has its relative merits depending on the dimension of ‘vulnerability’ that is of interest. The following sections attempt to elucidate these different dimensions through the results of previous studies of human-wildlife conflict with a particular emphasis on concepts and case studies that may facilitate the interpretation of the patterns of human-elephant interaction in Laikipia District identified in this thesis.

2.5.2 Ecological dimensions of human-wildlife conflict with a focus on conflict with elephants

In the Sebungwe region of north-west Zimbabwe (15,000 km^2) the intensity of human-elephant conflict at the ward level[12] was analysed in relation to elephant density, proximity to protected areas, area under human settlement, human population density and local rainfall (Hoare, 1999a). None of these were found to be predictive. Hoare (1999a) attributed the absence of spatial correlates in this study to the high number of incidents that involved male elephants (79%). Male individuals of large polygamous species of mammal are thought to be less predictable and more opportunistic than female individuals due to greater selective pressure (Sukumar, 1991). Hoare (1999a) speculated that just a few male elephants could be responsible for a large number of incidents in these areas with low overall elephant population densities and that this level of raiding could match levels in other areas where there are many occasional crop-raiders. This 'male behaviour hypothesis' has been supported by empirical observations made at other sites, particularly among Asian elephants (Osborn, 1998, Sukumar, 1991, Sukumar & Gadgil, 1988).

In the Tsavo ecosystem, Kenya, human-elephant conflict (measured as numbers of incidents per km^2 per year) was significantly related to distance to permanent water, mean elevation and length of protected area frontage (Smith & Kasiki, 2000). The presence of clear spatial correlates in this study, unlike Sebungwe, may be due to the preponderance of female elephants involved in conflict incidents. In the Mara ecosystem, where once again problem incidents involve mostly female led groups, Sitatiti et al. (2003) suggested that crop-raiding by female elephants could be predicted by percentage of area under cultivation and for male-led groups, proximity to settlements. In addition, elephant-induced injury and death was correlated with distance from roads. These Kenyan case studies demonstrate that human-elephant conflict can be spatially predicted, at least in some cases. In addition, the results from

[12] This is the lowest unit of administration in Zimbabwe and vary in size between 150 to 700km^2 (Hoare 1999a)

both the Kenyan and Zimbabwean case studies suggest that there are differences in the patterns, and therefore the determinants, of crop-raiding between male and female elephants, with possibly male elephants able to tolerate a higher risk threshold than female elephants.

As well as spatial components, human-elephant conflict is also believed to exhibit a temporal pattern. For example in another Kenyan study, government records indicate that levels of human-elephant conflict and injury were accentuated during times of drought (Thouless, 1994). Similar conclusions were drawn from a study carried out in the rangelands in and around Ambosli National Park (Kangwana, 1993), also in Kenya. In these cases, patterns of conflict were thought to reflect heightened levels of competition between elephants and pastoralists over access to water points, though recent research also suggests that access to grazing and high quality forbs could be equally important in determining patterns of conflict between people and pastoralists (Young et al., 2005).

In one study in India, crop-raiding by elephants reached a peak in October (Sukumar, 1989). Crop-raiding by elephants in a Zimbabwean study peaked during the transition between the wet and dry seasons (Osborn, 2004). This was also the case in a study of crop-raiding by elephants in Sumatra (Nyhus et al., 2000). In African savannah habitats such temporal patterns of crop-raiding by elephants have been attributed to the decline in the availability of wild foods, specifically high quality wild grasses (Osborn, 2004). Crop-raiding of maize around Kibale National Park, an equatorial forest reserve in Uganda, also demonstrated a temporal pattern, occurring approximately eight weeks after the onset of rains, although this pattern was not associated with a decline in the availability of wild foods but was instead related to availability of crops (Naughton-Treves et al., 1998). This temporal pattern of crop-raiding around Kibali has been further corroborated and thus it appears that while seasonal fluctuations in wild forage quality in African savannah habitats determine the temporal pattern of crop-raiding, in forest environments it is the availability of crops that is important (Chiyo et al., 2005).

2.5.3 Social dimensions of human-wildlife conflict

Where present, large bodied mammals are often ranked as the worst of a range of agricultural pests, (Naughton et al., 1999, Newmark et al., 1994). This was clearly illustrated in a review of 25 African case studies by Naughton et al. (1999) in which out of 38 species, elephants were the most frequently ranked as the 'worst animal'. As will be explored further below, such reports are often inconsistent with conclusions drawn from research that is carried out at national or regional scales and/or quantitative field surveys (Lahm, 1996, Naughten-Treves, 1997). This disparity is intriguing and merits further exploration.

Often the people interviewed in studies of human-wildlife conflict live adjacent to protected areas and this is highly likely to influence their responses to questions concerning livelihood constraints. In a survey of the attitudes held by local people living adjacent to the Kosi Tappu Wildlife Reserve in Nepal, respondents complained of regular crop-damage by wild water buffalo (Heinen, 1993). However a radio-tracking study of buffalo within the reserve revealed questionnaire responses to be fallacious. In addition this study found that local people, despite their interview responses, were more responsible for damaging the reserve fence than were crop-raiding 'park' animals. Similar discrepancies in interview responses were revealed in a study carried out adjacent to the Selous Game Reserve, Tanzania (Gillingham, 1998). In this case local people ranked crop-raiding by large mammals as the biggest problem associated with living next to the Game Reserve. However, regular field assessments found that it was actually smaller-bodied pests such as rodents, bush pigs and birds living within the settlement area and not large mammals from the national park that were responsible for crop-damage. These two studies exhibit a tendency among people living adjacent to protected areas to amplify levels of wildlife depredation by large mammals, a pattern noted elsewhere (De Boer & D.Baquete, 1998, Hill, 1997, Naughton-Treves, 1997). It has been suggested that the amplification of crop-loss to large mammals represents a form of local resistance and protest over resource constraints imposed by protectionist conservation strategies, regional land-tenure systems and their administrative representatives (Gillingham, 1998, Gillingham & Lee, 2003, Madden, 2004). Previous research suggests that there are four possible reasons for why large mammals are used as lightning rods in power struggles between the poor and those that control access to resources:

1. Large mammals, unlike smaller pests, are difficult to kill using traditional pest management systems. In addition, large mammals are often highly protected and therefore killing such animals entails the risk of being caught and punished by the wildlife authorities. This explains why for example animals that can be harvested (either legally or illegally) are generally better tolerated despite the costs they might incur (Naughton et al., 1999).

2. Large mammals present a risk of human injury or mortality (Thouless, 1994).

3. Although less frequent, crop-raiding by large mammals such as elephants can result in the destruction of an entire crop during a single foray, potentially creating an immediate subsistence crisis. Local perceptions of risk are likely to reflect these extreme events rather than average loss (Naughton-Treves, 1997, Naughton et al., 1999)

4. People living adjacent to protected areas are often aware that large mammals bring in revenue to the government through photographic and/or hunting based tourism (Gillingham, 1998, Newmark et al., 1993). Drawing attention to these specific animals through exaggerated reports of depredation is a strategy for potentially influencing future decisions with regards to revenue sharing and distribution.

In one of the few studies of its kind, Naughton-Treves (1998) compared farmer's perceptions of loss with actual loss as estimated by field surveys in sites adjacent to Kibale National Park in Uganda. In this study trained observers visited 1 x 0.5 km grids of farmland in six different villages every week over a period of two years. Crop-damage was estimated for all crop-types with the species of animal responsible identified. Results showed that there were clear differences in frequency of raids, damage per raid and total crop-damage between species. Redtail monkeys were the most frequent crop-raiders, followed by livestock and then baboons. Baboons were responsible for the greatest total damage to crops followed by elephants, redtail monkeys and bush pigs. Elephants caused the greatest damage per raid. There were also observed differences in crop-preference between species. Bush pigs targeted tubers, baboons targeted maize and sweet potato, chimpanzees ate bananas, and all species, including elephants, targeted maize.

Farmer's perceptions of crop-raiding reflected a focus on extreme events. For example while redtail monkeys carried out most crop-raiding events they were ranked by farmers as the fourth 'worst' pest species. Elephants, however, were responsible for only 1 % of all raids but were regularly reported as the 'worst animal'(Naughten-Treves, 1997). Interestingly, livestock, which caused the most damage in 13% of monitored farms surveyed and were the most frequent raiders in 23%, were not implicated as a 'problem animal' by a single farmer interviewed (n = 97). Another conclusion drawn from this study around Kibale, was that farmers' perspectives of the vulnerability of different crop species differed from estimates based on empirical observation. For example, although bananas sustained most of the damage, farmers perceived maize and sweet potatoes to be the most vulnerable crops. This perception may reflect the higher value assigned to maize and sweet potatoes, which are both staple crops. In addition these crops have short growing seasons and entire fields of plants ripen simultaneously which makes them particularly vulnerable to crop-raiding. Indeed incidents where entire fields of these crops were destroyed by baboons and/or bush pigs, were not uncommon, occasionally resulting in immediate household food insecurity (Naughten-Treves, 1997).

The disparity between perceived and actual loss to wildlife depredation can reflect individual experience which may be important in shaping the social dimension of vulnerability. Individual experience of wildlife depredation is the outcome of exposure to risk and is often related to the form of labour in which an individual is engaged. Divisions of labour can be ethnic, gender or even livelihood-based and merit further exploration in determining vulnerability of people to incidents of human-wildlife conflict.

Government records in Uganda were used to assess levels, causes and vulnerability of human depredation by wildlife since the 1920s with a focus on large carnivores (Treves & Naughton-Treves, 1999). Results from this study showed that men rather than women were more likely to be attacked by large carnivores indicating a sex-based division of labour and associated vulnerability among pre-colonial African societies. Similarly, Kenya Wildlife Service occurrence books held at various outposts have been used to describe and establish the intensity of various types of human-elephant conflict in Kenya. An analysis of these data indicated that men were more likely to be killed by elephants than women (Kiiru, 1995).

Vulnerability in the human-wildlife context has been attributed at least in part to ethnicity. For example the leaders of the well established Toro ethnic group in Uganda recognise the relationship between vulnerability to crop loss and proximity to the Kibale National Park boundary. As a consequence they allocate the land close to the park boundary, and thus risk, to immigrant farmers belonging to the Kiga ethnic group. In effect this creates a buffer zone of immigrant farmers between crop-raiders and Toro settlements (Naughten-Treves, 1997). Similar patterns of risk distribution in relation to crop-depredations have been recorded elsewhere (Hill, 1997). In these cases the role of ethnicity in mediating access to political and economic power was a key factor in determining vulnerability to crop-raiding.

Economic power is clearly also important in determining vulnerability to crop-loss. People with large farms have at their disposal several strategies for managing vulnerability to crop-raiding. For example they can create a buffer of less palatable crops between the forest/bush and their food crops or they can simply rent out the most vulnerable parts of their farms (Naughten-Treves, 1997, Naughton-Treves, 1998). In contrast, poorer farmers, often immigrants, typically have smaller land holdings and so are not able to adopt such flexible approaches for dealing with vulnerability.

Wildlife depredations also incur hidden costs that are less easy to measure such as the labour investment required for protecting crops and/or livestock. In some cases nocturnal guarding of crops may lead to greater exposure to vectors of disease such as malaria carrying mosquitoes. Children are often involved in protecting crops at night and as a result may miss days at school. The labour required for crop and livestock protection may be in short supply in many households. As a consequence, the old and the widowed may be particularly vulnerable to crop depredations. AIDS, so prevalent in parts of Africa, may be contributing to increased levels of household vulnerability to wildlife depredation by killing the young. In the third world context men are often engaged in or are searching for employment, leaving women with the responsibility of pest control. Thus the availability of labour is a critical factor to consider when assessing vulnerability at the household level. Another hidden cost is travel curfews imposed by the presence of large mammals. In Transmara District, Kenya, children attending schools within elephant ranges do not perform as well as children attending schools outside of elephant ranges (Wasilwa, 2001). This is because elephants are often travelling near or on roads in the early hours of the morning and in effect block children from getting to school on time. The correlation between elephant-induced injury and mortality with distance from roads found in Transmara is highly likely to reinforce this 'curfew' through heightened perceptions of risk (Sitati et al., 2003).

Many of the factors contributing to vulnerability that are considered here are generally applicable to small-scale farmers in Africa. However, different livelihood activities are likely to result in different sorts of experiences with wildlife. These context specific experiences are a particularly important consideration when studying human-wildlife conflict as they can both determine vulnerability and shape attitudes and thus tolerance towards wildlife. This was demonstrated in a study by Naughton-Treves et al. (2003) which aimed to evaluate the underlying factors shaping public attitudes towards wolves in Wisconsin (U.S.A) with a particular focus on the impact of compensation. This is a particularly relevant case study in that there has been a natural recovery of wolves in Wisconsin, a surprising trend given that public land is scarce in the state and this recovery has occurred among livestock producers and a large hunting community. Survey results showed that individuals that had lost a domestic animal to a wolf or other predator were more likely to favour reducing or eliminating wolves. However an individual's social identity or occupation (i.e. bear hunter, livestock producer or general resident) were shown to be the most powerful predictors of tolerance towards wolves. Occupation or 'lifestyle' has also been shown to affect tolerance of wildlife adjacent to Amboseli National Park in Kenya (Kangwana, 1993). This suggests that attitudes towards large mammals "are established early on in life, are deep rooted and value laden and are connected to individual lifestyles and views of the place of humans in nature" (Naughten-Treves et al., 2003).

2.6 DISCUSSION

This chapter has provided a review of the available literature on the interaction between large mammals and people with a particular focus on elephants. Clearly the relationship between people and elephants varies across time and space. Thus while elephants have been and in some places continue to be exploited for their ivory and killed in the interest of agriculture and settlement, elephants also present a constraint to the livelihoods of the people with whom they share their range. In yet other circumstances attempts have been made to protect elephants through landscape 'segregation'. A number of narratives have emerged to rationalise the patterns of elephant decline, human-elephant conflict and supposed elephant induced vegetation change. What is implicit to may of these narratives is the notion that people and elephants are somehow mutually exclusive, a notion reinforced by landscape segregation imposed through the creation of protected areas. However elephants and people have 'shared' landscapes and associated resources throughout human history and continue to do so. This thesis will examine patterns and implication of coexistence in the context of Laikipia. Previous studies of human-wildlife interaction demonstrate the need to consider both social and ecological parameters, justifying an interdisciplinary approach. The next chapter will describe the interdisciplinary data sources used in this thesis to investigate patterns of human-elephant interaction in Laikipia.

Chapter 3: Methods

3.1 INTRODUCTION

This chapter provides an outline of the data sources and data collection methods used to identify and understand patterns of human-elephant interaction in the Laikipia landscape. I also briefly describe the reasons behind the choice of methods used. Detailed and specific descriptions of data analyses are provided in each of the analytical chapters that follow. The research methods used are mainly quantitative as the thesis design is hypotheses driven. However the analytical framework was structured to acknowledge the significance of context (site, setting and history) using methods drawn from both the natural and social sciences and including qualitative material to frame research questions, facilitate interpretation of quantitative analyses and inform discussion.

3.2 GIS SECONDARY DATA & SOURCES

A GIS is a: "system for the management, analysis, and display of geographic information" (ESRI, 2004: 2). Within a GIS, geographic data are stored as a series of digital maps, known as 'coverages', each describing different information about the same study area (Smith & Kasiki 2000: 8). These spatial data typically come in either one of two formats (op. cit.):

1. Vector coverages: These data represent space as a series of point, line or polygon units
2. Raster coverages: These data represent space as a grid of equally sized squares with each square containing a numeric value that may represent membership of a particular group/classification (e.g. grassland) or the quantitative value for a phenomenon measured at that point (e.g. percentage of cultivation)

In this thesis I use several different GIS coverages from several different sources. In the analytical chapters that follow, I provide descriptions of how these data were manipulated and analysed. Some of these coverages I generated through my own fieldwork and I discuss these in subsequent sections of this chapter, but other coverages were made available by Kenyan based research institutions. These include:

1. A digital map (vector) of land tenure in Laikipia District produced in 1987 (Kohler, 1987) and made available through CETRAD[13]. This coverage is comprised of property boundaries of large-scale ranches, forest reserves, urban areas, communally owned group ranches and former large-scale ranches that were purchased by either cooperative land buying groups or the GoK and were subsequently sub-divided into smallholder plots. These smallholder areas were classified according to the proportion of plots that had been settled at the time of the survey.

2. Road and river vector files, digitised from 1:50,000 topographic sheets (GoK) and point files showing the location of water holes, also available through CETRAD.

3. A digital elevation model (DEM). A DEM (raster) is created by measuring elevation at various points, in this case from 1:50,000 topographic sheets (GoK), and then deriving the values between these points to create a continuous surface. The DEM for Laikipia was also available through the CETRAD GIS database.

4. A digital (raster) image of land cover for Laikipia District, and the surrounding area, derived from a supervised classification of two 2002 Landsat TM scenes, made available by Mpala Research Centre[14]. This image was comprised of individual pixels, each representing 30 x 30 metres and assigned one of 14 possible classes. Five of these classes were abiotic (urban, smoke, water, ice and bare rock), eight were for vegetation types and there was one category for ‘unknown’.

[13] Use of GIS data made available to me by CETRAD is guided by a collaborative agreement in which I have full rights of access to the data contained within CETRAD GIS database for my academic research providing that I make the results of my research available to CETRAD.
[14] Use of these land cover data are subject to an agreement with MRC under which I have been granted access to the data to use in my thesis and to facilitate with the development of a temporal model of crop-raiding in collaboration with MRC. This latter work is in progress and aims to use satellite data to predict crop-raiding vulnerability among smallholder cultivators in Laikipia. I have not included any of the preliminary results in this thesis though I hope to publish these in partnership with the current director of MRC, Dr. Nick Georgiadis, as an output of a three year DEFRA funded Cambridge University project beginning in 2006.

In addition to these GIS coverages, there were other GIS coverages that I used in this thesis that were also made available by Kenyan based research institutions. These other coverages describe the distribution and density of wildlife and human dwellings in the study area and because of their complexity are dealt with in detail in their own section below.

3.3 AERIAL SURVEYS

3.3.1 Sample aerial counts

The DRSRS has carried out systematic reconnaissance flights (sample surveys) in Laikipia since the late 1970s, using methods described by Norton-Griffiths (1978). These surveys followed fixed transects derived from 1:250,000 topographic maps and orientated in north and south directions. The aircraft used was a twin engine Partenavia P68 and travelled at a flying speed of 190 km/hr and a height of 122 m. Observations of animals and other features of interest (e.g. human dwellings) were made by two rear seat observers within a fixed strip width of 150 m on each side of the survey aircraft. The other two members of the crew consisted of a front seat observer, responsible for recording each observation relayed to him by the two back seat observers and the pilot. Initially these surveys followed transects that were spaced at 5 km intervals, representing a nominal sampling intensity of 9.6% of the total area. However, since 1991 there have been a total of seven aerial surveys carried out with double this sampling intensity (i.e. transects placed every 2.5 km).

Sample aerial count data were made available by the DRSRS through a grant provided by the British Institute of East Africa (BIEA). These data were provided in two forms:

1) Population estimates for domestic livestock (cattle and small stock), ostriches and 13 species of large mammal for each of 11 surveys carried out between 1985 and 2003. These estimates were calculated from sample count data using Jolly's method 2 for unequal sized sampling units (Box 3.1; Norton-Griffiths, 1978). This

technique takes into account the unequal length of transects (as perimeters of ecosystems are uneven).

2) GIS coverages (vector) of sample count results for small stock (sheep and goats), cattle, human dwellings, impala, elephants, Burchell's zebra and Grevy's zebra from surveys carried out between 1985 and 2003. A GIS coverage file was provided for each of these species from each survey. Each coverage file was comprised of a series of points distributed across a map of the district and spaced 2.5 x 5 km apart. Each point represents the centre of each survey sample unit (2.5 x 5 km) and came with an attribute file showing the number of animals of a particular species counted within that sample unit during that particular survey.

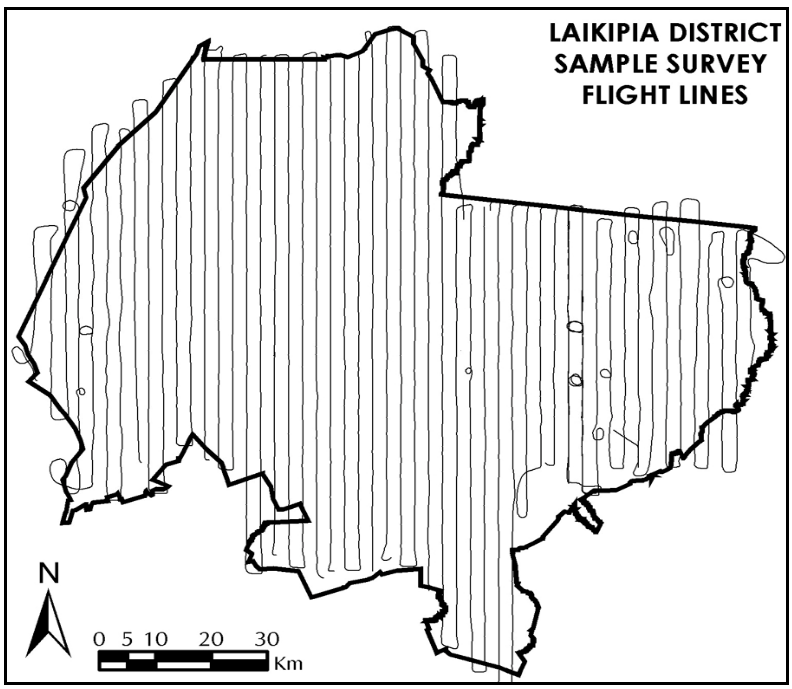


Fig. 3.1: 2.5 km sample survey flight path (adapted from Georgiadis et al., 2004a)

Box 3.1: Jolly's method 2 for estimating animal densities from systematic reconnaissance flight data (from Norton-Griffiths, 1978: 73).

$$(\hat{Y}) = Z \times \hat{R}$$

$$\mathrm{Var}\,(\hat{Y}) = \frac{N(N-n)}{n} \times \left(s_y{}^2 - 2 \times \hat{R} \times s_{zy} + \hat{R}^2 \times s_z{}^2\right)$$

$$\mathrm{SE}\,(\hat{Y}) = \sqrt{\mathrm{Var}\,(\hat{Y})}$$

Where:

$\hat{Y}$	=	estimate of the total population in region size Z
N	=	number of sample units in the population
n	=	number of sample units in the sample
Z	=	area of the census zone
z	=	area of one sample unit
y	=	number of animals counted in that unit
$\hat{R}$	=	ratio of animals counted to area searched = $\frac{\sum y}{\sum z}$
$s_y{}^2$	=	variance between animals counted in all the units
$s_z{}^2$	=	variance between the area of all the sample units
s_{zy}	=	covariance between the animals counted and the area of each unit

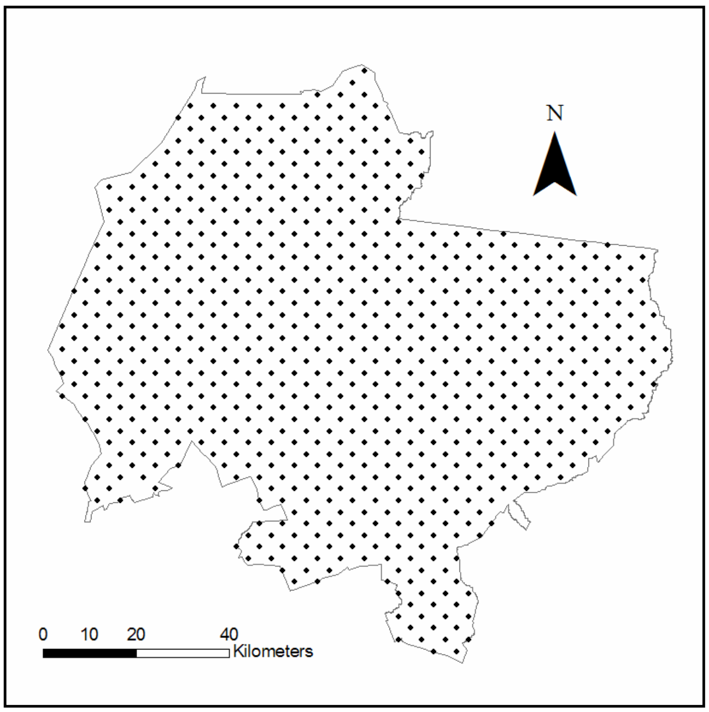


Fig. 3.2 Map showing a GIS point coverage file provided by the Department of Resource Surveys and Remote Sensing (DRSRS). Each point representing the centre of each survey sample unit (spaced 2.5 x 5 km apart) and contains an attribute file showing the number of animals of a particular species counted within that survey sample unit.

3.3.2 Total aerial counts

The first total count of elephants in Laikipia District and the adjoining districts of Samburu, Isiolo and Meru, was carried out in 1990 (Thouless, 1991). There have been several counts since and of these only two are in a digital format and thus immediately amenable for integration into a GIS (1996 and 2002). Total counts involved up to 10 aircraft with counting organised into blocks of between 200 and 500 km^2. In contrast to the aerial sample surveys which were carried out across the entire district, areas assumed to contain few or no elephants, such as those with dense settlement or cultivation, were omitted from the total aerial count surveys. Counting was systematically carried out along transects separated by 1 to 2 km between 0700 and 1030 am and between 1530 and 1830 pm. The methods for observing animals from the aircraft were similar to those described for the SRF method above. The location of flight paths and observations of elephants were recorded using a GPS so that double counts could be easily identified and eliminated after the survey was complete.

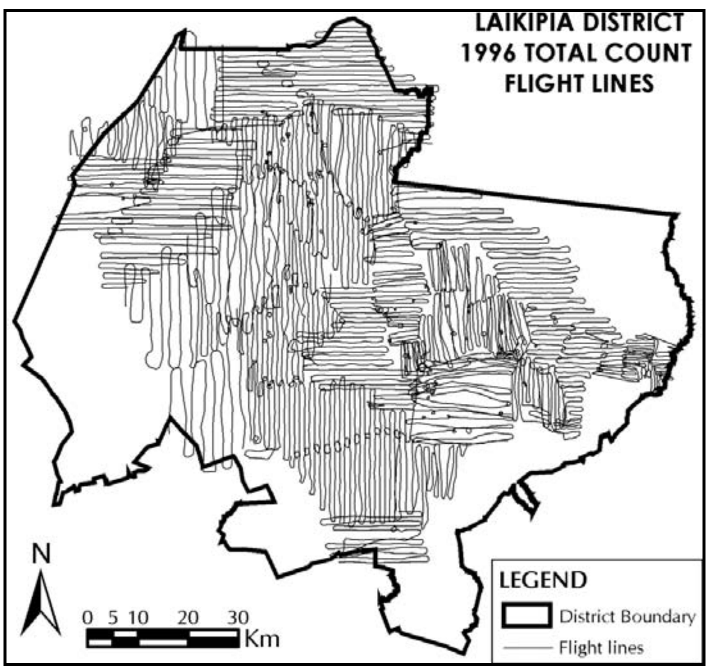


Fig 3.3 Total count flight lines for the 1996 survey (adapted from Georgiadis et al., 2004a). Flight lines were spaced between one and two km apart in contrast to the 2.5 km spacing used for aerial sample surveys

3.4 LINE TRANSECT SURVEYS

Over 100 kilometres of transects were walked to collect data on the relative abundance of elephants, human activities and vegetation cover across a range of discrete land units contained within Laikipia District. Details of the analyses of transect data are provided in chapter five. Here I describe the methods used to collect these data.

3.4.1 Sampling methodology

Fourteen discrete sample areas of variable sizes were purposively selected for the transect survey. There were four initial criteria for the selection of sample areas, though subsequently two further variables of interest became important and are discussed below. Firstly, sample areas were chosen with the objective of capturing the variation of resource use and management across Laikipia District. Thus sampling areas were drawn from each of the main land-tenure systems present on the basis of a land-tenure/land-use map (see section 3.2) and included: 1) forest reserves; 2) smallholder areas; 3) large scale ranches; and 4) communally owned group ranches (Fig. 3.4). I also attempted to capture the variation within each of these land-tenure systems so that not only differences in land-tenure but as much as was possible with the available information (see section 4.2), differences in land use were also purposively selected for. As a result several sample areas were chosen within each of the main land-tenure categories. Each of these sample areas is briefly described in Table 3.2.

Secondly, because elephant distribution and abundance in African savannas is strongly water dependent (Leuthold & Sale, 1973, Stokke & du Toit, 2002), the presence of permanent streams was a criterion in the selection of sample areas included. Information on the location of the main drainage features in Laikipia was available through the CETRAD GIS database (see section 3.2).

Thirdly, selection of study areas also took into account accessibility. Thus most of the sample areas, with the exception of Koija Group Ranch, were located on the eastern side of the district within easy access of Nanyuki.

Fourthly, sites were selected on the basis that elephants were known to be present. Information on elephant distribution was available from the 2002 aerial total count described in section 3.3.2 and further information on distribution (including crop-raiding) was gathered prior to the transect surveys through interviews with local people and personal observations.

Subsequently the relationship between elephant density and the risk presented to elephants by human occupants within Laikipia was explored by classifying sample areas into two groups: ‘tolerant’ (little to no risk to elephants of human inflicted injury/mortality); and ‘intolerant’ (the risk to elephants of injury or mortality through contact with human occupants is present). Distinguishing between these two categories was an iterative process involving several data types and sources. Details of how this was achieved are provided in Chapter Five.

During the course of fieldwork, it became clear that game fences were an additional element to consider in the grouping of data prior to analyses. There are an increasing number of electrified game fences in Laikipia, used for three purposes: to keep wildlife and/or livestock in; to keep people and livestock out; and to keep wildlife out (Thouless & Sakwa, 1995). They do this with different measures of success. Fenced and unfenced properties were distinguished for certain analyses. Many ranches in Laikipia are ‘fenced’, but some of these fences contain gaps specifically designed to allow passage of elephants. The latter were classified as non-fenced for the purpose of comparative analysis.

The use of dung counts for estimating the size of elephant populations is a well established method, used primarily for counting elephants in forests, where thick vegetation makes other methods of counting difficult, if not impossible (Barnes, 2001, Barnes et al., 1997a, Barnes & Jensen, 1987). Sampling effort in previous dung surveys was typically organised with the aim of reducing possible variance. For example if the survey area was expected to contain three ‘strata’ of low, medium and high wildlife density then survey effort was allocated across these three strata in proportion to the expected difference in elephant density (Barnes, 1996b). Further possible variance within these studies was reduced by ensuring that the survey was carried out within one season to minimise any potential inter-seasonal variability. In contrast, in this study there were already reliable estimates for the total size of the Laikipia elephant population based on aerial total count data and the aim of using dung counts was instead to identify and better understand the variation in abundance across space and time. Therefore survey effort was allocated evenly between strata and two seasons so as to derive estimates of relative density/abundance, as recommended in the literature (Buckland et al., 2001).

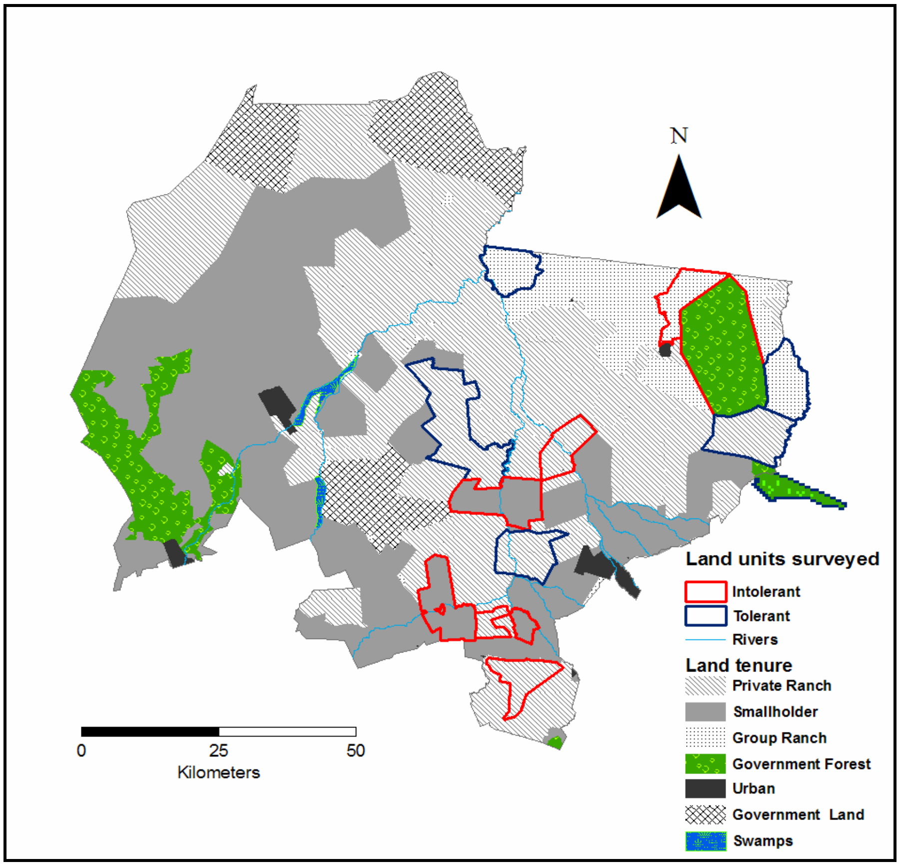


Fig.3.4 Sample areas included within the transect survey

Table 3.1 Sample areas selected for transect surveys, number of transects surveyed and brief description of land use

Sample area (fenced)	**Risk category**	**No. transects** (Total km)	**Land use**
Large-scale ranches			
Segera	Tolerant	8 (16)	Commercial livestock production, wildlife-based tourism
(Mogwooni)	Intolerant	8 (16)	Commercial livestock production, intolerant of all wildlife, particularly elephants
Borana	Tolerant	8 (16)	Commercial livestock production and wildlife based tourism
(Solio)	Intolerant	8 (16)	Private wildlife sanctuary, black rhino protection, intolerant of elephants
(Sweetwaters)	Tolerant	8 (16)	Private wildlife sanctuary, black rhino protection, tolerant of elephants
(Southern Ol Pejeta)	Intolerant	8 (16)	Large-scale commercial wheat farming
Smallholder areas			
Tigithi	Intolerant	8 (16)	>75% of smallholder plots settled, rain-fed cultivation, some irrigation with individual pumps
Ngobit	Intolerant	8 (16)	>90% of plots settled, irrigated cultivation
Endana	Intolerant	8 (16)	<50% of plots settled, abandoned plots occupied by pastoralists, mainly livestock production with some rain-fed cultivation
Forest Reserves			
Mukogodo	Intolerant	8 (16)	Occupied and traditionally managed by Mukogodo Maasai, mainly livestock production, some rain-fed agriculture, honey production, wild foods, occasional elephant hunting
Ngare Ndare	Tolerant	8 (16)	Fenced and actively protected/managed by Lewa Downs Conservancy and GoK Forest Department. Used by neighbouring communities for livestock grazing, firewood and forest products
Group Ranches			
Kuri Kuri	Intolerant	3 (6)	Subsistence livestock production, honey production, wild foods, occasional elephant hunting
Ilngwezi	Tolerant	8 (16)	Subsistence livestock production and wildlife-based tourism
Koija	Tolerant	8 (16)	Subsistence livestock production, wildlife-based tourism and honey production

3.4.2 Transect field methods

One hundred and twelve kilometres were surveyed, 56 km in each of two seasons: the long rains (April-June); and the long dry season (July-September). Four transects each of 2 km in length and of variable width were surveyed for elephant and human sign in each of the fourteen sample areas, with the exception of Kuri Kuri (Table 3.2). To ensure different vegetation types were sampled, and in light of the potentially confounding influence of water (see section 3.4.1), transects were placed at 2 km intervals along and perpendicular to major drainage features, following the methodology of Barnes et al (1991). Both the length of the transects and their placements were as recommended by standard transect survey techniques (Buckland et al., 2001, Norton-Griffiths, 1978). Distances along transects were measured using a 50 metre measuring tape. While this was quite laborious, several pilot surveys found a conventional 'hip chain' and a digital pedometer to be less reliable. At the starting point of each transect, a stake was cut into the ground at eye level. A sighting compass was then placed on the stake and orientated towards a predetermined compass bearing. An assistant traced or cut a path away from the compass person on the bearing. The compass person ensured that the assistant did not deviate from the straight line indicated by the bearing. Once it became difficult to see the assistant ('cutter'), they were told to stop and the compass person moved towards him with compass, recording all observations of dung. After each fifty metre interval a stake was planted and a ribbon attached[15] so that the same course could be followed precisely in the subsequent season. For each dung pile observation, the perpendicular distance was recorded to enable densities to be calculated using standard distance sampling methods (Buckland et al., 2001).

Dung density estimates are not only dependent on elephant density but are also dependent on dung 'decay' rates. Dung decay rates have been shown to vary across space in relation to diet (White, 1995) and rainfall (Barnes et al., 1997b, Nchanji & Plumptre, 2001) among other factors. In previous elephant population censuses based on dung counts, attempts have been made to account for potential local variation in dung decay by estimating 'local' dung decay rates. Elephant densities can then be calculated using the following equation (Barnes, 1996b):

$$E = \frac{Y \times r}{D}$$

Where:

[15] During the second season of transect surveys I found most of these ribbons had been removed by local people but the transect poles were left in place and I was able to relocate the starting position for each transect from the GPS coordinates recorded.

E = number of elephants
Y = dung-pile density
D = defecation rate
r = dung decay rate

While the use of dung counts in this study was not to estimate the size of the Laikipia elephant population, I felt that information on dung decay rates within each of four land-use/tenure categories (smallholder, forests, group ranches and large-scale ranches) would improve both analysis and estimates of dung density. To this end 20 fresh dung piles were marked in each of four sites representing each of smallholder, forest, group ranch and large-scale ranch categories with the intention of monitoring the number of days it took for each pile to disappear in each site. In addition, during the transect survey each dung pile that was observed was classified into one of four categories relating to different stages of decomposition or 'decay' (Beyers et al., 2001, White & Edwards, 2000):

A-Fresh: Sometimes still warm, with shiny fatty acid sheen glistening on exterior and strong smell

B-Recent: odour present, there may be flies, but the fatty acid sheen has disappeared.

C-Old: overall form still present although the boli may be partly or completely broken down into an amorphous mass, no odour

D-Very Old: flattened, dispersed, tending to disappear

The rationale here was that if information on the variability in decay rates was available then the sample of dung piles included in analysis of transect data could be either limited or expanded to one or several of the four decay stages to account for variation in decay rates within each land use/tenure category. Therefore, the final dung density estimates could arguably be more comparable between sites. Unfortunately the markers (coloured ribbons) and dung piles used in the first set of dung pile decay monitoring experiments were removed by local people and wild animals before decay estimates could be calculated. The markers used in the second set of experiments (painted rocks) were similarly tampered with and so information on dung decay was not available for this thesis. Therefore in the analyses presented in chapter five, I used all dung types as an indicator of density of use over the seasonal time span.

During the first, wet season, line transect survey all dung was removed from each transect to ensure that no old dung would be subsequently recounted during the second, dry season, transect survey. At each change in vegetation along a transect, the vegetation type was recorded together with the distance from the beginning of the transect. In the pilot survey vegetation was characterised as belonging to one of 13 categories based on a Laikipia vegetation map available from CETRAD and compiled by Taiti (1992). However the vegetation encountered did not always fit within the specific categories defined by Taiti and so during the main transect survey vegetation was instead classified into one of five simplified categories based on the standard East African rangeland classification system described in detail by Pratt et al. (1966):

1. Bushland: An assemblage of woody plants, mostly shrubby habit with a canopy of less than 6m in height and a canopy cover of more than 20%.

2. Woodland: Stand of trees up to 18m in height with open or continuous but not thickly interlaced canopy, sometimes with shrubs interspersed, and a canopy cover of more than 20%

3. Grassland[16]: Land dominated by grasses and occasionally other herbs; sometimes with widely scattered or grouped trees and shrubs, the canopy cover of which does not exceed 20%.

4. Forest: A closed stand of trees of one or more storeys, with an interlaced canopy

[16] In fact Pratt et al (1966) defined four categories of grassland: grassland, bushed grassland, wooded grassland and dwarf shrub grassland depending on the ensemble of species present within the grassland. I grouped all of these four types into one category of grassland as defined in the main text.

5. Cropland complex[17]: Small-scale agricultural enterprises; aggregation of cultivated fields with crops, trees, fallow or ploughed land with cover changing seasonally according to cropping practices and rains.

In addition to recording the simplified vegetation type encountered a note was made of the dominant species at each change in vegetation so that further detailed classifications could be carried out if necessary. For each transect, the proportion of the total length over which each vegetation type was encountered was calculated. Further detailed vegetation surveys were conducted along two 100 metre transect segments within each 2 km transect. The first of these segments was placed at the beginning of each transect, and the second was placed after 1 km. In each of these two one hundred metre segments, percentage of herbaceous cover and percentage of woody vegetation cover were measured. Woody cover was measured by recording the lengths along each transect intersected by each individual woody plant with a note made of the following attributes: species name, frequency and height class (Heady, 1983, McIntrye, 1953). Herbaceous cover was measured by calculating the proportion of herbaceous cover within a 0.5 x 0.5 metre quadrant, placed adjacent to each transect segment at every 20 metre interval. All vegetation that fell within the quadrant was clipped and bagged, providing 10 samples in total for each 2 km transect. These samples were subsequently dried and weighed to provide an estimate of the weight in grams of dry herbaceous biomass for each vegetation type which was then summed over those habitats' representation in a transect (Muchoki, 1988). These vegetation sampling methods were adapted from the existing vegetation survey protocol used by the DRSRS (formerly known as the Kenya Rangeland Ecological Monitoring Unit).

All evidence of human activity and presence along each transect were recorded. For example observations of footpaths, roads, sightings of people, livestock (or livestock spoor), evidence of wood extraction (machete cuts or tree stumps), homesteads, snares and bullet shells were noted.

[17] This vegetation category was adopted from the definition provided by Taiti (1992) as the classification system developed by Pratt et al (1966) was for natural vegetation cover types only.

3.5 HUMAN ELEPHANT CONFLICT ENUMERATION

I recruited and trained 10 local enumerators, ‘elephant scouts’ to systematically collect data on crop-raiding and other forms of human-elephant interaction in Laikipia District between November 2003 and October 2004. Scouts were recruited from locations in Laikipia that were identified as probable human-elephant conflict ‘hot spots’ based on results of previous research (Thouless, 1993, Thouless, 1994), reports compiled in the district office of the Kenya Wildlife Service (KWS) and interviews with local people. The KWS is the national wildlife authority and is represented locally through the district headquarters, based in Nanyuki, together with several small outposts across the district. The final sample of locations selected ensured that a scout was recruited from each of the main human-elephant conflict sites.

I recruited scouts by interviewing potential candidates nominated by local community leaders from each target area. Candidates were expected to have completed primary school education, and preferably secondary. In all cases potential candidates had to demonstrate basic writing skills and arithmetic. In most cases this recruitment strategy was effective and many of those initially selected proved to be reliable. This was not always the case, however, and in some places there was initially a high turnover of candidates until a reliable person was found. Scouts were provided with a Garmin Global Positions System and a mobile phone. They were trained on data collection protocols, using an adapted version of the IUCN’s *Training package for enumerators of elephant damage* (Hoare, 1999b). Each scout visited the location of any reported crop-raiding or human-elephant conflict incident that occurred in their area. Once verified, the location in Universal Transverse Mercator (UTM) coordinates and incident details was recorded on a standard reporting form (Appendix 2). For crop-raiding incidents, details of the area under cultivation, crop species damaged, time of incident and the number and sex of elephants involved were also recorded. In addition, scouts used their mobile phones to send text message reports to me and the KWS HQ in Nanyuki to track human-elephant conflict incidents in between supervisions and to enable the KWS to provide support when possible. While text message reports did not provide information that was any more useful for this thesis than the data reported on the standard forms, it did provide a service for both the KWS and local people, helping me to build trust among the people I was working with. This became particularly useful when I subsequently carried out a questionnaire survey and informal interviews. Supervision of scouts was carried out both in the field and through monthly meetings at an office in Nanyuki (Fig. 3.5). During the supervisions in Nanyuki all forms were thoroughly checked for errors and were then entered into a database by an assistant.

Fig. 3.5 Elephant scouts showing mobile phones and GPS units during a monthly supervision session in Nanyuki

3.6 ELEPHANT MORTALITY

To establish the spatial dimensions of risk to elephants from the deterrence activities of and direct hunting by local people, the GPS positions and further details (i.e. cause of death, sex and approximate age of elephants) were recorded for a total of 186 elephant carcasses in Laikipia between 2002 and 2004. Fifty nine of these carcasses were recorded either by me or by research assistants trained and employed by me in the field (see section 3.5). The remainder of the carcasses were recorded directly by Onesmus Kahindi, a MIKE[18] (Monitoring the Illegal Killing of Elephants) officer employed by Save the Elephants under the supervision of the KWS. Twenty six of the latter carcasses were verified in the field either directly by me or a trained enumerator (see section 3.5). In this thesis I present a table of carcasses from each of the 14 study areas surveyed during the transect survey (Table 5.3). All of the carcasses presented in Table 5.3, chapter five, were either recorded or verified directly by me or a research assistant. In this thesis I also present a map of elephant carcasses recorded in Laikipia between 2002 and 2004 using both sources of elephant carcass data (Fig. 5.8).

3.7 GPS TRACKING OF ELEPHANTS

3.7.1 Sampling

On the basis of an elephant distribution map from the 2002 total count (Omondi et al., 2002), six regions within Laikipia District were purposively selected for collaring operations with the objective of capturing elephant movement and behaviour across the district and within different landscape contexts in terms of ecological conditions, human land use and associated management. As a result of this sampling strategy, elephants were fitted with GPS collars from most, if not all, of the regions in Laikipia in which the major concentrations of elephants were observed during the 2002 total count (Fig. 3.6). In total ten male elephants and six female elephants were fitted with GPS collars. The initial aim was to fit an equal number of GPS collars on male and female elephants. However, the final batch of two GPS collars that I intended to deploy on female elephants had large counterweights (5kg) and in the end I decided these would be more appropriate for larger male elephants.

[18] The Monitoring the Illegal Killing of Elephants (MIKE) programme was established under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1999. It aims to "provide information needed for elephant range states to make appropriate management and enforcement decisions, and to build institutional capacity within the range stages for the long term management of their elephant populations." (Hedges & Lawson 2006: 4).

Published studies have shown that related adult female elephants live together with their immature offspring in cohesive groups defined as 'family units', representing the most basic social unit within what is believed to be a more complex, multi-tiered female social structure consisting of, in reverse order of hierarchy, 'bond groups' and 'clans'(Douglas-Hamilton, 1971, Moss & Poole, 1983, Wittemyer et al., 2005). As such, GPS collars deployed on adult female elephants capture the movements of an entire family group and not just an individual. There was not the time, nor the resources, to accurately estimate the size of the family groups associated with each female elephant collared in this study. However the median family group size estimated for a sub-population of elephants studied for over 21 months within the nearby Samburu and Buffalo Springs National Reserves was 9 with a range of 3 to 36 individuals (Wittemyer, 2001).

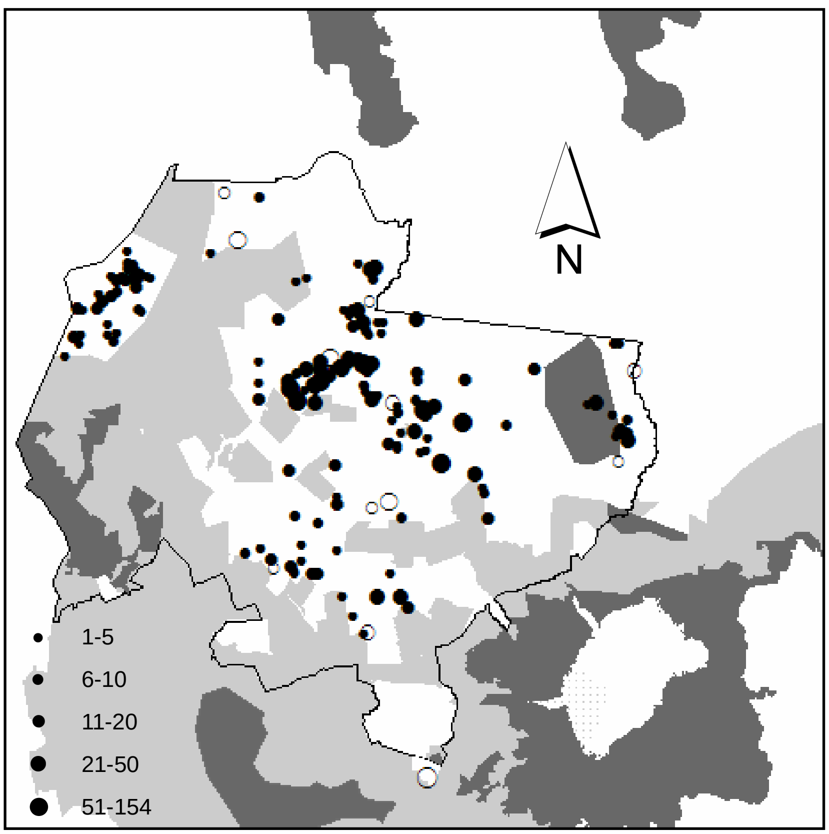


Fig. 3.6 Distribution of elephants observed in Laikipia during the June 2002 total count. Elephants observed in Samburu District are not shown. Hollow circles show the approximate location of elephants fitted with GPS collars in 2004.

In contrast to female elephants, long term studies have shown that male elephants become independent of their natal families after around 14 years (Lee & Moss, 1995, Lee & Moss, 1999). Thereafter male elephants can live alone or among other bulls or associate with other family groups, depending on age and sexual state (Poole & Moss, 1989). Therefore the GPS tracking results for male elephants are only directly representative of an individual, although male elephants collared in this study were observed with other male elephants during the collaring operations.

3.7.2 Elephant immobilisation

Sixteen elephants were immobilised using gun-propelled syringes (Fig. 3.7) containing between 12 to 21 mg of etorphine depending on the size of the target animal and were revived using deprenorphine (Fig. 3.10). The period over which each elephant was recumbent ranged between 10 to 32 minutes, during which a qualified vet monitored the elephant's vital signs, kept the elephant's eyes covered and moist and ensured the animal was able to breathe properly. Once the anesthetic took effect, most elephants fell on their side but on those few occasions when the elephant fell on its sternum (Fig. 3.8), it was pulled over onto its side with the use of a rope and vehicle or if there were enough hands on deck, a good shove. This latter precaution ensured normal respiratory function of the immobilised elephant was not compromised. GPS collars were fitted so that the sealed compartment containing the battery pack, GPS, GSM and VHF devices was placed above the neck of the animal and a counter weight weighing between 3 (14 collars) and 5 (2 collars) kilograms was placed below the neck. Each of the two flaps of the collar were clamped to either side of a counterweight below the animal's neck and fastened together with four bolts which were threaded through two metal plates either side of the counter weight and the four holes located in each corner of the counter weight. These blots were finally secured using four nuts (Fig. 3.9). Darting operations were carried out using a helicopter (4 operations), on foot (five operations) or from a vehicle (the remaining 7 operations). In those operations in which a helicopter was not used, a spotter aircraft was deployed to monitor the location of the darted animal and communicate with the ground team. There were no elephant mortalities recorded as a result of any of the collaring operations carried out during this study.

3.7.3 GPS collar design

The GPS telemetry unit used for tracking elephants has been described in detail by Douglas-Hamilton (1998) and Thouless (1996b). In summary the basic GPS tracking unit is comprised of a Global Positioning System receiver with built in nonvolatile random access memory (RAM) for storing location data, a two-way modem for data communication, a conventional VHF beacon and a battery. There were two designs of collars used in this study, both manufactured by African Wildlife Tracking, a specialised tracking company based in Pretoria, South Africa. Two of the collars deployed in Laikipia used a satellite modem for two-way data communication (Inmarsat-3 F1). The remaining 14 collars that were deployed in Laikipia used a Global system for mobile communication (GSM) modem for two-way data communication. The latter design used the mobile phone network of the largest Kenyan network provider, Safaricom Ltd. Two-way data communication enables location data to be downloaded remotely via the internet and provides a mechanism for remotely programming the settings of the GPS receiver. Because the GSM collars use a terrestrial communication platform they are more energy efficient than the conventional satellite collars and thus have a longer battery life. The AWT collars are designed so that the tracking unit components are encased in a single housing unit on the top of the collar. The position of the housing unit, placed facing upwards on top of the animal's neck, is secured by fitting a counterweight as described above.

Fig.3.7 Dart in the rump of an adult female elephant.

Fig.3.8 Large adult male elephant that landed on his sternum.

Fig. 3.9 Threading bolts through the counter weight

Fig. 3.10 Collared female elephant getting up after the antidote was administered.

3.7.4 Collar performance

Collar performance, in terms of the GPS fixes reported in relation to the GPS fixes that were expected based on the collar reporting schedule, are shown in Table 3.2. While generally the collars performed well, a number of problems were encountered. Due to their high power requirements, the two satellite collars deployed in Laikipia were programmed to record only a single GPS fix per 24 hours. Of these two collars, one failed after just two months while the other is still reporting GPS fixes after almost two years of use. The GSM collars were programmed to record a GPS fix every hour. The recording schedules on two of these GSM collars, K13 and K18, were, however, inadvertently rescheduled to take GPS fixes every four and fifteen hours, respectively. After nine months of regular hourly GPS reports, another collar, K19, was inexplicably rescheduled to take a GPS fix every minute and shortly thereafter the battery power on this particular collar was exhausted. There were other occasions, though less significant, where collar reporting schedules were temporarily altered. In addition several of the collars occasionally recorded more than one fix during a single hour. This occurred at random over the monitoring period. Invariably problems with erroneous collar reporting commands were caused by direct programming errors made by the data link hosts, Yrless International, based in Pretoria, South Africa. All elephant tracking data were filtered for spurious GPS fixes prior to analysis by excluding locations that were further than a realistic distance from the preceding location. For example for those collars scheduled to record a GPS fix every hour if a GPS fix was further than 10 km from the previous fix, it was excluded from the analysis.

Another problem experienced with the GSM collars was the loss of blocks of data over certain time periods. This occurred because GSM collars have limited inbuilt RAM so that when some of the tracked animals moved out of mobile phone network coverage for protracted periods, GPS positions were not downloaded onto a remote server and so were instead dumped. To help address this problem Safricom Ltd, the local corporate sponsor of the tracking project, provided a mobile GSM tower, colloquially known as a cell on wheels (COW). This occurred on two separate occasions, each over a period of several days. When made available, the COW was strategically moved to several different locations in the study area, enabling the successful download of GPS fixes for four different elephants that had been out of coverage for a protracted period. However problems with network coverage still resulted in loss of GPS location data from K20, K16 and K15. As the GSM network coverage continues to expand and improve in Kenya this type of problem is likely to be less of a constraint in future.

Table 3.2: Number of GPS fixes (minus spurious GPS fixes) recorded for each collar in relation to the expected number of fixes based on the recording schedule

Collar I.D.	Reports per24hrs	From (Date)	To (Date)	Actual Fixes	Expected Fixes	%
K13	4	04/05/2004 17:14	01/08/2005 20:12	2437	2905	84%
K15	24	04/05/2004 11:02	18/03/2006 01:05	11110	16404	68%
S3	1	14/10/2004 12:13	03/05/2006 12:50	533	567	94%
S4	1	14/10/2004 08:53	29/12/2004 05:44	74	77	96%
K11	24	24/04/2004 16:03	18/04/2006 01:59	12578	17365	72%
K2	24	21/04/2004 12:59	18/04/2006 15:02	16725	17445	96%
K8	24	20/12/2003 10:46	10/01/2005 10:01	7771	9255	84%
K14	24	22/04/2004 15:03	20/04/2006 17:01	16431	17480	94%
K9	24	23/04/2004 11:30	20/04/2006 15:02	23285	17450	133%
K19	24	28/08/2004 13:01	19/05/2005 18:58	5307	6344	84%
K22	24	13/10/2004 12:26	18/04/2006 14:00	14255	13275	107%
K21	24	12/10/2004 14:52	13/04/2006 13:59	12545	13157	95%
K7	24	12/10/2004 11:02	18/04/2006 14:59	14520	13302	109%
K16	24	04/05/2004 16:40	18/04/2006 13:52	10236	17142	60%
K18	1.6	18/08/2004 10:01	25/11/2005 15:18	672	742	90%
K20	24	18/08/2004 09:59	08/08/2005 09:55	4339	8506	51%

3.8 QUESTIONNAIRE SURVEY

A questionnaire survey (Appendix 3) was carried out in eight different sample areas between September and November 2003 with the objective of collecting information on: 1) household socio-economic profiles and patterns of resource use and management; 2) the likelihood of interaction with elephants during certain off-farm activities; 3) perceptions of elephants both relative to other livelihood constraints and more generally;

and 4) direct household responses to the presence of elephants. The choice of sample areas for the questionnaire survey was primarily guided by the location of transects used for measuring elephant distribution and density so as to provide a directly comparative basis between the ecological and social information collected and information for comparing human and elephant perspectives of the landscape. Thus, as with the transect survey, the sample areas captured a range of different human resource use contexts. This enabled information to be collected on patterns of resource use in relation to specific land-tenure/use types (government forests, community forests, group ranches and sub-divided ranches under different stages of settlement) and the implications in terms of interaction with and perceptions of elephants. The purposive sampling strategy also ensured that respondents were "people as direct doers of activities," (Poate & Daplyn, 1993) in consideration of the ecological patterns identified through dung counts presented in chapter five.

Four communal land units (Koija Group Ranch, Ilngwezi Group Ranch, Kuri Kuri Group Ranch and Anandangaru settlement in the Mukogodo Forest) and four smallholder land units (Tigithi, Ngobit, Endana and Ngare Ndare) were selected. The sampling unit used for the survey was the household, based on the following definition (Casley & Lury 1981: 188):

"*a person, or group of persons generally bound by ties of kinship, who live together under a single roof or within a single compound, and who share a community of life in that they are answerable to the same head and share a common source of food.*"

For each site an inventory of households was made with the help of a local representative of the district administration (Location Chief). The resulting list of households generated was used as the sampling frame and a target of 50 households was randomly selected, using a random number table, from this list for inclusion within the survey. Within each household, the household head was the preferred respondent. When s/he was not present, another adult member of the household was interviewed. On those few occasions when a household was unwilling to participate, (14 occasions), a new household was randomly selected from the sampling frame. In total the questionnaire was administered to 401 households of which 45 were discarded because of incomplete or unreliable information provided by respondents. The final sample prepared for analyses thus comprised 356 household questionnaires, an average of 44.5 households per site with a minimum of 39 (Mukogodo) and a maximum of 64 (Ngare Ndare), ensuring adequate sampling intensity (i.e. 15% or greater) for each site to draw inferences about the parent population (Oppenheim, 1992). Of these 25.9% were questionnaires carried out with female respondents. Six ethnic groups are represented within the survey sample of which two, the Kikuyu and Maasai made up 91%, with the Turkana and Samburu making up the majority of the remainder.

The questionnaire comprised 86 questions of which 16 were concerned with background information of the household, 39 with patterns of household production and resource use, 2 with livelihood constraints and the remaining 29 questions focussed on interaction and perceptions of elephants (Appendix 3). To build a rapport with respondents, the questionnaire was structured such that factual questions were placed at the beginning of the schedule and attitudinal questions were placed towards the end. The questionnaire was comprised of a mixture of ‘open’ and ‘closed’ questions. Closed questions were asked as open questions with responses field-coded and checked against a set of pre-determined response categories hidden from the respondent (Sudman and Bradburn, 1982). Some of the questions required respondents to recall events and thus it could be argued that responses could potentially have suffered from recall bias (De Vaus, 1991). However as the events that formed the basis of enquiry involved contact with elephants, if they had occurred, they were unlikely to have been forgotten easily. In addition the probability of recall bias was reduced by involving other household members (if present) to corroborate household responses to recall questions (Weladji & Tchamba, 2003). This latter strategy was also adopted for questions concerning activities that involved more than one household member and/or involving a household member other than the respondent. During the course of the interview, relevant qualitative comments made by the respondents in response to questions were recorded to enhance interpretation of the quantitative analyses (presented as *Q#* in the main text).

Interviews were carried out by four Kenyan field assistants, all residents of Laikipia and all having completed secondary education. None of these field assistants had prior research experience and so they were trained in the use of the questionnaire during a pilot survey carried out in Mutara, a settlement located in west Laikipia in July 2003. Research assistants had a certain degree of freedom as to exactly how they translated questions and in some cases, responses and qualitative discussions. With the aim of avoiding misunderstandings and mistranslation and to ensure consistency, during the pilot study I asked that translated responses were repeated to me in English with the aim of ensuring that the meaning of both the question and/or response had not been lost or changed. Once I was satisfied that research assistants were properly interpreting questions and recording qualitative material, they carried out questionnaires independently. Where used in this thesis, I have not edited research assistants' translations of qualitative comments made by respondents.

I assisted with ten interviews in each site, comprising 22.5% of the final household sample used in the analyses presented in this thesis. Where field assistants were not known within the study area, an additional local contact was used to facilitate introductions with potential respondents and provide an additional means of cross-checking responses. This was the case for Koija Group Ranch, Kuri Kuri Group Ranch and the Tigithi smallholder settlement. In each of these cases the local contact held no formal position in the local administration and appeared to be trusted and respected by the local people. All questionnaires that were completed by field assistants where I was not present were verified in the field within one week of the interview. Questions were asked in Kiswahili and where necessary field assistants asked questions in the vernacular including: Maasai, Kikuyu and Turkana. All responses were recorded in English on the questionnaire schedule in the field.

All questionnaire responses (with the exception of qualitative comments) were coded and entered into SPSS by an assistant. I randomly selected a sample of 10% of the questionnaires to check for data entry errors. The whole process was repeated twice due to problems encountered with data entry.

3.9 QUALITATIVE INTERVIEWS

The questionnaire survey provided a practical means for collecting descriptive and attitudinal data at the household level within the time frame available. However the suitability of questionnaires for studying social phenomenon is debatable (Chambers, 1994) and in particular they are inadequate for explaining *why* "phenomena occur and the forces and influences that drive their occurrence," (Ritchie & Lewis 2003: 28) and for gaining constructive insights into the 'life-worlds' of research subjects (Adams & Megaw, 1997). A range of less formal qualitative approaches have emerged from such critiques. These approaches include participant observation (Spradly, 1980), active interviews (Holstein & Gubrium, 1995) and discourse analysis (Adger et al., 2001). While aware of the relative merits of these latter approaches, I felt a 'fast and dirty' quantitative methodology was more appropriate for sampling human dimensions of interaction with elephants at a scale relevant in an elephant landscape within the time available. However with due regard to the criticisms of questionnaire surveys, qualitative material was also collected, albeit opportunistically (Ritchie & Lewis, 2003).

I trained research assistants to record relevant qualitative comments made by respondents during the questionnaire survey. I also carried out qualitative interviews with sixteen individuals from a wide range of backgrounds (presented as *I#* in the main text), to gain deeper insights into local patterns of interaction with elephants, local perspectives of such interaction and the underlying factors leading to such patterns. Interview respondents were selected purposively, to collect information with reference to specific places and on the basis that I had a strong existing rapport with them so that opinions could be expressed freely and without concern. Because of the latter requirement, these informal interviews were carried out towards the end of the field work period, after I had learnt conversational Kiswahili and built up trust among a network of informants. A list of interviewees and key informants is provided in Appendix 4.

Interviews were informal and conversational in style though were loosely guided by a schedule of topics for discussion. I carried out fourteen interviews in either English or Kiswahili. The remaining two interviews were carried out in Maasai through a research assistant who translated responses into English. All interviews were recorded using a mini-disk player and microphone if consent was given by the interview respondent. On those occasions where the respondent preferred not to be recorded on tape (n = 4), conversations were recorded using shorthand. Interviews carried out in Kiswahili were translated and transcribed by an assistant. I transcribed all informal interviews carried out in English (including the two interviews carried out in Maasai with English translations).

My fieldwork activities brought me into contact with a large number of actors within Laikipia's human-elephant interface, other than those formally interviewed, including members of government, local conservation actors, wildlife managers, and local people. This resulted in a large number of impromptu conversations of relevance to my research questions. Some of these conversations I recorded in my note book *ad libitum* providing a further source of qualitative data to draw upon when interpreting results from the more formal questionnaire survey and concurrent analyses (presented as *KI#* in the main text).

Informal interviews and impromptu conversations with key informants produced a substantial amount of detailed material on the topics discussed. A formal analysis of this material is beyond the scope of this thesis. Instead qualitative data are used to help inform and cross-check the quantitative analyses presented. Thus the final methodology was mixed so as to meet the research aims while also taking into consideration the field realities and time available. Further details of the social methods used in this thesis are provided in chapters eight and nine.

3.10 CONCLUSION

In this chapter I have described the different sources for the data used in subsequent analytical chapters. In the next chapter I begin analysing these data through an assessment of human land use and the relationship with wildlife distributions at the landscape level.

Chapter 4: Human land use and wildlife ecology at the Laikipia landscape scale

4.1 INTRODUCTION

As was discussed in the preceding chapters, the relationship between people and elephants in Laikipia District can be considered at different scales. This chapter presents landscape-scale information on wildlife and human use of Laikipia through a GIS. In addition, different modes of household production are presented based on the results from the questionnaire survey of Laikipia residents, described in the last chapter. While the ecological focus is on elephants, other species of wildlife, based on the aerial sample counts from the DRSRS (section 3.3), are also included in this chapter to illustrate broader ecological trends. Much past research on outcomes and processes of interaction between humans and wildlife has focused on the distribution of wildlife, assessed through techniques such as aerial counts. These distributions can be tracked over time, comparing data from consecutive years. In this chapter I use a similar approach to illustrate ecological change within the Laikipia landscape with a particular emphasis on the *c* 10 year period between the early 1990s and 2002. However, as will be demonstrated, multiple data types from different methods are needed to measure, effectively, the overlap between humans and elephants in their use of shared landscapes. Land use, in terms of the dominant modes of production (both subsistence and commercial), and the property rights regimes controlling production, are used as the key variable to contextualise the social and ecological patterns identified in Laikipia at the landscape scale.

4.2 METHODS

4.2.1 Land use

In Chapter One (Fig. 1.4), I presented a map showing broad land-tenure categories in Laikipia District for 2004. These were updated from a 1987 classification (Chapter Three, section 3.2), using ArcGIS 9 software (Environmental Systems Research Institute, Inc., Redlands, CA, 2004). Because of the micro-scale nature of land use, it was not possible to generate a detailed land use map. Instead, in this chapter, I generated another land-tenure map with an expanded list of land-tenure categories which, while not perfect, helps (cautiously) to better illustrate land-use in the study area. I included wildlife conservation within this expanded list of categories. The incorporation of conservation as a category of land-use reflects the extent to which land has been designated explicitly for this purpose both among individual large-scale private ranches and communally owned group ranches since 1987. Former large-scale ranches that have been sub-divided into individual smallholder plots were classified into two categories: 1) smallholder with <25% cultivation; and 2) smallholder with >25% cultivation. These categories were generated by reclassifying the individual 30 x 30 metre pixels from the 2002 MRC land cover image (see chapter 3, section 3.2) so that cultivated pixels received a value of 1 and all other pixels received the value of zero. Subsequently the proportion of each sub-divided ranch under cultivation was calculated as the number of cultivated pixels divided by the total number of pixels available. These two smallholder categories provide a proxy indicator for the boundaries between sub-divided ranches that have largely been settled by immigrant small-scale farmers and sub-divided ranches in which smallholder land holdings have largely been abandoned by the legal owners and are instead occupied and/or used opportunistically for livestock grazing by a range of different pastoralist groups.

Lastly, the new land use classification also included a category for absentee government land which is effectively under ‘open access’ use by pastoralists for livestock grazing. The updated land tenure map presented in Chapter One and the expanded land-tenure categories and associated map presented in this chapter were developed through an inductive process involving analysis of secondary data sources in addition to information provided through field observations and informal interviews with local pastoralists, farmers, ranchers and administrators.

Table 4.1 Expanded land-tenure categories used to illustrate land-use in Laikipia District

Land tenure/ use category	**Description**
Communally owned-pastoralist livestock production	Group ranch under livestock only
Communally owned-pastoralist livestock production & wildlife conservation	Group ranch under livestock and wildlife conservation and/or wildlife-based tourism
Government owned forest-communally managed forest conservation and extraction	Forest reserve occupied and managed by Mukogodo Maasai communities in the absence of government management
Government owned forest-forest conservation and extraction	Forest reserve under the management of the Government of Kenya Forest Department and used for timber and forest product extraction by the local people with and without the permission of forest department employees.
Government owned-uncontrolled pastoralist livestock production	Large-scale ranches purchased by the GoK that are under occupation and ‘open access’ use by pastoralists and their livestock.
Large-scale farming	Large-scale ranch under cultivation (wheat)
Large-scale ranch-commercial livestock production	Large-scale ranch under commercial livestock production with no explicit commitment to wildlife conservation
Large-scale ranch-commercial livestock production and wildlife conservation	Large-scale ranch under commercial livestock production with an explicit commitment to wildlife conservation and/or wildlife-based tourism
Large-scale ranch-wildlife conservation	Large-scale ranch or part of a large-scale ranch in which livestock have been either removed completely or exist at very low densities and where wildlife conservation, in particular the protection of black rhino, is the only form of land use
Smallholder with <25% cultivation	Large-scale ranch that has been subdivided into individual small-scale plots, most of which have been abandoned by the owners and are currently under occupation and ‘open access’ use by pastoralists and their livestock.
Smallholder with >25% cultivation	Large-scale ranch that has been sub-divided into individual small-scale plots, most of which have been settled and/or are under use by the current owners, particularly for cultivation.

4.2.2 Wildlife densities

I calculated the density of animals within each 2.5 x 5 km DRSRS sampling unit (section 3.3) by dividing the total number of animals of a particular species counted within that sampling unit by the area surveyed within that sampling unit (5 x 0.3 km)[19]. I then used the spatial join function in ArcGIS 9, to group, where appropriate[20], each of the new density values of each DRSRS aerial sampling units into one of three land-tenure categories, depending on spatial location: 1) communally owned group ranch; 2) privately owned large-scale ranch; and 3) smallholder areas (for this exercise I did not differentiate between smallholder categories as I did when generating the expanded land-tenure map described in section 4.2.1). Mean animal and settlement density values for each of these three land-tenure categories were then calculated for each aerial survey.

To map spatial changes in animal and human dwelling densities between aerial surveys, I interpolated DRSRS sampling unit values, using an inverse distance weighted (IDW) technique, to a 2.5 x 2.5 km grid using ArcGIS 9. IDW interpolation determines cell values using a linearly weighted combination of a set of neighbouring points (Philip & Watson 1982; Watson & Philip 1985) and is a standard tool available in the Spatial Analyst Extension of ArcGIS 9 (ESRI 2004). Density changes within each grid cell were then calculated and mapped to illustrate broad patterns of change between surveys. I then calculated the spatial extent of the occurrence of wildlife, livestock or human settlement as the proportion of the total sample of grid cells in which the presence of each of these attributes occurred. The occurrence of a combination of any of these three attributes could then also be calculated for each survey to give an indication of spatial co-occurrence.

[19] In section 3.3.1 I described how rear seat observers counted animals within a fixed 150 metre strip either side of the aircraft.
[20] Aerial survey sampling units that fell within forest reserves, government land and urban areas were omitted from the analysis.

4.2.3 Household subsistence patterns in time and space

Coarse patterns of household production were explored through a descriptive analysis of questionnaire survey results (see section 3.8) across three categories of land use/land-tenure:

- 'Communal': Communally owned (group ranch) with low annual rainfall (350-550mm per annum).
- Smallholder, low density: Sub-divided ranch with < 25% cultivation and <50% of designated smallholder plots settled[21] and low to medium rainfall (550-700mm)
- 'Smallholder', high density: Sub-divided ranch with >25% cultivation and > 75% of smallholder plots settled and medium to high rainfall (>700mm).

As described in Chapter One, distinctions among dominant modes of livelihood production within a defined geographical area are often associated with specific characteristics of the environment where people live. Such livelihood distinctions are important in the context of this study as they may shape the attitudes and responses of land occupants towards elephants. From an elephant's perspective different resource user groups and associated management practices can represent different levels and types of risk (and sometimes opportunity) to navigate. Simple descriptive analyses of household production data within land use/land tenure strata were carried out using SPSS (v.12) and Excel.

4.2.4 Seasonal elephant movement

As described in Chapter Three (section 3.7), sixteen elephants were fitted with GPS collars in this study. A detailed analysis and description of elephant movement based on these data is presented in Chapter Seven. In this chapter I carry out an analysis of

[21] Values for the proportion of smallholder plots settled within sub-divided ranches came from a 1995 land use classification carried out by and available in digital format from CETRAD (formerly known as the Laikipia Research Programme). This classification updated the earlier work carried out by Kohler (1987).

the response of elephants to seasonal variation in green vegetation biomass as a surrogate for rainfall. The aim here was to illustrate, at the landscape level, the extent to which both people and elephants depend on and respond to the same ecosystem processes (i.e. rainfall) across time and space to gauge the implications in terms of coexistence in the context of a shared landscape. This analysis was carried out in two parts: 1) establishing the seasonality of rainfall over the tracking period; and 2) assessing the effect of the seasonal pattern of rainfall on the size of areas used by elephants

4.2.4.1 Seasonality of rainfall over the elephant tracking period

As was mentioned in Chapter One, previous research has shown that rainfall in Laikipia and the surrounding region is typically bimodal, falling mainly in two seasons: ‘the long rains’, between April and June; and the ‘short rains’ between October and December (Gichuki et al. 1998b; Rasmussen et al. 2006; Thouless 1995). This previously identified pattern of rainfall provided the rationale for carrying out a seasonal analysis of elephant movement. However, rainfall is also highly variable in the Laikipia region both temporally and spatially (Thouless 1995) and so in order to justify carrying out a seasonal analysis of elephant movement it was first necessary to confirm if the general pattern of rainfall seasonality described in previous research also occurred over the period during which elephants were tracked. Ideally this would have been achieved using rainfall data. However, the main source of rainfall data for the region, NRM3, closed down in 2004 and I was not able to visit individual rainfall stations myself between 2004 and 2006. Therefore I decided instead to use normalized differential vegetation index (NDVI) data as a surrogate for rainfall.

NDVI is a remotely sensed relative measure of light absorbed by photosynthesizing green plant biomass, calculated as the ratio between red and near infrared reflection (Tucker et al. 1985). NDVI performs well as an index of green biomass in drier areas where it is closely related to rainfall (Georgiadis et al. 2004b). In contrast to point-sampled rainfall data, NDVI data is available over large areas and is therefore increasingly used as a measure of seasonal variation, performing well in ecological studies (Cerling et al. 2006; Rasmussen et al. 2006). For this study NDVI data were

available every 16 days at a resolution of 250m x 250m from the *Moderate Resolution Imaging Spectroradiometer* (MODIS). These data were downloaded from the internet and provided on request by Mpala Research Centre in Laikipia District.
To examine the distribution of NDVI values over time, an NDVI sequence was constructed for each of five elephants that were tracked for 24 months[22]. Twenty-four location points were identified for each of these five elephants, representing their location at the end of each month. Monthly NDVI values for these points were then calculated and averaged to give a plot of change in NDVI that represented the whole landscape through which this elephant ranged.

4.2.4.2 Seasonal home range size of elephants

The response of elephants to seasonal changes in green vegetation biomass was examined by estimating and comparing the sizes of areas used in different seasons using the Animal Movement Extension to ArcView (Hooge & Eichenlaub 1997). Two 'home range' estimates were used to calculate the size of areas used in different seasons: 1) the traditional and widely used 100 % minimum convex polygon (MCP-Hayne 1949), calculated as the area contained within the outermost locations at which an animal was observed over a specified time period; and 2) fixed kernel utilisation distributions (UDs) with 95% and 50% probabilities, describing the relative frequency distribution of location data over a specified time period (Powell 2000; Van Winkle 1975; Worton 1989).

Seasonal range estimates were derived by dividing all the location data available for each elephant into four three month blocks corresponding to the four seasons identified (i.e. 'short dry', 'long rains', 'long dry' and 'short rains'). To maintain consistency, seasonal range estimates for each elephant and associated analyses were derived only for those seasons that fell between October 2004 and September 2005. Data were not available for between 2004 and 2005 for elephant K8, so data from the previous year were used.[23]

[22] Out of the sixteen elephants fitted with GPS collars, these five elephants were monitored for the longest continuous period and therefore provided the most useful data set for tracking variation in NDVI over time.
[23] I felt this was acceptable because monthly NDVI values for K8, derived between January and September 2004 were positively correlated with monthly NDVI values between January and September

Of the sixteen elephants fitted with GPS collars, the data available for three were too incomplete for carrying out a seasonal analysis.

4.2.5 Measuring the co-occurrence of wildlife and people

The pattern of wildlife distribution in relation to human settlement, cultivation and livestock is analysed across two axes of variation: space and time. This was achieved in this chapter using methods adapted from Georgiadis et al. (2004). The co-occurrence of wildlife (Burchell's zebra, elephants, impala and Grevy's zebra) with various indices of human presence/use in Laikipia was measured and tracked over time at the landscape level in a GIS. The first method used interpolated values from sample counts for wildlife, livestock and human dwellings (described in section 4.2.2) to calculate the total proportion of 2.5 x 2.5 km grid cells in which wildlife species and indices of human presence (or combinations of the two) occurred. This analysis was carried out for different years to detect trends over time.

The second method also generated a matrix to explore co-occurrence, though this used only the latest sample aerial count data (2003). Elephant distribution in this analysis was determined by combining the 2002 aerial total count data for elephants with locations of human-elephant conflict incidents recorded by community scouts (described in chapter 3, section 3.5) and GPS positions of radio-tracked elephants (described in chapter 3, section 3.7) to create a more comprehensive layer of elephant distribution in the Laikipia landscape. Where one or more observations included within this layer fell within a 2.5 x 2.5 km grid cell, the cell was assigned a value of 1 to indicate elephant presence. To simplify the visual illustration of the spatial pattern of co-occurrence a weighted index of 'human use' was created representing a composite of settlement (2003), cultivation (2002) and livestock densities (2003). Composite scores of human use were calculated using the categories shown in Table 4.2.

2005 and there was no significant difference in monthly NDVI values between the two years (Pearson: $r = 0.77$, $P = 0.015$, $n = 9$; means: 2004 = 0.47, 2005 = 0.47; $t(8) = 0.18$, $P = 0.86$).

Table 4.2: Components of an index for intensity of human use

Element	Range	Value
Settlement/km^2	0	Low (1)
Settlement/km^2	.01-3	Medium (2)
Settlement/km^2	>3	High (3)
Livestock/km^2	0	Low (1)
Livestock/km^2	0.01-48	Medium (2)
Livestock/km^2	>48	High (3)
Cultivation (%)	0%	Low (1)
Cultivation (%)	.01-38%	Medium (2)
Cultivation (%)	>38%	High (3)

The human intensity index was calculated for each survey subunit by adding each of the category values in a weighted manner as follows:

Intensity of human use weighted=2*[Dwelling density] + 2*[Cultivation percentage] + 1* [Livestock density]

Livestock values were given a lower weighting than dwelling and cultivation values as there is evidence to suggest that large mammals, including elephants, can, in the absence of poaching pressures, better coexist with livestock ranching and traditional pastoralism than human settlement and cultivation (Homewood & Rodgers 1987; Kangwana 1993; Kock 1995; Kuriyan 2002; Thouless 1994; Western 1989). The final human intensity variable was grouped into four categories based on the 25 (slight), 25-50 (low), 51-75 (medium) and 76-100 (high) percentiles of the distribution values:

Human intensity weighted value	0-1	Slight (0)
Human intensity weighted value	2-4	Low (1)
Human intensity weighted value	5-8	Medium (2)
Human intensity weighted value	9-10	High (3)

Cells containing observations of elephants were then overlaid on top of cells showing index values for the intensity of human use within a two dimensional GIS to show, visually, the extent of overlap between human and elephant use of the Laikipia landscape.

4.3 RESULTS

4.3.1 Land-tenure and settlement patterns

During the colonial period most of Laikipia consisted of cattle ranches. As described in Chapter One, many of these large-scale properties have been purchased and sub-divided since Kenyan independence. This process of sub-division has progressively increased the total area of land made available for small-scale farming. In 1987, large-scale ranches were estimated to comprise 55% of the district, sub-divided land 28%, communally owned group ranches 8% and forests, swamps and urban settlements covered the remaining 9% of the land area (Kohler 1987). In 2004, large-scale ranches covered 42% of the district while sub-divided ranches intended for smallholder settlement had grown to comprise 37% of the district. I illustrated the current spatial pattern of land-tenure in Laikipia through a map presented in chapter one (Fig. 1.3).

The increase in the availability of smallholder land in Laikipia since Kenyan independence has been accompanied by a dramatic population increase (Table 4.3). For example the district's population increased from just 30,000 people in the 1960s to 134,500 in 1979, 176,000 in 1984, 220,000 people in 1989 and 310,000 people in 1995 (Kiteme et al. 1998). This represents an annual growth rate of 7% compared to a national growth rate of 4%. Some of this growth is urban centred (especially Nanyuki) but the rural population has also risen rapidly. There have been, and continue to be, two distinguishable flows of immigration into Laikipia. The first of these flows comprises immigration of small-scale farmers from the densely populated and fertile highlands to the south of the district and has been the major contributor to population increases in Laikipia since independence in 1963. The second flow of immigration comprises movements into Laikipia of a variety of pastoralist groups with origins north of the district.

When mapped spatially, the pattern of settlement density, as shown by aerial sample counts, has clearly been influenced by the prevailing pattern of rainfall (see section 1.3.1) and land-tenure, with dense settlement on sub-divided ranches in the wetter and more productive smallholder areas of the district in the west and south, and lower settlement densities recorded in ranch, group ranch and sub-divided ranch areas in the more arid central and northern parts of the district (Fig. 4.1)

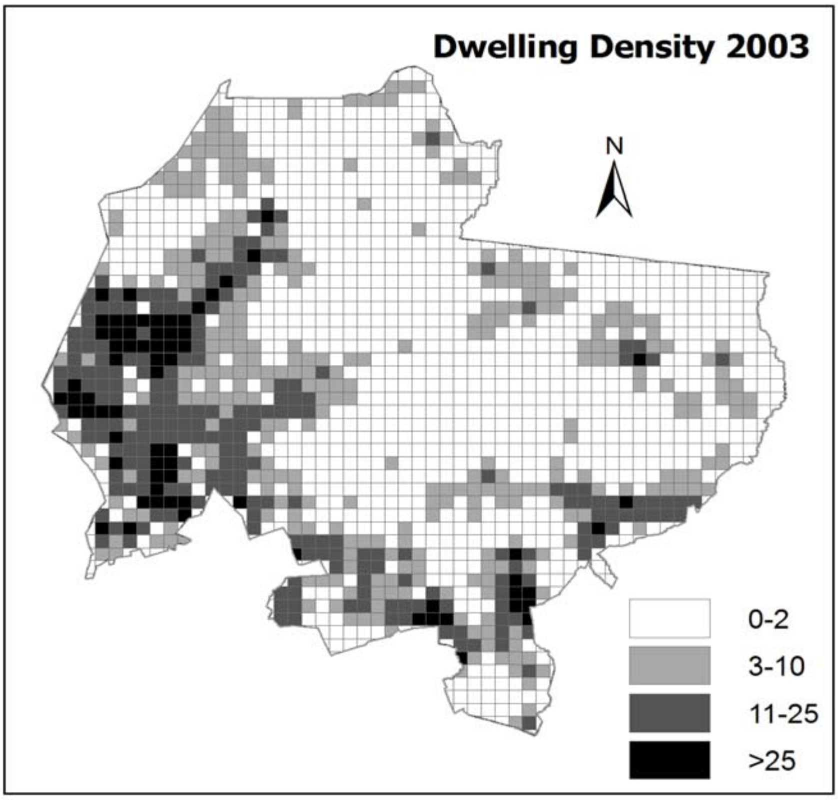


Fig. 4.1 Dwelling densities/km^2 in Laikipia in 2003 based on aerial sample count data provided by the DRSRS. Each of the individual grids is 2.5 x 2.5 km.

Table 4.3 Human population densities for Laikipia District by Division

Division	**Area (km^2)**	**1979**	**1993**	**1994**	**1995**
Rurmuruti	3498	13.8	26.1	27.3	29.5
Nga'arua	1070	32.6	61.6	64.5	65.6
Central & Lamuria	3989	10	19.1	19.9	21.5
Mukogodo	1166	9.9	17.4	18.2	19.7

Source: Laikipia Development Plan 1996

The human dwelling density estimates calculated for ranch land, settlement areas and group ranches (communal land), based on the aerial sample surveys for those years do not suggest dramatic increases in population growth over the last twenty years though there was a slight increase in human dwellings within smallholder settlement areas between 1994 and 2001 (Fig. 4.2). However, when mapped spatially, the aerial survey data do illustrate visually the expansion of human settlement within Laikipia in recent years. Increases in dwelling density based on sample surveys between 1991 and 2001 are illustrated in shades of red in Fig. 4.3 with declines shown in shades of green. This expansion and increase of dwellings is most pronounced within smallholder areas (subdivided ranches) in the west, south and east of the district. Dwelling densities within Laikipia's large-scale ranches remain largely unchanged as is indicated by the colourless 'core' of the district shown in Fig 4.3.

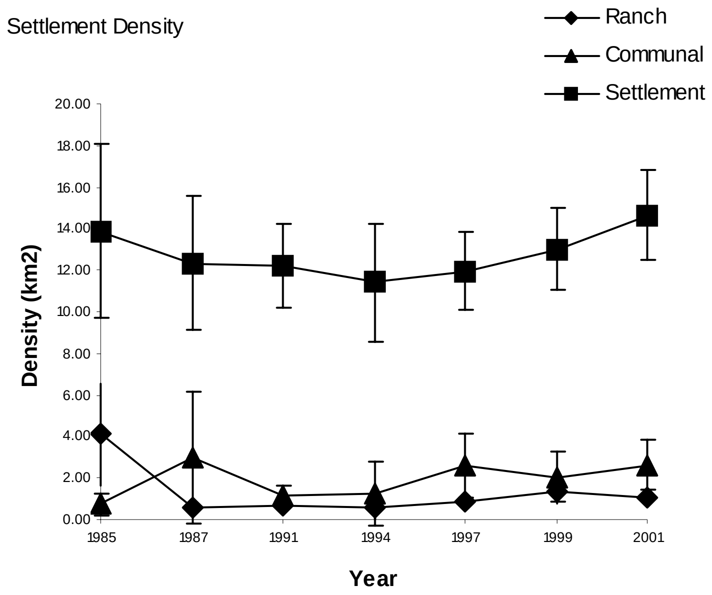


Fig 4.2 Dwelling densities within three land-tenure categories.[24]

The pattern of ethnicity among household respondents interviewed during the questionnaire survey illustrates the pattern of settlement within each of the three different land-tenure categories (Fig. 4.2). Low density smallholder land in Laikipia is sometimes intensively utilised by a diverse range of pastoralist groups on an informal (or illegal) basis and is reflected in the high diversity of ethnicity among household respondents within sub-divided ranches with a high proportion of abandoned smallholder plots (Fig. 4.4). In contrast, ethnicity was far less diverse in high density smallholder areas which have been mainly settled by Kikuyu small-scale farmers and communal areas which are owned and occupied almost exclusively by Mukogodo Maasai pastoralists. While ethnic identity is a highly complex construct and the social boundaries of seemingly distinct ethnic groups are often fluid (Spear & Waller 1993), the term ethnicity is used here to show the recent geographical origins of the people using three categories of land use/land-tenure in Laikipia.

[24] The settlement category in this and other figures presented in this chapter represents sub-divided ranches with both low smallholder density and high smallholder density.

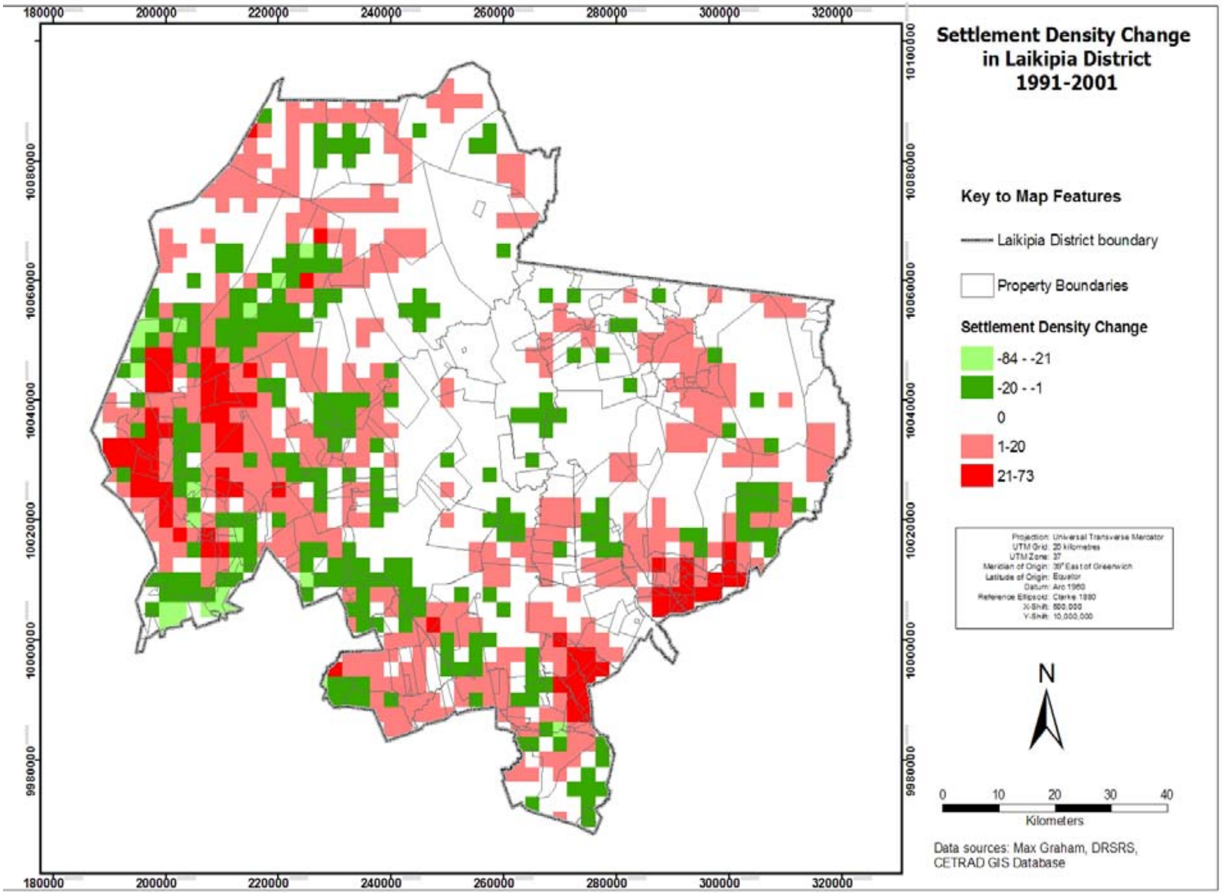


Fig 4.3 Dwelling density changes between 1991 and 2001.

4.3.2 Household production

Cultivation was most intense in relatively wet and arable areas to the southeast and southwest of the district and along the permanent rivers and streams originating in the Mt. Kenya and the Aberdare mountains (Fig. 4.5). For households located in the drier central and northern parts of Laikipia, livestock production is the main form of household subsistence. Since these two forms of production are the most significant in terms of household income and subsistence in Laikipia, they are discussed in some detail here.

Sixty five percent of households (n = 356) interviewed in Laikipia claimed to cultivate. However, the sophistication of arable farming and its significance in terms of household inputs varied markedly across the three land-use/tenure categories used in this chapter.

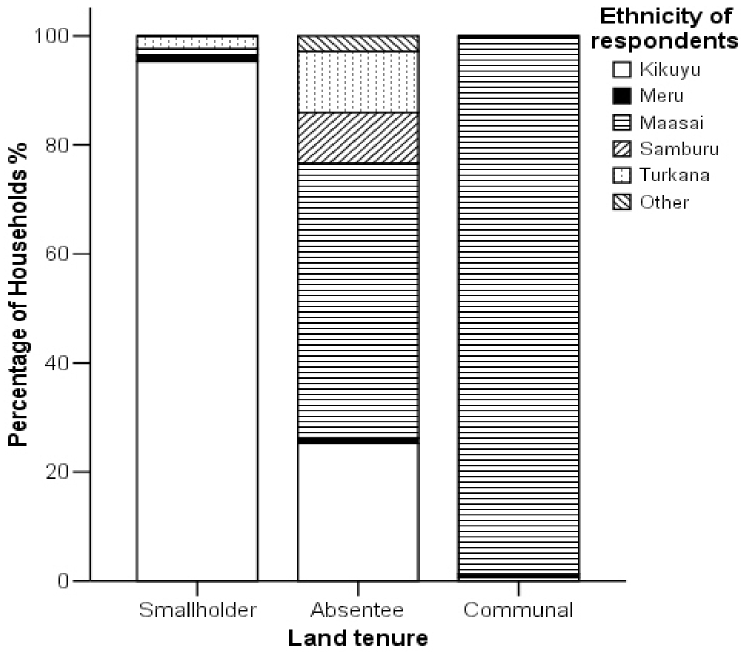


Fig. 4.4 Ethnicity of households located in different land tenure categories.[25]

Among the household sample surveyed within communal group ranches of Laikipia where annual rainfall is low, only 39% of respondents claimed to cultivate (n = 163) and of those that did, typically[26] only staple crops (maize and beans) were grown with little or no investment in agricultural inputs. This is in sharp contrast to the smallholder (high density) households located in the south of the district. Over 50% of these households grow five or more crop types (n = 86). Their use of chemical inputs is high with 70% using chemical fertilisers and 73% using pesticides (n = 86). In addition 70% of these smallholder households irrigate their farms.

Many households on sub-divided ranches with a high proportion of unoccupied land (smallholder, low density) also farmed (78%, n = 107). However, the number of crop types grown per household (mean = 2.6 ± 0.17, n = 107) together with the proportion of households investing in chemical inputs is lower compared with smallholder

[25] 'absentee' is used in figures in this chapter as a label for low density smallholder land while 'smallholder' is a label for high density smallholder land as described in section 4.2.3
[8] The exception here being the 'Ilngwezi' households who irrigated a range of crops next to the Laparua stream just northeast of Laikipia District. This is discussed further in chapter eight.

households located in wetter and more densely settled areas. This reflects the marginal conditions found in these dryer sub-divided ranches, where farming is risky. Prevailing rainfall patterns, assessed as mean monthly rainfall[27], have a clear influence on when households plant crops, across all land-tenure systems (Fig 4.6). Smallholder households in the wetter and more densely settled parts of the district have an extended planting season compared with households in drier areas. This is probably a result of greater crop diversification and wider access to irrigation systems among these smallholders. These factors are also likely to contribute to a higher number of 'harvest months' between wet seasons (Fig. 4.7).

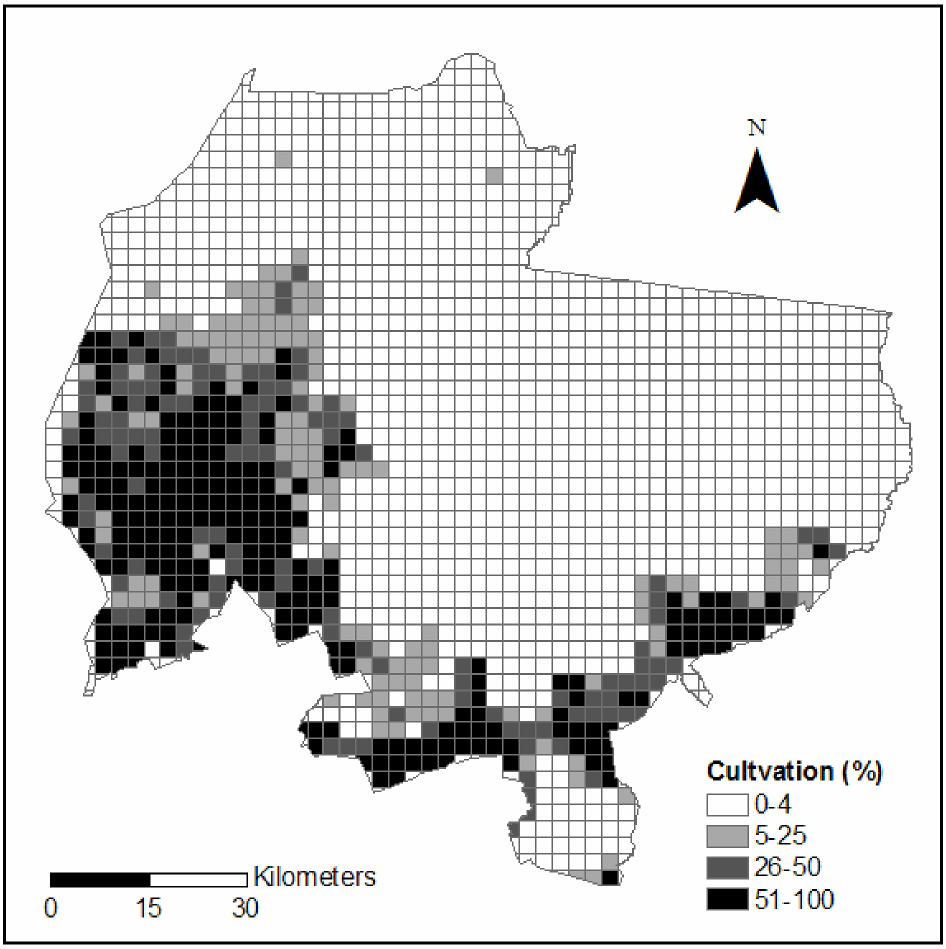


Fig. 4.5 Proportion of cultivation in Laikipia District in 2002 based on a land cover classification carried out and provided by Mpala Research Centre.

[27] Mean rainfall was calculated for each month by amalgamating data between 1990 and 2004 from 9 rainfall stations across Laikipia. These data were available from NRM[3]

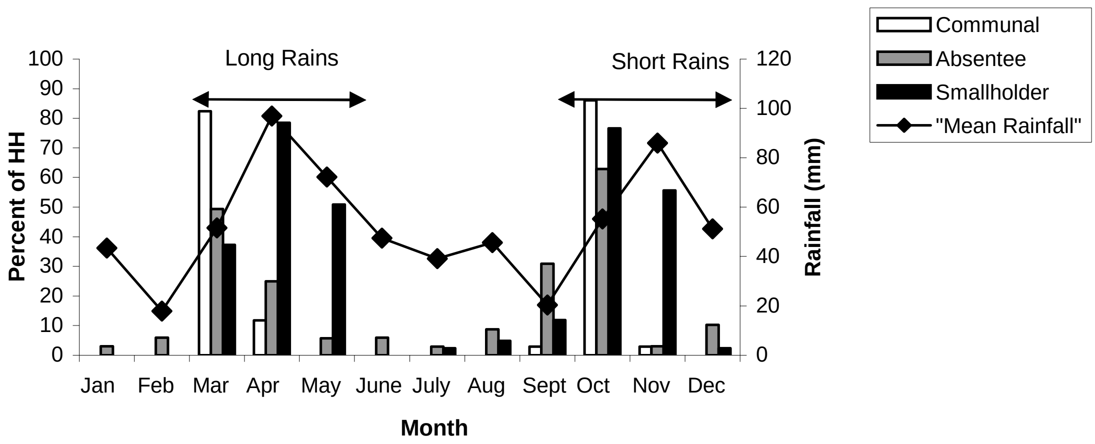


Fig 4.6 Mean monthly rainfall and percentage of cultivating households planting crops in that month

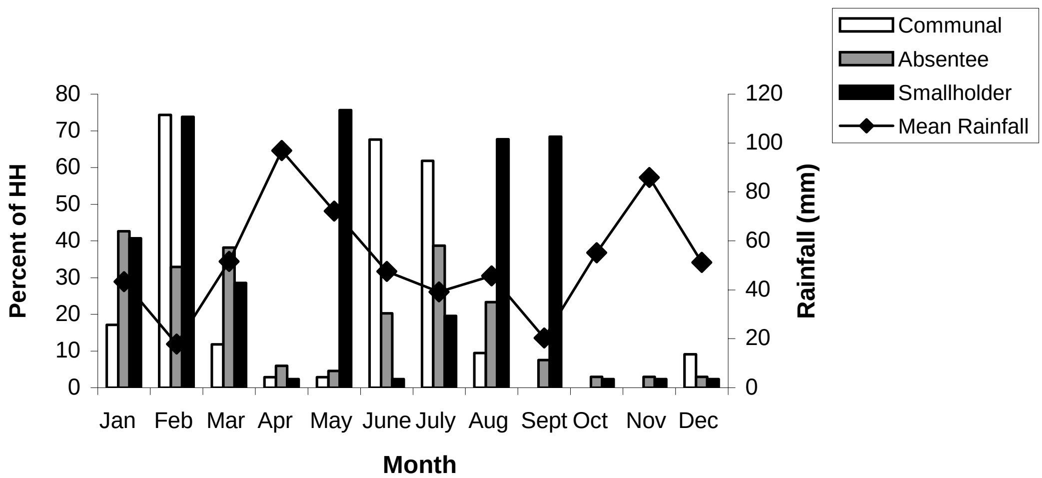


Fig 4.7 Mean monthly rainfall and percentage of cultivating households harvesting crops in that month.

Livestock is the other major source of household production in Laikipia District. Livestock numbers per household are greatest in communally owned group ranches and on low density smallholder land (Figs. 4.9 & 4.10). High density smallholder households own comparatively fewer cattle and small stock (sheep and goats) though given the small size of individual land holdings among these households (mean number of acres = 4.7 ± 0.74), livestock holdings were still relatively high. The size of the landholdings reported by individual households in both low density and high density smallholder areas (mean acres owned = 4.7 ± 0.6) was insufficient to provide grazing for the size of livestock holdings reported. Clearly in these cases livestock was being grazed on other open-access or communal land nearby. This suggests a high degree of flexibility in space among livestock producers and demonstrates the importance of unoccupied smallholder land as a source of grazing for households in Laikipia. Indeed unoccupied smallholder land was reported as an important source of grazing for households in all land-tenure categories, including group ranches (Figs. 4.10-4.12).

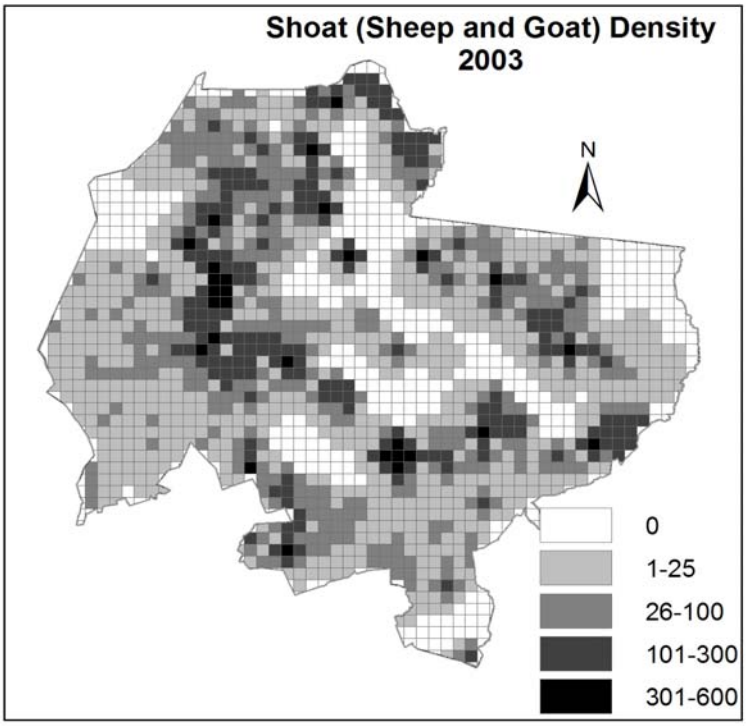


Fig. 4.8 Small stock densities/km in Laikipia in 2003, based on aerial sample count data provided by the DRSRS.

Reported sources of grazing in different seasons suggest a higher degree of mobility/flexibility among households located on group ranches and low density smallholder land compared with high density smallholder land. For many of the former, forest reserves provide critical dry season grazing. In addition to providing important year-round grazing for resident households, unoccupied land on sub-divided ranches is also used by non-resident pastoralist groups. For example, in December 2002 an opportunistic census revealed that twenty separate groups collectively herding approximately 4,670 cattle moved onto two sub-divided properties in central Laikipia, known as ‘Endana’ and ‘Northern Approaches’. In 1995 an estimated 70% of Endana was categorised as absentee (Kohler, unpublished data). Over half of these were Pokot pastoralists from Baringo District, located northwest of

Laikipia. Several other groups had travelled southeast from Samburu District. At the time large parts of Endana and Northern Approaches were effectively uncontrolled open-access resources whose small plot owners had not established effective occupancy, available for "invasion" by pastoralists.

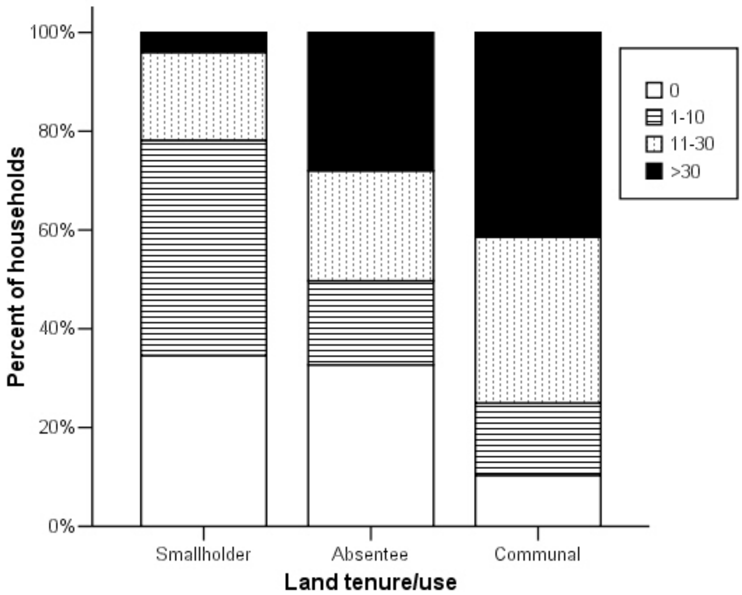


Fig. 4.9 Numbers of sheep and goats per household in different land-tenure systems

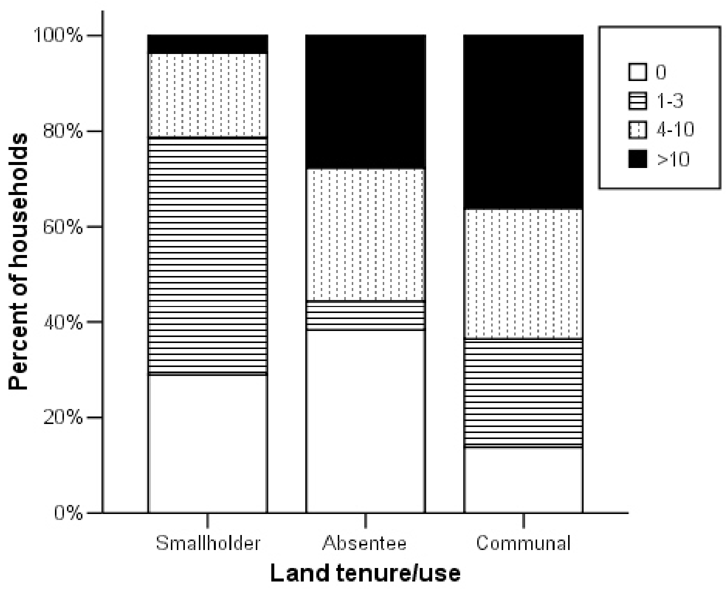


Fig. 4.10 Numbers of cattle per household in different land-tenure systems

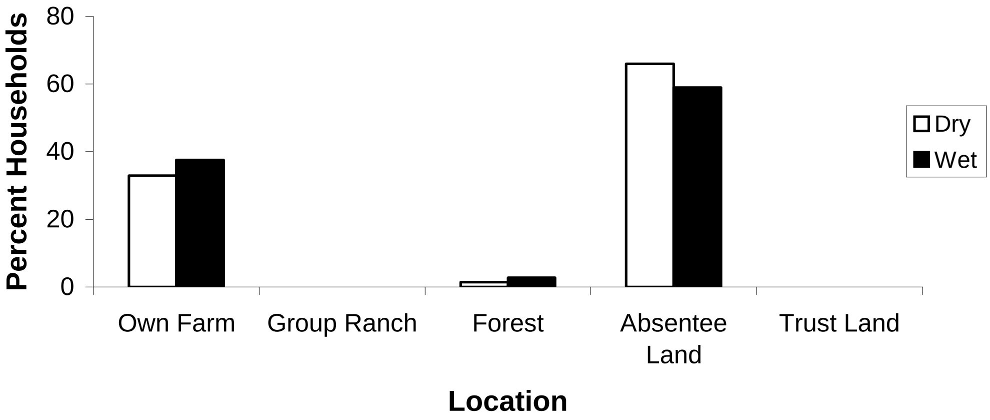


Fig. 4.11 Sites of seasonal grazing for smallholder - high density households with livestock (n = 73, 20% of respondents from the questionnaire survey)

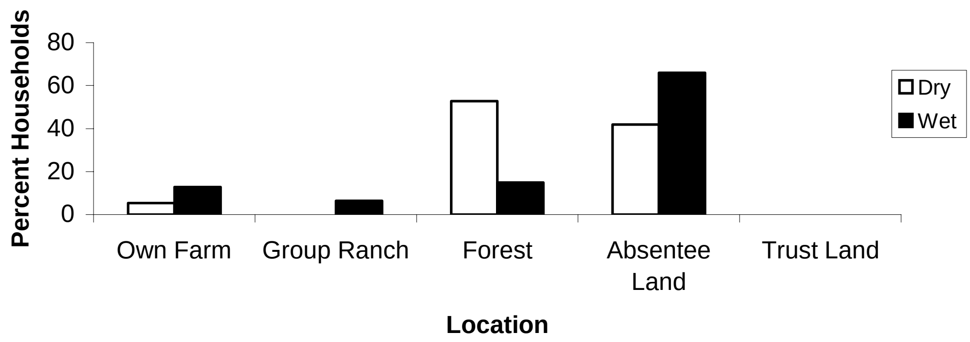


Fig. 4.12 Sites of seasonal grazing for smallholder - low density households (n = 91, 26% of respondents from the questionnaire survey)

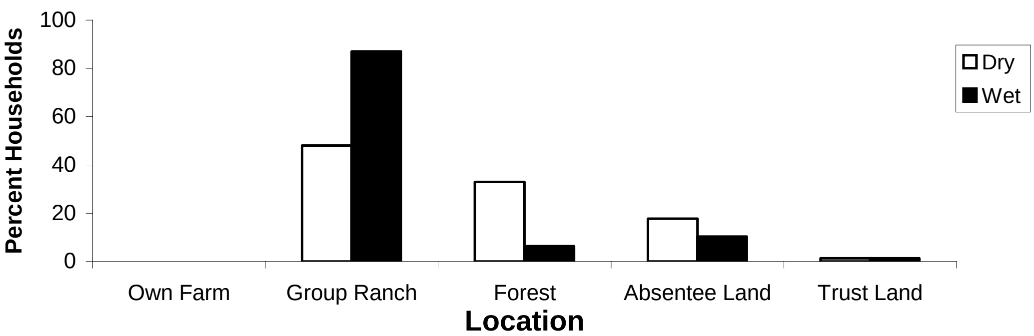


Fig. 4.13 Sites of seasonal grazing for group ranch households (n = 163, 46% of respondents from the questionnaire survey)

A major transition in land use within Laikipia has been the emergence of wildlife tourism and conservation. This transition has involved the de-stocking of livestock and construction of expensive lodges on both large-scale livestock ranches and communally owned group ranches. Five large-scale properties in Laikpia have established rhino sanctuaries and as a consequence are fortified with electrified game barriers and armed security (Fig. 4.14).[28]

Thus the transitions in land use in Laikipia are complex, involving conversing trends. Some properties have become more wildlife tolerant while other properties are now heavily utilised for livestock production and where arable, cultivation. The impact this has had on temporal and spatial patterns of wildlife is explored in the next section through an analysis of aerial count data.

[28]The Kenya Wildlife Service has strict security requirements that must be met before private landowners can be authorised to accommodate black rhino.

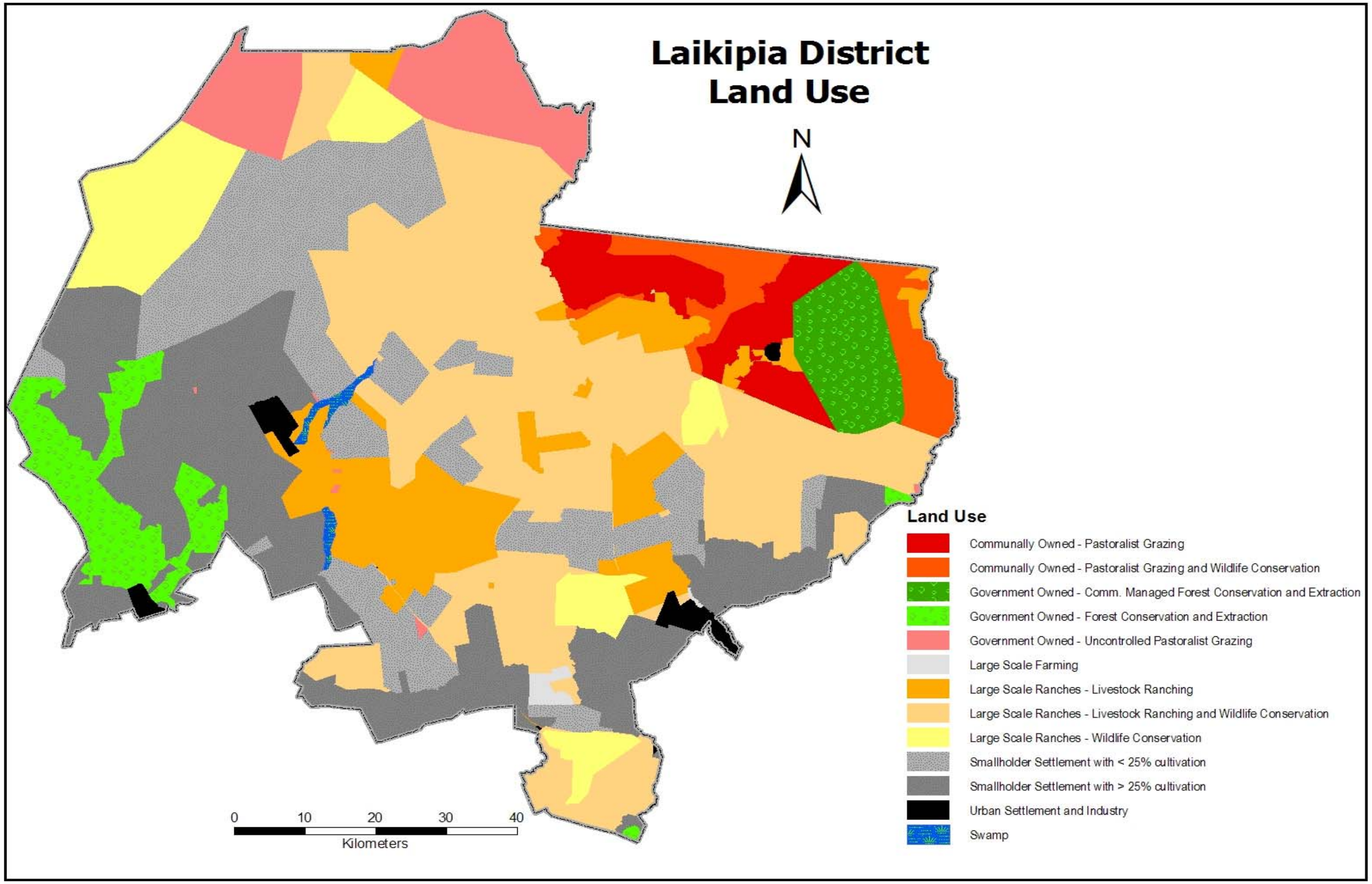


Fig 4.14 Land use in Laikipia in 2004 (updated from the classification carried out by Kohler 1987)

4.3.3 Temporal patterns of change in animal populations

Sample surveys were designed for surveying populations of large herbivores in African savannas. However, they present problems with precision when estimating total numbers of highly aggregated species such as elephants and buffalos (Norton-Griffiths 1978). The distribution of several other species were therefore analysed (Table 4.4) to indicate general changes in wildlife numbers and distribution within the ecosystem. Ten out of the fourteen species show a decrease in population estimates between 1991 and 2003. Six of these (eland, Thomson's gazelle, impala, kongoni, ostrich and warthog) decreases are statistically significant. Four species of wildlife; elephants, oryx, Grevy's zebra and Burchell's zebra, were found to have increased although none of these changes were statistically significant. On the other hand, numbers of small stock (goats and sheep) in the district have increased by over 40% in just 10 years.

Table 4.4: Population change between 1991 and 2003 based on sample counts.

	1991		2003				
Species	**Population**	**S.E**	**Population**	**S.E**	**Change**	**t function**	**Sig.***
Cattle	172,712	12,527	156,312	14,671	-16,400	0.85	p=N.S.
Sheep & Goat	194,707	17,336	473,856	48,027	279,149	5.47	p<0.05
Buffalo	3,192	1,372	1,953	765	-1,239	0.79	p=N.S.
Eland	6,485	1,431	1,562	489	-4,923	3.25	p<0.05
Elephant	1,337	319	2,947	948	1,610	1.61	p=N.S.
Gazelle Grants	7,449	800	4,956	1,031	-2,493	1.91	p=N.S.
Gazelle Thomsons	7,213	2,116	2,529	717	-4,684	2.10	p<0.05
Giraffe	2,110	570	1,395	272	-715	1.13	p=N.S.
Impala	8,405	1,334	4,389	888	-4,016	2.50	p<0.05
Kongoni	3,574	547	865	305	-2,709	4.32	p<0.05
Oryx	709	219	1,395	475	686	1.31	p=N.S.
Ostrich[29]	991	261	391	90	-600	2.17	p<0.05
Rhino	418	327	223	135	-195	0.55	p=N.S.
Warthog	1,628	374	363	132	-1,265	3.19	p<0.05
Zebra Burchell	35,357	3,627	36,372	5,777	1,015	0.15	p=N.S.
Zebra Grevy	691	285	948	373	257	0.55	p=N.S.

*Significant differences in population estimates between survey years were tested for using paired sample T-tests after Norton-Griffiths (1978: 81). Where t > 1.96, the two estimates are significantly different from each other at the 5% level.

Total counts of elephants in Laikipia corroborate the trend shown in Table 4.4. In 1992, 1018 elephants were counted in Laikpia (Thouless, 1992) while in 2002, the

[29] The Common and Somali Ostrich are both found in Laikipia District though it would be difficult to distinguish between the two races during aerial surveys.

total number of elephants counted in Laikipia was 3036 (Blanc et al. 2003). This represents an increase of around 6.3% per annum, higher than the estimated average natural growth rate within an unexploited elephant population (Douglas-Hamilton 1987). Based on results from the total counts (Table 4.5), elephant numbers appear to have also increased within the wider ecosystem (comprised of parts of neighbouring Isiolo and Samburu Districts), suggesting that the recorded increase in elephant numbers in Laikipia could be attributed to *in situ* growth. Some caution is needed in the interpretation of these results as there may have been further immigration of elephants into both Laikipia and the adjacent districts from less secure parts of the region, and there were some (minor) differences in the areas surveyed between the two censuses. Despite the potential influence of these confounding factors I would (cautiously) suggest that the increase in the Laikipia elephant population is partially, if not wholly, attributable to *in situ* population growth based on the pattern of *in situ* population increase recorded through a long term study of known individual elephants carried out in the nearby Samburu and Buffalo Springs National Reserves[30] (Wittemyer et al. 2005).

Table 4.5 Total counts for elephants in 1992 and 2002

District	1992*	2002**
Laikipia	1018	3036
Samburu	925	1762
Isiolo	1026	391
Total	**2969**	**5189**

*Thouless 1993; ** Omondi et al. 2002

It is interesting to compare density changes of elephants with those of more easily surveyed species. On Laikipia's large scale private ranches, Burchell's zebra densities have not changed significantly since 1991, varying between 4 and 5 animals per km^2, though there has been a slight increase in the numbers recorded since 1999 (Fig. 4.15). In contrast, in sub-divided ranches (both low and high density smallholder areas), zebra densities showed a steep decline from 3.7 per km^2 in 1997 to 1.4 per km^2 in 2001. Figure 4.16 illustrates visually the spatial pattern of zebra density declines in

[30] Save the Elephants' unpublished data from GPS collars fitted on elephants within the Samburu and Buffalo Springs National Reserves show that some of these elephants move into and have overlapping ranges with elephants in, Laikipia District.

shades of red and density increases in shades of green, based on interpolated values from the sample counts. Declines in zebra densities are most conspicuous in west and south-west Laikipia within settlement areas and abandoned government land. This pattern of change described for these areas together with the pattern of increase on large-scale ranches suggests that Burchell's zebras have been displaced from ranches sub-divided in the 1990s, probably as a result of the recent immigration of pastoralists and associated competition with livestock. Zebra densities within group ranches have remained consistently low since 1985. This pattern is likely to reflect competition with livestock and the threat posed by the traditional hunters occupying those communal areas.

Impala densities generally appear to be in decline across Laikipia (Figs 4.15 & 4.17). This decline is most pronounced within settlement areas [both high and low density smallholder land] and communally owned group ranches. On large-scale ranches impala densities dropped from over 1.5 per km^2 in 1997 to under 1 per km^2 in 1999 where they have remained. While the declines in impala numbers on smallholder and communal areas may be expected through the same pressures affecting Burchell's zebras (competition and illegal hunting), the declines on large-scale ranches were less expected. Caution is needed in the interpretation of these data as impala are a woodland species and therefore the marginal declines recorded on large-scale ranches may have been the result of problems associated with counting animals in thick vegetation. If this was not the case, however, and the declines recorded are in fact accurate then impala declines in large-scale ranches may also be the result of natural factors such as drought and predation or illegal hunting, possibly by ranch employees.

While cattle numbers have remained relatively constant in Laikipia since 1985 (Table 4.3), sheep and goat densities have increased sharply in recent years (Table 4.3 & Fig 4.18). This trend could be largely attributed to significant increases in small stock within settlement areas (Figs 4.15 & 4.18). In 2003 small stock densities within these areas reached almost 80 per km^2, double the densities found in 1999. This recent increase in small stock numbers is likely to reflect the recent immigration of pastoralists onto unoccupied smallholder land on sub-divided ranches and abandoned government land.

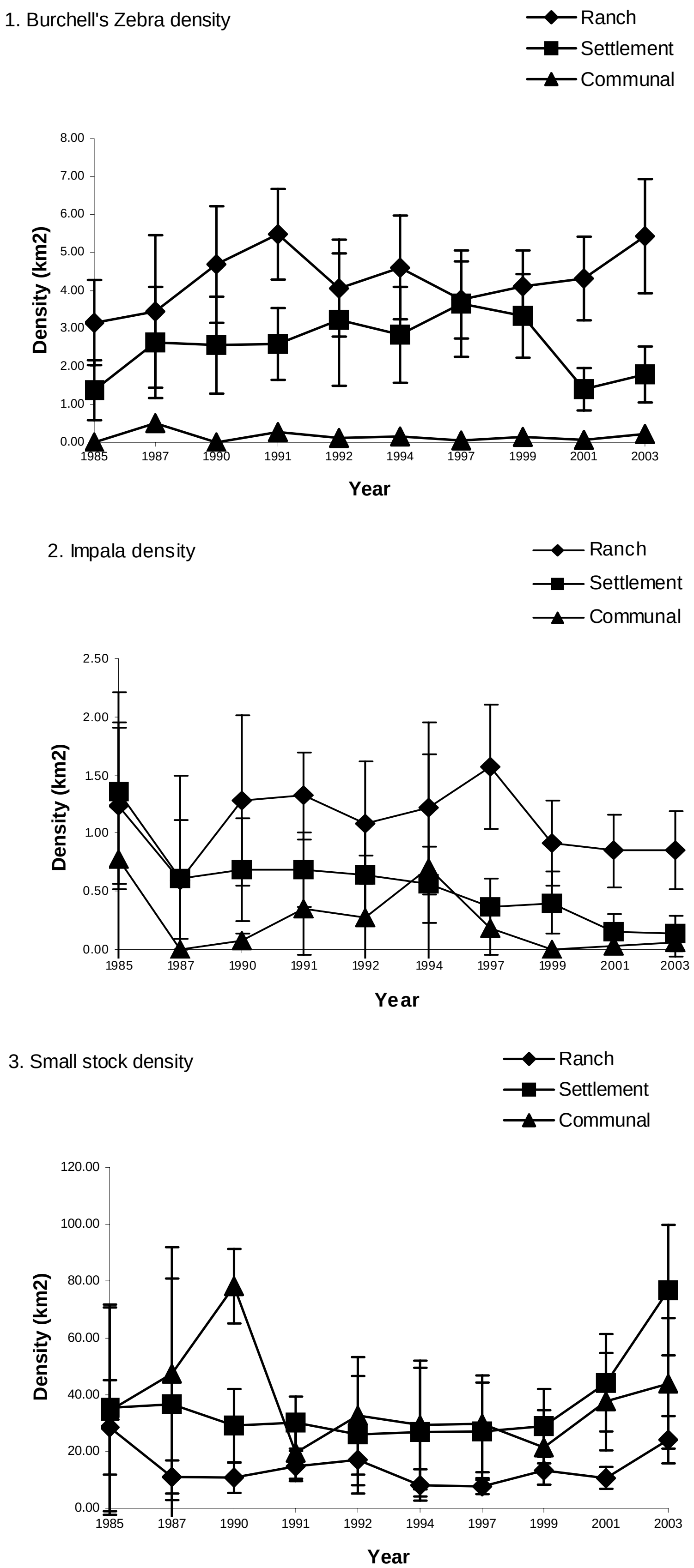


Fig 4.15 Animal density changes in different land-tenure systems within Laikipia

Fig. 4.16 Burchell's zebra density change between 1991 and 2003. Declines in zebra densities appear to be most common in the smallholder land units, corresponding with sites where small stock density has increased.

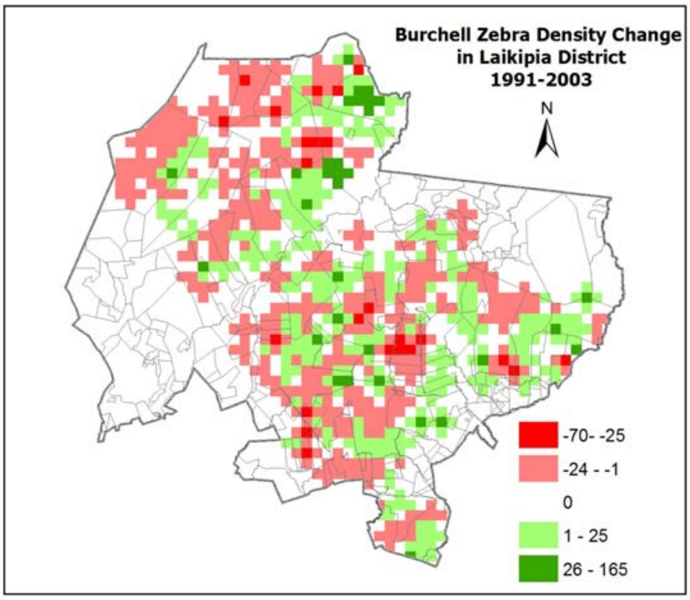


Fig 4.17 Impala density change between 1991 and 2003. Declines in impala density have been recorded throughout the district though net decline appears most obvious in the south and southwest.

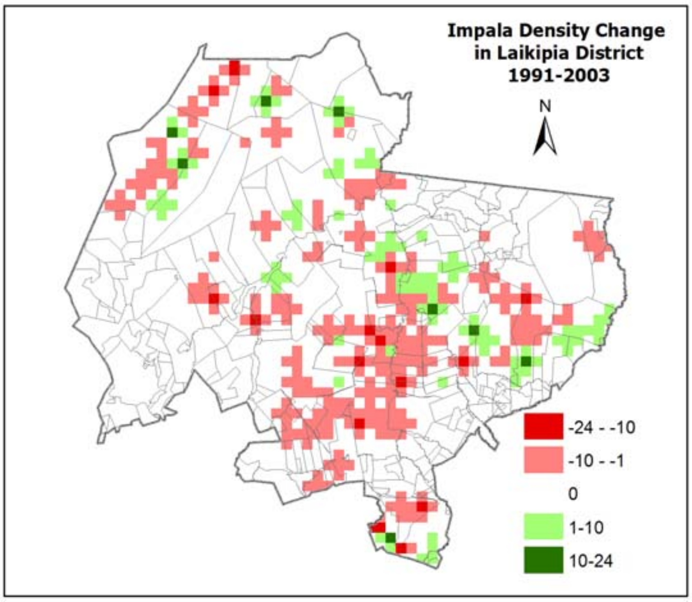
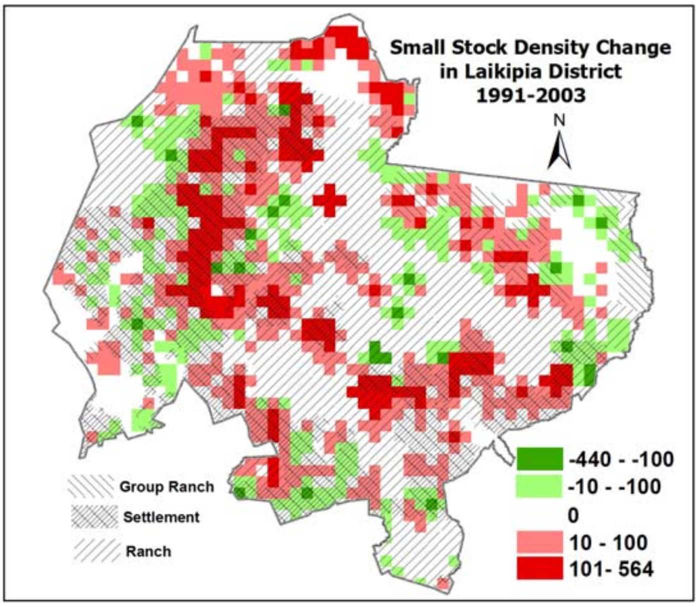


Fig 4.18 Small stock density has increased dramatically in Laikipia with the main locus of growth on sub-divided ranches in west, south and southwest Laikipia where the proportion of abandoned smallholder land is high.



4.3.4 Seasonal movement of elephants

Annual rainfall patterns over the study period and the associated response in vegetation productivity as measured by NDVI were characteristically bimodal with 'greenness' peaks during the 'long rains', between March and June, and the 'short rains', between October and December, although the short rains failed in 2005 leading to a protracted drought (Fig. 4.19). Median monthly NDVI values for the short dry season, long rains, long dry season, short rains and during the drought were 0.34, 0.5, 0.37, 0.47 and 0.3, respectively; these values were significantly different (Kruskal-Wallis: $\chi^2 = 35.2$, d.f.= 4, 110; $P < 0.001$) and therefore a seasonal analysis of the elephant movement data collected over the study period is justified.

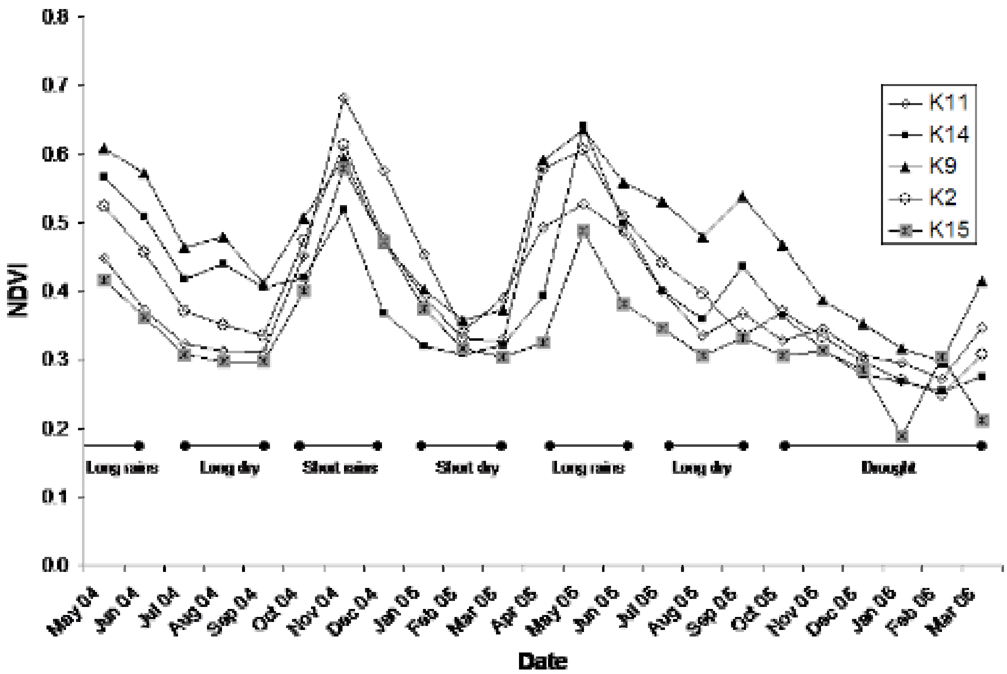


Fig. 4.19 Mean monthly NDVI values for a sample of locations extracted from each of the ranges of five individual elephants tracked in Laikipia District since May 2004.

The size of the area used during different seasons varied between elephants, as will be discussed in Chapter Seven. However, some general patterns did emerge through analyses of the pooled data sets. The sample of elephants tracked used a larger area, as measured by 95%, and 50% UDs in wet seasons compared with dry seasons (Fig. 4.20). This difference was significant for 50% UDs and approached significance for

95% UDs (95% UDs $U_{23, 25} = 200$, $P = 0.07$; 50% UDs $U_{23, 25} = 171$, $P = 0.016$). The same general pattern was evident for 100% MCPs (Fig. 4.22) although the difference between wet and dry season MCPs was not significant ($U_{23, 25} = 227$, $P = 0.21$). Six elephants had the largest seasonal ranges during the short rains between October and December. Relatively large seasonal ranges were also recorded for elephants during the short dry season between January and March. This is likely to be because several of the elephants monitored continued to move across relatively large areas in January, after the ‘short rains’ before returning to dry season ranges, within or close to Laikipia’s rivers and swamps. Responses to the long rains, between April and June, in terms of range size varied but movement over this period was generally less extensive than during the short rains. The smallest seasonal ranges for nine of the thirteen elephants included within the analysis were recorded during the long dry season between July and September.

This general pattern of inter-seasonal variation of elephant movement was corroborated by the distribution of monthly displacement values, representing the distance between the location of an elephant at the beginning and the end of each month (after Thouless 1995). Monthly displacement was highest during the short rains, followed by the long rains, the short dry season and the lowest displacement values were recorded during the long dry season between July and September (Fig. 4.21; Kruskal-Wallis: $\chi^2 = 10$, $P = 0.019$, d.f. = 3).

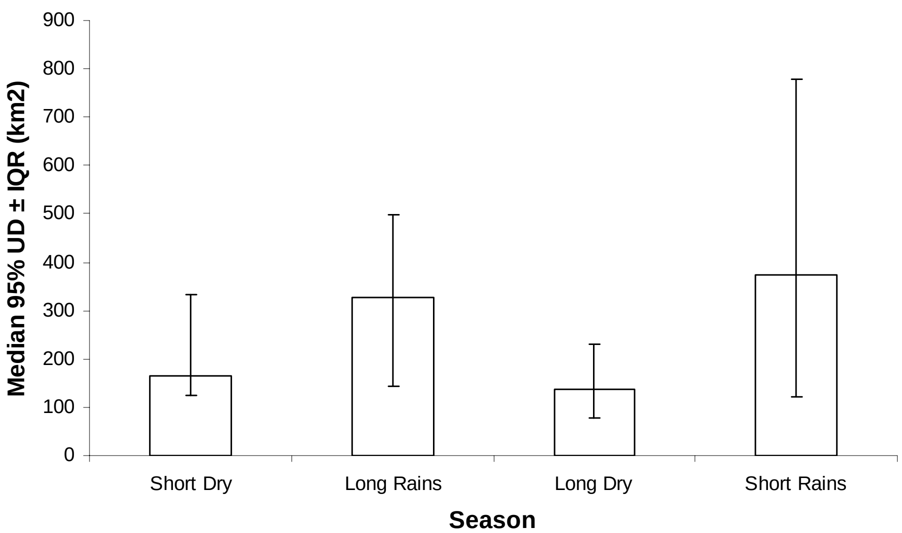


Fig. 4.20 Seasonal ranges range size of 12 elephants in 2004-5 for which comparative data was available, as measured by 95% UDs.

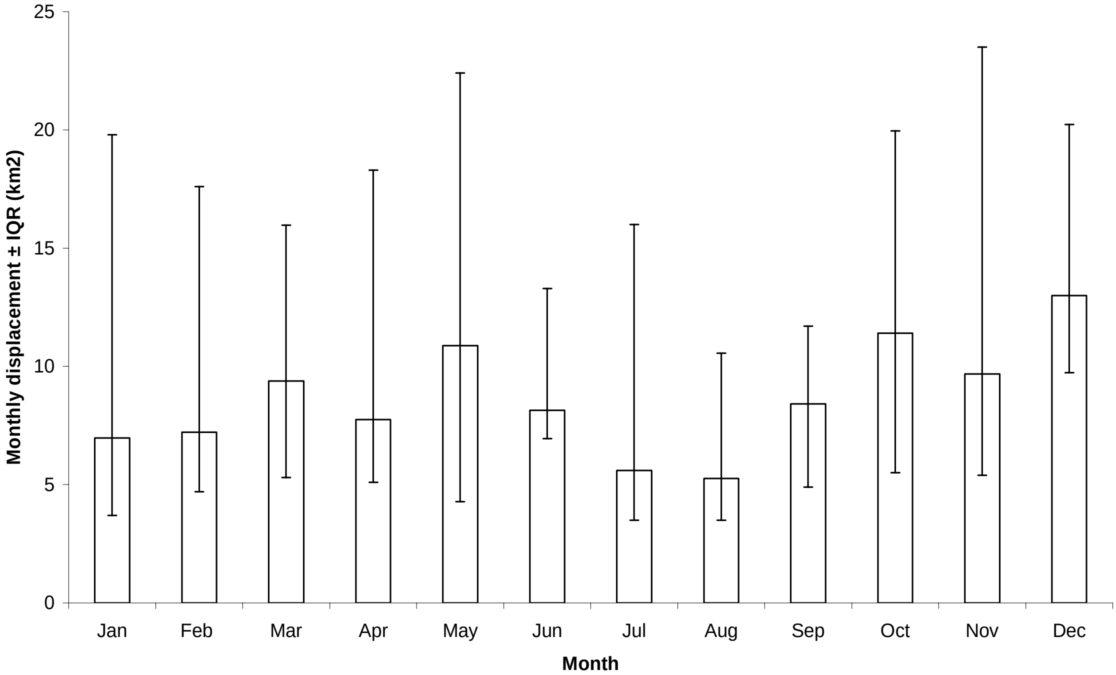
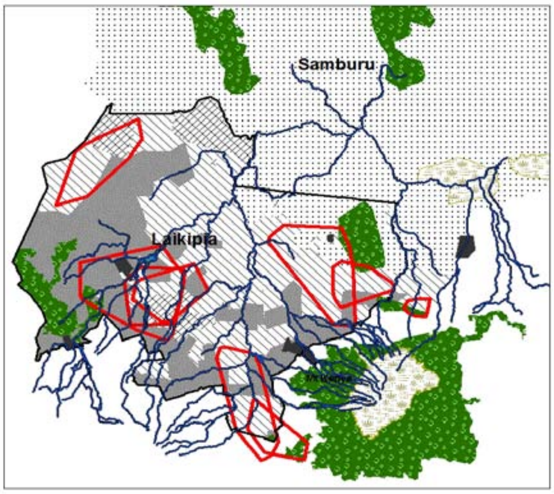
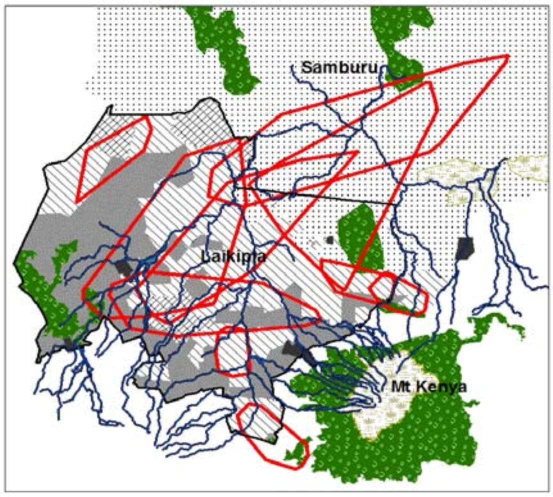


Fig. 4.21 Median monthly displacement for elephants tracked in Laikipia District between 2004 and 2005

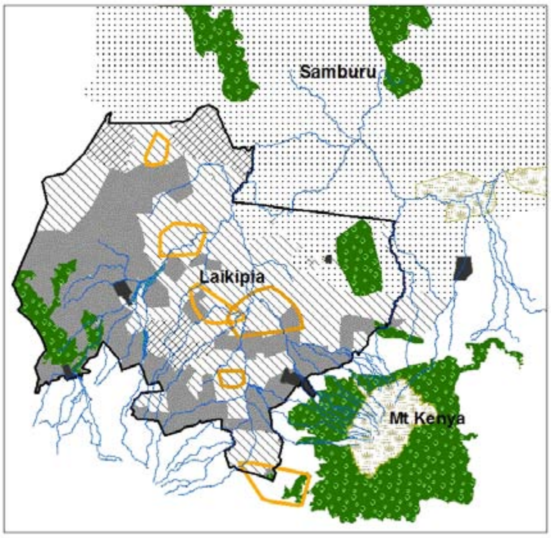
These results show that in general, the elephants monitored in Laikipia respond to the seasonal variations in primary production associated with rainfall, as indicated by NDVI. However this conclusion is complicated by seasonal range estimates for the period between October and December 2005 during which the ‘short rains’ failed (see Fig. 4.19). Despite the failure of the rains, the size of seasonal ranges for the period between October and December 2005, was smaller but not significantly different from the size of seasonal ranges during the short rains of 2004 (means: Oct-Dec 04 = 661, Oct-Dec 05 = 498.4; Wilcoxon signed ranks: Z = -0.7, P = 0.48, n = 8).



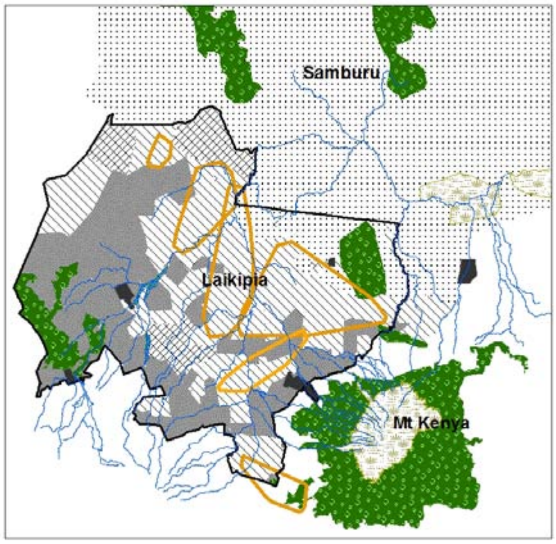
A) Male elephants: 'Long dry'



B) Male elephants: 'Short rains'



C) Female elephants: 'Long dry' season



D) Female elephants: 'Short rains'

Fig 4.22 Minimum Convex Polygons (MCPs) for male and female elephants calculated for the 'long dry' season and the 'short rains' between 2004 and 2005.

4.3.5 The human-wildlife interface

Table 4.6 shows the proportion of the total number of 2.5 x 2.5 km sample units (n=1680) in which the component elements of a human-wildlife interface (W=Wildlife, L=Livestock, S=Settlement (human dwellings), and their combinations occur based on aerial sample count data between 1991 and 2001. The total area in which wildlife (Burchell's zebra, elephants, impala and Grevy's zebra) occurred declined in size between 1991 and 2001. The spatial extent of livestock occurrence has remained relatively constant over this same time period while the total area occupied by dwellings has increased. There has been a sharp decline in the co-occurrence of livestock and wildlife (W+L) from 32% to 22% of the survey area. The co-occurrence of wildlife and dwellings (W+S) has remained relatively constant though shows a small decrease in 2001. A similar pattern is evident for the combination of wildlife, livestock and settlement (W+L+S)

Table 4.6 Percentage of total 2.5 x 2.5 km sample units (n=1680) in Laikipia in which component elements of the human-wildlife interface and their combinations occur based on interpolated values from aerial sample counts

Year	W	L	S	W+L	W+S	W+L+S
1991	44	64	37	32	14	13
1997	40	60	42	26	13	11
1999	39	66	43	28	14	14
2001	36	63	47	22	12	11

While these results corroborate the trends identified in previous research (Georgiadis et al. 2004), aerial sample count data can only provide a coarse ‘snap shot’ of wildlife distributions. A combination of methods is needed to establish the seasonal and nocturnal movements of wildlife and to develop a more precise assessment of the co-occurrence of humans and wildlife. I attempted this for elephants, finding a greater spatial overlap between people and elephants than previously estimated.

The matrix in Table 4.7 shows the percentages of the total number of 2.5 x 2.5 km sample units in which key attributes and their combinations occur. In this table I include cultivation as an additional attribute within the human-elephant interface. Aerial surveys provide the least information in terms of the extent to which elephants and people cohabit. Data from GPS radio collars and systematic observations from trained enumerators (scouts) show a far more extensive pattern of co-occurrence. Combining all data sets for elephant observations (scout observations, GPS collar data and aerial total counts) shows that elephants occupy almost 50% of the entire district and co-occur with cultivation, livestock and settlement in a high number of survey units. The distribution of elephants based on the combined data sources shows co-occurrence evenly distributed across the three land use types (χ^2 = 4.83, d.f. = 2, NS) while wildlife is associated with livestock areas (χ^2 = 13.82, d.f. = 2, P = 0.001).

Table 4.7: Matrix showing percentage of total survey subunits (n=1680) in Laikipia in which component elements of the human-wildlife interface and their combinations were observed using different data sets.

Wildlife Data (% of sampling units)	**Livestock (L) (65%) 2003**	**Cultivation(C) (33%) 2002**	**Settlement (S) (47%) 2003**	**L+C+S (22%)**
Wildlife (2003 Sample Count) (36%)	22	6	12	5
Elephants (2002 Total Count) (9%)	2	2	2	0
Elephants (2004-5 Collar Data) (36%)	17	5	13	4
Elephants (2003-4 Scouts) (12%)	9	8	9	6
Elephants (All Elephant Data) (47%)	24	11	20	8

Visual presentation of the co-occurrence of elephants with the intensity of human use index (see section 4.2.6) reinforces the impression that the human-elephant interface is extensive and that elephants occur even in the most intensively used parts of Laikipia District (Fig. 4.25). The resulting human-elephant interaction and the outcomes of such interaction in terms of ecological patterns and human social perspectives are assessed in the subsequent chapters.

Fig.4.23 Aerial count observations and intensity of human use. Such observations capture just a 'snap shot' of elephant occurrence suggesting little overlap between elephants and human use

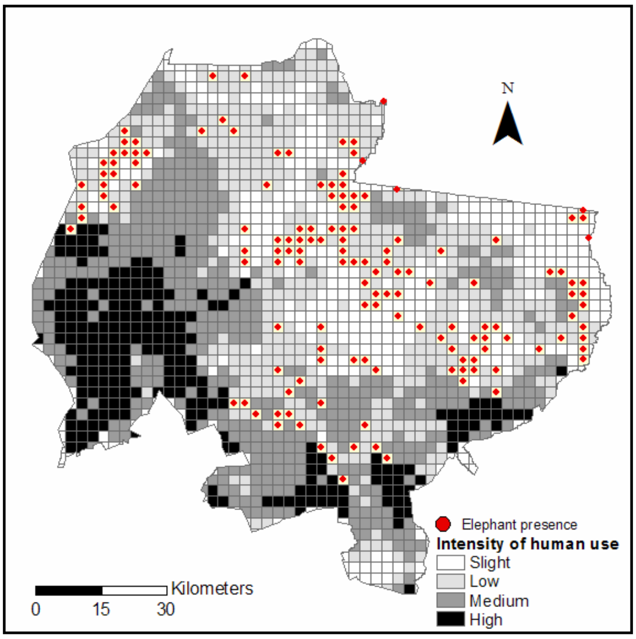


Fig. 4.24 Scout observations and intensity of human use. Systematic observations made by trained local enumerators show elephant use of areas intensively used by people for cultivation and settlement.

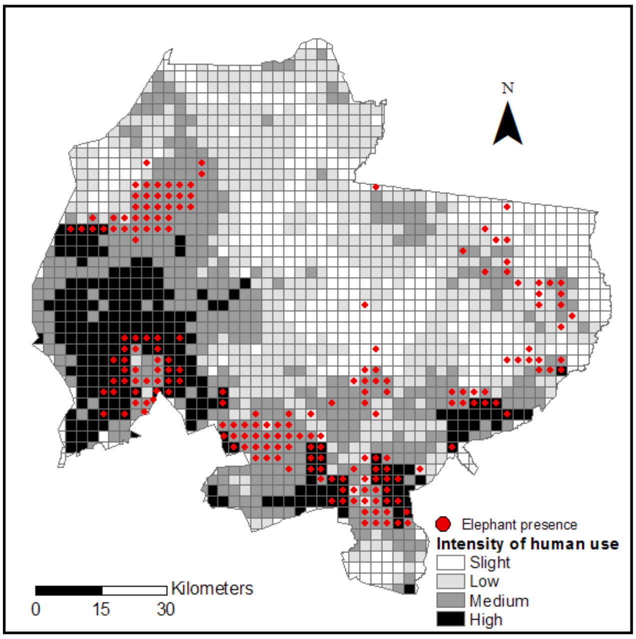
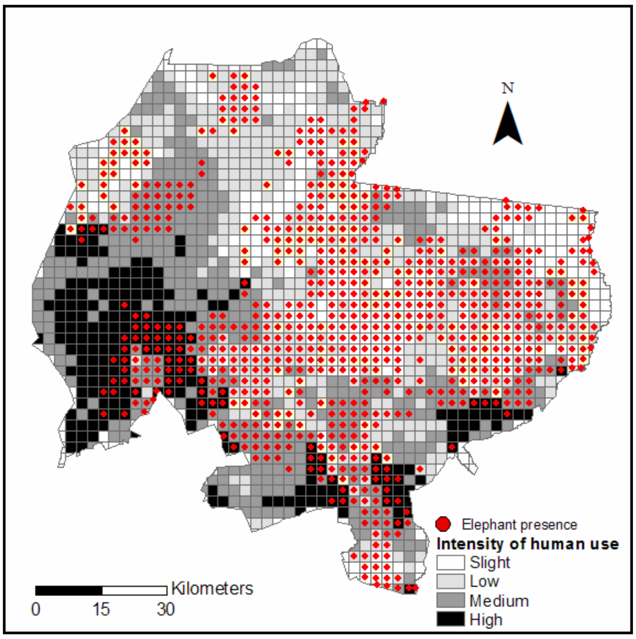


Fig. 4.25 Composite of elephant observations using GPS collaring data, scout data and total count data shows that elephants occur across much of the district, sharing large areas and local resources with local people.



4.5 DISCUSSION

Human use of Laikipia has intensified since Kenya's independence as many of the formerly European owned ranches have been sub-divided (and designated) for smallholder settlement and arable agriculture. The success of smallholder arable agriculture has however been limited, with settlement and cultivation by immigrant farmers largely confined to the wetter parts of the district. In more arid regions settlement and cultivation are 'patchy'; a large number of sub-divided properties have <25% cultivation and contain a high proportion of 'abandoned' smallholder plots. In such areas, the emergent smallholder economies are constrained, instead giving way to predominantly pastoral modes of production. This is demonstrated by the pattern of livestock density increase (particularly small stock) on smallholder land recorded since 1991. The rainfall gradient in Laikipia roughly stratifies economies along a north-south axis with decreasing dependence on cultivation and greater dependence on livestock keeping in the group ranches located in the drier northern parts of the district. In addition to varying spatially, patterns of household production also varied seasonally as was shown by seasonal activity profiles for cultivators and livestock keepers in each of three land use/land tenure strata.

The relationship between socio-economic change and the spatial pattern of wildlife distribution and density in Laikipia is complex. Over the last 10 years, there has clearly been a decrease in both densities and the diurnal distribution of some wildlife species. However, population estimates for other species, specifically Burchell's zebra and elephants, have increased over this same period. These latter species may be more tolerant of the recent human-induced transitions in Laikipia. This could be because elephants and zebra are more mobile than other species.

Some wildlife species are largely confined to areas where human use is minimal (the remaining large-scale ranches) and the aerial surveys suggest that the human-wildlife interface is shrinking as densities of human dwellings and small-stock increases on land outside of large-scale ranches. However, in this chapter the combination of different types of distribution data show that the overlap between elephants and human use of the Laikipia landscape is extensive. This may be because elephants are exceptional at adapting to human driven land-use change and may even benefit from some forms of land cover transformation associated with people (i.e. crops and fallow fields). That very adaptation, however, is the source of potential human-elephant conflict. The interaction resulting from the use of a ‘shared’ landscape, the risks entailed and the patterns of adaptation resulting from such risks are assessed and explored in subsequent chapters from both human and elephant perspectives.

Chapter 5: Elephant use of different elements of the Laikipia landscape

5.1 INTRODUCTION

The ecological patterns described in the last chapter were based largely on remote sensing data (air surveys), some of which were fairly coarse. In this chapter, I assess patterns of elephant abundance in relation to resource use and management, using ground observations from a transect survey. Survey effort was stratified to encompass a range of different land use types and associated vegetation cover. Retrospectively, the risk to elephants of injury or mortality presented by human users and managers of discrete land units was incorporated into the analytical design. The focus of this chapter is to explore one of the three main research questions presented in Chapter One:

<u>How does elephant distribution vary across and within different land-use types in Laikipia?</u>

Ground surveys have been used to determine the distribution and density of wildlife species where aerial surveys are not suitable, such as when vegetation cover is dense, (Jachmann and Bell 1984; Barnes et al 1991; Barnes 1996b). Such surveys aim to obtain a reasonably accurate population estimate, and thus areas where animals are believed to exist at very low densities are usually omitted from the designated survey area to narrow confidence intervals (Buckland et al 2001). Ground surveys can use sightings of animals, or sign, such as nests, vegetation damage, tracks or dung. The comparative advantage of a dung survey is that it allows the observer to determine wildlife use and abundance within an area of interest across a relatively long time interval (i.e. as long as it takes for the wildlife sign to decompose) compared with the brief 'window' provided by an aerial survey. In addition, contextual data on human use and vegetation cover of an area can be collected simultaneously. This approach has increasingly been used to explore the relationship between wildlife distribution and human activity and results from these studies suggest that levels of wildlife use and human use of defined areas are generally mutually exclusive. For example in the Amboseli region of Kenya, elephant dung surveys showed that the relative abundance of elephants increased with distance from permanent settlements (Kangwana, 1993). In another case study, in and around the Dzanga-Sangha Wildlife Reserve in the Central African Republic, encounter rates of wildlife signs, in particular those of western lowland gorillas, declined inversely with human activity (Remis, 2000; Blom et al 2005). In the mid-Zambezi valley wildlife density and diversity decreased with agricultural activity (Fritz et al 2003). As a final example, Barnes et al (1991) demonstrated that in northeastern Gabon, human activities were more important in determining the distribution of forest elephants than either soil or vegetation type.

Here I present the results from the 112 kilometres of transects I surveyed for this thesis (see Chapter Three, section 3.4.2). In the first part of the chapter the sample areas included within the survey (see Chapter 3, section 3.4.1 and Table 3.1) were grouped into the broad categories of land-tenure/use defined in Chapter Four (although in this chapter smallholder areas are not separated into sub-categories), and elephant abundance explored among these categories. In the second part of the analysis, the risk of injury/mortality to elephants within each discrete sample area is characterised through field observations and illustrated with key statements recorded during informal interviews with local resource users, ranchers, wildlife managers and administrators. Elephant carcass data collected over the course of the fieldwork period were used to reinforce the 'local explanations' (Hammersley & Atkinson, 1995) of risk to elephants. These sources of information provided a retrospective framework for the simple bivariate classification of sample areas into 'tolerant' and 'intolerant' categories. Once again elephant dung density was used to examine the difference in relative elephant abundance between these categories. In the third and final part of the analysis presented in this chapter, seasonal variations in the relative abundance of elephants across sample areas were assessed.

5.2 DATA ANALYSIS

Because the ability of an observer to detect elephant dung along a transect varies between seasons and/or habitats, encounter rates were considered too crude a measure for comparing elephant abundance between different sample areas in Laikipia. Instead dung densities were estimated for individual transects and sample areas using distance sampling methods (Buckland et al., 2001). This approach is based on the probability that an observer's ability to detect an object declines with the object's distance from the transect centre line. A detection function is estimated based on a sample of perpendicular measurements between the transect centreline and the objects of interest. The programme Distance v 4.1 (Thomas et al., 2003) estimates the detection function and the encounter rate separately and these results are combined to estimate elephant dung densities using the following formula:

$$D = \frac{n \times f(0)}{2L}$$

Where n is the number of dung piles recorded, $f(0)$ is the reciprocal of half the effective strip width and L is the length of transect.

Distance provides a number of semi-parametric models available to estimate the detection function. The suitability of a particular model depends on the empirical distribution of the perpendicular distance data and was assessed principally using Akaike's Information Criterion (AIC). Further proxy indicators were used to assess the suitability of the model including: comparing the detection function model curve with histograms of observations grouped into distance intervals (e.g. Fig. 5.2) , quantile-quantile (q-q) plots (Thomas et al., 2003)[31], and several goodness of fit tests (Buckland et al., 2001). Observations beyond the perpendicular distance at which the probability of detection was approximately 15% or less were discarded (ibid).

[31]Qq plots compare the distribution of two values. In *Distance* qq plots compare the fit of a detection function to the data by plotting the fitted cumulative distribution function (cdf) against the empirical distribution function. If the data fit the model then cdf and edf should be the same.

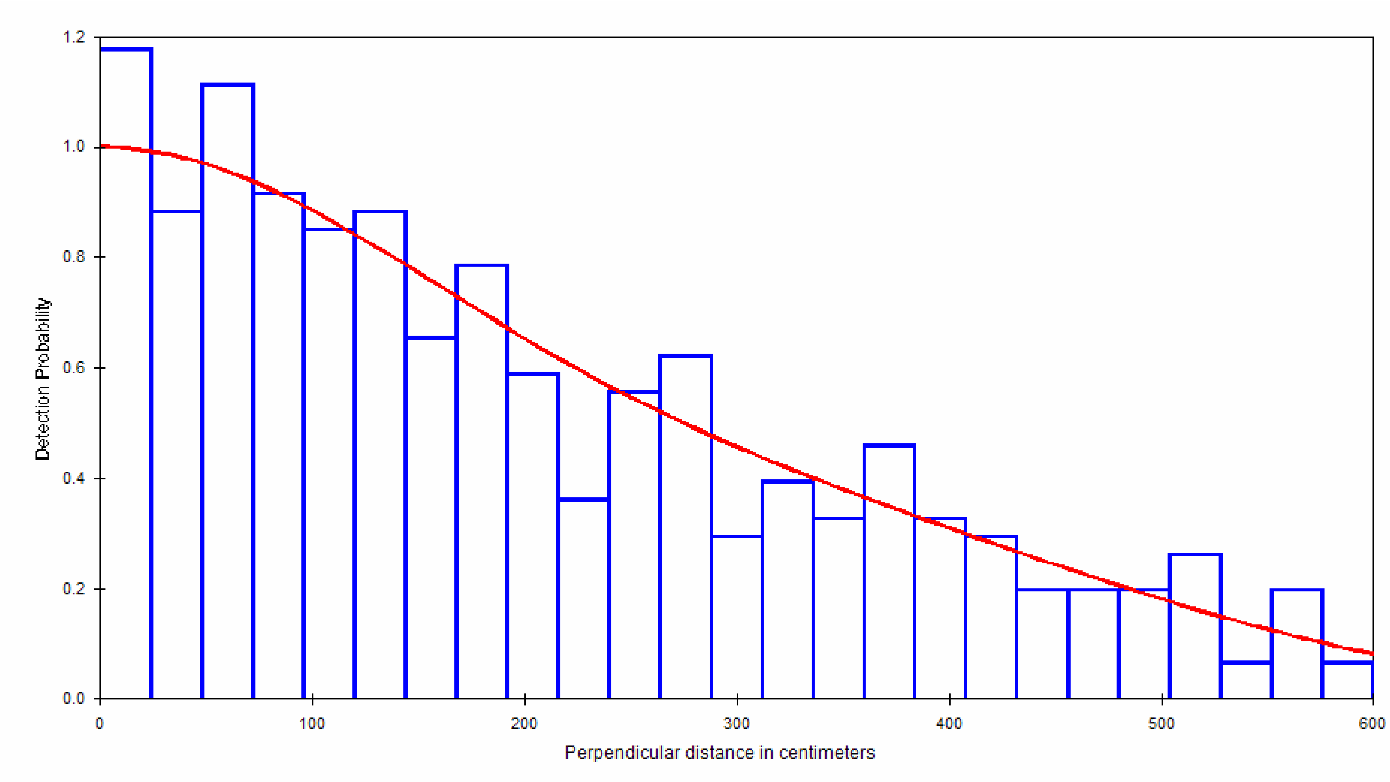


Fig. 5.1 Plot of detection function (half-normal model) for ranches in the dry season superimposed on a histogram of frequency counts of dung observations. This model appears to fit the data well and there is little evidence of 'heaping'.

Perpendicular observations of dung made along transects were pooled to estimate separate detection functions for each land-tenure category (i.e. ranches, forests, group ranches and smallholder). Detection functions were also fitted to each sample area included within the survey. If the sum of AIC values across sample areas was less than the AIC value from the pooled 'land-tenure' model, this indicated that the detection function varied between sample areas within each land-tenure category and should be fitted separately (Thomas et al., 2003). There were insufficient observations of dung along transects placed in the smallholder sample areas to accurately estimate the detection function and the corollary 'estimated strip width'. As a consequence these observations were pooled with observations recorded along transects within the adjacent ranches to generate a detection function, with which it then became possible to calculate dung density estimates for individual transects within smallholder sample areas (where dung was present).

The detection function was also estimated separately for wet and dry seasons and for all seasons combined (the latter by pooling dry and wet season data).

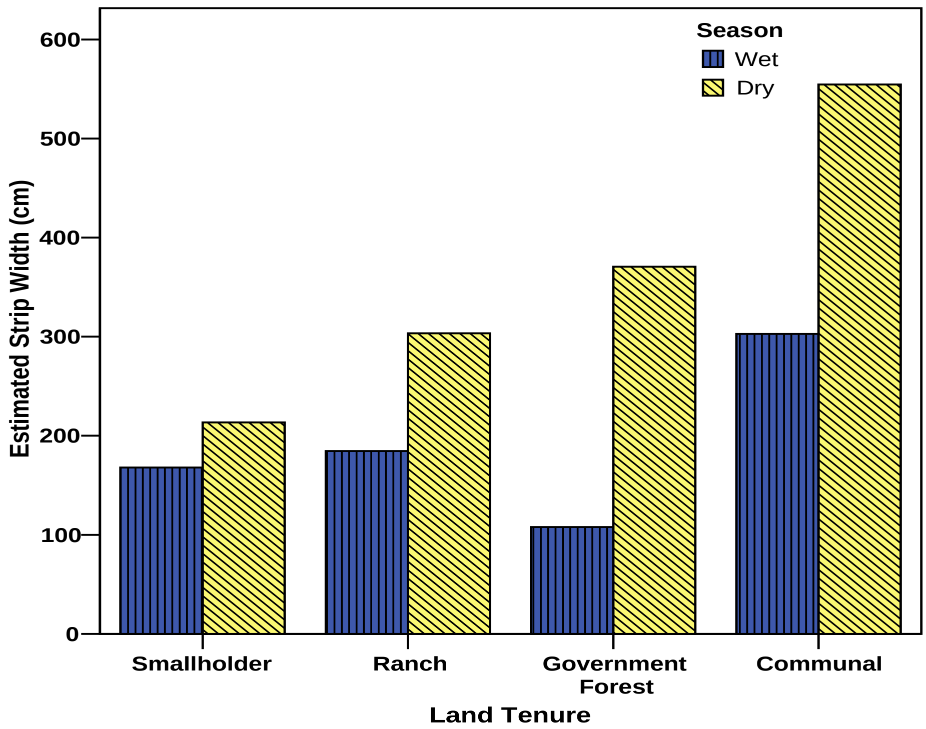


Fig. 5.2 Mean estimated strip widths in different seasons

The calculated estimated strip width was consistently smaller in the wet compared with the dry season (Fig. 5.2) exhibiting the influence of rainfall on vegetation cover and thus visibility from the transect centre line. This further justified the use of dung density in preference to dung encounter rates as a measure of elephant abundance.

Dung density, encounter rates of human activity and proportion of habitat types all exhibited highly skewed distributions among transects so that statistical tests assuming normality were not appropriate. Differences in these attributes were instead evaluated using non-parametric Kruskal-Wallis tests; post-hoc multiple comparisons for unequal sample sizes were carried out using Dunn’s tests. Seasonal comparisons in dung density were made using Wilcoxon Signed Ranks Tests. Differences in dung densities between tolerant and intolerant sample areas were evaluated using Mann-Whitney U tests. For spatial analyses of dung density (i.e. comparing differences in dung densities among different grouping categories), wet and dry season results were pooled to provide a single density estimate for each transect. Univariate correlations between dung density and potential explanatory variables were carried out using Spearman's rank correlations. All probability values are two-tailed unless otherwise stated.

5.3 LAND TENURE/USE AND THE RELATIVE ABUNDANCE OF ELEPHANTS

5.3.1 Habitat analysis

The frequency of habitat types varied between the four land-tenure categories surveyed (Table 5.1). Smallholder land units were characterised by a greater proportion of cultivation and grassland than the other land-tenure categories. Private ranches also had a high proportion of grassland but this was less frequently encountered than the dominant bushland vegetation. Cultivation was found on private ranches although this is wholly attributed to the inclusion of the southern portion of Ol Pejeta Ranch in the transect survey where large-scale wheat farming occurs. Woodland was relatively common in private ranches, typically within a riparian belt adjacent to permanent and seasonal rivers, streams and swamps. This belt of woodland was more extensive in communal areas although largely comprised of different species (Sp. *Acacia tortilis* as compared with the *Acacia xanthophlea*/*Acacia drepanolobium* woodland found in ranches). The highest proportion of bushland encountered was in communal areas. Only forest reserves included any substantial amount of closed canopy forest

Table 5.1 Proportion of habitat types encountered by land-tenure category

Habitat Type	Smallholder	Private Ranch	Communal	Forest	K-Wallis H	*P*
% Cultivation	26	8	1	1	21.5	.004
% Grassland	45	30	2	5	25.7	.000
% Woodland	3	9	15	0	15.2	.002
% Bushland	25	53	82	3	29.9	.000
% Forest	0	0	0	91	52.4	.000

Herbaceous ground cover, as measured by herbaceous biomass, also varied among the four land-tenure categories (Kruskal-Wallis: H = 16.2, $P < 0.001$, d.f. = 3). Herbaceous biomass was higher in private ranches (median = 85.3g, IQR = 2746.8, n = 13) compared with forest reserves (median = 32.1g, IQR = 10.4, n = 5), group ranches (median = 39g, IQR = 24.7, n = 5) and smallholder sample areas (median = 53.12g, IQR = 46.8, n = 6), although this difference with smallholder sample areas did not reach significance (Dunn's: Ranch-Communal Areas $q = 12.3$, $P < 0.05$; Ranch-Forest Reserves $q = 16.3$, $P < 0.01$; Ranch-Smallholder $q = 4.73$, NS).

5.3.2 Human Activity

The overall frequency of human activity encountered along transects varied among land-tenure categories (Kruskal-Wallis: H = 41.3, $P < 0.001$, d.f. = 3). Human activity was encountered more often in smallholder sample areas than in any other land-tenure category (Dunn's: Smallholder-Ranch $q = 49.73$, $P < 0.01$; Smallholder-Communal Areas $q = 42.64$, $P < 0.01$; Smallholder-Forest $q = 31.7$, $P < 0.01$). Human activity was encountered less frequently in forests, even less frequently in communally owned group ranches and was encountered the least in private ranches (Fig. 5.3).

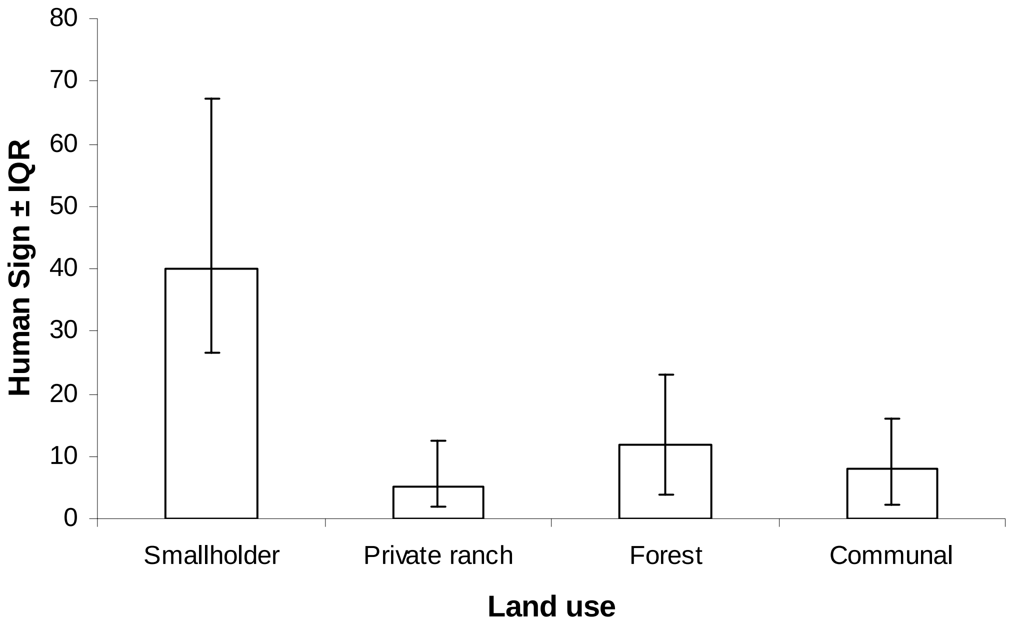


Fig. 5.3 Median encounter rates ± interquartile range (IQR) of human activity along transects in each of four land use/land tenure types

The nature of human activity observed along transects differed among land-tenure categories (Table 5.2). In smallholder sample areas, all categories of human activity were frequently encountered. Cultivation within smallholder sample areas is concentrated along permanent rivers; the same rivers were used as baselines for transects (see Chapter Three, section 3.4). As a result, evidence of settlement, cultivation, people, livestock and wood harvesting was frequently encountered. In contrast, evidence of human activity was less frequent in other land-tenure categories. The low level of human presence within communal areas was unexpected given the high density of use for grazing (Chapter Four). However, large parts of two out of three communally owned group ranches surveyed had been designated 'community conservation areas' where wildlife tourism was the main form of land-use. As such human settlement within these sample areas was restricted and concentrated away from permanent rivers, explaining the low level of human presence encountered.

Livestock, representing the main form of subsistence for pastoralists in north Laikipia (Chapter Four), were encountered relatively frequently along transects in group ranches (mean = 8.25 ± 2.74, n = 20). Herders were observed regularly watering their livestock near the permanent rivers that were used as ‘baselines’ for transect surveys. On average, livestock encounter rates were least abundant in private ranches, an indication of low stocking rates but also an indication of the extent to which wildlife was preferred as a form of land use within these properties. In two of the properties surveyed, ‘Sweetwaters’ and ‘Solio’ game reserves, there was no sign of livestock as was expected given that these properties are exclusively designated for wildlife.

Evidence of wood extraction (either for firewood or timber) was most frequently encountered in forest reserves. This was particularly noticeable in the Ngare Ndare Forest, which borders several substantial settlements in northeast Laikipia. In this government forest reserve evidence of commercial extraction of timber (mainly olive *Olea europa* and African cedar *Juniperus procera*) was frequently encountered. However, many of these signs were fairly old. More recent evidence of wood extraction could largely be attributed to firewood collection. Overall human activity was significantly higher in the Ngare Ndare Forest compared with the Mukogodo Forest (Mann-Whitney U test: $U_{9, 8} = 11$, $P = 0.014$). This difference is somewhat surprising given that there is a permanent settlement within the Mukogodo Forest and that the Ngare Ndare Forest is enclosed by an electric fence as well as patrolled by security teams from the adjacent private wildlife conservancy (Lewa Wildlife Conservancy). Wood extraction was also relatively abundant in the smallholder sample areas surveyed (Table 5.2).

Table 5.2 Human activity patterns along transects in Laikipia District

	Smallholder	Private Ranch	Communal	Forest Reserve
No of km surveyed	48	96	40	34
Median human presence*	9	0	0	1
/transect (IQR)	(14)	(2)	(3)	(1.5)
Median human access	15.5	3.5	1	4
/transect (IQR)	(14)	(5)	(5)	(11)
Median livestock sign	7	0	3.5	1
/transect (IQR)	(14)	(1)	(14)	(4)
Median hunting sign	0	0	0	0
/transect (IQR)	(0)	(0)		
Median wood harvest /	2.5	0	0	1
transect (IQR)	(10.7)	(0.75)	(1)	(8)
Median human sign total	40	5	8	12
/transect (IQR)	(41)	(11)	(14)	(19)

*agriculture, settlement and/or people (direct sightings or indirect such as tracks or noise)

5.3.3 Land tenure/use and abundance of elephants

Elephant density, as measured by dung density, varied significantly between land-tenure categories (Kruskal-Wallis: $H = 40.9$, $P < 0.001$, d.f. = 3). Elephant abundance was lowest in smallholder sample areas compared to private ranches, group ranches and forest reserves (Dunn's: Ranch-Smallholder q = 25.3, $P < 0.01$; Communal-Smallholder q = 53.4, $P < 0.01$; Forest-Smallholder q = 48.6, $P < 0.01$). Elephants were more abundant in communally owned group ranches and forest reserves than in private ranches, though this difference only reached significant in comparisons of communal with private ranches (Dunn's $q = 28.1$, $P < 0.01$; Forest-Private Ranch q = 23.3, NS). The difference between elephant abundance in forest reserves and communally owned group ranches was not significant (Fig. 5.4; Dunn's: $q = 4.8$, NS).

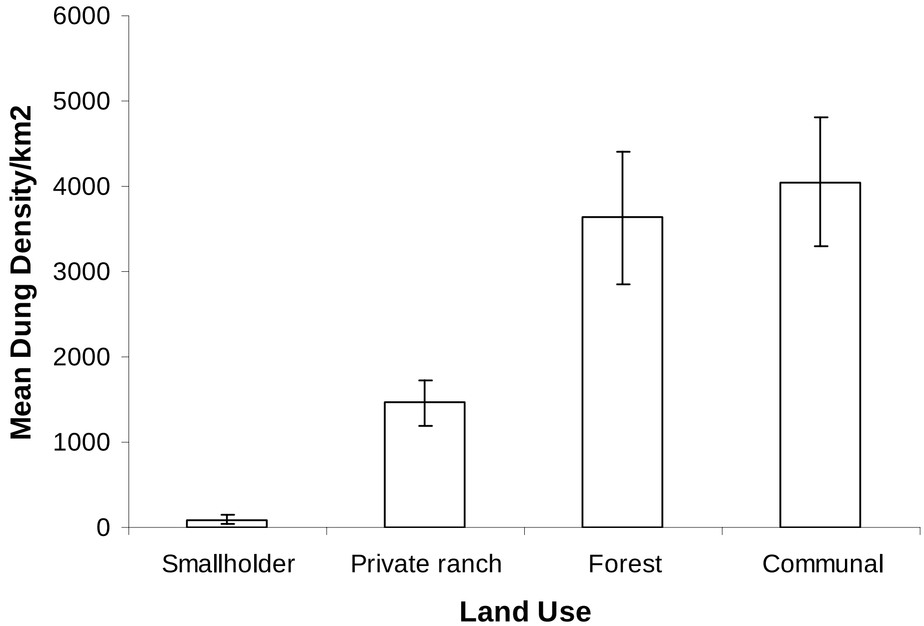


Fig. 5.4 Dung density (means ± SE) and human land use. Means are presented because medians were close to zero in the case of smallholder sample areas

A number of candidate variables were inter-correlated and so only three were included in the bivariate correlation analyses (human activity, herbaceous biomass [g] and proportion of woodland encountered). Elephant density was negatively correlated with human activity (Fig. 5.5; Spearman $r_s = -0.291$, n = 109, $P = 0.002$). There was no significant association between elephant abundance and either herbaceous biomass or proportion of woodland encountered along transects, although contrary to what might be expected these relationships were negative (Spearman dung density and herbaceous biomass, $r_s = -0.173$, n = 29, N.S.; dung density and proportion of woodland encountered $r_s = -0.171$, n = 56, N.S).

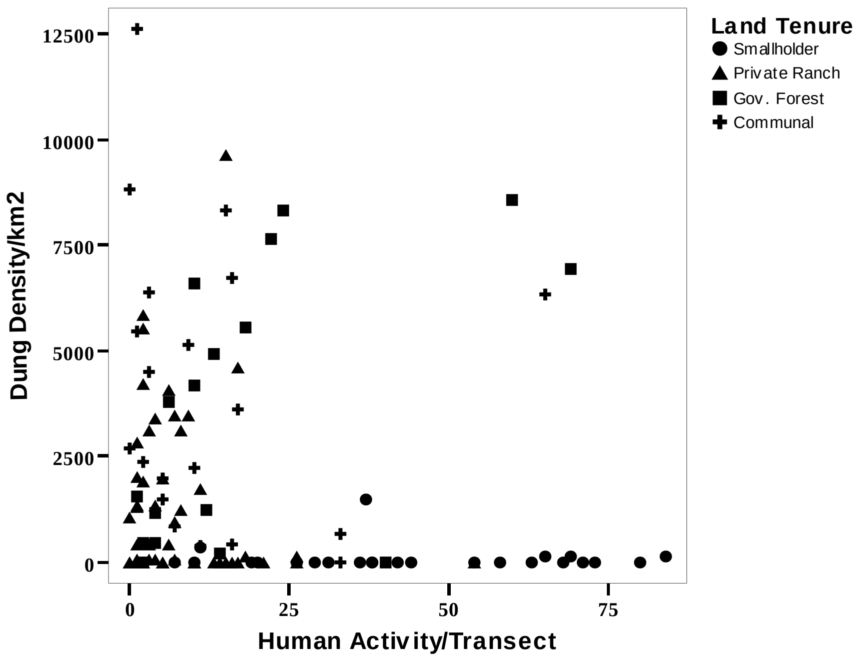


Fig. 5.5 Elephant dung density and human activity by land tenure type on line transects

5.3.4 Discussion

These analyses suggest that elephant abundance in different land-tenure categories in Laikipia broadly reflects the intensity of human use, corroborating results from other studies of human-elephant interaction carried out in Africa (Parker and Graham 1989; Happold 1995; Eltringham 1990; Barnes et al 1997). The relationship between dung density and human activity, however, did not follow a clear linear trend. For example while dung density was lowest in smallholder sample areas where human activity was most intense, dung density was not highest in private ranches, where human activity was lowest. Instead dung density was highest in group ranches, followed by forest reserves where human activity was higher compared with private ranches.

It may be that elephants may not respond to increases in human activity until a certain threshold is reached (i.e. Hoare and Du Toit 1998) and/or it is likely that elephants can co-exist with some forms of human activity more easily than with others. For example on one particular transect surveyed within a group ranch, dung density and human activity were both high (see Fig. 5.5), suggesting that elephants can better tolerate human activities associated with livestock husbandry than those associated with small-scale farming. Given that elephants in Kenya have historically ranged throughout areas used by transhumant pastoralists, this finding is unsurprising. There were also two transects on which high elephant dung density co-occurred with high human activity within forest reserves (Fig 5.5). As the majority of human signs encountered within forest reserves, in particular within the Ngare Ndare Forest, were related to wood extraction activities (stumps, machete cuts etc.), it is likely that elephants can tolerate this form of episodic human activity up to fairly high levels. Indeed evidence from other study areas suggests that elephants actually prefer secondary vegetation associated with previous human settlement and logging (Barnes et al., 1991). The co-occurrence of dung and human activity does not, however, mean simultaneous occupation but rather this pattern shows that humans and elephants can share their use of some habitats through spatial partitioning in time.

If elephants are not responding to the intensity of human activity at low to intermediate values, then within this range of human activity, there must be other factors determining the pattern of abundance across the sample areas surveyed. While differences in vegetation cover could possibly be a factor, simple bivariate correlations presented in this section suggest that the relationship between dung density and proportion of woodland encountered was: a) insignificant; and b) negative. It is possible that there are other less obvious vegetation-related factors (such as food palatability or quality) that explain the differences in the relative abundance of elephants among private ranches, forest reserves and group ranches. For example, as will be demonstrated later in this chapter, there is a seasonal influx of elephants into Laikipia's elephant tolerant group ranches immediately after the rains. During this time and in these areas, elephants invest considerable time digging up shallow rooted underground plant storage organs or corms (pers. obs.) in otherwise relatively bare glades. It may be that this seasonally available food source (possibly a 'Liliaceae') which is low in plant defences (i.e. tannins or alkaloids) and high in nutrients (simple carbohydrates and low in fibre) is one possible factor determining the spatial abundance of elephant dung between land-tenure categories at low to intermediate levels of human activity and certainly merits further research. Differences *within* land-tenure categories, however, may be more easily explained in terms of risk to elephants and will be explored further below.

5.4 ELEPHANTS AND RISK IN LAIKIPIA

In this section the risks to elephants within different sample areas selected for the transect survey are characterised based on observations made over the fieldwork period, illustrated with statements recorded by interviewees or key informants, and reinforced in some cases with records of elephant carcasses collected in the field. These data sources provide a useful framework for conceptualising and contextualising the risk to elephants within discrete properties and enabled a tentative classification of sample areas as either ‘tolerant’ or ‘intolerant’ from an elephants’ perspective. The principal focus of this section is on the ‘how?’ rather than the ‘why?’ in terms of risk to elephants within specific land units. However some of the underlying causes of the spatial variation in the level of threat to elephants from people are touched upon, albeit superficially in this section, and these will be explored in detail in chapter nine.

5.4.1 Characterising the risk to elephants in a land-use mosaic

In other studies of human-wildlife interaction, local people’s attitudes towards wildlife have been categorised in terms of tolerance (e.g. Marker et al 2003; Naughton-Treves et al. 2003). Tolerant and intolerant categories are also adopted in this chapter for the purpose of characterising individual sample areas and the analysis of the relative abundance of elephants. Sample areas were grouped into either tolerant or intolerant categories on the basis of the attitude of land owners as well as several other factors that were considered important for gauging the presence or absence of risk to elephants. This section explores these factors.

Elephants in Laikipia crop-raid within two different land-tenure/use systems: 1) smallholder areas; and 2) large-scale commercial wheat farming land. Tigithi, Endana and Sirima represent the former land-tenure/use systems and southern Ol Pejeta represents the latter. Elephant deterrence within all of these sample areas is motivated by threats to crops and arable farming livelihoods more generally. As might be expected, the level of resources available for deterring elephants differs between the large-scale wheat farm and the smallholder areas (Box 5.1). While smallholder households are clearly at a disadvantage in terms of the resources available to keep elephants out of their cultivated lands, these households are occasionally provided with assistance from armed and mobile Kenya Wildlife Service problem animal control (PAC) units and/or honorary wardens (Box 5.1). The former are either stationed in outposts or carry out their tasks from out of the district KWS headquarters using vehicles. Honorary wardens are volunteers nominated by the Kenya Wildlife Service to assist with wildlife conservation and management activities. In Laikipia the majority of honorary wardens are local ranch owners and/or managers. Because these individuals have resources at their disposal (i.e. vehicles, fuel and guns) and experience of killing large wild animals, they represent a considerable resource that the Kenya Wildlife Service can call on to assist with wildlife management in the district.

Until the emergence of wildlife tourism and substantial changes in land ownership (Chapters One and Four), large-scale ranching in Laikipia was orientated towards maximising stocking rates and, ultimately, meat production. Because of their perceived role in reducing grass cover, damaging infrastructure (fences and water pipes) and as vectors for livestock diseases (i.e. East Coast Fever), some species of wild mammals were not tolerated on many large-scale properties, and the philosophy that livestock and wildlife don’t mix was a common feature of ranch management. Furthermore many ranching operations managed their livestock through paddock systems which required extensive fencing, easily damaged by traversing wildlife (see Box 5.2).

Box 5.1: Comments made by local actors during qualitative interviews concerning the deterrence of elephants from cultivated land

Methods of deterrence

1.Within southern Ol Pejeta

I#1: "I send people there for 24 hour duty sometimes: drivers, guns, shotguns….I have to stock up with ammunition: bird shot, thunder flashes or bangers. Yeah we have to make the effort. We have to get the fence voltage up as high as possible."

I#2: "We have shot proven crop-raiders together with the KWS, so yes we have shot elephants."

2. Within smallholder land units

I#3:"The tamed ones they are dangerous because when you go there with a torch they are not scared but the wild ones when you go there with a torch they are scared, they shy away."

3. PAC by the Kenya Wildlife Service (KWS)/honorary wardens

I#3:"He [the KWS Laikipia Warden] asks me can I identify the real one and then he can come and get rid of it."

KI#1 "The only way to do it, is to drop them [crop-raiding elephants] right there and then in the *shamba* [cultivated farm] and then they won't come back for a while."

Today just five out of thirty-one large-scale ranches greater than 5000 acres in Laikipia continue to operate paddock systems. On Mogwooni Ranch the owners are completely dependent on livestock ranching as a source of livelihood. The potential damage elephants could, and occasionally do, cause to infrastructure on Mogwooni, particularly fencing and water pipes, and the economic margins within which this ranch operates due to low beef prices, has resulted in a strict 'elephant exclusion zone' policy (see Box 5.2). This policy is implemented through a regularly maintained electric fence and is enforced by armed employees. Solio game reserve is another property that attempts to exclude elephants using a similar approach. The game reserve is owned by and located within the larger Solio Ranch. The principal motivation behind excluding elephants from the game reserve differs to that of Mogwooni Ranch and relates to the owner's preference for woodlands which he perceives as threatened by the presence of elephants (see Box 5.2).

The other three large-scale private ranching properties included within the survey (Borana, Segera and Sweetwaters) are elephant-tolerant and capture the economic dimensions of elephant tolerance and more generally, the transition in land ownership within Laikipia that has occurred over the last *c* 20-30 years.

Box 5.2: Management of elephants on intolerant large-scale properties

Management perspectives of elephants

I#1: "They mess up all the fencing. It costs a lot of money. They destroy piping, they destroy water troughs. They destroy a lot of things, trees…"

I#5: "Elephants are just destroyers of infrastructure. If you're prepared not to have any fences and everything like that and just have a free range system, I don't see what, apart from drinking the water that you're pumping, which is a major hassle and a major expense, but they just destroy everything: tanks; troughs; fences; yards; any railings; pipes; and they scoff all your salt."

I#4: "We need a fence to keep them out because we have a beautiful forest"

Elephant deterrence

I#4: "Every year there's a Diwali festival and that's the only time you can buy fireworks so we stock up on rockets. You can position a rocket; aim so it explodes over them [elephants]……When it's dry we will use a shotgun, but you have to get up close"

I#5: "I think if an elephant does come in here, it gets a pretty hard time and so they [elephants] know they're not welcome."

Borana Ranch, covering 35,000 acres in northeast Laikipia operates two luxury tourist lodges[32] that earn substantial income. In addition the owners of this property are able to cross-subsidise ranch losses through profits made from cereal and horticultural production from a nearby large-scale arable farm that they also own. Thus Borana operates outside of the economic constraints of Mogwooni Ranch and has an economic incentive to not only tolerate but protect elephants, through the revenues earned from overseas tourists.

[32] http://www.borana.co.ke

Segera Ranch, covering an area of 50,000 acres, is owned by an expatriate businessman, who is interested in conserving, looking at and enjoying wildlife[33]. Thus Segera Ranch, unlike Mogwooni Ranch and perhaps Borana, represents a residential property (i.e. a second or holiday home) rather than a source of livelihood for the present owner. Once again Segera Ranch operates outside of the economic constraints facing Mogwooni Ranch because the owner has the capital to cross-subsidise the losses incurred by the ranch and even invest in the protection of the wildlife inhabiting his property. Thus the reasons elephants are tolerated on Segera relate more to their *intrinsic* rather than monetary value. However Segera Ranch does rent out a ranch house to tourists and several smaller houses to wildlife researchers, providing a small though relatively negligible additional *economic* incentive for both tolerating and protecting elephants and other wildlife species.

Sweetwaters Game Reserve which covers 24,000 acres in southern Laikipia, is part of a larger property, Ol Pejeta Ranch (the southern section of which is designated for large-scale wheat farming). The game reserve on Ol Pejeta has no livestock and/or commercial wheat farming and the management focus within the reserve is exclusively wildlife tourism with a lodge, tented camp and gate fees providing substantial revenues. Indeed these revenues are high enough in good years to provide a cross-subsidy for the other parts of the ranch where wildlife tourism does not exist (I#2). Like Solio Game Reserve, the game sanctuary contains endangered black rhinoceros and is bordered by smallholder land. However unlike Solio, Sweetwaters Game Reserve tolerates limited numbers of elephants within the sanctuary. Like Borana Ranch, the principle reason for tolerating elephants on Sweetwaters Game Sanctuary is the financial incentive provided by wildlife tourism.

Within both communally owned group ranches and forest reserves, the risk to elephants of human-inflicted injury or mortality could be attributed to ivory poaching and/or conflict with livestock herders. Traditionally the Yaaku people, whose descendents still

[33] Since the fieldwork period ownership of Segera Ranch has changed. However the new owner is also an expatriate businessman and the property continues to operate in much the same way as it did under the previous owner (i.e. minimum livestock production and wildlife conservation)

live in the Mukogodo Forest today, (chapters 1, 2 & 8), hunted elephants and other species of wild mammals. Historically there were also other socially distinct groups living in the region, such as for example the ‘Ngwesi’(Herron, 1991), who hunted elephants. As was discussed in Chapter Two, until the imposition of colonial game laws, ivory was an important barter item among these groups, traded for livestock and other goods with pastoralists, traversing slave/trade caravans and more recently, European explorers, hunters, settlers and administrators (Cronk, 2004). Given the historical ivory trade among the people living in and around the Mukogodo Forest, and the continued availability of illegal markets for ivory in nearby Isiolo Town, it is unsurprising that local hunters continue to kill elephants in this area (KI#2). To kill elephants, the Yaaku traditionally used a potent poison, extracted and refined from the bark of a local tree, *Acocanthera shimpira*, which was either applied to arrows or a drop-trap contraption (see Box 5.3). Over the course of the fieldwork period it was evident that this same hunting method is still occasionally used to kill or try to kill elephants in and around the Mukogodo Forest (Figs. 5.6 & 5.7). Given the availability of modern firearms in north Kenya, the continued use of traditional hunting methods may seem unexpected. However local people are clearly fearful of being caught killing elephants by the wildlife authorities and/or honorary wardens (see Box 5.3). The more silent traditional method of killing elephants are less likely to arouse suspicion among local KWS informants than if guns were used.

Fig. 5.6 Drop-trap arrow shaft embedded in the back of a sedated male elephant (Borana Ranch 06/08/04)

Fig. 5.7 Drop trap shaft with traces of poison still visible on the arrow head (Borana Ranch 06/08/04)

Box 5.3: Elephant hunting and conflict with wildlife authorities in the Mukogodo Forest

Elephant hunting by people living in the Mukogodo Forest

I#6: "If that thing, the black poison, is used to hit an animal like this goat, it dies instantly. That's it! You hit it here [where we are sitting], it will run away but must collapse before reaching that tree there….In the past, we sold it [ivory] in exchange for cows.

KI#2: "I think there has always been a little group of wazee [old men] there [i.e. Mukogodo] who just quietly plink a few elephants every year and sell the tusks in Isiolo."

Fear of the wildlife authorities

I#6: "Now the game is no longer hunted since the arrival of the white man. He brought game [wildlife authorities] called 'game' to guard animals. So what could people do? Just sit back and watch, even when elephants come to disturb us and raid our farms, we just leave it.....If they find you have killed one, they kill you, you could only be lucky if you are not shot nowadays."

Q#1: "An elephant was speared by one Mzee [old man] and the elephant just stayed in the *shamba* so the Mzee chased it away with a stick so that he wouldn't get in trouble with the KWS.

Between the 1980s and 1990s armed Somali poachers operated regularly in north Laikipia and the adjacent districts and were responsible for the majority of elephant poaching incidents over the course of the last 30 years. Their activities extended beyond wildlife poaching, including violent theft of livestock causing localised displacement of resident pastoral groups (see Box 5.4 & Box 5.6). While clearly less active in recent years, it is evident that local people perceive this source of insecurity to persist in some areas (I#8, I#6).

In addition to hunting elephants, local people using group ranches and/or forest reserves sometimes injure and/or kill elephants they encounter while herding their livestock. Elephants that are blocking paths or using watering points may be vulnerable to harassment and are sometimes injured or killed by aggressive and/or frightened herders. Harassing elephants may also be regarded as good fun for young men herding their livestock. This is perhaps more common now as a result of the availability and convenience of modern weapons for scaring off elephants (see Box 5.5). During dry periods elephants and livestock are more likely to use the same areas at the same time, for grazing and for access to water (Kangwana 1993). Thus, conflict with livestock herders resulting in elephant injury/mortality may be more prevalent in the dry season and/or during drought when resources are scarce and thus competition for them more intense (Thouless 1994).

Box 5.4: Somali elephant poaching

Somali poaching

I#8: "When the Somalis came here they started by fighting people and then chasing up this way. After chasing them, they were left now in that Sieku area and that Tassia area [these two areas are located in and adjacent to the Mukogodo Forest], all that area now. That is a very good area. Now there are many elephants down there. They could get them [elephants] easily because they had guns and they just get the tusks, take them to Isiolo and transport them to other places."

Somali presence today

I#6: "If you search, there is no one [still living in the forest], unless it is the enemy passing through the forest."

I#8: "And still there is a bit of insecurity."

Box 5.5: Conflict between livestock herders and elephants

Reasons for herders injuring/killing elephants

I#8: "Maybe one gets an elephant because maybe one has got a spear. Some could use other weapons nowadays, they can even decide to, because there is no way to get out of these elephants so you just shoot or spear but they don't go directly to killing these animals."

I#7: "So the Mukogodo forest is not a private place, anybody can be passing by and anybody can harass even if it is to kill [elephants]."

The presence of community-based wildlife tourism and/or security appears to mediate the level of risk to elephants [from these two sources of mortality/injury] in group ranches and national forest reserves. Of the three group ranches surveyed, ecotourism is now well established on both Koija and Ilngwezi group ranches. Both of these group ranches also have security and in the latter case this security is substantial (see Box 5.6). Kuri Kuri group ranch on the other hand has no such industry or security and the human occupants depend almost entirely on their livestock (I#8) to meet their subsistence needs. While there is no tourism in the Ngare Ndare Forest, it is patrolled by game scouts from Lewa Wildlife Conservancy (I#7). There is a security presence within the Ngare Ndare Forest (principally for wildlife but this security is also used to deter cattle rustling) because it shares an open boundary with Lewa Wildlife Conservancy[34], a heavily fortified private wildlife sanctuary that provides a home for 50 critically endangered black rhinos. The Mukogodo Forest has no such security presence and is larger and more remote than the Ngare Ndare Forest.

Box 5.6: The impact of security (or lack of) on group ranches and forest reserves

Security

I#8 "They have these soldiers, the game scouts with guns and now there is nobody who can go directly poaching in the group ranch [Ilngwezi group ranch] because they have security now"

I#7: "They [Lewa Downs Security] are there [Ngare Ndare Forest] 24 hours non-stop for sure, because there in Ngare Ndare, there is a repeater, up there, the rangers are there throughout."

I#9: "If Ilngwezi park had not been constructed here, we would have moved out of this place [Ilngwezi group ranch and surrounds] a long time ago because of cattle rustlers."

Wildlife distribution and insecurity

I#7: "But Mukogodo forest, they [elephants] fear some places, they fear like Sieku valley….In this Ngare Ndare Forest they don't fear, just like this…just passing you standing in this road, but in Mukogodo they are a bit coward."

I#8:"In a place like our place here [Kuri Kuri Group Ranch], not unless they [wildlife] move right into the forest, using the forest as their security, we don't have much animals living down here. So people like these animals. They like them but the problem is that there is no security."

The local perspectives briefly presented in this section, together with observations made in the field suggest that the underlying causes of risk to elephants from people are complex and vary as a function of land-tenure, the economic constraints that resource users operate under, the availability of economic incentives to either conserve or kill elephants and the presence of disincentives for killing elephants. More specifically there are several locally defined circumstances under which elephants are at risk:

[34] http://www.lewa.org

1) Risks through conflict over crops: As a result of crop-raiding by elephants which can lead to KWS Problem Animal Control (PAC) activities (e.g. shooting and killing crop-raiders or using fireworks and gunshots to scare elephants out of cultivated farms) or household deterrence activities (e.g. flashing torches, throwing missiles, lighting fires and in a small number of extreme cases, baiting crops with poison).

2) Intolerant ranch risks: Deterrence of elephants from certain large-scale properties such as wildlife intolerant commercial livestock ranches and/or private wildlife sanctuaries.

3) Pastoralist interaction risks: As a result of interaction with livestock herders in either group ranches or forest reserves. Such interaction may include competition over water sources and/or grazing.

4) Hunting risks: Elephant hunting by both resident and non-resident groups to procure ivory for sale among local traders or, to a lesser extent, for the purpose of engaging in ceremonies of a traditional nature.

While there are clearly different contexts and circumstances under which human risks to elephants manifest themselves, in this chapter it is the presence or absence of that risk that is important for constructing an elephant's perspective of the landscape. In other words, from an elephant's perspective it is unlikely to matter whether it is a small-scale farmer wielding a spear, a Somali poacher brandishing an AK47, a rancher firing off a shotgun or a traditional hunter gatherer perched in the boughs of a tree with a poison tipped drop-trap; what matters to an elephant is the likelihood of being injured or killed in a particular area. The exploration of the perspectives of local human actors facilitates the evaluation of the presence or absence of risk to elephants in a particular area and thus provides a more meaningful framework for grouping the sample areas used in this chapter into 'tolerant' and 'intolerant' categories.

In some cases statements made by local actors and respondents regarding the behaviour of human occupants towards elephants was reinforced by the distribution of dead elephants established during the fieldwork period (Table 5.3, Fig 5.8).

For example there were substantially more elephants poached in the Mukogodo Forest than in the patrolled Ngare Ndare Forest. In addition problem animal control shooting by the wildlife authorities and human-elephant conflict ('HEC') related deterrence activities were the only causes of elephant death in smallholder areas. In Tigithi there were no elephant carcasses recorded over the study period. However, there were seven carcasses recorded in the adjacent small-scale farming areas (Weruini and Matanya) that could be attributed to KWS PAC activity.

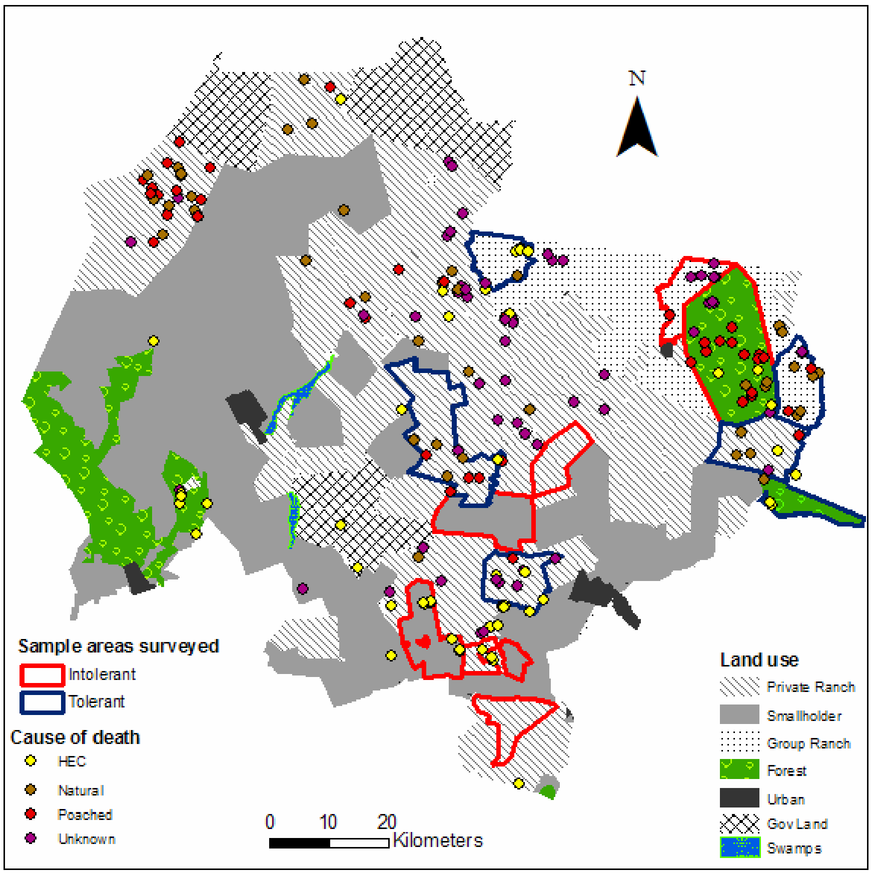


Fig. 5.8 Distribution of elephant carcasses recorded in Laikipia between 2002 and 2004. HEC is human-elephant conflict.

Table 5.3 Elephant carcasses within surveyed land units

Sample area	Land tenure/use	Risk category	No. of Elephant Carcasses				
			Poached	HEC	Natural	Unknown	Total
Segera	Private Ranch	Tolerant	3	1	5	1	10
Mogwooni	Private Ranch	Intolerant	0	0	0	1	1
Borana	Private Ranch	Tolerant	1	1	4	1	7
Solio	Private Ranch/ Game Reserve	Intolerant	0	0	0	0	0
Sweetwaters	Private Ranch/ Game Reserve	Tolerant	1	2	0	5	8
South Ol Pej	Large-scale farm	Intolerant	0	2	0	0	2
Tigithi	Small-scale farms	Intolerant	0	0	0	0	0
Sirima	Small-scale farms	Intolerant	0	5	0	0	5
Endana	Small-scale farms	Intolerant	1	0	0	0	1
Mukogodo	Forest Reserve	Intolerant	13	3	3	1	20
Ngare Ndare	Forest Reserve	Tolerant	2	2	1	1	6
Kuri Kuri	Group Ranch	Intolerant	1	0	0	5	6
Ilngwezi	Group Ranch	Tolerant	2	0	7	1	10
Koija	Group Ranch	Tolerant	0	3	1	1	5

The distribution and density of elephant carcasses were not sufficient for the classification of private and group ranches into tolerant and intolerant ‘risk’ categories for several reasons. Firstly, there appeared to be more elephants killed by people in tolerant compared with intolerant properties although this difference is not representative of the risk to elephants. While there were no elephant carcasses recorded in either Solio or Mogwooni ranches, the managers of these two properties also stated that they use non-lethal methods to deter elephants. Intolerance here was combined with frequent non-lethal methods[35]. Although the use of fireworks and shotguns may be non-lethal from a management perspective, it is unlikely that elephants can distinguish between these sorts of deterrence activities and the more potent threats presented by KWS PAC units, poachers and/or hostile livestock herders. Shotgun wounds inflicted on an elephant in an intolerant property could eventually kill that elephant after some time after it has moved into another area. Similarly, elephants that are shot or speared on smallholder properties, group ranches or forest reserves are often not killed immediately but die from wounds after they have moved onto private ranches. On some of the ranches surveyed, the managers together with the wildlife authorities carried out mercy killings on elephants

[35] In fact a bull elephant was killed (legally) in April 2006 on one of these properties in an attempt to control fence breaking by elephants.

that had been injured elsewhere. Lastly, it is important to take into consideration that the risk to elephants within individual properties is relative to the abundance of elephants within those properties. Survey areas were thus categorised as either tolerant or intolerant for elephants based on combining these considerations with the other factors unveiled through the brief exploration of local perspectives, and with personal observations made in the field (Fig 5.8). A summary of the attributes of sample areas included within the survey is provided in Table 5.4.

Table 5.4 Attributes of sample areas included within the transect survey (1 for presence, 0 for absence in all cases) showing the basis for the grouping of land units into tolerant and intolerant categories (i.e. economic, aesthetic, direct use or intrinsic).

Land Unit	Tenure	Land use			Elephant-intolerant			Elephant-tolerant	
		Livestock	Cultivation	Wildlife Tourism	Economic	Aesthetic	Direct Use	Economic	Intrinsic
Borana	Private Ranch	1	0	1	0	0	0	1	1
Segera	Private Ranch	1	0	1	0	0	0	0	1
Mogwooni	Private Ranch	1	0	0	1	1	0	0	0
Lengetia	Private Ranch	1	1	0	1	0	0	0	0
Sweetwaters	Private Ranch	0	0	1	0	0	0	1	0
Solio	Private Ranch	0	0	1	1	1	0	0	0
Koija	Communal	1	0	1	0	0	0	1	0
Ilngwezi	Communal	1	0	1	0	0	0	1	0
Kuri Kuri	Communal	1	1	0	1	0	1	0	0
Tigithi	Smallholder	1	1	0	1	0	0	0	0
Ngobit	Smallholder	1	1	0	1	0	0	0	0
Endana	Smallholder/ Absentee	1	1	0	1	0	0	0	0
Ngare Ndare	Government Forest	1	1	0	0	0	0	0	1
Mukogodo	Government Forest	1	1	0	1	0	1	0	0

5.4.2 Elephant abundance in tolerant and intolerant land units

Elephants were significantly more abundant in sample areas classified as tolerant compared with those classified as intolerant (Fig 5.9; Mann Whitney U test: Dung Density $U_{48, 61} = 312$, $P < 0.001$). The difference in the level of human activity between tolerant and intolerant properties was also highly significant (Mann Whitney U tests: human activity, $U_{48, 61}$ = 916, P < 0.001). Within each land-tenure/use category, dung density was consistently higher on transects in tolerant compared with intolerant properties, (Fig. 5.10; Mann Whitney: private ranches, $U_{24, 24}$= 8.5, exact P < 0.001; forests, $U_{8, 9}$ = 0, P < 0.001; communally owned group ranches, $U_{16, 4}$ = 0, exact P < 0.001). On the other hand the relationship between dung density and human activity at this resolution varied. For example the intensity of human activity was positively correlated with dung-density on transects in forest reserves (Spearman rank correlation: r_s = 0.544, n = 17, P = 0.024) and human activity was significantly higher in the Ngare Ndare Forest, where dung density was high compared with the Mukogodo Forest, where dung density was lower (Mann Whitney $U_{8, 9}$ = 11, P = 0.014). The opposite relationship was evident in group ranches ($U_{16, 4}$ = 8.5, P = 0.024), while on private ranches there was no significant difference in levels of human activity between elephant tolerant and intolerant properties (Fig. 5.11; $U_{24, 24}$ = 233.5, N.S.). This suggests that while the intensity of human activity contributes to differences in dung density between tolerant and intolerant group ranches, in forest reserves and private ranches factors other than levels of human activity were contributing to the variation in elephant abundance.

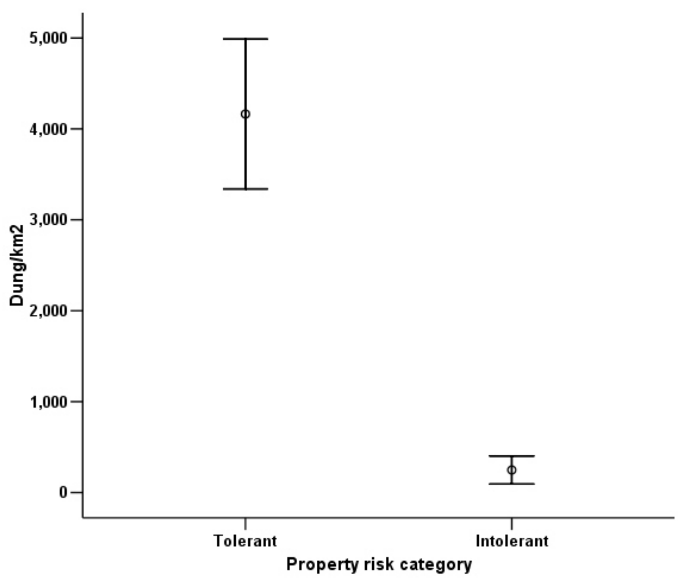


Fig. 5.9 Mean (± SE) elephant dung density in tolerant and intolerant properties. Means are presented here as median values for some categories were close to zero.

There were no significant differences in habitat attributes between tolerant and intolerant forests (Table 5.5), suggesting again that other factors underlie the differences in elephant abundance between the two forests surveyed. Given the relative density of elephant carcasses in the Mukogodo Forest, together with the statements made by key informants and interviewees, it is likely that the relative risk of being killed or injured underlies these differences.

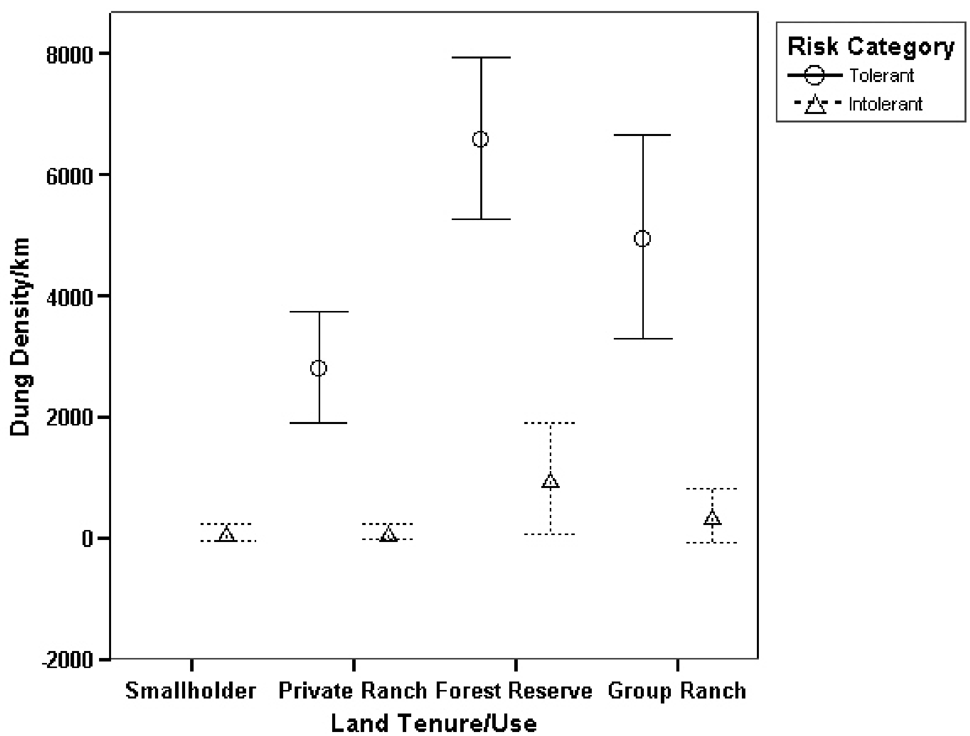


Fig. 5.10 Mean (± SE) dung density between elephant tolerant and intolerant sample areas in each of four land tenure/use categories in Laikipia. Means are presented here as median values for some categories were close to zero.

While there was no significant difference in the level of human activity encountered between tolerant and intolerant private ranches, there was a difference in the proportion of habitat types encountered (Table 5.6). The proportion of grassland encountered was higher ($U_{12,\,12} = 12$, $P < 0.001$) and the proportion of woodland lower ($U_{12,\,12} = 26.5$, $P = 0.007$) in elephant tolerant compared with intolerant ranches. However within tolerant ranches there were no associations between the proportion of these habitat types encountered and dung density (dung density and grassland: r_s = -.098, n = 12, N.S.; dung density and woodland: r_s = 0.032, n = 12, N.S.). Once again, given the different management policies towards elephants on tolerant and intolerant ranches identified in this study, it is likely to be the deterrent activities of ranch managers and employees that contributed to the pattern of elephant abundance on private ranches identified in Laikipia rather than habitat factors. Furthermore this pattern of elephant abundance is likely in turn to have had an impact on the pattern of vegetation cover observed; specifically, the greater occurrence of woodland habitat than grassland habitat on intolerant compared with tolerant private ranches. This pattern between elephant abundance and vegetation cover among private ranches is likely to reinforce the perspectives underlying the management approach of Solio game sanctuary (I#4, Box 5.2) where preserving woodlands is the priority (rather than preserving elephants at high densities).

Table 5.5 Habitat attributes in tolerant and intolerant forest reserves (n = transects)

Attribute	**Tolerant**			**Intolerant**			**Mann-Whitney** U	***P***
	n	Mean	S.E.	n	Mean	S.E.		
Biomass (grams)	2	32	8.3	3	32.7	1.2	_	_
Woody percent	2	65	34.9	3	88.5	6.5	_	_
Grassland cover	4	5.6	5.6	5	4.2	3.9	9.5	n.s.
Bushland cover	4	3.4	2.24	5	2.6	2.1	6	n.s.
Forest cover	4	91	4.9	5	91.8	4.8	9	n.s.

Table 5.6 Habitat attributes in tolerant and intolerant private ranches

Attribute	**Tolerant**			**Intolerant**			**Mann-Whitney** U	***P***
	N	Median	IQR	N	Median	IQR		
Biomass (grams)	7	68.7	64.5	6	87.7	48.5	20	n.s
Woody percent	7	41.1	48.8	6	42.1	46.7	20	n.s.
Grassland cover	12	41	39.3	12	1.1	16.4	0	<.001
Bushland cover	12	54	37.2	12	44.4	61.5	62.5	n.s.
Woodland cover	12	1.33	6	12	13.7	42	26.5	<.01

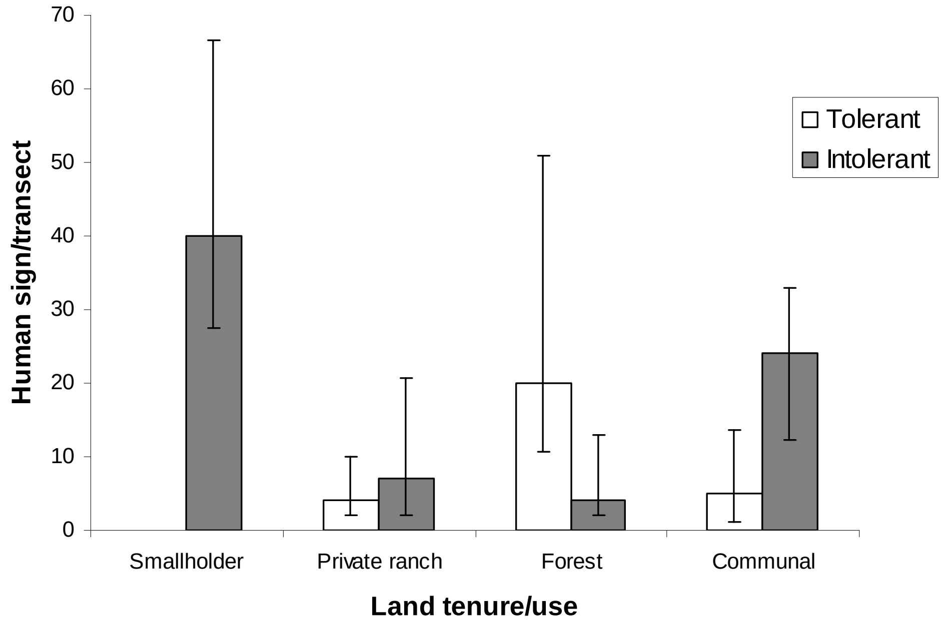


Fig. 5.11 Median (± IQR) human activity in tolerant and intolerant properties within four different land-tenure/use categories.

5.5 SEASONAL PATTERNS OF ELEPHANT USE

In the early 1990s, Thouless and Dyer (1992) found that the majority of elephants in Laikipia (1100 out of a population of 1950) regularly moved north into neighbouring Samburu District during the rains. This would have resulted in reduced elephant densities on some properties during wet seasons. In contrast, the relative abundance of elephants as shown by dung counts presented in this chapter suggest that there was no significant difference in elephant abundance between wet and dry seasons in Laikipia (median dung density-all transects: wet season 439.7/km^2, IQR = 4098.5, n = 54; dry season 411.86/km^2, IQR = 3130, n = 55; Wilcoxon signed ranks test: $Z_{53,53}$ = -1.5, N.S.). This is interesting and surprising. It is not clear why this is the case but it could be because I sampled just a fraction of the total area surveyed by Thouless and Dyer (1992). It may also be that elephants no longer move north in the numbers that they did over a decade ago. The results of the dung surveys are in fact even more interesting because the scale of movement recorded by Thouless and Dyer (1992) is reflected somewhat in some land tenure categories but not in others.

Seasonal patterns in elephant abundance did vary by land-tenure category and among individual sample areas. Pooled dung density estimates show that elephants use smallholder properties more often in the wet compared with the dry season (Table 5.7, medians: wet season = 0/ km^2, IQR = 148.9, n = 12; dry season = 0/ km^2, IQR = 0, n =12), although encounter rates of dung were very low in both seasons and this difference did not reach significance (Wilcoxon signed ranks test: $Z_{12, 12}$ = -1.5, N.S.). The marginally higher density of elephants detected in the wet season could be related to the cropping cycle in smallholder land units. The transect survey was carried out in the middle of June, at the end of the 'long rains' so as to capture any wet season use of designated land units. However the main maize harvest occurs in May (see chapter 4) and so it is possible that the elephant sign detected in June was recent and belonged to crop-raiding animals.

In communally owned group ranches, elephant dung density was significantly more abundant in the wet compared with the dry season (Table 5.7; medians: wet season 6337.8/km^2, IQR = 6043.9, n = 9; dry season 1981/km^2, IQR = 3836.3, n = 11; Wilcoxon signed ranks test, $Z_{9, 9}$= -1.8, $P < 0.039$ (one-tailed)). This pattern is consistent with results from previous research (Thouless, 1993, Thouless, 1995, Thouless, 1996a, Thouless & Dyer, 1992) in which elephants were recorded moving into the drier lowlands below and to the north of the Laikipia plateau during the wet season.

In private ranches seasonal differences in dung density were less obvious (medians: wet season 270.9/km^2, IQR = 3048.5, n = 24; dry season 411.9/km^2, IQR = 1956.3, n = 24) and the difference in elephant use of private ranches between seasons did not reach significance (Wilcoxon signed ranks test: $Z_{24, 24}$ = -0.46, N.S.). When ranches were grouped into fenced and unfenced categories, there was still little difference in median elephant abundance between seasons (Table 5.6; Dung density unfenced ranches medians: wet season 2574/ km^2, IQR = 2642, n = 8; dry season 2553/ km^2, IQR = 3233.1, n = 8; Dung density fenced ranches medians: wet season 0/km^2, IQR = 812.9; n = 16; dry season 82.3/ km^2, IQR = 411.9, n = 16; Wilcoxon signed ranks test: unfenced ranches $Z_{8,8}$ = -0.7, N.S.; fenced ranches, $Z_{16,16}$ = -0.7, N.S.). The only seasonal pattern that emerged among fenced private ranches was confined to Sweetwaters Game Sanctuary with higher dung densities recorded in the wet season than in the dry season. This could possibly reflect movement of elephants into the sanctuary (by breaking through the perimeter fence) or is perhaps a consequence of elephants concentrating along the permanent rivers at the time of the survey. In the fenced elephant-intolerant properties, encounter rates of elephant sign along transects were very low or absent in both the wet and dry seasons, although more signs were encountered in the dry compared with the wet season (Table 5.7). Greater movement into and through such properties in the dry season may be related to the availability of dry season foraging resources (i.e. woodland vegetation). African savannah elephant are both browsers and grazers though the proportion of browse (woody vegetation) to grass consumed varies among regions (Codron et al., 2006). Generally elephants consume relatively more browse in the dry season and relatively more grass in the wet season (Cerling et al., 2006, Owen-Smith, 1988). It is possible that the relative abundance of woodland vegetation recorded in Solio and Mogwooni ranches compared with elephant tolerant ranches attracted elephants in the drier months. The seasonal feeding ecology of elephants identified in previous research may also explain the higher abundance of dung found in Sweetwaters Game Sanctuary during the wet season, as the transects surveyed on this property intersected seasonally inundated grassland.

Results from the pooled analysis of transect data from forest reserves suggests that elephant use of forest reserves is higher in dry compared with wet seasons (Dung density medians: wet season 1158.7/km^2, IQR = 7067.8, n = 8; dry season 3985/ km^2, IQR=4860, n = 8). There were, however, differences in seasonal use between the two forests surveyed with elephants appearing to use the Mukogodo Forest proportionally more in the dry compared with the wet season (Table 5.7; dung density medians: wet season = 463.5/km^2, IQR.= 811.1; n = 4; dry season = 1408.6/km^2, IQR = 2784.4, n = 4), while in the Ngare Ndare forest elephant dung density was slightly higher in the wet compared with the dry season (Medians: wet season = 7299.5/km^2, IQR = 2433.3, n=4; dry season = 5769.9/km^2; IQR =3545.3, n = 4). The seasonal pattern of use recorded in the Mukogodo Forest is similar to that reported in other studies of elephants inhabiting savannah-forest mosaics (Cerling et al., 2006, Douglas-Hamilton, 1971). The Mukogodo Forest is also situated between the main block of contiguous elephant-tolerant private ranches in Laikipia to the south and the communal lands of both Laikipia and Samburu District to the north and is believed to be on the main travel path of elephants that move between the two regions (i.e. from Samburu south to Laikipia during the dry season and in the opposite direction during the wet season-Douglas-Hamilton, unpublished data). Thus, the higher densities of elephants detected in the dry compared with the wet season is perhaps representative of elephants moving through the forest from Samburu District and the Laikipia communally owned group ranches in the north to the private ranches of Laikipia District to the south.

Table 5.7 Seasonal comparisons of transect dung densities (wet>dry=number of transects with higher densities in wet compared with dry etc.)

Location	No. of Transects (wet and dry pairs)	Wet>Dry	Wet<Dry	Wet=Dry
Fenced Ranches	32 (16)	5	4	7
Sweetwaters	8 (4)	3	1	0
Ol Pejeta	8 (4)	0	1	4
Mogwooni	8 (4)	0	1	3
Solio	8 (4)	1	2	1
Unfenced Ranches	16 (8)	3	5	0
Segera	8 (4)	1	3	0
Borana	8 (4)	2	2	0
Group Ranches	18 (9)	7	2	0
Ilngwezi	8 (4)	3	1	0
Koija	8 (4)	4	0	0
Kuri Kuri	2 (1)	0	1	0
Forest Reserves	16 (8)	3	5	0
Mukogodo Forest	8 (4)	1	3	0
Ngare Ndare Forest	8 (4)	2	2	0
Smallholder	24 (12)	4	0	8
Tigithi	8 (4)	1	0	3
Ngobit	8 (4)	1	0	3
Endana	8 (4)	2	0	2

Seasonal differences in elephant abundance in the Ngare Ndare Forest were less obvious with high variance among the transects surveyed and if anything abundance appeared to be higher in the wet compared with the dry season. It is not entirely clear why this would be although this particular forest is intensively used by local people for livestock grazing during the dry season (see Chapters Four and Eight) which may have contributed to the lower density of elephants recorded using this particular forest in the dry compared with the wet season.

5.6 CONCLUSION

While no ecological factor influenced relative densities of elephants among sample areas, these were explored in order to explore the possibility that elephants would "tolerate" higher levels of risk when the habitat quality was much better. However, human activity appears to be the most important factor determining the spatial distribution of elephant abundance in Laikipia District, although human activity and elephant abundance were not linearly related. Indeed, on some properties elephant abundance was clearly unrelated to the level of human use (i.e. Solio and Mogwooni). This is because human activity does not represent a single continuous variable, as is sometimes inferred in conventional resource management science, but comprised a number of measurable components and some other elements which are qualitative or highly subjective. This chapter attempted to construct a more inclusive portrait of the nature of human activity on different land-tenure/use systems and subsequently attempted to identify specific activities that could result in risks to elephants of being injured or killed. Elephants appear to be better able to tolerate activities associated with traditional livestock husbandry and wood extraction, and thus be present in those areas, than with smallholder farming, large-scale wheat farming and intolerant commercial ranching.

Risk to elephants presented by human occupants was difficult to measure using quantitative methods although the spatial pattern of elephant carcasses did partly illustrate a spatial pattern of risk. An understanding of the spatial dimensions of risk was obtained principally through conversations with local people and observations made in the field, which were reinforced by the distribution of known elephant carcasses. Without these alternative sources of information, the distribution of elephants would have been difficult to interpret. Further research into wildlife distribution and ecology in land use mosaics could benefit from interdisciplinary methods that better identify the human related or qualitative variables.

The blending of qualitative and quantitative sources of data is unusual and challenging (Campbell et al., 1999, Campbell, 2005, Sayer & Campbell, 2004). Here, it provided a practical ‘tool kit’ for assessing a phenomenon in a complex landscape where the risks to elephants are sometimes determined by individual attitudes and sometimes are a result of multi-dimensional factors including the perspectives, goals, motivations and philosophy of a wide range of different, competing resource users. The underlying causes of risk to elephants, however, are complex and this chapter presents an introductory explanation of human perspectives and behaviour towards elephants. These attitudes and constructs will be examined in detail in subsequent chapters using data from questionnaires and further informal interviews.

Despite elephant distribution and densities being clearly influenced by human activity, particularly high levels of human activity, elephants still occurred in smallholder land areas where recorded levels of human activity were greatest. The presence of elephants in these areas presents considerable problems for smallholder farmers and the resulting conflict can lead to elephants being killed, as demonstrated by the elephant carcasses located in the smallholder land in southern Laikipia (Fig. 5.8). The occurrence of elephants in smallholder areas is thus an interesting phenomenon, both because it represents use by elephants of areas well above the thresholds of human population densities identified in previous research (Hoare & Du Toit, 1999, Parker & Graham, 1989) and because it creates a difficult and dangerous challenge for small-scale farmers. Thus the next chapter will explore the spatial pattern of elephant use of smallholder areas in more detail.

The seasonal pattern of increasing elephant densities in the lowlands north of Laikipia's large-scale ranches during the wet season corroborates earlier research on elephant movements in Laikipia (Thouless, 1995, Thouless, 1996a, Thouless & Dyer, 1992). However the change in abundance on unfenced large-scale private ranches that would be expected if this pattern was associated with movement of elephants north from these ranches in Laikipia, was not detected in dung counts carried out in this study. This may be the result of the sampling strategy used in this thesis with the ranches surveyed hosting largely resident as opposed to migratory populations of elephants and it may be that there are other properties that were not surveyed that do host migratory populations of elephants. Alternatively it could be that the seasonal movement north recorded in previous research is less significant than it once was. There have been some significant changes in the Laikipia landscape since the early 1990s when the previous study of elephants was carried out. These changes include large increases in livestock densities within the low density smallholder areas and communal ranches of Laikipia; and further sub-division of individual ranches (see Chapter Four). To properly assess the extent to which the pattern of elephant movement recorded by Thouless in the early 1990s still occurs today, two total aerial counts would need to be carried out across the Laikipia/Samburu elephant range within a single calendar year; one at the end of the 'long dry season' in September and one during the 'short rains' between October and December. While this was not possible for this thesis, the relationship between human land use and elephant movement will be explored in chapter seven, using the available GPS tracking data collected for this thesis, and this analysis may provide some clues as to what might be expected if such a survey were to be carried out.

Chapter 6: Spatial dynamics of crop-raiding by elephants in Laikipia

6.1 INTRODUCTION

The last chapter explored the relative abundance of elephants across a range of land-use categories. Results suggest that intensity of human activity and the risks to elephants of being killed or injured by human occupants determines the relative abundance of elephants across land in Laikipia District. Of the land-tenure/use systems assessed, human activity was highest and elephant abundance lowest in smallholder areas. However, as this chapter will demonstrate, elephants do in fact use smallholder areas, sometimes frequently, to forage on crops.

HEC, in particular crop-raiding, is perceived to be increasing in Kenya (Kangwana, 1995, Kiiru, 1995). Hoare (1999a) suggests that conflict between people and elephants is becoming more widespread as expanding cultivation lengthens the human-elephant interface. Similarly Barnes et al. (1995) and Sukumar (1991) propose that crop-raiding by elephants in Africa and Asia, respectively, will increase as the available elephant range decreases because of an associated increase in the probability of contact between elephants and human settlement. However, during the last century elephants have been extirpated from much of their former range in both Africa (Happold, 1995, Parker & Graham, 1989) and Asia (Sukumar, 1991) and therefore from an historical perspective the geographical extent of the area that is vulnerable to crop-raiding by elephants has in fact reduced in size (Naughton-Treves, 1997). Thus the reported increase in the incidence of human-elephant conflict is instead likely to reflect a) localised patterns; b) democratisation in elephant range states; and c) sustained political and media interest in the problem. The latter two factors and the spreading culture of elephant ‘intolerance’ to which they contribute present a considerable challenge to the conservation of elephants and the places they live (Lee & Graham, 2006). The alleviation of HEC is clearly an important step for addressing this tolerance issue (Hoare, 1999a, Hoare, 2000, Thouless, 1994). However efforts to understand the patterns of HEC and their ecological and social determinants are still in their infancy, (though see Sitati et al., 2003). This chapter explores the former through analyses of crop-raiding data collected in Laikipia district while social dimensions of human-elephant interaction and conflict are explored in Chapters Eight and Nine.

The temporal variation in crop-raiding by elephants is widely recognised (Bell, 1984, Bhima, 1998, Hoare, 1995, Osborn, 1998, Osborn, 2003, Osborn, 2004, Tchamba, 1996, Thouless, 1994) and increasingly understood (Chiyo et al., 2005). Clearly the cultivation cycles of local farmers together with predominant rainfall patterns define to a considerable extent the 'window' of vulnerability to crop-raiding by elephants by determining crop availability (Bell 1984; Sukumar 1989; Osborn 1993, Nyhus et al., 2000; Hillman Smith et al., 1995, Tchamba 1996). Spatial patterns of HEC are less well recognised and/or understood.

As described in Chapter Two (section 2.4.2) there have been several studies that have attempted to identify spatial patterns of crop-raiding by elephants and associated determinants. The first of these spatial analyses (Hoare, 1999a) failed to identify any strong spatial correlates for crop-raiding and this was attributed to the prevalence of 'unpredictable' male elephants in recorded incidents of crop-raiding. The second spatial analyses did identify spatial correlates (distance to permanent water, elevation and protected area frontage) and this was partly attributed to the greater proportion of female elephants involved in crop-raiding incidents (Smith & Kasiki, 2000). Both of these studies used administrative boundaries to delineate sampling units for the analysis of crop-raiding. The third and most recent spatial analysis of crop-raiding by elephants recognised that:

"*aggregating the value of independent variables such as distance from roads, water or protected area boundaries over large and irregular-shaped areas [i.e. administrative units] may obscure patterns that would be evident using a more refined spatial delineation of data points*" (Sitati et al., 2003: 668).

Thus, the authors in this latter study performed analyses using 1 x 1 and 5 x 5 km grid cells as sampling units with the aim of testing whether spatial predictors of crop-raiding could be derived regardless of the sexual composition of elephants groups involved. The results of this latter study showed that crop-raiding by both males and females can be spatially predicted (crop-raiding by male elephants was predicted by distance from towns and area under cultivation while crop-raiding by female led, family groups was predicted by area under cultivation alone).

Thus Sitati et al. (2003) effectively demonstrated the importance of considering ‘scale’ in the analysis of human-elephant conflict. The ‘issue of scale’ in the analysis and understanding of landscape patterns has long been recognised by ecologists (see Chapter Three) and:

“*Parameters and processes important at one scale are frequently not important or predictive at another scale*,” (Turner et al., 1989: 153).

Ecologists define scale as having two components (O'Neill & King, 1998):

1. Grain: The smallest spatial units used to aggregate a series of observations
2. Extent: Total area over which observations of a particular grain are made

Sitati et al. (2003) took into consideration the former component of scale in the analysis of crop-raiding incidents in southern Kenya. However they did not take into consideration the latter-‘extent’-in their analyses. Thus in this chapter I consider crop-raiding by elephants in Laikipia across both different grains and different extents.

While previous published studies of HEC have placed considerable emphasis on the sexual composition of elephant groups involved (Osborn, 1998; Hoare, 1999a; Sitati et al., 2003), little attention has been given to the difficulties of sexing crop-raiders. This is surprising given that crop-raiding occurs almost exclusively at night. The use of indirect methods, such as the examination of elephant spoor (Western et al., 1983), may be sufficient for estimating the number and in the case of older bulls, sex of elephants, involved in crop-raiding incidents. However, this method is inadequate for determining the sexual composition of crop-raiding groups. This is because male groups of elephants involved in crop-raiding incidents may possibly include young bulls (L. Osborn, pers. comm.), giving the erroneous impression that the crop-raiding group contains juveniles and is thus female-led. As a consequence, while trained enumerators also distinguished between male and female led groups involved in crop-raiding incidents in this study, these data were pooled prior to analysis. Risk taking was instead explored in relation to the size rather than the sexual composition of elephant groups involved in crop-raiding. Elephants are known to aggregate in larger groups both in response to the threat of being killed by people (Abe, 1995; Demmers and Bird, 1995; Kangwana, 1993) and prior to seasonal migration (Thouless, 1995). In this study I test whether similar behavioural responses to risk occur among elephants during crop-raiding.

Bell (1984) suggests that for human-elephant conflict incidents to occur in higher ranges of human density, then a nearby elephant 'refuge' must exist. In this chapter I will also use the term 'refuge' to refer to the places of natural or semi-natural habitat where human settlement is low or absent, where elephants live during the day and that occur within a wider human-dominated matrix from where elephants are absent during the day. Hoare and du Toit (1999) propose that the size and connectivity of the remaining patches of elephant habitat [i.e. refuges] are the main determinants of elephant persistence in landscapes with high levels of human settlement. Therefore it could be predicted that crop-raiding should increase with proximity to a defined elephant refuge. However in the two most recent spatial analyses of crop-raiding by elephants, distance from elephant refuges was found not to be a significant predictor (Sitati et al., 2003, Smith & Kasiki, 2000). This may have been because of the way elephant refuges were defined and delineated in these two studies. For example Smith and Kasiki (2000) did not define elephant refuges as such but instead chose to use distance from the boundaries of protected areas (Tsavo East and Tsavo West National Parks) as a candidate variable in their analysis on the basis that "elephants in the Tsavo ecosystem tend to remain within the NPs during the day and enter cultivated fields at night." However there are several large-scale ranches within the Tsavo Ecosystem which elephants also use during the day (e.g. Taita and Rukinga Ranches[36]) and therefore the choice of distance from a national

[36] I worked as an assistant in these ranches between 1999 and 2000 and observed elephants, sometimes in groups of up to 40 individuals or more quite regularly during the day. Both properties have invested in security, water and run tourist operations and therefore clearly are just as representative of 'elephant refuges' as are Tsavo East and Tsavo West National Parks.

park boundary as a candidate variable may not have been the most appropriate for the Tsavo Ecosystem. Sitati et al. (2003) suggest that because of an absence of elephant distribution data, the forest boundaries they used in their analysis of crop-raiding in Transmara District may not have adequately captured daytime elephant refuges which may explain why distance to forests was found not to be a significant predictor of crop-raiding in their analyses. In this chapter I use known elephant daytime refuges in the analysis of crop-raiding.

The aims of this chapter are to test and refine the application of the grid-based analytical procedure developed by Sitati et al. (2003) and to identify spatial patterns and predictors of crop-raiding in Laikipia District in northern Kenya. Careful consideration was given to both grain and extent in the spatial analysis presented in this chapter. With regards to crop-raiding ecology, the study tested ‘risk avoidance’ and ‘safety in numbers’ hypotheses. This was achieved within a spatial framework by taking into consideration distance from GPS locations where elephants had been killed in defence of crops and elephant group size in relation to distance from daytime elephant refuges (private large-scale ranches and forest reserves known to be occupied by elephants), respectively.

6.2 METHODS

6.2.1. Crop-raiding by elephants in Laikipia

Crop-raiding by elephants in Laikipia District in Kenya has been a reported problem for quite some time. For example the District Commissioner (DC) under the British colonial government reported elephants shot in defence of crops on European farms surrounding the Marmanet and Ol Arabel Forests in west Laikipia in 1928 (DC/LKA/1/115, 1928). These two forests have since been subjected to an unconventional land subdivision process (UNEP, 2006) and in this part of the district crop-raiding by elephants has largely disappeared (pers. obs). However elsewhere in Laikipia crop-raiding by elephants has since become widespread. The emergence of widespread crop-raiding by elephants in Laikipia has been attributed to the sub-division of a substantial proportion of the district’s large-scale cattle ranches after Kenyan independence in 1963 (see chapters 1 and 4) and the associated emergence and spread of smallholder agricultural production (Omondi et al., 2004, Thouless, 1994). In some cases this led to situations where settlement schemes were surrounded by large-scale ranches supporting large populations of wildlife. In other cases, as a result of the unplanned nature of sub-division, many designated smallholder plots were in fact marginal and were therefore abandoned so that those smallholders who chose to remain were surrounded by large areas of bush. These factors combined with the influx of elephants into Laikipia from Samburu and Isiolo Districts to the north in response to uncontrolled poaching in those districts during the 1970s and 80s (chapter one) led to the arrival of the two principal ingredients of human-elephant conflict in Laikipia: smallholder agriculture and elephants. The relative security provided by the district's existing large-scale private ranches together with permanent water and available forage has since resulted in large numbers of elephants becoming resident or semi-resident in Laikipia.

Management of crop-raiding in Laikipia has taken several forms. Elephants have been shot in defence of crops since the 1920s and continue to be shot on control (legal) by the wildlife authorities or killed by local farmers (illegal). In 1978, at considerable expense, a completely unsuccessful large-scale elephant drive was attempted, aiming to push elephants out of the arable southern portion of Laikipia and north into the arid and semi-arid rangelands of Samburu and Isiolo Districts (Mwenge International Ltd 1979). Subsequently the preferred HEC management approach for Laikipia has become electrified fencing (Thouless 1995). In 1982 a district-wide elephant fence was proposed separating elephant tolerant from elephant intolerant areas (Jenkins & Hamilton, 1982). Designs for the configuration of this fencing 'solution' were proposed in 1993 (Thouless, 1993), 1998 (Wafula, 1998) and 2002 (Thouless et al., 2002).

6.2.2 Data analysis

In this chapter I analyse data on crop-raiding incidents collected by trained enumerators between November 2003 and October 2004 (see Chapter Three, section 3.5). Eight candidate variables for predicting the spatial occurrence and intensity of crop-raiding were selected on the basis of hypotheses developed through a review of previous studies (Table 6.1). Individual properties were classified as daytime elephant refuges based on the 2002 aerial total elephant count data, GPS tracking data collected over the fieldwork period, an updated land use map, observations in the field and conversations with local people. Invariably these daytime refuges were large-scale private ranches and/or government forest reserves. To generate distances to sites where elephants had been killed in defence of crops, only those coordinates for elephants that had been killed (either legally by the KWS or illegally by local farmers) within the five years prior to the start of the study period (i.e. before November 2003) were included in the analysis. The most recent national population census was carried out in 1999 and can only provide human population information at a fairly coarse resolution (human population data was available for each sub-location which is the smallest unit of government administration in Kenya and on a map represents a number of irregularly shaped polygons of different sizes). A more refined measure of human population density was available in the form of the high resolution aerial sample survey data described in chapter 3 (section 3.3.1). Previous research has shown that dwelling density estimates derived from this source are significantly related to known numbers of people (Georgiadis et al., 2004)[37].

While previous spatial analyses of HEC have included elephant density as a potential spatial predictor (Hoare, 1999a, Smith & Kasiki, 2000), there is considerable movement of elephants among large-scale private ranches and forest reserves in Laikipia (Thouless 1995; Thouless 1996; also see Chapter 7) and I felt the use of aerial survey data based on a single snap-shot of occupancy to provide an indication of the relative density of elephants in individual land units would be misleading. Therefore elephant density was not included as candidate variable in this study.

[37] In their analysis Georgiadis et al. (2004) assessed known numbers of people from a national census against numbers of dwellings estimated in each sub-location (this is smallest unit of government administration in Kenya) from an aerial survey carried out in the same year (R^2=0.47, P<.001).

Table 6.1: Hypotheses and reference sources underlying the selection of candidate variables for analysing spatial patterns of crop-raiding in Laikipia District

Variable	Hypotheses	Source of hypotheses
Distance to roads	Human-elephant conflict is negatively correlated with distance from roads	Sitati et al (2003)
Distance to rivers	Human-elephant conflict increases with decreasing distance from water	Smith and Kasiki (2000)
Distance to waterholes		
Distance to daytime elephant refuges	Human-elephant conflict increases with decreasing distance from daytime elephant refuges	Bell, 1984, Hoare & Du Toit, 1999, Naughton-Treves, 1998, Newmark et al., 1994, Smith & Kasiki, 2000
Slope/elevation	Human-elephant conflict decreases with increasing slope	Smith & Kasiki 2000; Wall et al., 2006
Area under cultivation	Human-elephant conflict increases with increasing area under cultivation	Sitati et al., 2003
Dwelling density	Human-elephant conflict varies in relation to human population density	Barnes et al., 1995, Hoare, 1999a, Sitati et al., 2003, Smith & Kasiki, 2000, Sukumar, 1991
Distance from site of elephant killed	Elephants avoid risk	Barnes et al., 1991, Hoare, 1999a, Kangwana, 1993

Spatial analysis of crop-raiding data was carried out following methods adapted from Sitati et al. (2003). All crop-raiding incident data and candidate variables were imported into a GIS and superimposed onto a 1 x 1 km grid. Percentage of crop-cover in each 1 x 1 km grid cell was derived from the 2002 land cover image provided by Mpala Research Centre following methods described in chapter 4, section 4.2.1. The minimum distance from the centre of each 1 x 1 km grid cell to the water hole, river, elephant carcass, elephant refuge and road vector files described in chapter three (section 3.2) were calculated using the “Near” command, a standard tool available in ArcGIS 9. After the interpolation process described in chapter 4, settlement density data were available in the format of a 2.5 x 2.5 km grid. Each 1 x 1 km grid cell was assigned a settlement density value equivalent to the distance weighted average of the 2.5 x 2.5 km grid it was in plus the four adjacent 2.5 x 2.5 km grids using the 'latticespot' command in ArcGIS. The same procedure was used to derive average values of slope for each 1 x 1 km grid cell from the DEM.

To test the effects of changing the grain on the pattern of crop-raiding and to address the issue of spatial autocorrelation (see below), all variables were also superimposed onto a 5 x 5 km grid. In addition to assessing the effect of changing the grain, data were also analysed at two different spatial extents: 1) The district level, in which all grid cells within the entire Laikipia district were included (Fig. 6.1) and; 2) The HEC zone specifically (Fig. 6.2). The HEC zone was delineated by combining each of the minimum convex polygons (MCPs) created for each individual enumerator. MCPs are typically used in the field of wildlife tracking research to define the 'home range' of individual animals fitted with a radio-tracking device and are calculated by joining the outermost locations in an individual's range (Chapter 4, section 4.2.4). In this chapter I use MCPs to define the extent of a sampling frame representing the area where human-elephant conflict was intensively monitored by each trained enumerator over the study period. MCPs were used because despite the delineation of standardised areas for sampling, it was obvious that the size and shape of the area monitored differed between each enumerator depending on local topography, the general spatial pattern of crop-raiding (i.e. clustered or widely dispersed) and scout effort. Each MCP was calculated by using all of the spatial locations of crop-raiding incidents recorded by a single enumerator. This was achieved using the Animal Movement extension for ArcView v.3.2 (ESRI Inc., 1997).

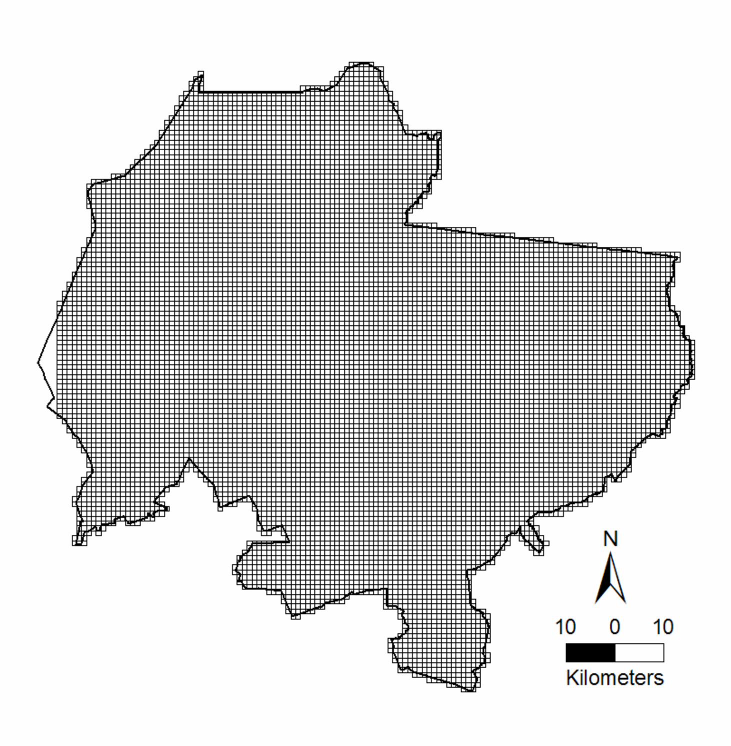


Fig.6.1 Spatial extent 1: District level sample of 1 km^2 grid cell sampling units

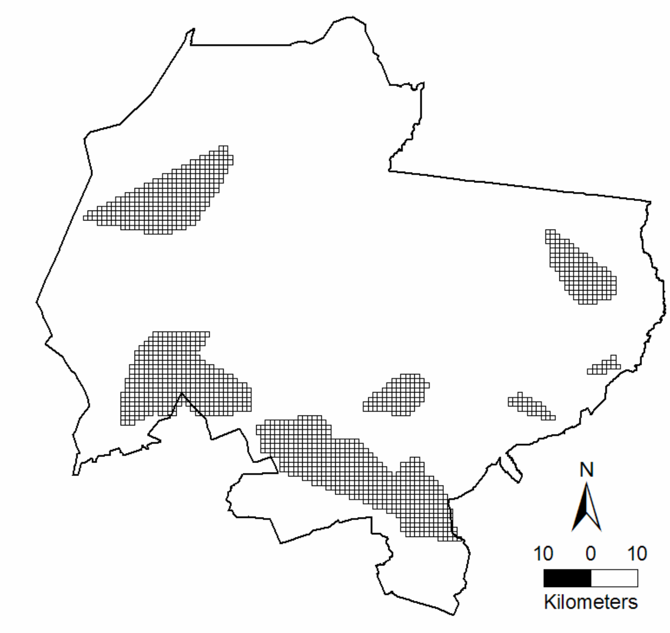


Fig. 6.2 Spatial extent 2: 1 km^2 grid cell sampling units within MCPs comprising the total area in which all crop-raiding events were recorded by each enumerator

Data were analysed in SPSS v.12. Because of the skewed distribution of crop-raiding data, parametric tests were not appropriate. Instead univariate Spearman's rank correlations were used to test the significance of relationships between crop-raiding intensity and individual potential predictor variables among individual grid cells. For multivariate analysis, crop-raiding data were binary coded into presence/absence to build logistic regression models. The entry and exit of potential predictor variables was determined by the Wald statistic using *P* values of 0.05 and 0.01, respectively. The relative significance of each variable included within logistic regression models was evaluated using the Wald statistic.

Where spatial dependence among data exists, statistical analyses can overstate the degrees of freedom, possibly reducing *P* values and thus increasing the risk of committing type 1 errors (Haining, 2003). The Moran's I statistic provides a measure for quantifying spatial dependence among data (Cliff and Ord, 1981). In the study carried out by Sitati et al. (2003), crop-raiding values among 1 x 1 km grid cells were found to be significant, as shown by the Moran's I statistic but values at the coarser 5 x 5 km grid cell level were spatially independent. In this study, spatial autocorrelation in the dependent variable was also tested for at both grains and at both spatial extents. Where spatial autocorrelation was significant, *P* values for correlation coefficients may be overestimated and so were not stated (Balmford et al. 2001; Sitati et al. 2003). To address the issue of spatial autocorrelation in logistic regression analyses, an autocovariate term was generated. Where spatial autocorrelation is present the use of an autocovariate term will both improve the fit of a logistic regression model and remove spurious variables from the analysis (Augustin et al. 1996; Sitati et al. 2003). The term used in this study was an inverse Euclidean distance weighted mean of conflict intensity in the eight surrounding cells of each cell in the sample, after Sitati et al. 2003.

Training and testing sets were generated for logistic regression analysis at both grains and both spatial extents. For logistic regression analyses carried out at the spatial extent of the entire district, a random set of approximately 50% of grid cells was used to train models (1 km^2 grid: 171 presences, 4536 absences; 25 km^2 grid: 34 presences, 138 absences) with the remaining 50% of cells used to test models (1 km^2 grid: 210 presences, 4633 absences; 25 km^2 grid: 49 presences, 164 absences). Within the smaller spatial extent of the HEC zone, as defined by the combination of individual enumerator MCPs, crop-raiding was present in 48 of the 200 1 km^2 grid cells used in the analysis. A random set of 180 training cells and 20 testing cells (5 presences and 15 absences) were generated to build and test the logistic regression models, respectively. This was repeated five times with each new testing set containing a unique set of cells not included within the previous testing set. As a result of this jack-knife procedure, a total of 100 testing cells from five separate analyses were generated. Of the 104 cells available for logistic regression analysis at the 25 km^2 scale, crop-raiding was present in 85. To build and test multivariate logistic models at this scale, a random set of 94 training cells and 10 testing cells (7 presences and 3 absences) was generated. The same adapted jack-knife procedure was used at this resolution so that a total testing set of 50 cells was produced from five separate analyses. Model performance for testing sets was assessed by calculating the area under the curve of receiver operating characteristics, ROC (Hanley & McNeil, 1982). ROC values range from between 0.5 to 1 with values above 0.7 indicating a good model fit (Sitati et al., 2003).

To assess the relationship between the size of elephant groups involved in crop-raiding incidents and risk, distance from each crop-raiding incident to the closest daytime elephant refuge (large-scale private ranch or forest) boundary was estimated, once again using the "Near" command in ArcGIS. Each crop-raiding incident was grouped into one of the following categories depending on the number of elephants involved: 1) lone elephant; 2) groups of 2-3; 3) groups of 4-5 and; 4) groups of greater than 5 elephants. Differences in distances travelled to crop-raiding incidents among the four categories of elephant group size were evaluated using a Kruskal-Wallis non-parametric analysis of variance test.

6.3 RESULTS

6.3.1 Crop raiding characteristics

Between November 2003 and November 2004 a total of 3668 incidents were recorded by enumerators in Laikipia District of which 2420 involved damage to crops. A total of twenty five different species of crop were damaged in crop-raiding incidents. Typically farmers planted several species of crop at once and so often more than one species of crop was damaged on a single farm. Maize was the species most frequently damaged (63% of cases), followed by beans (40%), potato (37%), sweet potato (20%), onion (17%) and sorghum (15%). In 50% of cases, 6% or less of the total cultivated area was damaged (median = 5.7, IQR = 14) and cases in which farms were severely damaged were relatively rare. For example cases in which 50% or more of the planted area was damaged comprised 8% of all cases. There were 66 cases (3% of the total number of crop-raiding incidents reported) in which 100% of the crop on a single farm was damaged.

Crop-raiding occurred exclusively at night. Groups of male elephants were implicated in 53% of the crop-raiding incidents recorded in Laikipia compared with 79% in a similar study carried out in Zimbabwe (Hoare, 1999a) and 32% in Transmara District (Sitati et al., 2005) while mixed groups of males and females or groups containing just females were reported in 47% of cases (though see concerns over methodology used for sexing elephants in section 6.1). Lone males were involved in 13% of crop-raiding incidents as compared with 2% in the Transmara region of Kenya (Sitati et al., 2003) and 19% in the north-west Sebungwa region of Zimbabwe (Hoare, 1999a). The number of elephants involved in crop-raiding incidents varied between 1 and 45 (Fig. 6.3; median = 3, n = 2418) with 90% of raids carried out by groups containing ≤ eight elephants.

On average, crop-raiding incidents occurred within 1.54 km of a daytime elephant refuge (n = 2420, S.D. = 1.98). The distance travelled by elephants to sites of crop-raiding varied significantly among different group size categories, with large groups travelling further than small groups (Fig. 6.4; Kruskal-Wallis H = 38.9, d.f. = 3, $P < 0.001$) suggesting a herding strategy during penetrative crop-raiding forays into areas of human settlement. This is a behavioural phenomenon not identified in previous studies of crop-raiding by elephants.

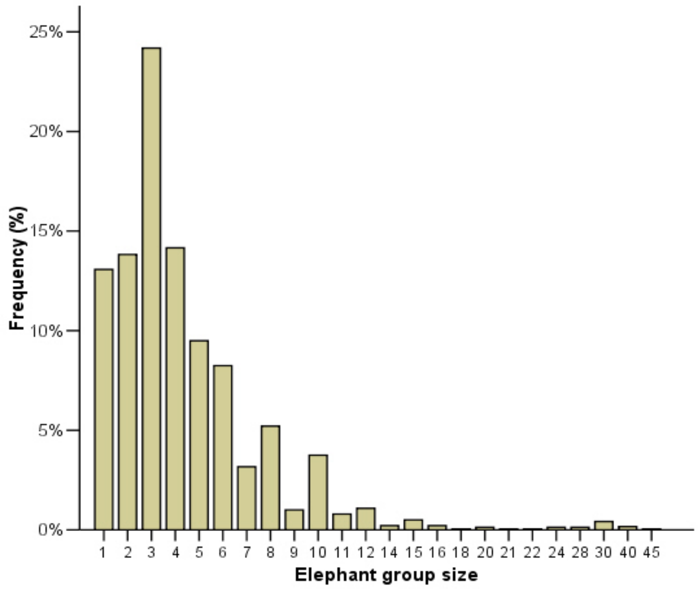


Fig 6.3 Size-frequency distribution of elephant groups involved in crop-raiding incidents recorded in smallholder areas in Laikipia District 2003-2004.

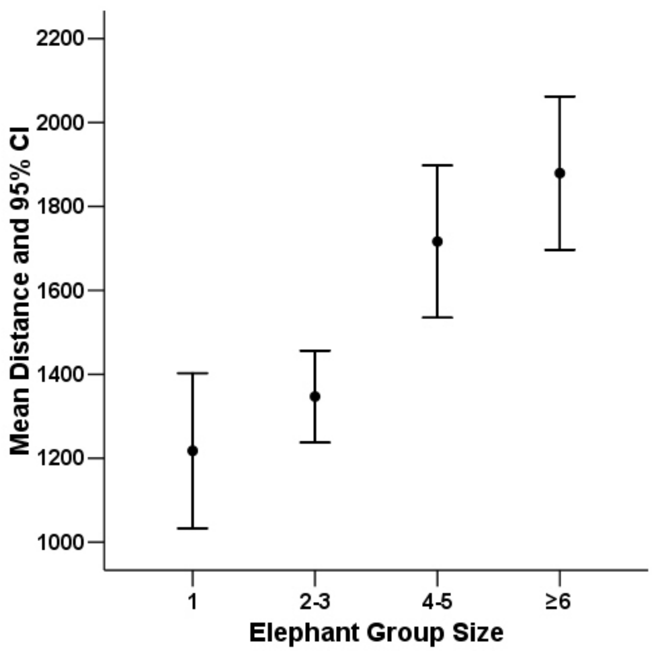


Fig.6.4 Differences between different sized elephant groups in the mean distance (metres) travelled from elephant refuges to sites of crop-raiding

6.3.2 Spatial pattern of crop-raiding at the Laikipia District scale

Crop-raiding incidents among 1 km^2 grid cells at the district spatial extent were highly clustered (Fig. 6.5) and significantly autocorrelated (Moran's I statistic = 0.22, $P < 0.01$). Crop-raiding incidents among 25 km^2 grid cells at this spatial extent were also significantly autocorrelated (Moran's I statistic = 0.21, $P < 0.01$). The relationship between crop-raiding intensity and the candidate variables varied between the two grains (Table 6.2). Among 1 km^2 grid cells crop-raiding intensity was strongly correlated with the autocovariate term and relationships with candidate variables were generally weak. After the autocovariate term crop-raiding intensity at this level was most strongly associated with settlement density (positive) followed by area under cultivation (positive), distance from daytime elephant refuge (negative) and distance to sites where elephants had been killed in defence of crops (negative). The relationship between crop-raiding intensity and settlement density exhibited a Gaussian distribution (Fig. 6.6) with crop-raiding intensity values non-existent to low in cells with very low settlement density, increasing sharply at intermediate values of settlement (5-15 dwellings per km^2) and then decreasing beyond a certain density 'threshold' of around 20 dwellings per km^2.

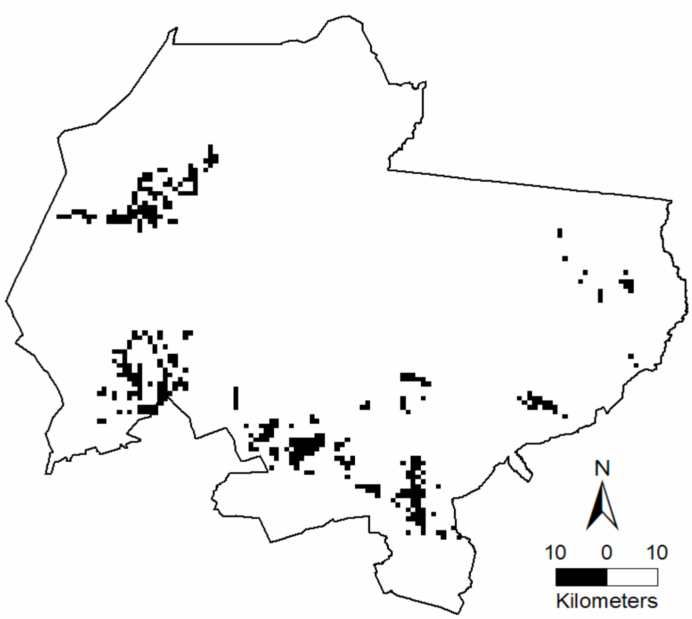


Fig.6.5 Occurrence of crop-raiding in 1 km^2 grid cells in Laikipia District

Among 25 km^2 grid cells the relationship between crop-raiding intensity and candidate variables was generally stronger compared with 1 km^2 grid cells and the correlation between crop-raiding intensity and the autocovariate term at this resolution was weak (Table 6.2). Among 25 km^2 grid cells crop-raiding intensity was most strongly correlated with settlement density (positive) followed by distance from daytime elephant refuge (negative), area under cultivation (positive) and distance from sites where elephants had been killed in defence of crops (negative).

At the district spatial extent significant logistic models for predicting the occurrence of crop-raiding were generated for both 1 km^2 and 25 km^2 sampling units (ROC = 0.913 and 0.824, respectively). The strongest predictor of crop-raiding among 1 km^2 grid cells was once again the autocovariate term followed by, in order of significance, distance from elephant refuge, settlement density and cultivation (Table 6.3). Crop-raiding among 25 km^2 grid cells was predicted by settlement density and distance from elephant refuge (Wald statistic = 16.3 and 13.1, respectively). The auto-covariate term was not a significant predictor of crop-raiding among 25 km^2 grid cells at the district scale.

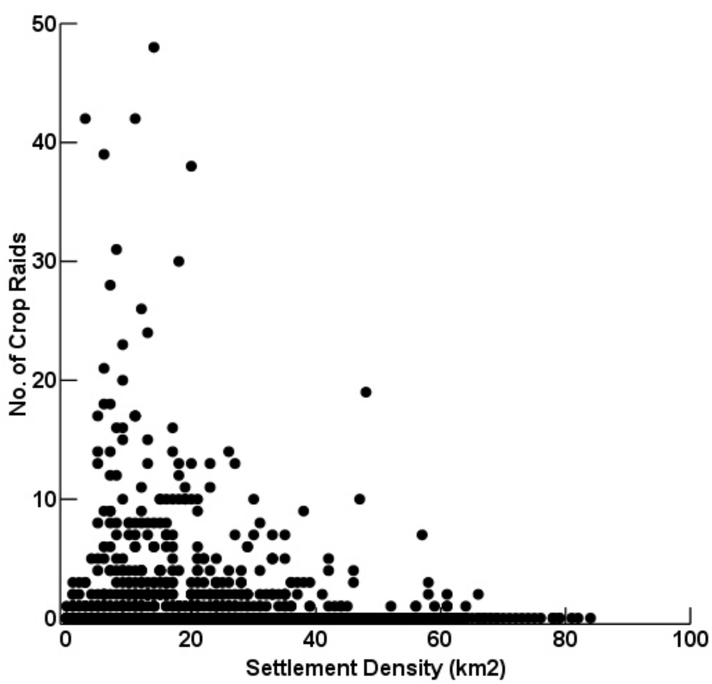


Fig. 6.6 The relationship between crop-raiding intensity and settlement density among 1 km^2 grid cells at the Laikipia District scale.

6.3.3 Spatial pattern of crop-raiding within the HEC Zone

Crop-raiding incidents among 1 km^2 grid cells within the smaller spatial extent of the HEC zone (see section 6.2.3) were also significantly autocorrelated (Moran's I statistic = 0.21, $P < 0.01$). Therefore a sample of 1 km^2 grid cells within the HEC zone was selected among which crop-raiding incidents were not spatially autocorrelated (Moran's I statistic: 1 km^2_{200} = 0.002, $P > 0.1$). Crop raiding incidents among 25 km^2 grid cells within the HEC zone were not significantly autocorrelated (Moran's I statistic = 0.004, $P > 0.1$). In the absence of spatial autocorrelation the significance of spatial correlations were discussed.

Despite the results of the Moran's I statistic crop-raiding intensity among the sample of two hundred 1 km^2 grid cells within the HEC zone was strongly correlated with the autocovariate term followed by, in order of significance, settlement density, area under cultivation and distance from rivers (Table 6.2). In contrast crop-raiding intensity among 25 km^2 grid cells within the HEC zone was not correlated with the autocovariate term and was most significantly correlated with distance from daytime elephant refuge (Fig. 6.7) followed by distance from water holes, distance from rivers, settlement density and slope (Table 6.2).

Within the HEC zone, logistic regression analysis once again generated significant models for predicting crop-raiding, though these were weaker than those generated at the larger spatial extent of the entire district (ROC Interquartile range: 1 km^2 = 0.75 - 0.73; 25 km^2 = 0.7 - 0.66). The only predictor of crop-raiding occurrence among 1km^2 grid cells at this level, other than the autocovariate term, was settlement density (Table 6.3). Distance from elephant refuge was the only predictor of crop-raiding occurrence among 25 km^2 grid cells within the HEC zone (Table 6.3).

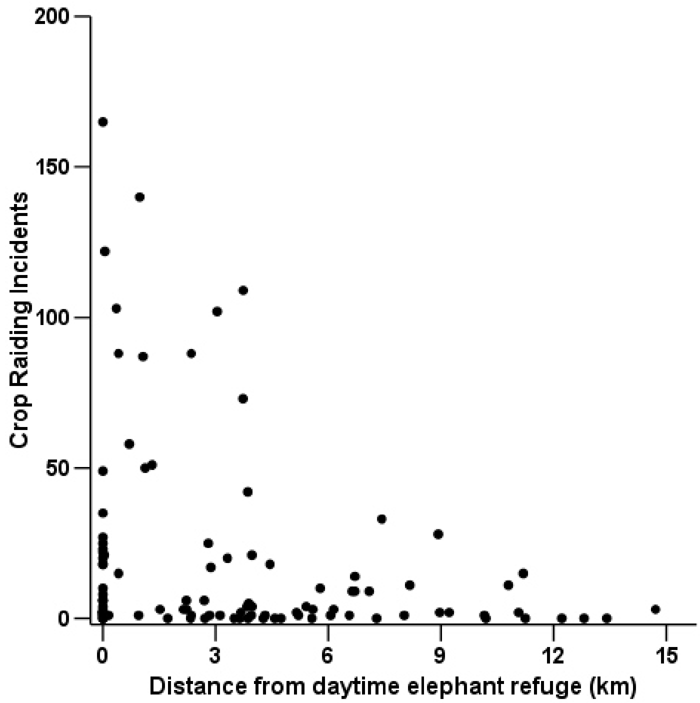


Fig. 6.7 Relationship between crop-raiding intensity and distance from elephant refuge among 25km^2 grid cells in the HEC zone scale.

Table 6.2: Spearman's rank correlations for associations between eight independent variables and crop-raiding among 1 km^2 and 25 km^2 spatial units at two different scales, *$P<0.05$, **$P<0.01$. Because of significant spatial autocorrelation at the district level, significance levels are not stated (Balmford et al 2001).

	Laikipia District Extent		HEC Zone Extent	
Variable	1 km^2	25 km^2	1km	25 km^2
Autocovariate term	0.555	-0.048	0.436**	0.097
Distance from refuge	-0.142	-0.352	-0.086	-0.260**
Distance from rivers	-0.085	-0.093	-0.149*	-0.19*
Distance from waterholes	-0.077	-0.011	-0.097	-0.213*
Area of cultivation	0.176	0.259	0.160*	0.013
Distance from carcass	0.102	0.210	-0.052	-0.061
Slope	-0.037	0.080	-0.043	-0.179*
Settlement density	0.191	0.395	0.166*	0.181*
Distance from roads	-0.071	-0.175	-0.036	-0.003

Table 6.3: Wald Statistic for significant variables included in the logistic regression models for crop-raiding at the 1 km^2 and 25 km^2 resolutions at two different sampling scales, +/– indicates the direction of the relationship.

Variable	District		HEC Zone	
	1 km^2	25 km^2	1 km^2	25 km^2
Area of cultivation	(+) 7.9	NS	NS	NS
Distance from refuge	(-) 28.9	(-)13.1	NS	(-) 6.6-4.2
Settlement density	(+) 17	(+)16.3	(+) 7.3-5.4	NS
AC	(+) 159	NS	(+) 5-3.9	NS

6.4 DISCUSSION

This study tested the spatial analysis procedure developed by Sitati et al. (2003) and the results corroborate that study's conclusion, in contrast to the work of Hoare (1999a), that determinants of crop-raiding by elephants can be identified through a simple GIS grid based analysis, even in places where crop-raiding is carried out largely by individual or groups of male elephants. However, the spatial correlates of crop-raiding identified for Laikipia differed from those identified in Transmara District. In addition, the strengths of underlying spatial relationships within this study were weaker when compared with results from the Transmara study. Finally, this study shows that the relationship between crop-raiding and potential predictor variables varied with the scale of analysis, in terms of both grain and spatial extent.

In contrast to previous spatial analyses of crop-raiding by elephants (Sitati et al., 2003, Smith & Kasiki, 2000), distance from daytime elephant refuge emerged as a significant predictor of crop-raiding in this study. This could be attributed to the fact that elephant count data and the availability of property boundaries enabled the accurate identification of daytime elephant refuges in Laikipia. Such data were not available for the Transmara study and so the forest polygons used in their analyses may not in fact have fully represented available daytime elephant refuges (Sitati et al., 2003). While in the Tsavo ecosystem Smith & Kasiki (2000) did not identify daytime elephant refuges outside of Tsavo East and Tsavo West National Parks. The majority of crop-raiding incidents recorded in this study occurred within 2 km of a daytime elephant refuge. There were, however, other incidents in Laikipia that occurred at locations some 10 km from a daytime elephant refuge. In these cases it is likely that there was another unidentified daytime elephant refuge nearby, possibly an area of untransformed thicket or bush that provided crop-raiding elephants with adequate cover to hide during the day. More detailed field surveys to identify these less obvious daytime elephant refuges could better explain some of the variance in crop-raiding intensity in both Laikipia and other study sites and should be a priority in further spatial analyses of crop-raiding in land-use mosaics.

The daytime elephant refuges identified in Laikipia for this study are mostly privately owned large-scale ranches. The spatial pattern of elephant crop-raiding identified in this chapter represents an existing and potential source of political tension between large-scale landowners and small-scale farmers. As such, these results provide retrospective justification for the district-wide elephant fencing strategy adopted by local conservation actors as a strategy to reduce raiding (Fig. 6.8; Thouless et al. 2002). This fencing strategy aims to separate elephant tolerant (private ranches and communal areas) from elephant intolerant (small-scale arable farming) land areas. Consideration will need to be given to the fact that many large-scale ranches in Laikipia, particularly those sharing a boundary with smallholders, are already fenced and the emergence of distance from daytime elephant refuge as a major predictor of crop-raiding in this study suggests that a number of these fences are ineffective. Thouless & Sakwa (1995) propose that enforcing fences (by shooting fence breakers) may be more important than fence design. If controlled shooting stops elephants from breaking electrified fences, it did not appear to stop elephant from crop-raiding in Laikipia.

The weak positive correlation between crop-raiding intensity and sites where elephants had been killed in defence of crops at the coarser spatial extent of the entire district was not surprising as across most of Laikipia there is no cultivation, elephants do not crop-raid and are therefore not killed in defence of crops. However the absence of any relationship between crop-raiding intensity and distance from sites where elephants were killed in defence of crops within the smaller spatial extent of the HEC zone suggests that this management approach is having little deterrent effect. This may be because the number of elephants killed in small-scale farms in Laikipia over the study period was small relative to the number of elephants involved in crop-raiding incidents and that there are multiple groups of elephants that may raid the same site at different times both within and between years. Therefore adopting a management policy to shoot ‘problem’ elephants may not meet the desired objectives not least because the management capacity and resources required to enforce a human-elephant interface on the scale represented by the proposed Laikipia elephant fence will be considerable. All of these factors will need to be carefully considered for any fence maintenance plan.

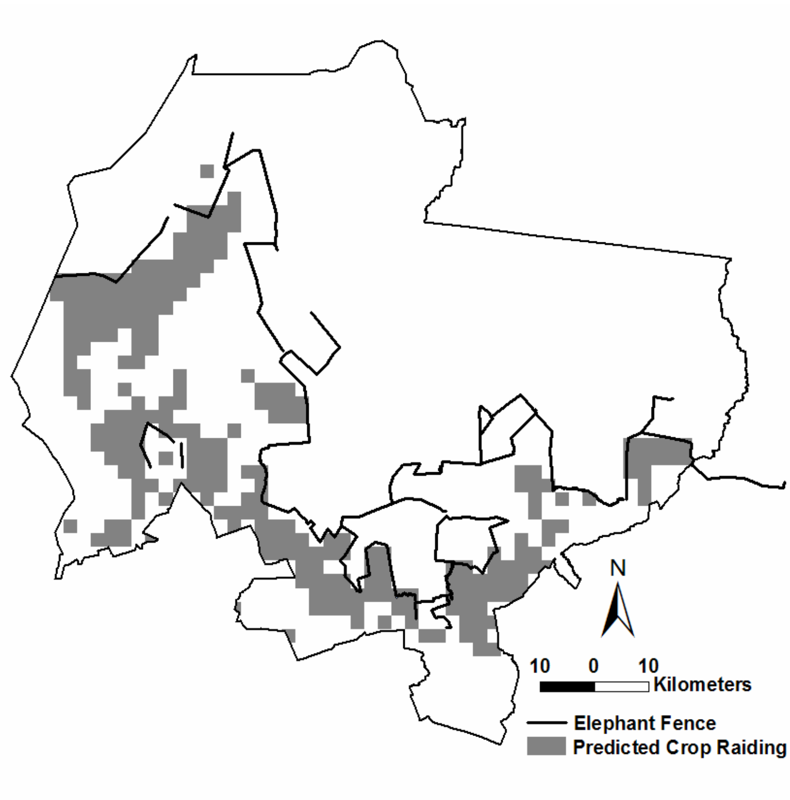


Fig. 6.8 Model results showing predicted occurrence of crop-raiding and the proposed district-wide elephant fence line

Settlement density was the only variable that was consistently related to crop-raiding intensity when grain and spatial extent were changed (Table 6.2) and was the only predictor of crop-raiding occurrence among 1 km^2 grid cells at both spatial extents. The relationship between settlement density and crop-raiding identified in this study is relevant for understanding HEC for principally two reasons. Firstly these results suggest that elephants occur well above the human population 'thresholds' of 82 persons/ km^2 and 15.6 persons/ km^2 posited by Parker and Graham (1989) and Hoare and du Toit (1999) for Kenya and Zimbawe, respectively (see chapter 2, section 2.2.2). That is not to say that at coarse resolutions such thresholds are not applicable but rather that the use of nocturnal distribution data (crop-raiding locations) at fine resolutions illustrates that elephants possess certain traits suggesting ecological resilience (Weaver et al., 1996) which enables this species to use landscapes with relatively high human densities. This study was the first to identify such a trait during crop-raiding in the form of the herding strategy adopted during more penetrative forays into settled land. Despite the empirical evidence to suggest that elephants in Laikipia use areas populated by people at high densities this pattern of use is probably only possible because of the availability of daytime elephant refuges in which human population densities are low. The data analysed here suggested that the analysis by Hoare and du Toit (1999) is likely to remain relevant for analyses carried out at coarser grains and larger spatial extents.

Secondly, the relationship between crop-raiding by elephants and settlement density illustrates the role of landscape structure (Formon & Godron, 1986) in defining the level of vulnerability among smallholders to crop-raiding. The Laikipia context, in which relatively low and unpredictable annual rainfall has constrained the expansion of smallholder settlement, is likely to be similar for many other HEC contexts in Africa's arid and semi-arid lands. The resulting settlement pattern where human dwellings and associated cultivation patches are clustered, typically close to permanent water, within larger areas of abandoned rangeland, leaves individual households acutely vulnerable to crop-raiding by elephants. Under such conditions the importance of land-use planning as a HEC management tool is obvious.

In the Transmara study, while crop-raiding intensity was positively correlated with human population density, this relationship was weak and human population density did not feature in logistic regression models (Sitati et al., 2003). This lack of appearance in their model could be attributed to the 1999 population census data used in their analyses. These census data provide information on human population densities within administrative sub-locations, a fairly coarse resolution that could overlook spatial variance at smaller scales. It is likely that such spatial variance in human population density is better captured in this study through the use of aerial count data as reflected in results of logistic regression analyses carried out among 1 km^2 grid cells. Spatial variance in settlement density was less pronounced among 25 km^2 grid cells.

Area under cultivation was identified as the major predictor of crop-raiding in Transmara District (Sitati et al., 2003). Area under cultivation was also a spatial correlate of crop-raiding intensity among both 1 km^2 and 25 km^2 grid cells in Laikipia at the district spatial extent as well as one of several predictors of crop-raiding occurrence among 1 km^2 cells at this level. This relationship was however weaker among both grains within the smaller HEC zone spatial extent and was not a predictor of crop-raiding occurrence among either 1 km^2 or 25 km^2 grid cells at this sampling level. The comparatively weak relationship between crop cover and crop-raiding results suggests that spatial variance of crop-cover was higher in the Transmara study compared with Laikipia District. This may be because the Transmara landscape is one in which cultivation is more clustered. Similar spatial clustering of crop-cover was captured in this study in analyses carried out at the larger spatial extent. Within the smaller HEC zone spatial extent, crop-cover was more uniform across grid cells compared with at the district spatial extent, particularly among 25 km^2 grid cells where residual differences in crop-cover between 1 km^2 cells were absorbed. It may also be that because rainfall is unpredictable in Laikipia, crop cover is in a constant state of transition and therefore satellite imagery of cultivation that is two years old may not have been as effective at capturing spatial variance in human use of the landscape as high resolution aerial counts of dwellings, particularly at the smaller spatial extent.

The differences identified between results from this study and the Transmara study and between results from different scales and resolutions of analysis within Laikipia, indicate that spatial predictors of crop-raiding vary depending on the structure of the landscape, the grain of analysis (size of sampling unit) and the spatial extent of analysis (size of the sampling frame). The latter two factors need to be taken into consideration in future spatial analyses of HEC. In this study spatial correlates of crop-raiding become less significant at smaller spatial extents. Within these smaller scales the ecological determinants of crop-raiding identified at large spatial scales (i.e. crop cover and distance from elephant refuges) become less variable and other factors are likely to become important. Identifying factors operating at these smaller spatial extents may require smaller sampling units (i.e. 100 x 100 metre grids) and more sophisticated spatial analysis methods to overcome the problem of spatial autocorrelation and should be a priority for further research. There are also likely to be socio-economic attributes of individual households (i.e. available labour, financial resources etc) and their respective deterrence strategies, operating within this scale and further research into the relationship between these socio-economic factors and vulnerability to crop-raiding will improve understanding of the spatial pattern of crop-raiding at this scale.

The ‘male behaviour’ risk taking hypothesis was not assessed using the data presented in this chapter. It would seem more appropriate to use direct observations of elephants, such as through high resolution radio-tracking of individuals carried out in the next chapter, to explore this hypothesis further.

Chapter 7: Fine-scale analysis of elephant movement in a land-use mosaic

7.1 INTRODUCTION

In the preceding chapters elephant distribution was assessed in relation to human land use, largely using indirect measures including dung counts and verified reports of crop-raiding. While the overall pattern of distribution found was unsurprising, with elephants occurring in higher densities within tolerant properties than in intolerant properties, the occurrence of elephants in intolerant properties, including smallholder farms, intolerant ranches and pastoral areas, is intriguing and shows that the Laikipia landscape is a landscape that is, for better or for worse, shared by people and elephants in complex ways. In effect this emerging pattern of co-occurrence reflects the property of 'resilience', a concept I alluded to in several of the preceding chapters.

The property of resilience within the context of human disturbance was defined by Weaver et al (1996) using illustrations from case studies of large carnivores in the Rocky Mountains. In summary resilience is the ability of a system to "absorb disturbance and still maintain the same relationship between populations or state variables" (Holling, 1973:14). In Chapter Two (Table 2.1) I presented a summary of the mechanisms through which resilience is manifested at different hierarchical levels: 1) at the individual level; 2) at the level of the population; and 3) at the level of the meta-population. The demographic response of elephant populations to human exploitation in the form of higher fecundity with declining density, is well documented (Laws, 1969, Laws et al., 1975, Western & Pilgram, 1986). In contrast, resilience at the individual level and to some extent, the meta-population level, is less well understood. Patterns of resilience at these latter two levels are investigated in this chapter by exploring behavioural plasticity in response to different ecological contexts and in response to different forms and levels of human disturbance, measured through patterns of elephant movement. The aim here is to answer the second research question posed at the beginning of this thesis:

Have elephants adapted their behaviour to negotiate the risk of being killed by human-resource users within the landscape?

Data collected in this study (see chapter 6) and results from studies carried out in other parts of Africa, suggest that elephants use the cover of darkness to negotiate human occupied landscapes, particularly cultivated areas (Bell, 1984, Cerling et al., 2006, Galanti et al., 2005, Hoare, 1995, Osborn, 1998, Sitati et al., 2003, Thouless, 1994). Similar behaviour has been recorded among other species of large mammals such as cougars (Beier, 1995) and even bears (Weaver et al., 1996). In this study this type of behavioural plasticity and examples of risk avoidance behaviour more generally, were tested for empirically among a sample of elephants fitted with GPS tracking collars. This was achieved by measuring and comparing the speed of elephant movement and the distribution of diurnal and nocturnal locations across different land-use types. To place these specific forms of movement in context and for comparative purposes, this chapter first describes the general pattern of movement of the elephants tracked during this study.

7.2 METHODS

7.2.1 Home range

Burt (1943:351) defined an animal's home range as: "that area traversed by the individual in its normal activities of food gathering, mating and caring for young." This original definition has since been refined and a home range was recently described as: "the extent of area with a defined probability of occurrence of an animal during a specified time period," (Kernohan et al., 2001: 126)

The conventional approach for measuring an animal's home range has been to calculate a minimum convex polygon (MCP), described in Chapter Four. Because the calculation of an MCP uses only the outermost observations for an individual, there are no assumptions with regards to the statistical independence of the observations used. However MCPs do not show intensity of spatial use (Harris et al., 1990) which has led to the emergence of utilization distribution (UD) techniques that describe the relative frequency distribution of location data over a specified time period (Van Winkle, 1975), of which kernel methods currently set the standard (Kernohan et al., 2001). In this thesis UDs of individual elephants were calculated using the fixed kernel method (Worton, 1989), a home range estimator that performs well in terms of accuracy and precision (Seaman & Powell, 1996, Worton, 1995) and has been used in recent published studies of elephant movement based on GPS tracking data (Galanti et al., 2006, Legett, 2006, Osborn, 2003).

In contrast to MCPs, UD techniques for estimating home range assume the location data used are statistically independent. This has led to the emergence of techniques in radio-telemetry studies for calculating the time interval necessary to achieve statistical independence between observation (Swihart & Slade, 1985). However several published studies have found that home range estimates based on independent locations were no different to those based on sequential locations (Anderson & Rongstad, 1989, Gese et al., 1990). In one case home estimates based on independent observations were in fact less accurate than estimates based on autocorrelated location data (Reynolds & Laundre, 1990). Furthermore the use of a sampling interval to generate spatially independent observations could bias location data towards activities that occur at a particular time, thereby reducing the biological relevance of the final home range estimate (de Solla et al., 1999). As with many other mammals, elephants are believed to have quite different patterns of behaviour and activity at night compared with during the day (see the results section in this chapter). The problems associated with attempts to achieve statistical independence with animal location data, led Kernohan et al. (2001: 130) to suggest that:

"*Adequately sampling animal locations throughout time is more important than determining a time interval between sampling that is statistically independent*."

For these reasons, with the exception of K19, all location data minus spurious GPS fixes were used for the calculation of Fixed Kernel UDs for each elephant tracked in this study. K19 recorded GPS fixes in one minute intervals for several weeks in 2005. These one minute interval data were resampled to generate hourly positions prior to analysis of the tracking data for this individual elephant. This high number of multiple fixes within a single hour did not occur on any of the other collars. However there were occasions when the other GSM collars recorded two positions in an hour, although this occurred randomly through time and was not common. As such these multiple hourly fixes were unlikely to make a significant difference to the final UD home range estimates and therefore I felt the substantial period of time required to filter these positions out was not justified. However, further research into the relationship between spatial autocorrelation and home range estimates is needed, particularly in light of the high resolution data now available through the new generation of GPS collars.

The extent of spatial use by each elephant tracked in this study was estimated by calculating 100% minimum convex polygons (MCPs) and Fixed Kernal Utilisation Distributions (Worton, 1989) using the Animal Movement Extension to ArcView (Hooge & Eichenlaub, 1997). The default option was chosen to calculate UD density estimates as 95% and 50% probability contours. While MCP home range estimates are now considered to overestimate spatial use, they are useful for indicating the total potential area available for each elephant and are also used in this chapter to make comparisons with previous studies of elephant movement (Harris et al., 1990). In addition to deriving home range estimates for the total period over which each elephants was tracked, MCPs and UDs were also derived for daytime locations (07:00-18:59) and for nighttime locations (19:00-06:59). I also present seasonal home range estimates for individual elephants in this chapter, used as the basis for the pooled analyses presented in chapter four (section 4.3.3).

In previous (radio-telemetry) studies of animal movement the minimum sample of points required to derive a reliable estimate of an animal’s home range based on 100% MCPs were established using the asymptote of area-observation curves with often between 100-200 animal locations needed (Harris et al., 1990, Kernohan et al., 2001). Thouless (1996a) found that home range estimates for the elephants he monitored in Laikipia District reached close to an asymptote at a sample size of approximately 45 relocations, equivalent to one year’s worth of monitoring. However the technology used in this study generated an unprecedented number of relocations per animal monitored. Furthermore the relocation reporting schedules varied between collars though none reported less than one position per day (see Table 3.2). Therefore, for comparative purposes, area-observation curves for elephants tracked using GPS collars in this study were instead plotted using number of months monitored rather than sample size.

7.2.2 Distribution across different land use types

The distribution of location data in relation to human land use was assessed by comparing elephant use with availability of each of four land-use types: 1) ranch; 2) smallholder; 3) pastoral; and 4) forest. Land was grouped into these categories on the basis of the updated land-tenure/use GIS layers described in chapters one, three and four. In this chapter I do not distinguish between low density and high density smallholder areas as I did in parts of chapter four. Use was calculated as the proportion of an animal's tracking locations that fell within a particular land-use type and availability was calculated as the proportion of an animal's total home range, as measured by minimum convex polygons (MCPs), covered by a particular land-use type. A selection index, adapted from Jacobs (1974: 147), was calculated as follows:

$$S = \frac{U - A}{(U + A) - 2UA}$$

Where: S = selection of land use type *x*; U = proportion of use of land use type *x* and; A = proportion of land use type *x* available in the MCP. Values of S between -1 and 0 indicate avoidance and values between 0 and +1 indicate preference. Use of different land-use types was also calculated separately for day time and night time. All spatial data were prepared using ArcGIS 9 (ESRI, 2004).

7.2.3 Speed of elephant movement

Speed of elephant movement was calculated as the distance between consecutive locations divided by time (km/h) and was assessed in relation to human land use, land cover and time of day (day or night). To assess speed of elephant movement across different land cover types, the categories of land cover available in the classified image provided by MRC (see chapter three, section 3.2) were grouped into two broad categories: 1) open (i.e. grassland, cultivation or bare rock); and 2) closed (i.e. woodland, forest and/or bushland)

7.2.4 Statistical analyses

All statistical analyses were carried out using SPSS v. 12.0 (SPSS, 2003). Dependent variables examined were home range size, seasonal range size, proportion of use and speed of elephant movement. Where the dependent variable was normally distributed parametric *t*-tests for independence were used to compare values between two groups, analysis of variance tests (ANOVA) were used to compare values between more than two groups and Pearson's correlation coefficients were used for liner regression analysis. Where the dependent variable was not normally distributed Mann-Whitney U tests were used to compare two groups, Kruskal-Wallis non-parametric tests were used to compare values across more than two groups, Wilcoxon-signed rank tests were used to compare values between two different conditions (i.e. night and day) and Spearman-rank correlation coefficients (r_s) were used for linear regression analysis. Observed proportion of use of different land-use categories was compared against expected proportion of use using the chi-square goodness of fit test (χ^2).

7.3 RESULTS

7.3.1 Home ranges

To establish the relationship between home range size and the length of time an animal was monitored (i.e. sample size), data were used from five elephants that had been tracked continuously for two years (Fig. 7.1). Home range estimates for three of these five elephants (K14, K2 and K9), all females, reached close to an asymptote after approximately nine months while the home range estimates for another elephant (K11), a male, reached close to an asymptote after 20 months. Home range estimates for the one remaining elephant tracked for two years (K15), another male, were larger than for any other elephant ever monitored in Kenya and continued to increase after almost two years of tracking suggesting that an asymptote had yet to be reached. This variation in the shape of area-observation curves suggests that the concept of a 'home range' may only be adequate for defining an animal's use of space during though not beyond the monitoring period, particularly in the case of long lived, adaptive and migratory animals such as elephants.

The difference in the shape and pattern of individual area-observation plots does, however, provide a useful indicator of the characteristics of the landscape within which an elephant lives (Figs. 7.4 to 7.6). Despite their potential short comings, 'home range' estimates are used in this chapter to describe and compare elephant movement over the study period and for the purpose of making comparisons with results from other studies.

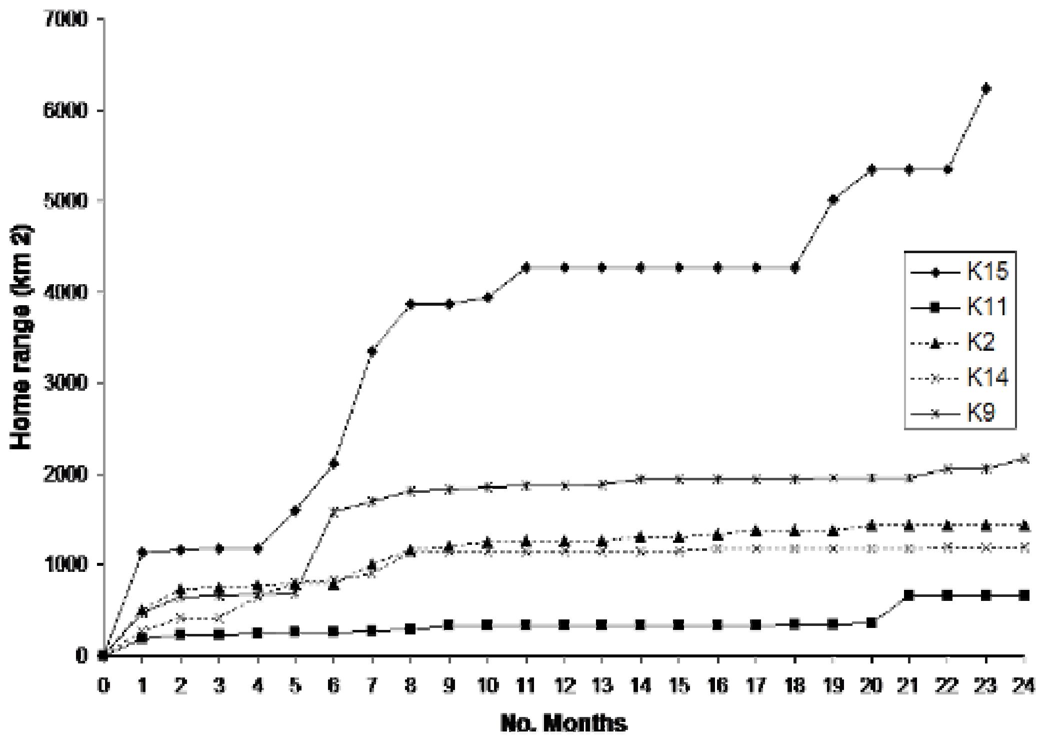


Fig. 7.1 Relationship between home range size (100% minimum convex polygons) and number of months tracked for five elephants that were monitored for two years. Dashed lines are records for female elephants while bold lines are for male elephants.

Home ranges based on 100% minimum convex polygons (MCPs) varied from 64.4 to 6235 km^2, representing both the smallest and largest values ever recorded for elephants in Kenya, while 95% fixed kernel utilization distributions (UDs) varied from 53 to 1218 km^2 (Table 7.1). Similar extremes in home range were recorded among elephants in the

Laikipia-Samburu elephant population in a previous study of elephant movement (Thouless, 1996a) and are unknown in any other single population (Table 7.2). On average 100% MCPs for male elephants (mean 100% MCP = 2211 ± 662, n = 8) were larger than for female elephants (mean 100% MCP = 799.6 ± 242.4, n = 5). The difference between male and female home range size was less pronounced using estimates based on 95% UDs (mean = 554.12 ± 148 and 314 ± 98, for male and female elephants, respectively). The difference in home range size between male and female elephants did not reach statistical significance (t(11), equal variance not assumed = 1.6 and 1.2, P = 0.08 and P = 0.2, for 100% MCP and 95% UD home range estimates, respectively).

Thouless (1996a) partially attributed the wide variation in home ranges within the Laikipia-Samburu elephant population to spatial variation in rainfall and found there was a significant negative correlation between home range size and mean annual rainfall. However in this study the relationship between rainfall and home range size, while also negative, was not found to be significant (Spearman rank correlation: r_s = -0.26, n = 13, P = 0.388).

One possible reason that the significant negative correlation between home range size and rainfall found by Thouless (1996a) was not found in this study is that rainfall is unlikely to be the only factor determining the size and structure of home range size in the Laikipia-Samburu ecosystem. Osborn (1998) suggests that while rainfall may have once determined the scale and structure of elephant movements in Africa, today human land use and direct conflict with people (i.e. poaching, harassment etc) are more significant factors. To test this hypothesis, the elephants tracked in this study were grouped into the following three categories according to the characteristics of the landscape that each elephant inhabited: 1) unfenced; 2) partially fenced; and 3) fenced. 95% UD home ranges for elephants varied significantly between these three landscape types (Fig. 7.8; ANOVA: F = 6.3, *d.f* .= 2, 10, P = 0.02) with the largest home ranges recorded among elephants inhabiting unfenced landscapes (mean = 768 km^2 ± 163), followed by elephants inhabiting partially fenced landscapes (mean = 395 km^2 ± 113), while the elephants with the smallest recorded home ranges (mean = 144 km^2 ± 46) spent all or most of the tracking period in a single fenced property. The difference in the size of 100% MCPs followed a similar pattern across these different landscape types but was not significant (ANOVA: $F = 2.75$, $d.f. = 2, 10$, $P = 0.112$).

There was also a striking difference in the shape of area-observation curves, based on MCPs, between elephants inhabiting fenced, partially fenced and unfenced landscapes (Figs. 7.9, 7.10 & 7.11) suggesting that landscape structure not only affects the extent of elephant movement but also the pattern of spatial use by elephants.

Table 7.1: Home ranges for elephants tracked in Laikipia since 2004 based on both 100% minimum convex polygons and 95% utilisation distributions. MAR is mean annual rainfall.

I.D.	Region collared	Sex	No. Months (fixes per 24 hrs)	MAR (mm)	No. Fixes	Home Range (km^2)		
						MCP 100%	FKDE 50%	FKDE 95%
K13	North	F	15 (6)	525.8	2443	774	36.6	345.6
K15	North	M	23 (24)	535.5	11176	6235.3	90.9	1218.5
S3	North	M	18 (1)	593.5	533	2667	82.6	999.1
S4	North	M	2 (1)	428.5	74	3793.4	820.7	3885.6
K11	East	M	24 (24)	569.2	12582	665.4	12.4	229.1
K2	East	F	24 (24)	547.3	16743	1439.4	54.2	575.2
K8	East	M	12 (24)	569.2	7799	748.4	6.8	79.3
K14	Central	F	24 (24)	541.4	16785	1190	35.5	464.3
K9	Central	M	24 (24)	615.7	23302	2177.5	36.6	590.4
K19	South	M	9 (24)	701.9	9322	967.4	14.6	114.8
K22	South	F	17 (24)	701.9	7171	530.2	15.1	130
K21	South	M	19 (24)	719.2	12558	1020.7	51.1	216.4
K7	South	F	19 (24)	719.2	14529	1176.1	16.1	189.1
K16	SWest	M	18 (24)	581.4	10337	3126.8	46.5	815.1
K18	West	M	15 (1.6)	611.2	671	1047.7	29.2	285.1
K20	West	F	12 (24)	611.2	4339	64.4	3.4	52.7

Table 7.2: Elephant home ranges reported in other studies of African savanna elephants based on 100% minimum convex polygons.

Location	Home Range (km^2)	No./Sex	Rainfall (mm)	Source
Namibia	871-12800	2-Females 6- Males	50-250	Legett, K., 2006
Mali	11651-24265	2-Females 1- Male	150-450	Blake et al., 2003
Tsavo East and West	408-2380	10-Females	300-550	Leuthold, 1977
Tsavo East and West	294-1209	4 Males	300-550	Leuthold & Sale 1973
Namibia	2136-10738	7-Females	315	Lindeque & Lindeque, 1991
Kruger NP	129-1255	21-Females	550	Whyte, 1993
Laikipia, Kenya	102-5527	17-Females	400-750	Thouless, 1996a
Laikipia, Kenya	64-6235	5 Females 8 Males	526-719	This study
Hwange NP	1038-2981	11 Females 7 Males	632	Conybeare, 1991
Sengwe, Zimbabwe	224-393	9-Males	688	Osborn, 2003
Uganda (QENP)	138-805	6-Female 6-Males	900	Abe, 1995
Lake Manyara NP	10-57	2-Females	1000	Douglas-Hamilton, 1971

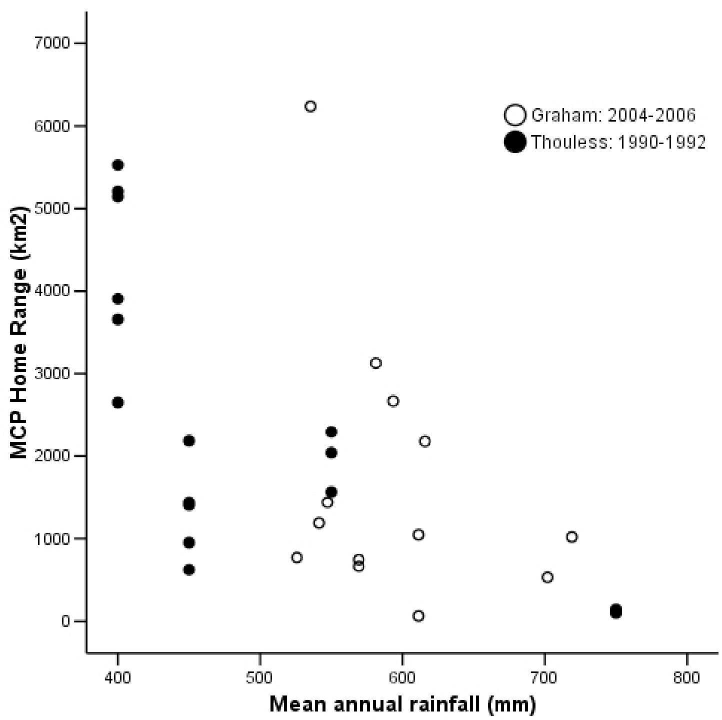


Fig. 7.2 Home range size (100% minimum convex polygons) for elephants tracked in Laikipia by Thouless (1990-1992) and for elephants tracked in this study, compared to mean annual rainfall.

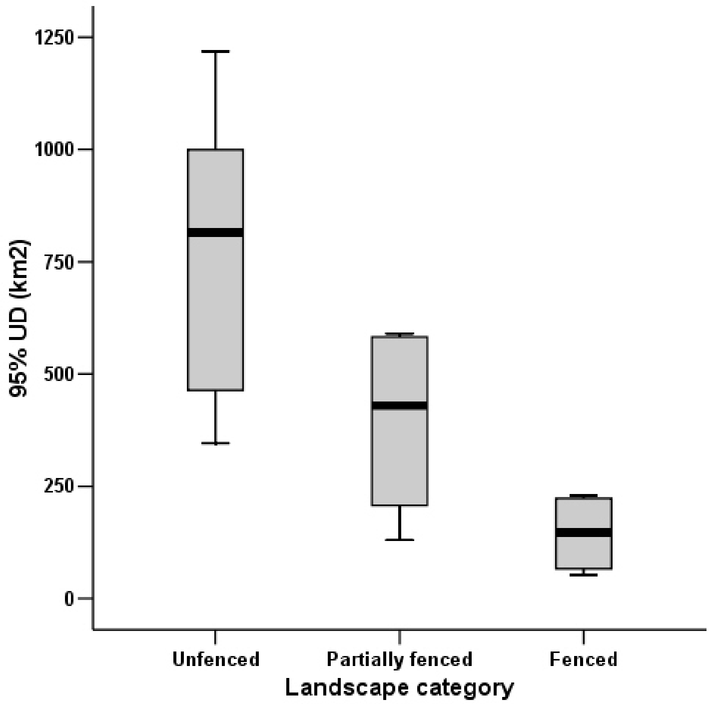


Fig. 7.3 Mean (± S.E.) home ranges (95% UD) for elephants inhabiting three different landscape categories.

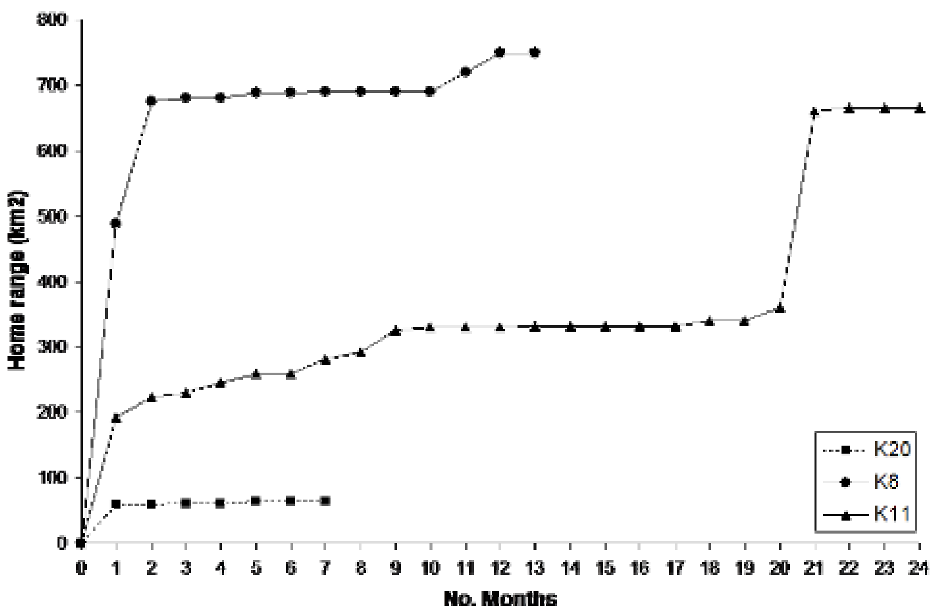


Fig. 7.4 Area-observation curves for three elephants inhabiting fenced landscapes. Broken lines are for female elephants while solid lines are for males. Note the length of time with which these three curves abruptly plateau. The shapes of these curves suggest that these elephants are confined and quickly utilise the available space.

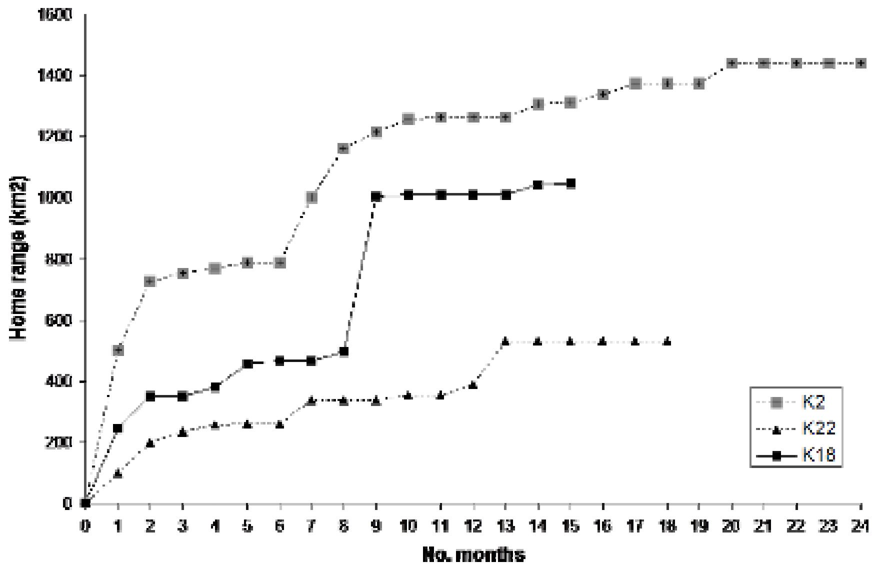


Fig. 7.5 Area observation curves for elephants inhabiting partially fenced landscapes. Broken lines are for female elephants while solid lines are for males. Note the 'stepped' structure of the curve.

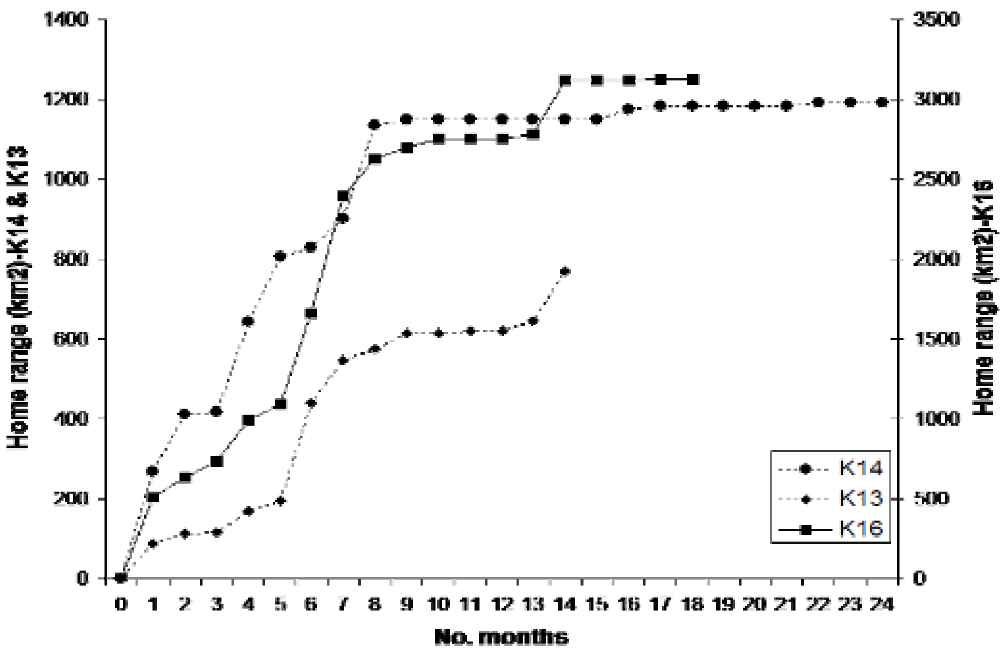


Fig. 7.6 Area-observation curves for elephants inhabiting unfenced landscapes. Broken lines are for female elephants while solid lines are for males. Note the steep slope of the curve and the length of time it takes for each slope to plateau in comparison with the area-observation curves shown in Figs. 7.4 & 7.5. This illustrates movement across an open landscape.

7.3.2 Description of movements

Despite the trends in differences in the extent of elephant movement between seasons identified through an analysis of the pooled tracking data and presented in chapter four, overall patterns of seasonal movement varied across the study area and between individual elephants (Table 7.3). So too did use of different land use types, direction of travel and geographical distribution. These differences and the landscape contexts within which they emerged merit further description, with the aim of informing a more quantitative analyses of behavioural responses (speed of travel, nocturnal use) to the different elements within a human occupied landscape. The elephants tracked could be divided into eight groups comprised of individuals with similar geographical distributions (Table 7.3), though I make no assumptions as to whether these groups could belong to distinct sub-populations. Here I describe the movements of elephants belonging to each of these eight groups.

Table 7.3: Seasonal range calculations (95% and 50% UDs and 100% MCPs) for each individual elephant tracked in Laikipia since 2004 (n=16). Elephant IDs in italics and underlined are for males while those in normal font are for females.

I.D.	Seasonal utilisation distributions (UDs) and minimum convex polygons (MCPs) (km^2)											
	Short rains (Oct-Dec 04)			Short dry (Jan-Mar 05)			Long rains (Apr-June 05)			Long dry (July-Sept 05)		
	95% UD	50% UD	100% MCP	95% UD	50% UD	100% MCP	95% UD	50% UD	100% MCP	95% UD	50% UD	100% MCP
Migrants												
*S4***	3885	826	3793	-	-	-	-	-	-	-	-	-
K15	1400	183	2272	1462	155	2918	384	56	1036	109	10	222.9
Ewaso												
K14	514	44	600	381	73	489	268	16	337	231	13	391
K13	370	61	403	190	17	391	124	13	184	79	3	130
Rumuruti												
S3	868	95	1658	124	11	355	734	120	688	707	93	713
K16	1394	105	1939	1025	202	1645	-	-	-	179	14	292
Central												
K9	471	47	1207	158	13	479	610	102	1041	60	4	221
K2	378	28	970	37	7	74	459	80	702	246	12	908
Ol Pejeta												
K7*	84	6	140	53	6	72.8	478	59	582.2	189	26	235.9
K21	153	23	181.4	170	22	502.4	164	29	210.3	137	19	456.9
Solio												
K19	177	20	308.1	125	13	283.05	-	-	-	-	-	-
K22	-	-	-	136	27	219.7	111	13	251.8	131	15	302.3
Lewa												
(K8)	89	11	187.7	187	12	645.2	35	5	95.9	7	0.8	43
K11	110	11	155.4	102	6	105.1	150	8	214.5	39	3	87.4
Mugie												
K20**	47	3	58.4	-	-	-	38	3	49.9	-	-	-
K18	94	18	366.9	191	19	411.2	462	85	941.5	153	19	179

Home range estimates for K8 (in parentheses) were derived from data collected in 2004 as comparable data in 2005 was unavailable

*Collar reported spurious values when south of the equator and so estimates excluded from quantitative analyses

**Seasonal home range estimates are derived from data collected over <3 months per season and were excluded from any quantitative analyses

Migrants

These two male elephants, S4 and K15, had the largest ranges of the elephants monitored in this study. Both were collared in northwest Laikipia, on private ranches to the west of the Ewaso Narok River and had overlapping ranges during the 'short rains' between October and December 2004. During the short rains both elephants moved long distances north to the plains just south and east of the Mathews Range in Samburu District. This long distance movement occurred over relatively short time periods. For example S4 travelled over 70 kilometres in just four days, moving from the confluence of the Ewaso Ngiro and Ewaso Narok Rivers on private ranch land in northwest Laikipia, north into the lowlands of Samburu District and then directly east to Laijok, a seasonally flooded swamp south of the Mathews Range and also located in Samburu District. On just one of the four days during which this journey took place (20th of November) S4 covered over 42 kilometres. In December of 2004 S4 travelled a further 50 kilometres to the northeast of the Mathews Range near a recently established community conservancy known as 'Sera'. At the end of December, 2004, the collar fitted on this elephant failed[38].

Over the course of one calendar year, K15 moved anticlockwise between different seasonal ranges (Fig.7.7). During the 'long dry' season in 2004, K15 spent most of the time on group ranches and private ranches to the west and south of the Mukogodo Forest in east Laikipia. During this season K15 travelled south, crop-raiding in smallholder farms on the south bank of the Timau River. In November, during the short rains K15 travelled north, through the Mukogodo Forest, travelling between the lowlands around the Sieku lugga in Laikipia, then moved in a northeast direction into Samburu District and the Kipsing lugga and then northeast to the Laijok swamp and finally to the plains just south and east of the Mathews range. In January K15 travelled southwest to ranches in the Ewaso Narok valley via the Kipsing lugga and then travelled east again and spent the rest of the short dry season on group ranches and Ol Naishu private ranch, south of the Mukogodo Forest. During the 'long rains' between April and June 2005, K15 moved

[38] In fact the collar from this elephant was recently recovered by STE. The collar had been deliberately buried and therefore it seems highly likely that S3 was killed by poachers.

north once again but only as far as the Kipsing lugga in Samburu District and then to the lowlands north and east of the Mukogodo Forest before returning to private ranches and group ranches located to the south and west of the Mukogodo Forest, respectively. While the rains failed in the short dry season between October and December in 2005, K15 still travelled north to the Mathews Range, suggesting that there may be rainfall-independent incentives for being in the Mathews Range area during this time of year such as, for example, female elephants in oestrus.

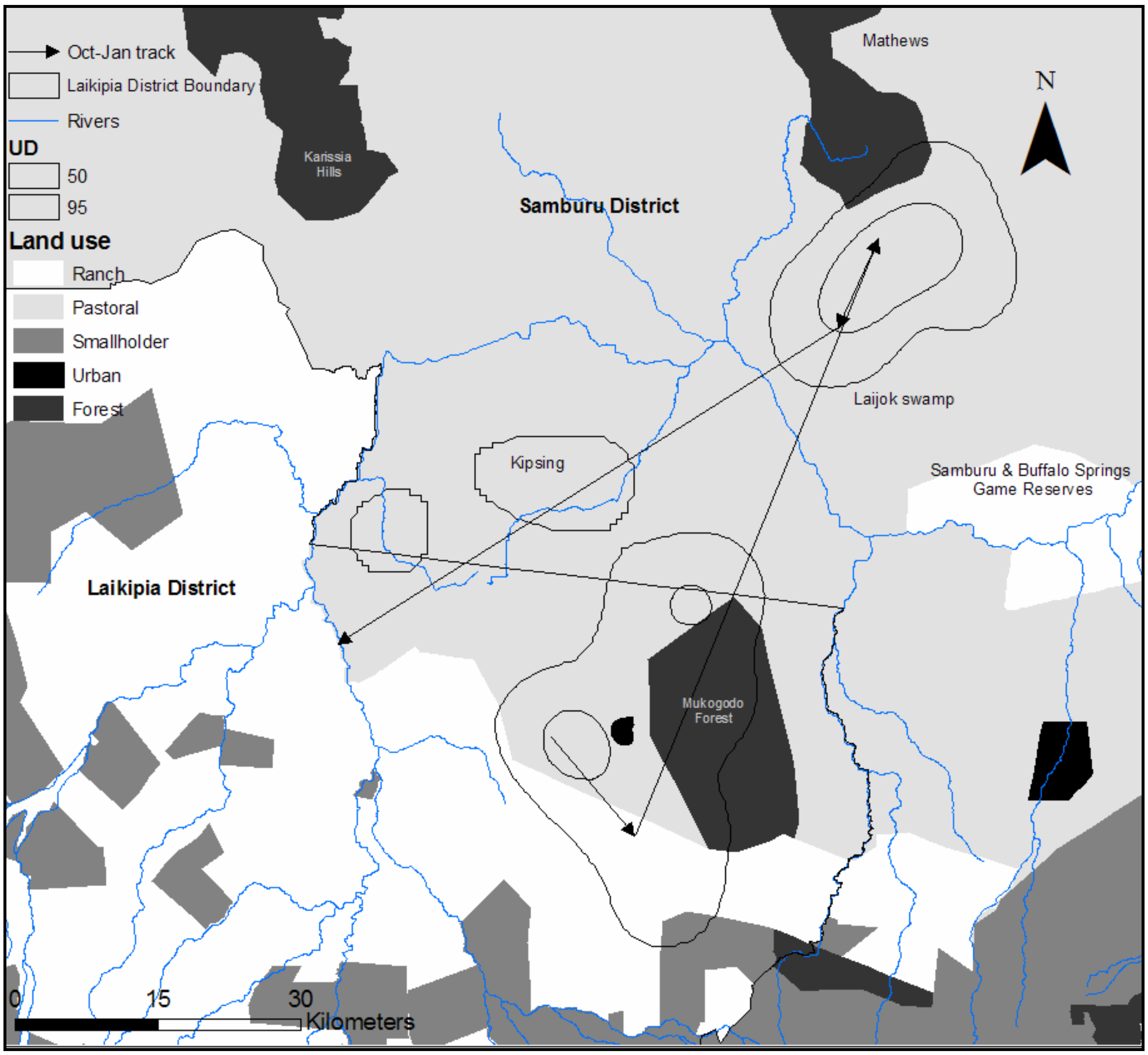


Fig. 7.7 Movements and spatial use (UDs) by K15 recorded during the 'short rains'. Arrows join positions recorded at monthly intervals.

Ewaso

K14 and K13, two female elephants, had distinct dry season ranges on private ranches centred along the west banks of the Ewaso Ngiro River and its tributary, the Ewaso Narok, respectively. During the 'short rains' both elephants moved north and had overlapping wet season ranges on drier northern private ranches near the confluence of the Ewaso Ngiro and Ewaso Narok rivers. While K13 spent the tracking period almost exclusively on private large-scale ranches, K14 did travel west onto large-scale ranches near Rumuruti in southwest Laikipia during the long dry season and from there made nocturnal incursions into smallholder areas in and adjacent to the Pesi Swamp, near the unfenced western boundary of ADC Mutara Ranch. Neither elephant spent any significant period of time on pastoral land (Fig. 7.8).

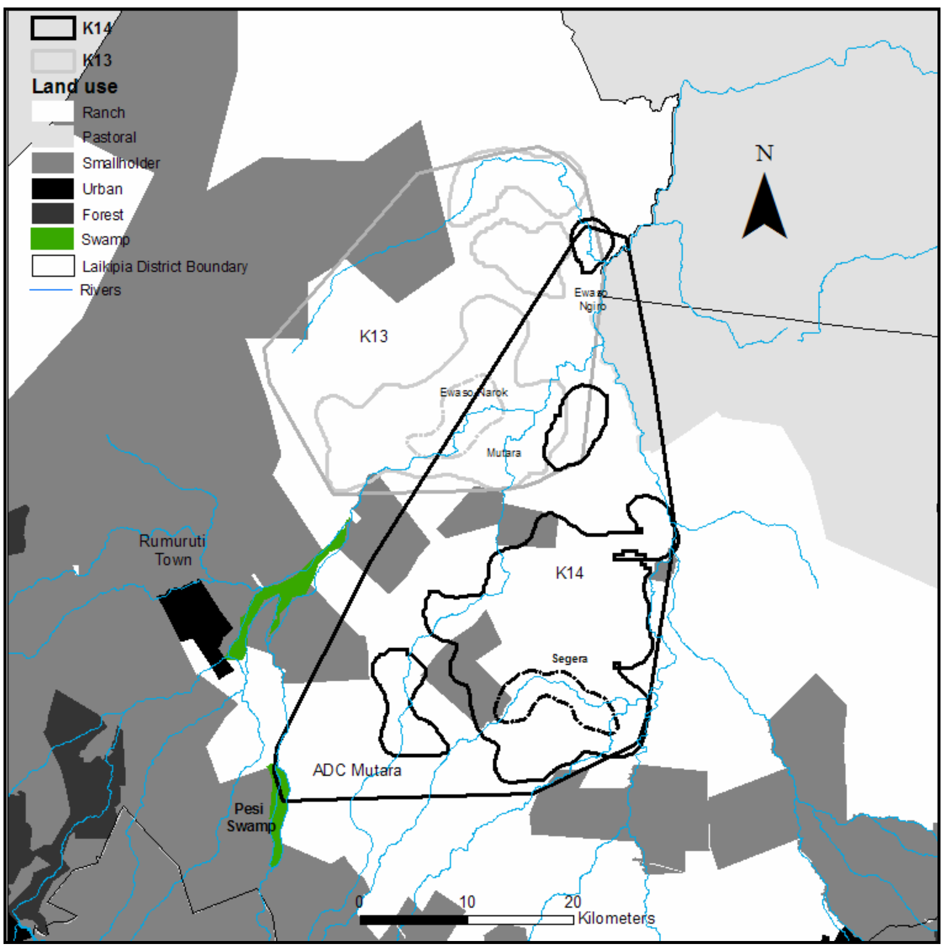


Fig. 7.8 Utilisation distributions (UDs-95% & 50%) and 100% minimum convex polygons (MCPs) for K13 and K14.

Central

Two elephants, K2, a female and K9, a male moved along an east-west axis in central Laikipia between ranges separated by the electrified boundary fences of private ranches (Fig. 7.9). K2 had a 'long dry season' range centred on private ranches in central Laikipia along the east bank of the Ewaso Ngiro River. During the short rains K2 moved north into drier northern private and group ranches and then travelled south and east through a 400 metre gap in an electrified fence to the Loldaiga range and then negotiated a gap in another electrified fence to reach Borana Ranch in east Laikipia (Fig. 7.10). K2 spent the entire short dry season on Borana and then returned west, through the same 400 metre 'gap' to private ranches on the east bank of the Ewaso Ngiro during the long rains and remained there until the end of the long dry season. During the monitoring period a new electrified rhino fence was erected around one of the private ranches bordering the east bank of the Ewaso Ngiro (Ol Jogi Ltd) on which K2 spent a substantial period of time. This had a noticeable impact on the movement patterns of K2 (Fig. 7.11). However after several months K2 was observed to navigate a number of 'gaps' that were created within this fence and designed to allow for the free movement of animals other than black rhinos.

K9 had a 'long dry season' range in southern Loldaiga Ranch, occasionally crossing the Timau River to the south to raid crops. During the 'short rains' K9 moved north and west through the 400 metre 'gap', described above, cross the Ewaso Ngiro and then travelled to private ranches in southwest Laikipia near Rumuruti Town. K9 stayed in this part of the district throughout the short rains and the short dry season, regularly moving into smallholder land, until the long rains after which K9 returned east to ranches bordering the Ewaso Ngiro River.

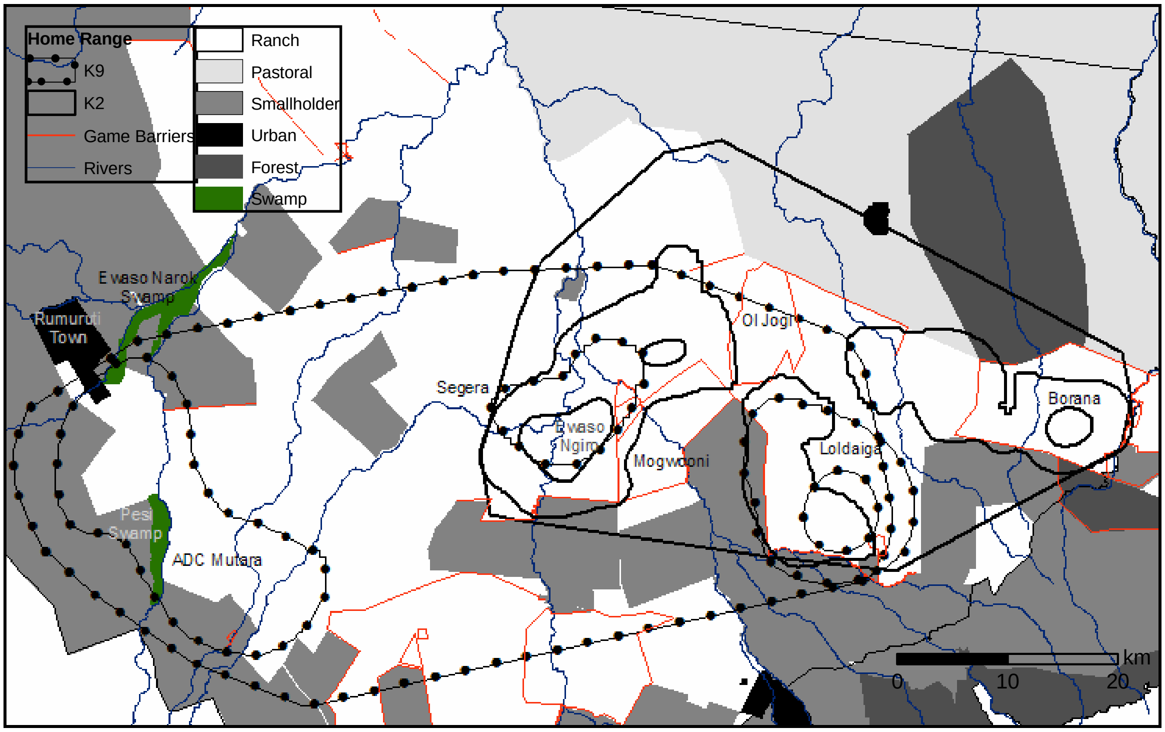


Fig. 7.9 Home ranges (100% MCPs & 95% and 50% UDs) for K9 and K2. These two elephants negotiated a small gap in between the electrified fences of Mogwooni and Ol Jogi Ranches to reach different parts of their respective ranges.

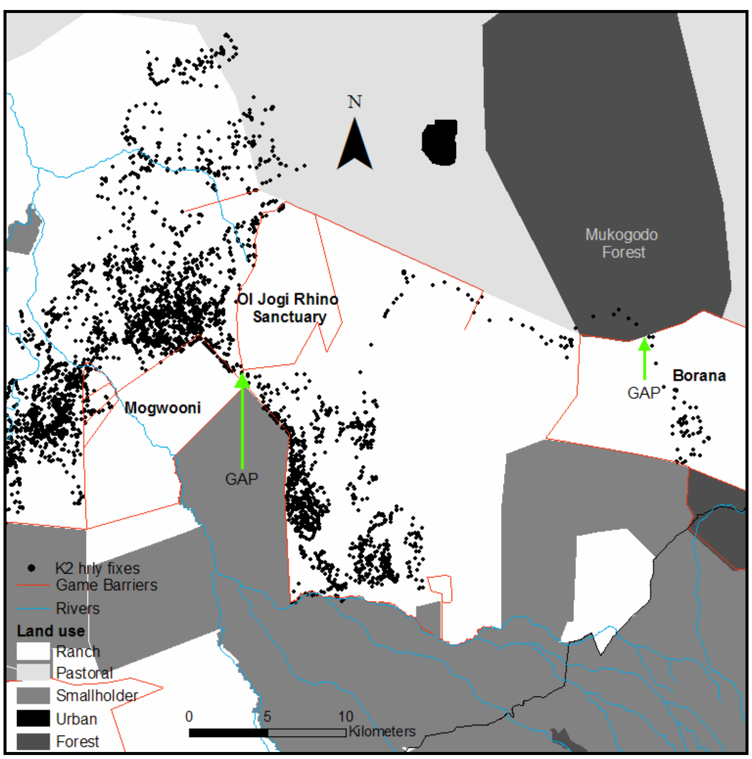


Fig. 7.10 Electrified fences and hourly positions for K2. This elephant has learned to use gaps in the Ol Jogi and Borana electrified fences to reach different parts of her range.

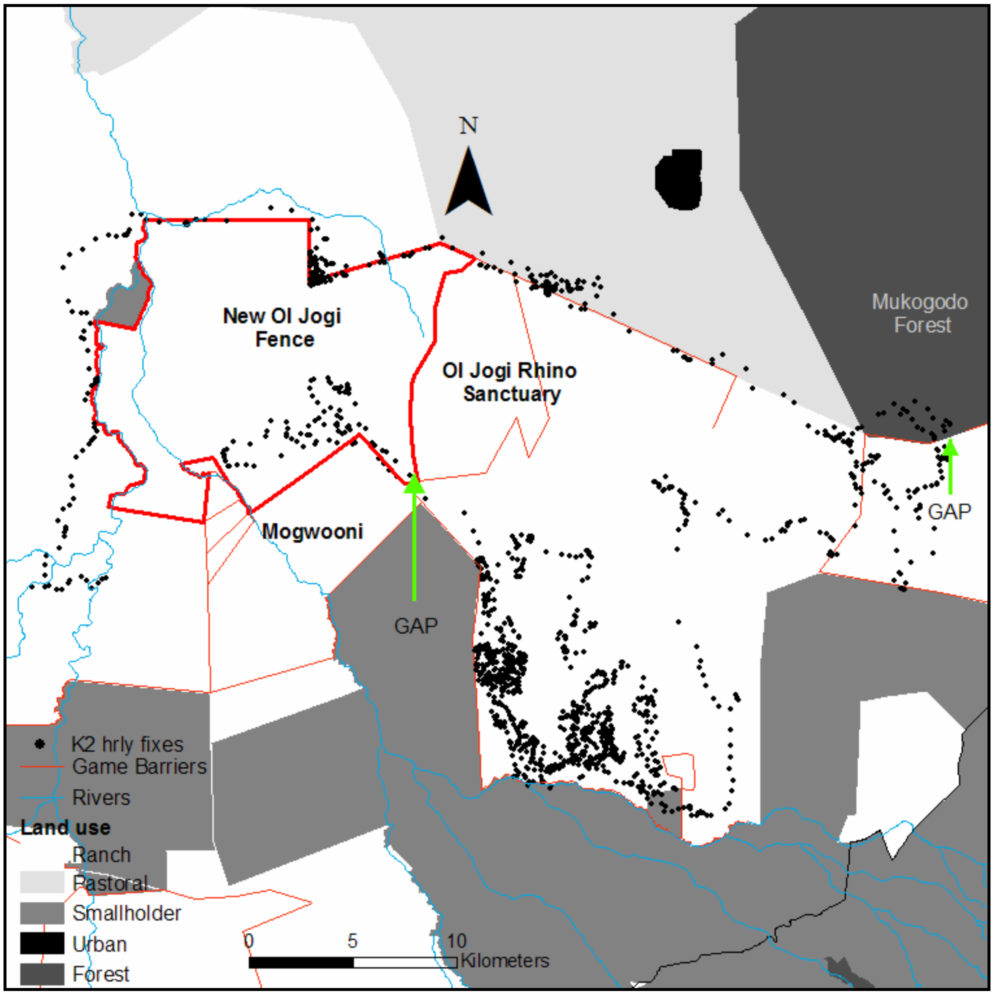


Fig. 7.11 Hourly positions for K2 between July and September 2005 after the construction of the new Ol Jogi fence. K2 moved outside of her usual range and north into pastoral land, then travelled west and south, following the perimeter of the new Ol Jogi fence, to gain access to her normal dry season range.

Rumuruti

S4 and K16, both males, had similar and overlapping ranges extending from southwest Laikipia to northwest Laikipia and beyond (Fig. 7.12). Both elephants moved onto drier ranches in northwest Laikipia during the short rains. During this time S4 travelled northeast into Samburu District south of the Ewaso Ngiro River but this movement was far less extensive that that of the 'migrant elephants' and occurred over a period of just several days before S4 returned to Laikipia. During the short dry season both elephants travelled to a seasonal range comprised of private ranches, two swamps (the Ewaso

Narok and the Pesi) and smallholder land in southwest Laikipia, near Rumuruti Town, the same area used by K9 as described above. While limited data were available for S4 (due to the limited battery life which only allowed for one fix per 24 hours to be taken), K16 regularly made forays into smallholder land and cultivated portions of the two swamps from the private ranches in southwest Laikipia. K16 also moved regularly from these large-scale ranches through smallholder land to the Rumuruti Forest and raided farms around this forest. In total K16 used smallholder areas for over 30% of the period he was tracked, more than any other elephant fitted with a GPS collar in this study and possibly the highest proportion of smallholder use ever directly recorded for an elephant. However K16 did not spend all of this time in cultivation. He used thickets within smallholder areas during the day and would make forays into the surrounding farms at night. This suggests that GPS tracking data could improve identification of daytime elephant refuges and thereby possibly better explain the variance in spatial patterns of crop-raiding (see chapter 6) in future analysis. During the long rains S4 moved north again onto private ranch land in between the Ewaso Narok and Ewaso Ngiro Rivers and remained in this area until the end of long dry season. While data was not available for K16 during the long rains of 2005, during the long rains of 2004 this elephant remained in southwest Laikipia. Both elephants ranged on the northern private ranches of Laikipia in October but after the short rains failed in late 2005 both elephants returned to southwest Laikipia.

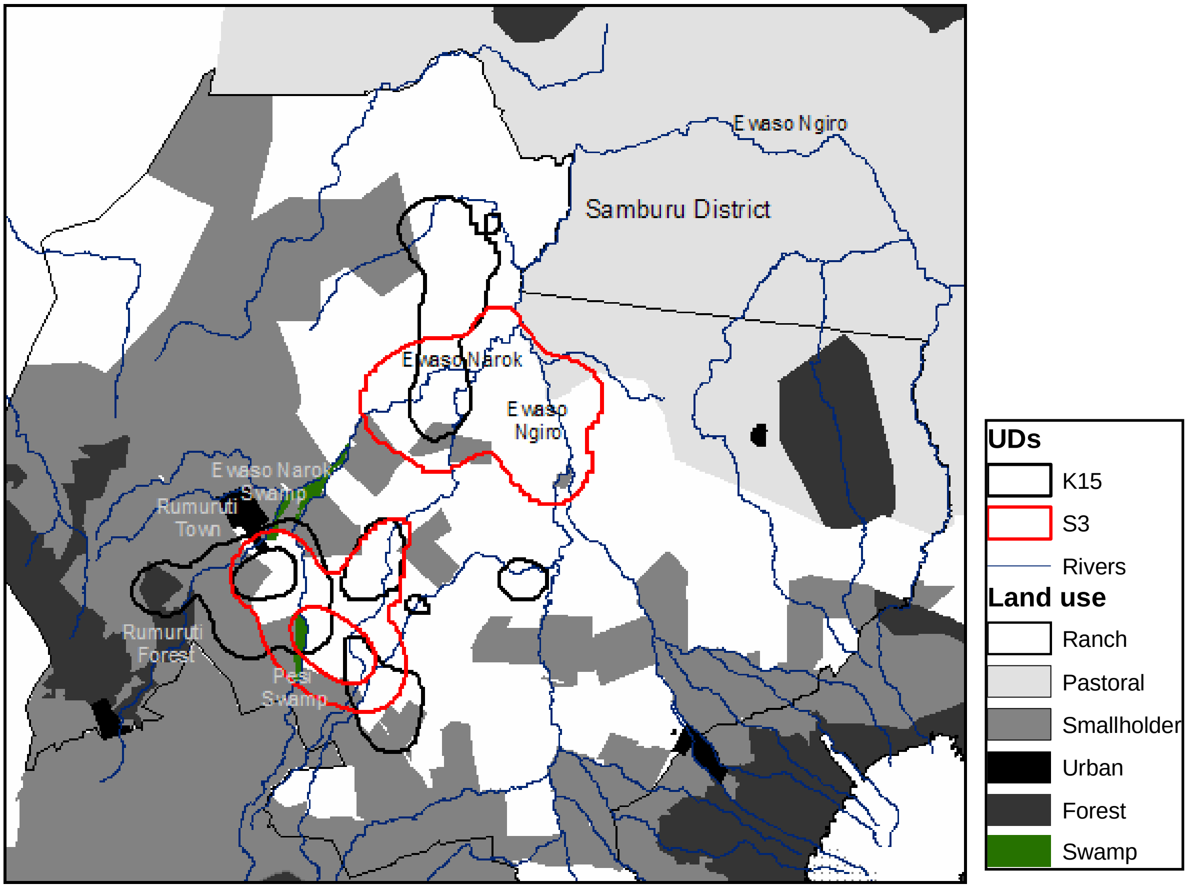


Fig. 7.12 Utilisation distributions (UDs-95% & 50%) for K15 and S3. K15 spent over 30% of the time in smallholder areas

Lewa

K11 and K8, both males, had overlapping ranges in east Laikipia and the adjacent district (north Meru). Both of these elephants spent most of the time in a single fenced property. K8 was fitted with a GPS receiver in December 2003 on communal land to the north of Lewa Downs Conservancy. In January K8 moved south through Lewa Downs Conservancy and into the Ngare Ndare Forest and stayed there for 10 months. In November this elephant moved west and north into Borana Ranch and in January, 2005 the collar on this elephant was removed as a precaution after showing visible signs of irritation. Lewa Downs, the Ngare Ndare Forest and Borana Ranch are all surrounded by electrified fences which have in the past been enforced by shooting persistent fence breakers (Thouless & Sakwa, 1995).

For nearly 20 months of continuous tracking K11 had a range that was almost entirely restricted to two ranches in east Laikipia, Borana and Ol Naishu. An electrified fence surrounding Borana separates these two properties, although there is a gap in the northern boundary fence, bordering the Mukogodo Forest. This gap was occasionally used by K11 to gain access to the forest and Ol Naishu Ranch through the latter's unfenced northern boundary. On several other occasions K11 broke Borana's western perimeter fence and then moved into Ol Naishu Ranch. From Ol Naishu Ranch K11 occasionally made nocturnal incursions into smallholder land located to the southeast of this property. After the short rains of 2005 failed, K11 travelled north of Borana into communal land and then southeast, into Lewa Downs Conservancy. This latter pattern of movement was not observed during the preceding 20 months of continuous tracking and may have been in response to the drought.

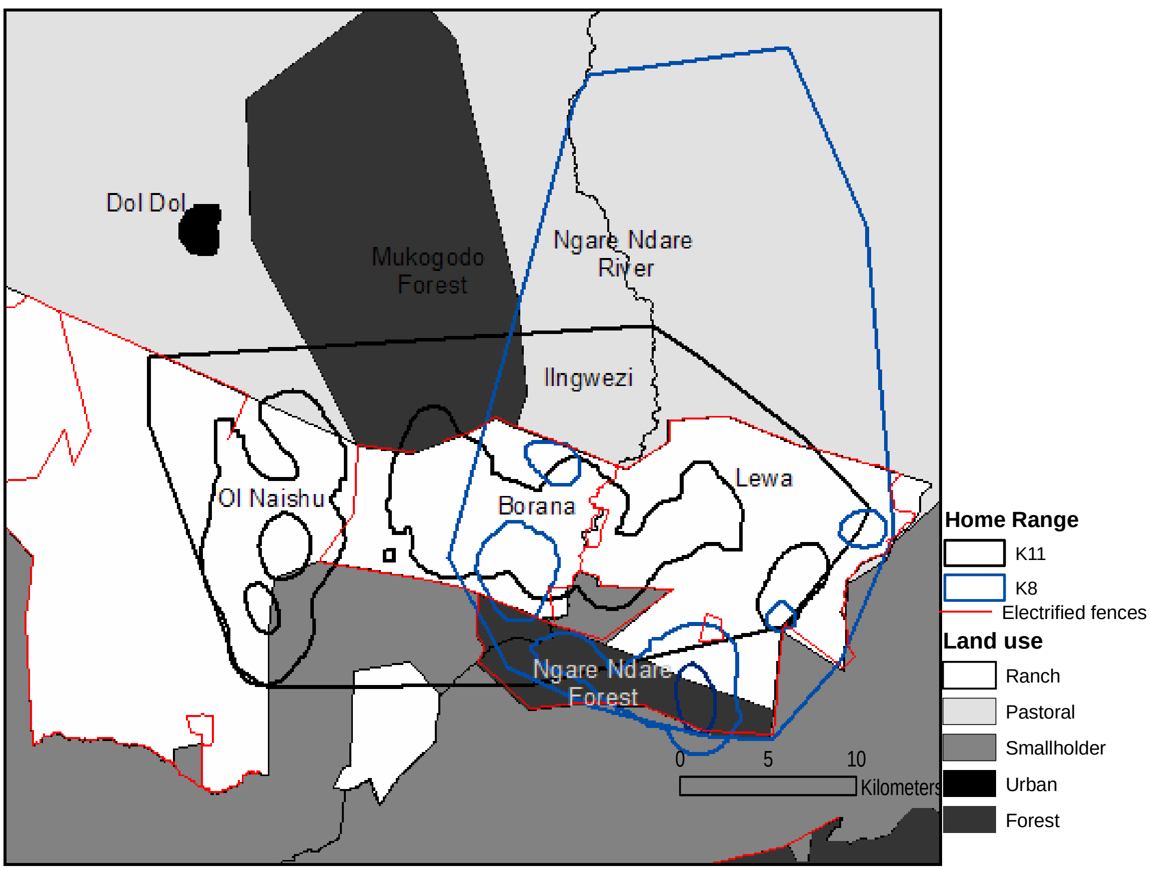


Fig.7.13 Home ranges (100% MCP, 95% UDs and 50% UDs) for K11 and K8, the 'Lewa group'.

Sangare

Two elephants, K19, a male and K22, a female elephant, belong to a remnant southern population numbering approximately 80 individuals that probably once moved between Mt.Kenya and the Aberdares (Meinertzhagen, 1957). These elephants occupy an area straddling Solio Ranch in southern Laikipia south to Sangare Ranch which is in Nyeri District and east to the Thego Forest, a peninsula of the Mt Kenya Forest. This area represents the most fragmented and intolerant of the elephant ranges identified in this study. As has been described in previous chapters, most of Solio Ranch has been designated as an elephant-intolerant rhino sanctuary, surrounded by an electrified fence with boundaries enforced using non-lethal (mainly shot guns and fireworks) and occasionally lethal deterrents. The northern boundary of Sangare Ranch is shared with Solio Ranch though the two properties are separated by an electrified fence. Sangare Ranch is separated from the Thego Forest, to the east, by approximately 6 kilometres of marginal and sparsely settled smallholder land, intersected by a main road. The Thego Forest is almost completely surrounded by cultivated smallholder land with the exception of a narrow corridor of forest in the east that is linked with the main Mt. Kenya forest complex.

There was considerable overlap in range between these two elephants (Fig. 7.15). In addition K19 and K22 were closely associated: the median distance between these two elephants was 1.6 km (range = 0.006 to 20 km) and for 25% of the time they were less than 146 metres apart (n=122[39]). Observations from protected area populations suggest that male elephants become independent of their family group shortly after puberty (Douglas-Hamilton, 1971, Moss, 1988) and therefore the high degree of association between K19, an adult male and K22, a female, was unexpected and probably reflects the high level of human disturbance in this particular range.

[39] Simultaneous location data for K19 and K22 was available for the period between 15/11/2004 and 19/05/2005. Distances were calculated between GPS fixes reported by each elephant at 12 noon. Days for which 12 noon GPS fixes were not available for both elephants were excluded from this analysis.

Both elephants moved between Solio, Sangare and the Thego Forest during all seasons though spent more time in the Thego Forest during the drier months and more time in Sangare Ranch during wetter months. The lack of distinct seasonal ranges is probably due to high levels of human disturbance, with both Solio Ranch and the Thego Forest being areas where this population of elephants are likely to be harassed, with individuals occasionally injured or killed. Both elephants made incursions into cultivated land on the south bank of the Amboni River, south of Sangare Ranch and surrounding the Thego Forest, although K19 spent more time in smallholder land than did K22. K19 also penetrated the southern Solio Game Reserve fence, spending time in the swamps found within, which K22 did not do. The collar on K19 failed on the 20th of June, 2005.

On the 10th of November 2005, K22 moved north of Solio through smallholder land into southern Ol Pejeta and was observed with a group of approximately 70 elephants in total. On the 11th of November all of these elephants were forcibly driven north by Ol Pejeta Ranch management (including K19) with the exception of K22 and two calves. K22 then returned south on the 13th of November. There was a significant difference in K22’s monthly use of smallholder land before and after this elephant was separated from the rest of the herd (Fig. 7.14; Wilcoxon signed ranks: Z = -2.02, P = 0.043, n = 5).

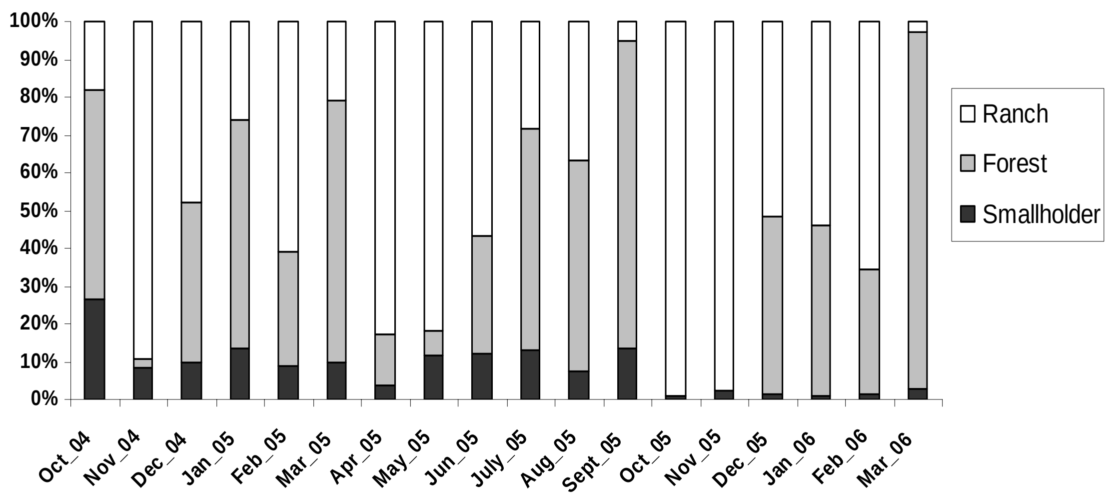


Fig. 7.14 Proportion of time spent by K22 in each of three different land use types for each month of study

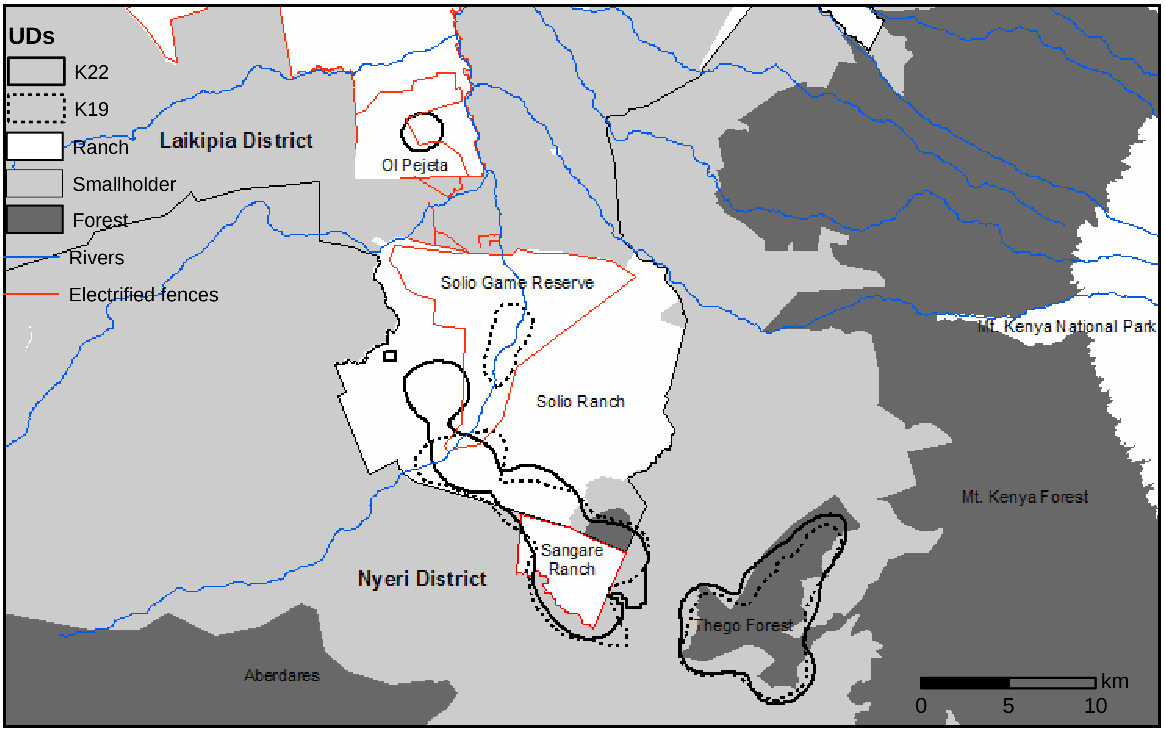


Fig. 7.15 95% utilisation distributions for K19 and K22. The extent to which the two elephants, one a female and one a male, shared the same range is contrary to what would be expected on the basis of published studies of elephant ecology from protected areas.

Mugie

Two elephants were fitted with GPS collars on Mugie Ranch in northwest Laikipia. K20, a female elephant, was fitted with a GPS collar within a recently established and fenced rhino sanctuary in the eastern portion of Mugie Ranch and never left this fenced sanctuary for the duration of the tracking period. This was despite gaps being created within the fenced perimeter of the sanctuary to allow for the free movement of wildlife other than rhinos. K18, a male elephant, moved between the western portion of Mugie Ranch (though did not enter the rhino sanctuary during the period tracked) and Ol Ari Nyiro Ranch to the south-west, traversing sparsely settled smallholder land. K18 spent most of the time on the northern section of Ol Ari Nyiro though occasionally travelled south. Despite high levels of crop-raiding recorded by trained enumerators in the areas to the south and southeast of Ol Ari Nyiro, K18 did not appear to enter smallholder land in these areas. On the 21st of May in 2005 this elephant travelled 43 kilometres north of

Mugie Ranch into an area of Samburu District comprised of patches of forest and wheat fields. This elephant returned the following day, completing a total round trip of 77 kilometres in just two days (Fig.7.16). It is not entirely clear what triggered this movement though the wheat fields may have provided an incentive.

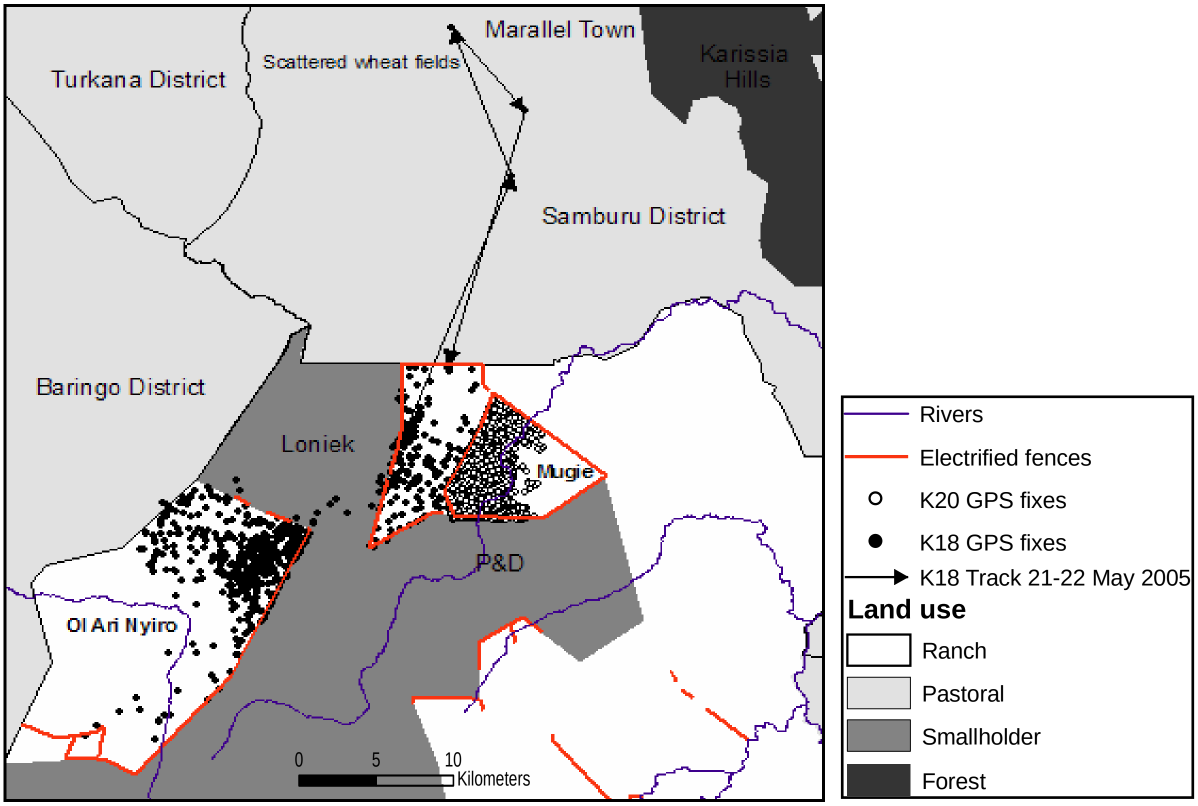


Fig.7.16 GPS fixes for K18 and K20 in west Laikipia and a track for K18 showing the direction of travel during an unusually long journey outside of this elephant's normal range. K20 did not move outside of the fenced rhino sanctuary for the entire tracking period.

Ol Pejeta

K21, a male elephant and K7, a female elephant were both immobilised and fitted with GPS collars in the southern section of Ol Pejeta Ranch (just north of the fenced wheat fields). Both elephants spent most of the time within Ol Pejeta which is surrounded by an electrified fence. However these elephants did not always share the same range, each displaying a distinct pattern of movement on two different occasions (Fig.7.17). In February 2005 K21 travelled south to Solio Game Reserve and then onto Sangare Ranch before returning north again to Ol Pejeta in the middle of the subsequent month. This journey involved breaking through five different electrified fences. During the long rains in 2005 K7 travelled from Ol Pejeta, northeast through smallholder land and then through an electrified fence to Loldaiga Ranch where this elephant stayed until October. In October K7 returned to Ol Pejeta again, though on this occasion K7 travelled west through the 400 metre gap between the electrified fences of Mogwooni and Ol Jogi Ranches that was used by the two 'central' elephants described above (Fig.7.11). K7 then travelled west, crossing the Ewaso Ngiro River and south to Ol Pejeta.

K21 made regular incursions into cultivated smallholder farms around Ol Pejeta Ranch, particularly on the east banks of the Ewaso Ngiro River, the south banks of the Ngobit River and rain-fed cultivated areas in Sirima, a smallholder area located west of Ol Pejeta. The GPS collar fitted on K7 was faulty, producing spurious location data near the equator, so that movement in south Ol Pejeta could not be defined with accuracy. As a result GPS tracking data from K7 were not used in any quantitative analyses.

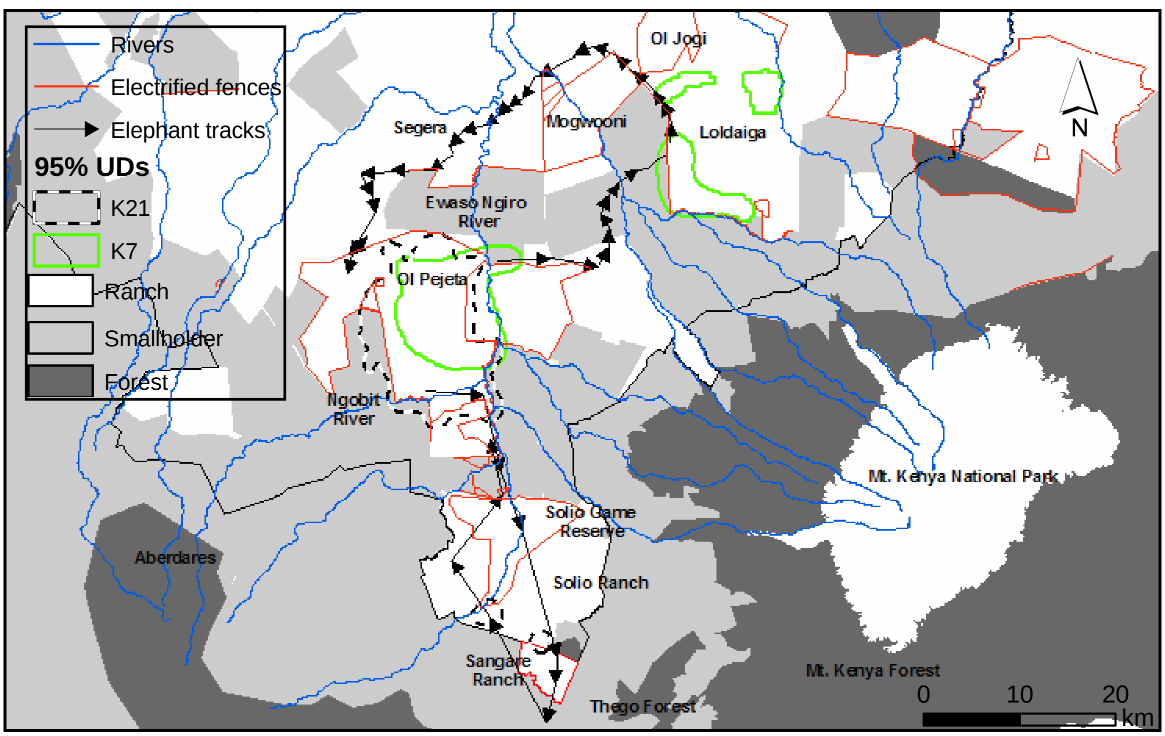


Fig. 7.17 95% UDs for K7 and K21. The tracks show direction of travel during sudden seasonal movements. The northern track from Ol Pejeta to Loldaiga and then back to Ol Pejeta again is for K7. The southern track from Ol Pejeta through Solio to Sangare and back again is for K21. Both of these journeys necessitated breaking electrified fences.

7.3.3 Elephant movement in relation to human land use

The distribution of elephant locations across the four land use types varied significantly from the distribution that would be expected based on availability (χ^2 = 30911.3; d.f = 3; $P < 0.001$). This variation is explained by a consistent preference across the individual elephants monitored for ranches and to a lesser extent, forest reserves over smallholder and pastoral land use types (Table 7.4). The same general pattern emerged when diurnal and nocturnal locations were analysed separately (χ^2 = 22408.3, d.f = 3, $P < 0.001$ and χ^2 = 9275.9, d.f = 3, $P < 0.001$), for diurnal and nocturnal locations, respectively). However there was also a consistent trend across the sample of elephants tracked in differences between intensity of use of each of the four land use types between daytime and night time (Table 7.5; Fig.7.18).

Elephants spent significantly less time in ranches at night than during the day (Wilcoxon: z = -2.8, P = 0.005, n = 12), significantly more time in pastoral areas at night compared with the day (Wilcoxon: z = -2.2, P = 0.025, n = 8), significantly more time in smallholder areas at night than during the day (Wilcoxon: z = -3.06, P = 0.002, n =12) and less time in forest reserves during the night than during the day, though this difference in time spent in forest reserves between diurnal and nocturnal hours did not reach significance (Wilcoxon: z = -1.7, P = 0.093, n = 8). Figure 7.19 shows the distribution of nocturnal and diurnal locations for K16, a crop-raiding male elephant, illustrating differences in patterns of spatial use between day time and night time. The pattern of differences in spatial use between night and day explains why home ranges based on nocturnal location data were consistently and significantly larger than home ranges based on diurnal data across the sample of elephants tracked in this study (Wilcoxon: z = -2.97, P = 0.003, n = 13 and z = -3.1, P = 0.003, n = 13 for 100% MCPs and 95% UDs, respectively). These results suggest that the elephants monitored use the hours of darkness to exploit certain areas that are likely to be difficult to access during the day because of the potential risks associated with people (i.e. small scale farms and some pastoralist areas). This is the first time to my knowledge that this pattern of behaviour among elephants has been demonstrated empirically in relation to human land use using GPS tracking data.

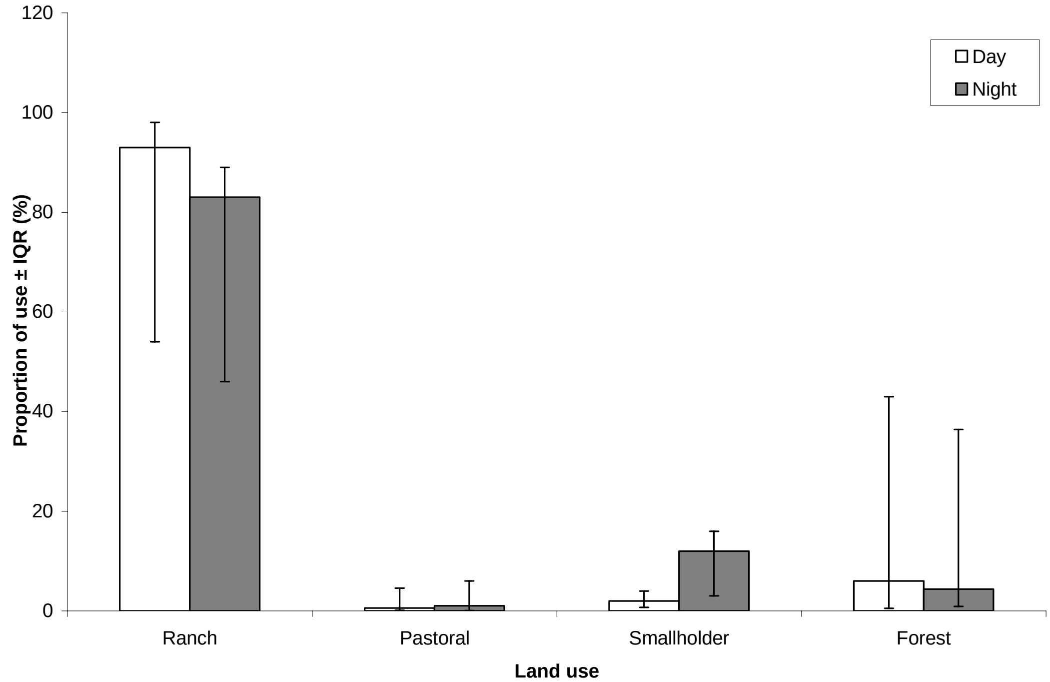


Fig. 7.18 Comparison of median proportion of elephant use of different land use types during diurnal and nocturnal hours

While selection indices suggest that elephants generally avoid smallholder areas, extent of use of smallholder areas varied considerably between individual elephants (Table 7.4). One elephant, K16, an adult male in fact showed a preference for smallholder areas at night (Table 7.5, Selection index = 0.05). Results also show that nocturnal use of smallholder areas was strongly correlated with the total area of smallholder land available within elephant home ranges (Fig. 7.25; $S_r = 0.73$, $P = 0.007$, n = 12). The same was not true of diurnal use of smallholder areas ($S_r = 0.23$, $P = 0.43$, n = 12).

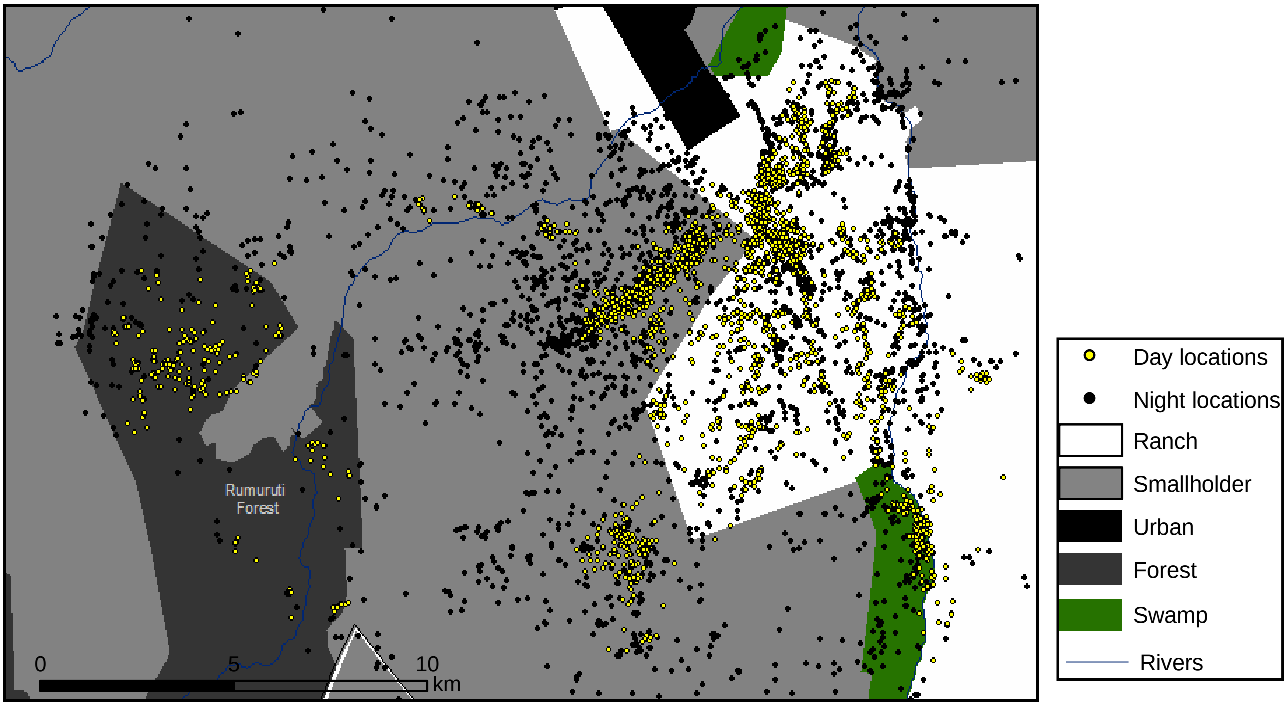


Fig. 7.19 Diurnal and nocturnal locations for K16 in southwest Laikipia. These location data illustrate differences in diurnal and nocturnal use of space in a land use mosaic.

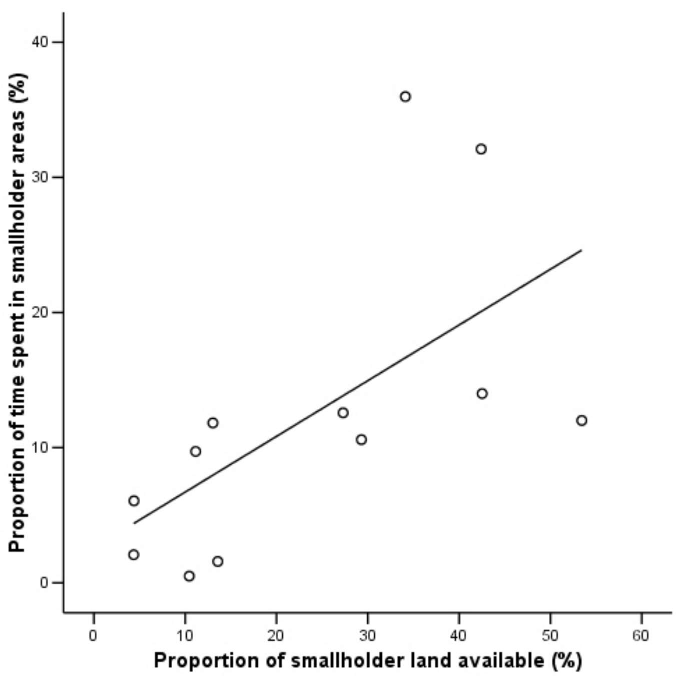


Fig.7.20 Elephant use of smallholder areas at night in relation to the proportion of smallholder land available within each elephant's home range (100% MCPs).

Male elephants used smallholder areas more than female elephants, although this difference was only weakly significant (Median: male elephants = 0.15, n = 8, female elephants = 0.01, n = 8; Mann-Whitney: $U_{8,5} = 7$, $P = 0.032$ (one-tailed)). These results do support the male-behaviour hypothesis concerning risk-taking among elephant populations (Hoare, 1999a, Osborn, 1998, Sitati et al., 2003, Sukumar, 1991). However female elephants also used smallholder areas and sometimes at relatively high levels (Table 7.5).

Elephant use of smallholder areas was higher in dry season months compared with wet season months (Mann-Whitney: $U_{81, 73} = 2418$, $P = 0.049$), although the pattern of monthly use of smallholder areas was not closely correlated with monthly NDVI for those elephants (n=11) that used smallholder areas ($r_s = -0.75$, $P = 0.34$, n = 154). The absence of a strong negative correlation between monthly NDVI and use of smallholder areas could be attributed to several possible factors. Given that use of smallholder areas is likely to be strongly associated with crop-raiding behaviour, the absence of a clear correlation with NDVI may reflect the diversity of cropping patterns among smallholder areas in Laikipia District; some smallholders irrigate and different varieties of rain fed crops, particularly maize, ripen over different periods of time (2, 3 and 5 month varieties of maize exist in Laikipia). It may also be that smallholder areas offer other foraging opportunities for elephants even when crops are out of season for example in the form of maize stores and fallow fields. While beyond the scope of this thesis, these results do merit further higher resolution analyses to better understand the relationship between NDVI, crop-availability and use of smallholder areas by elephants.

There were no significant difference in elephant use of the three other land-use types between wet and dry months (Mann-Whitney: $U_{90, 85} = 3437$, $P = 0.22$, $U_{33, 30} = 461$, $P = 0.62$, $U_{41, 38} = 688$, $P = 0.36$ for use of ranches, pastoral areas and forests, respectively). However patterns of forest use varied between those elephants (n=4) that spent between 5% or more of the monitoring period within forest reserves. K22 and K19, the 'Sangare group', used the Thego Forest, when NDVI values across their range were low (S_r = -

0.56, P = 0.008, n = 21). In contrast, K8, an adult male, used the Ngare Ndare Forest in both wet and dry months.

Table 7.4: Elephant selection of different land-use types in Laikipia. A= proportion of land use type available within the home range (MCP) of the elephant, U=proportion of locations that fall within the land use type, S=selection index; values between -1 and 0 show avoidance and values between 0 and +1 show preference. Elephant IDs that are in italics and underlined are for males while those in normal font are for females.

I.D.	N	**Ranch**			**Pastoral**			**Smallholder**			**Forest**		
		A	**U**	**S**	**A**	**U**	**S**	**A**	**U**	**S**	**A**	**U**	**S**
Migrants													
K15	11110	0.28	0.37	**0.19**	.59	.54	**-0.1**	.04	.01	**-0.5**	.08	.07	**-0.04**
Ewaso													
K14	16431	0.83	0.92	**0.42**	.05	.002	**-0.9**	.11	.07	**-0.24**	NA	NA	**NA**
K13	2437	0.89	0.99	**0.96**	.001	.00	**-0.6**	.1	.002	**-0.96**	NA	NA	**NA**
Rumuruti													
K16	10326	0.61	0.65	**0.09**	.02	.004	**-.59**	.36	.32	**-0.1**	.01	.03	**0.34**
Central													
K9	23285	0.7	0.87	**0.5**	NA	NA	**NA**	.3	.12	**-0.5**	NA	NA	**NA**
K2	16725	0.7	0.98	**0.89**	.11	.01	**-.84**	.14	.01	**-0.88**	.04	.003	**-0.88**
Ol Pejeta													
K21	12545	0.45	0.93	**0.89**	NA	NA	**NA**	.53	.06	**-0.88**	.02	.00	**-0.99**
Solio													
K19	5307	0.34	0.47	**0.26**	NA	NA	**NA**	.42	.17	**-0.56**	.23	.35	**0.29**
K22	14255	0.49	0.5	**0.03**	NA	NA	**NA**	.42	.08	**-0.8**	.09	.42	**0.77**
Lewa													
K8	7771	0.35	0.45	**0.19**	.53	.06	**-.88**	.04	.05	**0.06**	.07	.44	**0.81**
K11	12578	0.59	0.89	**0.71**	.15	.01	**-.84**	.13	.07	**-0.33**	.13	.02	**-0.74**
Mugie													
K20	4339	1	1	**1**	NA	NA	**NA**	NA	NA	**NA**	NA	NA	**NA**
K18	672	0.32	0.92	**0.92**	.4	.00	**-.97**	.27	.07	**-0.66**	NA	NA	**NA**

Table 7.5: Proportion of total diurnal and total nocturnal locations within different land use types in Laikipia. ± = direction of difference between diurnal and nocturnal use with + showing higher proportion of use during the day than during the night and – showing higher proportion of use during the night than during the day

I.D.	n Day (Night)	Ranch Day (Night)	±	Pastoral Day (Night)	±	Smallholder Day (Night)	±	Forest Day (Night)	±
Migrants									
K15	5613 (5495)	.41 (.32)	+	.50 (.59)	_	.00 (.02)	_	.08 (.07)	+
Ewaso									
K14	8227 (8203)	.95 (.9)	+	.00 (.00)	_	.05 (.1)	_	NA	
K13	1226 (1215)	.99 (.99)	+	.00 (0)	+	0 (.005)	_	NA	
Rumuruti									
K16	5186 (5137)	.71 (.59)	+	.0019 (.006)	_	.25 (.39)	_	.04 (.02)	+
Central									
K9	11853 (11442)	.91 (.84)	+	NA		.09 (.16)	_	NA	
K2	8363 (8357)	.99 (.96)	+	.008 (.01)	_	.004 (.02)	_	.0001 (.005)	_
Ol Pejeta									
K7	7368 (7145)	.98 (.96)	+	NA		.02 (.03)	_	NA	
K21	6381 (6162)	.99 (.88)	+	NA		.01 (.12)	_	0 (.00)	_
Solio									
K19	2497 (2583)	.56 (.39)	+	NA		.03 (.32)	_	.41 (.29)	+
K22	7172 (7080)	.54 (.47)	+	NA		.01 (.14)	_	.44 (.39)	+
Lewa									
K8	3991 (3777)	.43 (.46)	_	.06 (.07)	_	.04 (.06)	_	.47 (.41)	+
K11	6440 (6137)	.95 (.84)	+	.01 (.02)	_	.02 (.12)	_	.02 (.02)	_
Mugie									
K20	2197 (2142)	1 (1)		NA		NA		NA	
K18	343 (326)	.98 (.87)	+	.01 (.006)	+	.02 (.12)	_	NA	

7.3.4 Speed of elephant movement across different land-use types

Overall speed of movement within each of four land-use types was calculated and compared as another measure of elephant response to the variable levels of risk presented by human occupants in a land-use mosaic.

Speed of elephant movement varied significantly between land use types with elephant movement fastest in smallholder land units followed by pastoralist land units, private ranches and was slowest in forest reserves (Kruskal-Wallis: $\chi^2 = 2474.6$, $P < 0.001$, d.f. = 3).

The speed of elephant movement also varied between diurnal and nocturnal hours, although the direction of this difference varied in relation to human land-use (Fig. 7.21). Within ranches elephants moved more quickly during the day than at night (Mann-Whitney: $U_{53912, 52326} = 115021871$, $P < 0.001$). The opposite pattern was evident within smallholder areas, pastoral areas and forest reserves (Mann-Whitney: $U_{3331, 8502} = 12064906$, $P < 0.001$, $U_{3207, 3820} = 5877943$, $P < 0.001$ and $U_{6999, 5706} = 19040977$, $P < 0.001$ for smallholder areas, pastoral areas and forests, respectively). The latter three land use types are all used and occupied by people, sometimes at relatively high densities and sometimes presenting direct threats to elephants. The same pattern was evident when comparing tolerant and intolerant ranches with elephant speed significantly higher within intolerant private ranches during the night than during the day (Fig. 7.22; $U_{2668, 2933}=3295803.5$, $Z = -10.2$, $P < 0.001$).

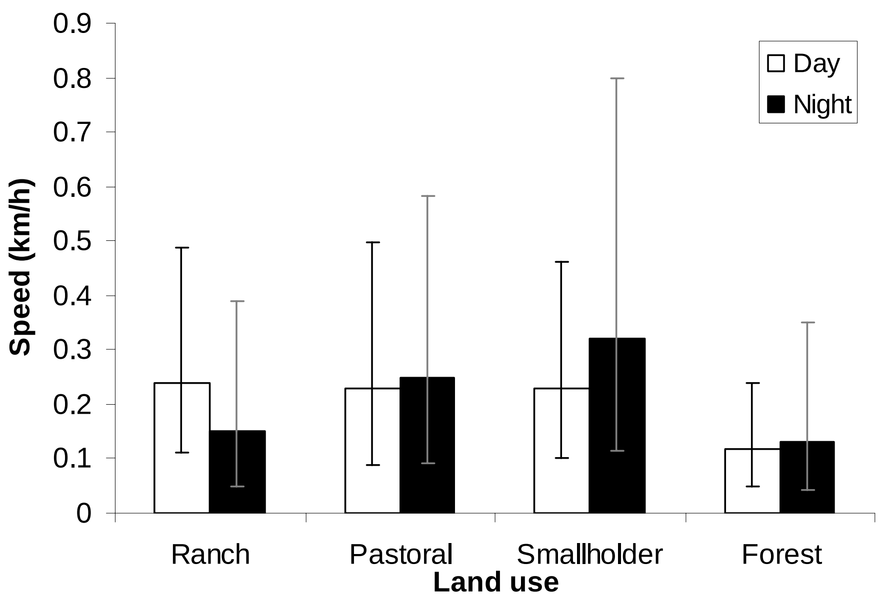


Fig. 7.21 Speed of elephant movement within four different land use types at night and at day. Figures show median values and the interquartile range (IQR).

Further evidence for this adaptive risk management strategy was tested for within this study by comparing speed of elephant movement within open land cover types, in which elephants would be more exposed and therefore conceivably more vulnerable to being harassed and/or attacked by people, to speed of elephant movement within closed land cover types, comprised of woody thickets in which elephants would be more concealed and therefore conceivably less at risk from being attacked by people. Forests were excluded from this analysis.

Within tolerant properties there was no significant difference between speed of movement within open and closed land cover types (Mann-Whitney: $U_{31345, 66437}$ =1035007936, Z= -1.5, P = 0.131). Within intolerant properties, however, speed of elephant movement was higher in open compared with closed land cover types (Fig. 7.23; Mann-Whitney: $U_{11543, 11365}$ = 61908336, Z = -7.4, P < 0.001). This pattern of behaviour is illustrated in figures 7.24 to 7.26, showing speed of movement for K22 across different land-use types.

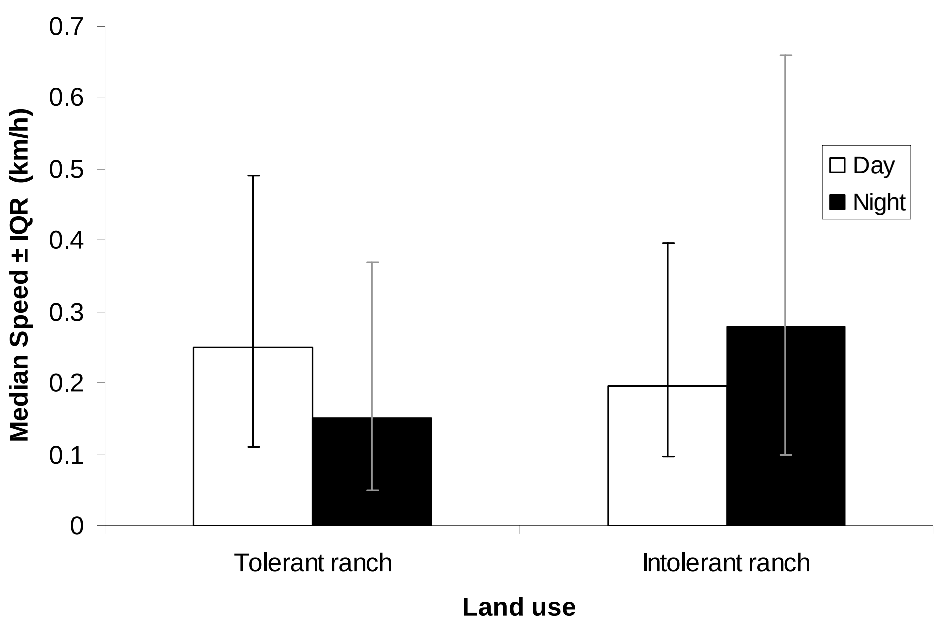


Fig. 7.22 Differences in overall speed of movement at night and during the day between tolerant and intolerant ranches in Laikipia.

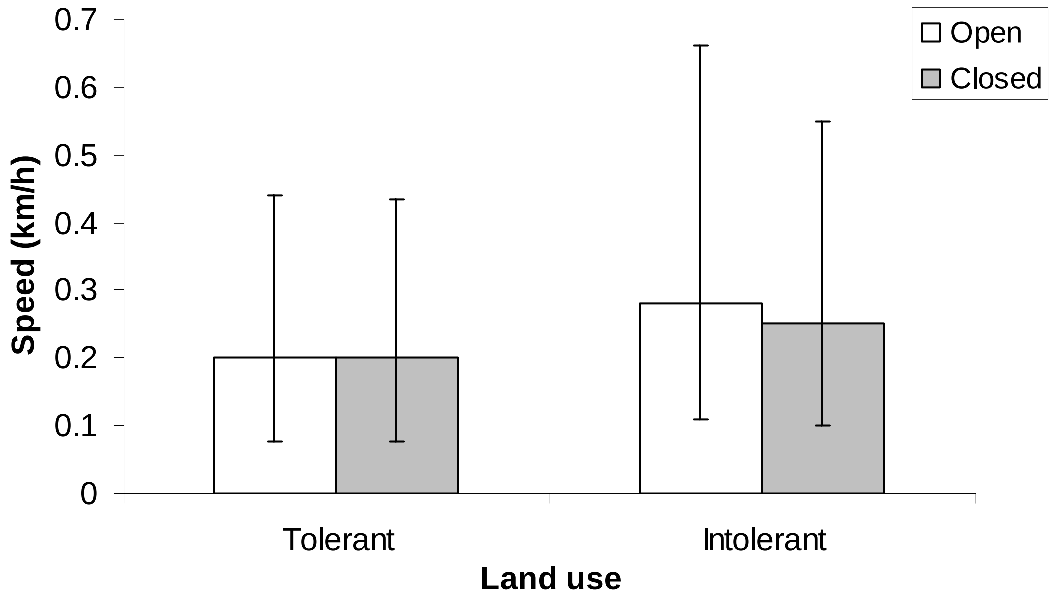


Fig. 7.23 Differences in speed of elephant movement (median ± IQR) in open and woody land cover types between elephant tolerant and elephant intolerant properties.

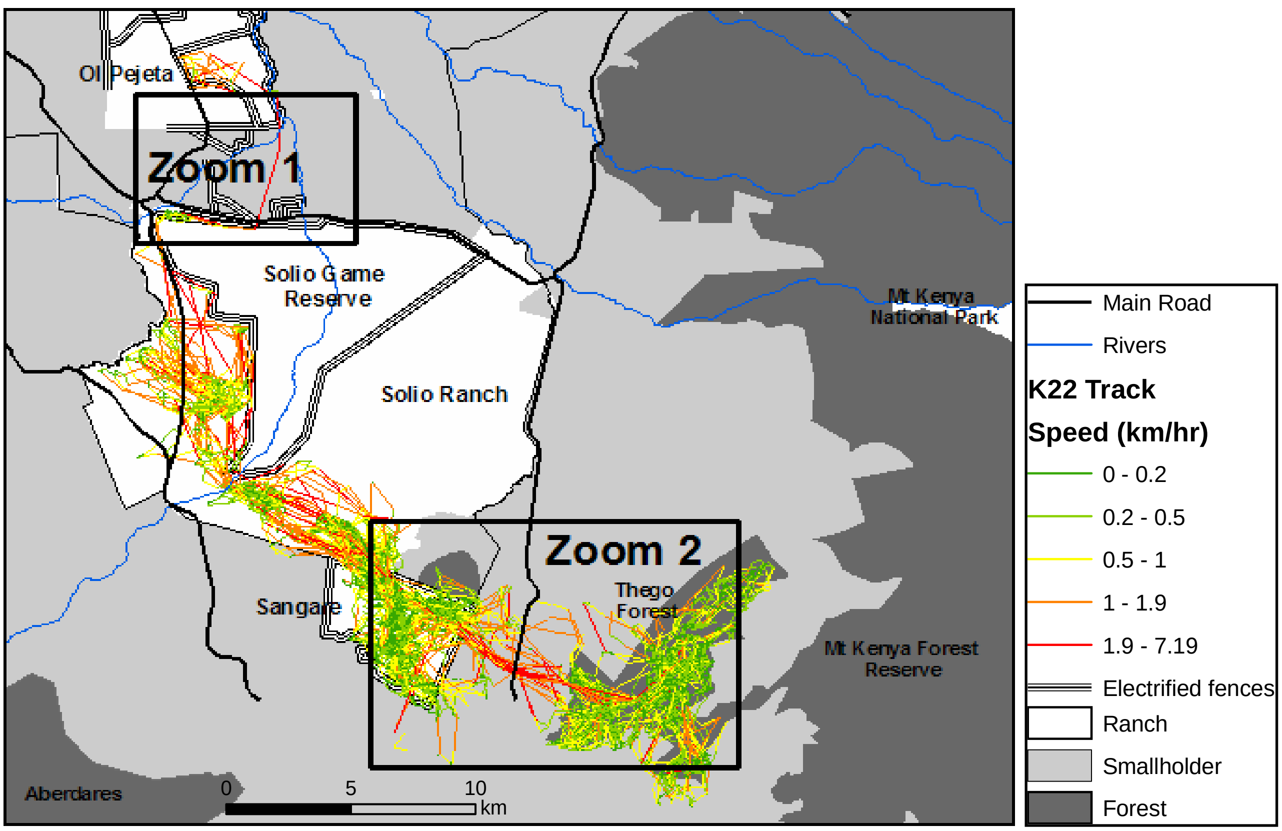


Fig.7.24 Movement tracks for K22. Tracks join consecutive hourly positions and are colour coded according to speed of travel.

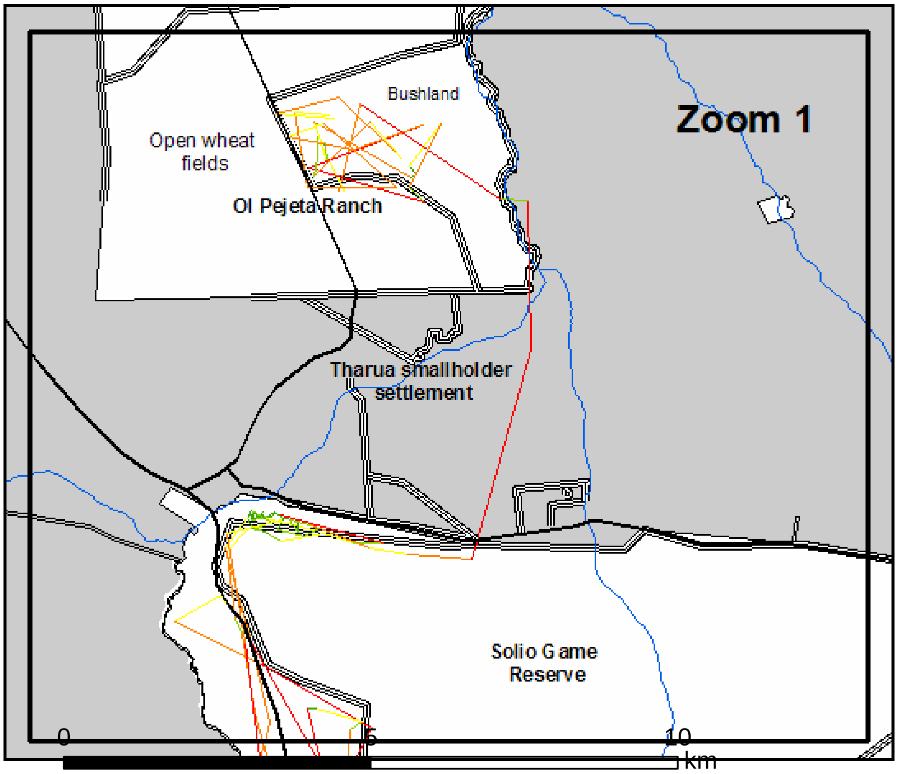


Fig. 7.25 Finer scale image of K22 tracks showing speed of movement across smallholder land and a main road between Solio Ranch and southern Ol Pejeta Ranch.

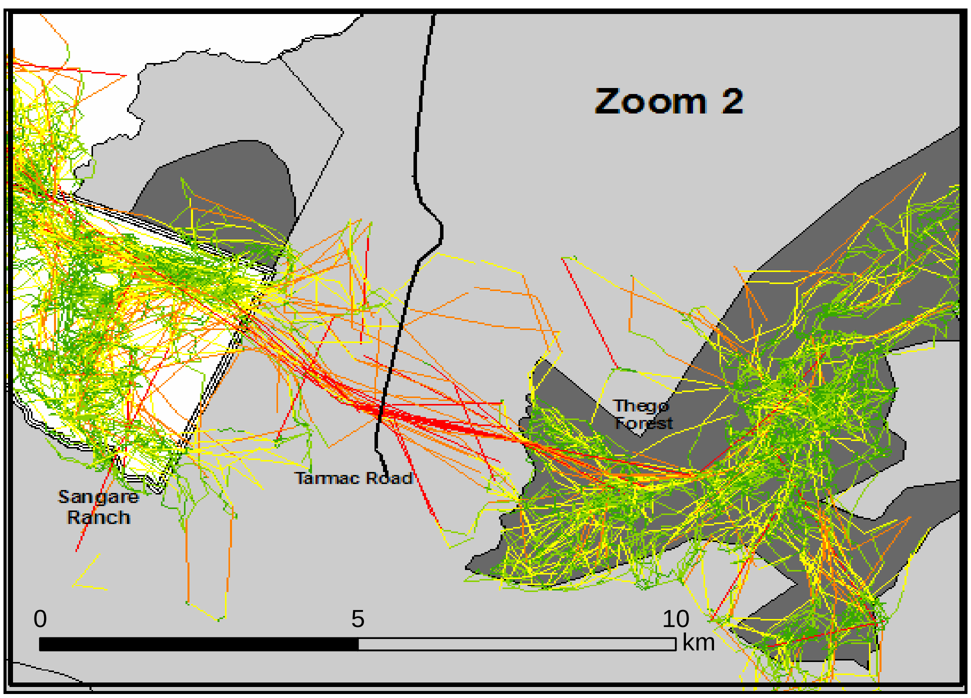


Fig. 7.26 Finer scale image of K22 tracks showing speed of movement across smallholder land and a main road between Sangare Ranch and the Thego Forest.

7.4 DISCUSSION

7.4.1 Home range

The extreme variation in home range size among the elephants tracked in this study is a pattern consistent with previous tracking work carried out in the region (Thouless, 1996a, Thouless & Dyer, 1992). While Thouless (1996a) largely attributed this variation to the marked gradient in rainfall across the Laikipia-Samburu elephant range, the relationship between mean annual rainfall and home range size was not significant in this study. Thouless deployed more collars on elephants that moved long distances between Laikipia and Samburu Districts in the previous elephant tracking study compared with this study (Thouless, 1995, Thouless & Dyer, 1992). Only two elephants recorded patterns of long distance movement (K15 and S4) in this study, of which the collar on one failed after just two months.

One possible explanation for why the previous tracking study captured a higher proportion of elephants that moved into Samburu District (35% of the sample collared at that time) than in this study could be because Thouless (Thouless & Dyer, 1992) carried out collaring operations in northwest Laikipia during the long dry season. In contrast, collaring operations in this study were carried out in northwest Laikipia during wetter months (May and October). However consideration must be given to the fact that the female elephants collared in central and northwestern Laikipia in this study avoided communally owned pastoralist areas. As was shown in chapter 4 with aerial count data from consecutive years, there has been an expansion of human settlement and a significant increase in the number of livestock among pastoralists in Laikipia District since the early 1990s and this trend is likely to be mirrored in neighboring Samburu District. It is thus possible that the long distance movements by family groups recorded by Thouless in the early 1990s have been disrupted. Further monitoring of elephant movement is required to establish the extent to which the seasonal movement of elephants between Laikipia and Samburu Districts has changed since the early 1990s.

This study also demonstrated the importance of landscape ‘structure’ in determining home range size. Elephants inhabiting landscapes with electrified fences and small-scale farming communities had smaller home ranges than elephants that lived in open unfenced landscapes. In addition, patterns of spatial use by elephants over time were quite different between different landscape types, as was demonstrated by the shape of area-observation curves. This suggests that rainfall could just be a proxy factor for the major determinant of home range size in Laikipia which is human land use and in particularly the presence of elephant barriers, armed pastoral communities, large numbers of livestock and smallholder settlements.

7.4.2 Patterns of movement

Coarse scale analyses demonstrated that elephants in Laikipia do generally respond to seasonal variation in rainfall and associated green biomass and differences in the extent of movement between wet and dry seasons (Chapter Four) were consistent with patterns previously identified in Laikipia (Thouless, 1995) and in other studies of African savannah elephants (Galanti et al., 2006, Legett, 2006, Leuthold & Sale, 1973, Osborn, 2003) with elephant movement restricted to smaller areas near permanent water sources during the dry season and elephant movement more extensive, covering larger areas in the wet season. However, despite this general trend, the relationship between NDVI and home range size in this study was not as strong as expected. Patterns of seasonal movement varied considerably between elephants, perhaps because of the sexual composition of the elephants tracked. Female elephants are believed to respond to the distribution of resources and risk in space and time (Rasmussen et al., 2006, Thouless, 1996b) whereas adult male elephants also respond to the availability of receptive females and competition with other males (Poole & Moss, 1981, Stokke & du Toit, 2002, Sumkumar, 1991). Therefore the larger proportion of male elephants tracked in this study may have biased results towards movement patterns representative of ‘opportunistic’ male behaviour.

However patterns of movement by females in this study did not always correspond closely with seasonal patterns in NDVI. Interestingly Thouless (1995) found that the six 'migratory' female elephants in his sample still travelled long distance north even when the rains failed in Samburu District. Therefore inter-sexual differences in ecology were unlikely to be the major factor shaping the variation in seasonal movement patterns across the sample of elephants tracked.

Instead the variability in the pattern of movement found in this study is more likely to once again reflect the diversity of human land use present in Laikipia. Thus the elephants living in landscapes that were largely open did display regular patterns of movement between distinct ranges. Similarly, the elephants inhabiting central Laikipia navigated electrified fences and also had regular patterns of movement between seasonal ranges. However there were other elephants that had ranges largely restricted to a single fenced property such as with the case of K21 and K8 while the movements of the 'Sangare' elephants and to a lesser extent, the 'Ol Pejeta' elephants are as likely to reflect persistent disturbance by local people and 'managers' as they are the distribution of resources across time and space. It could be argued that this diversity in the spatial and temporal pattern of movement between elephants found in Laikipia provides a model for understanding elephant behaviour in ranges across Africa that are under different states of human use. The fact that elephants alter their behaviour along a gradient of human land use reflects their ecological adaptability. The specific behavioural adaptations made in response to human land use was a major focus of this chapter and is further discussed here.

7.4.3 Human land use and elephant movement

While patterns of elephant movement in terms of distribution, direction, extent and proportion of use of different land use types varied considerably across the study area and between the individual elephants tracked, forms of response to the presence of risk from human occupants were consistent across the individual elephants tracked in this study.

Elephants varied speed of travel, diurnal patterns of occupancy and nocturnal patterns of occupancy in response to the variable levels of risks associated with tolerant and intolerant land units, respectively. The results presented in this chapter demonstrate how the collection of information on nocturnal distribution and high resolution data can improve understanding of elephant movement and ecology in a land-use mosaic.

Previous research has suggested that elephants use the cover of darkness to move through and access resources within human occupied landscapes, particularly cultivated areas at night (Bell, 1984, Cerling et al., 2006, Hoare, 1995, Osborn, 1998, Sitati et al., 2003, Thouless, 1994). The results presented by Galantei et al. (2006) from a GPS tracking study carried out in Tanzania show that elephants were more active during the day than at night inside protected areas, while outside of protected areas there was no significant difference between speed of movement during the day compared with speed of movement at night. However, their results were limited by the coarser resolution of data available as the collars they used reported GPS locations every four hours as opposed to the hourly location data available in this study. In addition they tracked a smaller sample of elephants and did not distinguish between different non-protected land use types.

More conclusive results of elephant behavioural adaptation in response to risk presented by people as measured by speed of travel were presented by Douglas-Hamilton et al. (2005). They show that speed of elephant travel was higher in ‘corridors’ than ‘home sectors’. Unfortunately their results did not take account of the landscape context within which movement occurred. They defined a corridor as a path of continuous movement over at least 10 km distance that connected two sectors (Douglas-Hamilton et al. 2005: 160). This definition is based solely on the pattern of movement rather than any physical function of land cover or human land although Douglas Hamilton et al. (2005) did suggest the ‘corridors’ identified occurred in unprotected areas and ‘home sectors’ occurred in protected areas.

Therefore the results presented in this chapter represent the first time to my knowledge that elephant behavioural plasticity in response to human land use in terms of speed of movement and nocturnal occupancy has been conclusively demonstrated across a well defined land-use mosaic in Laikipia District, empirically, using GPS tracking data.

Elephants have persisted in parts of the Laikipia-Samburu elephant range used by people at sometimes relatively high densities long after large mammals have become locally extirpated (e.g. the Rumuruti Forest, the Thego Forest and Sangare Ranch) suggesting that in the absence of commercial exploitation (i.e. for ivory), elephants are resilient to human disturbance. The persistence of elephants could be partly attributed to the ability of elephants to navigate risk, enabling individuals to move through and exploit the human dominated matrix outside of elephant refuges. Although the high level of government protection given to elephants and the difficulty in killing such a large animal without attracting undue attention may also be important factors (see Chapters eight and nine).

Another feature of elephant resilience, with respect to human land use, that emerged in this chapter was the ability to negotiate barriers. As was described in section 7.3.2 many of the elephants tracked often used purposely designed gaps in electrified fences or simply broke through electrified fences to reach different parts of their range. GPS tracked elephants were also recorded crossing main tarmac roads, as was illustrated in the case of K22.

The ability of elephants to cross barriers and negotiate the risks presented by human occupants is arguably an important ecological trait for ensuring elephant persistence in human dominated landscapes. At an individual level such behaviour allows elephants to better meet their nutrient requirements by enabling elephants to access food resources (including crops) that are otherwise scarce in space and time. At a population level the specific traits of resilience described in this chapter are important as they allow elephants to respond through the process of dispersal/migration to stochastic events such as for example drought or a sudden surge in poaching. Indeed the results described in this chapter suggest that in the context of the Laikipia-Samburu ecosystem elephants are able to maintain linkage, often independently of land-cover, between semi-isolated populations and thus arguably exhibit a metapopulation structure, as discussed in chapter two.

From an ecological perspective the results of this chapter suggest that elephants possess traits that stand them in good stead in the context of future human population growth, agricultural expansion and land use change. However these very same traits are also a major concern for elephant managers and conservationists as they can lead to human-elephant conflict.

The high correlation between availability and use of smallholder land presented in this chapter suggests that the potential for human-elephant conflict, particularly in the form of crop-raiding, increases along a gradient of smallholder land availability. This underpins both the significance of habitat fragmentation in determining actual levels of human-elephant conflict and the potential for land-use planning as a preventative management tool. However, many elephant ranges are already partially fragmented. Within the microcosm of African elephant ranges that the Laikipia landscape represents, the area inhabited by the ‘Sangare elephants’ is perhaps representative of the current situation for many small and isolated elephant populations surrounded by smallholder agriculture such as the populations found in West Africa (Blanc et al., 2003) and may be a foreshadow of the condition of many elephant ranges in years to come. In these fragmented landscapes elephant behaviour, in particular association between male and female elephants, may be quite different from behaviour observed in protected areas. The high level of association between K22 and K19 in the ‘Sangare range’ may represent an example of this sort of behaviour.

Under such circumstances electric fences have emerged as the management tool of choice but for those trying to maintain electric fences, the resilience of elephants in the face of change represents a major headache. Three male elephants in Laikipia, each fitted with a GPS collar in a different part of the district, all moved to southwest Laikipia near Rumuruti at some stage and it is likely that each of these elephants was responsible for damaging a great deal of crops. This is the only remaining part of the district where a major electrified fence separating ranches from smallholders is not present. Thus it appears that the existing electrified fences in Laikipia are possibly funneling conflict into one particular area. There is some evidence to suggest that well maintained fences can deter female elephants with calves (Sukumar, 1991, Sukumar & Gadgil, 1988). In this study a similar pattern emerged where in contrast to K21 and K19 (two male elephants), K22 (a female elephant) did not penetrate into the Solio Game Sanctuary or north through the southern Ol Pejeta fences. In addition the movements of several male elephants described in this chapter show that several were clearly accomplished fence breakers (e.g. K21, K11, K9, K19), passing through even the most sophisticated electrified fences.

The problem of fence breaking is well documented. The authors of an empirical study of the effectiveness of different designs of elephant barriers concluded that fence design was less important than fence enforcement through the shooting of fence breaking elephants (Thouless & Sakwa, 1995). It is believed that such a strategy could generate socially-learned avoidance (Hoare, 1992). There is some evidence that this strategy has been effective in controlling movement south of the fenced Ngare Ndare Forest Reserve in northeast Laikipia (Thouless & Sakwa, 1995). However as was described in chapter six, it would be a major challenge to develop the management capacity required to enforce fences in this way across Laikipia District, or any other elephant range for that matter. There are also obvious ethical implications of eliminating those elephants that display ecologically critical traits of resilience which could prove difficult for elephant managers to overcome. Thus while some movement of elephants may well be restricted in future, it is likely that elephant movement outside of private ranches will continue in Laikipia for the foreseeable future. The ability of these elephants to persist is therefore very much dependent on the willingness of people living outside of large-scale ranches to tolerate them. The next two chapters will explore current perceptions of elephants and strategies for responding to HEC among the people living outside of Laikipia's private ranches, in the human dominated matrix.

Chapter 8: Human interactions with elephants

8.1 INTRODUCTION

Much of the research into interaction between people and wildlife in Africa is framed in terms of either competition (Happold, 1995, Parker & Graham, 1989) or conflict (Hoare, 2000, Woodroffe et al., 2005). Such is the prominence of human-elephant conflict in Africa, meaning the "direct conflict with humans (i.e. incidents involving damage to crops, injuries and deaths to people and livestock, or retaliatory injuring or killing elephants themselves)," (Dublin & Hoare, 2004), that in 2000, the IUCN created the Human-Elephant Conflict Working Group (HECWG) to directly address the issue. While HEC is very clearly a severe problem for all concerned (i.e. conservationists, wildlife managers and local people living with elephants), it captures very specific forms of interaction over specific resources, usually over crops although sometimes over water, that are wholly negative in nature. As a result investigations of HEC are often rather restrictive in terms of their spatial focus within the human-elephant interface (agriculture-wildlife refuge boundaries), in terms of the types of household activities investigated (cultivation) and in terms of the human groups that comprise the subject of investigation (frontier cultivators). However elephants, for better or for worse, do coexist with people across approximately 80% of the African elephant range (Said et al., 1995), sometimes at relatively high levels of human density (Hoare & Du Toit, 1999). Thus elephants and people must interact within different land-use contexts and across different spheres of household activity. This interaction is not necessarily exclusively negative. For example strong customs and traditions for conserving elephants exist among the Samburu people of north Kenya (Kuriyan, 2002). However many of the household surveys that are designed to assess human-wildlife interaction often have a 'conflict' component. One of the reported problems associated with such surveys is that losses to wildlife are often exaggerated (Bell, 1984, Siex & Sturhsaker, 1999, Wakeley & Mitchell, 1981). In this study, the survey form designed avoided asking questions regarding crop-loss explicitly to avoid any possible problems of a mismatch between perception and measured loss of yield.

This chapter explores the human dimension of interaction with elephants in Laikipia starting from a reference point other than the conventional HEC focus (i.e. crop loss) so that in the subsequent chapter, HEC is contextualised within a continuum of human-elephant interactions. This is accomplished by exploring patterns of five off-farm household activities across different sites in Laikipia and assessing the implications of these activities in terms of likelihood of contact with elephants.

8.2. DATA ANALYSES

In this chapter I analyse responses from the questionnaire survey and qualitative interviews presented in chapter 3 (section 3.8). Patterns for five off-farm resource use activities and the likelihood of contact with elephants during these off-farm activities were analysed using descriptive statistics (SE values are presented as ±) and chi-square (χ^2) tests for independence. Where the two variables tested had just two categories each (i.e. a 2 x 2 table), Yate's correction for continuity is incorporated within the χ^2 value to compensate for a potential overestimate of the strength of the relationship between variables (Pallant, 2005). The descriptive data are presented as the percentage frequency of responses for the entire sample and for each land-use/tenure type and for each of the eight individual sample areas where household surveys were conducted. All quantitative data analyses were conducted using SPSS v.12 (SPSS Inc., Chicago, USA).

8.3 RESULTS

8.3.1 Household resource use and the likelihood of interaction with elephants

Human dimensions of interaction with elephants in Laikipia have both spatial and seasonal patterns that varied in relation to the context and the way that local people live. This was illustrated through an activity-specific analysis of human-elephant interaction. Table 8.1 summarises household patterns for five off-farm activities based on the entire Laikipia household sample, together with the reported occurrence of contact with elephants during those activities (n = 356). Most of the households surveyed in Laikipia reported having made contact with elephants while carrying out off-farm activities. Of the five household activities surveyed, firewood collection and livestock herding were the most frequently cited as resulting in contact with elephants. A large proportion of respondents also reported having noticed elephants while collecting wild plants, collecting drinking water and harvesting wild honey.

Table 8.1 Summary of off-farm resource use activities and the likelihood of contact with elephants during each activity based on household questionnaire data (n=356)

Resource use activity	**% HH doing it**	**Who in HH does it**	**Main Source areas** (other source areas)*	**% HH reporting contact with elephants**	**Relative % of HH reporting contact**
Wild plant collection	85.7	Women, Men	**Group ranch**, **Forest**, (Unoccupied land, Own farm)	48.3	56.4
Livestock herding	91	Men, Women & Children, Employees	**Group ranch**, **Unoccupied land**, **Forest**, (Own Farm)	70.5	77.4
Firewood collection	97	Women &Children	**Group ranch, Forest, Unoccupied land** (Own farm)	74.1	76.5
Drinking water collection	97.4	Women &Children	**River** , **Borehole,** (Collected rainwater, Spring)	47.7	49
Honey Harvesting	43.5	Men	**Group ranch**, **Forest,** (Unoccupied land)	39.6	91

* Bold type indicated most frequently reported source area; other source areas are in brackets.

Resource use patterns, however, varied across the study sites surveyed as did the characteristics of the resources themselves. Thus the likelihood of households making contact with elephants is much better evaluated and understood through an analysis of each of the five off-farm activities with specific reference to the social and ecological contexts of the household respondents.

8.3.2 Honey harvesting

The majority of the communal lands household surveyed reported harvesting honey, compared with a small proportion of smallholder households (71%, n = 163 and 20.8%, n = 192, respectively, $\chi^2 = 86.6$, $P < 0.001$). Honey harvesting from both man-made beehives and wild hives is an activity carried out exclusively by men. Honey represents an important resource for households located in Laikipia's group ranches and the Mukogodo forest (see Table 8.2) and was historically even more important for some communal land groups. Indeed honey may have once provided a source of concentrated and easily digestible carbohydrates that enabled foragers living in the Mukogodo area to avoid over-reliance on protein (Cronk 2004). The importance of honey among the ancestors of the current occupants of the Mukogodo Forest (*Yaaku*-see Chapter One) was such that this group delineated territories in the Mukogodo forest for hanging and defending beehives, an unusual trait unknown from studies of other East African hunter-gatherers (Cronk, 2004) and one that persists in some parts of the forest today. Theft of honey from an individual's beehives once invoked heavy fines, which even today involves payment of livestock (I#6, male respondent, Mukogodo Forest). In the oral traditions of both the 'LaUaso' and the Yaaku, two of the five distinct ethnic groups identified in Mukogodo Division by anthropologists[40], such was the importance of honey that beehives were once used to pay dowries (Brenzinger et al., 1994, Cronk, 2004, Herron, 1991).

[40] 'Mukogodo Maasai' is the generic ethnic label used by and for the maa speaking pastoralists resident to the group ranches and forest reserve within what was formerly known as the Mukogodo reserve in present day Laikipia District (created in 1936 after the Carter Commission report, that dealt with land policy and the demarcation of white and native areas, was published in 1934), the boundaries of which remain much the same and today constitute the administrative unit known as Mukogodo 'division'. While these pastoralists ostensibly refer to themselves as 'Mukogodo Maasai' to outsiders, share a common language and are officially labelled as such by the Laikipia administration, they share distinct origins and divergent resource use traditions. Anthropological work carried out in the Mukogodo region of north Laikipia has shown that in fact there are five ethnically distinct groups among the Mukogodo people: the Ilng'wesi, the Mumonyot, the Digirri, the LeUaso and the Mukogodo proper or Yaaku (Spencer, 1973; Herron 1991; Cronk, 2004).

In addition to providing a high energy food source, honey is also used in the production of honey wine, widely consumed among older members of communal land households.[41] Most honey is consumed locally shortly after harvests though some harvesting households also sell honey for cash income. While honey is typically sold locally, more recently honey harvesting households have generated income by selling honey comb in bulk to outside commercial distributors with markets in Nairobi and even overseas.

The man-made hives used by beekeepers in Mukogodo Division today are hollow logs about 3 feet long and of varying widths depending on the timber[42] used to construct them, with removable lids placed on either side of the log to facilitate harvesting. Throughout the fieldwork period I observed man-made hives placed in trees in remote parts of the Mukogodo Forest and along permanent rivers in Ilngwezi (the Ngare Ndare River) and Koija (the Ewaso Nigro and Ewaso Narok rivers) Group Ranches.

In addition to man-made beehives, wild hives also provide a significant source of honey for many 'Maasai' households in Laikipia. I observed honey 'hunting' from wild hives in hollow trees and clefts in rocks on several occasions during the course of my fieldwork and this appears to be a ubiquitous activity across the group ranches of Mukogodo division and among Samburu households living near the mountains of Samburu district (the Mathews ranges and the Karissia hills). Honey 'hunters' are greatly aided by the calls of a honeyguide bird of which two species exist in Mukgodo division (the lesser honeyguide and the greater honeyguide*)* representing an unusual symbiotic relationship between people and birds that probably evolved from the original relationship between the honeyguide and African honey badger (Kingdon, 2001).

[41] The questionnaire survey coincided with a major honey harvest and on several occasions the older men in the Mukogodo households were too drunk to interview.
[42] In the Mukogodo forest, beehives are made from African cedar logs (*Juniperus procera)* while in Ilngwezi and Koija group ranch, beehives are made from the bark of *Il popongi (Euphorbia magnicapsula)*. The latter are strengthened using cow dung and mud.

Table 8.2: Summary of household profile data for patterns of honey harvesting and the proportion of households reporting contact with elephants during honey collection

Land-tenure	*Site*	*% HH harvest wild honey (n)*	*Who harvests*	*Purpose of harvest*	*% HH contact with elephants*	*Season of greatest contact*
Communal	Mukogodo	69.2 (39)	Men	Domestic Sale	64	Long Dry Short Rains
	Koija	88 (42)	Men	Domestic Sale	86	Short Rains (Short Dry)
	Ilngwezi	75 (40)	Men	Domestic Sale	72.5	Long Dry
	Kuri Kuri	50 (42)	Men	Domestic Sale	47.6	Long Dry Short Rains
Smallholder	Ngare Ndare	37.5 (64)	Men	Domestic (Sale)	34.3	Long Dry Long Rains (Short rains)
	Tigithi	4.4 (45)	Men	Domestic	2.2	Long Dry
	Endana	20.9 (43)	Men	Domestic (Sale)	9.3	Long Wet
	Ngobit	12.5 (40)	Men	Domestic (Sale)	10	Long Dry

Of the five off-farm activities surveyed, honey harvesting was reported to involve the greatest relative likelihood of contact with elephants (Table 8.1) with 91% of respondents (n = 155) that harvest honey stating that they had noticed elephants while collecting honey. This could be explained by two factors: 1) the distribution of beehives/bee nests within the study areas and; 2) the timing of the honey harvesting seasons. Honey harvesting households in the Mukogodo Forest and Kuri Kuri Group Ranch placed their man-made beehives and harvested honey from wild hives in remote parts of this forest, often in defined territories. Elephants also use these remote parts of the Mukogodo Forest. In Koija Group Ranch beehives were placed along the permanent Ewaso Ngiro and Ewaso Narok Rivers. These rivers represent the most significant natural source of water for elephants in west Laikipia, probably contributing to the high elephant densities estimated for Koija Group Ranch based on data collected during the transect survey (see chapter 5). The pattern of beehive distribution and honey hunting was similar for Ilngwezi Group Ranch, where riparian trees along the permanent Ngare Ndare River were used for hanging man-made beehives. As with Koija Group Ranch so too is the riparian belt within Ilngwezi an area of high elephant density, as shown by the results of the transect survey (ibid.). The co-occurrence of bees and elephants[43] across all of these sites is unsurprising given that both species are water dependent.

Honey harvesters within Laikipia's communal land areas noticed elephants most frequently during the main honey harvesting season (Table 8.2, Fig. 8.1) which occurs when local tree species are in full blossom (mainly *Acacia* spp. though this varies in the Mukogodo Forest), just prior to the short rains [between September and October]. This main honey harvesting season coincides with the driest time of year when elephants concentrate along Laikipia's permanent rivers and streams and within forest reserves (see Chapters Five and Seven) validating the pattern of responses among honey harvesters.

The only smallholder study site within which a substantial number of households reported harvesting honey was Ngare Ndare (see Table 8.2). This is explained by the origins of the households within this study site with many having immigrated from Laikipia's beekeeping communities, in particular the Mukogodo Forest and the adjacent group ranches. Once again a high proportion of these honey harvesting households reported noticing elephants when harvesting honey. This could again be explained by the local spatial and temporal pattern of honey harvesting. The adjacent Ngare Ndare Forest is the main source of honey for the households in this particular area, with harvesting typically occurring towards the end of the long dry season. Transect surveys and radio-tracking data show that the Ngare Ndare Forest supports relatively high densities of elephants and is clearly an important dry season refuge and source of forage underlying the pattern of response among Ngare Ndare honey harvesting households.

[43] While bees and elephants are both water dependent and thus co-occur where forms and/or intensities of human activity allow, recent research suggests that bees perhaps deter elephants from foraging on trees that harbour either man-made or wild beehives (Vollrath and Douglas-Hamilton 2002)

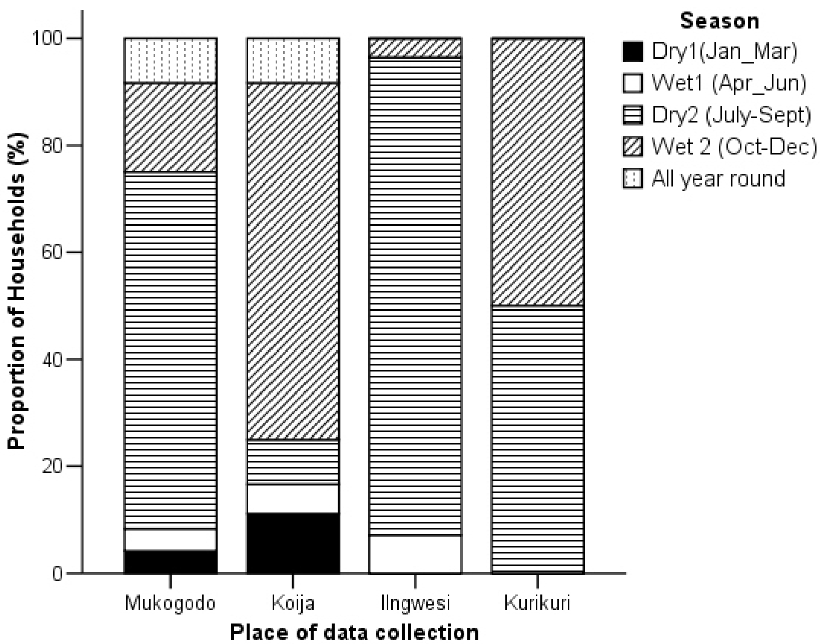


Fig 8.1 Seasons when elephants were noticed while harvesting honey in Laikipia's communal areas

8.3.3 Livestock herding

Livestock herding is another off-farm/non-farm household activity that reported a high likelihood of contact with elephants (Table 8.1). However this likelihood varied within sites, between sites and across seasons (Table 8.4). Unlike other household activities such as honey harvesting or firewood collection, livestock herding can involve both genders and several household members but who herds which animals and when is sex and age-specific (Table 8.3). This division of labour with respect to livestock husbandry defines who within the household is exposed to risk of contact with elephants and the level of that risk.

The ideal labour investment required for livestock herding within households located in Mukogodo Division was established through intensive household surveys carried out by Herron (1991) and is summarised in Table 8.3.

While a substantial number of the households surveyed by Herron (1991) diverged from the optimum or ideal livestock labour investments, with up to 47% (n = 25) of households having to rely on either an elder male or wife/wives for livestock herding, Table 8.3 does indicate the difference in *ideal* labour requirements between herding units and seasons in Mukogodo Division.

Table 8.3 Herding units and the associated 'ideal' labour investment in Mukogodo Division (adapted from Herron 1992)

Herding unit	Ideal[44] labour investment
Adult cattle (10-60 animals)	Boy of 12-14 years of age, a younger child is sufficient in the wet season when cattle do not graze far from the *boma* (corral)
Older suckling calves and small stock (50 + animals)	Boy or girl of 6-7 years of age in the wet season, older child + an adolescent boy or an adult male required in the dry season
Kids, lambs and young calves	No herder required as these are usually kept near the *boma* and tended to by women and small children

These differences were emphasized during the course of an interview with a respondent from Ilngwezi group ranch:

"*It depends with livestock. You know there are those that are herded easily and children can easily take them out to nearby places. It also depends on the way you herd. If it is in an area near to home, then the children and women will do it but if it involves travelling to far off places, say 7 to 8 miles away, then young people* [adolescent boys] *and men are likely to go. There are dangers from elephants, lions, and leopards since they feed on livestock and then the only person who can* [herd] *is an adult male. He is the one who can protect the livestock and even wrestle it back from a predator and herd the livestock away* [from danger] *when he sees elephants from a distance*."
I#9, male respondent, Laparua village [adjacent to Ilngwezi Group Ranch], September 2003.

[44] Herron did note that there were a number of households that diverged from the 'ideal' or optimum labour investment

In summary then, the division of herding labour within Mukogodo Division households varies seasonally and is dependent upon the composition of the household herd. More competent herders (i.e. older boys or men) are required for herding cattle as cattle have higher grazing requirements and thus have to be herded further away from the homestead in areas where grazing resources are more abundant. In addition a higher labour investment is required during the dry seasons when suitable pasture is likely to be located a considerable distance from the homestead. For example I observed young and older men from Mukogodo Forest households setting up temporary dry season 'grazing camps' in the Sieku valley, located approximately 15 to 20 km from their homesteads.

These patterns in the division of household labour with regard to livestock herding suggest that older boys and men are more likely to make contact with elephants during this activity. However where there are shortages in household labour, women and even children may be likely to make contact with elephant, particularly where resources are insufficient to employ hired labour.

Labour investments in livestock husbandry differed for smallholder households. More smallholder households invested in employees to herd their livestock compared with communal land households (27.4%, n = 164 and 8.8%, n = 160, respectively, $\chi^2 = 17.6$, $P < 0.001$). This was particularly apparent for households in Ngare Ndare and Tigithi study sites (32%, n = 63 and 36%, n = 39, respectively). Ngare Ndare households own on average the greatest number of livestock compared with households in any of the other smallholder study sites (mean livestock units = 34.6 ± 5.8, n = 63) and thus labour demands for livestock herding are relatively high. These relatively high labour demands are compounded by the prevailing land tenure system; occupied private land holdings in this study site dominate so despite the presence of unoccupied smallholder land, grazing resources are restricted, particularly in the dry season. As a consequence livestock have to be herded into either the nearby Ngare Ndare Forest or on pasture located in other parts of the district, a requirement that demands competent herders (i.e. older boys or men). In addition most Ngare Ndare households are engaged in cultivation (87.5%, n = 64) and thus employed herders are an important means for plugging labour deficits. The relatively high number of employed herders among Tigithi households is less easily explained because on average livestock holdings are much lower (mean livestock units = 4.9 ± 1.3, n = 44). However once again high recruitment of herders could be attributed to competing labour demands for cultivation, household labour shortages and higher affluence of Tigithi households. In both Tigithi and Ngobit, the relatively small number of livestock holdings per household, with consideration to some notable exceptions, together with the restricted grazing access (as a result of high occupation of smallholder plots), means there is generally far less demand on herders compared with Mukogodo Division and Ngare Ndare households. Indeed many households located in Tigithi and Ngobit grow sufficient fodder for livestock on their farms. In Endana however, investments in herding labour differ again. Here there are a large number of opportunistic 'squatter' pastoralists living on unoccupied smallholder land, and the overall number of households that do not cultivate is relatively high (35%, n = 43). Mean livestock holdings per household are second only to the Ngare Ndare among the four smallholder study areas (mean livestock units = 9.3 ± 2.3). Livestock grazing occurs in the extensive area of unoccupied smallholder land and where possible, local ranches, so is generally localised and less labour intensive than in Ngare Ndare or any of the communal land households.

Livestock owning households located in communal areas reported having made contact with elephants more frequently than households located in smallholder areas (95%, n = 160 and 61.5%, n = 161, respectively, χ^2 (2) = 50.9, P < 0.001). Households using Ilngwezi Group Ranch were the most likely to notice elephants while grazing their livestock, followed closely by Koija Group Ranch households. This is likely to reflect the relatively high use of both group ranches by elephants in comparison to other sample areas (see Chapter Five) as a result of the presence of both wildlife based tourism enterprises (and therefore security for elephants) and permanent rivers. The majority of Kuri Kuri Group Ranch and Mukogodo Forest households also reported having noticed elephants while grazing their livestock (Table 8.3), which could be attributed to dependence of both livestock and elephants on the Mukogodo Forest for forage.

Collectively 75% of communal land households (n = 149) reported noticing elephants while grazing livestock during the ‘short rains’, between October and December. While a survey was not carried out during the short rains specifically, results from the transect surveys presented in Chapter Five do show that elephant densities on the Mukogodo Group Ranches increase significantly after the rains, probably in response to the flush of new vegetation (i.e. grass and forbes), confirming the pattern of household responses. This pattern did vary for the Mukogodo Forest, where a substantial number of household respondents reported making contact with elephants in the dry season between July and September. This is a time when elephants move into the forest for dry season forage as was shown by the seasonal variation in elephant densities presented in chapter five.

Several Mukogodo Forest households referred to specific drought years as a time when they and their livestock competed with elephants over water (6 respondents). Under these circumstances further investments in labour were required to protect wells from being either damaged or polluted by elephants, as described by the following respondent:

“There was a time when I would scare elephants away from getting water during the dry season. I made a fire next to where the spring is located and then guarded it. In 1996 there was a shortage of water but since 1997 there has been a lot of water. We as a community had a particular spring and we would take turns protecting it.” Questionnaire #2, male respondent, Mukogodo Forest, September, 2003.

And a key informant reported:

“*Between 1991 and 1996 there was a shortage of water in the forest. The wazee* [elders] *grouped together to dig wells in the forest and then they guarded against non-group members and elephants during the dry season. They defended against elephants by building fires next to the wells which they would take turns in guarding.*”
Key informant # 3, male respondent, Mukogodo Forest, September 2003.

According to these respondents and other local informants, livestock herders had not had to defend their water sources from elephants in the Mukogodo Forest since water became abundant after the El Nino rains in 1998 (suggesting a substantial increase in the water table). However competition over water sources during dry periods was reported by households, informal interview respondents and key informants from Ilngwezi and Kuri Kuri Group Ranches and in the Ngare Ndare Forest (Q#96, Q#98, I#8 and Q#50 respectively). Indeed one respondent from Ngare Ndare reported using knowledge of elephant movement patterns to avoid conflict incidents:

"*Elephants have routes inside the forest that they use to go to water*. *Elephants also have a day that they stay without drinking water and that is when I take my livestock to get water*." Questionnaire #50, Male respondent, Ngare Ndare, October 2003.

Previous research into human-elephant conflict using Kenya Wildlife Service occurrence book records suggests that access to water represents the main conflict between people and elephants in Laikipia's pastoralist areas (Thouless, 1994), thus confirming comments made by questionnaire respondents and key informants.

Among smallholder sample areas, Ngare Ndare had the greatest proportion of households that reported noticing elephants while herding livestock (Table 8.4). This, combined with the reported temporal pattern of contact with elephants during livestock herding among Ngare Ndare households, with 58% (n = 43) stating they had noticed elephants between July and September and the majority of the remainder stating they had seen elephants in October, suggests a common dependence among elephants and livestock on the Ngare Ndare Forest during the dry season.

There was a less obvious pattern of response among households in Tigithi, Ngobit and Endana (Fig 8.2). This could be attributed to the relatively more localised movements of elephants in these latter sites. Elephants living in these areas are believed to be largely resident on the neighbouring large-scale ranches (Thouless, 1996a) resulting in a potential likelihood of contact between elephants and livestock herders that is probably similar throughout the year. However it is important to consider that elephants were rarely if ever observed in any of the four smallholder sample areas during the day, a pattern confirmed by the information on crop-raiding systematically collected over the course of the fieldwork period (see Chapter Six). As a consequence contact with elephants and smallholder livestock herders would only be likely if those herders were illicitly herding their livestock into the neighbouring ranches during the day. I observed the latter on several occasions over the course of the fieldwork period. In addition the illicit use of ranch pasture by local livestock owners was confirmed by local ranch employees, other key informants and during the course of interviews (Box 8.1) and it is likely that respondents were referring to such occasions when they noticed elephants. The relatively high proportion of Ngobit households that reported noticing elephants while herding livestock during the dry season months between July and September could be attributed to the presence of the permanent Ngobit River which marks the boundary between smallholder settlement and Ol Pejeta Ranch. It is possible that elephants in Ol Pejeta were observed by the neighbouring smallholder households at this river during these dry season months.

Box 8.1: Statements made by informal interview respondents regarding illicit grazing in ranches

"Again on the side of livestock, before in [redacted] *[name of a large-scale ranch] people used to sell grass. The security used to organise with the outsiders [local community members neighbouring the ranch], because they are the ones who know when* [redacted] *and* [redacted] *[names of the ranch manager and head of security respectively] do their rounds. In some places, for instance a place called* [redacted] *[name of a specific site on a particular ranch] up the other side they know* [redacted] *[head of security] cannot come the following day after his patrol. So they take advantage and communicate with the livestock owners and give an indication of where they should graze and for what duration of time and when they must move out. When* [redacted] *[head of security] comes he will meet me and ask: "how are you?" "I am fine." "How is the work?" "Everything is okay." and off he goes without noticing anything. Such things happen in these ranches."*

I#10, male respondent, former ranch employee, Endana, November, 2003

"*Now they [local community members neighbouring a private ranch] don't take their cattle in large numbers but I can't say one hundred percent."*

I#3, male respondent, smallholder, Tigithi, November, 2003

Table 8.4: Summary of household profile data for patterns of livestock grazing and the proportion of households reporting contact with elephants as a consequence of herding activities

Land-tenure	*Site*	*% HH livestock (n)*	*Who grazes*	*Wet season grazing*	*Dry season grazing*	*% HH contact with elephants*	*Season of greatest contact*
Communal	Mukogodo	97.4 (39)	Men, Women, Children, (Employees)	**Forest**	**Forest**	87.2	Short rains Long dry (Short dry)
	Koija	97.7 (42)	Men, Women, Children	**Group Ranch**	**Group Ranch**	97.6	Short Rains
	Ilngwezi	100 (40)	Men, Women, Children	**Group Ranch** (Trustland)	**Group Ranch** (Trustland)	100	Short Rains
	Kuri Kuri	97.6 (42)	Men, Women, Children	**Group Ranch**	**Forest Reserve** (Group Ranch)	90.5	Short Rains Long Dry
Smallholder	Ngare Ndare	98.4 (64)	Employee, Men, Women, Children	**Unoccupied Land**	**Forest Reserve** (Unoccupied land)	71.2	Long Dry Short Rains
	Tigithi	86.7 (45)	Men, Women, Children (Employee)	**Unoccupied Land**	**Unoccupied Land**	53.3	Long Rains Long Dry (Short Rains)
	Endana	65.1 (43)	Women &Children Employees Men	**Unoccupied Land**	**Unoccupied Land**	30.2	Long Rains Short Rains
	Ngobit	85 (41)	Men, Women & Children	**Own Farm** (Unoccupied land)	**Unoccupied Land**	40	Long Dry Short Rains

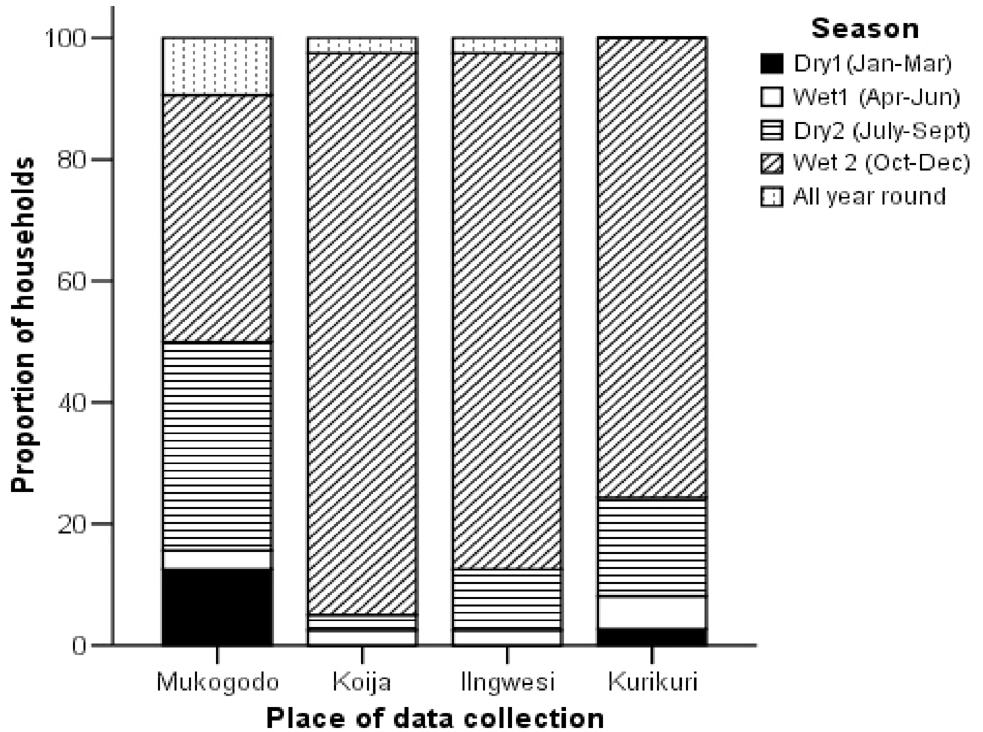


Fig 8.2 Seasons when respondents located on communal lands reported making contact with elephants while herding livestock

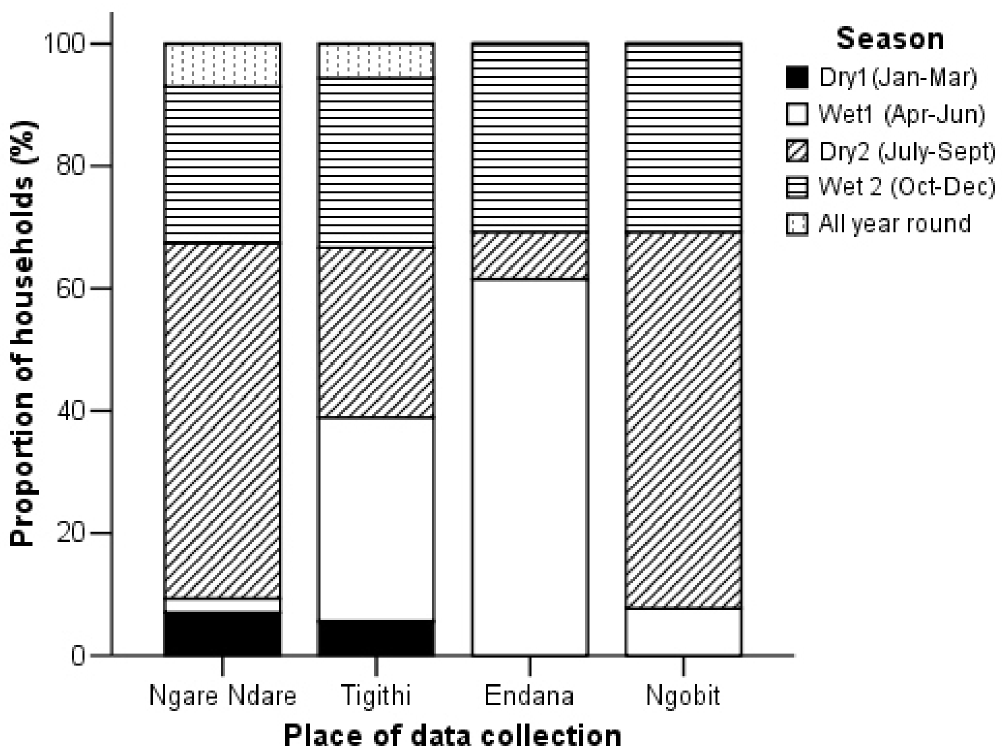


Fig 8.3 Seasons when respondents located in smallholder areas reported making contact with elephants while herding livestock

8.3.4 Drinking water collection

Among the households surveyed, collection of drinking water was an activity carried out almost exclusively by women and children. The relative likelihood of contact with elephants during drinking water collection was lower than during honey harvesting or livestock herding but was still substantial (Table 8.1). Once again significantly more communal land households claimed to have noticed elephants while collecting drinking water than smallholder households (68.7%, n = 163 and 30.4%, n = 191, respectively, $\chi^2 = 50.3$, $P < 0.001$). However this likelihood was clearly context-specific and very much dependent on the source of drinking water used.

Across the sample of households surveyed, the most frequently cited source of drinking water was a local river, followed by boreholes and springs. Additional, though less important sources of drinking water were dams and rainwater. The latter source was collected off corrugated roofs with guttering feeding into a holding tank, many of which had been provided by local aid organisations.

Collection of drinking water from springs entailed the greatest likelihood of contact with elephants relative to the proportion of households using that source, followed by boreholes and rivers while collecting drinking water from dams or collected rainwater, involved the lowest likelihood of making contact with elephants (Fig 8.4). The likelihood of contact with elephants associated with a particular drinking water source did, however, vary between sites (Fig 8.5). This was most conspicuous in the case of rivers, where a high proportion of communal land households in Koija and smallholder households in Tigithi reported making contact with elephants while collecting drinking water compared to relatively few in all six other sites (Fig. 8.5 a).

Table 8.5: Summary of household profile data for patterns of drinking water collection and the proportion of households reporting contact with elephants during drinking water collection

Land-tenure	*Site*	*% HH collecting drinking water(n)*	*Who collects*	*Source*	*% HH contact with elephants*	*Season of greatest contact*
Communal	Mukogodo	100 (39)	Women Children (Men)	**Spring** (Borehole)	49%	Short Rains Long Dry (All year)
	Koija	100 (42)	Women Children	**River**	95.2%	Short Rains
	Ilngwezi	100 (40)	Women Children (Men)	**River** (Spring)	45%	Short Rains
	Kuri Kuri	100 (42)	Women Children (Men)	**Borehole** (Rainwater)	83%	Short Rains
Smallholder	Ngare Ndare	100 (63)	Women Children (Men)	**Borehole** (River)	19%	Short Rains
	Tigithi	97.8 (45)	Women Children (Men)	**River**	64.4%	Short Rains
	Endana	93 (43)	Women Children (Men)	**River** (Rainwater)	16.2%	Long Dry Short Rains
	Ngobit	95 (40)	Women Children (Men)	**River** (Rainwater Borehole, Dam)	25%	Long Dry Short Rains

Although Koija and Tigithi are located a substantial distance apart, households in both sites rely almost exclusively on the Ewaso Ngiro River for their drinking water. The importance of the Ewaso Ngiro River for elephants in and around Koija Group Ranch has been discussed (Chapter Five). However the Ewaso Ngiro River also acts as the boundary between Ol Pejeta Ranch and the Tigithi smallholder area so that here too it is shared by both people and elephants. While there are no alternative sources of water for elephants on Koija Group Ranch and relatively limited alternative water sources on the adjacent private ranches, there are many alternative sources of water for elephants on Ol Pejeta Ranch (i.e. water tanks, dams and other rivers) and so the high likelihood of contact with elephants reported by Tigithi households is less easily attributable to elephant dependence on Ewaso Ngiro River for drinking water. Radio-tracking results suggest that the riparian land adjacent to the Ewaso Ngiro River and abutting the Tigithi smallholder area is used both as a corridor for movement south and as a crop-raiding platform (see chapter 7) which may explain the high reported occurrence of contact between household members collecting drinking water and elephants in this particular site.

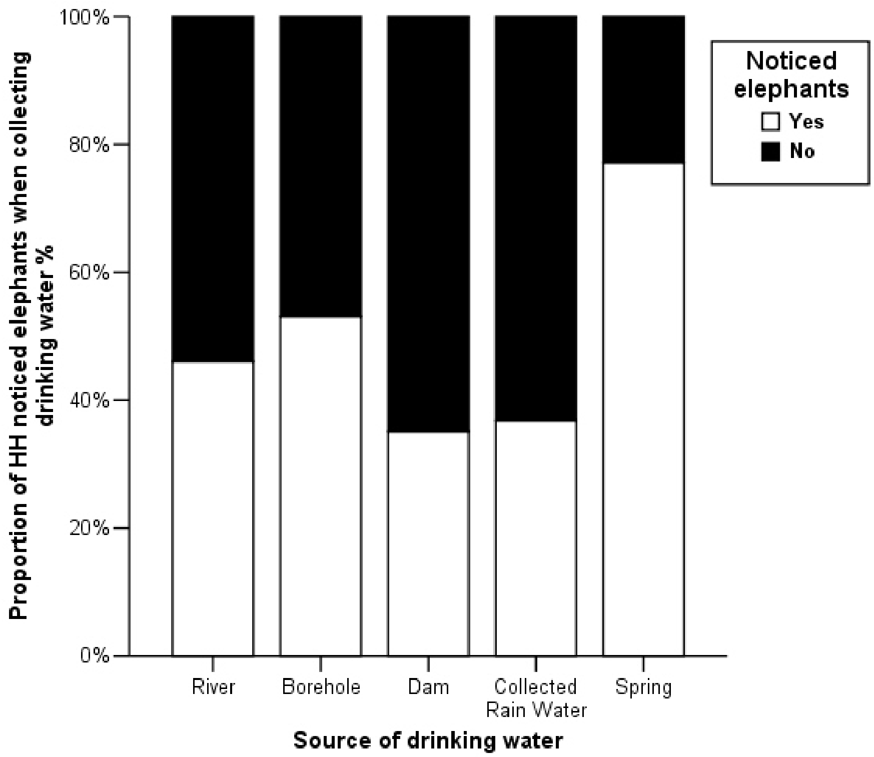


Fig. 8.4 Relationship between source of drinking water and the likelihood of contact with elephants while collecting drinking water for all households (n = 354)

Most of the Ngare Ndare households that depend on a river for drinking water use a section of the Ngare Ndare River that is located just north and outside of the gazetted Ngare Ndare Forest Reserve. As discussed in Chapter Six and Seven, this forest reserve is surrounded by possibly one of the most effective electrified fences in the Laikipia region, enforced through controlled shooting of fence breaking elephants by local wildlife managers (Thouless & Sakwa, 1995) confirming the pattern of response among Ngare Ndare households.

The low proportion of Ilngwezi households that reported making contact with elephants while collecting drinking water from a river was unexpected. This result can be attributed to the presence of a small permanent stream (the Laparua River rather than the main Ngare Ndare River that formed the baseline for carrying out transect surveys in Ilngwezi Group Ranch) that flows through and is largely controlled by settlements containing a high proportion of the households included in the sampling frame for Ilngwezi Group Ranch. As surface flow from this stream is confined to a relatively small area that has been settled and cultivated, it is relatively inaccessible to elephants.

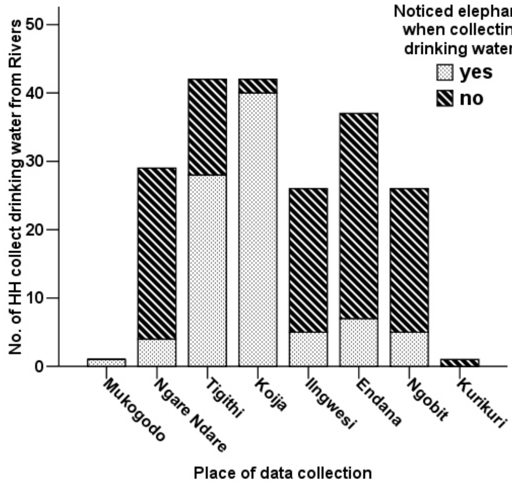
While the Ewaso Ngiro River also flows through the Endana study site, elephant use is restricted by the presence of an electrified fence north of Endana and the presence of relatively high densities of homesteads within the riparian belt and so the likelihood of making contact with elephants for Endana households using the Ewaso Ngiro River is relatively small. The low proportion of contact with elephants reported by Ngobit households using the Ngobit River for drinking water may appear intriguing, particularly as this river, like the case of the Ewaso Ngiro River and Tigithi, marks the boundary between Ngobit smallholder households and Ol Pejeta Ranch. However the difference in the pattern of household responses between the two smallholder land units is explained by the presence of an irrigation furrow in Ngobit which in effect provides local people with access to drinking water away from the main Ngobit River channel, thereby reducing the likelihood of contact with elephants during drinking water collection.

Use of natural springs for the collection of drinking water, proportionally resulted in a higher likelihood of contact with elephants than the use of any other source of drinking water (Fig. 8.5 c). Households in just four study areas used natural springs. Respondents in Kuri Kuri, Ilngwezi and Mukogodo all used springs in the Mukogodo Forest while just one Ngare Ndare household reported using natural springs in the Ngare Ndare Forest. These springs are clearly an important source of drinking water for elephants, particularly in the dry season when elephants move into the forests, which probably explains the high likelihood of interaction reported by households using these same sources of drinking water.

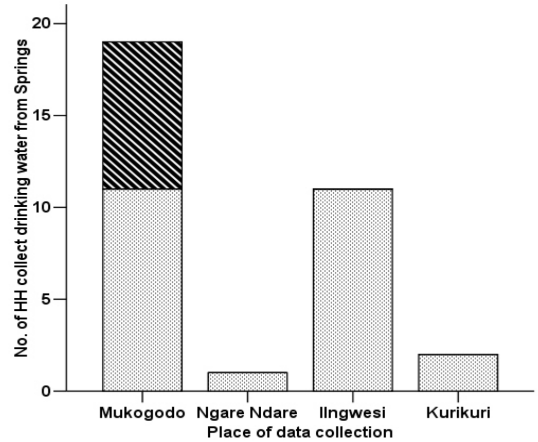
The proportion of household using boreholes that reported noticing elephants was relatively low in the Mukogodo and Ngare Ndare sample areas and relatively high in Kuri Kuri. The pattern of responses among households in both the Mukogodo and Ngare Ndare sites could be attributed to the characteristics of the boreholes used in these sites which are a) located within settlements and b) need to be hand operated and are thus inaccessible for elephants. However the borehole used by the majority of Kuri Kuri Group Ranch household respondents is located adjacent to a dam used frequently by elephants, which also explains the pattern of responses among Kuri Kuri households using dams illustrated in Fig. 8.5 d.

Most respondents claimed to have noticed elephants while collecting drinking water during either the long dry season between July and September or during the short rains between October and December (22.5% and 63.6% respectively, n = 151).

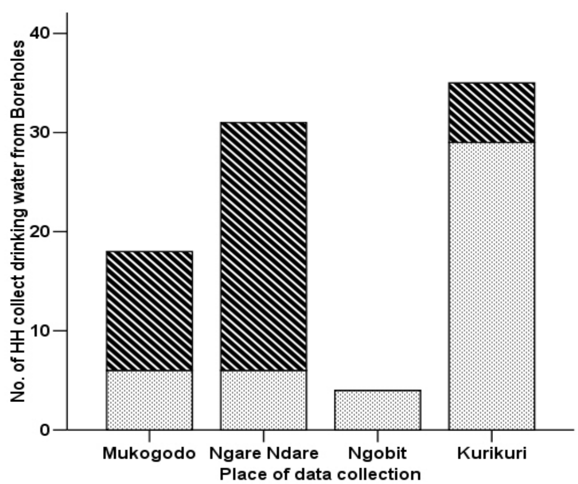
a. Rivers



c. Springs



b. Boreholes



d. Other Sources (Dams and Rainwater)

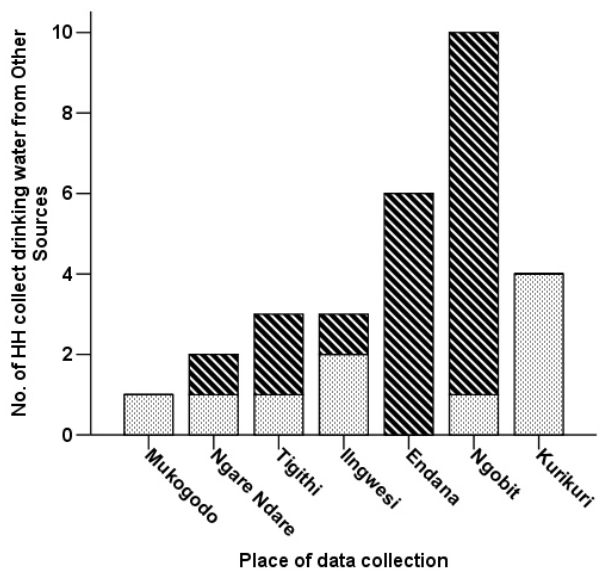


Fig. 8.5 a, b, c and d. No. of households in each study site that use one of four drinking water sources and the proportion of those households that made contact with elephants while collecting drinking water.

8.3.5 Firewood collection

Ninety-eight percent of respondents reported using firewood for cooking (97.8%, n = 356). The collection of firewood, like the collection of drinking water, is another domestic task carried out exclusively by women and children among local households in

Laikipia. More households reported making contact with elephants as a result of firewood collection than as a result of any of the other four off-farm activities surveyed and the reported relative likelihood of contact with elephants during firewood collection (i.e. the number of households that noticed elephants while collecting firewood/the number of households that collect firewood) was only slightly lower than for livestock herding (Table 8.1). Like drinking water collection, gathering of firewood is a daily chore but firewood, unlike drinking water, is often scarce near to the homestead, necessitating long excursions that inevitably increase with higher rates of extraction, explaining the difference in the reported relative likelihood of contact with elephants between the two activities. A very high proportion of communal land households and a smaller though still substantial proportion of smallholder households reported making contact with elephants while collecting firewood (Table 8.6). Differences between communal land survey sites in the proportion of households noticing elephants while gathering firewood is most probably explained by patterns in elephant distribution and abundance given that firewood availability and patterns of extraction are probably similar across these sites. However differences between smallholder sites exemplify differences in the source of firewood used. For example a high proportion of Ngare Ndare household respondents reported noticing elephants while collecting firewood because the source of firewood for these households is the Ngare Ndare Forest which harbours relatively high numbers of elephants. For Ngare Ndare households the presence of elephants can impede women from gathering firewood as was illustrated by the following comment made by an interview respondent:

"*A week ago my wife came back home without firewood because of elephants and there have been many other times*"

Questionnaire # 50, Male respondent, smallholder, Ngare Ndare, October 2003

As with livestock herding, the reported occurrence of contact with elephants among the other three smallholder study sites while collecting firewood is less easy to explain from an exploration of the *reported* sources of firewood. This is because elephants are rarely if ever present on all three of these smallholder areas during the hours of daylight when women and children typically gather firewood. Thus it is likely the nearby large-scale ranch, where elephants are present during the hours of daylight was a source of firewood for those households that reported making contact with elephants and that respondents were unwilling and perhaps uncomfortable with openly stating that they were accessing the local ranch for this purpose. Conversations with key informants confirmed that the adjacent ranch is indeed an important source of firewood for smallholder communities (I#2, I#3 and I#10). One questionnaire respondent specifically referred to the likelihood of noticing elephants when collecting firewood from Ol Pejeta Ranch despite stating that he bought firewood:

Interviewer: *"In the last year have you or whoever collects firewood noticed elephants when collecting firewood"*

Respondent: "Yes *during those days that Ol Pejeta let us collect firewood*."
Questionnaire # 94, male respondent, smallholder, Ngobit, October 2003.

Generally the local ranches are a less important source of firewood for Endana households as unoccupied smallholder land is extensive here and thus firewood is locally abundant.

Table 8.6: Summary of household profile data for reported patterns of firewood extraction and the proportion of households reporting contact with elephants during firewood collection

Land-tenure	*Site*	*% HH use (n)*	*Who collects*	*Source*	*% HH contact elephants (n)*
Communal	Mukogodo	100 (39)	**Women**, (Children)	**Forest Reserve**	92.3 (36)
	Koija	100 (42)	**Women**	**Group Ranch**	97.6 (41)
	Ilngwezi	100 (40)	**Women**	**Group Ranch** (Trustland)	100 (40)
	Kuri Kuri	100 (42)	**Women**	**Group Ranch , Forest Reserve**	88 (37)
Smallholder	Ngare Ndare	98.4 (64)	**Women**	**Forest Reserve,** (Own Farm)	65.6 (42)
	Tigithi	93.3 (45)	**Women**	**Own Farm Absentee land** (Private Ranch?)	77.8 (35)
	Endana	97.6 (43)	**Women**	**Absentee land** (Private Ranch?)	32.6 (14)
	Ngobit	87.5 (40)	**Women**	**Own farm Absentee land** (Buy locally, Private Ranch?)	52.5 (21)

8.3.6 Wild plant harvesting

Wild plants are harvested by households in Laikipia District under different circumstances and for different reasons. Some seasonally available fruits such as *Sanangur* (*Scutia myrtina*) and *Lamuriak* (*Carissa spinarum*) are harvested opportunistically. Household respondents reported that these seasonal fruits were collected by children or during livestock herding. Some household respondents distinguished these fruits from ‘food’, possibly illustrating perceptions of their relative insignificance in terms of overall household dietary requirements. Other plants, also seasonally available, were clearly a more significant source of food and were deliberately sought after, harvested and included within household meals. This was certainly the case with smallholder households. For example in Ngobit several households reported using a variety of wild spinaches including *Managu* (*Solanum nigrum*) and/or *nterere* (*Amaranthus graecizans* or *Amaranthus curentus*). These grow near or in household cultivated plots as weeds. However of the households that reported harvesting wild plants, most did so for medicinal purposes. Medicinal plants are used to treat a range of illnesses and were often the only form of medicine readily available for a large number of households, particularly in the communal land areas. My research coincided with a UK government funded project on indigenous plant-based healing, carried out by Anne Powys and Leslie Duckworth (Powys & Duckworth, 2006). Some of the unpublished data they collected in Laikipia (among the Mukogodo people) is presented in Appendix 5, and demonstrates the depth of knowledge among local people on plant uses.

Knowledge and use of wild plants varied across the study sites (Table 8.7). Households in communal land areas reported harvesting plants more frequently than smallholder households (χ^2 (2) = 20.3, $P < 0.001$), though this difference was greater for medicinal plant use (95.1% of communal land households compared with 59.4% of smallholders, χ^2 (2) = 58.9, $P < 0.001$) than for wild food plant use (77.2% of communal land households compared with 62% of smallholders, χ^2 (2) = 8.8, $P < 0.01$). Through personal observations, many of the people living in Mukogodo division possess an almost encyclopedic knowledge of wild plants and wild plant uses (also previously documented by Brenzinger et al., 1994) and traditional healers with knowledge of locally available medicinal plants are often consulted by Mukogodo households. This is in sharp contrast to a number of the smallholder households surveyed, captured by the following comment made by a household respondent in Tigithi:

"*I don't use medicinal plants because there is a cheap dispensary here and good* [conventional] *medicine is available."* Q#169, male respondent, smallholder, Tigithi, October 2003.

Thus the form and pattern of plant use among households appeared to be a function of resource use traditions, resource availability and in some study sites, the availability of alternative medicine. This had implications for plant harvesting households in terms of their likelihood of contact with elephants (Table 8.7). Among Mukogodo households, where plants represent an important household resource (i.e. medicine) that sometimes entail purposive forays into elephant habitat, the likelihood of contact with elephants was higher compared with smallholder households (77.9% of communal land households noticed elephants while harvesting wild plants compared with 23.6% of smallholder households, $\chi^2 = 101.8$, $P < 0.001$). Among the four communal sites there was little difference in the pattern of plant harvesting and likelihood of contact with elephants during harvesting, with the exception of Kuri Kuri Group Ranch. Dol Dol Town is located adjacent to Kuri Kuri Group Ranch, reducing the dependence on wild plants for medicine and perhaps reducing the incentive for harvesting wild plants for food. Smallholder study sites households in Tigithi and Ngobit reported using plants for food more frequently than they reported using plants for medicine. The opposite pattern was evident in Endana and Ngare Ndare sites, where there were a greater proportion of households with medicinal plant use traditions (i.e. Samburu, Mukogodo Maasai, Turkana and Pokot people with origins in places where conventional medicine is unavailable or scarce). There was little difference in the likelihood of contact with elephants between smallholder study sites, probably representing the localised nature of plant harvesting within these sites (i.e. close to the farm).

Table 8.7: Summary of household profile data for patterns of plant use and the proportion of households reporting contact with elephants during plant collection

Land-tenure	***Site***	***% HH use (n)***	***Who collects***	***Purpose of use***	***Patterns of use***	***Source***	***% HH contact elephants (n)***
Communal	Mukogodo	100 (39)	Women, Men, Children	Medicine(1) Food(2)	Needed Seasonal	**Forest Reserve**	74.3 (29)
	Koija	100 (42)	Women, Men, Children	Medicine(1) Food(2)	Needed Seasonal	**Group Ranch**	83.3 (35)
	Ilngwezi	100 (40)	Women, Men, Children	Medicine(1) Food(2)	Needed Seasonal	**Group Ranch** (Trustland)	85 (34)
	Kuri Kuri	80.9 (42)	Women, Men, Children	Medicine(1) Food(2)	Needed Seasonal	**Group Ranch** (Forest Reserve)	69 (29)
Smallholder	Ngare Ndare	84.3 (64)	Women, Men, Children	Medicine(1) Food(2)	Needed Seasonal	**Forest Reserve**	25 (16)
	Tigithi	60 (45)	Women	Food(1) Medicine(2)	Available Needed	**Own Farm** (Unoccupied land)	24.4 (11)
	Endana	83.7 (43)	Women	Medicine(1) Food(2)	Needed Available	**Unoccupied land**	18.6 (8)
	Ngobit	80.4 (40)	Women	Food(1) Medicine(2)	Available Needed	**Own farm** (Unoccupied land , buy locally)	24.4 (10)

8.3.7 Composite score for the likelihood of contact with elephants

To summarise the main findings for this chapter and to generate an independent variable to test against perceptions of elephants in the next chapter, a composite index of the likelihood of contact with elephants during off-farm activities was calculated. This index was calculated for each household by summing the values of the reported occurrence (1) or absence (0) of contact with elephants for each of the five off-farm household activities surveyed. The resulting values ranged from 0 to 5 and were subsequently recoded to reflect varying degrees of interaction with elephants across the five off-farm activities as follows: 0-1= low; 2-3 = medium; and 4-5 = high. While not a measure of the frequency of contact between people and elephants this index does incorporate the probability of interaction between people and elephants across a range of household activities performed by different members of the household (i.e. both women and men of different ages). Therefore this index provides a useful proxy for reported exposure to contact with elephants for the *entire* household, rather than just for any specific activity or for any one individual.

The distribution of composite scores for the likelihood of contact with elephants was as expected from the patterns described above, and show that communal land households in Laikipia were substantially more likely to make contact with elephants during off-farm activities than were smallholder households, with 73% reporting they had made contact with elephants during four or more separate off-farm activities compared with just 9.3% of smallholder households (χ^2 (2) = 163.14, $P < 0.001$, n = 356). While Koija and Ilngwezi had the first and second highest proportion of households that reported having made contact with elephants across all five of the activities surveyed, generally there was relatively little difference in the distribution of the three composite scores for the likelihood of contact with elephants across the four communal land sites (χ^2 (6) = 7.8, P = 0.251, n = 163) and most households in these sites reported making contact with elephants during most if not all of the five off-farm activities surveyed. In contrast there were significant differences between the four smallholder sites (Fig. 8.6; χ^2 (6) = 30.8, P < 0.001, n = 193). These differences were illustrated in the activity specific analyses, with households in Ngare Ndare and Tigithi noticing elephants during off-farm activities more frequently than households in either Endana or Ngobit.

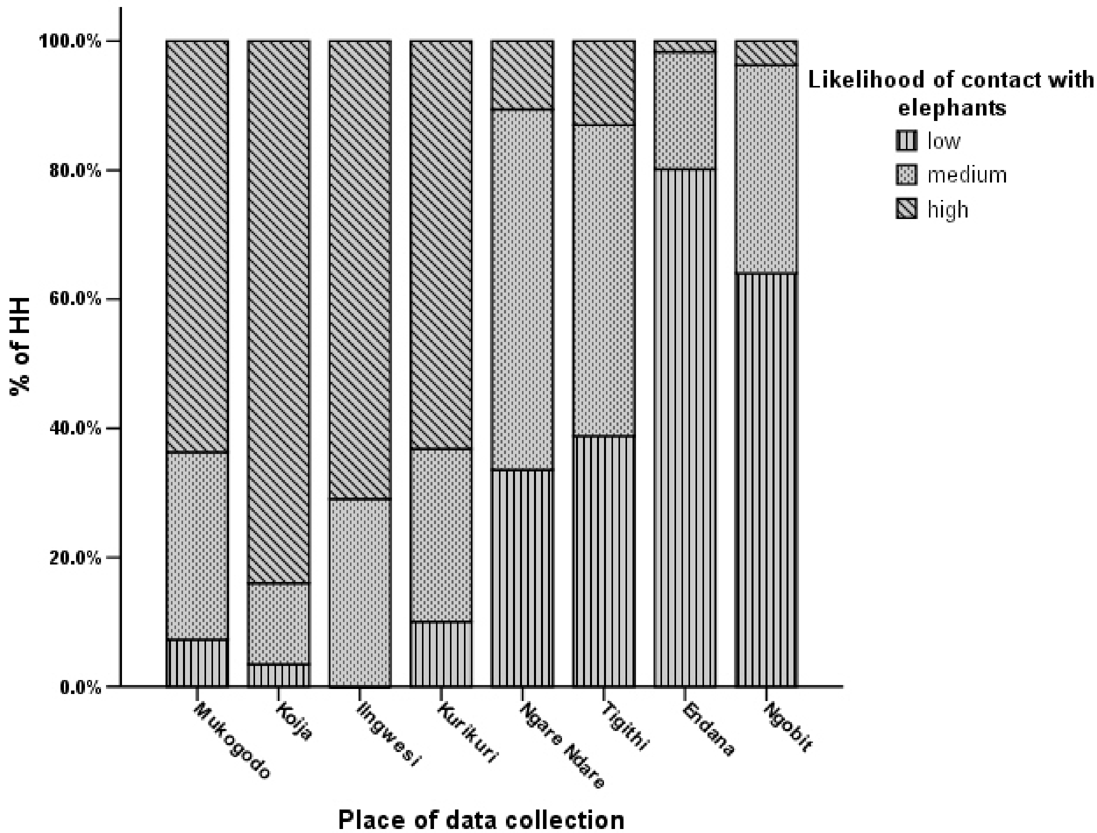


Fig. 8.6 Proportion of households that reported making contact with elephants during 0-1, 2-3 and 4-5 of the household activities surveyed (coded as low, medium and high likelihood of contact with elephants, respectively)

8.4 DISCUSSION

Differences in the likelihood of contact with elephants between land-tenure contexts and between individual survey sites in Laikipia are the result of three factors:

1) Differences in patterns of resource use between households;
2) Differences in the availability and nature of the natural resources used; and
3) The distribution and movement patterns of elephants across the survey sites.

Starting with the first of these factors, communal land households were very clearly involved in a wider range of off-farm resource use activities to meet their household needs compared with smallholder households. This range of activities sometimes results in members of communal land households travelling long distances away from their homes. For example the district's honey harvesters, typically male members of communal land households, travelled to beehives/wild bee nests within forests or riparian woodlands. In addition, communal land households own substantial numbers of livestock and are thus generally more mobile than smallholders (with the exception perhaps of some smallholder households in Ngare Ndare and Endana), with herders, typically older boys or men often travelling long distances to find pasture or water for their livestock. Lastly communal land households are more dependent on local plants for medicine than the recently settled smallholders, which can entail moving beyond the immediate household sphere. In summary, members of the communal land households surveyed spent more time away from home carrying out off-farm livelihood activities, which involved moving through elephant habitat and therefore entailed a greater likelihood of contact with elephants, compared with the relatively more sedentary smallholder households surveyed.

The source of the resources used by local people demonstrated a clear relationship to the relative likelihood of contact with elephants. For example, natural sources of drinking water within particular contexts entailed a greater likelihood of contact with elephants than man-made sources. This was illustrated in the case of the Mukogodo Forest where household respondents that used natural springs for their drinking water reported making contact with elephants more often than the respondents that used the local borehole. The Ewaso Ngiro River, represented a major contact point for elephants in two sites (Tigithi and Koija), but for different reasons. The sources of firewood used also produced different probabilities of contact with elephants. This was clearly illustrated in Tigithi and Ngobit where high local levels of extraction resulted in limited local availability of firewood encouraging households to extract (with and without permission) firewood from the neighbouring ranch, and thus a relatively high proportion of households in these sites reported making contact with elephants during firewood collection compared with during any of the other four off-farm household activities. Similarly for Ngare Ndare households, dependence on the neighbouring forest reserve for firewood contributes to the high proportion of households making contact with elephants when gathering firewood.

Interaction with elephants in some sites clearly had a strong temporal dimension, relating to seasonal resource use patterns and the seasonal movement patterns of elephants. This was illustrated in the case of honey harvesting households, which typically reported making contact with elephants during those drier months (September and October) just prior to the short rains when elephants concentrate in Laikipia's forests or along the perennial rivers, both important sites for traditional bee keeping/harvesting. Perhaps the most obvious seasonal pattern of contact between households and elephants recorded during this study is during the short rains between October and December when herders with their livestock and elephants converge on Laikipia's group ranches in response to the flush of new vegetation. While the short rains was the most frequently cited season of contact with elephants for livestock herders in Laikipia's group ranches, this is not a period associated with high conflict between herders and elephants (Thouless, 1994) suggesting that high contact with elephants does not necessarily result in 'conflict'. This unexpected result will be further explored in the next chapter which focuses on perceptions of elephants as a wildlife pest.

Chapter 9: Human perceptions of elephants and risk among Laikipia households

9.1 INTRODUCTION

In the previous chapter the likelihood of interactions between people and elephants was explored in relation to each of five off-farm activities. The majority of households surveyed in Laikipia experience interactions with elephants and a substantial number, particularly those located in communally owned group ranches and in the Mukogodo Forest, make contact with elephants during most if not all off-farm activities. This high likelihood of contact means that in such locations, several members of a single household are reported interacting with elephants. In this chapter, I assess how perceptions of elephants are shaped by, among other factors, experience of this interaction with elephants.

Experience or perceived experience of loss is, perhaps unsurprisingly, a factor commonly associated with negative attitudes towards wildlife and/or conservation more generally and is believed to shape perceptions of risk (Hill, 2004). For example, a study in Botswana found that experience of crop-damage strongly influenced negative attitudes towards wildlife (Parry & Campbell, 1992). Past experience or perceived experience of this and/or other forms of negative interaction with wildlife was also found to be important in shaping attitudes towards several protected areas in Tanzania (Newmark et al., 1993), predicting tolerance towards a recovering wolf population among rural people in Wisconsin, U.S.A (Naughton-Treves et al., 2003) and towards cheetahs among a sample of Namibian farmers (Marker et al., 2003). Recognition of the influence of the experience of human-elephant conflict on conservation attitudes towards elephants and the potential consequences this could have on elephant populations has led to calls for new management approaches where the "objective should be to reduce it [HEC] to a level that local people can tolerate" (Hoare, 2000). Of course conflict is just one form of interaction and as was shown in the last chapter, human-elephant interaction can in fact take many forms and can occur under a range of different circumstances. Thus in this chapter several variables were generated to capture several different forms of experience of human-elephant interaction, with each variable tested against perceptual indices representing the perceived magnitude of elephants as a wildlife pest species. The first of these independent variables was based on results from the last chapter in the form of a single composite index of the likelihood of contact with elephants during five off-farm activities. The presence or absence of an experience of trying to scare elephants away is used as another independent factor to assess perceptions of elephants as a wildlife pest. Perceptions of wildlife are not necessarily always a function of actual loss or negative experiences but can also be shaped by the degree to which a wildlife species is considered dangerous (Hill, 2004, Naughton-Treves & Treves, 2005) and so the presence or absence of knowledge of a person that had been either killed or injured by an elephant was also another variable used in this chapter to assess the distribution of perceptions of elephants among Laikipia households.

Previous research has shown that socio-economic variables can be significant in shaping conservation attitudes. For example positive perceptions of wildlife among people living around the Selous Game Reserve in Tanzania were influenced by the gender, wealth and/or education of respondents, with more educated or wealthier respondents more likely to perceive wildlife as a source of benefits, while women were less likely to be positive about wildlife than men (Gillingham, 1998, Gillingham & Lee, 1999). Conservation attitudes were also linked to wealth and education in an attitudinal survey in Natal in South Africa (Infield, 1988). In a recent study of ranchers' attitudes towards jaguars in the Pantanal of Brazil, older respondents appeared to hold more negative attitudes towards jaguars than did younger respondents (Zimmermann et al., 2005). Thus perceptions of elephants among household respondents in Laikipia were also explored against several socio-economic variables, including the wealth, education, age and gender of household respondents.

Recognition of the inequitable distribution of benefits accrued from wildlife in relation to the costs borne by wildlife (Ghimire & Pimbert, 1997) contributed to the ascent of integrated conservation and development approaches in which rural communities were encouraged to participate in, benefit from and support wildlife conservation (Anderson & Grove, 1987, Wells & Brandon, 1988, Western et al., 1994). In Laikipia this integrated approach is well established and local communities have received benefits from both consumptive (zebra culling revenue) and non-consumptive use of wildlife (eco-tourism), typically through partnership with local ranches, often fostered by the Laikipia Wildlife Forum, a local conservation N.G.O. Thus in this chapter the relationship between reported access to wildlife benefits and perceptions of elephants as a wildlife pest is also explored.

So as to contextualise perceptions of elephants within a wider arena of livelihood challenges and associated perceptions, this chapter first explores and compares the ranks assigned to livelihood constraints identified by household respondents in Laikipia.

9.2 METHODS

9.2.1 Quantitative data analyses

In this chapter I further analyse results from the questionnaire survey and qualitative material described in Chapter Three. All quantitative analyses in this chapter were carried out using SPSS v. 12. Perceptions of the relative impact of different livelihood constraints (including the perceived relative threat presented by different species of wildlife) were analysed using descriptive statistics (SE in this chapter are presented as ±) and simple cross-tabulations. Results are presented as the percentage frequency of respondents giving each response. To facilitate analyses of the distribution of responses to ranking questions across groups, a weighted rank index (WRI) was calculated for each response using the following formula (Gillingham & Lee, 2003, Nepal & Weber, 1993):

$$WRI = \sum_i^n (1/R_i)/N$$

Where: n = number of respondents, R_i = rank of the ith order and N = total number of respondents in the sample.

WRI values were calculated to measure the perceived relative significance of each form of livelihood constraint cited and each wildlife pest species cited across the entire sample and to assess differences in perceptions among land-use/tenure types and the eight focal study areas

To assess the significance of a range of factors in shaping household perceptions of elephants as a wildlife pest, the ranks assigned to elephants by households in terms of potential for loss relative to other pest species were binary coded into high (1-3) and low (>3) values. The frequency distribution of these two values was subsequently examined in relation to each of nine independent variables using simple cross-tabulations and chi-squared tests. These independent variables included age, household wealth, livestock wealth, education, gender, land use, access to wildlife benefits, perception of who owns elephants, knowledge of people that had been killed or injured by elephants and experience of trying to scare an elephant away from crops. Details of the data and results from these bivariate analyses are presented in Appendix 6, Tables I to III and are summarised in Table 9.6 in this chapter. Results from these preliminary analyses were used to select variables for inclusion within logistic regression analyses. This analytical approach was used on three separate samples of household responses producing three different sets of results. The first analysis was carried out on the entire sample of household respondents. The entire household sample was then stratified into communal-land and smallholder groups to generate the second and third analyses, respectively.

For logistic regression analyses, entry and exit of variables were specified by the Wald statistic with probabilities of 0.05 and 0.1, respectively. Goodness of fit of the models was assessed by calculating the area under the curve of the receiver operating characteristics plots (see Chapter Six, section 6.2.3).

9.2.2 Wealth indicators

Generating wealth indicators for households in Laikipia required careful consideration principally for two reasons. Firstly, due to the sensitivities of land ownership in the study area, with a large proportion of the households living on sub-divided ranches on Laikipia not owning the land they live on nor the land they cultivate nor indeed the land used for grazing their livestock, household responses to questions regarding land owned or under cultivation could well have been misrepresented. In addition the values placed on land ownership and livestock, respectively, differed between the different communities surveyed, with immigrant small-scale farmers generally investing in land rather than livestock and vice versa for pastoralists. Thus two measures of household wealth were generated. The first was a simple household possession score to provide a universal, if crude, indication of household wealth. In developing a household possession score I was guided by the work of Gillingham (1998) who was similarly constrained and stated the following advantages of using such a strategy:

1) Household possession scores are based on definite answers to simple, factual questions;
2) It is possible to corroborate the accuracy of household responses received;
3) This strategy overcomes potential risks of respondents to misrepresent their household circumstances and/or distortions in the data caused by lapses in their memory.

The household possession score used in this study differed from that generated by Gillingham (1998) and was calculated using items defined as relevant to the Laikipia context by local key informants. The various values assigned to each item are presented in Table 9.1. Total scores computed for each household ranged from 0 to 23 (mean score $= 8.8 \pm 0.2$, $n = 356$). Households were grouped into wealth categories based on 25 (poor), 26-50 (middle), 51-75 (rich) and >75 (richest) percentiles of the distribution of possession scores.

Four strata of livestock wealth were used based on the PhD work carried out by Herron (1991) who explored the ethnography of the Mukogodo people of north Laikipia District. In his study wealth categories were qualitatively described by Mukogodo elders as follows:

1) Those who are really rich: they can live easily, are able to buy and sell livestock whenever they want and drink milk three times a day
2) Those who can manage well: They are not really well off but "can sleep without being hungry or without sorrows or fear"
3) Those who can manage but barely: In the dry season this group encounters problems but at least they can still drink tea with milk
4) Those who need help: This group is carried by their neighbors and friends; they sleep hungry and are forced to sell their livestock in despair "throw away animals" and some even own no livestock at all.

Table 9.1: Items used for calculation of the household possession score

	Item	Value	Points
Household structure	Mud wall + Thatch roof Metal wall + Metal roof Timber walls+ Metal roof	Insignificant Small Medium	0 1 2
Manufactured goods	Radio TV	Small Medium	1 2
Source of lighting	Firewood Kerosene lamp Solar panel & battery	Insignificant Small High	0 1 3
Transport	Bicycle Motorbike Vehicle	Medium High High	2 3 3
Large stock (cattle, camels)	1-3 4-10 >10	Small Medium High	1 2 3
Small stock (goats and sheep)	1-10 6-40 >40	Small Medium High	1 2 3
Chickens	1-5 6-40 >40	Small Medium High	1 2 3

Note: ranges between items are not equivalent but a validation survey confirmed that categories are broadly sound

Herron (1991), with the help of key informants, subsequently assigned quantitative values in terms of livestock to each of the four categories above. To do so he used livestock equivalents (LEs), coefficients derived from Maasai livestock in Kajiado and based on surveys of herd structure and the calculation of metabolic weights which are closely related to food energy requirements. The coefficients used were 0.71 for cattle and 0.17 for sheep and/or goats. Thus to determine the number of livestock equivalents in a household herd, these coefficients are multiplied by the number of animals. Very poor households were categorized as those with less than 5 LEs; Poor with between 5 and 9 LEs; Medium with between 10 and 20 LEs; and Rich with greater than 20 LEs.

Both livestock and household possession based indices of wealth were used as independent variables to assess the distribution of perceptions of elephants as a wildlife pest species among household respondents.

9.2.3 Measuring crop-raiding levels in relation to rank responses

The significance of experiencing negative forms of human-elephant interaction in shaping the perceived magnitude of potential for loss to elephants was further explored by testing for differences in the background level of crop-raiding among households that ranked elephants as the worst wildlife pest compared with those that did not. Only those households that fell within the areas which field assistants systematically collected information on human-elephant conflict (see chapter 3, section 3.5), were included within the analysis (n = 171). Crop-raiding values within 1 km^2 of each household were calculated based on reports collected by enumerators (see chapter three, section 3.5) between the months of January and September 2003 (i.e. 9 months prior to the household questionnaire survey).

9.2.4 Damage by elephants compared with damage by other species

Data on crop-raiding by elephants and all other crop-raiding species were collected within a discrete 1 x 1 km cell adjacent to the Ngobit River between August 2003 and December 2004. The extent of damage to crops was estimated for individual farms for each raid day (i.e. any 24 hours in which a crop-raid event occurred) with damage from all species (other than elephants) combined to generate a single ‘other-pest’ crop-damage value. Crop-raiding by elephants was also monitored over this same period and the same approach was used to estimate elephant crop-damage values (i.e. number or amount of crops damaged per day) within the 1 x 1 km monitored cell. In addition background crop-damage values were estimated for elephants within a wider 5 x 5 km cell in the same area. This wider 5 x 5 km cell was also systematically monitored between August 2003 and December 2004 though for crop damage by elephants only.

9.3 RESULTS

9.3.1 Wildlife as a livelihood constraint

Responses to a ranking question in the questionnaire survey demonstrate that drought is the greatest perceived threat to livelihoods among the households surveyed, followed in order of importance by disease, wildlife, cattle rustling and other livelihood constraints (Table 9.2). The prominence of drought as a perceived livelihood threat across households exemplifies the challenges of both livestock-based and arable farming-based economies in an environment where rainfall is marginal and unpredictable across space and time. This perception was likely to have been compounded by the experience of a prolonged drought in Laikipia between 1999 and 2000. Seventy-eight percent of Mukogodo households and 69% of smallholder households reported that this drought resulted in livestock mortalities. Of the Mukogodo communal land households that reported losing cattle to the 2000 drought, 45% (n =116) claimed they lost between 60% and 100% of their cattle herds. In contrast, 23% of smallholder households reported losing similar proportions of their household herds during the drought (n = 93). Koija Group Ranch was particularly badly affected by the 2000 drought with 57% (n = 35) of respondents claiming to have lost all of their cattle:

> “*I would have been rich if it weren’t for the 2000 drought,*”Q#297, male respondent, pastoralist, communal land area, December 2003.

Thus when the sample of households was stratified into communal and smallholder groups, the predominance of drought as the primary perceived livelihood constraint among the communal land household sample, as defined by the WRI, was expected. Among the smallholder household sample however, drought was in fact ranked second to disease as a livelihood threat. The difference in perceptions of the primary livelihood threat between households living in the two land-tenure contexts reflects differences in household production, investment and settlement patterns with communal land households representing predominantly livestock keepers and smallholder households representing predominantly cultivators.

The perception of disease differed between the two land-tenure contexts. Communal land households referred to livestock diseases, especially East Coast Fever but also foot and mouth and anthrax, when responding to the ranking question, while smallholders referred to crop and human diseases. East Coast Fever is a tick-borne protozoal disease[45] that becomes more prevalent at higher altitudes. Households in the Mukogodo Forest are located at an altitude of between 2000 and 3000 metres. In addition to exposure to greater prevalence of tick-born diseases, Mukogodo Forest households also have greater access to natural sources of water and experience higher levels of annual rainfall. These factors may explain why, in contrast to the other individual communal land household samples (i.e. for Koija, Ilngwezi and Kurikuri), disease was ranked first and drought second for the Mukogodo Forest household sample.

Table 9.2: Livelihood constraints (% frequencies) reported by all respondents interviewed (n = 357) during the questionnaire survey, perceived relative importance of these problems as shown by % of respondents ranking each as the primary livelihood constraint, and the overall Weighted Rank Index value for each problem.

Constraint	% of households reporting problem	% of households ranking problem 1st	Weighted Rank Index	WRI Order
Drought	87.9	41.7	.63	1
Disease	82.3	37.8	.59	2
Wildlife	61.3	9.5	.27	3
Cattle Rustling	32.7	5	.14	4
Other*	15.1	0.8	.05	5

*Other (Fire, poaching, grazing by outsiders)

[45] East Coast fever is a lethal cattle disease that stems from lymphatic infection by protozoans of the genus *Theileria* (*T. parva*) transmitted by ticks especially of the genera *Rhipicephalus* and *Hyalomma.* Its prevention and treatment are costly, ineffective and difficult to administer.

Table 9.3: Summarised household ranks for 5 livelihoods constraints in terms of perceived threat to livelihood for each of the eight sample areas. Ranks are based on a weighted rank index (WRI) and are shown in bold. WRI values are in brackets.

Location	N	Cattle Rustling	Disease	Drought	Wildlife	Other
Smallholder	194	**4** (.16)	**1** (.56)	**2** (.54)	**3** (.29)	**5** (.05)
Endana	43	**4** (.17)	**2** (.39)	**1** (.55)	**3** (.18)	**5** (.09)
Ngare Ndare	64	**4** (.108)	**1** (.82)	**2** (.65)	**3** (.29)	**5** (.06)
Ngobit	41	**3** (.3)	**1** (.54)	**2** (.47)	**4** (.22)	**5** (.01)
Tigithi	46	**4** (.11)	**3** (.44)	**1** (.49)	**2** (.47)	**5** (.06)
Communal	163	**4** (.12)	**2** (.61)	**1** (.73)	**3** (.26)	**5** (.04)
Ilngwezi	40	**4** (.21)	**2** (.55)	**1** (.76)	**3** (.26)	**5** (.02)
Koija	42	**4** (.06)	**2** (.59)	**1** (.82)	**3** (.2)	**5** (.02)
Kuri Kuri	42	**4** (.12)	**2** (.55)	**1** (.81)	**3** (.26)	**5** (.08)
Mukogodo Forest	39	**4** (.09)	**1** (.76)	**2** (.52)	**3** (.31)	**5** (.03)

Across the study sites surveyed, wildlife was consistently ranked third as a livelihood constraint (Table 9.3), with the exception of Tigithi and Ngobit where wildlife was ranked second and fourth, respectively. The consistency with which wildlife was cited and ranked among the different study sites underlies the perceived significance of wildlife pests as a livelihood constraint and will be further explored in the next section.

Cattle theft ranked fourth as a livelihood threat among the study sites surveyed, although historically it may have been a much more significant source of income loss for many households in Laikipia. Among the pastoralist groups living within Laikipia and the wider region, stealing cattle from neighbouring tribes represents a traditional means of reinforcing social identity among young men belonging to warrior age sets. It is also traditionally a means of reinforcing and even extending territories and associated pasture.

Smallholder farmers that moved onto their purchased parcels of sub-divided ranches in Laikipia from the 1970s onwards were particularly vulnerable to livestock theft. The livestock keeping pastoralists in the Laikipia region have strong traditions of sharing, close community relations and communal land management and they were (and are) quickly able to mobilise groups of cattle raiding parties comprised of young men for acts of ritualised theft. This was and is in sharp contrast to the socially divided immigrant

Kikuyu small-scale farmers with divergent origins and livelihoods based on socially and economically individualised resource use and land-tenure. In addition the marginal arable farming potential of Laikipia that resulted in haphazard and scattered Kikuyu settlement patterns and contributes to ecological vulnerability to crop-raiding by elephants (see chapter 6), equally contributed to vulnerability to cattle theft.

> *"I came here in Endana in 1996. From 1992 up to 1996 there were very few people here and pastoralists were also very few. Only farmers were dominant. There also used to be a lot of theft because the Samburus used to come from the Mukogodo forest, and a place called Kiamundura to steal from people. Again there used to be little or no security. For instance this anti-stock theft post at Naibor was not there then; they used to stay here at Ngare Ngiro. So they could just steal and escape and the Kikuyu were the majority and could be beaten and robbed with little difficulty. When I came here in 1996, there still was theft up to around 1998 when it went down a little and today it is unheard of here."* I#10, male respondent, smallholder, Endana, November 2003.

Cattle rustling, however, was not only reported by small-scale farmers. Other groups, particularly on Mukogodo group ranches, were particularly vulnerable to livestock theft from larger well armed pastoralist groups with origins north of Laikipia District. Indeed it was the insecurity presented by these latter groups which underpinned the successful transition of Ilngwezi Group Ranch to an internationally renowned community wildlife conservancy and eco-tourist destination; use of Ilngwezi Group Ranch by its members was hindered by the presence of the neighbouring pastoralists and thus the opportunity cost of designating livestock pasture for wildlife conservation in exchange for security through a deal with the neighbouring large-scale private ranch (now known as Lewa Wildlife Conservancy), was relatively low:

> *"If Illngwesi Park had not been constructed here, we would have moved out of this place a long time ago because of cattle rustlers."* I#9, male respondent, communal land area, September 2003.

On the back of this success, and based on the same formula of converting livestock pasture into wildlife conservancies in exchange for security and tourism development but principally security, similar community initiatives are taking place in group ranches across north Kenya (initiatives spearheaded by the recently established Northern Rangelands Trust with support from the Lewa Wildlife Conservancy). This trend suggests that insecure pastoralist land is probably the most economical for conservation investment, in terms of area of land designated for wildlife per dollar, in Kenya. This phenomenon of frontier conservation would be a worthy topic of research in its own right.

In recent years security has improved in Laikipia, principally through a series of radio-networks established by the Laikipia Wildlife Forum and private wildlife conservancies and made available to community groups and the district administration. This is probably why security is no longer perceived as one of the top three livelihood constraints among most of the households surveyed.

9.3.2 Ranking elephants as a wildlife pest

Across the entire sample of households, weighted rank index values show that elephants are perceived as the worst of 10 different wildlife pests, followed by leopards and hyaenas (Table 9.4). Among the smallholder households sampled, the WRI values suggest that elephants were the worst perceived pest followed by leopards and bushpigs, while across the communal land household sample, WRI values show that leopards were perceived as the worst pest species followed by hyaenas, with elephants ranked third. The WRI value associated with leopards within the smallholder sample is biased by responses from the large Ngare Ndare household sample (n = 63), where questionnaire results suggest that livestock represents a major source of household production and that the Ngare Ndare Forest, which is inhabited by large predators, is the main source of pasture.

The pattern of differences in perception between smallholder and communal sites in the rank order of crop-raiders (elephants, bushpigs etc.) vs. predators (leopards, lions and hyaenas) was confirmed by the spatial pattern of human-wildlife conflict reports collected by various researchers between February and August 2004 (Fig 9.1). These data show that the pattern in the distribution of different forms of human-wildlife conflict is synonymous with the rainfall gradient, with livestock predation more prevalent in and adjacent to communal group ranches located in the relatively arid northern parts of Laikipia district and within large-scale ranches, while crop raiding, mostly by elephants, was mostly recorded on smallholder land in the wetter and more arable southern and western parts of the district although scattered incidents were also recorded in northeast Laikipia.

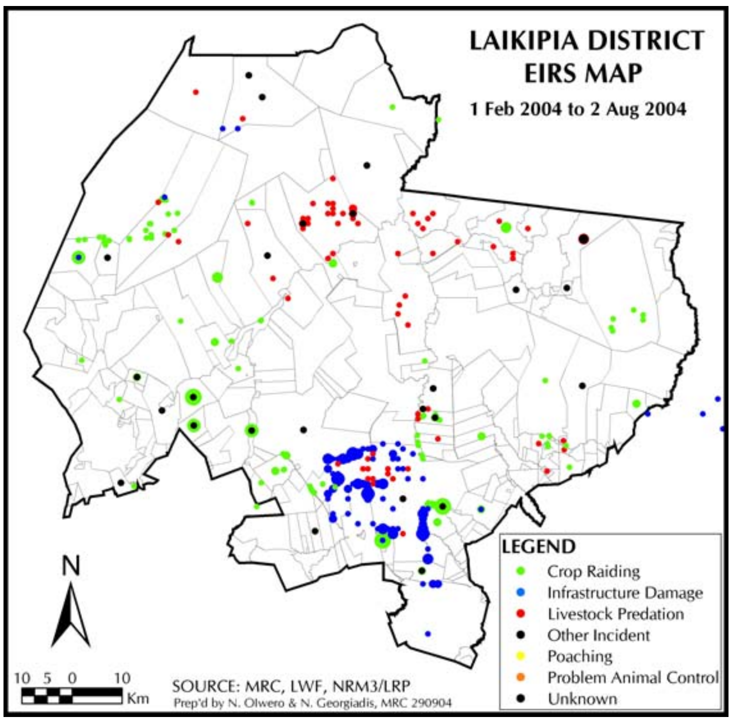


Fig. 9.1 Ewaso Incident Reporting System (EIRS) map showing the spatial distribution of human-wildlife conflict incidents in Laikipia. These data were collected by various designated reporters, including the author, through a collaborative agreement and were subsequently collated into a single GIS database by Mpala Research Centre.

While the order within which wildlife species were ranked as pests varied between sites, the consistency with which households ranked elephants as a significant wildlife pest is conspicuous (Table 9.5). The only sites where WRI values infer that elephants were not perceived as one of the top three wildlife pest species were Ilngwezi and KuriKuri group ranches. Other studies have found discrepancies between perceived and actual losses to wildlife pests (Gillingham & Lee, 2003, Naughton-Treves, 1997, Naughton-Treves & Treves, 2005), and thus while these results provide a good barometer for local attitudes they do not necessarily reflect actual losses per species (although see below). None the less, these results for Laikipia are intriguing, especially given the spectrum of livelihood strategies sampled (i.e. both small-scale farmers and pastoralists), and beg the question:

Why were elephants ranked so highly across study sites?

Table 9.4: Rank of wildlife pest species that constrain livelihoods as reported by respondents interviewed during the questionnaire survey (n=342).

Species	% of households Reporting problem	% of households ranking problem 1st	Weighted Rank Index	WRI order
Elephant	71.6	39.2	.5	1
Leopard	53.5	26	.36	2
Hyaena	47.7	9	.23	3
Baboon	31.5	10.5	.19	4
Lion	45.3	5.5	.18	5
Vervet Monkey	25.7	2.9	.11	6
Porcupine	29.8	.6	.1	7
Bush pig	18.7	2.6	.089	8
Other	20.2	3.5	.088	9
Birds	20.5	1.46	.07	10

Table 9.5: Summarised household ranks for wildlife pest species for each of the eight study sites, (WRI in brackets).

Location	N	Birds	Vervet Monkey	Porcupine	Baboon	Bushpig	Leopard	Hyena	Lion	Elephant	Other
Smallholder	185	**9** (.09)	**7** (.1)	**10** (.098)	**5** (.13)	**3** (.15)	**2** (.28)	**6** (.12)	**4** (.133)	**1** (.61)	**8** (.099)
Endana	41	**8** (.01)	-	**5** (.113)	**3** (.21)	**9** (.04)	**2** (.24)	**6** (.1)	**4** (.15)	**1** (.57)	**7** (.06)
Ngare Ndare	61	**5** (.14)	**7** (.12)	**6** (.13)	**8** (.07)	**9** (.074)	**1** (.69)	**3** (.28)	**4** (.26)	**2** (.29)	**9** (.071)
Ngobit	40	**7** (.035)	**4** (.07)	**6** (.04)	**3** (.125)	**2** (.35)	**9** (.012)	-	**8** (.013)	**1** (.8)	**5** (.06)
Tigithi	43	**6** (.127)	**2** (.18)	**7** (.09)	**5** (.128)	**3** (.173)	-	-	**8** (.02)	**1** (.85)	**4** (.17)
Communal	157	**9** (.05)	**6** (.11)	**7** (.09)	**4** (.27)	**10** (.02)	**1** (.46)	**2** (.37)	**5** (.25)	**3** (.36)	**8** (.07)
Ilngwezi	40	**8** (.08)	**4** (.22)	**7** (.18)	**1** (.55)	**9** (.03)	**2 (.49)**	**3** (.23)	**6** (.19)	**5** (.21)	**10** (.016)
Koija	41	-	-	-	-	-	**2** (.52)	**1** (.78)	**4** (.19)	**3** (.24)	**5** (.04)
Kuri Kuri	39	**7** (.024)	**10** (.08)	**9** (.012)	**4** (.18)	**8** (.016)	**1** (.66)	**3** (.3)	**2** (.47)	**5** (.15)	**6** (.14)
Mukogodo Forest	38	**9** (.08)	**4** (.148)	**3** (.19)	**2** (.36)	**10** (.03)	**7** (.12)	**6** (.13)	**5** (.146)	**1** (.83)	**8** (.11)

9.3.3 Factors affecting perceptions of elephants as a wildlife pest

Fifty-one percent (n = 356) of household respondents ranked elephants as one of the top three worst pest species. Thirty-seven percent of respondents assigned elephants the highest rank in terms of potential for loss relative to other pest species. Seventeen and a half percent of respondents assigned elephants a rank below third as a wildlife pest while a further 31.2 % did not rank elephants as a wildlife threat at all.

Bivariate analyses of factors influencing perceptions of elephants as a wildlife pest are presented in Appendix 6, Tables I to III and are summarised in Table 9.6 below. Age, gender and perceptions of who owns elephants were insignificant as influences on the likelihood of either a high or low rank for elephants relative to other wildlife pest species. In addition household wealth, as measured by the household possession score, was only significant in influencing the likelihood of the presence or absence of a high rank response for elephants among cases within the communal land household sample. Variables identified as significant through these cross-tabulations were used to build the logistic regression analyses presented in Tables 9.7 to 9.9.

Results of the logistic regression model for the entire household sample (Table 9.7) suggest that land use is the most significant predictor of negative perceptions of elephants with households that reported growing crops more likely to rank elephants as one of the top three wildlife pest species than households that did not cultivate. This was confirmed by a simple comparison of cultivating and non cultivating households showing that 81.1% of household respondents that did not cultivate either ranked elephants as a minor wildlife pest (i.e. below the top three) or did not rank elephants as a wildlife pest at all compared with just 31 % of households that did cultivate (χ^2 (1) = 77.6, $P < 0.001$, n = 355). Conversely households that owned substantial numbers of livestock were less likely to rank elephants as a significant wildlife pest compared with households with few or no livestock.

Table 9.6 Summary of results for bivariate analyses of the factors related to perceptions of elephants as a wildlife pest in terms of rank relative to other wildlife pests,* *P* < 0.05, ** *P* < 0.01, ****P* < 0.001.

Variable	All HH (n=356)		Communal HH (n=163)		Smallholder HH (n=193)	
	χ^2 *(d.f.)*	*P*	χ^2 *(d.f.)*	*P*	χ^2 *(d.f.)*	*P*
Age	2.12 (2)	N.S.	0.45(2)	N.S.	4.2 (2)	N.S.
Gender	0.5 (1)	N.S.	0 (1)	N.S.	0.53 (1)	N.S.
Education	27.9 (2)	***	0.03 (1)	N.S.	22 (2)	***
HH Wealth (Possessions)	0.7 (3)	N.S.	9.17 (3)	*	6 (3)	N.S.
Livestock holdings	46.1 (3)	***	10.3 (3)	*	37 (3)	***
Grow crops	77.6 (1)	***	28.5 (1)	***	30.5 (1)	***
Wildlife benefits	0.01 (1)	N.S.	10.3 (1)	**	5 (1)	*
Perceived elephant owners	4.6 (2)	N.S.	5.2 (2)	N.S.	0.01 (2)	N.S.
Knowledge of people killed/injured	24.8 (1)	***	11.1 (1)	**	12.2 (1)	***
Scared elephant away (from crops)	75 (1)	***	14.3 (1)	***	48.3 (1)	***
Likelihood of elephant contact	13.6 (2)	**	.62(2)	N.S.	4.2 (2)	N.S.

Households that knew of somebody who had been killed or injured by an elephant were also more likely to perceive elephants as a significant wildlife pest. In addition experience of scaring an elephant away was a highly significant factor with households that reported having had an experience of trying to scare an elephant away more likely to report elephants as a major wildlife threat than households that did not report this experience. Intriguingly, households that reported making contact with elephants during two or more off-farm household activities were less likely to rank elephants as a major wildlife pest than households that had a lower frequency of contact with elephants during off-farm activities.

Overall 77% of cases were correctly predicted by this first logistic regression analysis with the occurrence of high and low rank responses predicted in equal proportions (77.1% and 76.9%, respectively). The area under the curve of the ROC plot was 0.86, suggesting good model performance.

The independent variables found to be significant in the first logistic regression model were also significant for the logistic regression analysis carried out on the communal-land household sample (Table 9.8) with the exception of livestock holdings and likelihood of contact with elephants. This model was also found to be relatively accurate with 76% of cases correctly predicted although responses that indicated elephants were one of the top three wildlife pests were better predicted than responses that indicated elephants were a less significant or insignificant wildlife pest (80.2% and 67.7%, respectively; ROC = 0.8).

Results from the smallholder logistic regression analysis (Table 9.9) suggest that smallholder households that either grow crops and/or had experienced trying to scare elephants away from their crops were more likely to report elephants as one of the top three wildlife pest species than smallholder households that do not grow crops or had not tried to scare elephants away from crops. The more livestock a smallholder household owned, the less likely household respondents were to perceive elephants as one of the three worst wildlife pest species. This model was also very accurate at correctly predicting a high rank for elephants as a wildlife pest species and was less accurate, though still adequate, at predicting a low or insignificant value for elephants as a wildlife pest species (87.4% and 68.6%, respectively; ROC = 0.86).

Table 9.7: Logistic regression of the factors affecting the likelihood of respondents ranking elephants as a significant wildlife pest across the entire sample of households (N=356). A negative coefficient (*B)* indicates reduced likelihood of a high rank for elephants, whilst a positive coefficient indicated an increased likelihood. Entry and exit of variables were specified by the Wald statistic with probabilities of 0.05 and 0.1, respectively (*P<.05, **P<.01, ***P<0.001; df = 1, 191)

Factors	*B*	SE	Wald
Knowledge of person killed or injured by an elephant	0.88	0.32	7.6**
Experience of trying to scare an elephant away	1.72	0.34	26.2***
Grow crops	2.04	0.34	36.3***
Livestock holdings			12.94**
Livestock holdings (1)	0.13	0.41	0.1
Livestock holdings (2)	-0.67	0.41	2.66
Livestock holdings (3)	-1.1	0.37	8.8**
Likelihood of ely contact			6.68*
Likelihood of ely contact (1)	-0.64	0.37	3.0
Likelihood of ely contact (2)	0.21	0.39	0.28
Constant	-1.86	0.5	13.87***

Table 9.8: Logistic regression of the factors affecting the likelihood of household respondents ranking elephants as a significant wildlife pest across the communal-land household sample (df= 1, 163).

Factors	*B*	SE	Wald
Knowledge of person killed or injured by an elephant	1.2	0.47	6.6*
Experience of trying to scare an elephant away	1.4	0.5	8.3**
Grow crops	1.8	0.38	21.9***
Constant	-2.46	0.47	27.6***

Table 9.9: Logistic regression of the factors affecting the likelihood of household respondents ranking elephants as a significant wildlife pest across the smallholder household sample (df = 1, 191).

Factors	*B*	SE	Wald
Grow crops	2.4	0.8	8.97**
Experience of trying to scare an elephant from crops	1.9	0.47	17.8***
Livestock wealth			12.8**
Livestock wealth (1)	-0.54	0.57	0.88
Livestock wealth (2)	-0.99	0.56	3.2
Constant	-1.7	0.49	12.3**

9.3.4 Background crop-raiding values and perceptions of elephants

The experience of negative forms of human-elephant interaction was thus highly significant in determining the likelihood of respondents assigning either high or low ranks for elephants relative to other species in terms of their perceived potential for loss. Indeed of the households that reported an experience of trying to scare elephants away, 53.4% (n = 163) ranked elephants as the wildlife species presenting the greatest threat to livelihoods, compared with 24.5% of households that reported not having had this experience (n = 192; χ^2 (1) = 30.1, $P < 0.001$). The proportion of households ranking elephants as the worst wildlife pest species was even higher among the sample of households that reported the experience of defending their crops from elephants (70.5%, n = 112) compared with those that did not report this experience (22.5%, n = 244; χ^2 (1) = 73.3, $P < 0.001$).

The significance of the experience of crop-raiding in shaping perceptions of the magnitude of potential for loss to elephants relative to other wildlife pests was further confirmed by an analysis of the distribution of background crop-raiding levels among households. Crop-raiding levels were significantly higher within 1 km^2 of households that ranked elephants as the worst wildlife species (mean = 4.7 ± 5.5) than within 1 km^2 of those households that did not rank elephants as the worst wildlife species (mean = 1.8 ± 4.2; Fig. 8.7; t (219) = - 4.5, $P < 0.001$). In addition there was a strong negative correlation between background crop-raiding intensity and the rank assigned to elephants by individual households in terms of livelihood threat (Fig 9.2; $r_s = 0.413$, $P < 0.001$, n = 171), suggesting that perceptions of the risk elephants present in terms of potential for loss were linked not only to the experience of but also the background intensity of crop-raiding among household respondents.

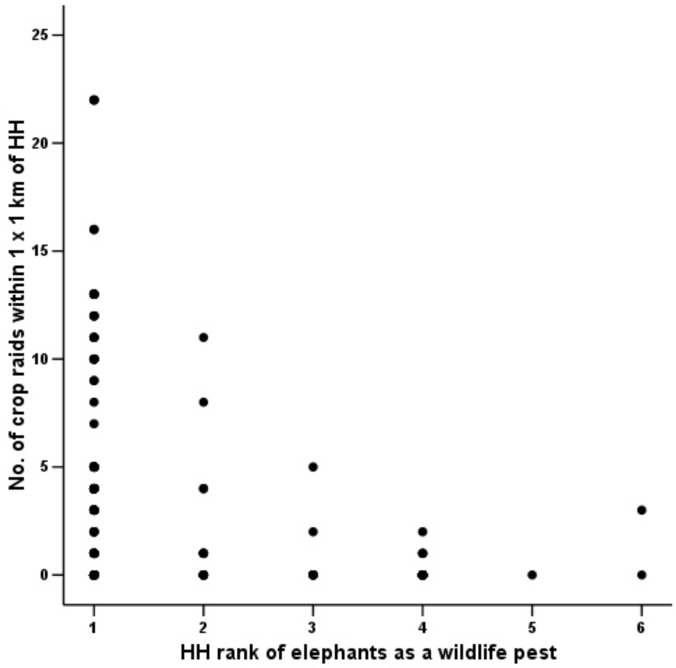


Fig 9.2 Relationship between crop-raiding intensity and household rank of elephants as a wildlife pest.

9.3.5 Loss to elephants relative to other pest species

One possible reason for why experience of crop-raiding by elephants amplified perceptions of potential for loss among household respondents is that elephants are capable of causing severe damage during single forays. Several respondents complained of having lost an entire crop to elephants in a single night:

> "*Elephants are the worst because they cause a lot of damage and once they caused my family to almost starve to death by eating an acre of maize*" Q#80, female respondent, smallholder, Ngobit, October 2003.

> "*Sometimes elephants can go into the field unnoticed and damage my crop completely*" Q#92, female respondent, smallholder, Ngobit, October 2003.

The perceived relative magnitude of crop loss incurred by elephants relative to other pest species compared with the actual magnitude of crop-loss relative to other pest species was empirically tested for within the Ngobit smallholder sample area (see section 9.2.3)

The WRI value for elephants based on questionnaire responses suggests that elephants are the worst perceived wildlife pest at Ngobit (Table 9.5). Results from a comparative analysis of the extent of damage to crops by elephants compared with the extent of damage to crops by other pest species within a designated monitoring site of 1 x 1 km adjacent to the Ngobit River do indeed show that elephants damaged more on average per farm per raid than all other species combined. Moreover out of the seven crop-raiding incidents involving elephants within the 1 x 1 km cell, one incident involved damage to greater than 50% of the crops planted. In the wider 5 x 5 km grid elephants destroyed 100% of the crops planted in two out of 145 recorded incidents of human-elephant conflict (Table 9.10).

Table 9.10 Table shows values for crop-damage caused by elephants and crop damage caused by all other species combined between August 2003 and December 2004 within a 1 x 1 km small-scale farming area bordering Ol Pejeta Ranch and adjacent to the Ngobit River. Background elephant crop-damage was estimated from incidents that occurred within a wider 5 x 5 km area.

Animal		Area damaged (acres)			Proportion of crop damaged (%)	
	N	Total	Mean±SE per farm	Max. per farm	Mean per farm	Max. per farm
All other species*	361	11.97	.03 (.002)	.35	1.6	27.5
Elephant	7	1.48	.2 (.06)	.44	14.8	57
Elephant (background)	145	.74**	.13 (.04)	6.3	9.1	100

*Includes baboon, bush pig, porcupine, vervet monkey, cane rat, helmeted guineafowl, yellow-necked spurfowl and other species of birds
**Standardised estimate calculated by dividing the total acreage damaged within the 5 x 5 km area (18.6 acres damaged) by 25

While these results confirm the qualitative comments made by some household respondents, showing that elephants can and occasionally do inflict extremely high losses, such events were in fact rare and overall elephants contributed to just 13% of the total extent of crop-damage caused by wildlife pests within the 1 x 1 km area monitored.

9.3.6 Other factors affecting perceptions of elephants

In Laikipia dominant modes of household production are important in shaping perceptions of elephants with households that cultivated far more likely to perceive elephants as a major wildlife pest compared with households that did not cultivate.

Similar results have been found in other studies. For example agriculturalists living adjacent to Amboseli National Park were generally less positive towards elephants than pastoralists (Kangwana, 1993) and negative attitudes towards wildlife among rural communities in the Chobe enclave in Botswana were inversely related to livestock numbers (Parry & Campbell, 1992). There are, however, several caveats to this conclusion.

First of all, while an effect of livestock holdings was present in the logistic regression model constructed using cases from the smallholder household sample, it was not present in the model constructed using cases from the communal land household sample. Overall results were thus likely to be biased by the Ngare Ndare sample which comprised the majority of households within the entire smallholder sample that reported owning substantial numbers of livestock (χ^2 (3) = 83.36, $P < 0.001$, n = 193). These households are separated (geographically though not in terms of all livelihood activities-see chapter 8) from elephants by a highly effective electric fence so that despite the high number of households cultivating, the risk of crop-raiding here is lower than in any of the other smallholder sites with just 14.1% (n = 64) of respondents claiming that they had scared elephants out of their crops compared with 71.1%, 55.8% and 41.5% of households in Tigithi, Endana and Ngobit[46], respectively. The distribution of high rank values for elephants, in terms of potential for loss relative to other wildlife species, across these sites confirms this interpretation with just 31% of households in Ngare Ndare assigning elephants a rank of between 1 and 3 compared with 88.9%, 58.1% and 87.8 % of households in Tigithi, Endana and Ngobit, respectively (χ^2 (3) = 51.7, $P < 0.001$, n =193).

[46] The relatively few number of household respondents in Ngobit that reported scaring elephants away from their crops may also explain why Ngobit households ranked wildlife pests fourth as a livelihood constraint below disease, drought and cattle rustling.

The significance of livestock holdings in predicting a low rank for elephants relative to other wildlife pests within the logistic regression models is thus as likely to be a feature of the effectiveness of the electrified elephant fence surrounding the Ngare Ndare Forest as it is to be related to the dominant mode of household production.

Conversely the significant effect of cultivation in determining perceptions of elephants as a major wildlife pest also needs to be considered within context. This is exemplified by the Ilngwezi sample where, while 52% of households reported growing crops, just 22.5% of households ranked elephants as a major wildlife pest. While most Ilngwezi households grow crops and contact with elephants among these households was reported during most if not all off-farm activities (see chapter 8), few households experienced crop-raiding by elephants.

These results from the Ngare Ndare and Ilngwezi survey sites suggest that it is not just modes of household production but experience and knowledge of human-elephant interaction that shapes perceptions of elephants as a wildlife pest species. Interestingly the logistic regression models show that the forms of human-elephant interaction that shape perceptions of elephants are in fact quite specific as households that reported making contact with elephants across a range of every day activities such as herding livestock, collecting firewood, collecting water etc., do not necessarily perceive elephants as a major wildlife pest (Table 9.7). Rather, through these quantitative analyses, the experience of negative human-elephant conflict, specifically crop-raiding, its intensity, and knowledge of the occurrence of extreme events of human-elephant conflict (i.e. human deaths or injuries) emerge as the salient features shaping perceptions of elephants among local households in Laikipia.

Comparative analyses carried out in Ngobit also suggest that perceptions of elephants as a crop pest are shaped by rare, extreme damage events rather than the persistent events that cumulatively have a greater effect, corroborating conclusions about miss-matches between perceptions and events from other studies (Anderson & Grove, 1987, Bell, 1984, Gillingham & Lee, 2003, Naughton-Treves, 1997). This is also likely to be the main reason why knowledge among respondents of people that had been either killed or injured by elephants increased the likelihood that respondents would rank elephants as one of the three worst wildlife pests (Tables 9.6 & 9.7). Of the household respondents that knew of somebody that had been killed and/or injured by an elephant, 60% (n = 260) ranked elephants as one of the three worst wildlife pests compared with 29% (n = 96) of household respondents that had no knowledge of an elephant killing or injuring somebody (χ^2 (1) = 24.8, $P < 0.001$, n = 356).

Knowledge of the danger that elephants present, makes them a particularly difficult and perhaps unique wildlife management problem as was illustrated by the following comments:

> "*I can keep baboons away if I try but elephants I cannot. My husband should spear an elephant that enters our crops but he fears them even more than me. Once an elephant tastes maize, there is no way he can move.*" Q#2, female respondent, Mukogodo Forest.

> "*Elephants are the worst because once they enter my crop field they can finish it in one day and they can threaten my life if I try to scare them away*" Q#13, female respondent, Mukogodo Forest

Official records of the numbers of people either killed or injured by elephants in Laikipia show that in fact this risk does exist. For example between 2000 and 2003 the Kenya Wildlife Service recorded twenty-six incidents in which people were either killed or injured by elephants in Laikipia District (Table 9.11). Circumstances under which people were killed included walking home at night drunk, cutting grass, collecting firewood, walking in the bush, protecting crops and herding livestock. One man was killed by a family group of elephants while building a community road after those elephants had been shot at by police in a neighbouring smallholder area. The average number of people killed per year between 2000 and 2003 was under 4 compared with an average of 5 people killed per year between 1989 and 1992 (Thouless, 1993).

Table 9.11: Human deaths and injuries in Laikipia by land-tenure type, 2000-2003

	Smallholder	Private Ranches	Communal	Other/Unknown
Deaths	7	5	3	
Injuries	4	2	4	1
Total	11	7	7	1

Another reason underlying perceptions of elephants as a significant wildlife pest in Laikipia is that unlike other wildlife pests, elephants are perhaps unique in that they are both protected and also highly conspicuous. As a consequence, in contrast to other wildlife pests (protected and unprotected), they are difficult, if not impossible, to kill without attracting the attention of the wildlife authorities and thus the costs that elephants incur are often perceived as ‘imposed’ (see box 5.3, chapter five):

> “*The reason people* [people in the Mukogodo Forest] *feel that elephants are the worst is because unlike lions, elephants are difficult to kill. With lions I can just put a bit of poison in some meat.*” I#15, male respondent, Mukogodo Forest, November 2003.

> “*They* [the people living in the Mukogodo Forest] *make a lot of noise because they cannot kill elephants. I can tell you all these guys have no spears left because they have thrown them at elephants but at their legs. They don’t know how to kill them.*” KI#5, male respondent, Community Liaison Officer, September 2003.

This resentment of ‘imposed’ costs was reflected in the apparent relationship between perceptions of elephants as a problem and the perceptions of elephant ‘ownership’. Ninety percent (n = 78) of respondents that thought elephants were owned by foreigners (‘white men’, ‘white ranchers’ or ‘tourists’) stated that they did mind the presence of elephants compared with 65% (n = 204) of the respondents that thought elephants were owned by the government and 52% (n = 61) of the respondents that thought elephants were owned by the community (χ^2 (2) = 24.7, $P < 0.05$, n = 342).

These results together with the qualitative comments expressed by household respondents in Laikipia corroborate conclusions drawn from other studies of human-wildlife conflict that costs that are perceived to be ‘imposed’, have an amplifying effect on resentment arising from conflict with large charismatic mammals (De Boer & D.Baquete, 1998, Gillingham, 1998, Naughton-Treves & Treves, 2005).

The analyses of survey data show that land use and the experience and/or knowledge of negative forms of human-elephant interaction are clearly significant factors in shaping the perceived rank of elephants in terms of potential for loss relative to other wildlife species among Laikipia households. The qualitative data collected through both formal and informal interviews both facilitated interpretation of the quantitative analyses and on occasion helped to identify some of the underlying complex and sometimes idiosyncratic factors that were not captured by the quantitative data but were also important in shaping questionnaire responses. This is best illustrated using Tigithi and Koija Group Ranch as two case study areas.

In addition to collectively having the highest WRI score for elephants as a wildlife pest among the study sites surveyed (Table 9.5), households in Tigithi and more generally east of Ol Pejeta Ranch, were clearly the most intolerant of elephants. This became apparent during the course of my fieldwork period when these farmers collectively protested against elephant incursions onto their land by effectively blockading public access, and therefore tourist revenue, to the adjacent Ol Pejeta Ranch private wildlife sanctuary (Sweetwaters Game Reserve) on two separate occasions. In addition, grass on Ol Pejeta Ranch was deliberately set on fire in an arson attack in 2003, apparently motivated by grievances over human-elephant conflict.

In a group interview with a local women’s group in Tigithi (Wadani Women’s Group, Tigithi, 9/11/03), while respondents were quite clearly disturbed and frightened of elephants, insects (caterpillars) were ranked as the worst crop-pest. In addition an interview respondent suggested that local loss to elephants was greatly exaggerated by local farmers in Tigithi (I#3). Furthermore while crop-raiding events were also high in

Tharua, south of Ol Pejeta Ranch, Ngobit/Sirima, west of Ol Pejeta Ranch and Mutara, northwest of Ol Pejeta Ranch, farmers within these areas were not as vocal in their complaints of human-elephant conflict. Within these sites crop-raiding occurred at levels of 0.19/km^2, 0.8/km^2 and 5.2/km^2 respectively, compared with 2.3/km^2 in the Tigithi area, east of Ol Pejeta Ranch[47]. Why was it that among all of these smallholder groups living adjacent to Ol Pejeta Ranch that experienced relatively high levels of crop-raiding by elephants, none protested as vociferously and/or as aggressively as the smallholders living east of Ol Pejeta Ranch?

The qualitative material collected together with personal observations that I made suggest that there appear to be three main factors causing the scale of resentment and protest arising as a consequence of human-elephant conflict in Tigithi:

1) Tigithi is a short distance from Nanyuki, the main town and administrative centre of Laikipia. Thus smallholder farmers living within this site are relatively easy for campaigning politicians to meet and vice versa.

2) Unlike the other three smallholder communities adjacent to Ol Pejeta, Tigithi is adjacent to a section of the ranch that has been designated exclusively for wildlife and wildlife-based tourism with tourists visiting in large numbers. Thus the elephants that are involved in crop-damage are perceived to be in effect ‘farmed’ or *owned* by Ol Pejeta Ranch and/or the government for the explicit purpose of making money and thus crop-damage by those same elephants is especially resented. Disproportionate complaints of crop-loss to elephants and protests by local farmers therefore represent a “weapon of the weak” (Scott, 1976) in a struggle to redress social imbalances in the costs incurred and benefits gained from elephants:

[47] These crop-raiding density values were calculated from data collected between November 2003 and October 2004 (see chapter 6) when all sites were simultaneously monitored and so only provide an indication of crop-raiding vulnerability for each site prior to the interview survey between October and November 2003.

> *"You know we had some very bad intentions…you know this Ol Pejeta, our neighbours here, because the elephants those elephants they do go there to hide so people tend to think they don't want that shamba* [farm] *so because of those politics we could not understand each other with that Mzungu* [white man-the manager of Ol Pejeta Ranch specifically]. *So people were very bitter about it…It could be the cause of all this noise."* I#3, male respondent, smallholder, Tigithi, 10 November 2003.

> *"Their view is simple: 'You are farming elephants. You brought them here for your rich clients so you can make money but you are not stopping your animals from coming into our farm and destroying our livelihood.' It's a very simple equation and I can see where they are coming from."* I#2, male respondent, ranch manager, 28 November 2003.

3. The belief among some of the smallholders in Tigithi that if they were vocal enough about the damage inflicted by 'Ol Pejeta elephants' that Ol Pejeta Ranch could be sub-divided and given to them:

> Interviewer: *"So were they hoping to get money from Ol Pejeta and they thought that by making a lot of noise they might get some?"*

> Respondent: *"Or that shamba might be sold to them. Yeah something like that. Like what the neighbour of Session did* [Tharua Ranch formerly owned by a European who sold and sub-divided it for smallholder settlement in 1999]. *People are very happy about that because Tharua Farm was sold to this community so me when I walk with them I get this information. Most of them they tend to think they will be happy if this shamba* [Ol Pejeta Ranch] *is sold to them. Not really money but for this shamba to be sold to them."* I#3

This ulterior motive underlying protest over crop-raiding with elephants was also identified by the manager of Ol Pejeta Ranch (I#2):

> "*I think elephants are a symptom of a much a greater problem as perceived by the politician which is the distribution of land. In other words what they* [politicians] *are reacting to is the demand from their constituents for land and they may see elephants and the problems they create as a way of getting at Ol Pejeta, not because elephants per se are the problem but they want to create a situation of uncertainty which pressurises a place like Ol Pejeta into giving up its land to people who demand it*."

The case of Tigithi highlights that the factors underlying responses to the ranking questions within the questionnaire survey and more generally negative perceptions of elephants are sometimes complex and intrinsic to the social context within which human-elephant conflict occurs. This is also demonstrated in the case of Koija Group Ranch, a site where households do not cultivate and therefore are not exposed to experiences of crop-raiding and yet still elephants were ranked relatively highly as a wildlife pest.

In Koija Group Ranch, the weighed rank index based on household questionnaire data placed elephants below hyaenas and leopards and above lions as a wildlife pest. This high rank for elephants was intriguing given that: 1) there was no cultivation recorded among Koija Group Ranch households; 2) elephants are not a major threat to livestock and; 3) Koija Group Ranch apparently receives wildlife-linked benefits from a community eco-lodge and through direct support from the neighboring large-scale ranch. This suggests the existence of other factors influencing household responses to the ranking question. One likely source of conflict with elephants is the local honey industry which is clearly an important livelihood activity with 87 % of household respondents in Koija claiming to harvest honey, a higher proportion of households than in any of the other seven sample areas (Table 8.2). Indeed an informal interview respondent in Koija suggested that honey was the main source of revenue for Koija households:

> *"So our main business is in honey…yes that is where we get more income. If you get customers, people are even able to buy cows!"* I#12, male respondent, Koija Group Ranch, November 2003

The same respondent also described the damage elephants can cause to beehives:

> "*I see that they can destroy so many of these trees carrying beehives. You know they are many and they can destroy even twenty trees at one time. So when you estimate the cost, you see it is much because if twenty trees are destroyed and one tree carries twenty beehives, thirty in another….so you see*!"

Beehive destruction was explicitly cited as a form of conflict with elephants by several questionnaire respondents (Q#303, Q#311 and Q#315) although there was no question within the questionnaire survey that referred specifically to beehive destruction.

9.4 DISCUSSION

Elephants are perceived to be a major if not the major pest species for a large number of households in Laikipia. The bases for ranking elephants in such a way appear to relate to the perceived potential of elephants to inflict huge loss, both in terms of damage to property and to loss of human life. These perceptions are clearly reinforced by the knowledge of someone that had been killed and/or the direct experience of trying to scare an elephant away. However, such extreme events were rare among the sites surveyed and therefore the pattern of responses identified also relates to a battery of other factors which has led elephants to be identified by a large number of Laikipia households as a major pest. These other factors include resentment over 'imposed costs', frustration over the difficulty in killing elephants without being caught, and the struggle over the inequitable distribution of resources in Laikpia. All of these factors constitute the 'culture' of blame that prevails in zones of human-elephant conflict and are not unique to Laikipia by any means. Yet for a substantial number of households in Laikipia, principally those for whom livestock represents the main source of livelihood, elephants are a part of everyday life. These households meet elephants while gathering firewood, herding livestock, harvesting honey, fetching drinking water and collecting medicinal plants. Yet despite the high likelihood of contact with elephants among these households, and the nuisance this probably entails, they do not perceive elephants as a major wildlife pest. Indeed several of such households referred to elephants as “god’s animals”, while others talked of the relationship between elephants and rain in positive terms. For these households, elephants are as much a part of the landscape as their cattle. Such positive attitudes are likely to be reinforced with growing allocation of conservation investments among pastoralist communities in Laikipia and north Kenya.

These stark differences in perceptions among people in Laikipia underpin the importance of land-use planning in containing the potential for negative experiences with elephants, particularly over crops. However results from this chapter also infer that responsibility for elephants and the losses they inflict is often perceived to rest with ‘others’ such as the government, the KWS, private ranches and/or foreigners. The devolution of this responsibility to local people will therefore be a key element within any meaningful future strategy to address negative perceptions of elephants in Laikipia and beyond.

Chapter 10: Conclusions

10.1 INTRODUCTION

In Chapter One I argued that much of the previous research into the ecology of large mammals has been carried out in particular contexts, where human occupancy and land use is limited, such as protected areas, and that such contexts were not fully representative of all the places that large mammals live. I argued that large mammals, including elephants, often live and/or depend on areas outside of strictly protected areas, including a range of land use systems occupied by a range of human land users, and that given current trends this pattern was likely to become more prevalent in future. Therefore an understanding of how large mammals live in human-dominated landscapes and interact with the ensemble of land use systems and associated human occupants present is important for understanding the current and future potential of wildlife persistence. In chapter two I examined the wider body of literature relevant to investigations of wildlife ecology in human-dominated landscapes and human-wildlife interaction more generally. This exploration yielded a number of key principles guiding the methodological design:

1) Ecological patterns must be understood within their particular context (site, setting and history)

2) Ecological patterns and processes occur at multiple scales.

3) Social research methods may be as, if not more, important than natural science research methods for identifying and understanding context specific processes contributing to patterns of wildlife ecology and human-wildlife interaction, more generally.

While this thesis focuses on elephants, the three principles outlined above and, in particular, the need to carry out interdisciplinary research at different scales, could be used to guide future studies of wildlife species that live beyond strictly protected areas, in the human-dominated matrix. This thesis examined the patterns, determinants and implications of human-elephant coexistence in Laikipia District. Here I bring together the results of the analyses carried out in each chapter to assess progress made against the main research questions posed in the introduction. Implications of these results in terms of further research and future conservation and management, in Laikipia and beyond, are discussed.

10.2 Research questions

<u>How does elephant distribution vary across and within different land use types in Laikipia District?</u>

In Chapter Four I demonstrated that elephants occurred across almost 50% of Laikipia District, including a substantial proportion of the areas under human use for settlement, cultivation and/or livestock husbandry. The extent of co-occurrence in Laikipia only became evident after using a combination of data types on elephant distribution including: aerial count data; locations of crop-raiding collected by trained ‘scouts’; and GPS tracking locations. This pattern of co-occurrence suggests that elephants can tolerate different forms of human land use, corroborated by the increase in the total population of elephants recorded in the district between 1992 and 2002. This pattern of increase described for the elephant population occurred against a background of increasing human settlement, land sub-division and livestock densities in particular areas. While not conclusive, preliminary results suggest that during this 10 year period when elephant numbers increased in Laikipia, the process of land use change recorded contributed to declines in the populations of other species of large mammals, such as impala and eland. Distribution data alone, however, cannot show the extent to which elephants use the different land use types identified in Laikipia, the explanatory factors underpinning patterns of relative use, nor explain how and why elephants are able to occupy land under intense human use. These questions were instead dealt with in Chapters Five, Six and Seven.

In Chapter Five results from the transect survey demonstrated that the abundance of elephants in Laikipia District was generally negatively correlated with human activity and did not appear to be influenced by any of the ecological factors measured, with the exception of rainfall in some places. The relationship between elephant abundance and human activity was complex. This became apparent after a more detailed analysis of elephant abundance within specific sample areas. For example, while elephant abundance was lowest in smallholder areas where the level of human activity recorded was highest, elephant abundance was also low in some ranches in which levels of human activity were also very low. In other properties, such as one of the forest reserves and several of the group ranches surveyed, human activity was relatively high but elephant abundance was also relatively high. These results were intriguing and show that it is not necessarily the level but the type of human activity that is important in determining patterns of elephant abundance. I proposed that this could best be understood in terms of the risk to elephants of being injured of killed by human occupants. While this factor is difficult to measure and quantify, I was able to characterise risk within each sample area through my personal observations, by examining the distribution of elephant carcasses reported during the fieldwork period and by exploring the qualitative comments made by key informants and interview respondents. The results of this iterative analysis were presented crudely as a map with sample areas classified into either elephant tolerant or elephant intolerant properties, showing a landscape of risk. While only preliminary, this classification explained much of the variance in elephant abundance among the areas surveyed.

The approach used to classify discrete areas in terms of risk could be further refined in the Laikipia context. For example, it might be possible to take into account seasonal variability in the level of risk to elephants present in certain areas, reflecting the seasonal variability in patterns of resource use among local people. Future research into wildlife distribution and abundance could benefit by using local knowledge, and other proxy sources, to define the spatial and temporal parameters of risk in relation to human land use and management.

While the results presented in Chapter Five helped to explain the relative abundance of elephants across Laikipia, the occurrence of elephants in elephant intolerant areas, particularly smallholder farms, shows that despite the general trend, elephants can and do use such areas. Results from the transect survey were insufficient to adequately establish or explain patterns of elephant use of smallholder land, nor show how an animal as conspicuous as an elephant is able to navigate the risk presented by human occupants. These issues were instead investigated using different data sources in Chapters Six and Seven.

Crop-raiding by elephants was shown to be highly clustered in space, a pattern consistent with recent spatial analyses carried out in other sites (see Chapter Six). This spatial clustering may explain the paucity of dung found in smallholder areas during the transect surveys. In contrast to the work by Hoare (1999a), significant correlates were identified for crop-raiding by elephants in this study. The identification of spatial correlates for crop-raiding in this study confirms the conclusions reached by Sitati et al. (2003) that crop-raiding by elephants can be spatially predicted even when a high proportion of the incidents recorded were likely to involve 'unpredictable' male elephants. The identification of spatial correlates in this study was, however, complicated by the variance in the relative importance of candidate variables at different scales (grain and extent). For example, when the entire district was considered, crop-raiding was strongly correlated with area under cultivation, but when just those areas intensively monitored by local scouts were considered, the significance of crop cover in determining crop-raiding disappeared. Future research into spatial patterns of crop-raiding, and indeed other ecological phenomenon, must take into account this issue of scale when interpreting and/or extrapolating results.

In this study, the analysis of crop-raiding carried out at different scales provided a means of triangulating results to establish the consistency with which predictor variables were relevant. Distance from daytime elephant refuges and settlement density both emerged as significant determinants of crop-raiding patterns when assessed at different spatial scales. Neither of these variables was significant in previous spatial studies of human-elephant conflict, despite inclusion as potential candidate variables in previous analytical designs (see Chapter Six). It is possible that the identification of these variables as significant in this study could be attributed to the type and quality of the data available for defining candidate variables.

In contrast to previous studies of human-elephant conflict, daytime elephant refuges were easy to identify in Laikipia because of the detailed information available on elephant distribution, land-tenure and land use. It is likely that had I properly identified daytime elephant refuges within smallholder land, perhaps using land cover information together with local knowledge, as opposed to assuming that only ranches and forests with known populations of elephants could be daytime elephant refuges, then this variable would have been even more significant in determining spatial crop-raiding patterns. The proper identification of these daytime elephant refuges could also help guide elephant conservation and management decisions. It may be that such refuges are little more than staging posts for crop-raiding and their occurrence presents a major hindrance to effective management. In other cases, daytime elephant refuges may be critical for the future persistence of the local elephant population either because of their large size or because they contain important resources (minerals, water) or because they represent stepping stones between refuges, facilitating links between otherwise isolated populations. The relative significance of each of these arguments will need to be weighted in context and will obviously vary, depending on the objectives of the local managers/conservation authorities (i.e. eliminate crop-raiding or maintain elephant habitat and linkage).

Spatial information on dwelling (settlement) density was available at a higher resolution within this study compared with previous analyses. The pattern of the relationship between crop-raiding and dwelling density identified in this study demonstrates why elephant crop-raiding has been such a persistent problem in Laikipia. Crop-raiding intensity was highest at low to medium dwelling densities and decreased at higher densities. As described in Chapter Four, while smallholder cultivation and settlement has been attempted across large parts of Laikipa, cultivation and settlement has in fact largely been constrained by the prevailing pattern of rainfall. Many smallholder settlement schemes created either by the government, or through land buying companies, have effectively failed, and a large number of individual plots have been abandoned because of the unsuitability of the land for arable agriculture. Within these areas, those that do attempt to cultivate are often surrounded by bush and are acutely vulnerable to crop-raiding by elephants and other animals. In the more arid parts of the district, however, crops often fail and a high proportion of the immigrant land occupants subsist on food aid. Even where cultivation is feasible, such as through irrigation from the perennial rivers, it creates problems for downstream users living under even less predictable circumstances (in terms of lower rainfall). The 'patchy' nature of smallholder settlement in Laikipia also leaves immigrant farmers vulnerable to livestock theft and associated violence from resident and traversing pastoralist groups. On occasion this has led to entire settlements being abandoned overnight. Therefore, while crop-raiding by elephants is clearly a persistent problem in Laikipia, it only represents one of a battery of problems associated with smallholder production in an area in which rainfall is marginal. Given these circumstances, the most sensible management option for the alleviation of human-elephant conflict in Laikipia is the development and implementation of a clear land use plan, in which cultivation is restricted to where it is viable and livestock and wildlife based enterprises are encouraged in the more marginal parts of the district. A similar conclusion was reached by Thouless (1993), although subsequent efforts to try and get such a plan endorsed officially were derailed by unknown elements within the then government.

Given these previous experiences in Laikipia it appears that the prevailing struggle and associated politics over land both in Laikipia, and in Kenya more generally, is likely to be a significant and possibly, insuperable, barrier to the implementation of a sensible land use plan for alleviating human-elephant conflict. Under these circumstances, the electric fencing strategy adopted and currently being implemented by the Laikipia Wildlife Forum is therefore one of the few partial solutions to crop-raiding that is available. Elephants are, however, remarkably adept at getting around electrified fences and negotiating risk in human landscapes generally, as was shown in an analysis of GPS tracking data collected over the study period.

Have elephants adapted their behaviour to negotiate the risk of being injured or killed by human-resource users within Laikipia?

The occurrence of elephants in smallholder land and other areas in which local people pose a significant risk was intriguing: how and why do elephants use these areas? The crop-raiding data presented in Chapter Six clearly illustrated the motivation behind use of smallholder areas. In addition the positive relationship between elephant group size and distance from daytime elephant refuges provided preliminary evidence of aggregating behaviour in response to risk. This aggregating behaviour in response to the risk of predations is consistent with previous studies (Abe, 1995, Demmers & Bird, 1995, Hamilton, 1971, Kangwana, 1993) though has not been demonstrated during crop-raiding forays among elephants. Further evidence of this pattern of behaviour was possibly illustrated by the difference in the proportion of time spent crop-raiding before and after one of the tagged elephants (K22) tracked in southern Laikipia was separated from the main group of elephants resident to the area (see Chapter Seven). Given the hierarchical social structure among elephants, crop-raiding by groups of elephants and risk-taking more generally, may involve individual 'leaders', either older female or older male elephants. Further high resolution GPS tracking work, combined with direct observations, would help to confirm this pattern of behaviour. If this pattern of behaviour does indeed exist then it would confirm the prevailing perspective among wildlife managers in Laikipia and elsewhere, that eliminating individual 'rogue' animals could help alleviate crop-raiding, although the ethical implications of such a strategy, particularly within family groups which are largely dependent on matriarchs for survival, would be a concern among many conservationists. The task of identifying these 'individuals' would also be highly challenging for the reasons outlined below, particularly given the scarcity of resources available to most national wildlife authorities in Africa.

The high resolution GPS tracking data presented in Chapter Seven provided further compelling evidence of behavioural plasticity among elephants in response to risk. For example each of the elephants tracked used areas where they were not tolerated more often at night than during the day with the opposite pattern evident in areas where they were tolerated. In addition, speed of movement was consistently faster in areas where elephants were tolerated, compared with areas where elephants were not tolerated. Within elephant-intolerant areas this pattern was corroborated, with elephants moving more quickly across open compared with closed habitat types. This is the first time to my knowledge that such behaviour has been conclusively demonstrated in a land-use mosaic using GPS tracking data. The behavioural adaptations demonstrated suggest that elephants are able to maintain linkage between otherwise isolated elephant refuges. This has implications for elephant persistence for a number of reasons. Firstly, it shows that at an individual level elephants are able to respond to human induced landscape change by moving between the remaining elephant habitat 'patches', thereby optimising access to resources (food and water), separated by intolerant human land use systems. Secondly, if elephants can move across human occupied landscapes, where elephants are not tolerated, then otherwise isolated elephant populations can remain genetically connected, through the function of immigration, reducing the potentially negative impact of inbreeding. The effect of immigration could also be to stabilise local populations affected by higher mortality ('sinks'-see chapter 2) associated with human-elephant conflict. Thus the movements between elephant refuges demonstrated among the elephants tracked in this study suggests that the population in Laikipia displays characteristics consistent with the concept of a metapopulation, discussed in Chapter Two. From an ecological perspective the characteristics outlined above are all 'good' for elephant persistence in Laikipia. The behavioural traits important for enabling elephants to remain 'connected' and access scarce resources across space, however, also present a major nuisance for the people with whom elephants have to share the Laikipia landscape.

In Chapter Seven I demonstrated that the higher the proportion of the total area under smallholder use within an elephant's home range, the more often that elephants will use such smallholder land. This appeared to be the case with both male and female elephants and may seem like an obvious and expected result, but this result also broadly demonstrates that 'risk-taking' is a function of habitat fragmentation. This may ultimately be the outcome of necessity as elephants simply need to opportunistically move between and within smallholder areas to meet their nutritional requirements in fragmented landscapes. Male elephants tracked in this study, however, used smallholder land and other elephant-intolerant areas more often than the female elephants tracked in this study. Therefore the GPS tracking results are also consistent with the male behaviour hypothesis regarding risk taking among elephants referred to in previous studies (Chapters Two, Six and Seven). Further high resolution GPS tracking work both in Laikipia and in other study areas would be useful for confirming this gender-based trend in risk-taking behaviour.

The ability of elephants to navigate risk allows elephants to opportunistically forage on smallholder crops and generally live in places under human use. Results from the GPS tracking work carried out in this study suggests that managing this 'conflict' through lethal control is likely to be highly challenging. As was shown in Chapter Seven, elephants can and will 'hide' during the day either in elephant-tolerant properties or in thickets within elephant-intolerant areas and can move quickly into and through smallholder areas at night and between refuges if necessary. Several of the fences used to control elephant movement in Laikipia were broken by the elephants tracked in this study on many occasions. Once again, from an ecological perspective while this behaviour may be 'good' for connectivity, and enhance potential for elephant persistence in Laikipia, fence breaking from an elephant manager's perspective is a major nuisance. Some managers in Laikipia have resorted to enforcing fences by eliminating persistent fence breakers. While I did not have the time to fully investigate the efficacy of this strategy, it does appear that some fences that are enforced (i.e. Ngare Ndare Forest and Mogwooni Ranch) are more effective than others that are not (i.e. Sangare, Ol Ari Nyiro). This was also the conclusion reached in a previous study (Thouless, 1993; Thouless & Sakwa 1995). Given the length of the elephant fence proposed for Laikipia, the challenge of implementing a 'fence enforcement strategy' will be considerable, particularly in light of the extraordinary behavioural plasticity demonstrated by elephants fitted with GPS tracking devices in this study. Therefore elephants in some parts of Laikipia are likely to continue to move beyond the places that they are 'supposed' to live, such as private ranches and wildlife sanctuaries, and into the places where local people try and make a living. Ultimately the ability of elephants to coexist with people outside of ranches in Laikipia in the future will depend on the willingness of local people to tolerate them. Therefore, an understanding of local attitudes and perceptions towards elephants in the context of a ‘shared landscape’ is important for assessing the future of coexistence in Laikipia and beyond. This was dealt with in Chapters Eight and Nine.

While the GPS tracking results suggest that elephants are responding to rainfall, the strong seasonal difference in the distribution and movement of elephants out of Laikipia identified by Thouless (1996a) among a substantial proportion of the Laikipia elephant population was not identified in this study. This perhaps suggests that the longer term trend in the area is elephants stay in the elephant-tolerant ranches in Laikipia more than they used to, possibly reflecting a long term response to land use changes in the north (more livestock, more guns) and south (more cultivation, more conflict). However, there were sampling biases in this study that may have overlooked migratory movements of elephants between Laikipia and the rangelands to the north in Samburu and Isiolo Districts. Two total aerial counts across the wider ecosystem, one in the ‘short rains’ and one in the ‘long dry season’, carried out in a single year, would help to establish the extent of movement between the two districts and change from the patterns observed by Thouless in the early 1990s, and should be a priority for future elephant research in the area.

<u>How do responses to the presence of elephants vary among local people in Laikipia District?</u>

In Chapter Eight I demonstrated that crop-raiding by elephants in Laikipia in fact occurs within a continuum of human-elephant interactions. Local people also make contact with elephants across a range of household activities including firewood collection, water collection, livestock grazing, honey harvesting and wild plant foraging. The likelihood of contact with elephants varied between communal land households and smallholders as the former are more mobile and have a greater reliance on a higher number of widely distributed natural resources (e.g. plants for medicine) where as the latter are more sedentary, meeting their needs through farm-based livelihood activities and the urban market. Contact with elephants also varied among livelihood activities and in relation to the distribution of resources used. There were clear divisions of labour within the households surveyed so the circumstances under which contact was made with elephants varied among household members with, for example, women and children exposed to the risk of contact with elephants as a result of firewood and water collection while men were more likely to meet elephants through livestock herding as a result of the labour demands associated with this particular activity. Lastly, contact with elephants had a clear temporal dimension, relating to the temporal availability of resources used by households and the movement patterns of elephants. This was illustrated in the case of honey harvesting, with the majority of respondents reporting high levels of contact with elephants in the dry months (September and early October) prior to the short rains.

There was not sufficient time during the fieldwork period to establish the actual frequency of contact with elephants among households during specific off-farm livelihood activities. Instead, I used recall information to establish the occurrence of contact with elephants. While this provided a useful proxy indicator for understanding levels and types of interaction across a range of activities rather than just arable farming, I feel that further research into this area would be highly rewarding. For example, intensive household studies in which specific individuals or groups of individuals within households are regularly interviewed (i.e. on a weekly or monthly basis) could be used to establish actual levels of contact with elephants.

Assessing the relationship between livelihood activities and interactions with elephants is important for understanding the spatial and temporal dimensions of vulnerability to human-elephant conflict. Based on the results from Chapter Eight it would seem logical to assume that households in Laikipia's communal lands would be more vulnerable to conflict with elephants than smallholders based on their daily livelihood activities and associated levels of contact with elephants. The quantitative analyses of questionnaire results presented in chapter nine, however, show that households reporting a high incidence of interaction with elephants during off-farm activities did not in fact perceive elephants to be a major wildlife pest relative to other mammal species. Negative perceptions of elephants are more directly linked to the experience of crop-raiding and/or knowledge of events in which people had been killed and/or injured by elephants, rather than the level of contact with elephants. This suggests that in the absence of conflict over crops and incidents in which people are killed by elephants, local people in Laikipia can tolerate even high levels of interaction with elephants, providing that elephants are not perceived to be owned and exploited by 'outsiders'.

10.3 INTERDISCIPLINARY RESEARCH FOR UNDERSTANDING ENVIRONMENTAL PROBLEMS

This thesis used research methods from both the social and natural sciences. Designing an interdisciplinary study was enormously challenging because of the different sorts of knowledge structures, questions and research methods used between the two disciplines (Campbell et al., 1999, Campbell, 2003, Campbell, 2005, Daily & Ehrlich, 1999, Pickett et al., 1999). I was greatly facilitated in meeting this challenge by adopting a spatial framework, implemented through a GIS. The GIS allowed me to construct and move between layers and scales within a multi-dimensional landscape comprised of both ecological and human components. Therefore I could establish the extent to which space was 'shared' by people and elephants, providing the basis for finer scale research into how and why the spatial phenomenon of coexistence occurred in particular places.

As a further note I would like to emphasise that the maps I generated with reference to the Laikipia landscape created a common reference point and medium through which both social and natural scientists communicated to one another, enabling them to define respective roles and opportunities for synergy within the research project. There is growing interest and demand for interdisciplinary research into environmental problems (Daily & Ehrlich, 1999, Thornhill, 2003). My experience during the course of this study suggests that GIS can provide the bridge between social and natural sciences, a finding consistent with other interdisciplinary research projects (eg. Boulton et al., 2005). Therefore I would strongly recommend the use of GIS as the basis for planning, implementing and assessing other interdisciplinary research studies into environmental problems.

10.4 ALLEVIATING HUMAN-ELEPHANT CONFLICT

The alleviation of human-elephant conflict in Laikipia, and the wider area, constitutes two overlapping challenges. The first of these challenges, and one that has been assessed and discussed in detail in this thesis, is the problem of negative impacts on the livelihoods of the people that share resources with elephants in Laikpia. As was shown in this thesis, this problem is mainly in the form of damage to crops, though also includes loss of life, and to a lesser extent, competition over water resources. The second challenge for the alleviation of human-elephant conflict in Laikipia is securing the space to accommodate a growing elephant population. This challenge is one that has not been explicitly examined in this thesis, other than a discussion of the 'elephant problem' identified in other parts of Kenya and Africa, although the potential impact of elephants on woodlands was shown to be a major factor in the exclusion of elephants from certain large-scale properties in Laikipia, namely Solio and Mogwooni Ranches (see Chapter Five). In this concluding section, I will discuss each of these challenges in turn, with a view to highlighting both future areas of research and action that, I think, could be beneficial for elephant conservation and management in Laikipia and beyond.

Efforts are underway to reduce crop-raiding in Laikipia in the form of a district-wide electrified fencing strategy. I have argued that the effectiveness of electrified fencing varies and that such fences come with sustainability issues associated with recurrent maintenance costs. That is not to say that electrified fencing does not work and that there is not merit in the fencing strategy currently implemented by the LWF. However, given their limitations, electrified fences need to be used in combination with other methods, particularly in contexts where local 'communities' are charged with sourcing funding for recurrent fence maintenance. In addition, fencing could, possibly, lead to vegetation change and biodiversity loss within the enclosed area, and decreased resilience to stochastic events among the confined elephant population. It may also be important to note that the results from the questionnaire survey suggest that perceptions of who owns the Laikipia elephants may influence local attitudes towards, and tolerance of, elephants.

The creation of a district-wide fence may, in fact, reinforce negative attitudes towards elephants among local people living on the elephant-intolerant side of the fence.

Perhaps, therefore the most sensible long-term option for the mitigation of crop-raiding in the Laikipia area is through land use planning, although as I mentioned earlier, this option is beset with political problems both in Laikipia and beyond. Until the political will is available to pursue land use planning as a solution to HEC, other approaches will need to be used by elephant managers. One approach that merits consideration, and could be used alongside electrified fencing, is Community Based Problem Animal Control (CBPAC), originally developed in Zimbabwe (Osborn & Parker, 2002, Osborn & Parker, 2003) and recently trialled with some success in Transmara District, Kenya (Sitati & Walpole, 2006). This approach aims to shift responsibility for deterring crop-raiding elephants from wildlife managers to local farmers through the provision of simple and affordable elephant deterrence tools. These include passive 'barrier' methods (including ditches, walls, fences and hedges) and active deterrents (including torches, burning chillies *Capsicum* spp., throwing missiles, lighting fires and using various noise makers).

Between 2004 and 2005, with the help of an assistant, I trialled CBPAC methods with local farmers in three sites in Laikipia: Mutara, Rumuruti and Ol Moran. These farmers were provided with the following CBPAC treatments:

1. <u>Chilli rope fences:</u> Fences made of locally available sisal rope were erected around cultivated farms. A mixture of ground dried chillies and engine grease was regularly applied to the rope.
2. <u>Cow bells:</u> Metal cow bells, manufactured in the local town, were hung from each chilli fence to act as an alarm if an elephant tried to break through the perimeter fence.
3. <u>Chilli smoke briquettes:</u> Farmers were trained on the production of chilli dung briquettes, made by mixing chillies with elephant dung and a little water in a mould and leaving to dry in the sun. These briquettes were then placed on fires on the perimeter of farms at night to generate a noxious chilli smoke.

4. Noise makers: Purchased bangers and locally manufactured ‘banger sticks’ (these are made using local materials and match stick heads) were distributed to farmers within the trial areas.
5. Watchtowers: Watchtowers (20-30 feet high) were constructed on farms located close to elephant refuges and the farmers that man these watchtowers were provided with powerful torches.

While there was insufficient time to formally analyse and present results from these CBPAC trials in Laikipia for this thesis, uptake of these methods among farmers has been high, in some areas, and informal interviews with local farmers suggest that these methods do appear to be helping to reduce levels of crop-raiding and overall damage to crops. In other areas, however, uptake was in fact quite low. This variability in uptake was interesting, could be attributed to a number of possible factors, and raises some questions not properly addressed by the recent published studies of CBPAC trials.

In Chapter Six I demonstrated that with decreasing spatial extent, and thus, resolution, the strength of explanatory variables in determining the distribution and intensity of crop-raiding decreased. This could be the result of increased ‘noise’ associated with spatial autocorrelation, which further, more sophisticated spatial analyses, would demonstrate. However it could also be that at finer spatial extents, environmental variables become less important than socio-economic variables. This brings me back to my point about varying uptake of crop-raiding deterrents among smallholder farmers and leads to an important question: Are some farmers less able to take up crop-raiding deterrent tools, and therefore, more vulnerable to crop-raiding than other farmers?

The elephant scouts I employed for the fieldwork component of this thesis reported that some farmers were crop-raided more often than other farmers. I have not had the time to confirm these reports empirically, though this pattern does seem plausible, given that recent studies suggest improved guarding reduces crop-raiding (Sitati and Walpole, 2006), and that some individual farms in Laikipia are clearly less endowed with labour resources than others. Availability of labour may, therefore, be an important determinant of patterns of crop-raiding among households at the micro-scale. So too could household income, cultivation patterns, length of residence and status within the wider community. An assessment of these factors and other socio-economic variables in determining vulnerability to crop-raiding could be a rewarding area of further research and may help wildlife managers to consider a different strategy for managing HEC, by focusing resources on identifying and assisting the most vulnerable groups within a community, rather than attempting to cordon off the entire human-elephant interface. It may be that crop-raiding by elephants is as much a human social problem as it is an ‘elephant problem’. Are the farmers that are vulnerable to crop-raiding, equally as vulnerable to other socio-economic problems (drought, disease, theft etc.)? Over the course of the next three years I will be examining these questions and carrying out further HEC mitigation trials in the Laikipia area as part of a Cambridge University UK Darwin Initiative Project.

Creating an environment in which elephants are secure from the threat of poaching and harassment and therefore, perhaps, are less inclined to threaten the lives of the people with whom they share their range, is a challenge. The research presented in this thesis shows that the households living in the communal lands of north Laikipia were more tolerant of elephants than smallholder households. This could be largely attributed to the fact that smallholders grow and depend on crops, and are therefore, more vulnerable to losing food and income to elephants than the predominantly pastoral communal land households. It was, however, surprising and interesting to identify relatively high tolerance of elephants (or at least absence of intolerance) among communal land households, despite the high level of contact with elephants reported among these households. This could be because these communities have shared space with elephants for generations and are simply used to doing so. In addition they may hold traditional beliefs that provide elephants with a bequest value, as has been recorded among the Samburu people to the north of Laikipia (Kuriyan, 2002). These pastoral communities will have certainly benefited from exploiting elephants in recent history. Whatever the cause, the presence of relatively positive attitudes towards elephants among the communal land households surveyed may provide opportunities for reducing the threat of harassment and poaching that these households present to elephants. Moreover, these communities and their pastoralist neighbours to the north may present the best opportunity for addressing the possible emergence of an ‘elephant problem’ in Laikipia.

One approach for reinforcing any positive attitudes held by the households located on communal lands in north Laikipia and beyond is to provide wildlife-based benefit streams to the people that live with elephants. In southern Africa, sport hunting has provided the basis of revenue streams to local people living with wildlife. Although this may increase tolerance among people towards wildlife, it is most unlikely to increase tolerance among wildlife towards local people. Consumptive utilisation is not legal in Kenya, though the wildlife policy is being reviewed and there is a possibility that it could become legal in the future. While sport hunting and associated revenue is currently not available for Kenyan communities living with elephants, in north Laikipia and the rangelands north of Laikipia, in Samburu, Isiolo and Marsabit Districts, non-consumptive approaches have led to the creation of community wildlife conservancies and the development of eco-tourism infrastructure. In these areas, rainfall is marginal, cultivation is not present or feasible, and therefore wildlife could, possibly, deliver revenue on a par with livestock husbandry.

In this study elephants demonstrated a clear preference for landscapes where the human occupants are elephant-tolerant, including several group ranches committed to wildlife conservation. Therefore, the establishment of further elephant-tolerant areas north of Laikipia could address the potential of an emerging ‘elephant problem’ in Laikipia, by providing vast areas of elephant-vacant habitat that elephants could recolonise. There is considerable evidence to suggest that given the right conditions, in particular security and water availability, elephants will disperse to such areas (van Aarde and Jackson, 2007). The communities of north Kenya, therefore, may well provide an ideal elephant management tool, from the ‘bottom up’, and without the ethical dilemmas of culling currently debated in southern Africa.

Many of the places in which community conservancies have been established in north Kenya are, however, insecure, fought over by competing groups of armed pastoralists.

Therefore, the opportunity cost of 'conservation' in these places for the land owners, in collaboration with conservation security 'enforcers', is in fact rather low. Once the dust settles and the land units in question are secured, how will conservation and wildlife-based enterprises compete with traditional high-density livestock keeping in Laikipia and the northern rangelands? This will really depend on the ability of conservation and tourism-based revenue streams to: a) generate incentives that are substantive enough to offset the opportunity cost of lower livestock stocking rates; and b) individualise conservation benefits so that the appropriate individual stakeholders receive direct benefits, rather than the current systems of collective benefit sharing, which is mostly indirect, vulnerable to individual exploitation and corruption and does not offset individual costs (Walpole & Thouless, 2005).

In addition to carrying out trials for the reduction of crop damage by elephants, I had the opportunity to trial community-based production of elephant dung products with the aim of generating individual benefit streams to offset the cost of living with elephants. A sample of elephant dung paper is included in this thesis. This paper is now produced by a group of women in the Mukogodo Forest who receive between 80 to 300 dollars (U.S.) of direct revenue per month. The production of this paper is cheap and simple using waste paper, elephant dung and wood glue. The concept here is to both offset the costs associated with living with elephants and engender a sense of ownership and responsibility for elephants through the provision of benefits to *individuals*. With careful marketing and further development these products may provide part of a HEC alleviation tool kit for Laikipia and beyond, alongside crop-raiding deterrents and wildlife conservation-based enterprises that generate individual benefits.

Fig. 10.1 Women making elephant dung paper on Anandangaru plain in the Mukogodo Forest, Laikipia District.

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African Mammals

African bush elephant:	*Loxodonta africana africana*
African buffalo:	*Syncerus caffer*
African forest elephant:	*Loxodonta africana cyclotis*
Baboon (olive):	*Papio anubis*
Beisa Oryx:	*Oryx beisa*
Brush-tailed porcupine:	*Atherurus africanus*
Bush pig:	*Potamochoerus larvatus*
Cheetah:	*Acinonyx jubatus*
Eland:	*Taurotragus oryx*
Giraffe (reticulated):	*Giraffa camelopardalis reticulate*
Grant’s gazelle:	*Gazella granti*
Grevy’s zebra:	*Equus grevyi*
Impala:	*Aepyceros melampus*
Kongoni (Hartebeest):	*Alcelaphus buselaphus*
Leopard:	*Panthera pardus*
Lion:	*Panthera leo*
Ratel (Honey badger):	*Mellivora capensis*
Redtail monkeys:	*Cercopithecus ascanius*
Rhinoceros (black):	*Diceros bicornis*
Spotted Hyaena:	*Crocuta crocuta*
Thomson’s gazelle:	*Gazella rufifrons*
Vervet monkey:	*Cercopithecus (a.) pygerythrus*
Warthog (common):	*Phacochoerus africanus*
Western lowland gorilla:	*Gorilla gorilla gorilla*
Wild dog:	*Lycaon pictus*
Zebra (common):	*Equus quagga*

Other Mammals

Cougars (mountain lions):	*Puma concolor*
Grizzly bears:	*Ursus arctos horribilis*
Jaguars:	*Panthera onca*
Wolves:	*Canis lupus*

Birds

Common Ostrich	*Struthio camelus massaicus*
Greater honey guide	*Indicator indicator*
Lesser honey guide	*Indicator minor teitensis*
Somali Ostrich	*Struthio (camelus) molybdophanes*

Cultivated Plants

Maize	*Zea mays*
Bananas	*Musa spp.*
Beans	*Phaseolus vulgaris*
Onion	*Allium cepa*
Potato	*Solanum tuberosum*
Sorghum	*Sorghum vulgare*
Sweet potato	*Ipomoea batatas*

TODAY'S DATE: .... DATE OF INCIDENT: ....INCIDENT NO…………..

LOCATION OF INCIDENT: .... TIME INCIDENT OCCURRED:..............................……

NAME OF REPORTER:..………………………… AREA CODE…………………………………………

INCIDENT TYPE:

CROP DAMAGE	☐	ELEPHANT INJURED/KILLED	☐	
THREAT TO LIFE	☐	DAMAGE TO FOOD STORE	☐	
HUMAN INJURY	☐	DAMAGE TO WATER SUPPLY	☐	
HUMAN DEATH	☐	FENCE BREAK (voltage?)	☐	……………..
NON LETHAL PAC	☐	THREAT TO LIVESTOCK	☐	
OTHER	☐			

PROVIDE DETAILS………………………………………………………………………………………………
………..
………..

GPS x ☐☐☐☐☐☐☐ GPS y ☐☐☐☐☐☐☐ GRID REFERENCE………………..

REPORTED TO KWS (tick): Yes ____ No: ____ Date/Time of report: _______

ELEPHANTS INVOLVED:

GROUP SIZE (Total)	GROUP TYPE Bulls,Cows,calves or Mixed	VISUAL ID (complainant)	VISUAL ID (reporter)	TRACK ID (reporter)

QUALITY OF COUNT (Estimate/Exact) DETAILS:……………………………………………………..………..

ELEPHANT DIRECTION OF TRAVEL: Came From: ________ Went To: _________

ELEPHANT IDENTIFICATION:

TRACK I.D.	**Adult/Calf**	**Length**	**Width**	**Comments (if any)**
Dung 1				
Dung 2				
Dung 3				
Dung 4				
Dung 5				
Footprint 1				
Footprint 2				
Footprint 3				
Footprint 4				
Footprint 5				

DATE……………..   INCIDENT NUMBER…………

SHAMBA (Name of owner/Plot number): ______________________

ELEPHANT: VISIT ☐ RAID ☐   GPS X ☐☐☐☐☐☐☐   GPS Y ☐☐☐☐☐☐☐

			Quality of Crop			Age of Crop		
Crops Present	Planted area	Damaged area	Good	Medium	Poor	Seedling	Interim	Mature

ELEPHANT DETECTED AT TIME OF INCIDENT? YES ☐   NO ☐

METHOD OF DETECTION: Dog ☐ Seen ☐Heard ☐ Other ☐ Details:…………………………………..
ELEPHANT DETERRENT USED ………………………………………………………………………………
RESPONSE OF ELEPHANT/S (None, ran away, charged, other)…………………………………………..
………
OTHER DAMAGE (provide Details):……………………………………………………………………

SHAMBA (Name of owner/Plot number): ______________________

ELEPHANT: VISIT ☐ RAID ☐   GPS X ☐☐☐☐☐☐☐   GPS Y ☐☐☐☐☐☐☐

			Quality of Crop			Age of Crop		
Crops Present	Planted area	Damaged area	Good	Medium	Poor	Seedling	Interim	Mature

ELEPHANT DETECTED AT TIME OF INCIDENT? YES ☐   NO ☐

METHOD OF DETECTION: Dog ☐ Seen ☐Heard ☐ Other ☐ Details:……………………………….
ELEPHANT DETERRENT USED ……………………………………………………………………..
RESPONSE OF ELEPHANT/S (None, ran away, charged, other)………………………………………….
………
OTHER DAMAGE (provide Details):……………………………………………………………………

SHAMBA (Name of owner/Plot number): ______________________

ELEPHANT: VISIT ☐ RAID ☐   GPS X ☐☐☐☐☐☐☐   GPS Y ☐☐☐☐☐☐☐

			Quality of Crop			Age of Crop		
Crops Present	Planted area	Damaged area	Good	Medium	Poor	Seedling	Interim	Mature

ELEPHANT DETECTED AT TIME OF INCIDENT? YES ☐   NO ☐

METHOD OF DETECTION: Dog ☐ Seen ☐Heard ☐ Other ☐ Details:…………………………………..
ELEPHANT DETERRENT USED ……………………………………………………………………
RESPONSE OF ELEPHANT/S (None, ran away, charged, other)……………………………………………
……….
OTHER DAMAGE (provide Details):…………………………………………………………………….

Questionnaire number: ____________ **Date:** __________________

Interviewer: ____________________ **Time:** _________________

Study Site: _____________________ **GPS:** __________________

The purpose of this questionnaire is to understand how different groups of people in Laikipia use their environment and live with wildlife. Any information you provide will be used anonymously. This questionnaire is part of an independent study being conducted by Max Graham, a PhD student from Cambridge University in the U.K.

We would be very grateful if you could participate. Thank you for your cooperation.

A. Background of Respondent

1. Name: ___________________ **2. Age:** ________

3. Gender: 1=Male 2=Female

4. Ethnicity of respondent

1=European 2=Kikuyu 3=Meru 4=Maasai 5=Samburu 6=Turkana
7=Pokot 8=Other: _________________

5. How many people live in this household?

	Male	Female	Total
Household Head			
Spouse			
Children (1-18 years)			
Elders			
Dependents			
Employee			
Other: ___________ ___________			
Total			

6. Land user category

1=pastoralist 2=agriculturalist 3=other___________________________

Notes:____
____
____
____

7. Do you live here most of the time?

1=Yes 2=No

If not, where do you live most of the time? ________________________________

8. Do you own a shamba?

1=Yes 2=No

Notes: ____
____
____

9. Level of Education

1=None 2=Primary 3=Secondary 4=Tertiary

10. Do your children go to school?

Number of children	**School Level**	**Yes**	**No**		**Private or Government**
None		1	2		
	Don't go to school	1	2		
	Primary	1	2		
	Secondary	1	2		
	Tertiary	1	2		

11. For how long have you lived/worked in this area?

1=All my life 2=Other: _________________________________

If respondents have lived here for the duration of their lives go to 13

12. Where did you live before you moved here? ______________________________

13. Why did you move here?

1=Insecurity in area of origin 2=Lack of land in area of origin
3=Drought in area of origin 4=To find employment
5=Other: ______________________________

14. What are your goals with regards to use of this land?

15. How do you go about achieving these goals?

16. Do you depend on this land to live?

1=Yes 2=No

Notes: ______________________________

B. Crop Production

1. Do you grow crops? 1=Yes 2=No

2. Which crops do you grow?

Crop Type	**Yes**	**No**		**Area Cultivated (Acres)**	**Months Planted**	**Months Harvested**	**Units harvested (last harvest)**
Maize	**1**	**2**					
Sorghum	**1**	**2**					
Beans	**1**	**2**					
Potatoes	**1**	**2**					
Sweet Potatoes	**1**	**2**					
Cabbages	**1**	**2**					
Wheat	**1**	**2**					
Millet	**1**	**2**					
Spinach	**1**	**2**					
Tomatoes	**1**	**2**					
Sugar Cane	**1**	**2**					
Other: ________ ________ ________							

3. Do you use fertiliser? 1=Yes 2=No

4. Do you use pesticides? 1=Yes 2=No

5. Do you irrigate? 1=Yes 2=No

6a. Who looks after your crops during the day?

1=I do 2=employee 3=wife and/or daughters
4=sons 5=other:____

6b. Who looks after your crops at night?
1=I do 2=employee 3=wife and/or daughters
4=sons 5=other:____

Notes:____
____

C. **Animal Husbandry**

1. Do you keep livestock? 1=Yes 2=No

Type	**Yes**	**No**		**Number**	**Visual verification (Tick)**
Cattle	1	2			
Goats	1	2			
Sheep	1	2			
Chickens	1	2			
Camels	1	2			
Donkeys	1	2			
Other: ________ ________	1	2			

2. Do you keep beehives?

	Yes	No		Units consumed/sold (last harvest)
No I don't keep beehives	1	2		
Yes to produce honey for home consumption	1	2		
Yes to produce honey to sell	1	2		

3. Do you dip your cattle? 1=Yes 2=No

If yes, how often? ____

4. Who looks after your livestock?

1=I do 2=employee 3=wife and/or daughters
4=son/s 5=other:____

5. Where do you graze your livestock during the rains?

1=on my own farm 2=in the group 'ranch'
3=in the forest reserve 4=in the community 'reserve'
5=wherever I can find grazing
6=other: ____

6. Where do you graze your livestock when it is dry?

1=on my own farm 2=in the group 'ranch'
3=in the forest reserve 4=in the community 'reserve'
5=wherever I can find grazing
6=other: ____

7. Where did you graze your cattle during the 2000 drought?

1=on my own farm 2=in the group 'ranch'

3=in the forest reserve 4=in the community 'reserve'
5=wherever I can find grazing
6=other: ____

8. Where do you get water for your livestock during the rains?

1=River 2=Borehole 3=Dam
4=Collected rainwater 5=Spring 6=Other: ____________________

9. Where do you get water for your livestock when it is dry?

1=River 2=Borehole 3=Dam
4=Collected rainwater 5=Spring 6=Other: ____________________

10. Did you sell any cattle during the drought in 2000?

1=Yes 2=No

If yes, how many and what proportion of your herd?
____
____
____
____

11. Why did you sell your cattle?

1=I didn't sell my cattle.
2=To pay for foodstuff and household goods 3=There was no grazing
4=Other____

12. Did any of your cattle die during the 2000 drought?

1=Yes 2=No

If yes, how many and what proportion of your herd?
____
____
____
____

13. In the last year have you or whoever herds your livestock noticed elephants while out grazing or watering your livestock? If yes, in which seasons

1=Yes 2=No

If yes, when? ____

D. Fuel

1. What fuel do you use for cooking?

1= firewood 2=charcoal
3=kerosene 4=gas
5=electricity 6=other________________________________

2. Where do you get your fuel?

1=from my own farm 2= in the group 'ranch'
3=in the forest reserve 4=in the community 'reserve'
5=I buy it 6=from the neighbouring ranch
7=other____

3. Who collects your firewood?

1=Don't use firewood 2=I do 3=wife and/or daughters 4=son/s
5=employee 6=other____

4. In the last year have you or whoever collects your firewood noticed elephants while out collecting firewood?

1=Yes 2=No

If yes, when?____
____

E. Water

1. Where do you get your drinking water?

1=River 2=Borehole 3=Dam
4=Collected rainwater 5=Spring 6=other___________________________

2. Who fetches your drinking water?

1=Don't fetch drinking water 2=I do 3=wife and/or daughters
4=son/s 5=employee 6=Other__________________________

3. In the last year have you or whoever fetches your water noticed elephants while out collecting firewood?

1=Yes 2=No

If yes, when?____

F. Bush food and other naturally occurring 'non-managed' products

1. Do you use plants from the bush to cure illness?

1=Yes 2=No

2. Do you use plants from the bush for food?

1=Yes 2=No

If yes, under what circumstances and how often do you eat plants from the bush?
____
____
____

3. In the last year have you or whoever collects plants from the bush noticed elephants while out collecting plants?

1=Yes 2=No

If yes, when?____

4. Do you collect honey from the bush?

	Yes	**No**		**Units sold/ Consumed**
I don't collect honey from the bush	1	2		
Yes for home consumption	1	2		
Yes to sell	1	2		

5. In the last year have you noticed elephants while out collecting honey?

1=Yes 2=No

If yes, when?____

6. During the 2000 drought did you eat food that you wouldn't otherwise eat?

1=Yes 2=No

If yes, what was it that you ate? ______________________________________
____
____

7. Have you eaten animals that are pests?

1=Yes 2=No

If yes, which animals have you eaten? __________________________________

____
____
____

8. Do people who use this land eat bush meat?

1=Yes 2=No

If yes, which animals are eaten?______________________________________
____
____

Notes: ____
____
____
____

G. Wildlife Benefits

1. Have you received any benefits from wildlife in Laikipia?

Benefit Type	**Yes**	**No**	
Don't know	1	2	
None	1	2	
Hotel/Lodge bed nights	1	2	
Gate entry fees	1	2	
Sale of farm produce to lodges	1	2	
Sale of craft items	1	2	
Employment	1	2	
Cash from cropping schemes	1	2	
Community project: (Details):____________________________________ _ ______________________________________ ______________________________________	1	2	
Other:	1	2	

2. Does anyone else receive benefits from wildlife in Laikipia?

1=Nobody 2=the neighbouring ranch/es 3=KWS
4=Kenyan government 5=Other__________________________________

3. Does Kenya receive benefits from wildlife in Laikipia?

1=Yes 2=No

Notes: ____

H. Other sources of income

1. Do you have any other sources of income?

Income Source	**Yes**	**No**	
No other sources of income			
Employment	1	2	
Business	1	2	
Property rental	1	2	
Other:	1	2	

2. Have you got savings to help cover your living costs when resources are scarce such as in the 2000 drought?

1=Yes 2=No

Notes:

I. Perceptions of Risk

1. What are the threats to your income security?

Threat	**Yes**	**No**		**Rank**
None	1	2		

Drought	1	2		
Disease	1	2		
Cattle rustling	1	2		
Wildlife	1	2		
Illegal grazing	1	2		
Fire	1	2		
Poaching	1	2		
Other:____________________ ____________________ ____________________ ____________________	1	2		

2. Which wild animals threaten your income security?

Animal	**Yes**	**No**		**Rank**
Baboons	1	2		
Monkeys	1	2		
Porcupines	1	2		
Birds	1	2		
Bush pigs	1	2		
Elephants	1	2		
Lions	1	2		
Hyenas	1	2		
Leopards	1	2		
Other: __________ __________	1	2		

Please rank in terms of which animals present the greatest threat to your income security where 1=greatest threat

Notes:____
____
____
____
____
____
_

J. Interaction with Elephants

1a. In the last year have you noticed elephants in this area during the rains?

1=Yes 2=No 3=Other______________________________ [ ]

If yes, in which months?____

1b. In the last year have you noticed elephants in this area when it was dry?

1=Yes 2=No 3=Other______________________________ ☐

If yes, in which months?____

1c. In which of the months mentioned did you see elephants most often?

1=Jan-March 2=Apr-June 3=July-Oct 4=Nov-Dec ☐

2. When did you last notice elephants in this area?

1=In the last week 2=In the last month 3=In the last three months
4=In the last six months 5=Longer than six months ago
6=Other____ ☐

3. How did you notice them?

1=I saw them 2=I heard them 3=Dog barking
4=My friends/neighbours told me 5=Other______________________________ ☐

4. Where were they when you noticed them?

1=Near my homestead 2=In a field 3=In the forest 4=In a private ranch
5=In a group ranch 6=In the community ‘reserve’
7=Other: _______________________ ☐

5. What were you doing when you noticed them?

1=travelling on foot/bicycle 2=travelling by motorbike/vehicle
3=tending crops 4=looking after livestock 5=collecting wild foods
6=fetching water 7=collecting firewood
8=other__________________________________ ☐

6.What time of day did you notice them?

1=Night 2=Day ☐

7. How many were there?

1=don’t know 2=only 1 3=1-5 4=5-15
5=15-25 6=25-50 7=>50 ☐

8. Were there any small elephants in the last group you saw?

1=Yes 2=No 3=Don't know

9. What did you do when you noticed them?

1=nothing 2=I ran away and tried to hide
3=I tried to scare it/them away 4=I tried to kill it/them
5=Other____

10. Why?

1=they were too far away to be of concern
2=I like them 3=they don't bother me 4=I feared for my life
5=they were in my crops 6=they were damaging my infrastructure
7=they were competing with my livestock for grazing/water
8=Other____

11a. Since you have been here have you noticed if elephants in this area have migratory routes?

1=Yes 2=No

If yes, describe these migratory routes:
____
____
____
____

11b. Since you have been here have you noticed if elephants prefer to come here during certain times of the year?

1=Yes 2=No

If yes, when is this?____
____
____
____

12. Do you mind elephants coming into this area?

1=Yes 2=No

Why?____
____

____
____
____

13. Are there occasions when you have tried to prevent elephants from coming near you and/or your property (cattle/your crops/infrastructure)?

1=Yes 2=No

(If no go to question 21)

14. Under what circumstances have you tried to do this?

Circumstances	**Yes**	**No**	
When they entered my crop field	1	2	
When they entered my ranch	1	2	
When they damaged my fences	1	2	
When they damaged my water pipes	1	2	
When they prevented my livestock from drinking	1	2	
When they blocked my path	1	2	
When they threaten my life	1	2	
Other	1	2	

Notes:____
____
____
____
_

15. When did you last try to prevent elephants from coming near you and/or your property?

1=In the last week 2=In the last month 3=In the last three months
4=In the last six months 5=Longer than six months ago
6=Other____

16. Why?

1=they were in my crops 2=they were preventing my livestock from drinking
3=they were damaging my fences 4=they were damaging my water pipes
5=they were blocking my path 6=they were threatening my life
7=they compete with my livestock for grazing

8=other____

Notes: ____

17. What method did you use to prevent the elephant/s from coming near you/your property?

Method Used	**Yes**	**No**	
Gun shots (Rifle/shotgun) near elephant	1	2	
Gun shots (Rifle/Shotgun) at elephant	1	2	
Thunderflashes/Fireworks/Flares	1	2	
Torch	1	2	
Traditional (details)	1	2	
Dogs	1	2	
Other:	1	2	

18. How did the elephant/s respond?

1=no response 2=ran away 3=charged

19. Did anyone else help you try and scare away the elephant/s?

	Yes	**No**	
Nobody else helped me	1	2	
My neighbours and friends	1	2	
KWS	1	2	
Other	1	2	

Notes:____

20. Are there certain times of year that you attempt to scare away elephants away from this area?

1=I don’t try to scare elephants away 2=rainy season 3=dry season
4=all year round 5=Other____

Notes: ____

____

____

____

21. In the 2000 drought what did you notice about the elephant population in this area?

1=I wasn't here in the 2000 drought   2=I didn't notice anything
3=there were many elephants here   4=there were very few elephants here

22. In the 2000 drought did you have to prevent elephant/s from coming near you/your property more often than in a normal year?

1=I didn't scare elephants away   2=Yes   3=No
4=Other____

If yes, why?____

____

____

23. Do you use barriers to prevent elephants from moving into certain areas?

1=Yes   2=No

Barrier	**Yes**	**No**	
Wall (details)	1	2	
Electric Fence (details)	1	2	
Trench (details)	1	2	
Other (details)	1	2	

24. What are electric fences for?

	Yes	**No**	
To demarcate a boundary	1	2	
To keep people and livestock out of private ranches/sanctuaries	1	2	

To prevent wildlife (elephants) from breaking out of private ranches/sanctuaries	1	2	
Other:	1	2	

Notes:____

25. Have you requested the KWS to assist you with scaring away elephants that were giving you problems?

1=Yes 2=No

If yes, describe what they did to assist you and when?

26. Did this solve the problem?

1=Yes 2=No

Notes:

27. Has anyone been injured or killed in this area by an elephant?

	Yes	**No**	
Nobody has been injured or killed by an elephant here	1	2	
People have been injured by elephants here	1	2	

(who/when/how)			
People have been killed by elephants here (who/when/how)	1	2	

28. Have any elephants died in this area?

	Yes	No	
None	**1**	**2**	
Yes elephants have died here. (When/where/how/sex)	**1**	**2**	

29. Who owns the elephants in this area?

1=Nobody 2=the neighbouring ranch 3=KWS
4=Kenyan government 5=Other____

Notes:____
____
____
____
____
____
____
____
____
____
_

Appendix 4: Interview respondents and key informants

Interview No.	Group	Place name	Individual interviewed
I.1	Ranch	Southern Ol Pejeta	Commercial wheat farmer
I.2	Ranch	Ol Pejeta	Manager
I.3	Smallholder	Tigithi	Wildlife Group Chairman/ smallholder
I.4	Ranch	Solio	Manager
I.5	Ranch	Mogwooni	Manager
I.6	Forest	Mukogodo	Yaaku elder/former hunter
I.7	Communal	Kuri Kuri	Ranch employee/livestock keeper
I.8	Communal	Kuri Kuri	Group Ranch Secretary/livestock keeper
I.9	Communal	Ilngwezi	Group Ranch Director/livestock keeper
I.10	Smallholder	Endana	Former ranch employee/ smallholder
I.11	Forest	Mukogodo	Location Chief
I.12	Communal	Koija	Elder/livestock keeper/bee keeper
I.13	Ranch	Segera	Manager
I.14	Forest	Mukogodo	GoK Councillor
I.15	Forest	Mukogdo	Youth leader/livestock keeper
I.16	Forest	Ngare Ndare	Location Chief
KI.1	Management	-	Honorary warden, rancher
KI.2	Management	-	Executive Director, private conservancy
KI.3	Forest	Mukogodo	Elder/livestock keeper
KI.4	Communal	Koija	Community conservation officer

Appendix 5: Indigenous plants used by the Mukogodo people

Botanical name	Vernacular name	Human health	Animal health	Other uses
Acacia drepanolobium	Luwai	The bark is boiled with soup and given to mothers after giving birth.		The young galls are edible.
Acacia brevispica	Giri giri			The roots are boiled and the solution given to cows to expel the placenta.
Acacia mellifera	Oiti	The bark boiled in water is given as a purgative to cure malaria.		The blossom produces nectar and is one of the most productive honey bearing Acacias.
Acacia nilotica	Kiloriti	The bark is mixed with soup and drunk to aid digestion after feasting on meat. The sap in the unripe pods is applied to open wounds.	The sap of unripe pods is applied to open wounds on livestock.	The bark is used as a substitute for tea leaves. The dry seed pods are used to make tea.
Acacia senegal	Il derkesi	The bark is boiled and used as a treatment for general stomach pain.		The resin is edible.
Acacia tortilis	Il tepes	The roots and the bark are used to treat backache. The resin melted in water is used to treat infected eyes.	The seed pods are high quality dry season fodder.	The pods are edible.
Acokanthera schimperii	Morijoi			The roots are boiled to create a sticky substance. This is subsequently applied to the arrow shaft as a potent poison. The fruit are edible.
Ajuga remota	Menangi	The leaves are soaked in water and used to treat malaria.		
Aloe secundiflora	Sukuroi	The sap is used topically on burns and wounds. It is taken orally for general stomach pain.		The main root is used as a fermenting agent in the production of honey wine.

Botanical name	Vernacular name	Human health	Animal health	Other uses
Asparagus falcatus	Ltiadoi			The swollen roots are edible.
Aspilia mossambicensis	Laiyabasei	The roots are boiled in water. This is used to treat digestive problems in children.		
Balanites aegyptiaca	Ngoswa	The resin is mixed with water to treat pneumonia and tuberculosis.		The fruit are edible.
Carissa spinarum	Lamuriak	The roots are used as a tonic and for aching joints.		The fruit are edible.
Combretum molle	Mararoi	The bark and roots are used for back aches, (possible kidney problems)		
Commelina benghalensis	Ngaiteteiyai	The mucus in the fleshy stem is applied topically to open wounds.	The succulent stems and leaves are of high nutritional value to small stock	A revered plant used in all ceremonies where blessings are involved.
Croton dichogamus	Lakiridangai	The roots are steeped in hot water as a cure for serious chesty cough. The same is used as a tonic.		The root bark is used as a perfume mixed with ochre and sheep fat. The branches are insect resistant and are used for building.
Euclea divinorum	Il kinyei	The roots are boiled and used as an emetic. A solution from the roots is used to cure mouth ulcers in babies.	In severe droughts the cattle will eat the foliage as the tree is evergreen.	The branches are used to protect travellers on long journeys.
Indigofera swaziensis	Njokisheke	The roots are chewed for sore throats.		
Indigofera vohemarensis	Songoyo			The stem bark is used to make scented necklaces and bracelets.

Botanical name	Vernacular name	Human health	Animal health	Other uses
Ipomoea kituiensis	Lokitengi	The roots are boiled in water. This is taken to stop bleeding in early pregnancy.		
Juniperus procera	Mtarakwa	The bark is steeped in hot water for all general stomach pain.		The gum is edible. The leaves are used in wedding ceremonies as a blessing.
Lannea triphylla	Lampirori			The fruit are edible. The young stem bark is used for rope. Older bark is a substitute tea.
Lippia kituiensis	Sinoni	The leaves are crushed and inhaled to ease nasal congestion. The leaves are boiled and the solution applied to treat skin with measles.		
Maerua tryphilla	Latasha	The leaves are crushed and inhaled for sinusitis. The roots are boiled in milk and fat and used to treat coughs and chest pain.		
Maytenus putterlickioides	Laimurungai	The roots are made into a soup and used as a cure for rheumatoid arthritis.		
Myrothamnus flabellifolius	Naisulan'nkek			The dry leaves make an aromatic tea. The branches are used as a toothbrush.
Mystroxylon aehiopicaum	Lodonganayoi			The older bark is made into tea. The fruit are edible.
Ocimum americanum	Il korompole			The whole plant is aromatic and is used as a brush to sweep the home. The flowering stems are used as a bee attractant in beehives.

Botanical name	Vernacular name	Human health	Animal health	Other uses
Ocimum gratissimum	Lemurran	The leaves are steeped in hot water to treat gaseous stomach and pain.		The leaves were once chewed like tobacco.
Olea europea ssp.africana	Lorien	The bark is used as an anthelmintic.	The bark is made into a decoction and given as a drench to cows after birth.	The dry wood is burnt and used to scour milk gourds as a sterilizing agent.
Omocarpum keniense	N'kikembaus		Leaves and young pods make good fodder for livestock.	The young branches are used as toothbrushes.
Pappea capensis	Kisikongo	The roots make a tonic.The bark soaked in water is a cure for stomach pain.		The fruit are edible.
Psiadia punctulata	Labai	The roots are boiled and given as a cure for malaria.		The branches are burnt and the smoke used as an insecticide. The stems are used to make arrows.
Rhamnus staddo	Il kokolai	The bark mixed in a soup is a cure for colds.The roots boiled in water for malaria.		
Rotheca myricoides	Makutikuti	A concoction is made from the roots for venereal diseases. The same is used to treat tuberculosis. The smoke from the roots is inhaled for sinusitis.		
Scutia myrtina	Sananguri	The roots are used as a tonic.		The fruit is edible.
Tarenna graveolens	Il maasaei			The fruit is edible. The main stem is used as the main arrow shaft in the drop trap.

Zanthoxylum chalybeum	Loisuki	The seeds are crushed and mixed with water and honey as an important cold/cough remedy. The bark is boiled in water and mixed with milk to treat malaria.	The seeds are crushed and mixed with soda. This is administered orally to all livestock and washed down with water as an important anthelmintic.	

Table I: Distribution of the ranks (as a wildlife pest species) elephant were assigned (1-3=high, >3=low) by households in relation to independent variables across entire household sample.

Variables & Categories	Response Category % (N)		χ^2	*d.f.*	***P***
	High	**Low**			
Land Use					
Cultivate	68.7 (160)	31.3 (73)	77.6	1	.000***
Don't cultivate	18.9 (23)	81.1 (99)			
Age					
18-35	45.7(43)	54.3 (51)	2.12	2	.346
36-50	51.1 (70)	48.9 (67)			
>50	55.7 (68)	44.3 (54)			
Wealth (Possession Score)					
Very Poor	50 (52)	50 (52)	.7	3	.875
Poor	50 (73)	50 (73)			
Middle	55.6 (30)	44.4 (24)			
Rich	53.8 (28)	46.2 (24)			
Wealth (Livestock)					
Very Poor	69.9 (86)	30.1 (37)	46.06	3	.000***
Poor	65.6 (40)	34.4 (21)			
Middle	34.9 (22)	65.1 (41)			
Rich	31.1 (33)	70 (28)			
Gender					
Male	50.2 (136)	49.8 (135)	.5	1	.48
Female	55.3 (47)	41.3 (38)			
Education					
None	40.3 (79)	59.7 (117)	27.9	2	.000***
Primary	60.2 (62)	39.8 (41)			
Secondary or higher	77.8 (42)	22.2 (12)			
Scared Elephant					
Yes	68.1 (111)	31.9(52)	31.8	1	.000***
No	37.5 (72)	62.5 (120)			
Scared Elephant from Crops					
Yes	85.7 (96)	14.3 (16)	75	1	.000***
No	35.7 (87)	64.3 (157)			
Received Wildlife Benefits					
Yes	51 (75)	49 (72)	.01	1	.916
No	52.2 (108)	47.8 (99)			
Perceived Elephant Owners					
Government	48.5 (99)	51.5 (105)	4.6	2	.1
Foreigners	61.5 (48)	38.5 (30)			
Community	45.9 (28)	54.1 (33)			
Knowledge of People Killed or Injured by Elephants					
Yes	59.6 (155)	40.4 (105)	24.8	1	.000***
No	29.2 (28)	70.8 (68)			
Likelihood of Contact with Ele					
Low	68.6 (59)	31.4 (27)	13.6	2	.001**
Medium	55.1 (59)	44.9 (40)			
High	72.2 (13)	27.8 (5)			

Table II: Distribution of the ranks (as a wildlife pest species) elephant were assigned (1-3=high, >3=low) by households in relation to independent variables across communal land household sample.

Variables & Categories	**Response Category % (N)**		χ^2	***d.f.***	***P***
	High	**Low**			
Land Use	64.1 (41)	35.9 (23)	28.5	1	.000***
Cultivate	21.2 (21)	78.8 (78)			
Don't cultivate					
Age					
18-35	36.8 (14)	63.2 (24)	.45	2	.798
36-50	35.3 (24)	64.7 (44)			
>50	37.7 (23)	32.7 (33)			
Wealth (Possession Score)					
Very Poor	25.9 (14)	74.1 (40)	9.17	3	.027*
Poor	41.5 (34)	58.5 (48)			
Middle	64.7 (11)	35.3 (6)			
Rich	30 (3)	70 (7)			
Wealth (Livestock Units)					
Very Poor	33.3 (9)	66.7 (18)	10.3	3	.016*
Poor	61.8 (21)	38.2 (13)			
Middle	30.6 (11)	69.4 (25)			
Rich	31.8 (21)	68.2 (45)			
Gender					
Male	38.3 (49)	61.7 (79)	.0	1	1
Female	37.1(13)	62.9 (22)			
Education					
None	39.2 (51)	60.8 (79)	.03	1	.86
Primary or higher	35.5 (11)	64.5 (20)			
Scared Elephant					
Yes	57.9 (33)	42.1 (24)	13.4	1	.000***
No	27.4 (29)	72.6 (77)			
Scare Elephant from Crops					
Yes	70.2 (21)	30 (9)	14.3	1	.000***
No	30.8 (41)	69.2 (92)			
Received Wildlife Benefits					
Yes	50.6 (42)	49.4 (41)	10.3	1	.001**
No	25 (20)	75(60)			
Perceived Elephant Owners					
Government	30 (27)	70 (63)	5.2	2	.07
Foreigners	58.3 (7)	41.7 (5)			
Community	43.4 (23)	56.6 (30)			
Knowledge of People Killed or Injured by Elephants					.001**
Yes	46.6 (54)	53.4 (62)	11.1	1	
No	17 (8)	83 (39)			
Likelihood of Contact with Ele					
Low	50 (3)	50 (3)	.62	2	.73
Medium	34.2 (13)	65.8 (25)			
High	38.7 (46)	61.3 (73)			

Table III: Distribution of the ranks (as a wildlife pest species) elephant were assigned (1-3=high, >3=low) by households in relation to independent variables across smallholder household sample.

Variables & Categories	Response Category % (N)		χ^2	*d.f.*	*P*
	High	**Low**			
Land Use					
Cultivate	70.4 (119)	29.6 (50)	30.5	1	.000***
Don't cultivate	8.7 (2)	91.3(21)			
Age					
18-35	51.8 (29)	48.2 (27)	4.2	2	.12
36-50	66.7 (46)	33.3 (23)			
>50	68.2 (45)	31.8 (21)			
Wealth (Possession Score)					
Very Poor	76 (38)	24 (12)	6	3	.1
Poor	60.9 (39)	39.1 (25)			
Middle	51.4 (19)	48.6 (18)			
Rich	59.5 (25)	40.5 (17)			
Wealth (Livestock)					
Very Poor	19.8 (19)	80.2 (77)	37	3	.000***
Poor	29.6 (8)	70.4 (19)			
Middle	59.3 (16)	40.7 (11)			
Rich	70 (28)	30 (12)			
Gender					
Male	60.8 (87)	39.2 (56)	.53	1	.36
Female	68 (34)	32 (16)			
Education					
None	42.4 (28)	57.6 (38)	22	2	.000***
Primary	67.5 (54)	32.5 (26)			
Secondary or higher	84.8 (39)	15.2 (7)			
Deterred Elephant					
Yes	73.6 (78)	26.4 (28)	10.3	1	.001**
No	50 (43)	50 (43)			
Scared Elephant from Crops					
Yes	91.5 (75)	7 (8.5)	48.3	1	.000***
No	41.4 (46)	58.6 (65)			
Received Wildlife Benefits					
Yes	51.6 (33)	48.4 (31)	5	1	.02*
No	69.3 (88)	30.7 (39)			
Perceived Elephant Owners					
Government	63.2 (72)	36.8 (42)	.01	2	.99
Foreigners	62.1 (41)	37.9 (25)			
Community	62.5 (5)	37.5 (3)			
Knowledge of People Killed or Injured by Elephants					
Yes	70.1 (101)	29.9 (43)	12.2	1	.000***
No	40.8 (20)	59.2 (29)			
Likelihood of Contact with Ele					
Low	68.6 (59)	31.4 (27)	4.2	2	.12
Medium	55.1 (49)	44.9 (40)			
High	72.2 (13)	27.8 (5)			