LAND USE AND TENURE CHANGES AND THEIR IMPACT ON THE KITENDEN WILDLIFE CORRIDOR, AMBOSELI ECOSYSTEM, KENYA

By

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DECLARATION

I hereby declare that this thesis is my original work and has not been presented for a degree in any other University.

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This thesis has been submitted for examination with our approval as University Supervisors.

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DEDICATION

This work is dedicated to

My late father Mr. Andre Mbane Ogoonoum who through his value for education tought me how to challenge myself and made me the hardworking man I am today.

My loving mother Mrs. Therese Aleka, Ogoonoum with whose love, God fearing guidance and prayers has given me the strength to stand the challenges of this life that led me to this successful end. Mum you are the best and forever will be my inspiration.

My loving sister Karine Djane Ogoonoum who gave me the opportunity to do this Master degree.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDIXES

ACRONYMS AND ABBREVIATIONS

AERP	Amboseli Elephant research Project
ANP	Amboseli National Park
AWF	African Wildlife Foundation
DPM	Disc Pasture Meter
GPS	Global Positioning System
IUCN	International Union for conservation of Nature
KNP	Kilimanjaro National Park
KWC	Kitenden Wildlife Corridor
KWS	Kenya Wildlife Service
PCQ	Point Centered Quarter

ABSTRACT

This study was conducted in Kitenden Wildlife Corridor (KWC), within Amboseli Ecosystem between October 2011 and January 2012. The research sought information to enhance conservation and management of KWC. The objective was to determine the ecological viability of KWC to wildlife movement between Amboseli National Park (ANP) in Kenya and Kilimanjaro National Park (KNP) in Tanzania. Data on land use and tenure were obtained through questionnaire administration and secondary sources. Vegetation and animal were sampled in the five following habitats *Licium europeanum* grassland, *Acacia tortilis* bushland, *Acacia mellifera* bushland, *Commiphora shimperi* bushland and farmland. Herbaceous vegetation was sampled using a 2m by 2m quadrat and a Disc Pasture Meter (DPM). PCQ and belt transect methods was use to sample woody plants. Animal count was done using sample foot count. This study found that people in KWC were mostly engaged in mixed farming (livestock and cultivation), and they were more people cultivating than those raising livestock. Initially being a community land, it was found that 30.12% of the study area was privately owned while 69.88% was still under community group ranch. Woody species mean densities ranged between 56.4±13.23 trees/ha estimated in *Commiphora shimperi* bushland and 15.35±5.98 trees/ha estimated in *Licium europeanum* grassland. Woody species density differed significantly ($F_{4, 52} = 3.576$, $p<0.05$) among habitats. The study area was dominated by poor quality grass for grazers, and increaser I with (19%) cover was highest and forbs the lowest with (7%). There was a significant difference in mean cover among the four herbaceous vegetation categories (decreaser, Increaser I, Increaser II, and Forb) ($F_{3, 524} = 29.015$, $p<0.05$). Mean wild herbivores population density ranged between 19.23±4.43 animals/km^2 estimated in *Commiphora schimperi* bushland and 4.59±0.45 animals/km^2 estimated in Farmland. No significant difference ($F_{4, 38} = 1.841$, $p>0.05$) was found among the five habitats. Human activities in the KWC are causing degradation and constriction of wildlife habitat and pose heavy threats on the viability of the corridor for wildlife movement.

The study recommended that conservation organizations should lease the KWC from land owners to prevent further spreading of cultivation in the corridor, and pasture management strategies should be put in place for example by reducing the grazing stock and re-seeding the corridor with decreaser species, and an exclusive wildlife use zone delimitated.

CHAPTER ONE: INTRODUCTION AND LITERATURE REVIEW

1.1. Introduction

Most of Kenya's wildlife is found in the less productive and semi-arid rangelands. Amboseli Ecosystem (AE) in which is located the Kitenden Wildlife Corridor (KWC) is a rangeland environment. Rangelands are fragile ecosystems due to the erratic rainfall regime and scarcity of water resources that renders the survival of the biodiversity in these systems very difficult. They are nevertheless important areas for biodiversity conservation and are known to have very high wildlife concentration in Kenya (Herlocker, 1999). Wildlife has for many years been the backbone of tourism industry in Kenya hence playing an important role in the economy of the country (Herlocker, 1999).

Kenya is considered to have a very high biodiversity in Africa, with high abundance of plants, animals, and micro-organisms (Okello and Kiringe, 2004). This wide range of biological resources is an important source of food, beverages, medicines, forage, vegetable oil, fibre, hides and skin. Further, since Kenya's national economy is predominantly hinged on biological resources, wildlife protected areas are an important asset from which a significant amount of foreign exchange is derived (Okello et al., 2001). However, some of the key species that are very important for tourism industry are known to be endemic and threatened. This poses as a serious conservation and economic challenge.

Amboseli National Park (ANP) is a small conservation area of 392 km^2 surrounded by community group ranches. The wildlife depends on the adjacent areas as for dispersal during the wet period (Western, 1975). The Park is progressively undergoing insularization as a result of human population growth and changing land use and land subdivision in the dispersal area. Degradation and loss of such vital dispersal areas and migratory corridors has been recognized as a key factor contributing to wildlife decline in Kenya (Norton-Griffiths, 1997; Western, 1997; Ottichillo, 2000).

Kitenden Wildlife Corridor is a stretch of land between Kilimanjaro National Park (KNP) in Tanzania and Amboseli National Park (ANP) in Kenya. It is a vital linkage that allows the natural movement of elephants and other wildlife species between the two parks every year. To enhance wildlife diversity and ensure that ANP continues to be a key wildlife conservation area in Kenya, there is need to ensure that Kitenden Wildlife Corridor as well as the others surrounding dispersal areas and movement corridors are maintained. This requires ecological data and information on land use and tenure changes and trends, as well as the impact of these changes on biodiversity.

The purpose of this study was therefore to determine the ecological viability of the Kitenden Wildlife Corridor to wildlife movement between ANP and Tanzania, for better management and to ensure the conservation of this critical wildlife corridor.

1.2. Literature Review

1.2.1. Wildlife conservation in Africa

Over the past century, African nations have established an extensive network of protected areas, which play an essential and central role in conserving species and ecosystems. More than 1100 national parks and related reserves have been created in sub-Saharan Africa of which 36 are designated world heritage sites (WCMC, 2004). Since the 1970's, total protected area in Africa has nearly doubled, and encompasses 3.06 million square kilometer of terrestrial land mass and marine habitat (WCMC, 2004). While the expansion of protected area coverage in Africa over the past 30 years is extremely encouraging, the capacity of selected reserves to maintain viable populations of many wildlife species over the long term is threatened by the combination of human-influenced activities within and outside protected areas (WCMC, 2004; Newmark, 2008).

Wildlife conservation in Africa is facing major environmental challenges today due to rapid human population growth. Between 1975 and 2001, the human population in sub-Saharan Africa was reported to have doubled and is expected to double again by 2034 (UNDP, 1998). The need for more land and more resources to sustain this population will likely lead to more people encroaching on wildlife habitat for their livelihoods, such as agriculture, livestock farming, and settlement leading to habitat loss and wildlife species extinction. The survival of different species is influenced by the size and condition of their habitat, therefore supporting species conservation through improving connectivity and reducing habitat fragmentation is key for successful conservation in Africa (Andrew, 2002).

In Kenya, wildlife is protected in national parks, national reserves, marine parks/ reserves and sanctuaries. The wildlife conservation areas cover a total area of nearly 4.8 million hectares or just 8% of Kenya's land mass (KWS, 1990; Mwangi, 1995). The majority of the populations of most large mammal species occur outside protected areas, although this proportion is declining at a high rate (Ottichilo *et al.*, 2000; Okello, 2009; Okello and Kioko, 2010). Between 1970 and 1990, the total wildlife population across Kenyan rangelands declined by 39% (Ottichilo *et al.*, 2000), with reductions in the population of individual species ranging from 2% to 72%. Habitat loss and poaching were believed to be the most important drivers of that decline (Newmark, 2008).

1.2.2. Drivers of land use changes

Prior to the colonial period, Maasai were mainly pastoralists herding cattle, sheep and goats. Under this land use, wildlife was abundant and tolerated by Maasai. When colonizers came, they diminished the power of herding societies, restricted their control over their land, and encouraged expansion of cultivation in Maasai land (Campbell *et al.*, 2000). This marks the beginning of land use change in Maasai land.

The driving forces of land use change are both local and external, and have altered in their intensity over time (Campbell *et al.*, 2003; Noe, 2003). These include international initiatives, for example Convention on Biodiversity (CBD) and Structural Adjustment Programmes (SAPs); national policies, including the Arid and Semi Arid Land (ASAL) development programme (Kenya, 1979) and wildlife management (Western, 1982); and local process such as immigration of farming communities, institutional and economic change among herders, economic opportunities in horticulture and tourism, population growth and revision of land tenure rules (Campbell *et al.*, 2000, 2003; Noe, 2003).

Group ranches were formed under the Land (Group Represerntative) Act of 1968. This Act of parliament provided for the incorporation of representatives of groups who have been recorded as owners of land under the Land Adjudication Act, and the group representatives managed the resources of the group ranches on behave of the group ranch members (Ntiati, 2002). In 1981, the government of Kenya enacted a policy to promote the subdivision of group ranches to individually owned parcels of land (Mbote, 2005). That was the beginning of the change in land ownership from group ranch to individual.

1.2.3. Ecological role of corridors and factors influencing wildlife movement in Kenya.

Habitat corridors, also known as conservation or movement corridors are stretch of land linking primary habitat patches or strips of land running between reserves. Corridors are very important for conservation of biodiversity because they allow plants and animals to disperse from one protected area to another facilitating gene flow and colonization of suitable sites. Corridors also can help to preserve animals that must migrate seasonally among a series of different habitats to obtain food, water resources or to escape from environmental changes (Andrew, 2002). They are very important linkages and dispersal environment for protected areas because they allow these areas to renew their population through enhancing gene flow and reduce the pressure on the PAs by allowing migration of wildlife to adjacent areas or parks.

When protected areas were designed, they did not take into consideration all wildlife requirements and ranges, therefore gradually turned into ecological islands, a process known as insularization (Western and Ssemakula, 1981). Increasing insularization of protected areas by human related activities is causing wildlife population isolation. Such situation may lead to isolated population failing to interact with others for the purpose of breeding, therefore ending inbreeding leading to loss of genetic vigor within the population as weak individuals who are not well adapted to environmental conditions will pass on their genes to the next generation.

Confining animals to a protected area may not sustainably support the growing population and may lead to the population surpassing the carrying capacity of their environment, resulting in increasing depletion of the available resources and degradation of the habitat that will in turn negatively affect the said population. This has happened in ANP where certain species (browsers) have completely left the park to find refuge in the surrounding group ranches that still have significant diversity of habitat (Western, 2006).

Both intra-specific and inter-specific competitions are other potential effects of insularization. These could consequently lead to constriction of the niches of species competing. The end result would be death of animals through starvation, increased predation and spreading of diseases or environmental stochasticities.

In the last century, increase in human population has created a large demand for land and associated natural resources in Kenya (Mwale, 2000). Human encroachment on critical biodiversity sites in search of agricultural land has since the 1970's and 1980's shifted to low potential rangelands which coincidentally are the prime wildlife ecosystems (Sindiga, 1995; Mwale, 2000). Human activities such as construction of settlements and infrastructures like roads, schools and crop farming and fencing are, however, gradually eliminating wildlife on lands adjacent to parks (Western, 1997; Okello, 2009).

If protected areas have no dispersal environment and migration corridors, wildlife are likely to face local extinction and the ecological integrity and resilience of the protected areas would be compromised (Western, 1982). Conservation area like ANP and KNP largely depend on the adjacent land for wildlife dispersal. Loss and degradation of dispersal areas and migration corridors has already caused decline in wildlife number in the country (Ottichilo, 2000; Kiringe and Okello, 2007), thus having a negative impact on the Kenyan tourism industry and economy.

Dispersal areas and migration corridors between protected areas and dispersal ranges continue to decline. This was observed around Tsavo-Amboseli area and Maasai Mara national reserve (Ottichilo, 2000), Kilimanjaro National Park (Noe, 2003), Nairobi National Park (Western, 1997) and around Amboseli National Park (Okello and Kioko, 2010) where they have been taken away by human settlement and cultivation. It is therefore very important to enhance the protection and conservation of migration corridor and dispersal ranges in other to achieve sustainable development.

1.2.4. Landscape conservation

While the expansion of protected area coverage in Africa over the past 30 years is extremely encouraging, the capacity of selected reserve to maintain viable population of many wildlife species over the long term is threatened by a combination of human-influenced activities outside reserves (Newmark, 2008). The threat of biodiversity loss is an eminent one for East African protected areas as they become increasingly insularized by the growing human population in surrounding areas outside protected area, human activities such as settlement, agricultural cultivation, and active elimination of wildlife on land adjacent to parks (Okello and Kiringe, 2004; Okello, 2005). It is therefore necessary to stress the need to view national parks within a broad ecological and human framework, rather than as biological islands; a view that arises from a purely preservationist approach (Western, 1982; Newmark, 2008; Okello, 2009).

The conservation of natural resources in Kenya since 1940's has been largely based on the National Park Model classified as Category II of IUCN network of protected areas in the world (Mackinnon *et al.*, 1986). This has been characterized by the government or local agencies identifying an area based on resources endowment criteria, displacing the local communities, outlawing their settlements and designating the area as Protected (Wishitemi and Okello, 2003). This approach is known to be limited because more biodiversity and representative ecosystems are located outside the current network of protected area in Kenya (Western, 1982; Okello and Kiringe, 2004). An alternative model of conservation that goes beyond park boundaries, involving local communities and bridging the hostile gap between conservation of natural resource ideals and the aspiration of local communities is urgently needed to safeguard vast landscapes of cultural, ecological and historical significance in Kenya as well as in the whole world (Brown *et al.*, 1994; Bereford and Phillips, 2000; Wishitemi and Okello, 2003).

The Protected Landscapes Model (IUCN Category V) provides the framework for the achievement of conservation objectives and sustainable development. This model is considered as the meeting place between humans and environment, and product of the inter-relationship between nature and community, and is regarded by Beresford and Phillips (2000) as the "conservation model for the 21st century".

1.2.5. Factors influencing vegetation composition and biomass production

Several studies have been carried out on the factors influencing vegetation composition, primary productivity and conditions in different part of the world (Kinyamario, 1987; Kiringe, 1990; Mwangi, 1994; Trollope and Trollope, 1999; Vos, 2002; Western and Maitumo, 2004; Western, 2006). These studies have established that various factors influence species composition, diversity and primary productivity. Climate, fire, elephants and human impacts have been cited as major causes of woodland loss. Western (2004) in a study to test overgrazing, pathogen, climate and elephant browsing theory, found that elephants alone were preventing regeneration of the woodland in Amboseli National Park.

In a study of grassland conditions in Nairobi National Park, Vos (2002) found that herbaceous species composition was significantly affected by large herbivore grazing. He also noted that the lower grazing pressure in the park allowed the more palatable decreaser species to maintain a high proportion as compared to the outside of the park that was over grazed. Gichohi (1993), studied vegetation in Nairobi National Park and found that non-preferred plant species were abundant in heavily grazed area while in some habitat certain forbs were eliminated.

Njenga (2007), in a study characterizing vegetation and large herbivore at Il N'gwesi Community Conservancy in Laikipia District found that there was a significant difference in herbaceous layer standing crop yields between wet and dry period. Kiringe (1993), also found that there was two peaks of primary production, which coincided with the occurrence of long and short rains, such that there was a significant correlation between rainfall and primary production.

Mwangi (1994) defined a habitat as the sum total of the physical and chemical conditions surrounding a single species or group of species. The loss of wildlife habitat caused by human population encroachment, expansion of agriculture in area around the parks, were considered to be the most severe threat to biodiversity conservation in Kenya by Kiringe and Okello (2007). These do not only refuse wildlife access to wet season dispersal areas but also interfere with migratory routes and corridors. Consequently wildlife is restricted within parks area placing a lot of pressure on food and water resources in these protected areas (Western, 1982).

1.2.6. Large herbivore population dynamics and distribution

There are two main aspects to consider when predicting the distribution and number of animal. The first is resources; resources that are needed for an animal growth and reproduction. For example: food, water, cover. The second is what could be called negative influences or environmental factors that reduce the growth of a population. Such factors include stressful temperature, areas of human settlement and predator density. In other words factors that animals will tend to avoid (Western and Grimsdell, 1979).

According to McNaughton and Georgiadis (1986), the distribution and abundance of large herbivores is governed by physical, biotic and historical factors. Among the physical factors, rainfall, temperature and soil are of very high importance. Rainfall variability directly influences vegetation characteristics including forage composition, quality and quantity, therefore defining the movement and distribution of large herbivores. Okello and Kiringe (2011), found that Amboseli National Park has a dry season metabolic biomass density of wildlife of (2357.68 ± 81.81 kg per km^2) over three time that of the wet season (693.71 ± 69.70 kg per km^2). Overall, over 70% of large mammals left the park during the wet season, with similar trends for individual species, which greatly increase in the park during the dry season when the only available waters in the ecosystem are found in the park.

Kiringe (1993) in his study of The Ecology of Large Herbivores in Hell's Gate National Park, Naivasha- Kenya noted that the distribution pattern of herbivores appeared to be influenced by both topography and vegetation type. The same author in 1990 considered factors such as topography, nature of vegetation, availability and distribution of food and water resources as factors that influence the herbivores movement and distribution. The good management of vegetation for increased primary productivity and quality will therefore determine the species diversity and abundance of herbivores in a given area.

1.2.7. Justification of the study

Kitenden Wildlife Corridor is a critical area for the dispersal and movement of many wildlife populations in the Amboseli Ecosystem. However, the progressive change in land use from pastoralism to agro-pastoralism and the land subdivision process that it is undergoing is of major concern for the long-term viability of this important wildlife corridor. Land use change is causing a gradual change in natural vegetation and food availability for large herbivores. It was proven by previous studies (Ottichilo, 2000; Kiringe and Okello, 2007) that degradation and loss of dispersal areas and migration corridors are important cause of decline in wildlife number. If this trend is not controlled, Amboseli National Park in Kenya and Kilimanjaro National Park in Tanzanya are likely to lose their connectivity therefore becoming less ecologically viable (Soule *et al.*, 1979; Newmark, 1996).

A wide range of research studies have been done in Amboseli National Park and in the group ranches adjacent to it, but there is a lack of scientific information on the impact of land use and tenure changes in the Kitenden Wildlife Corridor. The current study was motivated by the need to determine the ecological viability of the Kitenden Wildlife Corridor for wildlife dispersal and movement. For effective management of this critical dispersal area and movement corridor for Amboseli National Park and Kilimanjaro National Park, there is a need to know its current status in terms of land use, tenure, vegetation characteristics and animal occupancy.

1.2.8. Objectives and Hypothesis

The main objective of the study was to determine the ecological viability of the Kintenden Wildlife Corridor to wildlife movement between ANP and Kenya/ Tanzania border.

The specific objectives were:

1. To determine land use and tenure changes in Kitenden Wildlife Corridor.
2. To characterize woody and herbaceous vegetation in the Corridor.
3. To determine wildlife and livestock composition and spatial distribution.

Hypothesis

Human modifications of Kitenden Wildlife Corridor have not affected it as a viable wildlife corridor between ANP and Kenya/Tanzania border.

CHAPTER TWO: STUDY AREA, MATERIALS AND METHODS

2.1. Location of the Study Area

Kitenden Wildlife Corridor (KWC) is located in Amboseli ecosystem, South-East of ANP in Loitokitok District, Kajiado County of Kenya. It is part of Olgulului-Ololorashi group ranch that surrounds about 90% of ANP. KWC covers a total area of 16,753.19ha (167.53km^2), is a dispersal area and movement corridor linking ANP in Kenya to Kilimanjaro National Park (KNP) in Tanzania. It is a cross border corridor that lies between latitudes 2° 44' 49" and 2° 52' 13" S and longitudes 37° 21' 45" and 37° 21' 44" E. KWC is bordered to the North by ANP, to the South by Kenya/Tanzania border, to the East and West by Olgulului-Ololorashi group ranch (Figure 1 and 2).

2.2. Physical Characteristics

2.2.1. Topography

The topography of KWC much like the majority of the ecosystem is gently undulating plain with volcanic hills. KWC altitude ranges between 1200-2000m above sea level with poorly drained soils and a few seasonal rivers flowing from south to North as dictated by the topography of the area. The majority of the soils are dominated by saline sodic conditions and highly susceptible to erosion (Western and Maitumo, 2004)

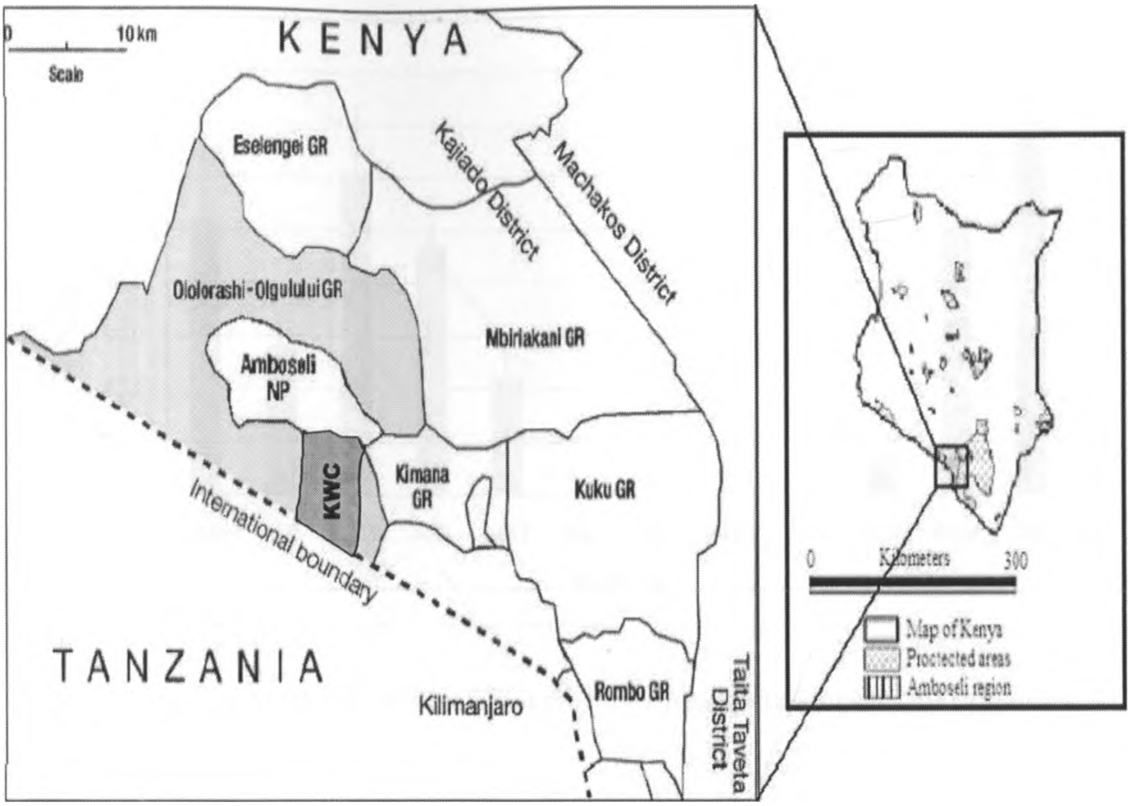

Figure 1: Amboseli Ecosystem location of Olgulului-Ololorashi group Ranch and Kitenden Wildlife Corridor (KWC) in Kenya. (Source Okello and Kioko, 2010)

2.2.2. Climate

2.2.2.1. Rainfall

The climate of the area is warm and dry, and receives 250-300 mm of rainfall per year. The rainfall pattern is bimodal with long rains occurring in March- May, while the short rains are in October- December. Although rainfall is seasonal, it tends to be patchy, unpredictable and erratic and is highly dependent on altitude (Western and Maitumo, 2004). Figure 2 shows the mean rainfall patterns of the study area over twenty two years.

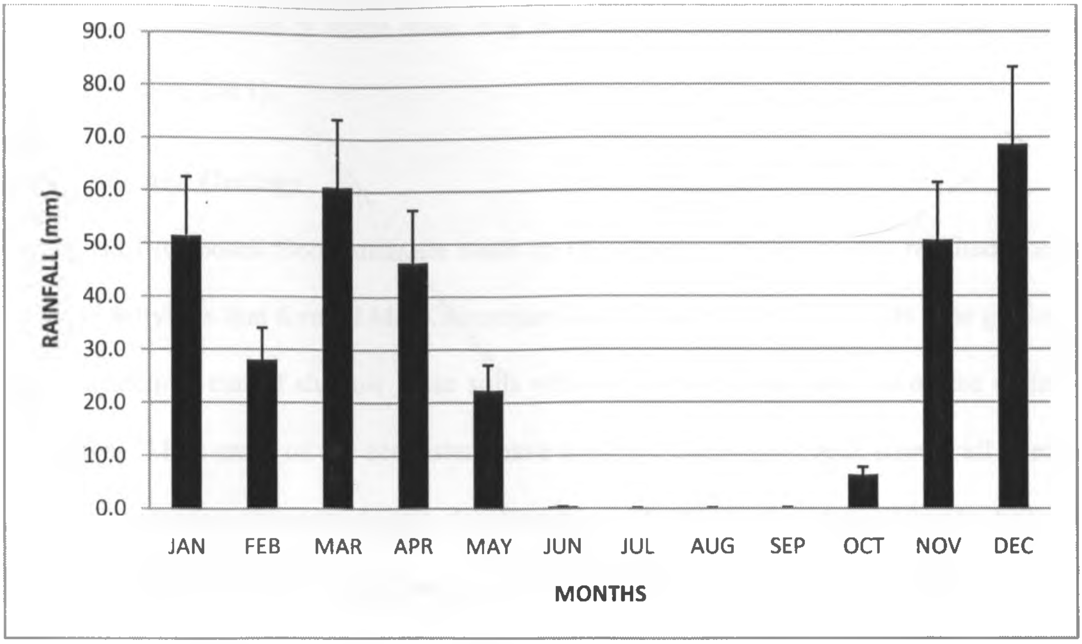

Figure 2: Mean (± SE) Monthly Rainfall of the Study Area between 1990-2011 (Source: AERP, 2011)

2.2.2.2. Temperature

The KWC's daily temperature ranges between 30 – 35° C with the temperature being low during the months of May – July. The rest of the months experience high temperatures that are characteristic of semi-arid conditions (Western and Ssemankula, 1981).

2.2.3. Hydrology

KWC has a poor drainage system with a few seasonal rivers that flow from the slope of Mt Kilimanjaro into the lowland of ANP as dictated by the topography of the area. Seasonal rivers are from East to West Lengiten, Kamwanga, Lomotiok, and Loogom-lokoroi. They are provisioned by the water coming from the higher elevation area around Mt. Kilimanjaro. The water of these rivers last only for a few hours after the rain in the upper part of the corridor, and then all of it flows down to the low lying ANP leaving the KWC only with some water pools dug by elephants or some dams dug by the local community (Maasai elder, personal communication, 2011).

2.2.4. Soil and Geology

The soils of Amboseli Ecosystem are made up of volcanic ash deposit that resulted from the volcanic activities that formed Mt. Kilimanjaro and the adjacent Chyulu hills. The geology of the ecosystem is that of shallow loose soils with volcanic bedrock exposed on the surface in most areas. Most areas of the ecosystem have scattered deposits of rock strewn all over as a result of volcanic eruption during the formation of Mt. Kilimanjaro, Chyulu hills, Mt. Longido and the Namanga hills (Katampoi *et al.*, 1990). A series of low laying hills are found in the KWC as exemplified by Irkaswa and Lemomo.

2.2.5. Flora

The vegetation of the Amboseli Ecosystem falls broadly under the Pratt, Greenway & Gwynne (1966) Ecological Zone V of the East African rangeland classification. The plant communities of the Amboseli basin are dominated by bushland and open grassland. A typical composition of *Acacia-Commiphora* can be found throughout the bushland, along with a varying gradient of grassland dominated by *Penisetum stramineum*. Recent trends show reduction in the amount of woodland cover in most of the group ranches as bush encroachment takes place and both rainfed and irrigated agriculture expand (Campbell *et al.*, 2003). Shift from nomadic pastoralism to sedentarisation by the Maasai, has led to severe rangeland degradation which has resulted in loss in range productivity and increased erosion (McCabe, 2003).

2.2.6. Fauna

A total of 36 mammal species were reported in the Amboseli Ecosystem by Nyeki (1993). These species are African crested porcupine *(Hystrix cristata),* Aardvark *(Oryctoropus afer)*, African elephant *(Loxodonta Africana)*, Bat-eared fox *(Otocyon megalotis)*, Black-backed jackal *(Canis mesomelas)*, Black rhinoceros *(Diceros bicornis)*, Burchell's zebra *(Equus burchellii)*, Bushbuck *(Tragelaphus scriptus)*, Buffalo *(Syncerus caffer)*, Cheetah *(Acinonyx jubatus)*, Coke's hartebeest *(Alcelaphus buselaphus cokii)*, Eland *(Tragelaphus oryx)*, Hippopotamus *(Hippopotamus amphibious)*, Reedbuck *(Redunca arundinum)*, Warthog *(Phacochoerus aethiopicus)*, Waterbuck *(Kobus ellipsiprymnus)*, Wildebeest *(Connochaetes taurinus)*, Fringed-eared oryx *(Oryx gazella callotis)*, Gerenuk *(Litocranius walleri)*, Golden jackal *(Canis aureus)*, Grant's gazelle *(Gazella granti)*, Duiker *(Sylvicapra grimmia)*, Impala *(Aepyceros melampus)*, Kirk's dik-dik *(Madequa kirkii)*, Klipspringer *(Oreotragus oreotragus)*, Leopard *(Panthera pardus)*, Lesser kudu *(Tragelaphus imberbis)*, Lion *(Panthera leo)*, Maasai giraffe *(Giraffa camelopardalis)*, Yellow baboon *(Papio cynocephalus anubis)*, Serval cat *(Felis serval)*, Spotted hyaena *(Crocuta crocuta)*, Striped hyaena *(Hyaena hyaene)*, Syke's monkey *(Cercopithecus mitis)*, Thomson's gazelle *(Gazella thomsonii)*, and Vervet monkey *(Cercopithecus aethiops).*

The Ecosystem has a rich bird fauna, with over 400 bird species recorded, including over 40 birds of prey. The main avian species include the Yellow-necked Spurfowl (*Francolinus leucoscepus*), Eastern Chanting-goshawk (*Melierax poliopterus*), Black-faced Sandgrouse (*Pterocles decoratus*), Red-bellied Parrot (*Poicephalus rufiventris*), White-bellied Go-away-bird (*Corythaixoides leucogaster*), Sombre Nightjar (*Caprimulgus fraenatus*), White-headed Mousebird (*Colius leucocephalus*), Abyssinian Scimitarbill (*Rhinopomastus minor*), Eastern Yellow-billed Hornbill (*Tockus flavirostris*), Von der Decken's Hornbill (*Tockus deckeni*), Black-throated Barbet (*Tricholaema melanocephala*), Red-and-yellow Barbet (*Trachyphonus *erythrocephalus*), D'Arnaud's Barbet (*Trachyphonus darnaudii*), Rosy-patched Bush-shrike (*Rhodophoneus cruentus*), Long-tailed Fiscal (*Lanius cabanisi*), Taita Fiscal (*Lanius dorsalis*), Red-throated Tit (*Parus fringillinus*), Somali Tit (*Parus thruppi*), Pink-breasted Lark (*Mirafra poecilosterna*), Tiny Cisticola (*Cisticola nanus*), Grey Wren-warbler (*Camaroptera simplex*), Banded Warbler (*Sylvia boehmi*), Rufous Chatterer (*Turdoides rubiginosa*), Northern Pied-babbler (*Turdoides hypoleuca*), White-breasted White-eye (*Zosterops abyssinicus*), Hildebrandt's Starling (*Lamprotornis hildebrandti*), Fischer's Starling (*Spreo fischeri*), Bare-eyed Thrush (*Turdus tephronotus*), African Grey Flycatcher (*Bradornis microrhynchus*), Kenya Violet-backed Sunbird (*Anthreptes orientalis*), Hunter's Sunbird (*Nectarinia hunteri*), Black-bellied Sunbird (*Nectarinia nectarinioides*), White-headed Buffalo-weaver (*Dinemellia dinemelli*), Taveta Golden Weaver (*Ploceus castaneiceps*), Speke's Weaver (*Ploceus spekei*), Blue-capped Cordonbleu (*Uraeginthus cyanocephalus*), Purple Grenadier (*Uraeginthus ianthinogaster*), Grey-headed Silverbill (*Lonchura griseicapilla*), Steel-blue Whydah (*Vidua hypocherina*), Straw-tailed Whydah (*Vidua fischeri*), Kenya Grosbeak-canary (*Serinus buchanani*), White-bellied Canary (*Serinus dorsostriatus*) (Birdlife, 1999).

2.3. Materials and Methods

2.3.1. Determination of land use and tenure changes

To produce representative data and capture diversity of opinion of the local people in Kitenden, over 30% of the households in each of the two settlement areas (Lower belt n = 75, Upper belt n = 94) were randomly sampled. The Lower belt represented by villages like Eldepen, Olmoti, Emurraa Oldule, Elmarba, and Enkong Narok; is the lowland area of the corridor with low rainfall and the upper belt represented by Irkaswa and Imisingiyio village, is the highland or rain fed agricultural area. Interviews were conducted with members of different households between October and November 2011. The randomness was achieved by interviewing only one adult (household male or female) first encountered from each family within a boma. Interviewers fluent in both English and Maasai languages who were familiar with the Olgulului group ranch and locations of the bomas conducted the interviews. Each question was discussed with the interviewers to ensure that they precisely understood the questionnaire. The interviewers were required to translate the questions into Maasai language to respondents who were not very conversant with English. The interviews were aimed at getting information on: (1) Main land use strategies, (2) the most beneficial land use, (3) Crop grown and livestock kept, (4) Human wildlife conflict incidences, and (5) Land ownership. Spatial analysis technique (GIS) was used to generate data on the extend of cultivation and the area covered by privately owned land within the KWC.

2.3.2. Vegetation characterization

An extensive field survey was carried out during the month of September 2011 to characterize different vegetation types within the study area. Five vegetation types were characterized for their species composition and density. The vegetation classification followed that of Pratt *et al.*, (1966).

2.3.3. Vegetation types and woody species characterization

Representative vegetation stands characterized by homogeneity in species composition and physiognomic structures were selected for stratified sampling. The grid map horizontal lines were used as baselines. In each of this stratum, a line transect starting point was randomly selected by assigning a number to each baseline within the stratum. The numbers were also written on pieces of paper, folded and put into a basket from where one of the number was picked to represent the starting point of the first transect. The other transects starting point were systematically placed at 3 km interval from the previous one, for transects on the same baseline, and at 2km intervals from the end of the previous transect for the once on either side of it, following the lines of the grid map. Systematic sampling was chosen in other to have the sampling transects distributed in the whole study area. All transects were 1km long. Transects orientation from the starting point was determined by the nature of the topographic features of the area, with transects cutting across drainage channels.

A total of 18 Point Centered Quarter (PCQ) transects each 1Km long were established to determined woody species composition in four vegetation types with the exception of farmland. The number of transects to be sampled in each habitat was calculated proportionally to the area covered by each habitat. Eight transect were set up in the *Licium europeaneum* grassland, three transects in *Acacia tortilis* bushland, five transects in the *Acacia mellifera* bushland, and two transects in the *Commiphora schimperi* bushland.

The transects were sampled systematically at every 100m intervals, where the area around each point was divided into four equal parts or quarters by use of a second line perpendicular to the line transect at the sampling point. The individual woody species nearest to the point in each quarter was located and its point to individual distance, basal diameter and height measured. Woody species with basal diameter less than 1cm was not considered for PCQ analysis.

The point to individual distance was measured to the center of the plant (Chira, 2005) by use of a measuring tape, woody species basal diameter was measured by use of vernier-callipers, and height was estimated by use of range finder. The data were collected between November and December 2011.

The point to individual distance were first totaled for all species and all points and then averaged to give the mean point to individual distance in each vegetation type. The mean point to individual distance squared gave the mean area per individual which is the average area of surface on which an individual occurs. The densities per hectare in the area sampled were obtained through the following equations:

$$Total\ Density\ of\ all\ species = \frac{10{,}000m^2}{(Mean\ point\ to\ individual\ distance)^2}$$

$$Relative\ Density = \frac{Number\ of\ individuals\ of\ species}{Total\ number\ of\ individuals\ of\ all\ species} * 100$$

$$Density = \frac{Relative\ Density\ of\ species\ * Total\ Density\ of\ all\ species}{100}$$

$$Dominance = Density\ of\ species\ * Average\ Dominance\ value\ for\ species$$

$$Relative\ Dominance = \frac{Dominance\ of\ a\ species}{Total\ Dominance\ for\ all\ species} * 100$$

$$Frequency = \frac{Number\ of\ point\ at\ which\ species\ occurs}{Total\ number\ of\ point\ sampled}$$

$$Relative\ Frequency = \frac{Frequency\ value\ for\ species}{Total\ Frequency\ value\ for\ all\ species} * 100$$

$$IVi = Relative\ Density + Relative\ Dominance + Relative\ Frequency$$

IVi =Important Value index

The farmland was sampled using the belt transect method. This method was chosen for this habitat since it was found to capture more woody species and give a better estimate compared to (PCQ). A baseline and transect starting point were randomly chosen as explained above in PCQ sampling. On this baseline, two transects 1km each were systematically established at 3km interval from each other. Along each transect, five belts 100m length and 20m width each were placed at 100m interval from one another. A total of 10 belts were sampled in this habitat. Tree species name, basal diameter and height of all the trees falling in a belt were recorded on the data sheet. The following parameters were calculated (Brower *et al*, 1990).

$$Density\ for\ species\ i = \frac{Number\ of\ individual\ of\ species}{Total\ area\ sampled}$$

$$Relative\ Density\ for\ species\ i = \frac{Density\ for\ species\ i}{Total\ Density\ for\ all\ species} * 100$$

$$Frequency\ for\ species\ i = \frac{Number\ of\ plots\ with\ species\ i}{Number\ of\ plots\ sampled}$$

$$Relative\ Frequency\ = \frac{Frequency\ for\ species\ i}{Total\ frequency\ for\ all\ species} * 100$$

$$Dominance\ for\ species\ i = \frac{Total\ area\ covered\ by\ species\ i}{Total\ area\ sampled}$$

$$Relative\ Dominance = \frac{Dominance\ for\ species\ i}{Total\ Dominance\ of\ all\ species} * 100$$

$$IVi = Relative\ Density\ + Relative\ Dominance\ + Relative\ Frequency$$

2.3.4. Similarity indices between various habitats types.

The Sørensen similarity coefficient was used to compare woody species composition between habitats. The following equation was used for calculating the similarity coefficient.

$$Ss = \frac{2c}{a + b + 2c}$$

Where: Ss = Sørensen similarity coefficient

a = Number of species in habitat type A

b = Number of species in habitat type B

c = Number of species common to both habitat types

The Sørensen coefficient gives weight to the species that are common to habitat types rather than those that only occur in either habitat type.

2.3.5. Herbaceous vegetation characterization

2.3.5.1. Herbaceous vegetation composition and cover

The 20 transects used for woody vegetation sampling were also sampled for herbaceous layer. The data represents information on herbaceous vegetation standing crops and cover during the rainy season of November and December 2011.

The herbaceous layer was sampled using a 2m x 2m quadrat. Along each 1km transect, quadrats were systematically placed at 100m interval from each other. A total of 10 quadrats were sampled on each transect. Individual dicots and grasses species were sampled in each quadrat. Percentage cover for dominant species in each quadrat was recorded on data sheet. The data were analyzed for species composition and species diversity. The total cover for dominant species was divided by the number of quadrats sampled in each habitat to obtain the average cover for each species. Following the classification by Trollope and Trollope (1999), the herbaceous species were grouped in the following categories (decreaser, increaser I, increaser II and forbs).

Decreaser – Grass and herbaceous species which decrease when rangeland is under or over utilized.

Increaser I – Grass and herbaceous species which increase when rangeland is underutilized or selectively grazed.

Increaser II – Grass and herbaceous species which increase when the rangeland is over utilized.

2.3.5.2. Herbaceous biomass estimation

Grass biomass was estimated using the Disc Pasture Meter (DPM) (Trollope and Trollope, 1999). This method was preferred to the harvest method because it is less destructive. Others advantages of the DPM are that it is simple to apply, quick, cost effective, accurate for estimation of grass biomass and has been used throughout the grassland savannas of Africa (Trollope and Trollope, 1999; Vos, 2002). For every 1km transect 10 points were systematically set at every 100m intervals. These points were considered as starting point for sampling. From each starting point, 20 points were systematically sampled at every 1m intervals. A total of 200 points were sampled per transect using a disc made of acrylic plastic (plexiglass) (diameter = 45 cm; mass= 1.5 kg) (Trollope and Trollope, 1999), that was drop onto the grass sward from a standard height of 60cm. Data on grass height were collected and later converted into biomass using a calibration equation for the study area.

For calibration 6 random points in each of the five habitats was sampled. A quadrat of $0.25m^2$ was set at each point. The DPM was use to measure the height of herbaceous vegetation within the quadrat. After the height was recorded, a pair of scissors was used to clip all the herbaceous material within the quadrat to ground level. This was put in well labeled paper bags then carried to the University of Nairobi where it were oven dried to constant weight at 65° C for 72 hours. The dry weight for herbaceous material in each bag was measured using a weighing balance (Max weight=3500g, Accuracy=0.01g). The biomass was graphed against corresponding grass heights to give simple regression equation y=a+bx, (where y=grass biomass in g/m^2 and x=mean disc height in m) using SPSS program. The equation was later used to convert disc grass height measurements into grass biomass for the study area.

2.3.6. Large wild mammals and livestock distribution and composition

Sample foot count was used to collect data on wildlife and livestock (Norton-Griffiths, 1978; Caughley & Sinclair, 1994). This method was preferred due to the relatively large area of KWC, combine with the poor road network and the rough terrain.

The lines of the grid map oriented South (Kenya/Tanzanian border) - North (ANP) were used as transect line. The first transect line was chosen at the extreme west of the KWC because of its isolation and difficult accessibility. From this first transect, four other were systematically chosen at 3km interval from one another and sampled once every month between October and December 2011 using a belt transect method. Along each transect, a 1km sampling unit starting point was establish at the Tanzania/Kenya border. The research team walked along the sampling units and animals within 100m on either side were identified and counted using a pair of binocular. A range finder was used to estimate the distance to the animal from the center of the belt transect where the team was not sure. The length of sampling unit was monitored with a GPS. Between one sampling unit and the next a buffer zone of 500m was established where no counting was done. Whenever habitat changed, sampling unit was terminated and a new one begun in the new habitat. A minimum of 8 sampling units were sampled on each transect. Wild ungulates (larger than Kirk's dik-dik *Madequa kirkii*), carnivores and all primates were identified and counted.

When animals were sighted, the following data were recorded; habitat type, species name, number of individuals. The data obtained were used to estimate the population density, biomass and species diversity for each habitat. Wildlife and livestock density, biomass were calculated using the following formulas

$$Density\ of\ species = \frac{Number\ of\ animals\ counted}{Transect\ length * transect\ width}$$

$$Biomass = Density\ of\ species * \ Mean\ weight\ for\ species$$

$$Mean\ weight\ for\ species = \frac{Mean\ wt\ male + Mean\ wt\ female}{2}$$

The species mean weight was calculated from the mean weight for adults male and female. Mean weight for wildlife was obtained from Haltenorth and Diller (1980) and for livestock from Bekure *et al* (1991).

Species diversity was estimated using the Shannon-Weaver diversity index as in Zar (2010).

$$H' = -P_i log P_i$$

Where: $P_i = n_i/N$ and n_i is the number of individuals of a species and N is the total number of individuals of all species.

2.3.7. Data analysis

Data were entered into the computer using Excel and all statistical analysis were performed using SPSS (SPSS.PASW.Statistics.v18.Multilingual-EQUiNOX) and PAST data analysis programs. The data for land use and tenure changes collected using a questionnaire interview method were entered into SPSS and Chi-square test was performed to test for significant differences in land use and tenure changes. Shannon-Weaver diversity indices (H') for various habitats were generated using PAST program and t-statistic was used to test for differences in species diversities between habitats. This was done for data on plants and animals. The percentage cover for different herbaceous species category (decreaser, increaser I, increaser II and forbs) and cover were calculated for each quadrat sampled and data transformed using Arcsine, then analyzed for differences using one way ANOVA and t-test. F-statistic was also performed to test for significant differences in density of plants and animals among habitats using SPSS. All statistical tests were considered significant at $p< 0.05$ confidence level (Zar, 2010).

CHAPTER THREE: RESULTS

3.1. Land Use and Tenure Changes

3.1.1. Land use change and agricultural expansion

The results showed that respondents in the study area tended to practice both cultivation and livestock raising. Figure 3 shows different types of socio-economic activities by the local community in KWC.

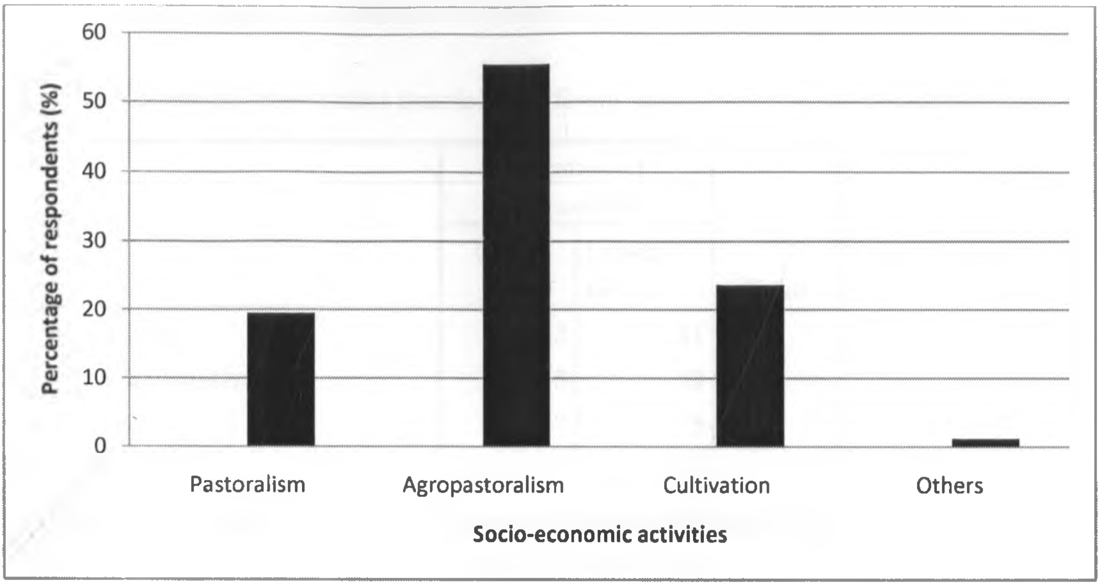

Figure 3: Percentages of respondents practicing different types of socio-economic activities in KWC.

Most respondents (85%) considered cultivation more beneficial than pastoralism, while 11% thought vice versa and a small portion 4% did not have an opinion. The results indicated that maize; beans, potatoes, tomatoes, water melon and other crops (sunflower and banana) were the main crops grown in the KWC. Beans (34.8%) and maize (34.5%) were the dominant crops while banana and sunflower were the least dominant, grown only by 1.9% of the respondents (n = 169). Potatoes, tomatoes and water melon represented the rest of 28.8%.

The livestock found in this area were cattle, goat, sheep and donkey. The cross-tabulation between main livelihood strategy and locations (Upper belt and lower belt) of respondent revealed that there was a significant difference in the proportion of respondents engaged in cultivation or livestock raising among locations ($\chi^2_{0.05,3} = 57.701$, $p<0.05$) (Table 1). The results show that in the upper belt (rain fed agricultural area), residents were primarily engaged in mixed farming (livestock and cultivation) and cultivation, while in the lower belt (lowland) the residents were engaged in mixed farming and livestock raising (Table 1).

Table 1: Number of respondents practicing different activities in the two locations.

Land uses	Location of respondent		Total
	Upper belt	Lower belt	
Livestock only	2	**31**	33
Livestock and cultivation	**55**	**39**	94
Cultivation only	**37**	3	40
Others strategies	0	2	2
Total	94	75	169

$\chi^2_{0.05,3} = 57.701$ is significant, $p<0.001$ level comparing across locations

3.1.2. Land tenure change

The results from the interviews revealed that in KWC almost all the respondents (87.4%) owned a piece of land within the corridor and only (12.6%) of them did not have land. There was no significant difference in land ownership between respondents in the upper belt and those in lower belt ($\chi^2_{0.05,1} = 0.728$; $p>0.05$), meaning that land ownership within the KWC was independent of whether the person came from the lower or the upper belt.

The map of the study area shows parcels of land that were demarcated and allocated to some members of the group ranch. There were about 1,246 demarcated parcels of land within the study area covering an area of 5,046.3 hectares or 30.12% of the study area. The mean size of individual land parcel was 4.05 hectares. The area covered by these parcels of land is potential area for expansion of cultivation and settlement judged from its higher rainfall compared to the lower belt. By the time of this study, 25.77% of this potential agricultural area was under cultivation (area represented by farmland in Figure 4). These parcels of land are all located in the upper belt next to the Kenya/Tanzania border, creating a potential barrier between ANP and KNP in Tanzania (Figure 4).

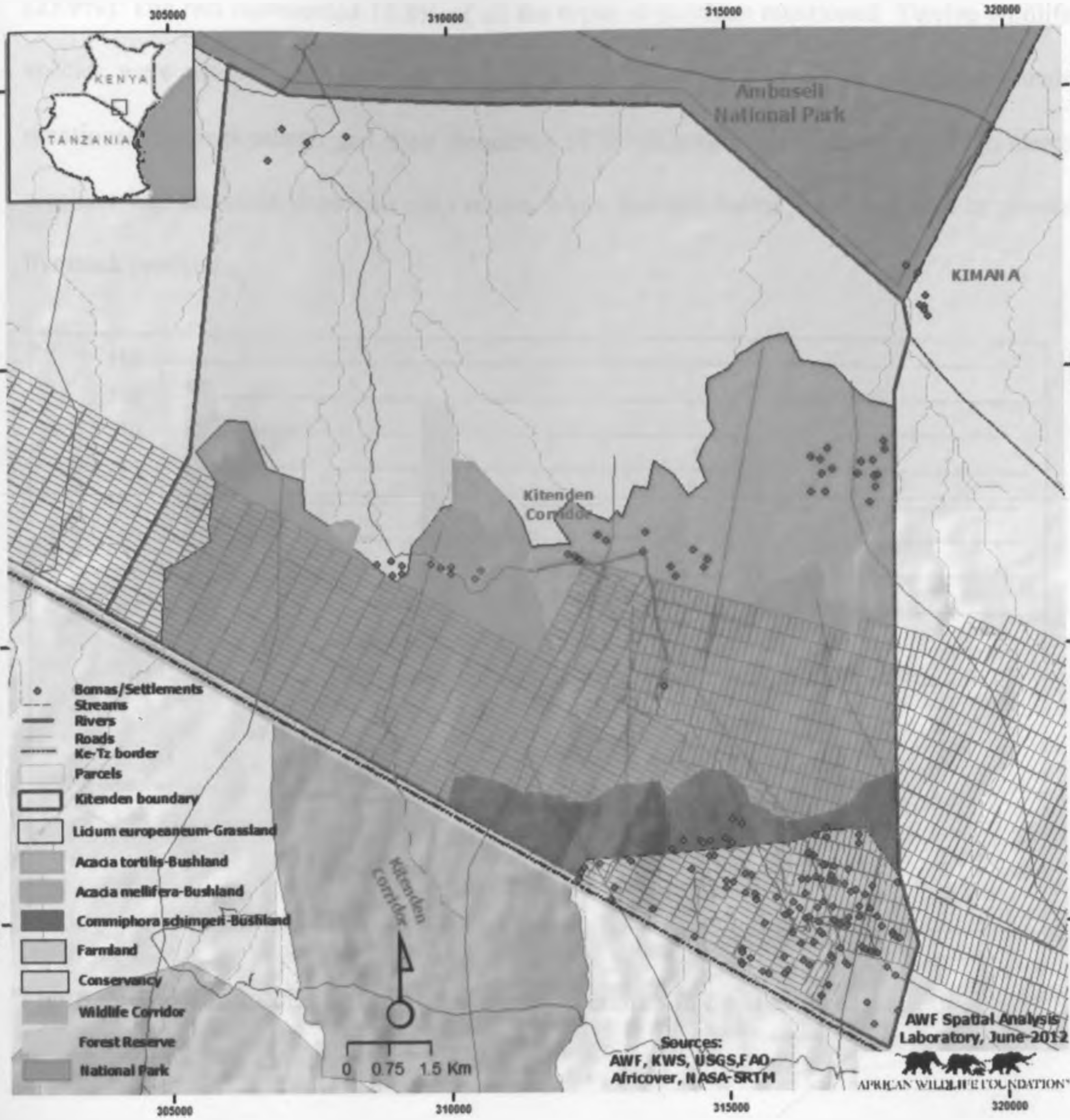

Figure 4: Map of the study area showing the demarcated parcels of land (Source: AWF spatial analysis laboratory, May 2012)

3.1.3. Human wildlife conflicts and problem animals

The type of conflicts reported to be most prevalent in the study area were crop raiding, destruction of properties, disruption of social activities, human injury and death, and livestock depredation. Of these type of conflicts, livestock depredation was mentioned most frequently (32.0%) followed by crop raiding (28.3%) and disruption of social activities (23.9%). The rest represented 15.8% of all the types of conflicts mentioned. Twelve wildlife species were associated with these conflict issues. Figure 5 shows the problem animals mentioned by respondents and their frequency of incidences. According to the respondents elephant was the most important crop raider, while lion and hyena were the most important livestock predators.

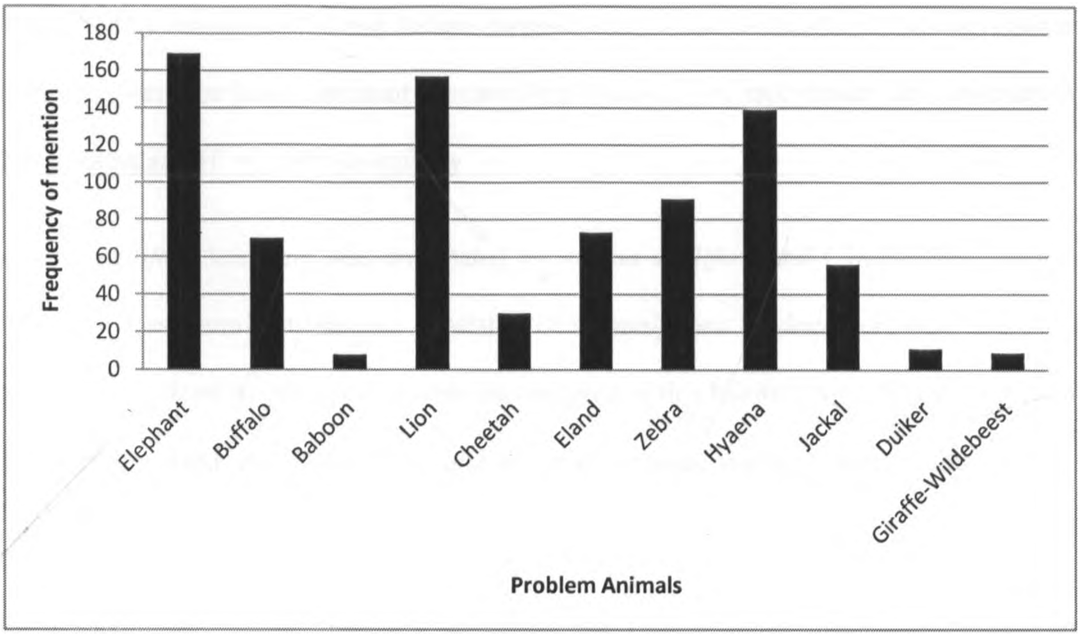

Figure 5: Wildlife species mentioned as conflicts animals in the study area.

3.2. Vegetation Characterization

3.2.1. Woody species composition, density and diversity

Five main vegetation types also referred to in the study as habitats or vegetation communities were identified. The five habitats were *Licium europeaneum* grassland, *Acacia tortilis* bushland, *Acacia mellifera* bushland, *Commiphora schimperi* bushland and Farmland. Farmland consisted of the area of the corridor where crop farming had modified the natural vegetation.

A total of nine woody species were found in *Licium europeaneum* grassland habitat. This habitat was dominated by *Licium europeaneum* and *Maerua edulis,* while the least dominat species was *Azima tetracantha* followed by *Commiphora schimperi* (Appendix 3). Woody plants absolute density and species diversity estimated for *Licium europeaneum* grassland vegetation type was 138 trees/ha and H' = 1.59 respectively.

In *Acacia tortilis* bushland a total of eight woody species were encountered. These were dominated by *Acacia tortilis* and *Licium europeaneum,* while *Grevia tembensis and Balanites aegyptica* were the least dominant species (Appendix 4). The tree density and diversity was 200 trees/ha and H' = 1.69 respectively.

Acacia mellifera bushland was dominated by *Acacia mellifera* and *Commiphora schimperi* while the least dominant species consisted of *Commiphora madagascariensis* and *Cordia monoica.* Eighteen woody species were encountered in this habitat (Appendix 5). For *Acacia mellifera* bushland, absolute density and diversity estimate was 291 trees/ha and H' = 2.04 respectively.

In *Commiphora schimperi* bushland vegetation type, twelve woody species were encountered and were dominated by *Commiphora schimperi* and *Acacia nilotica. Maytenus putterlickioides* and *Lannea rivae* were the least dominant species (Appendix 6). Woody plants absolute density and species diversity was estimated at 677 trees/ha and H' = 2.18 respectively in this habitat.

The farmland vegetation type had a total of ten woody species. This habitat was dominated by *Acacia drepanolobium* and *Ozoroa insignis* woody plant species. *Cordia monoica* and *Acacia mellifera* were the least dominant species in this habitat (Appendix 7). For the farmland, woody species absolute density was estimated at 189 trees/ha while the species diversity was H'= 1.45.

The mean density of woody species range between 56.4±13.23trees/ha and 15.35±5.98trees/ha estimated in *Commiphora schimperi* bushland and *L. europeaneum* bushland habitats respectively (figure 6). There was a significant difference in woody species mean population density among habitats ($F_{4, 52} = 3.576$, $p<0.05$).

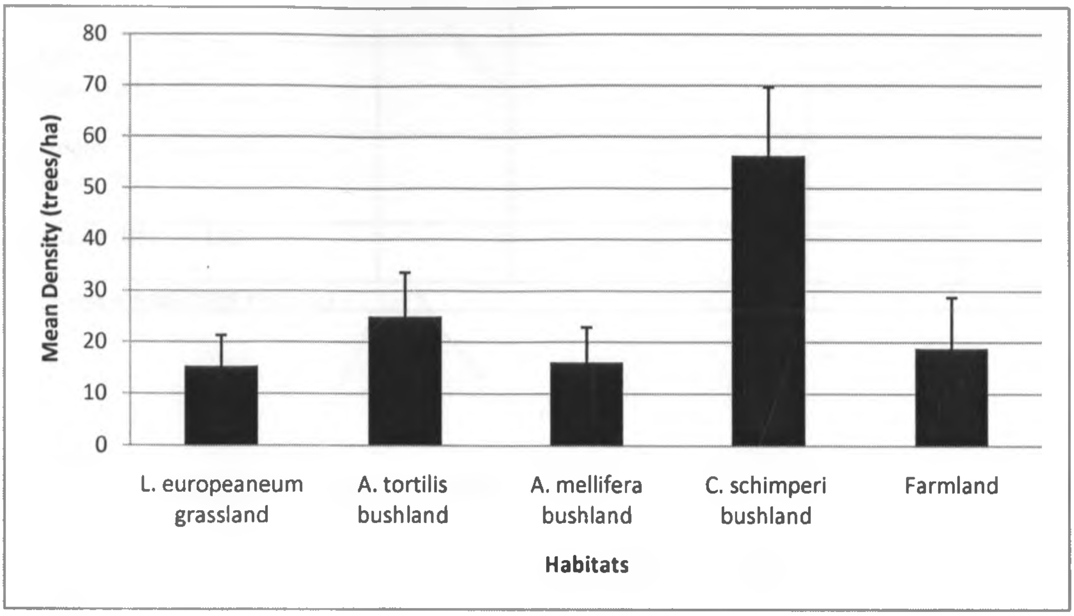

Figure 6: Mean density (±SE) of woody plant species in different habitats in KWC

Shannon-Weaver diversity t-test revealed that there was a significant difference in woody species diversity between all pairs of vegetation types with the exception of *Licium europeaneum* grassland and farmland; *Acacia mellifera* bushland and *Commiphora schimperi* bushland. The highest woody species diversity was realized in *Commiphora schimperi* bushland, while the lowest was that of farmland (Table 2).

Table 2 : Woody species diversity comparison between habitats.

Habitats	Species Diversity (H′)	B1	B2	B3	B4	B5
L. europeaneum Grassland (B1)	1.59		$t_{211.2}=-0.94$, $P<0.05$*	$t_{299.33}=-4.15$, $P<0.05$*	$t_{139.07}=-5.68$, $P<0.05$*	$t_{656.98}=1.94$, $P>0.05$
A.tortilis Bushland (B2)	1.69			$t_{305.38}=-2.91$, $P<0.05$*	$t_{180.99}=-4.10$, $P<0.05$*	$t_{252.49}=2.42$, $P<0.05$*
A.Mellifera Bushland (B3)	2.04				$t_{243.99}=-0.93$, $P>0.05$	$t_{342.62}=5.34$, $P<0.05$*
C. schimperi Bushland (B4)	2.18					$t_{164.28}=6.87$, $P<0.05$*
Farmland (B5)	1.45					

(* shows significant results)

3.2.2. Similarity between habitat types

Figure 7 is a dendrogram showing the pattern of similarity in species composition in various habitat types in KWC. It was obtained by taking the pair with the highest similarity and joining them with a horizontal line at the level of their similarity coefficient on the vertical axis. The pair was treated as a single sample and compared with the rest of the habitat types. The highest emerging similarity index shows where the incoming habitat type connects with the first pair. The triple habitat types were again treated as a single pair and compared with the rest of the habitats types. Farmland and *Commiphora schimperi* bushland were most similar in species composition at 42%, and are more similar to *Acacia mellifera* bushland at 30%. The triple is similar to *Acacia tortilis* bushland at 33%, than *Licium europeaneum* grassland at 32%.

B_5 = Farmland
B_4 = *Commiphora schimperi* bushland
B_3 = *Acacia mellifera* bushland
B_2 = *Acacia tortilis* bushland
B_1 = *Licium europeaneum* grassland

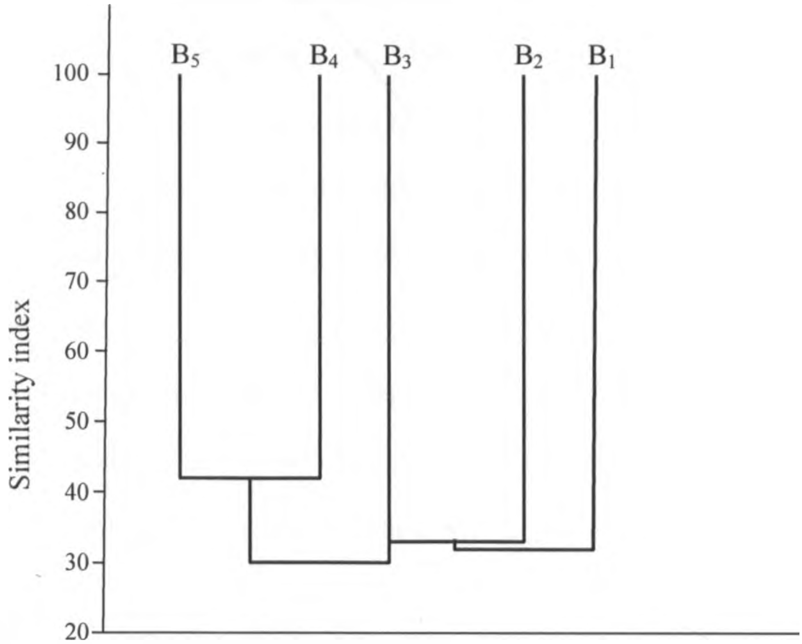

Figure 7: Comparison of similarity indices between various habitats in KWC

3.2.3. Woody species age classes

The nine woody species encountered during PCQ sampling in *Licium europeaneum* grassland, constituted 21.07% of saplings (<1m), 64.29% immature class (1-3m), and 14.64% of mature class (>3m). Among all the woody species identified in this vegetation type only *A. tetracantha* and *C. schimperi* were not represented in the sapling class, with *L. europeaneum* being the dominant species with 49.15%, followed by *M. edulis* constituting 25.42% of the woody plants. The immature class was dominated by *L. europeaneum* (41.11%) followed by *M. edulis* (25.55%). In the mature class *A. tortilis* (43.90%) was the dominant species followed by *B. glabra* (31.71%). Woody species mean density ranged between

9.87±4.18trees/ha and 4.05±1.57trees/ha estimated in immature and mature class respectively. There was no significant difference in woody species mean densities ($F_{2, 18}$ = 1.05, p>0.05) among the three height classes in *Licium europeaneum* grassland.

Out of the eight woody species encountered during the sampling in *Acacia tortilis* bushland, 14.91% contributed to the sapling class, 57.89% immature, and 27.19% to the mature class. *L. europeaneum* with 35.29%, followed by *A. tortilis* 23.53% were the dominant species in the sapling class. All the species identified in this habitat were represented in the immature class and *A. tortilis* dominated with 43.08%, followed by *L. europeaneum* 23.08%, while *A. tortilis* and *A. mellifera* constituted 54.84% and 16.13% respectively dominating the mature class. The mean densities in this habitat varied from 14.49±5.80 trees/ha for immature class and 5.97±1.43trees/ha for sapling class. No significant difference in woody species mean density was found among the three height classes in *Acacia tortilis* bushland ($F_{2, 15}$ = 0.701, p>0.05).

Acacia mellifera bushland with eighteen woody species was composed of 6.74% of sapling, 60.62% immature class and 32.64% mature class. The sapling class was dominated by *A. mellifera* with 46.15%, followed by *C. schimperi* and *M. edulis* each contributing 15.38% of all individuals plant species. *A. mellifera, C. schimperi* and *L. europeaneum* dominated the immature class at 29.06%, 23.93% and 7.69% respectively. The mature class was dominated by *A. mellifera* at 58.73%, followed by *C. schimperi* 12.69% and *A. tortilis* 9.52%. Woody species mean density vary between 11.76±3.80trees/ha estimated in immature class and 3.27±1.19trees/ha in sapling class. There was no significant difference in woody species mean density ($F_{2, 28}$ = 0.775, p>0.05) among the three height classes in *Acacia mellifera* bushland.

The woody species identified in *Commiphora schimperi* bushland constituted 6.25% of sapling class, 35% immature, and 58.75% mature tree canopy. *C. rostrata* with 40% dominated the sapling class, while the immature class was dominated by *A. drepanolobium* with 22.58%, followed by *C. schimperi* and *B. aegyptica* constituting 16.13% each. *C. schimperi* with 25.53%, followed by *A. seyal* 23.40%, and by *A. drepanolobium* and *A. nilotica* contributing 17.02% each dominated the mature class. There was a significant difference in woody species mean density among the three height classes in *Commiphora schimperi* bushland ($F_{2, 18} = 3.584$, $p<0.05$). The mature class had the highest mean density (49.71±13.23trees/ha) and the lowest was that of sapling class (10.57±2.11trees/ha).

The sapling canopy contributed 9.79% of the woody plant species in farmland. *A. drepanolobium* at 37.84% followed by *A. seyal* (27.03%) dominated this canopy. The immature class contributed 61.9%, and *A. drepanolobium* (60.26%) followed by *A. seyal* at 11.97% dominated this class. The mature canopy with 28.31% of the species present in the farmland habitat was dominated by *A. drepanolobium* at 47.66% followed by *R. vulgaris* 14.95%. No significant difference in woody species mean density was found ($F_{2, 19} = 0.467$, $p>0.05$) among the three height classes in farmland. It ranged between 11.7±6.73trees/ha and 3.7±1.19trees/ha estimated in immature and sapling class respectively. Figure 8 shows the contribution of different tree canopies in each of the five habitats.

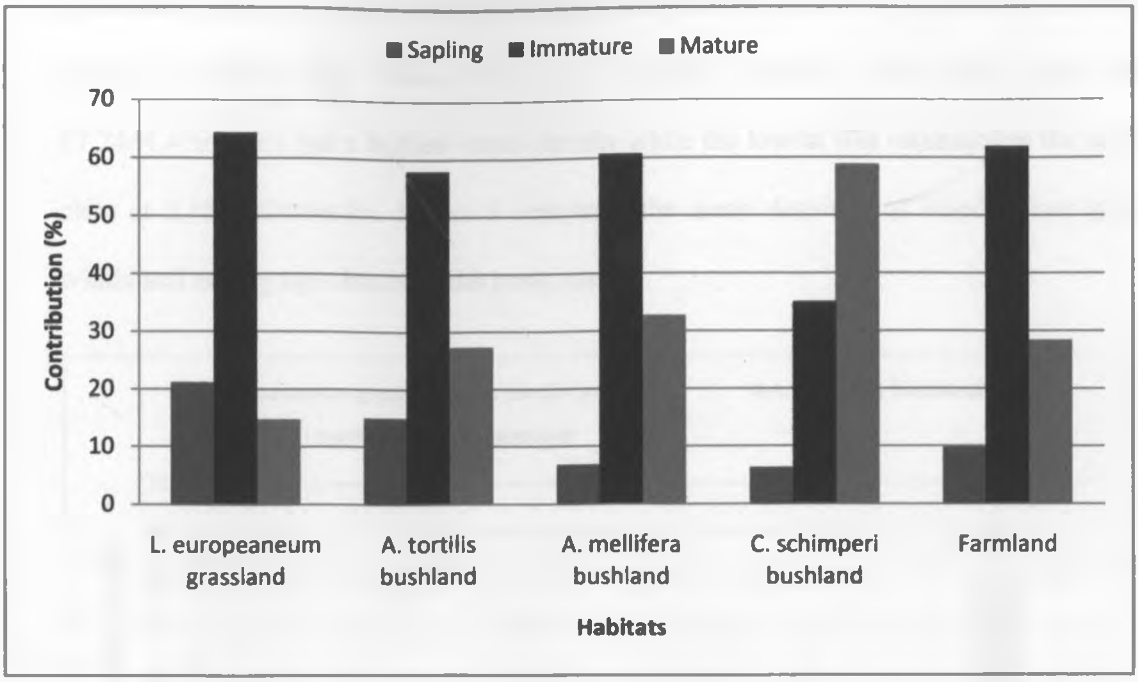

Figure 8: Woody plant species contribution to each of the age class in the five habitats

Comparison of woody species density of each age class among the five habitats, showed that in the sapling class, there was a significant difference among habitats ($F_{4, 22} = 2.752$, $p<0.05$). *Commiphora schimperi* bushland with 10.57±2.11trees/ha had the highest mean density and *Acacia mellifera* bushland with 3.27±1.19 trees/ha the lowest.

Woody species density in the immature class ranged between 26.32±4.97trees/ha and 9.87±4.18trees/ha estimated in *Commiphora schimperi* bushland and *L. europeaneum* grassland respectively. No significant difference in woody species densities was found among the five habitats ($F_{4, 46} = 1.567$, $p>0.05$) in this age class.

Tree densities in the mature class showed a significant difference ($F_{4, 30} = 6.088$, $p<0.05$) among habitats, and *Commiphora schimperi* bushland (49.70±13.22trees/ha) had a highest density and *L. europeaneum* grassland the lowest (7.64±3.15trees/ha).

In the study area as a whole, there was a significant difference in woody species mean density among the three age classes ($F_{2, 110} = 3.663$, $p<0.05$). The mature class with 17.74±4.49trees/ha had a highest mean density while the lowest was estimated in the sapling class at 5.16±0.83trees/ha. Figure 9 compares the mean densities of woody plant species within and among age classes in the study area.

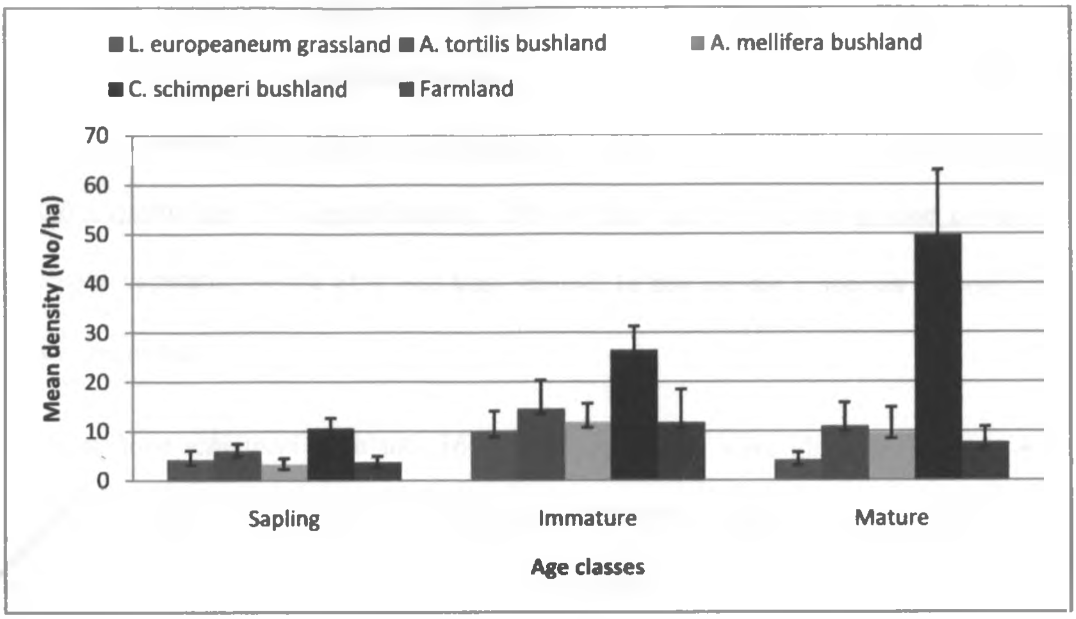

Figure 9: Mean density (±SE) of woody species in different age classes

3.2.4. Herbaceous vegetation composition and cover

Twenty two herbaceous species were indentified in *Licium europeaneum* grassland, of which 13 were grasses and 9 were dicot plants. The herbaceous species percentage cover was dominated by *Pennisetum stramineum* at 9%, followed by *Dactyloctenium aegyptium* and *Pennisetum mezianum* at 3% each. The herbaceous vegetation cover represented 31% of this habitat, while the bare ground accounted for 69%. Species diversity in this habitat was H' = 2.65.

Thirteen herbaceous species were present in *Acacia tortilis* bushland, 10 were grasses and 3 were dicot species. The percentage cover was dominated by *Cynodon dactylon* at 9%, followed by *Dactyloctenium aegyptium* 8% and *Eragrostis tenuifolia* at 6%. The bare ground represented 63% of this habitat and vegetation cover was at 37%. H′ = 2.28 was the species diversity in *Acacia tortilis* bushland.

A total of 25 herbaceous species were identified in *Acacia mellifera* bushland. Twelve of them were grasses and 13 were dicot species. This habitat ground coverage was dominated by *Pennisetum stramineum* which was estimated at 14%, followed by *Pennisetum mezianum* at 5% and *Cyperus spp* 3% approximately. 39% of this habitat had the ground covered by herbaceous vegetation while 61% was bare ground. In this habitat a species diversity H′ = 2.68 was recorded.

In *Commiphora schimperi* bushland, 16 herbaceous species were identified with 11 being grass species and 5 dicot plants. *Pennisetum stramineum* with 14% had the highest percentage cover in this habitat, followed by *Melinis minutiflora* 12% and *Pennisetum mezianum* with 5%. A total area of 43% of this habitat was covered by herbaceous vegetation while 57% represented bare ground. H′ = 2.39 was the species diversity in *Commiphora schimperi* bushland.

The herbaceous layer had 16 species identified in farmland habitat, of which 10 were grass and 6 were dicot species. Herbaceous vegetation ground coverage in this habitat was dominated by *Pennisetum mezianum* at 8%, followed by *Melinis minutiflora* 6% and *Cynodon dactylon* at 5%. The herbaceous vegetation covered a total area of 47%, while 53% of this habitat was bare. This habitat had a species diversity of H′ = 2.61.

There was a significant difference between proportion of herbaceous vegetation cover and bare ground ($t_{2,382}$=-9.68, $p<0.05$). The mean proportion of bare ground (65%) was higher.

Herbaceous species diversity was highest in the *Acacia mellifera* bushland, while the lowest was recorded for *Acacia tortilis* bushland. Shannon-Waever t-tests revealed that significance difference in herbaceous species diversity existed between *L. europeaneum* grassland and *A. tortilis* bushland, *L. europeaneum* grassland and *A. mellifera* bushland, and *A. mellifera* bushland and *C. schimperi* bushland. The highest herbaceous species diversity was recorded in *A. mellifera* bushland while the lowest was estimated in *A. tortilis* bushland (Table 3).

Table 3: Difference in herbaceous species diversity among habitats in KWC

Habitats	Species Diversity (H')	B1	B2	B3	B4	B5
L. europeaneum Grassland (B1)	2.657		t_{154}=4.0624 P<0.05 *	t_{375}=-0.028 P>0.05	t_{83}=2.751 P<0.05*	t_{38}=1.724 P>0.05
A.tortilis Bushland (B2)	2.289			t_{182}=-3.807 P<0.05*	t_{108}=-0.3452 P>0.05	t_{50}=-0.875 P>0.05
A.Mellifera Bushland (B3)	2.682				t_{97}=2.626 P<0.05*	t_{43}=1.686 P>0.05
C. schimperi Bushland (B4)	2.394					t_{67}=-0.5077 P>0.05
Farmland (B5)	2.614					

(* shows significant results)

3.2.5. Standing crop biomass

The calibration equation generated by plotting disc grass height and quadrat biomass showed that ($y= 56.53+39.46x\pm138.44$ g/m^2), which was found to be statistically significant ($F_{1, 28}$=362 84, $p<0.05$, $r=0.96$). Figure 10 shows the calibration curve developed from the data obtained with the DPM and quadrat.

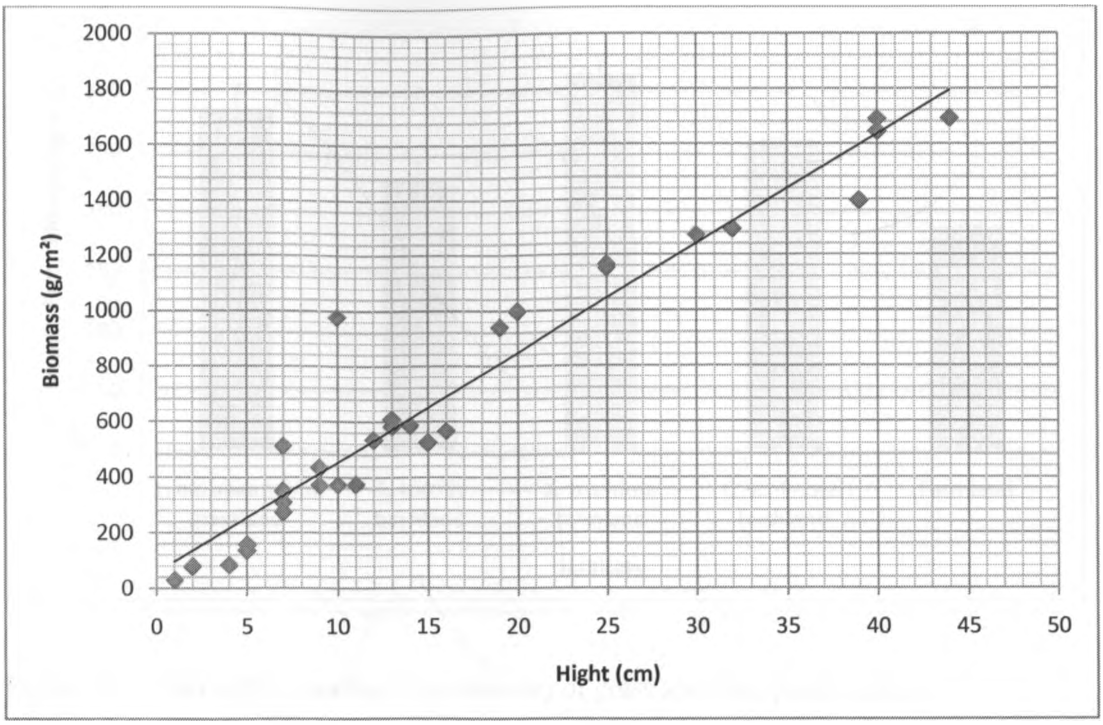

Figure 10: Calibration curve developed from the DPM and grass biomass in KWC

The mean standing crop biomass was estimated among habitats and the results are shown in Figure 11. There was a significant difference in mean standing crop biomass among habitats ($F_{4, 3771}$ = 3.51; $p<0.05$). The highest mean standing crop biomass (316±11.74g/m²) was estimated in *A. mellifera* busland while the lowest (187.54±11.19g/m²) was in farmland.

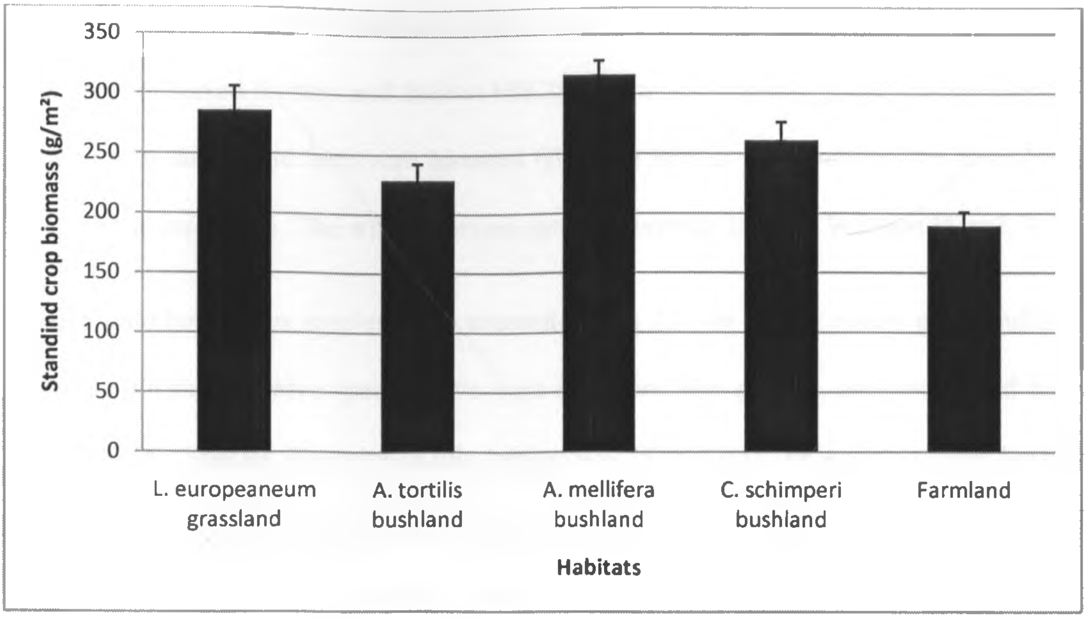

Figure 11: Mean (±SE) standing crop biomass of grass species in each habitat.

3.2.6. Difference in percentage cover among herbaceous vegetation categories

There was a significant difference in mean percentage cover among the four herbaceous vegetation categories (Decreaser, Increaser I, Increaser II, and Forb) ($F_{3, 524} = 29.015$, $p<0.05$). Increaser I with 19% had the highest mean cover and forbs with 7% the lowest.

3.3. Wildlife Composition and Distribution

Twenty two species of animals were sighted during this study. Four of them were livestock species, two carnivore species, and sixteen wild herbivores. The sixteen wild herbivores species were classified into feeding guilds (browser, grazer, and mixed feeder) for the purpose of analysis (Appendix 8). The mean herbivores density ranged between 9.37±2.71 animals/km² estimated for mixed feeders and 8.38±2.27 animals/km² estimated for browsers. No significant difference was found in mean wild herbivores population density ($F_{2, 40}$ =

0.047, $p>0.05$). The mean herbivore biomass varied between 6484.04±3546.34 kg/km^2 estimated for mixed feeders and 2665±1150.25 kg/km^2 for grazers. There was no significant difference in mean wild herbivore biomass ($F_{2, 40}$= 1.080, $p>0.05$) among the three feeding guilds in the study area. The wild herbivore species diversity in the KWC was H' = 2.307.

Twelve wild herbivores species were encountered in *Licium europeaneum* grassland during the study. Of these twelve species, five were browsers, five grazers, and two mixed feeders (Appendix 8). Species diversity in this habitat was H' = 1.965. In *Acacia tortilis* bushland, eleven wild herbivores species were counted, among which six were browsers, three grazers, and two mixed feeders (Appendix 8), with species diversity of H' = 1.87. Fourteen of the sixteen large wild herbivores species sighted in the study area were counted in *Acacia mellifera* bushland. Among these species, seven were browsers, three grazers and four mixed feeders (Appendix 8). In this habitat species diversity was H' = 2.2. Only four of the sixteen wild herbivores species in the study area were sighted in *Commiphora schimperi* bushland habitat. Two species were mixed feeders, browsers and grazers had one species each (Appendix 8). H' = 1.31 was the species diversity for *Commiphora schimpera* bushland.

No significant difference in wild herbivores mean population density and biomass among feeding guilds was found in these four habitats.

In the farmland only two wild herbivores species were sighted. Both species were mixed feeders (Appendix 8) and the species diversity was H' = 0.689.

There was no significant difference in mean densities and mean biomass of browsers, grazers and mixed feeders among habitats. The density of wildlife among habitats showed no significant difference ($F_{4, 38}$ = 1.841, $p>0.05$) and ranged between 19.23±4.43 animal/km^2 estimated in *C. shimperi* bushland and 4.58±0.42 animals/km^2 gotten in farmland. The mean biomass among habitats varied between 4658.76±26kg/km² for *L. europeaneum* grassland and 61.35±37.6kg/km² for farmland, and no difference existed ($F_{4, 38} = 0.216$, $p>0.05$) among the five habitats.

Species diversity indices showed a significant difference between all the habitats. The highest wild herbivore species diversity was realized in *Acacia mellifera* bushland, while the lowest was in farmland (Table 4)

Table 4: Differences in wild herbivores species diversity among habitats

Habitats	Species Diversity (H')	B1	B2	B3	B4	B5
L. europeaneum Grassland =(B1)	1.965		$t_{429}=2.1535$ P<0.05 *	$t_{1280}=-6.8641$ P<0.05*	$t_{99}=12.66$ P<0.05*	$t_{37}=30.299$ P<0.05*
A.tortilis Bushland =(B2)	1.869			$t_{594}=-6.5503$ P<0.05*	$t_{219}=8.3098$ P<0.05*	$t_{121}=19.837$ P<0.05*
A.Mellifera Bushland =(B3)	2.231				$t_{143}=15.964$ P<0.05*	$t_{64}=31.621$ P<0.05*
C. schimperi Bushland =(B4)	1.313					$t_{85}=10.17.$ P<0.05*
Farmland =(B5)	0.689					

(* shows significant results)

3.4. Livestock Composition and Distribution

Four species of livestock were counted in the study area, sheep (*Ovis aries*), goat (*Capra hircus*), cattle (*Bos indicus*), and donkey (*Equus asinus*). Donkeys were not included in the analysis because there were very few individual sighted during the counts. There was no livestock species sighted in *Commiphora schimperi* bushland therefore it was not included in the analysis. ANOVA test performed on livestock densities show that there was a significant difference in mean livestock densities ($F_{3, 57} = 3.973$, $p<0.05$) among four habitats. The highest livestock density 300.69±68.71animals/km² was that of *Acacia tortilis* bushland and farmland had the lowest 91.15±18.24 animals/km². A significant difference was found in mean livestock biomass among livestock types in the study area ($F_{2, 58} = 7.427$, $p<0.05$) and cattle with 37,383.36±10,919.89kg/km² had the highest biomass and goat with 4,579.05±1,208.13 kg/km² the lowest. No significant difference in mean livestock biomass was found among habitats ($F_{3, 57} = 1.684$, $p>0.05$). Livestock biomass ranged between 29,764.86±11,387.76 kg/km² estimated in *A. tortilis* bushland and 6,050.82±2,960.69 kg/km² estimated in *A. mellifera* bushland.

CHAPTER FOUR: DISCUSSION

4.1. Discussion

4.1.1. Land use and tenure changes

Among the Maasai in the KWC there is land use and cultural change from pastoralism to agropastoralism. Most respondents were practicing mixed farming as shown in figure 4, making cultivation a key livelihood strategy while livestock raising is becoming secondary. The desire for direct household benefits and alternatives to the unpredictable and declining pastoral lifestyle, the suitable soil and rainfall seem to encourage cultivation expansion in the corridor, hence leading to wildlife displacement as observed in the farmland. Given the fact that crop farming is considered more beneficial form of land use according to local community perception, more people are likely to engage in this activity thus causing its further expanding in KWC. The area designated as farmland in the study area is a key horticultural production area that supplies large cities like Arusha in Tanzania, Mombasa and Nairobi in Kenya. The availability of market for horticultural products is also a key driver that is likely to lead to more people switching from livestock keeping to crop farming. The expansion of cultivation and settlement in the corridor has led to the conversion of natural habitat into farms, reducing food availability for wildlife. Crop farming is not compatible with wildlife conservation. It is causing constriction of wildlife grazing range and dispersal area, and could result in retaliatory killing of wildlife by local farmers. Similar findings were also reported by Campbell *et al.* (2000) in Kajiado district and Okello and Kioko (2010).in Olgulului-Ololorashi group ranch.

Human-wildlife conflicts resulting from livestock depredation and crop raiding were the dominant conflicts mentioned by respondents in the corridor. Among respondents, elephants, lion and hyena were most frequently mentioned problem animals. Elephant was considered as the most destructive animal, this could be because of its large body size (between three to five tons) and they eat approximately 6% of their own weight per day (about 300 kg per day for male adults) (Estes, 1991 cited in Okello, 2005). Elephants are able to eat and destroy entire crops on many agricultural farms in a short period of time. Another reason probably making this animal to be very destructive is their nature of migrating or moving over large areas or home ranges. They easily make a stop in the farms to feed on crops on the way to or from KNP. Elephants and most of the crop raiders in the area are known to forage in farms at night making it difficult for the locals to protect their crops. These poor people are often subjected to more suffering when their only annual crop production or their livestock are destroyed or killed by wildlife, and the Kenyan government has no compensation program in response for these damages (KWS, 2008). KWS and others conservation NGOs in the Amboseli Ecosystem have developed a consolation scheme, thus a modest amount of money is being paid to livestock owners whose livestock is killed by predators or elephants. The local community feel that is not enough though; hence there is a high negative resentment for KWS and negative perception for wildlife in the area.

Another important threat to wildlife conservation in KWC is the land tenure change from communal to private ownership and the subdivision process. About 30.12% of the study area was under private ownership by the time of this study and the subdivision process is to continue. The parcels of land that have already been allocated to some group ranch members are located in the upper belt along the Kenya/Tanzania border as clearly shown in Figure 4. If settlement and cultivation expand to the whole area covered by these parcels of land as is likely to happen if nothing is done now, it will create a barrier between ANP and KNP. This will curtail wildlife dispersal and movement therefore reducing the viability of the corridor for wildlife and the ecological integrity of the two parks will be threatened. Western (1997) reported a similar trend in the area around Nairobi National Park.

Many researchers predict that subdivision will likely result in increased fencing, increased number of non-pastoral ethnic groups (whose activities are incompatible to wildlife conservation) purchasing land, reduced available pastoral land, and increased human population in the area (Rutten, 1992; Seno And Shaw, 2002; Ntiati, 2002) and all these are likely to happen soon in the Kitenden area.

4.1.2. Vegetation characterization

Woody plants sampling in KWC shows that habitats or vegetation communities can be characterized by the dominance or co-dominance of one or two of the woody species found in this area. The five vegetation types were dominated by *Licium europeaneum, Acacia tortilis, Acacia mellifera, Commiphora schimperi,* and *Acacia drepanolobium.* Woody vegetation density and species diversity varied significantly from one habitat to another (Figure 6 and table 2). This variation in woody vegetation could probably be explained by several factors like elephants, other wildlife and livestock browsing intensity and human impact on vegetation through their various activities. The vegetation could also be influenced by the variation in micro-climate and soil conditions along the altitudinal gradient as was also noted by Chira, (2005) in Mwea National Reserve.

The study found that the density of woody plants in the sapling class was low compared to other classes, meaning that recruitment to the upper classes was not adequate. High density of livestock over browsing in the area, trampling and uprooting on seedlings by elephants are the likely causes of the low recruitment observed. The unbalance between recruitment and the upper classes is likely to result in the conversion of KWC to grassland in the long run, and bushland or woodland dependent animal species are likely to become locally extinct. The woody species compositional difference between all the five habitats was not highly significant ranging between 42% and 30% (Figure 7), but compared two by two some pairs showed a low similarity (Appendix 9). These differences in similarity between pairs of habitat that were not adjacent could be explained by the difference in edaphic factors along the altitudinal gradient. For example, farmland and *Commiphora schimperi* bushland were located at higher altitude, moister area than *Licium europeaneum* grassland and *Acacia tortilis* bushland, showed a low similarity in species composition (Appendix 9).

The low woody species density and diversity realized in *Licium europeaneum* grassland could probably have been as a result of elephant impact on vegetation by breaking of plant parts during feeding, trampling on seedling, debarking, felling and uprooting mature trees, and human activity through firewood collection and cutting down trees for building material. These led to the natural vegetation being opened up and replaced from probably being a bushland to the actual grassland habitat. The loss of woody species seen in broader taxonomic terms has probably caused biodiversity loss in this habitat. That could be the reason why bushland species like gerenuk, dikdik and lesser kudu were not seen in the grassland. Similar situation was reported by Western and Maitimo (2004) in ANP. The results showed that grassland was also dominated by *Licium europeaneum* and *Maerua edulis* shrub that could have colonized this habitat as the initial tree cover was being removed. *Acacia tortilis* bushland and *Licium europeaneum* grassland had a high similarity index (41.37%) suggesting that the grassland was initially an *Acacia tortilis* bushland. This high similarity could also be due to similarity in soil condition and the progressive expansion of shrubs into *Acacia tortilis* bushland as trees were being knocked down by elephants or cut down by humans. The low recruitment in *Acacia tortilis* bushland raises the risk of disappearance of woody vegetation and conversion of this habitat to grassland.

The high similarity index between *Commiphora schimperi* bushland and farmland habitats could be suggesting that they were initially the same habitat before crop farming spread out to the actual farmland habitat. The low density and species diversity observed in farmland was probably due to the high human pressure through settlement and clearing of the natural vegetation for cultivation. The farmland and *Commiphora schimperi* bushland are located at high altitude where rainfall is important and suitable for rain fed agriculture. If the current trend in cultivation and settlement continues, *Commiphora schimperi* bushland is likely to be converted into farmland, further causing displacement of wildlife and biodiversity loss.

The KWC as a whole was dominated by grass species belonging to the increaser category. The increaser I category was composed of *Pennisetum stramineum* and *Pennisetum mezianum* grass species. These *Pennisetum* species had the highest frequency in all the five habitats. This could probably be due to their ability to withstand the different micro-climatic conditions such as soil moisture, soil texture and structure. According to Ibrahim and Kabuye (1987), these species grow well in deciduous Acacia/Commiphora bushland, often on black clays or volcanic soils, sometimes on rocky sites. These grass species are highly appreciated by grazers when young but have a low palatability when mature. This increaser species show high adaptation potential therefore could be indicating a deteriorating range dominated by low palatable species. Trollope and Trollope (1999) suspected that *Pennisetum* may have an allelopathic effect on surrounding plants, which could be the reason for its persistence in this rangeland.

Only one decreaser species (*Cenchrus ciliaris)* was found in the whole study area and at a low frequency and cover meaning that high palatable decreaser species are being replaced by the less palatable increaser species and forbs. This trend could be explained by the high population of livestock grazing in this area. Increaser and forbs species which could be seen as invasive species here, may be taking advantage of the disturbance to colonize this area. As this corridor is undergoing transformation, wildlife species utilizing this corridor may have to move elsewhere soon due to lack of good grass. Hobbs and Huenneke (1992) argued that disturbance is known to increase the invasibility of a community and can affect the community structure and functions. A similar trend was also reported by Njenga (2007) who found that highly palatable decreaser species were being replaced by increaser at Il N'gwesi community conservancy in Laikipia District. The invasion of the study area by increaser species was also confirmed by the high herbaceous species diversity in the study area, as is proven that disturbance increases species diversity and richness (Oba et al, 2001) by suppressing the dominance by a few species. The overall dominance of increaser grasses indicates that this area is in poor condition and need a better management to avoid a further degradation of the corridor that will reduce its importance for wildlife conservation.

Percentage cover of herbaceous vegetation in the five habitats was low as compared to bare ground, indicating that the study area is highly exposed to erosion. The high soil erosion potential could be caused by high grazing pressure and trampling by livestock and human activities like cutting grass for roofing of their manyattas. So soil fertility in the corridor is reducing setting the ground and condition for invasive species. Although the mean standing crops biomass in the study area was high, the grasses were of poor quality for grazer. The lowest mean standing crop biomass was realized in the farmland, which could be due to the high human population density cultivating and settled in this habitat coupled with impact of their livestock grazing.

4.1.3. Determination of wildlife and livestock distribution and composition

Twenty two mammal species were identified in the study area, which can be generally considered a high number when compared to the twenty six species reported by Okello (2005) in Maasai Kuku Group Ranch. This high species richness was probably as the result of the high habitat mosaic observed in KWC. The corridor was found to have a high woody and herbaceous species diversity which was probably the driver of animal species richness. Another factor that was in favour of high animal species richness was the fact that sampling was done during the rainy season when water and forage was readily available in the whole corridor.

There was no significant difference in large wild herbivores population density and biomass among habitats ($p>0.05$), hence the hypothesis that wild mammal population density and distribution vary significantly among habitat is not true. This result could be explained by the fact that sampling was done during rainy season when grasses and water were available in the whole corridor. Animals were probably moving out of ANP to KNP through the corridor. Species diversity realised in the corridor was relatively high ($H' = 2.307$), and could be as the result of the high habitat diversity that was able to attract animals of different feeding guilds.

The lowest wild herbivore population density and diversity was realized in the farmland. This could probably be due to the high concentration of human and their associated activities in this habitat. The low grass biomass recorded in this habitat could also have influenced the wild herbivores presence. Wild ungulates were not seen in the farmland, probably because they visited this area at night when they raided crops, and tend to avoid it during the day when there were much human movement. Over the three months during which sampling was done, only baboon and vervet monkey were seen in the farmland habitat. The presence of these two species in this area could be explained by their feeding habit. Both of them being mixed feeders and could be attracted to this area by human's food and crops grown in the farms. The study has shown that wildlife was displaced in the farmland due to human settlements and crop farming. Probably avoiding persecution by farmers if found in their farms. Okello (2009) reported similar factors to cause range contraction and wildlife displacement in Kimana Group Ranch near ANP.

Acacia mellifera bushland was the second habitat with high wild herbivore population density (Appendix 8) and had the highest species richness and diversity. The highest species diversity noticed in this habitat could probably be associated to high standing crop biomass and the high habitat diversity. Buffalos were sighted in large herds in this habitat, and their large number here could be due to the thickness of *Acacia mellifera* bushland during the period of the count. According to Kiringe (1990), buffaloes like to stay in thick bushes. The highest densities of gerenuk, lesser kudu and dik dik were realised in this habitat and could be associated with their browsing habitats.

Acacia tortilis bushland had the second lowest wild herbivore population density after farmland (Appendix 8), and had high species richness but low diversity, though the herbaceous species diversity and standing crop biomass were high. This could be due to high number of human settlement and very high density of livestock present in this habitat all competing with wildlife for the same resources.

Licium europeaneum grassland with the highest wild herbivore population density had a high richness and species diversity. This could be explained by the high herbaceous species diversity, standing crop biomass and the proximity to ANP. In ANP there are permanent swamps and minimum or no competition with livestock, therefore the density of wild herbivores in this grassland could be as result of the edge effect.

Livestock mean density recorded in KWC was high, ranging from 91.15±18 animals/km^2 in farmland to 300.69±68.71 animals/km^2 in *Acacia tortilis* bushland. Due to high intensity of grazing and trampling by livestock, the study area is highly exposed to erosion and invasion by herbaceous species of low palatability to grazers. This high density of livestock is also causing over browsing in the area leading to low recruitment of sapling to the upper canopies. The low recruitment is likely to cause a progressive conversion of the habitat to grassland. The over stocking is also cause of over grazing as indicated by the dominance of increaser species and forbs in the corridor. If this trend is not urgently controled the KWC will continue losing its herbaceous vegetation cover and become unimportant for wildlife, thus increasing the risk of human wildlife conflict because wildlife will move straight to the farms to feed on crops. This will probably lead to killing of wildlife by the local farmers to protect their crops.

4.2. Conclusions

This study was done with the aim of producing ecological information to improve the management of KWC as an important dispersal area and movement corridor for wildlife in the Amboseli Ecosystem.

The desire for direct household benefits and alternatives to the unpredictable and declining pastoral lifestyle seem to be encouraging cultivation expansion in the corridor hence leading to wildlife displacement as observed in the farmland. Crop farming and settlement are likely to expand westwards of the corridor in the area that is privately own by local community. Consequently this will curtail wildlife movement between ANP and KNP, increasing the risk of genetic invariability, species local extinction and human wildlife conflict, reducing the resilience of species to random events like climate change, and increase the pressure on ANP.

The farmland had the lowest wildlife density and species diversity this was due to high concentration of human activities (cultivation and settlement) and the low standing crop biomass. Wildlife distribution and composition were found to be influenced by the quality of the habitat in terms of food availability, habitat diversity, and human activities (settlement and cultivation) in the study area.

The Kitenden Wildlife Corridor as dispersal area and migration corridor is in poor condition with poor quality grass progressively colonising the area, degradation of soil fertility due to high erosion, extension of cultivation and settlement, reduction of woody vegetation cover through low recrutment. The ecological suitability of this corridor for wildlife is threatened and could soon become unimportant for wildlife dispersal and movement between ANP and Kilimanjaro National Park in Tanzania if management actions are not taken to reverse the current situation.

4.3. Recommendations

1. The KWC is a key wildlife movement corridor linking ANP in Kenya to KNP in Tanzania. It was found to be reducing in area due to the human population growth and the expansion of cultivation and settlement. To ensure the suitability of this corridor it is recommended that conservation organizations initiate a lease agreement or programme with the local community and landowners so that they may set aside part of their land for wildlife conservation. An agreement like this would help to control the spreading of settlement and farms westward into the corridor.

2. Consolation scheme and other conservation cost deflecting mechanisms to the local community currently being undertaken should be improved in the KWC and the Amboseli Ecosystem as a whole. People living in this area should be compensated not only for wildlife-related injury but also property damage, including livestock depredation and crop raiding so that they do not resort to retaliatory killing of wildlife. This will help to improve the negative attitude of the locals toward KWS and wildlife species.

3. Community wildlife conservation has the potential to bring tourism revenue to the people, so long as it is properly designed, supported by the community and economically viable. The local community should be empowered to participate in conservation through awareness and enactment of transparent benefits system for them to view wildlife as viable land use option.

4. Livestock number should be reduced to address the grazing pressure to avoid irreversible damage, and specific grazing areas should be delimitated and grazing time table developed to allow for regeneration of highly palatable species of grasses.

5. Highly palatable decreasers are almost disappearing in the KWC, calling therefore for re-seeding of the area with high quality grass species. The re-seeded area should be protected to allow successful re-establishment of grasses.

6. There is need to consistently monitor the trends in human population, agricultural development and human settlement clusters expansion so that appropriate actions are taken on time to limit impact of human in this corridor.

More studies should be carried out on:

- The seasonal distribution of wildlife in relation to vegetation and water availability in the KWC for enhanced wildlife management.
- Investigate the response of herbaceous species to different grazing intensity for the purpose of developing predictive models and enhancing suitable rangeland conservation.
- Determination of factors influencing recruitment of woody species in the KWC.
- Role of Elephants in vegetation dynamic and woody species recruitment rate in Kitenden Wildlife Corridor with special attention to *Acacia tortilis* bushland.
- Community involvement in conservation effort and benefit sharing to establish their appreciation about wildlife conservation and the likelihood of developing a community conservancy or conservation area within KWC.

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APPENDICES

Appendix 1: List of woody plants species encountered in the study area.

Scientific name	**Family**
Azima tetracantha Lam.	Salvadoraceae
Acacia brevispica Harms	Mimosaceae
Acacia drepanolobium Sjostedt	Mimosaceae
Acacia mellifera (Vahl) Benth	Mimosaceae
Acacia nilotica (L.) Del.	Mimosaceae
Acacia senegal (L.) Willd	Mimosaceae
Acacia seyal Del.	Mimosaceae
Acacia spp	Mimosaceae
Acacia tortilis (Forssk.) Hayne	Mimosaceae
Balanites aegyptica (L.) Del.	Balanitaceae
Balanites glabra Mildbr & Schltr	Balanitaceae
Combretum molle G. Don	Combretaceae
Commiphora madagascariensis Jacq.	Burseraceae
Commiphora rostrata Engl.var. rostrata	Burseraceae
Commiphora schimperi (O. Berg.) Engl.	Burseraceae
Commiphora spp	Burseraceae
Cordia monoica Roxb	Boraginaceae
Grewia bicolor Juss.	Tiliaceae
Grewia tembensis Fresen	Tiliaceae
Grewia villosa willd	Tiliaceae
Lannea rivae (Chiov.) Sacl.	Anacardiaceae
Lycium europeaneum L.	Solanaceae
Maerua edulis (Gild-Ben & Benedict) De Wolf	Capparaceae
Maytenus putterlickioides (Loes) Exell & Mendonça.	Celastraceae
Opilia campestris Engl. Var. campestris	Opiliaceae
Ozoroa insignis Del. ssp. Recuticulata (Bak. f) Gillett	Anacardiaceae
Rhus vulgaris Meikle	Anacardiaceae

Appendix 2: List of hebaceous plants species encountered in the study area

Scientific name	family
Achyranthes aspera L. Devil's Horse Whip	Amaranthaceae
Adenia volkensii Harms	Passifloraceae
Aristida kenyensis Henrald	Gramineae
Asystasia schimperi T. Andes	Acanthaceae
Barleria eranthemoides C.B. Cl.	Acanthaceae
Cenchrus ciliaris L.	Gramineae
Chroris roxburghiana Schult	Gramineae
Commelina africana L.	Commelinaceae
Commicarpus pedunculosus (A. Rich.) Cuf.	Nyctaginaceae
Crabbea velutina S. Morre	Acanthaceae
Cucumis dipsaceus Spach	Cucurbitaceae
Cyathula cylindrical Moq	Amaranthaceae
Cynodon dactylon (L). Pres.	Gramineae
Cyperus spp	Cyperaceae
Cypostemma serpens (Planch.) Alston	Vitaceae
Dactyloctenium aegyptium (L) Beauv.	Gramineae
Digiteria scalarum (Schweing)Chiov.	Gramineae
Dychoriste thunbergiflora (S. Moore) Lindau	Acanthaceae
Eragrostis cilianensis (All.) Link ex Lutali	Gramineae
Eragrostis tenuifolia (A.Rich.)Steud	Gramineae
Felicia muricata (Thunb.)Nees (Aster municatus Less.)	Compositae
Gynadropsis gynandra (L.) Briq.	Cappaidaceae
Harpachne shimperi A. Rich.	Gramineae
Heliotropium scottiae Renddle	Boraginaceae
Hibiscus micranthus L.	Malvaceae
Indigofera schimperi Jaub. & Spach	Papilionaceae
Ipomea obscura (L.) Ker-Gawl.	Convolvulaceae
Ipomoea kituiensis Vatke	Convolvulaceae
Melinis minutiflora Beauv	Gramineae
Ocimum americanum L.	Labiatea
Oxygonum sinuatum (Meisn.) Dammer	polygonaceae
Pachycymbium dummeri (N.E.Br.) M. Gilbert	Asclepiadaceae
Pennisetum mezianum Leeke	Gramineae
Pennisetum stramineum Peter	Gramineae
Pentanisia ouranogyne S. Moore	Rubiaceae
Portulaca oleracea L.	Portulacaceae

Appendix 2: List of hebaceous plants species encountered in the study area (Cont')

Seteria verticillata (L.) Beauv.	Gramineae
Solanum incanum Linn.	Solanaceae
Sonchus luxurians (R.E.Fries) C. Jeffry	Compositae
Sporobolus fimbriatus Nees	Gramineae
Sporobolus pyramidalis Beauv.	Gramineae
Tribulus terreetris L.	Zygophyllaceae
Vigna shimperi Bak.(inc. V. Fisheri of ed. 1)	Papilionaceae

Appendix 3: *Licium europeaneum* grassland species composition, relative (frequency, density in trees/ha, dominance) and important values. The species are arranged in alphabetical order.

Species	No. Ind	Rel. Den.	Density	Frequency	Rel. Freq.	Av. Dom	Dominance	Rel. Dom	IVI
A. mellifera	10	3.58	4.95	0.1	4.85	42.49	210.32	1.25	9.68
A. tetracantha	1	0.36	0.49	0.01	0.61	5.8	2.88	0.02	0.99
A. tortilis	31	11.11	15.35	0.25	12.12	315.69	4,845.84	28.88	52.11
B. Glabra	49	17.56	24.26	0.33	15.76	244.36	5,928.17	35.33	68.65
C. schimperi	1	0.36	0.497	0.01	0.61	36.32	18.05	0.11	1.08
Commiphora spp	2	0.72	0.99	0.025	1.212	25.52	25.26	0.15	2.08
L. europeaneum	105	37.63	51.99	0.62	30.3	33.78	1,756.22	10.46	78.39
M. edulis	67	24.01	33.17	0.59	28.48	91.06	3,020.46	17.99	70.48
O. Campestris	13	4.66	6.44	0.12	6.06	151.14	973.34	5.8	16.52
Total	279	100.00	138.14	2.06	100.00	946.16	16780.54	100.00	300.00

Appendix 4: *Acacia tortilis* bushland species composition, relative (frequency, density, dominance) and important values. The species are arranged in alphabetical order.

Species	No. Ind	Rel. Den	Density	Frequency	Rel. Freq.	Av. Dom	Dominance	Rel. Dom.	IVI
B. Aegyptica	3	2.63	5.26	0.03	1.31	18.87	99.26	0.26	4.20
A. mellifera	13	11.4	22.82	0.23	10.04	238.24	5,436.86	14.24	35.67
A. tortilis	37	32.46	64.98	0.70	30.57	348.80	22,665.02	59.37	122.40
B. glabra	5	4.38	8.77	0.10	4.37	451.43	3,958.04	10.37	19.11
G. Tembensis	2	1.75	3.5	0.03	1.31	26.50	92.75	0.24	3.30
L. europeaneum	34	29.82	59.7	0.60	26.20	28.91	1,725.93	4.52	60.54
M. edulis	13	11.4	22.82	0.37	16.16	43.23	986.51	2.58	30.15
O. campestris	7	6.14	12.29	0.23	10.04	261.01	3,207.81	8.40	24.57
Total	114	100.00	200.14	2.29	100.00	1416.99	38,172.18	100.00	300.00

Appendix 5: *Acacia mellifera* bushland species composition, relative (frequency, density, dominance) and important values. The species are arranged in alphabetical order.

Species	No. Ind.	Rel. Den.	Density	Frequency	Rel. Freq.	Av. Dom	Dominance	Rel. Dom	IVI
A. Brevispica	1	0.52	1.51	0.02	0.93	50.62	76.44	0.20	1.65
A. mellifera	78	40.41	117.62	0.62	28.97	223.21	26,253.80	69.19	138.57
A. Nilotica	6	3.11	9.05	0.12	5.61	95.27	862.19	2.27	10.98
A. senagal	6	3.11	9.05	0.08	3.74	12.19	110.32	0.29	7.14
A. tortilis	13	6.73	19.60	0.18	8.41	102.85	2,016.13	5.31	20.46
B. glabra	10	5.18	15.08	0.14	6.54	179.29	2,703.69	7.12	18.84
C. Madagascariensis	1	0.52	1.51	0.02	0.93	3.80	5.74	0.02	1.44
C. schimperi	38	19.69	57.30	0.38	17.76	43.90	2,515.47	6.63	44.07
C. Monoica	1	0.52	1.51	0.02	0.93	28.27	42.69	0.11	1.56
Commiphora spp	1	0.52	1.51	0.02	0.93	44.18	66.71	0.17	1.62
G. Bicolor	3	1.55	4.52	0.04	1.87	89.27	403.50	1.06	4.47
G. tembensis	3	1.55	4.52	0.06	2.80	13.09	59.17	0.15	4.50
G. Villosa	3	1.55	4.52	0.06	2.80	35.08	158.56	0.42	4.77
L. europeaneum	11	5.70	16.59	0.08	3.74	42.11	698.60	1.84	11.28
L. Rivae	3	1.55	4.52	0.04	1.87	73.80	333.58	0.88	4.29
M. edulis	8	4.14	12.06	0.14	6.54	56.82	685.25	1.80	12.48
O. Campestris	3	1.55	4.52	0.04	1.87	34.28	154.94	0.41	3.84
M. putterlickioides	4	2.07	6.03	0.08	3.74	132.54	799.22	2.11	7.92
Total	193	100.00	291.02	2.14	100.00	1260.57	37946	100.00	300.00

Appendix 6: *Commiphora schimperi* bushland species composition, relative (frequency, density, dominance) and important values. The species are arranged in alphabetical order.

Species	No. Ind.	Rel. Den.	Density	Frequency	Rel. Freq.	Av. Dom	Dominance	Rel. Dom.	IVI
A. Drepanolobium	13	16.25	109.99	0.45	18.00	35.30	3,882.65	4.36	38.61
A. nilotica	8	10.00	67.68	0.20	8.00	372.07	25,181.70	28.26	46.26
A. senegal	2	2.50	16.92	0.10	4.00	5.43	91.87	0.10	6.6
A. seyal	12	15.00	101.53	0.25	10.00	48.89	4,963.80	5.57	30.57
B. aegyptica	6	7.50	50.76	0.15	6.00	4.87	247.20	0.28	13.77
C. molle	3	3.75	25.38	0.15	6.00	225.37	5,719.89	6.42	16.17
C. Rostrata	6	7.50	50.76	0.25	10.00	24.38	1,237.53	1.39	18.9
C. Schimperi	18	22.50	152.29	0.55	22.00	159.76	24,329.85	27.31	71.82
L. Rivae	2	2.50	16.92	0.05	2.00	14.80	250.42	0.28	4.77
O. Insignis	1	1.25	8.46	0.05	2.00	1,385.44	11,720.82	13.16	16.41
R. vulgaris	8	10.00	67.68	0.25	10.00	168.51	11,404.76	12.80	32.79
M. putterlickioides	1	1.25	8.46	0.05	2.00	7.06	59.73	0.07	3.33
Total	80	100	676.83	2.50	100.00	2451.88	89,090.22	100.00	300.00

Appendix 7: Farmland species composition, relative (frequency, density, dominance) and important values. The species are arranged in alphabetical order.

Species	No ind.	Density	Rel. Den.	Frequency	Rel. Freq.	Total Area I	Dominance	Rel. Dom.	Ivi
A. drepanolobium	206	103	54.5	0.9	20.45	2505.35	$1.253x10^{-5}$	9.74	84.68
A. mellifera	1	0.5	0.26	0.1	2.27	7.07	$3.535x10^{-8}$	0.03	2.56
A. nilotica	45	22.5	11.9	0.7	15.91	3917.07	$1.959x10^{-5}$	15.22	43.03
A. seyal	53	26.5	14.02	0.4	9.09	2269.21	$1.135x10^{-5}$	8.82	31.93
C. molle	11	5.5	2.91	0.3	6.82	1690.39	$8.452x10^{-6}$	6.57	16.30
C. monoica	1	0.5	0.26	0.1	2.27	7.07	$3.535x10^{-8}$	0.03	2.56
C. schimperi	9	4.5	2.38	0.4	9.09	1736.7	$8.684x10^{-6}$	6.75	18.22
M. putterlickioides	3	1.5	0.79	0.2	4.55	29.8	$1.49x10^{-7}$	0.12	5.46
O. insignis	11	5.5	2.91	0.5	11.36	8997.65	$4.499x10^{-5}$	34.96	49.23
R. vulgaris	38	19	10.05	0.8	18.18	4574.86	$2.287x10^{-5}$	17.78	46.01
Total	378	189	100.00	4.4	100.00	25735.17	$1.287x10^{-3}$	100.00	300.00

Appendix 8: Feeding guilds, density (animals/km^2) and biomass (kg/km$^{2)}$ of each wildlife species in the five habitats

		B1	B1	B2	B2	B3	B3	B4	B4	B5	B5
Species	Feeding guild	Density	Biomass	Density	Biomass	Density	Biomass	Density	Biomass	Density	Biomass
Eland	B	7.57	4353.56	0.48	275.38	3.50	2010.18	0.00	0.00	0.00	0.00
Gerenuk	B	0.00	0.00	2.39	92.79	2.13	82.46	0.00	0.00	0.00	0.00
Grant's gazelle	B	38.88	2138.41	15.57	856.08	6.69	367.84	0.00	0.00	0.00	0.00
Dikdik	B	0.00	0.00	1.44	6.61	0.91	4.20	0.00	0.00	0.00	0.00
Lesser kudu	B	0.27	25.58	0.96	89.80	4.26	399.00	0.00	0.00	0.00	0.00
Giraffe	B	12.89	8379.72	22.27	14475.57	18.85	12251.10	11.75	7638.89	0.00	0.00
Ostrich	B	6.68	762.05	0.00	0.00	1.67	190.61	0.00	0.00	0.00	0.00
zebra	G	25.51	6919.83	9.10	2468.27	10.18	2762.39	17.09	4636.75	0.00	0.00
Buffalo	G	0.34	221.69	0.00	0.00	20.37	13239.09	0.00	0.00	0.00	0.00
Warthog	G	1.30	108.54	0.48	40.11	0.00	0.00	0.00	0.00	0.00	0.00
Wildebeest	G	5.46	1166.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thomson's gazelle	G	7.09	154.29	9.34	203.13	2.74	59.51	0.00	0.00	0.00	0.00
Elephant	M	8.87	31479.36	9.10	32303.64	3.19	11331.51	0.00	0.00	0.00	0.00
Impala	M	3.48	195.68	0.00	0.00	2.89	162.45	16.03	901.44	0.00	0.00
Baboon	M	0.00	0.00	0.00	0.00	22.04	523.45	32.05	761.22	4.17	98.96
Vervet monkey	M	0.00	0.00	1.44	6.82	4.26	20.22	0.00	0.00	5.00	23.75
Total		**118.35**	**55905.13**	**72.56**	**50818.21**	**103.66**	**43403.99**	**76.92**	**13938.30**	**9.17**	**122.71**
Mean		**9.86**	**4658.76**	**6.59**	**4619.84**	**7.40**	**3100.28**	**19.23**	**3484.57**	**4.58**	**61.35**
S.E		**3.30**	**2573.46**	**2.18**	**3052.95**	**1.99**	**1349.63**	**4.43**	**1650.13**	**0.42**	**37.60**
Bat-eared fox	C	0.20	0.77	0.96	3.59	0.00	0.00	0.00	0.00	0.00	0.00
Hyaena	C	0.48	36.77	0.00	0.00	1.52	117.04	0.00	0.00	0.00	0.00

B1- *Licium europeaneum* grassland **B2-** *Acacia tortilis* bushland **B3-** *Acacia mellifera* bushland

B4- *Commiphora schimperi* bushland **B5-** Farmland

Appendix 10: Questionnaire on respondent background, land use and tenure, and human wildlife conflicts in KWC

Date____________Recorder's name___________________ Location_________________

To assist us with classification of responses, kindly provide the following informations. Tick where applicable.

Respondent background and land use

1. Gender
   □ Male □ Female
2. Age bracket
   □ 25-44 □ 45-55 □ over 55
3. Main livelihood strategy
   □ Pastoralism □ Agropastoralism □ Cultivation
   □ Others _______________________
4. Do you own a piece of land within the KWC?

   □ Yes □ No

5. If yes how many acres?

   ____

6. Which crops do you grow?

   ____

7. Which livestock do you keep

   ____

8. Which activity do you think is more beneficial between the following?
   □ Pastoralism □ Cultivation

Human wildlife conflicts

1. Have you experienced any conflict with wildlife for the last one year?
   □ Yes □ No
2. What type of wildlife related problems have you experienced?
   □ Crops raiding □ Livestock depredation □ Human injury □ Human death
   □ Destruction of properties □ Disruption of social activities (eg: school going children, night patrol to reduce crops raiding and livestock depredation, …etc)
3. What are the main problem wildlife species from your experience?

   ____