SPATIAL DYNAMICS OF HUMAN, LIVESTOCK AND WILDLIFE INTERACTIONS IN KAJIADO CENTRAL DIVISION, KAJIADO DISTRICT, KENYA.

by

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DECLARATION

DECLARATION BY THE STUDENT

The work presented in this thesis is the result of my own investigations and has not been presented for a degree in another university. All sources of information have been specifically acknowledged by means of references.

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Abstract

Over the past decade in Kajiado district, there have been changes of property rights in pastoral rangelands from communal ownership, to group ownership, and recently to private ownership. The area is classified as part of the arid and semi-arid lands (ASALs) of Kenya and is home to a large numbers of wildlife and livestock. The main socio-economic activity is pastoralism, though there is a shift to other economic activities such as mining and agriculture which has led to fencing in some area and hence increased incidences of conflict between people and wildlife where wildlife depredate livestock.

Elangata Wuas group ranch is in the process of undergoing further subdivision and finally fencing of individual ranches. This process is bound to further aggravate conflict as the movement of wildlife will be curtailed by fences which will lead to personalization of forage and watering points. The main objective of this study is to establish to what extent wildlife and human utilization of habitats and various resources overlap. This was achieved by conducting total counts and using transects sampling methods along with quadrats and a pin-frame, in areas under differing grazing pressure and relating this to such variables and density of human settlement, roads and streams.

From the data, human settlement, road networks, streams, livestock and wildlife distribution were analyzed and mapped. Generally, wildlife preferred areas with low concentrations of human settlement. This was consistent with the prediction that the wildlife tends to avoid areas that are intensively used by humans and their livestock. Specific consistence of the predictions on animal distribution was shown where 12 species did not show any preference for areas used by human beings but two species; baboon and Impala, tended to aggregate close to human settlements. Gerenuk, reedbuck and wildebeest utilized area with high grass cover while zebra tended to utilize area with taller grass.

To ensure minimal conflict, in-depth studies into means to scale predator-prey ratios need to be looked into as predators are the main animal guild in conflict with people, yet direct methods of studying predators are insufficient to give good estimates of predators. The

wild herbivore biomass present appears to be sufficient as there are very few reported cases of depredation on livestock.

The way forward is to implement projects that endeavor to capture the link between livestock, herbivore and predators that will allow for a conclusion on the proponent of change in this environment and implementation of appropriate measures for reduction of conflict in a changing land-use setting.

CHAPTER 1

1.1 Introduction

The arid and semi-arid lands were occupied by the pastoralist communities, their livestock and wildlife before the advent of colonial interests in Kenya. Pastoralists, their livestock and wildlife were able to live in relative harmony as traditional pastoralist activities were separated spatially and temporaly minimizing losses due to disease and predation (Scoones, 1994; Rutten, 1992; Western, 1992).

Increasing demand for agricultural land by the colonial authorities lead to the conversion of the former Maasai pastoral lands to agricultural areas referred to as White Highlands, effectively confining the Maasai to the African Reserves and destabilized the ecological balance. In an effort to protect wildlife from 'poaching', Maasai lands were also converted to National parks and reserves like the Amboseli, Nairobi and Maasai Mara (UNEP, 1988; Western, 1992). These developments led to the Maasai people being displaced from their traditional herding grounds and concentrated in the southern parts of Kenya, that are presently Kajiado and Narok Districts (Galaty, 1992; Western, 1992). After Kenya's independence in 1963, the Maasai sold more arable land to the agrarian communities, further compounding the problem of availability of grazing areas that allowed for their transhumance in this harsh climatic area and increasing conflict over resources (Verlinden *et al.*, 1998; Lamprey & Reid, 2004).

Over the past decade in Kajiado district, there have been changes of property rights in pastoral rangelands from communal ownership, to group ownership, and recently to private ownership. Furthermore, the increase in the human population in this arid area over the past three decades has also contributed greatly to an escalation of conflicts in these pastoral lands. This has been brought about by increased pressure for utilization of land set aside for wildlife protection which has lead to an additional reduction in the total area of rangeland that is freely available to wildlife (Woodroffe, 2000). Subsequently, the rate and distance of both livestock and wild herbivore migration has increased facilitating conflict due to their water requirements and predation, as predators have also been known to follow the migratory routes of their prey ensuring food supply during these dry seasons (Paine, 2003; Woodroffe *et al.*, in press). Such a scenario presents a potential source of conflict on resource utilization between livestock and wildlife (Macdonald & Sillero-Rubiri, 2002).

The study area consists of Elangata Wuas group ranch of Kajiado Central division, which is undergoing further subdivision and privatization. With this prospect of further land adjudication, it is expected that the pastoralist way of life will be changed due to the inevitable fencing and individualization of such resources as boreholes and dry season grazing areas and increase conflict with wildlife. The area is important as the community is in transition between transhumance and complete sedentarization. For that reason information gathered will be important as baseline data in formulating wildlife management policies. This is especially so in situations where it can be compared with areas that have been established to be capable of sustaining wildlife and livestock activities but have undergone these subdivisions.

The study also intends to augment previous studies on wildlife and livestock that have concentrated on their distribution in relation to either subdivision or physical factors and avoided merging the two variables. In this way this study intends to give a complete representation of the bigger picture in the impacts of these variables with on the distribution of wildlife.

1.2 Literature Review

The semi arid and arid lands in Kenya have undergone major changes over the past decade. These changes were accelerated by colonial policies such as the creation of the "white highlands", post colonial policies: sedentarization of pastoral communities and migration of agrarian communities into ASALs, increase in population in these areas and a shift from exclusive pastoralism due to such factors as rural-urban migration and drought (GOK, 1992; Western, 1992; GOK 1999). Most of these policies were based on the attitudes and professional inclinations of the policy makers and ignored the needs and traditional practices of the indigenous people (Anderson & Grove, 1987). These policies have led to increased pressure on dryland productivity particularly on water and grazing resources. This pressure has led to loss of any potential the land had as most of it is reduced from once fertile land that supported such activities as shifting cultivation, to desert like conditions (Harrison, 1987; GOK 1992). These factors have culminated in interactions that have precipitated the present day conflict, between human beings and wildlife, where human beings, their livestock and wildlife compete for the limited resources (Scoones, 1994; Anderson & Grove, 1987).

The treaty signed in 1902 and 19[illegible] between the colonial administration in Kenya and Laibon Lenana the Maasai spiritual leader, was meant to prohibit further annexation of Maasailand and leave the Maasai people free to develop along their own lines effectively reintroducing the traditional pastoralist ways (Kantai, 1971). The treaty was soon contradicted by the National Park Ordinance of 1945 (Western, 1992). This ordinance paved way for a shift in conservation policy from hunting legislation to preservation through land protection and brought into effect the creation of parks such as Nairobi, Maasai Mara and Amboseli (Western, 1992). Creation of these parks effectively excluded the Maasai and their livestock from some traditional grazing areas and watering points. A relatively recent case is that of the Mkomazi Reserve in Tanzania where large pastoral herds have been excluded from land they previously used for grazing (Boyd *et al.*, 1999). In the past though, human and livestock populations were relatively small and widely dispersed (Boyd *et al.*, 1999) therefore allowing for segregation. With the increasing population and most of the previously avoided areas being cleared of tsetse-flies (Lamprey & Waller, 1990; Boyd *et al.*, 1999) pressure was exerted on the authorities to come up with policies that would allow the Maasai use of some of the protected area for grazing and watering of their animals. To address this issue of access to pature, the Kenya Government land adjudication programme was implemented in the mid 1960's, in which, groups of Maasai were issued with title deeds, thereby establishing the 'group ranches' (GOK, 1968a; Lamprey & Reid, 2004).

The precedence for the formation of the group ranches was laid by the finding that pastoralism was a hugely inefficient way of using land (Rutten 1992; Scoones, 1994). The adjudicated agricultural lands were found to be more productive than the unadjudicated lands leading the governments to sink a lot of effort into land adjudication (GOK, 1968b). The first stage in adjudication was to bring the higher potential pastoral lands into agricultural production; then the group ranch process to raise the productivity per unit area (GOK, 1992).

Kajiado District was the experimental district for the implementation of the post-colonial government designed group ranch programme with the establishment of 52 group ranches. These ranches covered an area of 1,526,812 hectares, which constituted about 76.4% of the previous trustland. The remaining 23.6% of the trustland involving some 472,000 hectares was adjudicated into 378 commercial ranches. This excludes land owned by the government or land meant for public utilities. The group ranch programme, therefore, covers the largest part of the land area in Kajiado District (GOK, 1992).

The group ranch programme had three main objectives. First and most important was the objective of making the group ranch a vehicle for bringing development assistance to pastoralists in terms of communal facilities, such as boreholes, dams, and dips (Lamprey & Reid, 2004; GOK, 1968b). By sharing these facilities, individual pastoralists were able to reduce unit costs due to the economies of scale. Second was the objective of increasing the off-take of pastoral livestock for commercial sale and thereby meeting the objective of satisfying the beef demand of urban markets and also commercializing livestock production for the benefit of the pastoralists. The third objective was to allow communal grazing, just like traditional pastoralism, which would enable pastoralists to make a smooth transition to commercial private ranching while maintaining viable ranches (GOK, 1968b; Rutten, 1992).

The objectives set above were not achieved in many areas due to mismanagement and heavy reliance on the government for inputs and technical advice with the richer members of the groups opting for individual ownership and this led to fragmentation of the group ranches (Lamprey & Reid, 2004). Fencing naturally followed this individualization of the ranches and many pastoralists became permanently settled, leading to an increase in competition for scarce grazing and water resources and the potential for conflicts between livestock owners and wildlife managers (Macdonald & Sillero-Rubiri, 2002; Lamprey & Reid, 2004). Part of the land was converted to crop farming as agro-pastoralists moved into these marginal lands. The increase in the incidences of snaring of animals near protected areas was also attributed to the influx of these agrarian communities into the vicinity of protected areas. These human activities and settlement have now blocked vital migration corridors, isolating animals within parks or areas that do not meet their dry season foraging needs (Verlinden, 1997).

The main factors still driving transformations in these arid and semi-arid lands (ASALs) are increasing demographic pressure, the expansion of cultivation and the reduction in rangeland resources. The rangeland resources include the soils, water and vegetation, particularly grass. These resources are reduced through privatization for commercial agriculture and ranching, and nationalization for conservation (Boyd *et al.,* 1999). These factors put livestock farmers and wildlife managers on opposing sides leading to conflicts when grievances were not accorded the desired level of urgency (Woodroffe *et al.,* 1997; Macdonald & Sillero-Rubiri, 2002).

These factors coupled with the colonial and present day government policies on rangelands emphasizing sedentarization and transformation from pastoralism to agrarian economies have created a situation where there is increased interaction between wildlife and humans. This is evident in times of drought where herders are forced to travel over long distances for forage and water. Traveling over these distances and the consequent disruption in the traditional methods of herding, has led to an escalation of conflicts with wildlife on many fronts (Macdonald & Sillero-Rubiri, 2002). Firstly there are concerns for personal safety as confrontations with predators can be fatal (Treves & Karanth, 2003). Secondly there is predation on livestock which is predominant in areas where the natural prey has been depleted through legal and illegal hunting (Linnell *et al.,* 1999; Swarner, 2004). Thirdly, competition between pastoralists and wildlife for grazing areas and water are also sources of conflict. Wild herbivores are also seen as transmitters of diseases such as malignant catarrh from the wildebeest (Macdonald & Sillero-Rubiri, 2002). Wild herbivores are also in conflict with the agro-pastoralists where in their migration they cause damage to cultivated crops.

Most of these conflicts come about when there is competition for water and pasture or predation. Resources are not distributed evenly and there is usually movement between areas that may be classified as "hot spots" of resources. Wild animals will generally aggregate in these hot spots that fulfill their dietary needs and so will livestock. In such situations where there is antagonism over shared resources, livestock typically out compete and even exclude wild herbivores, because they are derived from wild herbivore ancestry and are similar to wild herbivores in their dietary requirements. They also have a relatively recent history of co-existence with wild herbivores and show lower levels of resource partitioning with wild herbivores and most importantly, they are often buffered from harsh conditions like resource depletion through human supplementation giving them a competitive edge (Verlinden, 1997). The critical factor leading to conflict is lack of resource partitioning between livestock and wild herbivores. Livestock will always be herded to areas that provide sufficient forage and water, for example, cattle are exceptionally water dependant and must drink at least daily. Given cattle dependence on permanent water sources for survival in the arid lands, studies have revealed that their distribution is related to the presence of permanent water points. They have been shown to be mainly found in close proximity to permanent water sources though they move over long distances in search of quality forage and prefer areas with high grass cover and good grass quality (Verlinden, 1997, Lamprey & Reid, 2004). Sheep and goats on the other hand are highly adaptable and can inhabit ranges no longer able to support cattle and are associated with very low grass quality as they specialize in browse material and/or low grass cover and may forage in the vicinity of boreholes (Verlinden, 1997).

Wild herbivores also prefer areas with greener grass to meet their water and nutrient requirements. Eland (*Taurotragus oryx*, Pallas), wildebeest (*Connochaetes taurinus*, Burchell) and Thomson's (*Gazella Thomson*, Gunther) are found more in areas that have greener grass and had been burnt (Reid *et al.*, 2002). They are however found at a radius of more than 10 km away from the boreholes, which were taken to represent areas that had low human impacts, meaning they avoided areas with human activities and in the case of wildebeest, competition with water dependent cattle (Verlinden, 1997). Impala (*Aepyceros melampus* (Lichtenstein) are found in areas close to human settlements and permanent sources of water as they are highly water dependent. Their presence in areas occupied by cattle may be due to the fact that their dietary overlap with the livestock is low to moderate. It may also be sue to the fact that in these areas there is a higher abundance of woody vegetation which facilitating browsing (Reid *et al.*, 2002; Worden, 2003).

Grant's gazelle (*Gazella granti,* Brooke) is a mixed feeder and feed on grass and also browses on bushes. Their ability to go for long durations without water and their feeding strategy puts them in competition with goats and sheep (Verlinden, 1997, de leeuw *et al.,* 2001). Zebra (*Equus burchelli,*Gray), are mainly grazers, digging for grass rhizomes and corms in the dry season and are as highly dependant on water as cattle. This puts them in competition with cattle as they are dependant on the same resources and is indicative of the low levels of resource partitioning between livestock and wildlife.

Lesser kudu (*Tragelaphus imberbis,* Blyth) and giraffe (*Giraffa camelopadalis tippelskirchi,* Le Conte) are also browsers but are not reported to be in serious conflict with livestock rearing. The kudu are browsers that inhabit acacia thickets, dense scrub and drink regularly when water is available. In the dry season however, they are able to endure longer periods without water. Their choice of habitat minimizes encounters with human beings and consequently conflict. The ostrich though a mixed feeder and in minimal conflict with humans, is hunted for eggs, feathers, meat and skin, leading to a decline in their numbers in many areas (de Leeuw *et al.*, 2001).

All the wildlife species mentioned above limit competition amongst themselves by specialization. Wildebeest, Thomson's gazelle and Zebra are migratory species and have been documented to have grazing facilitation though all these species are grazers (Krebs, 1985; Murray & Brown, 1993). Zebras mainly feed on stems and sheath and almost no grass leaves, Wildebeest eat more sheath and leaves and Thomson's gazelles feed on grass leaves and herbs not eaten by the other two. Though Zebra feed on the same parts of grass as wildebeest, they do not feed in the same area at the same time. The zebra generally feed on areas that have been previously grazed by wildebeest and have the stem and sheath of grass remaining (Krebs, 1985).

The main area of conflict with human beings is generally due to predation and the need for pasture as evidenced above. The escalation of conflict due to predation has led to the large carnivores being at risk with many of them being classified as endangered, vulnerable or extinct (Nowell & Jackson, 1996). From previous predator studies, it has been established that, most of the large carnivores use about 400 km^2 of range so as to have enough prey biomass and reduce interspecific competition (Mizutani, 1993; Woodroffe & Ginsberg, 1998; Radloff & Du toit, 2004). There may be areas of utilization that overlap but for these large carnivores to coexist, the area must be also large enough and able to sustain sufficient numbers of preferred prey (Mills *et al.,* 1997; Linnell *et al.,* 1999; Patterson *et al*, in press).

Due to the policies of sedentarization, transformation from pastoralist to agrarian economies and demographic pressures in Kajiado district, the levels of conflict have increased, consequently reducing the numbers of predators (Swarner, 2004). These conflicts are manifested in the retaliatory killings of lions and other predators around such parks as Amboseli and Nairobi (KWS, unpublished). This may be explained by the increase in the chance encounters of carnivores by the pastoralists (Scoones, 1994; Anderson & Grove, 1987). There is also a general perception that the revenue from activities associated with wildlife, and especially predator viewing, does not trickle down to the local communities (Boyd *et al.*, 1999).

The predators are difficult to see as they have an evasive nature. Due to the protective measures that have to be taken in studies involving predators, these carnivores are perceived to be risky to study. Their ecology and the great reduction in their numbers outside the parks necessitates the generation of empirical data that supports the predation claims and the presence of counteractive measures. This will be important in securing the long-term survival of these carnivores in Kajiado district where a large number are found outside the protected areas (Anderson & Grove, 1987).

Some of the carnivores that have greatly declined in numbers due to loss of habitat, poaching and retaliatory killings are the Lion (*Panthera leo*), Leopard *(Panthera pardus)*, Cheetah (*Acinonyx jubatus*) hyena (*Crocuta crocuta)* and Wild dogs (*Lycoan pictus*). The lion originally occupied large areas but is now mostly confined to the protected areas. In Maasailand, it is perceived to be the main cause of depredation as it predates on cattle, which are the mainstay of pastoralism and may cause loss of a whole year's income to most families in these areas (Ogada *et al.,* 2003; Woodroffe *et al.*, in press). Hence, in cases of lion predation, there are higher incidences of retaliation than in cases involving the other large carnivores i.e. Leopards and Cheetahs. Another factor affecting lion numbers is that they are highly susceptible to diseases such as canine distemper (Frank, 1998). These factors have led to their decline to the current estimates of 17,000 to 23,000 worldwide.

The leopard populations in Africa as well as the Middle East and Asia are listed as endangered. The entire species is regulated in international commerce by CITES as an Appendix I species. As a species, IUCN considers the leopard vulnerable although many individual subspecies or populations are assigned much higher categories of threat. The main threats to the leopard is poisoning and shooting by farmers in retaliation for predation.

The cheetah population is estimated at 12,000 to 15,000 individuals worldwide and is classified as vulnerable in most of its range but as critically endangered in Iran and North Africa. The main threats to these carnivores are the depletion of their prey and being killed by ranchers especially in Southern Africa. They are also the smaller of the large carnivores and are therefore at a disadvantage when in encounters with especially lions and hyenas.

Spotted hyaena accounts for the highest number of large carnivores in areas where large ungulates are in high numbers. Spotted hyanea were historically distibuted throughout Eurasia and Africa but are now confined to sub-Saharan Africa. This species has been categorized as a Lower Risk species by the IUCN Hyaena Specialist Group. In addition, the group has identified this species as Conservation dependent. This means that there is currently a conservation program aimed at this species, but without this program the species would most likely be eligible for threatened status within 5 years. Under CITES, spotted hyaena do not have any special status.

The African wild dogs currently occupy only 25 of the 39 countries in which they were formally recorded. Only six populations are believed to number more then 100 animals. In total, only about 3,000 to 5,500 wild dogs, in between 600-1000 packs remain. Most of these populations are in southern and eastern Africa and only small remnant populations remain in West and Central Africa (Woodroffe *et al.*, 1997)

These large carnivores have shown continuous decline in numbers in their natural habitats and in some cases have undergone local extinction. The main factors leading to this decline can be summarized as habitat loss and degradation, reduction in their natural prey base, disease impacts, human-wildlife conflict and unsustainable levels of trophy hunting (Swarner, 2004; Woodroffe *et al.*, in press).

The decline in carnivore numbers has led to increased interest in their interactions with human beings and the other extrinsic factors that affect their continued existence in the wild (Gittleman, 1996; Ogada *et al.*, 2003; Paine, 2003; Kissui and Packer, *in press*). As has been stated before, anthropogenic factors are important determinants of carnivore habitat use. Studies have shown that carnivores avoid areas inhabited by human beings (Boydston *et al*, 2003; Reid *et al.*, 2003; Lamprey and Reid, 2004). Though there is evidence of an avoidance strategy, which is a positive attribute for coexistence of predators and human beings, the predator numbers are still on the decline. A case in point is the spotted hyena (*Crocuta crocuta*) which appears to avoid areas containing a large abundance of prey perhaps because these were the same areas of most intensive livestock grazing (Boydston *et al*, 2003). They have also been reported to be more active at night which coincides with reduced human activity as animals are already locked up (Boydston *et al*, 2003). Wild dogs too are known to avoid areas inhabited by human beings and concentrate in large ranches in Laikipia District in Kenya where they can utilize their exclusive territories that encompass 400-700 km^2 (Swarner, 2004). Though most of the wild dog packs studied den far from human settlements, one group has been studied in the eastern extension of Baringo district and has denned quite close to a town and are recreating the old misconception that wild dogs are a menace to livestock rearing by their depredation (Woodroffe *et.al.,* in press).

Estimating the large terrestrial carnivore numbers is difficult, expensive and time consuming leading to the use of indirect methods of predator sampling, which are often cost effective, repeatable and objective. This involves developing indirect methods of predator sampling in which such data as spoor and number of prey species is collected (Radloff & Du Toit, 2004; Carbone & Gittleman, 2002, Stander, 1998).

Avoidance strategy, by wildlife seen with such animals as the lesser kudu, gerenuk and most predators, of areas inhabited by human beings may give managers the options of conserving wildlife either by zoning or conserving both livestock and wildlife in a multi-use landscape. The realization that there is minimal overlap in the use of habitats by both wildlife and livestock necessitates an in-depth analysis that will help generate empirical data to back this conclusion (Swarner, 2004; Woodroffe *et al., in press).*

By gathering data on the distribution of wildlife in relation to human beings and livestock, this study endeavors to provide empirical information that will augment available information on the interactions. The study will also consolidate information on other explanatory variables in the environment such as roads and streams that interrelate with the choice of habitat by wildlife to allow for habitat sharing with human activities. This information is important to all the stakeholders in wildlife conservation areas as it places them in an informed position on the spatial requirements of wildlife. Wildlife has a high aesthetic value and has the potential to counterbalance losses associated with conflict situation. By linking empirical data and the aesthetic value of wildlife, the study hopes to achieve security for wildlife in communally owned land. This will be achieved by the generation of information that facilitates managers' development of innovative solutions that can preserve wildlife on the ranches and offset losses associated with sharing of resources.

1.3 Justification

While most wildlife has been eliminated from the agricultural areas of East Africa, the semi-arid areas represent an opportunity for balancing the needs of wildlife with those of the pastoral people. With a great number of these wild animals existing outside parks, there is need for better understanding of the dynamics of animal numbers, distribution and their interactions with human beings. In Kajiado District of Kenya, there is a large number of wildlife that roam free among the cattle grazers and have been in co-existence for a long time with there being tolerable harm to livestock. In recent times though, the level of conflict with wildlife has escalated partly due to an increase in human population and increasing pressure on available resources.

Many remedial measures have been proposed for conflict resolution, ranging from extermination of animals like lions, leopard and cheetahs n cases of predation (Sedeinsticker *et al*, 1999; Woodroffe, 2000) to relocation of animals like elephants where crops are damaged. These measures have not succeeded and conflict is still the single most important threat facing wildlife conservation in East Africa today. Knowledge of the relative abundance of prey, their distribution and resource utilization in the study area will give a better perception of the factors that lead to these conflicts and ways of mitigating them. Changes in the land adjudication and tenure in Kajiado Central provide an ideal site for a study into the effect of changing land-use patterns on wildlife habitat utilization. This study intends to evaluate the prospects for continued coexistence of pastoral livestock, other human economic activities and wildlife by analyzing the nature of interaction and the extent of overlap in resource utilization and identifying potential for conflict resolution.

The study also aims to provide data on the distribution and density of different guilds of herbivores that are a food source for large carnivores. With the advances in indirect methods of predator number estimation such as scaling of prey and predator biomasses, the data will provide baseline information on prey biomass. In future, scaling the prey-predator biomass will be able to give an empirically recognized number of predators being maintained in communal areas. This will allow managers to formulate policies that will manage predator numbers so as to be able to have lead to little or tolerable loss to predation and minimize conflict.

1.4 Objectives

Main objective

The main objective of the study is to establish the impact of human activities on wildlife distribution in Kajiado District.

Specific objectives

1. To establish environmental variables that affect livestock and wild herbivore distribution
2. To determine the extent to which habitat utilization overlap between wildlife and livestock.
3. To assess the level of human-predator interactions.

Hypothesis

1. Animal distribution is affected by environmental variables.
2. There is no overlap in the utilization of various habitats by both wildlife and livestock
3. There are high levels of human-predator interactions in the area.

CHAPTER 2

2.0 Study Area and materials and methods

2.1 Location of the study area.

Kajiado District is located at the southern tip of Rift Valley Province and is bordered to the north east by Nairobi, to the south east by Taita Taveta district, by Machakos to the east, Kiambu district to the north and Narok district to the west (GOK 1992). The district is primarily inhabited by the Maasai people who practice nomadic pastoralism and other immigrant communities that practice subsistence agriculture in well-watered areas. The total population in Kajiado district is approximately 406,054 people (G.O.K, 1999). Sedentary farming communities occupy highland areas such as Ngong Hills, Nguruman escarpment and the lower slopes of Mount Kilimanjaro in Loitokitok area, while the pastoralists occupy areas to the west and south east of the district. Human population density is highest in Ngong (36 persons/km^2) followed by Loitokitok (18 persons/km^2) as per the 1999 government census (G.O.K, 1999).

The study area is located in the western part of Kajiado district and covers 408 km^2 comprising Elangata Wuas group ranch. Elangata Wuas group ranch lies about 20 km south of Kajiado town and has a population of 2,764 people at a density of 9 people/ km^2 (G.O.K, 1999). It is bordered by Kilonito Group ranch to the north, which covers an area of 250 km^2. These group ranches are accessible by use of the government maintained Kenya Marble Quarry road. In the rainy season, the road network is still motorable though it may be interrupted by gullies especially in the southern parts near the Oliosur Hills.

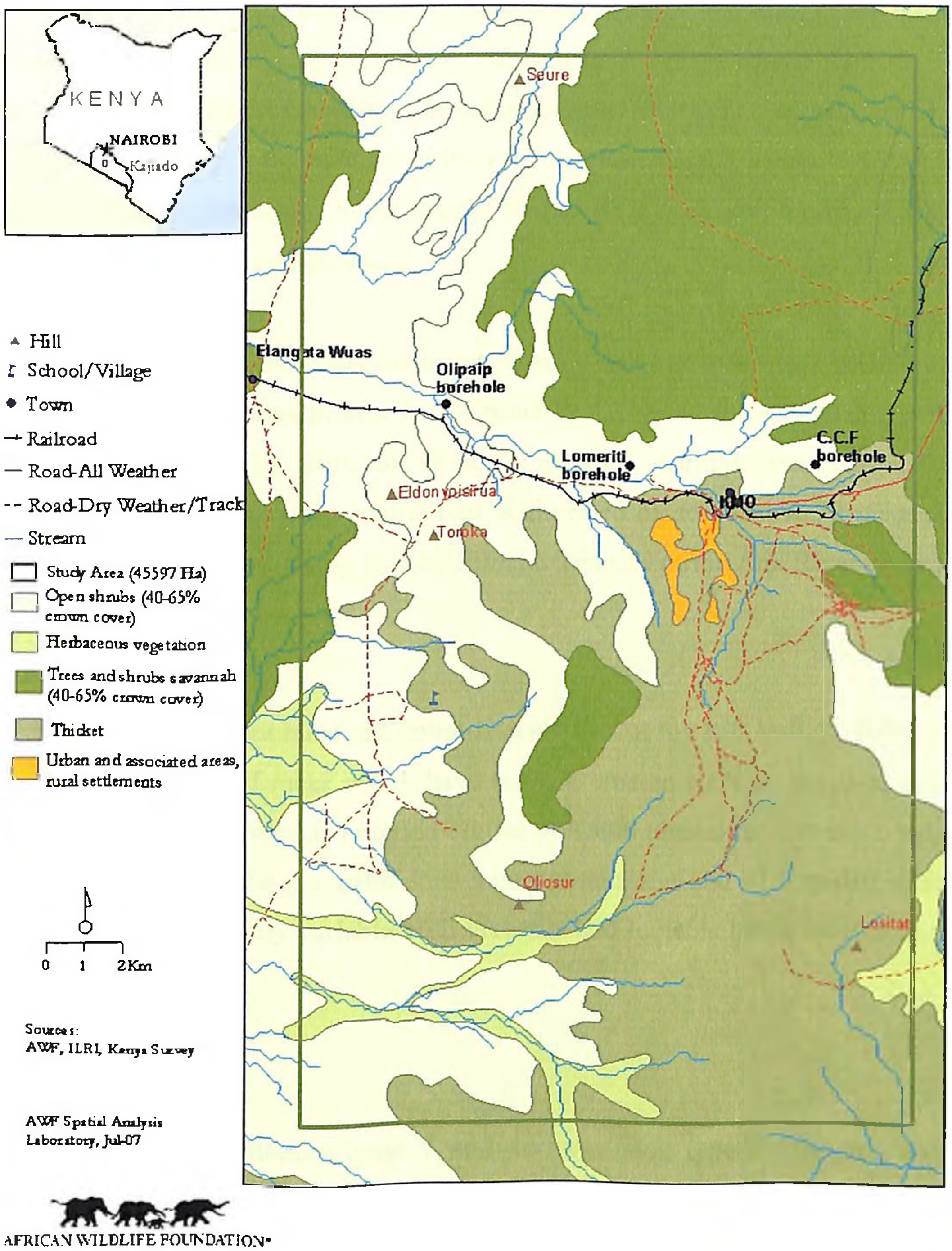

Figure 1. Study Area

2.1.1 Physiography

The study area lies to the south-eastern edge of the Athi-Kapiti Plains where the terrain gets steeper to the east. Numerous gneiss and limestone hills protrude from the slope, the largest, on the southern boundary, Oliosur, rising to 1700 m. The topography of the area is slightly undulating and lies at an altitude of between 1300m to about 1700m a.s.l. The lower altitude region occurs to the west of Elangata Wuas shopping centre and descends to the Rift Valley in the far south west.

Wetlands are closely associated with permanent rivers or springs and are characterised by large seasonal variations in size hence water resources in the district are scarce. These wetlands occur in the form of swamps, marshes, springs, seasonal and temporary pools. In the study area, the central part is dissected by seasonal water courses that drain into the north-easterly flowing Kiboko River, a tributary of the Athi River (Worden, 2003).

2.1.2 Soils

Volcanic rock occupies most of Central Kajiado east of the Rift Valley. Hills are common and are as a result of rocks which have resisted erosion such as gneisses, quartzites and marbles. Others are volcanic eruption centres of Kapiti phonolites. Soils are red, sandy and often shallow with the dominant soils being grumosolic and of impeded drainage. The other soils are generally variable with vertisols and luvisols being most common (GOK, 1992).

2.1.3 Vegetation

The area is in Eco-climatic zone V and the vegetation type is bushland and shrubland mainly composed of *Acacia Commiphora* bushland and grasslands supported by the soils type present. The dominant species of trees are *Commiphora africanus, Acacia mellifera, A. nubica, A. seyal, A. tortilis* and *Balanites aegyptiaca* that form good browse material. On volcanic ash in this zone, there are Rhodes grass (*Chloris gayana*) and a stoloniferious perennial species of *Dactyloctenium* spp. The grasses are species of *Sporobolus, Pennisetum strammineum* and *Cynodon plectostachyus*. Other common perennial grasses include *Cenchrus ciliaris, Chloris roxburghiana* and *Eragrostis superba.* In the grumosolic clay soils, *Pennisetum mezianum* dominates as it most often out competes *Themeda triandra* (Pratt & Gwynne, 1977). Lines of isolated trees also follow the seasonal river courses.

2.1.3 Climate

The study area lies in semi-arid and arid zones V, characterized by an arid to semi-arid type of climate. The area has a moisture index of -42 to -51 and rainfall rarely exceeds evaporation. Rainfall is bimodal and is concentrated in the months of March to May with a peak in April, which is categorized as long rains season while the short rains season occurs in October to December. Mean annual rainfall ranges is around 300mm though it may rise to about 700mm Figure 2. The highest temperatures are experienced twice in the year, firstly in the months of January to March and the secondly in September. During the dry seasons, day temperatures are consistently above 30° C and do not drop below 20° C at night. These high temperatures and the low elevation of the area account for the high rate of evaporation.

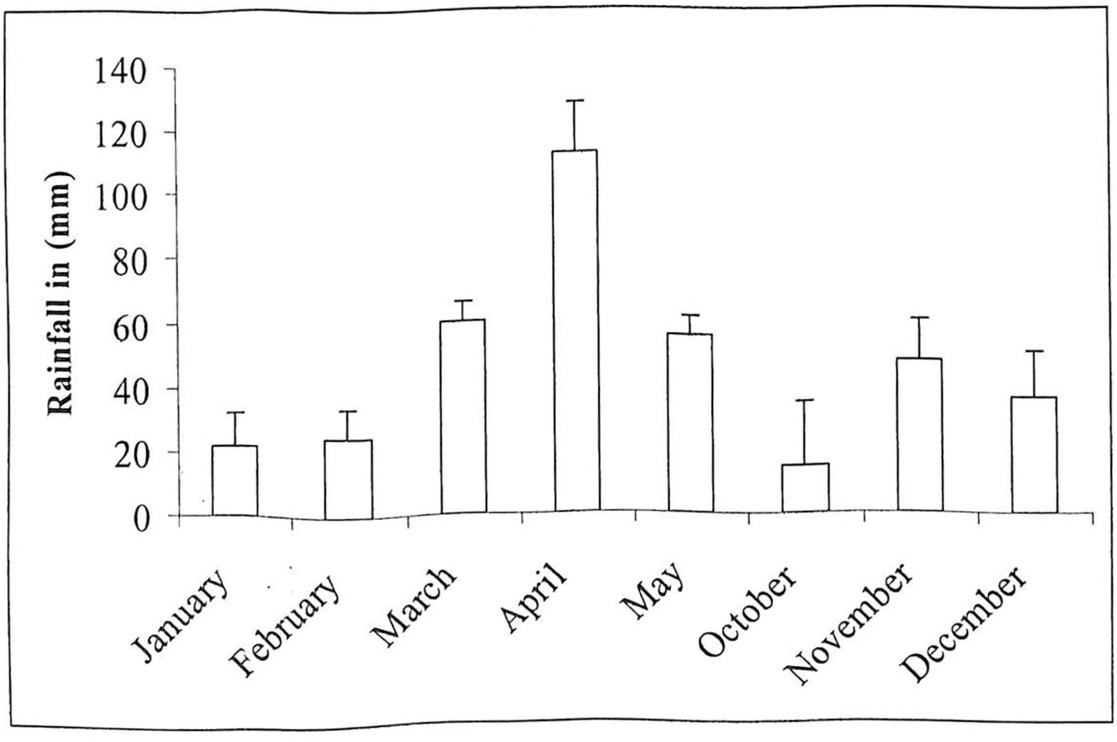

Figure 2. Mean monthly rainfall (mm) from KMQ and Ecosystem field station (Worden *et al.*, 2004)

2.1.4 Hydrology

There are no perennial rivers and the seasonal Toroka River is the main one draining through the study area. Most of the streams in the study area drain into the seasonal Kiboko River which is made up of the Olkejuado and the Selenkei tributaries. The Selenkei is an important water course in the area as it provides water for both humans and livestock late into the dry season. This river is seasonal and retains water in the sand which is important for the dry season watering of livestock and wildlife.

Available information from 32 boreholes drilled in the basement system indicated water yields ranging from 0 - 719 cubic metres per day obtained from various depths, ranging from 66m to 183m. Of the 32 boreholes, 23 produce water of good quality, while four have slightly saline water. The other five boreholes have so far not produced water.

2.1.5 Wildlife

Wildlife is an important feature within dispersal areas that consist of group and individual ranches. The ecology of the area favours wildlife and livestock cohabitation and a sparse human settlement density allowing for free movement of wildlife. Apart from the common free movement of wildlife, there are also dispersal zones which are dictated by climate.

The dominant wildlife in the study area include; Maasai giraffe (*Giraffa camelopadalis tippelskirchi,* Le Conte), Grant's gazelle (*Gazella granti,* Brooke), Gerenuk (*Litocranius walleri,* Brooke), Grant's zebra (*Equus burchelli bohmi,* Gray), Thompsons gazelles (*Gazella Thompsoni,* Gunther),Common warthog (*Phacochoerus aethiopicus,* Pallas), Ostriches (*Struthio camelus,* Linnaeus), Impala (*Aepyceros malampus,* Lichtenstein) Greater kudu (*Tragelaphus strepsiceros,* Pallas), Lesser kudu (*Tragelaphus imberbis,* Blyth), Kongoni (*Alcelaphus buselaphus cokii,* Pallas). The main Carnivores in the area include: Lion (*Panthera leo,* Lichtenstein), Leopard (*Panthera pardus,* Lichtenstein), Cheetah (*Acinonyx jubatus* Schreber), Hyaena (*Crocuta crocuta,* Erxleben) and the

Black-backed jackal (*Canis mesomelus,* Schreber). Other common mammals are, Olive baboons (*Papio anubis,* Fisher) and Vervet monkey (*Cercopithecus aethiops*, Johnstonii).

2.2 Materials and Methods

2.2.1 Stratification of study area

The study area covers a large portion of Elangata Wuas group ranch, covering an area of 408 km^2. This are is currently undergoing subdivision though fences have not yet been erected. Stratification of the group ranch was based on the estimated grass cover in three different categories. Three categories were chosen based on this estimated percentage cover in the area conducted during a reconnaissance of the study area. This was done with the aid of quadrats. The three categories were referred to as low cover, medium cover a high cover areas. The low cover category represented an area with a percentage grass cover of 0-25%, the medium cover category 26-50% and the high cover stratum was represented an area with a grass cover greater than 50%.

For the study to achieve optimal spatial resolution to describe the relationships, a topographical sheet of the study area at 1:500000 scale (Survey of Kenya, 1973) was divided into 500 by 500 m UTM grid squares that were used to record animal presence in each of the strata (Sinclair & Arcese, 1995). These 500 by 500 m grids were generated on the one kilometer squared grids already on the topographical sheet of the area by numbering the one kilometer grids sequentially by rows and columns using the latitudes and longitudes as reference (Figure 3). The one kilometer grids were then overlaid with 500 by 500 m grids that were numbered sequentially, i.e. 3697.1, 3697.2, 3697.3 and 3697.4, to represent the numbers assigned to each of the sub-blocks making up the one kilometer squared blocks (Reid *et al.*, 2002). At the 500 by 500 m spatial resolution, interactions between livestock, wildlife, human settlements, roads, streams and watering points are well documented , hence the choice of the 500 by 500 m grid (Worden, 2003).

The grids were also important in demarcating the boundaries in which animal could be counted. They were also used to calculate the distance at which animals were located from roads, streams and human settlements. This was achieved by taking the UTM location at the centre of the grid in which an animal was counted and calculating the distance from that point to the nearest road, stream or settlement using a distance estimator in ArcGIS. Counting stations and one kilometer transects were also located within each strata such that there was an equal number in each strata. Location of transects was done randomly and to minimize overlap, the start of each transect was at a minimum of two kilometers from the nearest transect. The GPS location of each transect start was stored in a GPS so as to allow for easy location of each transect. Data on livestock and wildlife numbers in these strata was converted to biomass and correlated to grass biomass from pin-frame data for each of the categories.

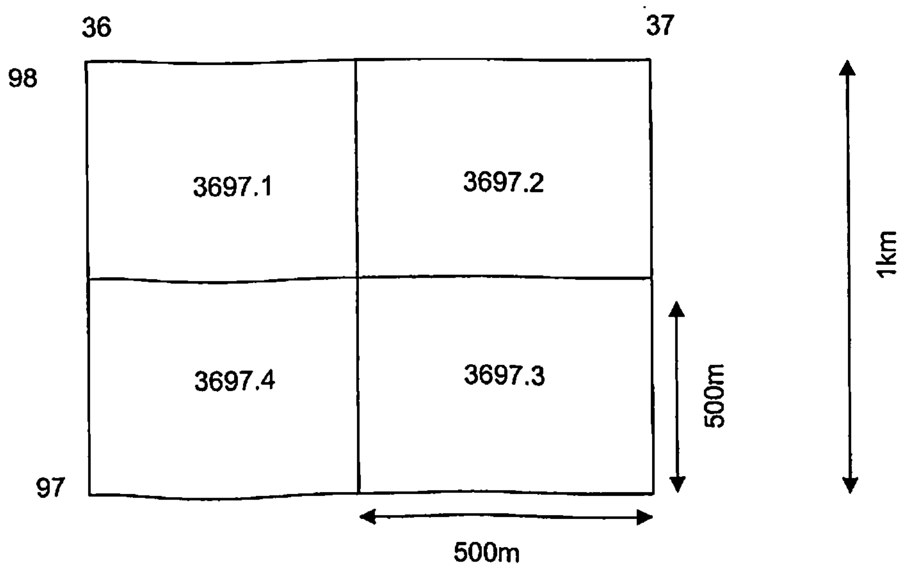

Figure 3. Illustration of topographic sheet showing the counting blocks for the study.

2.2.2 Selection of herbivore counting stations

Selection of counting stations from which surveillance would be conducted was done on the topographical sheet mentioned in section 2.2.1 above. These stations were selected on the basis of their elevation ensuring that they were the highest points at each of the counting areas in line with point counting. To ensure consistency in the total area that would be surveyed, counting stations were all selected with elevations ranging from 1500-1700m above sea level. The highest counting station was on Seure hill in the north of the study area at 1700m above sea level. The efficiency of this method of counting was estimated using GIS area estimations of the number of grids that were surveyed at each counting session. From this analysis 18 counting stations were selected for conducting herbivore censuses. Using area estimation calculations of reconnaissance counts, the projected area that could be surveyed at this elevation was $40km^2$ in a day and boundaries were set using such landmarks as bomas and trees.

2.2.3 Herbivore counts

In this study total counts of the different livestock and wildlife species found in the study area were used. Three counts were done bimonthly in the months of February, April and June 2004. For these counts, the 500 by 500 m grids were used to assign a location to the animals counted from the counting stations. These grids also aided the enumerators to place animals counted into recognizable grids as the actual GPS location of the animal count not be estimated from this distance.

Herbivore counts involved three enumerators scanning the area below the counting station for 10 minutes. Each enumerator had a counting sheet that with the 500 by 500 m grids labeled. Distinct features of the scanning area, such as bomas, gullies and conspicuous trees were also indicated on the counting sheet. These features also functioned as the counting boundaries for each counting station. Counting was done at nine o'clock in the morning and three enumerators scanned an area demarcated on the counting sheet to minimize the possibility of double counting. Each enumerator ensured no animals were counted twice by scanning clockwise from the landmark determined during the efficiency estimation in section 2.2.2. Counting involved scanning over the area below the observation point with the aid of binoculars and whenever an animal or a herd were seen in each grid, the enumerator stopped scanning and recorded the animal species and the number of individuals. The domestic animals counted were cattle, shoats (sheep and goats) and donkeys. Sheep and goats were counted as shoats due to the limitations of the elevated counting stations in distinguishing between them as they are herded together. The wildlife species counted were baboon, dik dik, eland, giraffe, Grant's gazelle, gerenuk, impala, lesser kudu, ostrich, reedbuck, Thompson's gazelle and zebra. When these counts were completed, the enumerators then moved to the next counting station and the same procedure repeated.

Counts of each block were then summed up per species giving a total count of the animals over the 3 months of counting. The data collected was used to map out animal distribution and the degree to which habitat use overlapped. Animal biomass is known to scale as a result of mass-related energy requirements but may also be affected by variation in the availability of the resources.

The following assumptions were made during the census:-

1. Each grid was well searched and all the animals located and counted accurately.
2. Counting was done in uniform habitat and weather conditions.
3. The number of animals moving out was compensated for by the number of animals moving in and none were counted twice or more.

2.2.4 Estimating grass cover

A combination of transect and quadrat method were used to determine grass cover and colour. Each transect was one km long and the quadrat was 10 m^2 in area. To ensure a good representation of the cover, a total of 84 transects were laid such that they were evenly distributed over the study area. With the aid of ArcView GIS, the 84 transects were selected with each transect two kilometers away from the neighboring transect ensuring no overlap in transects. Randomization of the direction of each transect was achieved by selecting random bearings using random numbers from a random numbers generator in ArcView GIS.

Once a transect was located, the direction in which the transect would be sampled was then established and a quadrat placed to the right of the data collector on the transect line. In each quadrat, the following vegetation parameters were recorded: grass cover, grass height and palatability of the herbs (Woodroffe *et al.*, in press). To estimate grass cover, the quadrat was divided into four, and the estimated cover of each ¼ was added up to give the total cover in the quadrat. Estimates by two observers were used by taking the average value of cover assessed and recording this as grass cover. This data collection was then repeated at four more sampling points which were systematically set 250m apart along the transect. Grass height was measured in centimeters using a meter rule. Grass was classified as palatable and non-palatable by the assistants based on their indigenous knowledge of preferred livestock forage and was further identified in the herbarium to translate local names to scientific names.

2.2.5 Pin-frame grass biomass estimation

Grass biomass was estimated by the use of a pin-frame. Six transects each 200 m were established in the low cover, medium cover and high cover strata. These transects were selected randomly from the one kilometer transects used in section 2.2.4 ensuring that there were two per strata. At the start of each transect, a random direction was generated and along each of the transects, sampling was done at four plots, each 50 meters away from the preceding one. The species composition was determined using a pin-frame with 10 incline pins that were passed through the frame at an angle of 45 degrees (Gichohi, 1990). For each pin, the species of grass and number of hits between the canopy and the ground were recorded. This was repeated for all six transects in the three habitats. The data collected here was used to determine the dominant grass species in each habitat and also to estimate grass biomass

2.2.5.1 Calibrating hit-per-pin into standing biomass

Measurements obtained from pin-frame can be converted into biomass by calibration of the hit-per-pin correlated to biomass. To achieve this in this study, a calibration for hits per site was done for all the study sites. In each site, a total of six 0.5m by 0.5 m quadrats were sampled. This was done using 10 pins for which the species of grass and the number of hits were recorded. The 0.5m by 0.5 m quadrat was then placed in uniform pasture and the different grass species clipped and placed in separate bags for oven drying and weighing. This calibration was carried out in the month of February when the vegetation was not too dry.

2.2.6 Human settlement

Human population numbers and their distribution is a major factor affecting the distribution of both livestock and wildlife (Muchiru, 1992; Reid *et al.*, 2002; Worden *et al.*, 2003). The human settlements in this study were located on the map overlaid with the 500 by 500m grids during a reconnaissance of the area. Different thatching material was used to classify the houses into tin roofed and Maasai Manyatta. The aim of classifying into house types was to use this classification as an indicator of the sedentarization extent and the levels of poverty and therefore the level of human impact on animal distribution (Reid *et al.*, 2002, Worden *et al.*, 2003). Human population density estimates of the study area were acquired from census data from 1999 (GOK, 1999).

2.2.7 Habitat use determination

A major objective of the study was to establish the extent to which wildlife and livestock overlap in their use of habitats. In this study, habitat utilization by wildlife and livestock was measured through an indirect method in which dung presence / absence was used as an index of habitat use. This data was collected along with the grass quality and cover data on the one kilometer transects described in section 2.2.4 and sampled within the three habitats. The presence/ absence data was collected at the start of each transect and subsequently at 250 m along the one kilometer transects. This gave a total of 5 sampling points along each one kilometer transect (Woodroffe *et al.*, in press).

The $10m^2$ quadrat was scanned for presence of readily recognizable dung samples and whenever dung was encountered, the observer recorded the species name, the condition of the dung with the aid of a tracker and the GPS coordinates at the center of the quadrat. The amount and age of dung in each quadrat was taken into account. The presence of identifiable amounts of dung in the quadrat was recorded as presence of that particular species in the habitat. The age of the dung also aided in classifying the dung as an indicator of habitat use by the particular species. The quadrat measurements were then taken at the subsequent 250 meter mark along each transect until the 1000 meter of along the transect was reached and the measurements repeated for all the transects in the study area.

2.2.8 Indices to sample for predator presence

As predation was a major factor attributed to conflict between wildlife and human beings, the study incorporated an indirect method of predator sampling (Stander, 1998). This was achieved by collecting data on predator spoor along the one kilometer transects described in section 2.2.4. This involved walking along each transect and scanning for any predator signs. When a predator sign was encountered, the GPS co-ordinates, the species and the sign; i.e. scat, print or kill, and distance along each transect were recorded. This data collection did not involve the use of a quadrat hence the recording of the distance along the transect at which predator spoor was encountered (Stander, 1998). The data was intended for calculation of predator density in the study area by use of the distance methods as the length of the transect, the point at which the spoor was encountered and the distance away from the transect where recorded. The data would further be used to determine the level of human-predator interactions

Another index that would compliment the above information is that on prey biomass in an area. Due to the ability to of animals' biomass to scale as a result of mass-related energy requirements, it is possible to estimate the number of predators that can be maintained in the study area. This can be achieved by the use of data on herbivore numbers which would provide an index for calculation of scaling ratios similar to those shown in appendix 1 for use in calculation of predator numbers.

2.2.9 Predation reports

Depredation reports in the study area were also collected to assess which predator species was the most problematic in terms of livestock predation. The reports indicated the location of the kill, the species of the animal responsible for the predation i.e. lion, leopard, hyena, how many individuals were involved as well as animal species killed i.e. cattle, sheep, goat. Six informants from six villages in the study area were selected to carry out the verification of the reports. The six villages selected had in the past been involved in a study conducted in 2002 on human perceptions of lions, leopards, cheetahs and hyenas in Kajiado Central Division (Rainy, unpublished). This allowed for a comparison of the community perception information with more empirical data collected during this study.

By having informants in the villages, data on predation could be collected almost as soon as it happened thereby increasing the accuracy and verification of incidences (Woodroffe *et al.*, in press). The informants were fluent in the local language, had good knowledge of the terrain and could write.

2.2.10 Spatial mapping of wildlife and livestock distribution

To determine the level of spatial/ temporal convergence of the wildlife and livestock, the grids in which animals counts and human settlements were recorded were converted to Universal Transverse Mercator (UTM) coordinates. This allowed for georeferencing and merging of the animal distribution, human settlements, road, slope and streams for analysis using the ArcView GIS 3.2 (ESRI, 2000) as this linked the grids. The topographical sheet of the area was digitized as a GIS project; this was then overlaid with the 500 by 500 m grids. Using the centre of the grids in which animals were counted, measures of distances from human settlements, roads and streams were calculated using GIS. This was done by taking the coordinates at the center of the grid and automating the distance to the streams and roads. The slope measurements were acquired from the contour lines on a topographical sheet that had been digitized and analyzed in the same manner as the road and stream data. The maps were then used to visualize the level of overlap in habitat use based on topography and human influence.

2.2.11 Analysis

Data analysis was done using Statistical Programme for Social Sciences (SPSS) and Statistical Analysis Software (SAS). Spearman rank correlation was used to examine the relationship between animals and environmental covariates at three spatial scales, i.e. 250 by 250 m, one km^2, and 25 km^2. This was done so as to establish at which scale the two sets of variables had the strongest relationship (Ogutu *et al.*, in prep, Appendix 2).

The data was then tested for normality using the Kolmogorov-Smirnov test for continuous variables. Where the data did not fit the assumptions of analysis of variance (ANOVA), Non-parametric tests were used. The hypotheses were also tested using the two-tailed t-tests and the significance reported at the 95% confidence interval.

Spearman rank correlation was used to relate animal biomass to grass biomass per kilometre squared in the strata. To analyze the habitat utilization data, logistic regression was used as it does not assume linearity of relationship between the independent and dependent variables and does not require normally distributed variables or equal variance within each group. The data was also dichotomous i.e. Yes/No representing the presence/absence observations of spoor. This regression related the presence/absence of each species of wildlife and livestock separately to elevation, slope, distance to road, distance to stream, grass cover and height. The model further allowed for the potential for error in locating for the presence or absence of animals within the quadrat.

In ArcView GIS, the data was used to plot the utilization of the area by wildlife and livestock in relation to environmental variables such as watering points, topography and vegetation condition. This gave a pictorial representation of overlap in habitat use and areas of possible human-wildlife conflict.

Chapter 3

3.0 Results

3.1 Animals distribution in Elangata Wuas group ranch.

3.1.1 Livestock / wildlife populations in the study area.

In this study, a total of 15,203 animals belonging to 15 mammalian species were counted (Table 1). The species were further assigned functional groups based on their feeding habits and categorized as grazers, browsers and mixed feeders (Table 1). The browsers comprised of five species, the grazers of four species and the mixed feeders comprised of six species. This species classification was based on Western (1975) with a few modifications from Worden (2003). Livestock constituted the largest proportion of herbivores counted at 88.72% while wildlife accounted for only 11.28% (Table 1). Amongst the livestock, shoats accounted for the highest numbers, followed by cattle and finally donkeys.

Livestock numbers varied among the three areas though they were not significantly different ($F_{2,8} = 0.073$; $p > 0.05$). The highest livestock density was counted in the medium cover area, 3.46 individuals/km^2. This medium cover area was also the area with the highest number of shoats, 1132 shoats. The highest number of cattle, 464 cattle, was counted in the high cover area.

When these livestock numbers were converted to biomass, highest livestock biomass, 1007 kg/km^2, was recorded in the area with high grass cover. The medium cover and low cover areas had 707 kg/km^2 and 806 kg/km^2 livestock biomass each, which were lower then the livestock biomass in the high cover areas. Though the medium cover area had the highest livestock numbers, 3.46 individuals/km^2, among the three; 2.86 individuals/km^2 and 2.40 individuals/km^2 for high cover and low cover strata respectively, this area had the lowest livestock biomass. This is due to the medium cover strata containing the highest number of shoats which have a lower individual biomass, 18 kg, then the donkeys, 130 kg or cattle, 180 kg. The high cover stratum has the highest livestock biomass as most of the biomass is contributed by cattle which have high individual weights, 180 kg, than the shoats in the medium cover strata.

Among the wildlife counted, baboon, Grant's gazelle and impala at 464, 427 and 287 respectively, accounted for the highest numbers of wildlife in the count while dik dik, and reedbuck at 3 and 17 respectively, accounted for the lowest counts. The baboon, Grant's gazelle and impala characterized the bulk of the mixed feeder biomass (Table 1). Wildlife numbers per kilometer square varied across the three habitats with the highest number of wild animals being counted in the area with low grass cover, 0.45 animals/km^2. A higher browser biomass density in the low cover area was attributed to the higher number and biomass of eland and giraffe in this area. These two species have high individual biomass weighing an average of 350kg and 1250kg for the eland and giraffe respectively and hence the high biomass density seen among the browsers.

Table 1. Animal species and unit biomass used to calculate total biomass in each of the sites animals in Elangata Wuas group ranches.

Species	Animal numbers	Average individual weights (Kg) (Western, 1975 and Worden, 2003)	Estimated total biomass in kg	Animals density per km^2 (408km^2)	Feeding strategy
Baboon	464	20	9280	1.24	Mixed feeder
Dik dik	3	7	21	0.01	Browser
Eland	233	350	81550	0.62	Browser
Giraffe	31	1250	38750	0.08	Browser
Gerenuk	69	40	2760	0.18	Browser
Grant's gazelle	427	40	17080	1.14	Mixed feeder
Impala	287	40	11480	0.77	Mixed feeder
Lesser kudu	42	160	6720	0.11	Browser
Ostrich	13	114	1482	0.03	Mixed feeder
Reedbuck	17	30	510	0.05	Grazer
Thompson's gazelle	42	15	630	0.11	Mixed feeder
Zebra	86	300	25800	0.23	Grazer
Cattle	4006	180	721080	10.68	Grazer
Donkey	480	130	62400	1.28	Grazer
Shoats	9003	18	162054	24.01	Mixed feeder

Table 2. Animal densities and biomass density recorded in the three habitats in the study area.

Feeding strategy	High cover area	Medium cover area	Low cover area
Browser numbers per km^2	0.04	0.02	0.22
Browser biomass per km^2	19	2	329
Grazer numbers per km^2	0.14	0.05	0
Grazer biomass per km^2	51	18	0
Mixed Feeder numbers per km^2	0.20	0.14	0.09
Mixed Feeders biomass per km^2	54	28	21
Livestock numbers per km^2	2.86	3.46	2.40
Livestock biomass per km^2	1135.80	708.93	947.12

3.1.2 Grass and herbivore biomass assessment

To estimate grass biomass at these three sites, pin-frame data was calibrated by regressing hits-per-pin against biomass of grass collected at harvest plots at each transect. A regression that pooled the data was derived and used to estimate the herb layer biomass from the hits-per-pin measurements obtained in the field. The regression showed a highly significant relationship between the hits-per-pin and the biomass in g/m^2 ($y = 23.648x + 1.9119$, $R^2 = 0.1653$, $F_{1, 25} = 4.920$, $p < 0.05$). This regression equation was then used to convert hits-per-pin taken in the three sites into biomass g/m^2.

Analysis of variance was used to establish the difference in the calculated grass biomass between the high cover, 1932.7 g/m^2, medium cover, 1772.89 g/m^2, and low cover, 1412.44g/m^2, areas. There was a significant difference between the three sites ($F_{2, 27} = 5.132$, $p < 0.05$) and Tukey test shows that the biomass in the low cover area differed significantly from that in both the high cover and medium cover areas Figure 4.

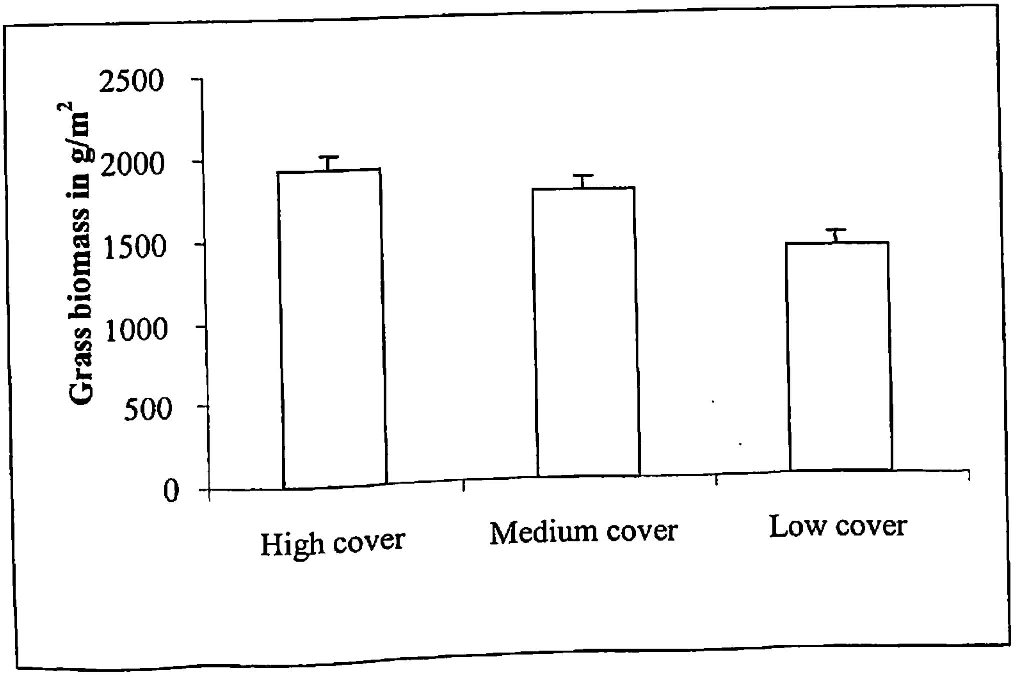

Figure 4. The total grass biomass in three areas that were represented by high cover, medium cover and low cover.

Analysis of variance was further used to compare animal biomass in kilograms per kilometer squared across the high cover, medium cover and low cover areas. When biomass of livestock and wild herbivore grazers, from Table 1 was taken exclusively and compared across the three sites, there was no significant difference in the biomass, which stood at 669.69 ± 87.5 kg/ km^2 and 23.38 ± 15.25 kg/ km^2 ($F_{2,8} = 0.073$, $p > 0.05$; $F_{2,3} = 0.741$, $p > 0.05$ for livestock and wild herbivores respectively). Similarly, browser biomass, 116.51 kg/ km^2 ± 106.33 kg/ km^2 and mixed feeder biomass, 104.24 kg/ km^2 ± 27.92 kg/ km^2 in the three areas did not differ significantly ($F_{2,15} = 2.101$, $p > 0.05$; $F_{2,9} = 1.047$, $p > 0.05$) The combined biomass of all the herbivores in the three sites, high cover ,780.8 kg/km^2, medium cover, 1208.27 kg/km^2 and low cover, 1055.39 kg/km^2 sites, was then analyzed but there was still no significant difference in their densities in the three sites ($F_{2,57} = 0.691$, $p > 0.05$). Though the biomass did not differ significantly, livestock and wildlife biomass differed across the areas with livestock biomass being higher, 1135.80

kg/km², in the low cover area (Figure 5). On the other hand, wildlife biomass was lowest in the low cover, 47.59 kg/km², highest in the medium cover areas, 401.06 kg/km² ($F_{2,8} = 0.7135$, $p > 0.05$) (Figure 6).

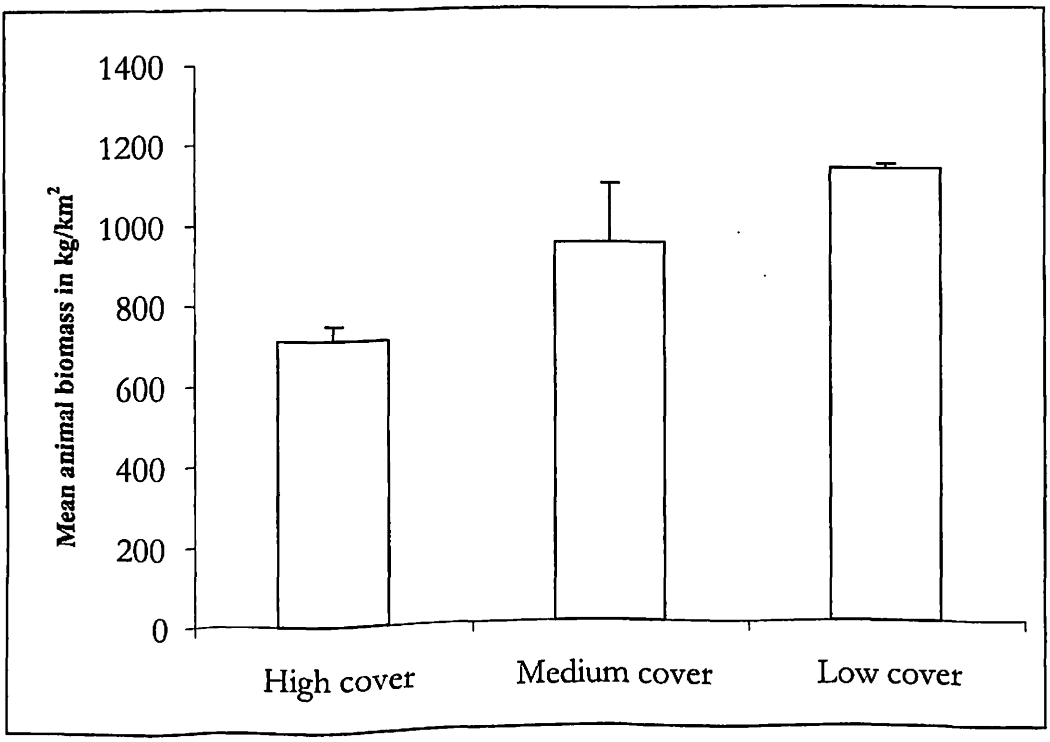

Figure 5. Livestock biomass per square kilometre in the high cover, medium cover and low cover areas calculated using values in tables 1.

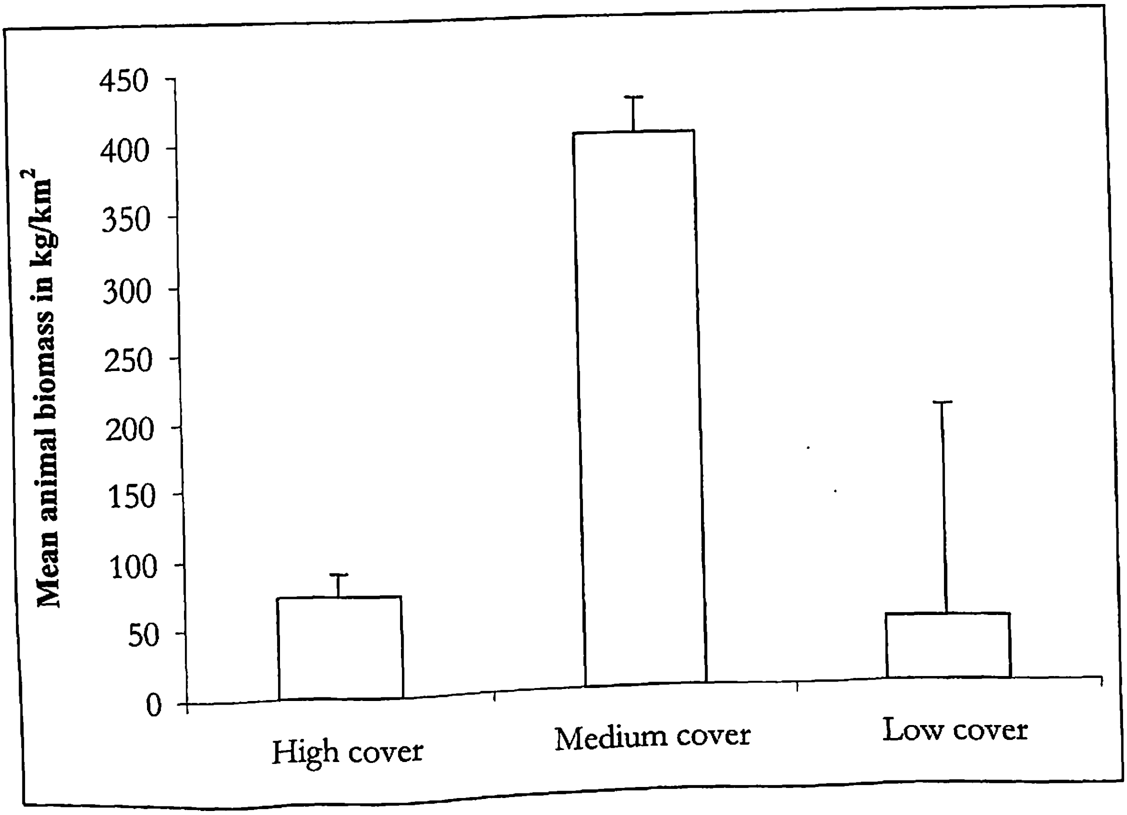

Figure 6. Wildlife biomass per kilometre square in the moderately used, slightly used and highly used areas using values in tables 1.

The biomass values for the three functional groups were correlated with the grass biomass in the three different areas. Browsers and grazers showed negative correlations with the grass biomass as though these values did not differ significantly ($r^2 = 0.90$, $n = 17$, $p > 0.05$; $r^2 = 0.9361$, $n = 5$, $p > 0.05$). Though the mixed feeder biomass was positively correlated to the grass biomass this was not significant ($r^2 = 0.9056$, $n = 9$, $p > 0.05$). Combined animals biomass in the three areas was then correlated to grass biomass and in the medium cover area these two variables showed a negative relationship with grass biomass increasing as animal biomass decreased ($r^2 = -0.462$, $n = 11$,$p < 0.05$). In the two other areas, low cover and high cover areas, there was also a negative correlation between the grass biomass and the animal biomass although these relationships were not significant ($r^2 = -0.044$, $n = 9$, $p > 0.05$, $r^2 = 0.328$, $p > 0.05$).

3.1.3. Impact of human settlements on the distribution of the mammalian species

Maasai "Manyatta" accounted for a large proportion of the house types recorded in the study area when the data on human settlement was summarized Table 3. The Maasai "Manyatta" accounted for 79.25% of the houses recorded while the modern or tin roofed houses accounted for only 20.25% of the house types which illustrates that there is still a large proportion of the population that is still nomadic. When the density of houses was calculated, it was estimated that there are two houses per kilometer square. When this data was analyzed, there was a significant difference in their distribution within the three strata in the study area ($F_{2, 14} = 5.35$; $p < 0.05$).

Among the wildlife baboon seemed to cluster in areas with high densities of the Maasai "Manyatta" but decrease in number in areas with high densities of the modern house types ($r^2 = 0.329$; $n = 15$; $p > 0.05$). Impala numbers were significantly affected by the density of settlements and their numbers were higher in the areas with Maasai "Manyatta" ($r^2 = 0.64$; $n = 15$; $p < 0.05$), but were not significantly affected by the density of the modern houses ($r^2 = 0.576$; $n = 15$; $p > 0.05$).

Table 3. The total number and density of the Maasai "Manyatta"" and Tin roofed houses in the study area.

Variable	Total	Density per km^2
Maasai "Manyatta"	693	1.848
Tin roofed houses	176	0.469
All huts	869	
Human population estimate*	4,006	10.682
Proportion of Maasai Manyatta	0.7975	
Proportion of Tin roofed houses	0.2025	

3.1.4. Impact of environmental variables on the distribution of the mammalian species.

Donkey and giraffe are the only species whose distribution was significantly affected by environmental variables. Donkey preferred steep areas as they occupies the higher cartena in areas where they were counted, 3.5683 ± 0.413 ($r^2 = 1.321$; $n = 15$; $p < 0.05$), whereas giraffe distribution occupied areas that were about two kilometers from streams 2631 ± 149.33 m ($r^2 = 0.183$; $n = 15$; $p < 0.05$).

The other animal species seemed not to be significantly affected by the slope 4.033 ± 1.601 , distance to road 838.77 ± 149.33 m or distance to the streams 1031.753 ± 565.216 m though there were more of the Thompson's gazelle and the zebra seen further from the streams.

3.1.5 Spatial representation of wildlife and livestock distribution

The low cover stratum encompassed most of the south and this may explain higher number of livestock and human settlement to the north. From figure 1, these were also the areas with a very few boreholes. The area with the high grass cover encompassed more of the eastern portion of the study area and in the north was the medium cover stratum. Spatial representation showed that, there were higher numbers of settlements in the north of the study area and animal distribution (Figure 7). Livestock distribution followed the same trend and was in lower numbers to the south of the study area (Figures 7, 8, 9, 10). However, wildlife and livestock distribution differed over the study area. Cattle and zebra showed spatial separation with zebra occupying areas only to the east of the study and avoiding area used by cattle (Figure 8). Similar distribution was seen between donkey and zebra with more donkey in the lower catena and zebra concentrated to the east of the study area (Figure 9). The donkey and cattle were mapped separately to illustrate the difference in habitat selection and husbandry between these two species. Eland were distributed mainly in the medium cover area while baboons were for the most part distributed to the high cover area in the north. Sheep and goat were encountered in some areas that were used by Thomson's gazelle. Impala and Grant's gazelle were encountered more in the low cover and medium cover areas then in the high cover areas (Figure 10).

3.1.6 Habitat use by wild herbivore and livestock

The highest grass cover was recorded in the north of the study area and averaged 38.78% ± 2.55, in the central section of the study area it averaged 22% ± 2.20% and in the south average grass cover had a mean of 19.33% ± 1.70%. On the other hand, there was taller grass in the south of the study area at an average height of 15.64cm ± 7.74 cm while to the north the grass height averaged 12.97 cm ± 6.7 cm.

The grass cover and height affected the degree of use of the habitat. Logistic regression showed that the cattle and shoats had high spoor density in most of the study area. Gerenuk, reedbuck, shoats wildebeest and zebra utilization of the area was on the other hand, significantly affected by the level of grass cover. In this study, shoats and zebra spoor density reduced as the grass cover increased. Contribution to spoor density at the different levels of grass cover was 50% of spoor at 0% grass cover to 5% at 83.3% grass cover for shoats, 26% at 16.7 % grass cover to 0% at 83.3% grass cover for zebra, ($F_{1,320} = 16.24$, $p < 0.05$ and $F_{1,320} = 4.35$, $p < 0.05$) indicating reduced utilization of areas with high grass cover. On the other hand, gerenuk, reedbuck and wildebeest seemed to prefer areas with higher grass cover as their spoor density increased with an increase in the percentage grass cover. Contribution to spoor density was 20% at 33.3% grass cover which increased to 60% at 66.7% grass cover for gerenuk, increased from 20% at 8.3% grass cover to 40% at 75% grass cover for wildebeest and from 20% at 16% grass cover to 25 % at 75% grass cover for reedbuck ($F_{1,320} = 7.01$, $p < 0.05$, $F_{1,320} = 15.26$, $p < 0.05$, $F_{1,320} = 21.26$, $p < 0.05$ respectively).

The height of grass also affected the choice of habitat by the animals where cattle seemed to use areas with shorter grass. The cattle spoor index reduced as the height of the grass increased from 20.09% to 7.31% for cattle spoor density at a grass height of 60 cm ($F_{1,320} = 4.53$, $p < 0.05$). The zebra on the other hand, seemed to prefer areas with taller grass as they were higher in index in the areas with taller grass. Zebra spoor density was at 5.25% at the tallest grass height, 95cm ($F_{1,320} = 5.49$, $p < 0.05$).

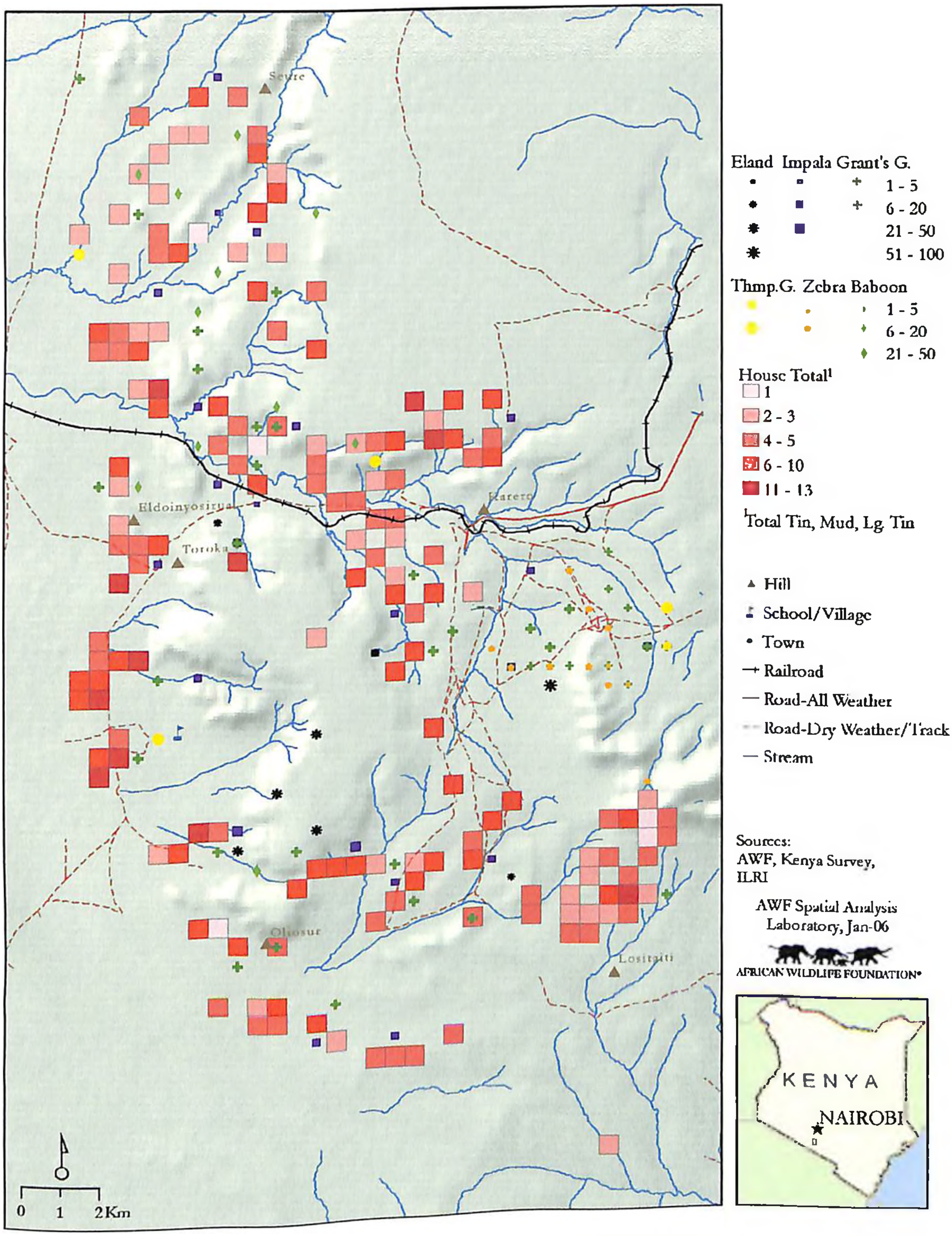

Figure 7. Spatial representation of human, livestock and wildlife use of the study area.

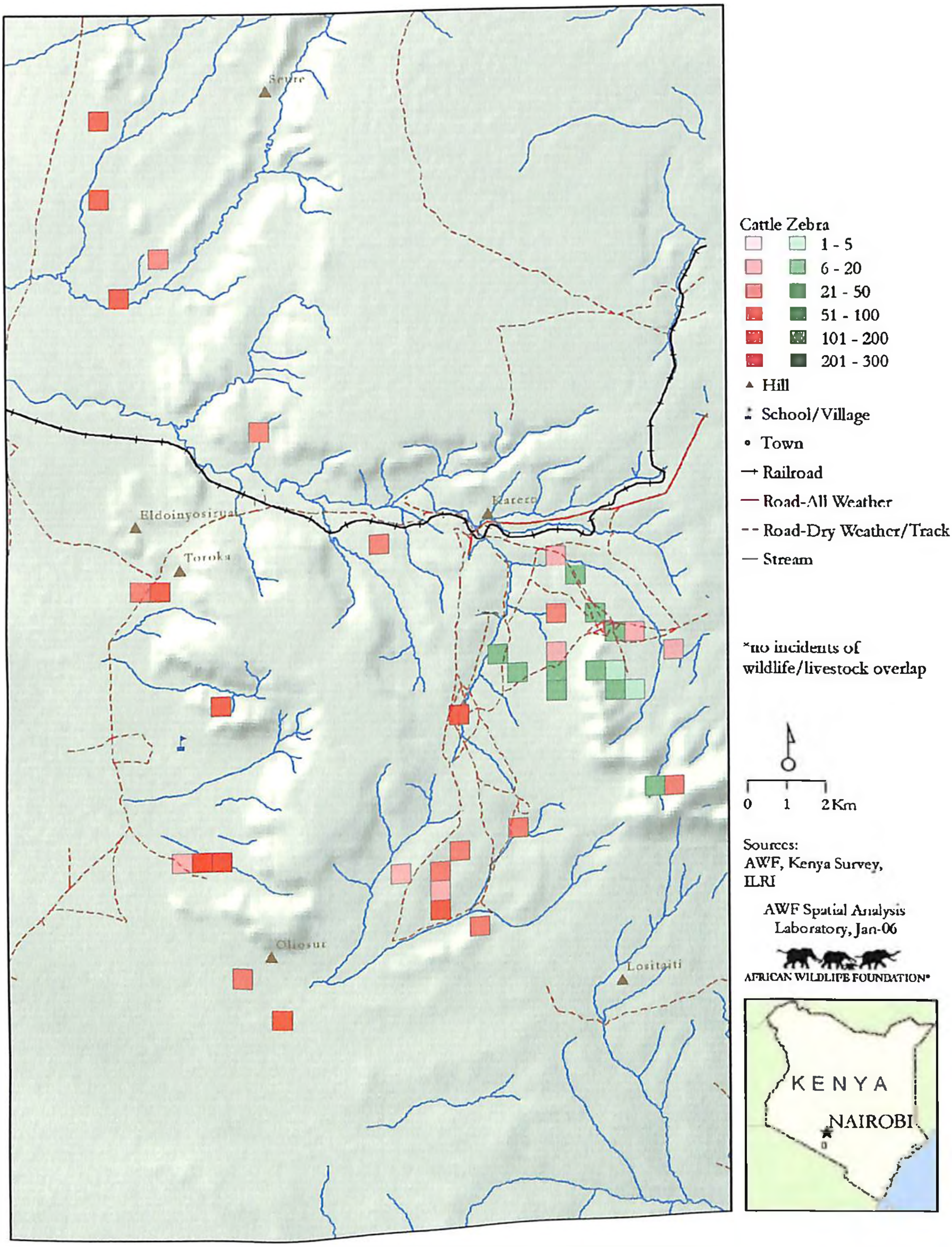

Figure 8. Relationship between zebra and cattle distribution in Elangata Wuas group ranch, showing spatial segregation of two potential competitors.

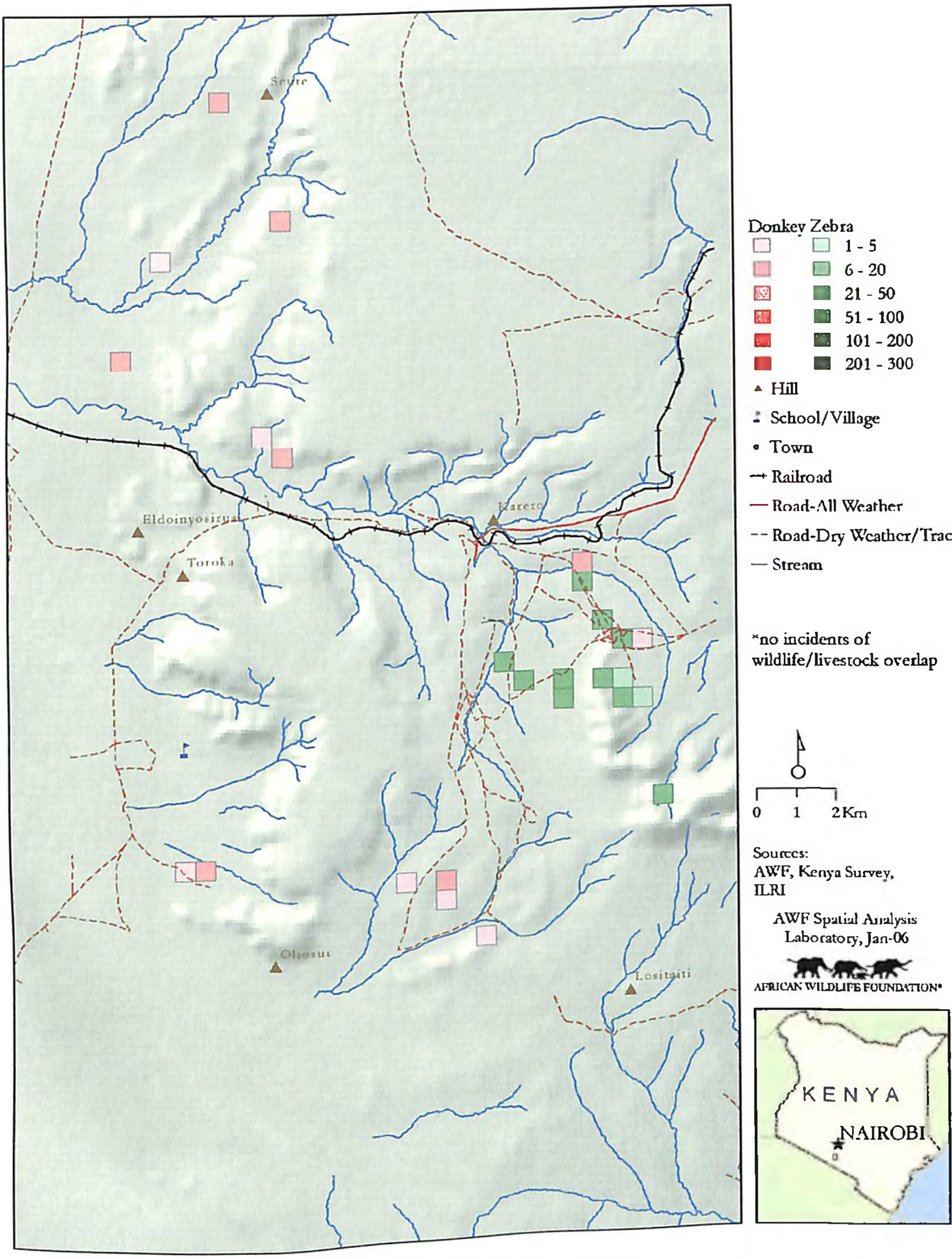

Figure 9. Relationship between zebra and donkey distribution in Elangata Wuas group ranch, showing the spatial separation between a domestic species that is not herded and a wild potential competitor.

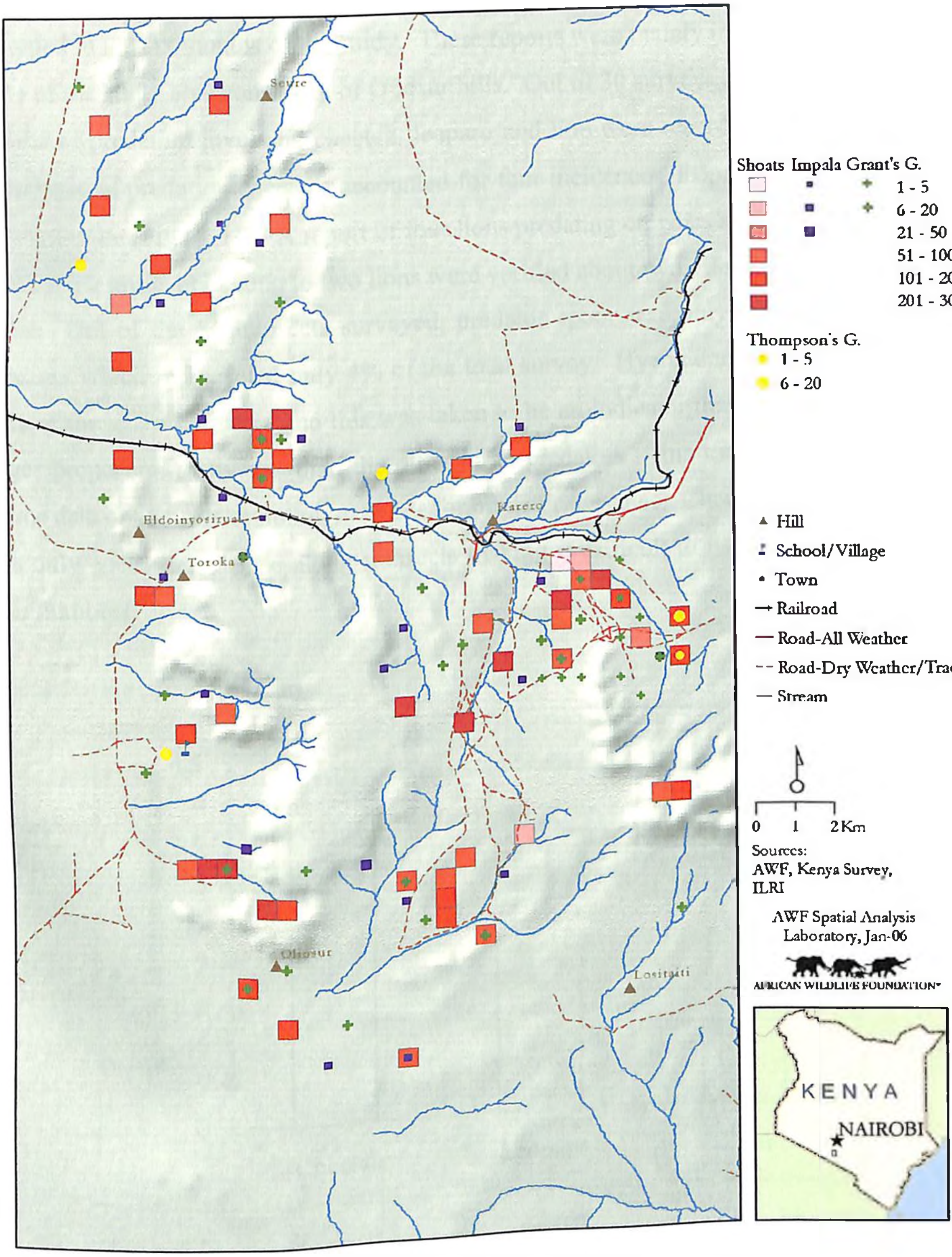

Figure 10. Map representing the relationship between sheep and goat, Impala, Grant's and Thomson's gazelle distribution in Elangata Wuas group ranch, showing the higher concentration of shoats in the medium cover strata.

3.1.7 Predation reports.

Predation reports were also collected during the study and only seven verified reports were recorded in the six months of the study. These reports were mainly in the south and central parts of the study area consisting of Oliosur hills. Out of 30 surveys conducted, only seven reports of predation involving cheetah, leopard and lion were recorded. Out of the seven incidences of predation cheetahs accounted for four incidences, leopards two and the lions one incidence (Figure 11). A report of four lions predating on goats at Karero hills was not verified but prints belonging to two lions were verified about two kilometers away from the scene. Out of the 84 transects surveyed, predator spoor was only encountered along 4 transects which represented only 4% of the total survey. Hyena dung accounted for most 75% of the spoor collected and this was taken to be an indicator that there are a relatively larger proportion of hyenas than the other large predators This translated to their being scarce data on indirect sampling methods for predator presence. Cheetah and leopard spoor was only encountered once along transects making it difficult to use the data to estimate their numbers.

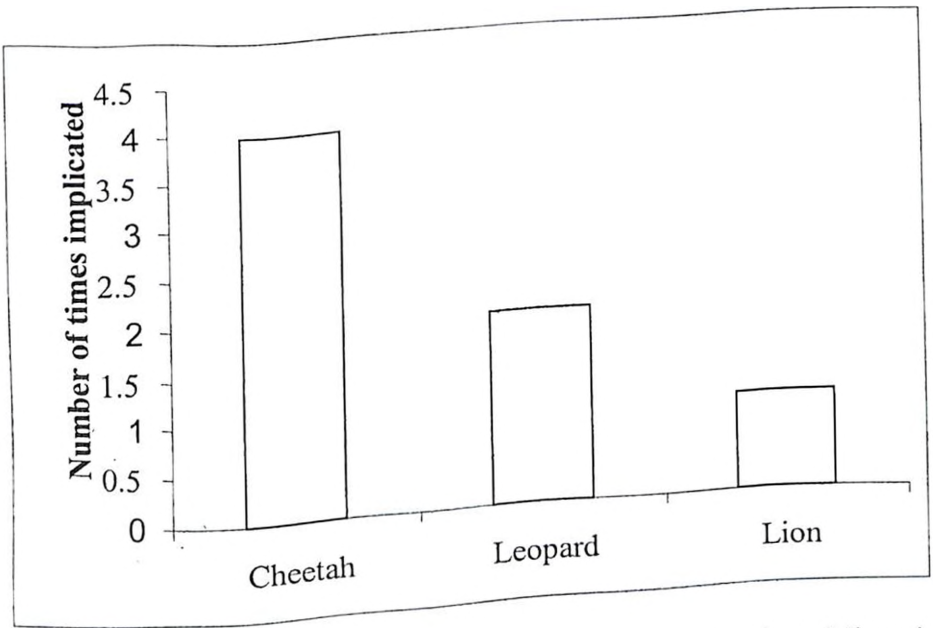

Figure 11. Number of kills that were attributed to Cheetahs, leopards and lions in the study area.

Reports of predator sightings estimated the predator numbers in the area as 5 lions, 3 leopards and 11 cheetahs.

3.2 Discussion

3.2.1 The effect of human and environmental variables on wildlife and livestock distribution

Three factors have been shown to influence the distribution of livestock and wildlife: (1) differentiation of feeding strategies where we have grazers and browsers which are dependant on the amount of woody species in the diet; (2) habitat, which in this study is taken to be differing grass height, colour and cover, degree and density of human influence and settlement, roads and water availability; and (3) topographic or edaphic gradient which in this study is represented by slope (Sinclair and Arcese, 1995).

The distribution of the 15 species of herbivores studied was evaluated based on the influence of these three factors. In general, cattle are spread in all the study area in all the habitats but are topographically selective, occupying areas that are lower in relief which comprise the valleys and flats. In comparison among the species, cattle accounted for the highest biomass densities in the counts which is expected due to their large numbers and large individual biomass. Sheep and goats also show a pattern similar to that of cattle and are spread out in the study area. In terms of numbers, they are the most numerous and account for the second highest biomass in the area. This apparent divergence from traditionally higher numbers of cattle to the present domination in sheep and goat as the mainstay in this pastoral landscape is indicative of harsher climatic conditions that lead to raring of the more drought tolerant shoats. During the study period, there was no rain and hence these predictions of lower numbers of cattle may also be due to movement in search of better quality pasture for the cattle.

As expected, cattle and zebra showed spatial separation and this is reflective showing some degree of resource partitioning to minimize competition that may be brought about due to their similar feeding strategies. The zebra concentrated in the east of the study area, an area that is of higher elevation than that used by cattle. This separation may be facilitated by the fact that the zebra is a coarse feeder and was able to cope with the coarser grass found here after the wet season grazing in these higher elevations.

Goat competitors like the Grant's gazelle which are opportunistic browsers, showed some spatial separation by feeding in the same area that was used by the zebra. This assemblage has minimal conflict as the Grant's gazelle are able to browse in these higher areas thus avoiding competition with sheep and goats in the valleys and also grazing zebras.

In contrast, impala have low to moderate dietary overlap with livestock and use the same areas as the cattle and shoats. Water requirements of impala are also to some extent dependent on the amount of shade available and there are more acacia trees in these areas of lower relief making it an area of choice for this water dependent species (Reid *et al.*, 2002).

Thomson's gazelle, on the other hand, are restricted to the east of the study area, ranges used by zebra and Grant's gazelle effectively avoiding areas that are used extensively by livestock. This distribution is expected as zebra often exhibit resource partitioning when feeding grazing alongside Thomson's gazelle. Zebra fed on the coarse grass stems allowing Thomson's gazelle's access to more nutritious grasses that come up and Acacia leaves. Thomson's gazelles are small in size making them highly selective and leading to competition with sheep and goats in areas of overlap. Though Thomson's gazelles use similar areas as the Grant's, they avoid area used by impala as their dietary preferences are similar and due to their larger size, impala are not as selective as Thomson's gazelle, making it easier for them to out compete them.

Eland prefer areas that cover terrain that ranges from level to steep comprising dense bushy vegetation. They seem to avoid all other animal species as they do not share any habitats with the other species. Giraffe though prefer woodland on flat or gently undulating terrain. They are browsers of much taller plant species then the other ungulate species and therefore pose minimal competition.

Most wildlife species avoid areas that are extensively used by human beings (Treves & Karanth 2003; Lamprey and Reid, 2004). The distribution of livestock, however, is governed by the need to ensure their access to quality forage. The access to quality forage and water is ensured by human beings and therefore, the distribution of livestock follows human distribution gradients. Along these human gradients are features that alter habitats like roads, settlements and fences. These human influences that create a variation in vegetation features, in turn affect the distribution of wild herbivores.

Giraffe, impala, baboon, zebra and ostrich distribution revealed patterns of either evasion or preference for habitats that are used by human beings. Giraffe generally did not cluster around homesteads nor were they seen distinctly near streams as expected. They seemed to avoid human settlements probably due to the fact that their numbers were few to start with and there have been incidences of the community hunting giraffe in the past (Mike Rainy, pers comm.)

Impala are also associated with utilization of areas that are at close proximity to human settlements. Grasses in most areas that are used by human beings are either short and in some areas there is no grass cover. These areas form good habitats for impala as they prefer areas with grass cover generally lower then 40 cm (Sinclair and Arcese, 1995). The grass near the bomas have been shown to be shorter and more nutritious attributed to the droppings that accumulate from livestock when the bomas are occupied and the subsequent fallowing which provide an excellent habitat for grass growth when bomas move (Muchiru, 1992).

In contrast, other wildlife species like the zebra and ostrich prefer areas far from human settlement. The zebra is a coarse feeder and is better suited for the areas with taller less nutritious grass and the areas around bomas do not fulfill this requirement as the grass height here is reduced by livestock grazing. The ostrich may be actively avoiding human settlements due to poaching as they have been hunted for their eggs, feathers, meat and skin in the past (Mike Rainy, pers comm.)

Cattle do not show a strong correlation to watering points though they use habitats that are not too distant from streams or boreholes. This is due to their requirements for more abundant forage which are not found close to watering points. However, though shoats are not as dependent on water as cattle, they are closely associated with watering points. This is probably because sheep are able to cope with the short and modest grass cover around these watering points. The clustering of giraffe away from the streams is not expected and may be attributed to the time of day at which the counts were conducted. In contrast, eland, impala and zebra use areas that are not too far away from the streams to be able to balance their need for water and forage by clustering at this distance, which is not too far from water or affected too much by overgrazing or trampling (Reid *et al.*, 2002; de Leeuw *et al.*,2001)

Topographical effect on wildlife and livestock species is seen where donkeys and giraffe avoid using areas with steep slopes. Donkeys are mainly confined to areas around the homesteads which are mainly in the plains as they are tended to by people and do not go to the areas of higher relief. The avoidance of sloppy areas is also seen in cattle and shoats which were recorded for most part in the plains. These two groups utilize the hills when the dry season has continued over a long period and cattle migrate to other areas. Giraffe avoid slope due to the limited distribution of their preferred forage at these elevations.

3.2.2 Carnivore conservation in Elangata Wuas Group ranch

Most of the predators in the community ranches in the world over are in danger of extirpation due to both real and perceived danger to humans and their livestock (Linnell, *et al.*, 1999; Paine, 2003). In the study area, the lions are the main target for retaliatory killings (Mike Rainy, unpublished data) though the cheetah and the leopard are responsible for more cases of depredation on livestock than the lion. This may be due to the fact that cattle are the main victims of lion depredation which educes greater losses (Frank, 1998; Ogada *et al.*, 2003). In traditional pastoralist communities, cattle are the main income earner and food provider. Therefore, in situations where cattle are killed, the household looses a large portion of their subsistence (Boyd *et al.*, 1999).

The study indicates there are a number of carnivores. Though the levels of conflict with carnivores were expected to be high, only seven cases of depredation were reported. In order to tie the findings here with those in other areas that have similar interactions between human beings and predators, an assessment of the prey numbers in relation to predators was looked at. Lions are maintained on a diet of the larger ungulates which area abundant in the area. There is a large number of Grant's gazelle, Eland, and Impala, which form part of the preferred diet of the lions. The leopards too are catered for by the animals with an average biomass of 17-29.2 kg which comprise of the medium sized ungulates like the impala and Grant's gazelle. Further, their diet also includes baboons which are in large numbers in the study area contributing to 27.1% of the total wildlife counts. Though cheetah's main diet consists of the smaller sized ungulates, like the Thompson's gazelle, one of the kills attributed to cheetahs was of Grant's gazelle indicating that the amount of herbivore biomass present in the study area can sustain a substantial number of cheetahs. Lastly, the Wild dog may not be sustained in the study area, as their preferred species are in low numbers i.e. 3 dik dik and 42 Thompson's gazelle were counted (Table 1). This may lead to a situation where they may predate on livestock thereby escalating the level of conflict between the community and predators.

The presence of a large biomass of wild ungulates is a good indicator that predators can be maintained in the area. The Grant's gazelle, impala, eland, baboons and zebra are in numbers that would be able to sustain the estimated rate of about 150 kills a year for the larger carnivores: lion, leopard and cheetah (Sinclair *et al.*, 2003). The wild dog on the other hand, cannot be maintained in the area as their preferred prey; Thompson's and dik dik, are in densities too low to sustain their hunting rate of about 1-4 animals/day (Creel and Creel, 1996; Mills and Gorman, 1997), These herbivores may be utilized in creating a prey base for carnivores. The carnivores in turn attract tourism and the potential to recompense losses due to predation is great. The reduction in the devastating impacts of predation will ensure the continued existence of predators in these ranches.

CHAPTER 4

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

With adequate knowledge on the human population density from counts, road networks; which translates to access to resources for man, and distribution of watering points that are accessible to wildlife, many conflicts on the utilization of resources can be averted. The relationships between these variables are played out well in this study which gives baseline information on the human-wildlife interface at a time when the level of land subdivision is still conducive to the maintenance of a relatively large number of wildlife. Secondly, the study shows that there are substantial numbers of wildlife in the area and that the integrated wildlife-livestock systems are productive as losses to predation were minimal (Woodroffe *et al.*, in press). The lower numbers of cattle also shows that exclusive pastoralist economies may no longer be sustainable. Finally, the density of the houses is over the ideal distribution of 0.17 bomas per km^2 and the intended subdivision may lead to further wildlife loss which necessitates swift action if the human-wildlife interactions are to be maintained at a productive level.

Conflict in utilization of resources

Conservation of natural resources has in the past mainly been concerned with preventing decline in wildlife numbers through protectionism, exclusion and policing effectively creating areas that minimized human-wildlife interaction and leading to the creation of islands of wildlife (Boyd *et al.*, 1999). Unfortunately, there has been continued decline in wildlife numbers as most of the protected areas have not met all the requirements of the wildlife. This decline is attributed to increasing demand for land, a reduction in the livestock units per person and an influx of agrarian communities in these pastoralist dominated landscapes (Boyd *et al.*, 1999). For instance, the changes in land-use in the study area have been documented for a long time by the Kenyan government and have shown a trend towards continued subdivision of land and consequent fencing (Gok 1992). The government reports show that the ratio of cattle to small stock: sheep and goats, has increased, indicating a shift from the more traditional cattle rearing.

This is also an indication of habitat degradation as cattle are unable to cope with the diminishing levels of grass cover and increasing tree and shrub cover. Cattle also have to travel long distances to water which makes the area unsuitable for cattle raring.

Human settlements, competition between livestock and wildlife and their effect on animal distribution

The decline in wildlife numbers caused by increasing human population and degradation of the environment are characterized in the distribution of wildlife in relation to human settlements, road networks and watering points. The distribution of human settlements generally mimics the distribution of permanent water sources as well as the road networks. Most settlements are close to springs, streams and bore holes. In areas with bore holes, most pastoralists have assumed some form of sedentarization. The shift in the socio-economic structure of the community is seen in the increasing proportion of tin roofed houses to the traditional manyatta. The presence of about 6 boreholes in the area is also an indication of some degree of improved socio-economic status of the community. There are 2.317 houses per km^2 in the study area (Reid and Lamprey, 2004); this is about three times the ideal density that can sustain a healthy number of wildlife with manageable conflict, combined with the shifting lifestyle are indicative of the eminent escalation in competition for resources and inevitably, conflict.

Wildlife species have differing interspecific habitat requirements as a means to minimize competition for resources. Conversely, wildlife is not evolutionarily different from livestock and consequently will still exhibit some degree of competition between these two groups of animals when in situations where resources are shared. The main areas of conflicts are on access to forage and water where livestock are always the favoured competitors as humans secure prime areas for livestock by denying wildlife access to these areas. This creates a situation where livestock are diffusely distributed across a landscape and wildlife is confined to patches that meet their dietary requirements and are not utilized by livestock. Wildlife such as zebra, wildebeest, Grant's gazelle, Thomson's gazelle, reedbuck, gerenuk, dik dik and eland have demonstrated this spatial segregation by avoiding areas that are extensively used by human beings and their livestock. The highest densities of wildlife is seen in the east and central area of the study area which are not as densely settled by human beings or road networks do not host a large number of livestock. These areas are also characterized by steep slopes that seem to be a deterring factor in the distribution of human beings and livestock. Human activities such as settlements and livestock foraging are concentrated in areas of low elevation allowing the wildlife to use the higher catena areas. An exception to this distribution pattern is seen in the distribution impala and baboon. These two species seem to prefer areas that have a moderated density of human settlements. The large number of impala may be due to the fact that there is some semblance of a refuge for wildlife against predation. These areas are also dominated by *Acacia* trees that provide shade which impala need for rest and ruminating. Baboons were also common in areas with high density of "manyatta", which were also areas with high numbers of the young of sheep and goat that were reportedly preyed upon by baboon though this was not observed during the study period (Kilonito Chief, pers, comm.). In other areas, baboons are associated with crop raiding on maize and banana plantations (Treves-Naughton, 1998) and are also positively correlated with human settlements.

Poaching is another human influence that affects the distribution of wildlife. Ostrich and giraffe are few in number and their scarcity has been attributed to the fact that giraffe were initially heavily poached for their meat. On the other hand, ostrich are not reported to be poached in this area but their low numbers have been attributed in other areas to harvesting of their eggs and sometimes poaching of the adults for their meat.

Carnivore conservation in Elangata Wuas

While the above mentioned species of animals do not have a colossal effect on the levels of conflict, the predators generally lead to losses in hundreds of dollars. These losses come about due to the fact that most of the large predators target large stock which is the mainstay of pastoralist. However, in this study, the level of human-predator interaction is too low to make clear conclusions on the level of conflict between these two groups. To maintain the current status, where there is minimal conflict with predators, losses for depredations need to be compensated especially when you take into consideration the fact that the returns from wildlife related activities are large but only the affluent continue to benefits from the revenues (Reid and Lamprey, 2004). .

4.2 Recommendations

Though this study was unable to estimate the numbers of predators present, the low levels of predation and subsequently conflicts solicits the conclusion that it is possible to maintain a reasonable number of predators in this area. The relatively high number and biomass of wildlife may also act as a buffer to predation on livestock. Future studies into human-predator interactions should incorporate such variables as habitat, fencing and human settlement densities into models to enable concise predictions of potential conflict between people and predators.

A clear understanding of changes in animal distribution on the spatial and temporal scale can only be obtained by continued comprehensive surveys that collect and store such information as availability of resources, trends in numbers of humans and animals and their distribution. Repeated over time monitoring of the distribution of animals and people will give valuable information on how these variables are changing both spatially and numerically. This information is important towards generating empirical data on wildlife dynamics in a continually changing environment.

To ensure continued existence of wildlife in Elangata Wuas group ranch continued monitoring of the progress in fencing and its effect on the distribution of wildlife needs to be carried out. This will provide concise data on whether fencing has an effect on the distribution of wildlife in Elangata Wuas group ranch. In other areas of Kajiado Distict, conservancies are being set up to ensure continued co-existence between the communities and wildlife. The community management should look into the possibility of setting aside conservation areas before actually partitioning and fencing of individual parcels is carried out.

Lastly, to better understand spatial dynamics of animal distribution, one has to accurately define the factors affecting habitat selection. Such information as the soil types and vegetation characteristics; species diversity and dominance, will need to be collected to augment data on animal distribution.

5.0 References

Anderson, D., & Grove, R. (eds.) (1987). Conservation in Africa-people, policies, and practice. New York: Cambridge University Press.

Boyd, C., Blench, R., Bourn, D., Drake, L. and Stevenson, P. (1999). Reconciling interests among wildlife, livestock and people in Eastern Africa: A sustainable livelihoods approach. Natural Resource Perspectives. ODI. **Number 45.**

Boydston, E E., Kapheim, K. M., Watts, H. E., Szykman, M. and Holekamp, K. E. (2003). Altered behaviour in spotted hyenas associated with increased human activity. *Animal Conservation* **6**: 1–10

Caro,T.M (1999). Demography and behaviour of African mammals subject to exploitation. Biological Conservation **91**:91-97.

Carbone, C. and Gittleman, J. L. (2002). A common rule for the scaling of carnivore density. *Science* **295**: 2273-2276.

Creel , S. and Creel, N.M. (1996). Limitation of wild dogs by competition with larger carnivores. *Conservation Biology* **10**:536-538.

Cullin, A. and Watson, C. (2004). *Winners and Losers: Privatising the Commons in Botswana. Briefing Paper.* International Institution for Environment and Development & RECONCILE.

De Leeuw J. Waweru,. M.N., Okello, O.O., Maloba, M., Nguru, P., Said, M.Y., Aligula M.H., Heitkonig, I.M.A. and Reid, R.S. 2001. Distibution and diversity of wildlife in northern Kenya in relation to livestock and watering points. *Biological Conservation* **100**:297-306.

Frank, L.G. (1998). *Living with lions: carnivore conservation and livestock in Laikipia District, Kenya.* US Agency for International development, Conservation of Biodiverse Resource Areas Project, 623-0247-C-00-3002-00,pp.1-63.

Galaty, J.G. (1992). "The land is yours": Social and economic factors in the privatization, sub-division and sale of Maasai ranches. *Nomadic Peoples* **30**:26-40.

Gittleman, J. L. (1989). Carnivore Behavior, Ecology, and Evolution. Cornell University Press.

Gichohi, H. W. (1990). The ecology of a truncated ecosystem; The Athi-Kapiti plains. Thesis. University of Nairobi.

GoK. (1992). Environmental Action Plan for Arid and Semi-Arid Lands in Kenya. Ministry of Reclamation and Development of Arid and Semi-Arid areas and Wastelands.

GoK. (1968 a, b). The land adjudication act. Chapter 284 of the laws of Kenya. Nairobi, Kenya. Government Printers.

Kantai, B. (1971). "Forword"In the Maasai. By S. Sankan. vii-xxxi. Nairobi. Kenya Literature Bureau.

Kenya, Republic of. (1968a). The land adjudication Act. Chapter 284 of the laws of Kenya. Nairobi, Kenya. Government Printer.

Kissui, M.B. and Packer, C (in press). Top-down population regulation of a top predator: lions in the Ngorongoro Crater. *Proc.R.Soc .Lond.B*

Krebs, J.C. (1999). Ecological Methodology. Second Edition. Addison-Wesley Educational Publishers, Inc.Don Mills, Ontario. pp. 105-260

Krebs, J.C. (1985). Ecology: The experimental analysis of distribution and abundance. Third Edition: Harper and Rowe, Publishers Inc. New York. pp.

Lamprey, R. H. and Waller, R. (1990). The Loita Mara Region in historical times: patterns of subsistence , settlement and ecological change. Early pastoralists of southwestern Kenya (ed. P Robertshaw), pp. 16-35.Memoir 11, British Institute in Eastern Africa, Nairobi, Kenya.

Lamprey , R. H. and Ried, R. S (2004). Expansion of human settlement in Kenya's Maasai Mara: what future for pastoralism and wildlife? *J.Biogeogr.* (2004) **31**:997-1032.

Linnell, J.D.C., Odden, J. Smith, M. E., Aanes, R. and Swenson, J.E. (1999). Large carnivores that kill livestock: do "problem individuals" really exist? *Wildlife Society Bulletin* **27**:698-705.

Macdonald, D.W and Sillero-Zubiri, C. (2002). Large carnivores and conflict: Lion conservation in context. Pp. 1-8 in A.J. Loveridge, T. Lynam and D.W. Macdonald (Eds.) *Lion conservation research. Workshop 2: modelling conflict.* Wildlife Conservation Research Unit, Oxford University.)

Mills, M.G.L. and Gorman, L.M (1997). Factors affecting the density and distribution of wild dogs in the Kruger National Park. *Conservation Biology* **11**: 1397-1406.

Mills, M. G. L. and Shenk, T.M. (1992). Predator- prey relationships: the impact of lion predation on wildebeest and zebra populations. *Journal of Animal Ecology.* **61**: 693-702.

Mizutani, F. (1993). Home range of leopards and their impact on livestock on Kenyan ranches. In: Dunstone, N. Gorman, N.L. (Eds), In Mammals as Predators. Clarendon Press, Oxford, pp. 425-439.

Muchiru, A. (1992). The role of abandoned pastoral settlements in the dynamics of African large herbivore communities. *Thesis*, University of Nairobi.

Munei, K. (1987). Grazing schemes and group ranches as models of developing pastoral lands in Kenya. In *Property, poverty and people: Changing rights to property and problems of pastoral development.* Eds. Baxter, P.T.W. and Hogg, R. Department of Social Anthropology and International Development. Manchester, England.

Murray, M.G. and Brown, D. (1993). Niche separation of grazing ungulates in the Serengeti: an experimental test. *Journal of Animal Ecology* **62**:380-389.

Nowell, K. and Jackson, P. (1996). Wild Cats: status survey and conservation action plan.World Conservation Union, Gland, Switzerland.

Ogada, O.M., Woodroffe, R., Oguge, O.N. and Frank, G.L (2003). Limiting depredation by African carnivores: The role of livestock husbandry. *Conservation Biology.* **17**: 1521-1530.

Paine, S. (2003). Last of the lions. *NewScientist.* 20 Sep 03:37-39.

Patterson, B.D., Kasiki, M.S., Selempo, E. and Kays, W.R. (in press). Livestock predation by lions (*Panthera leo*) and other carnivores on ranches neighboring Tsavo national Parks, Kenya. *Conservation Biology.*

Pratt, D.J. and Gwynne, M.D. (1977). Rangeland management and ecology in East Africa. Hodder and Stoughton, London.

Radloff, F. G. T. and Du Toit, J. T. (2004).Large predators and their prey in a southern African savanna: a predator's size determines its prey size range. *Journal of Animal Ecology* **73:** 410 –423.

Reid, R.S., Rainy, M., Ogutu, J., Kruska, R.L., Kimani, K., Nyabenge, M., McCartney, M., Kshatriya, M., Worden, J., Owuor, J., Kinoti, J., Njuguna, E., Wilson, C.J. and Lamprey, R. (2002). People, Wildlife and Livestock in the Mara Ecosystem: the Mara Count 2002. Report, Mara Count 2002, International Livestock Research Institute, Nairobi, Kenya.

Rutten, M.M.E.M. (1992). Selling wealth to buy poverty: the process of the individualization of landownership among the Maasai pastoralists of Kajiado district, Kenya, 1890-1990. Breitenbach, Saarbrücken. Pp 340.

Scoones, I. (eds) (1994). Living with uncertainty: New Directions in Pastoral Development in Africa. Intermediate Technology Publications, London.

Sedensticker, J., Christie, S. and Jackson, P. (eds). (1999). Riding the Tiger: Tiger conservation in human-dominated Landscapes. Zoological Society of London and Cambridge University Press, Cambridge, UK.

Sinclair, A.R.E. and Arcese, P. (eds) 1995. Serengeti II: dynamics, management and conservation of an ecosystem. University of Chicago Press, Chicago. USA.

Sinclair, A.R.E., Mduma, S. and Brashares, J.S. (2003). Patterns of predation in a diverse predator-prey system. *Nature* **425**:288-290

Stander, P.E. (1998). Spoor counts as indices of large carnivore populations: the relationship between spoor frequency, sampling effort and true density. *Journal of Applied Ecology*. **35**: 378-385.

Swarner, M. (2004). Human-carnivore conflict over livestock: The African wild dog in central Botswana. Center for African Studies. Breslauer Symposium on Natural Resource Issues in Africa. University of California, Berkeley.

Treves-Naughton, L. (1998). Predicting Patterns of Crop Damage by Wildlife around Kibale National Park, Uganda. *Conservation Biology* **12**:156-168.

Treves, A. and Karanth U. K. (2003). Human-Carnivore Conflict and Perspectives on Carnivore Management Worldwide. *Conservation Biology* **17**:1491-1499.

UNEP (1988). People, parks and wildlife: Guidelines for public participation in wildlife conservation. UNEP building. Nairobi, Kenya.

Verlinden, A. (1997). Human settlements and wildlife distribution in the Southern Kalahari of Botswana. *Biological Conservation* **82**:129-136.

Verlinden, A., Perkins, J.S., Murray, M. and Masunga, G. (1998). How are people affecting the distribution of less migratory wildlife in the southern Kalahari of Botswana? A spatial analysis. *Journal of Arid Environments* **38**:129-141.

Walpole, M. J. and Harold, J. G (2001). Local attitudes towards conservation and tourism around Komodo National Park, Indonesia. *Environmental Conservation* **28** (2): 160–166

Western, D (eds) (1992). Conservation for the Twenty First Century. Oxford University Press. UK. 390 pg.

Woodroffe, R., Lindsay, P., Romanach, S., Stein, A. and Ronah, S. (in press). Livestock predation by endangered African wild dogs *(Lycaon pictus)* in northern Kenya. *Conservation Biology*.

Woodroffe, R. (2000). Predators and people: Using human densities to interpret declines of large carnivores. *Animal Conservation* **3**:165-173.

Woodroffe, R. Ginsberg, J.R. (1998). Edge effects and the extinction of populations inside protected areas. *Science* **280**:2126-2128.

Woodroffe, R. Ginsberg, J. R and Macdonald, D.W. (1997) (*ed*). *The African Wild Dog – Status Survey and Conservation Action Plan*. IUCN, Gland Switzerland. 166 pp.

Worden, J., Robin, R. and Gichohi, H. (2003). Land-Use Impacts on Large Wildlife and Livestock in the Swamps of the Greater Amboseli Ecosystem. *LUCID working paper 37*.

Appendix 1. Summary of carnivore mass and prey biomass. The number of carnivores per 10,000 kg of prey biomass was estimated from the ratio of carnivore population density (number per 100 km2) to biomass density (in units of 10,000 kg per 100 km2) of the main prey species averaged for each species. (Carbone & Gittleman, 2002: Radloff & Du Toit,2004)

Species	Average body mass of predator (Kg)	Mean prey body mass (kg)	Number of predators per 10,000 kg of prey biomass	Number of predators per 100 km^2	Prey biomass (10,000kg per 100 km^2)
Lion	142	126	3.40	0.80 to 38.50	0.01 to 116.99
Cheetah	50	25	6.17	0.61 to 7.79	0.16 to 6.69
Leopard	46	25.2	2.29	0.50 to 37.04	0.03 to 41.63
Wild dogs	25	29.8	1.61	0.07 to 15	0.16 to 110.00

Appendix 2: Correlation coefficients for animal species against elevation, aspect, slope, major road, stream and minor road at 250m, 1km and 5km spatial scales. Showing significance at 5km scale

Species	Slope	D major road	D stream	D minor road	Grid size
Cattle	0.050	-0.049	-0.074	-0.017	250 m
Shoats	0.087	-0.069	-0.094	-0.052	250 m
Donkey	0.060	-0.012	-0.036	-0.010	250 m
Ostrich	-0.009	0.021	-0.006	0.015	250 m
Baboon	0.059	0.057	-0.028	0.025	250 m
Dikdik	0.030	0.038	0.005	0.022	250 m
Eland	0.070	0.020	-0.021	-0.006	250 m
Giraffe	-0.005	-0.006	0.022	-0.020	250 m
Gerenuk	0.022	-0.033	0.003	-0.005	250 m
Impala	0.078	-0.018	-0.058	-0.010	250 m
Lesser Kudu	0.054	0.012	-0.042	-0.024	250 m
Ggazelle	0.095	-0.068	-0.047	-0.083	250 m
Tgazelle	0.003	-0.038	-0.034	-0.053	250 m
Reedbuck	0.073	0.012	-0.006	-0.020	250 m
Zebra	0.078	-0.062	0.007	-0.086	250 m
Cattle	0.094	-0.067	-0.120	-0.008	1 km
Shoats	0.136	-0.140	-0.165	-0.082	1 km
Donkey	0.111	-0.034	-0.061	-0.001	1 km
Ostrich	-0.020	0.022	-0.025	0.029	1 km
Baboon	0.138	0.127	-0.040	0.061	1 km
Dikdik	0.054	0.079	-0.021	0.041	1 km
Eland	0.123	0.027	-0.052	-0.014	1 km
Giraffe	-0.010	0.003	0.058	-0.043	1 km
Gerenuk	0.049	-0.075	0.023	-0.002	1 km
Impala	0.153	-0.007	-0.105	-0.016	1 km
Lesser Kudu	0.114	0.032	-0.042	-0.051	1 km
Ggazelle	0.161	-0.108	-0.070	-0.127	1 km
Tgazelle	-0.006	-0.101	-0.083	-0.112	1 km
Reedbuck	0.168	0.030	0.014	-0.042	1 km
Zebra	0.120	-0.112	0.008	-0.163	1 km
Cattle	-0.090	0.054	-0.233	-0.084	5 km
Shoats	0.225	-0.375	-0.429	-0.246	5 km
Donkey	0.640	0.041	-0.236	0.269	5 km
Ostrich	-0.247	0.371	-0.124	0.371	5 km
Baboon	0.008	0.393	0.014	0.413	5 km
Dikdik	-0.124	0.433	0.124	0.062	5 km
Eland	0.274	0.070	-0.021	-0.028	5 km
Giraffe	0.174	0.061	0.023	-0.036	5 km
Gerenuk	0.004	-0.197	-0.222	0.149	5 km
Ggazelle	0.276	-0.259	-0.393	-0.142	5 km
Impala	0.375	-0.409	-0.229	-0.151	5 km
Lesser Kudu	0.326	-0.038	-0.144	-0.266	5 km
Tgazelle	0.117	-0.197	-0.337	-0.110	5 km
Reedbuck	0.401	-0.130	-0.307	-0.213	5 km
Zebra	0.284	-0.344	-0.441	-0.344	5 km