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Study Abroad Research Context

My research focused on Kimana Group Ranch (KGR), an area 251.2 square kilometers in size that forms a major portion of the primary wildlife dispersal corridor between Amboseli National Park and Chyulu Hills/ Tsavo National Parks. Traditionally, humans and wildlife co-existed peacefully on this land, which occupied mainly by the Maasai ethnic group. The Maasai conventionally practiced nomadic pastoralism, a land use compatible with both the migrations of wildlife and the semi-arid environment of the Tsavo/Amboseli ecosystem. British colonialism, however, brought new emphasis on development of the rangelands and subsequent increase of infrastructure and sedentary lifestyles within KGR. Thus, my study sought to determine the current status of Kimana Group Ranch as an effective wildlife dispersal area and corridor by mapping the area occupied by infrastructure as well as wildlife distributions and displacement distances from human activities.

In preparation for my research, I spent eight weeks studying Kenyan wildlife ecology and management, as well as environmental policy and local cultures. Actually living in the community I was seeking to help was my motivation for success. Experiencing a land and culture unlike any available to me in the United States, the kind I'd only read about in National Geographic magazines as a little girl, challenged and changed me in a way I could never fully express with mere words.

The dramatic landscapes and warm people that comprise Kenya allowed me to experience a side of life that is unavailable to me at home. I was exposed to an outlook which is foundationally different than the rushed success-driven mentality with which I was accustomed. Living side-by-side with the community my research would affect gave me an understanding of the area's critical needs and concerns that cannot be taught. Thus, my research became valuable not only as an instrument of personal growth, but also as a medium through which I could give back to my host community. My research on wildlife dispersal areas and human-wildlife conflict were topics of concern in my community. As such, my results and recommendations, which were gathered through first hand experience and not theorized in a lab thousands of miles away, were appreciated because of their ability to help solve these challenges in a manner which was practical for the local community. Perhaps the best moment of my research was a final presentation to community elders, leaders, educators, and policy makers. I was able to see my hard work reach the community in a tangible way, and my results begin to have an immediate impact, something that is not always possible as a student in the United States.

Furthermore, international research gave me the opportunity to study wildlife, landscapes, and cultures which are only present in a few countries throughout the world, and to become intimately familiar with them through hands-on application. Overall, conducting research in an international setting strengthened my flexibility, ingenuity, dedication, and passion in ways not possible in the comfort and familiarity of home.

Wildlife Displacement and Dispersal Area Reduction by Human Activities within Kimana Group Ranch Corridor Near Amboseli, Kenya

Introduction

The Tsavo/Amboseli Ecosystem represents one of the major remaining wildlife conservation blocks in Kenya (Wishitemi and Okello 2003). This ecosystem consists of four protected areas which are safe havens for wildlife: Amboseli National Park, Kimana Wildlife Sanctuary, Tsavo West National Park, and Chyulu Hills. Many wildlife species migrate outside protected areas on a seasonal basis in search of new resources, breeding sites and birthing sites (Western 1982). In addition, most protected areas are too small on their own to provide all the resources needed to sustain a diversity and density of wildlife as large as that found within the Tsavo/Amboseli system (Newmark 1993). According to Seno and Shaw (2002), even Maasai Mara National Reserve (1520 km^2 compared to Amboseli's 392 km^2) is a small enough area that it cannot support all the wildlife in the region without wildlife dispersing into adjacent group ranch land.

As a result of the limited resources of protected areas and the migratory behavior of many species, most wildlife spends about 70 percent of the year outside of protected areas (Norton-Griffiths 1996). It is therefore necessary to focus conservation efforts not only within protected areas, but alsoon the group ranch lands surrounding them which are used by wildlife for dispersal and migration. In Kimana Group Ranch, the majority of people are members of the Maasai ethnic group; a people who traditionally lived as nomadic pastoralists but have gradually been shifting to a more sedentary way of life with the advent of agriculture (Norton-Griffiths 1996, Seno and Shaw 2002). Nomadic pastoralism is a land use which is traditionally compatible with wildlife conservation (Oba *et al.* 2000, Seno and Shaw 2002). Pastoralists and wildlife had co-existed for hundreds of years while managing to preserve biological and ecological biodiversity (Kimani and Pickard 1998, Campbell *et al.* 2000, Oba *et al.* 2000, Nicholson 2001, Berger 2003).

After Kenya gained its independence in 1963, however, the government developed policies which encouraged nomadic peoples such as the Maasai in the Amboseli-Chyulu-Tsavo areas to live more sedentary lifestyles because pastoralism was viewed as a primitive and non-lucrative land use (Berger 1993). In addition, pastoralism was blamed for rangeland resource depletion due to the erroneous assumptions of scholars such as Garrett Hardin, author of "The Tragedy of the Commons" (1968). Thus, the group ranch system was initiated in 1968. Under this land tenure structure, a large area containing all the resources necessary for the pastoral lifestyle was designated as group ranch land for the people living within that area. It was hoped that people would become more sedentary, restricted by the boundaries of the group ranch, and that they would develop the land through agriculture, contribution to the beef industry, and construction of towns and markets (Kimani and Pickard 1998; Seno and Shaw 2002).

While the group ranch system did not eliminate the pastoral way of life, it did result in a much more sedentary style of pastoralism. As Maasai become more settled, markets and other infrastructure such as roads and fences are constructed. As a result, even more people settle in the built-up areas of group ranches, thus perpetuating the cycle of development. Land which is used by wildlife, especially those areas with limited resources such as water, is quickly settled by humans (Mwale 2002). Thus, as land development increases, wildlife lose dispersal area and become compacted into small sections of land, most often national parks and other protected areas (Newmark 1996). These small areas often do not have enough resources to support high concentrations of wildlife and quickly become depleted and unavailable for future use (Mangat 1994, Newmark 1996).

As population numbers continue to increase, the Maasai are finding it difficult to support their families in the traditional pastoral way. It is becoming more and more necessary to extract maximum profits from each unit of land in order to meet the needs of the growing population (Norton-Griffiths 1996). Thus, costs incurred by co-existence with wildlife such as destruction of property, competition for water and food resources, and danger to the lives of humans and livestock which could be tolerated in the past are no longer bearable by the Maasai landowner (Norton-Griffiths 1996, Campbell *et al*. 2000). Hence, more and more people are turning to land uses such as agriculture which are more profitable and less compatible with wildlife conservation (Norton-Griffiths 1996, Kimani and Pickard 1998). Peaceful co-existence with wildlife is quickly becoming a memory of the past.

Further, in an effort to secure land rights and to ensure more effective land management, the majority of the group ranches have been undergoing the process of sub-division in which the communal ranch land is divided into individually-owned parcels of land (Norton-Griffiths 1996, Kimani and Pickard 1998, Campbell *et al*. 2000). Large areas of Kimana Group Ranch have already been privatized, which has allowed the owner of each parcel of land to develop it how he pleases. As a result of sub-division and in an effort to earn more money, many Maasai have begun to lease their land to immigrant farmers or to practice cultivation themselves (Kimani and Pickard 1998, Campbell *et al*. 2000, Mwale 2002, Seno and Shaw 2002). This amounts to land loss for wildlife which once migrated through the former rangelands. In addition, once land is sub-divided, many individuals may choose to fence in their land, fragmenting wildlife habitats and blocking traditional migratory routes (Kimani and Pickard 1998).

As land within Kimana Group Ranch (as well as the other group ranches comprising the wildlife corridor) becomes developed and settled, less area is available for wildlife to disperse and migrate in the Tsavo/Amboseli ecosystem. The destruction and fragmentation of wildlife habitat due to human activities such as cultivation is the largest threat to wildlife, causing a large number of local extinctions within protected areas (Newmark 1996, Fahrig 1997, Kimani and Pickard 1998, Mwale 2002, Seno and Shaw 2002). The protected areas of Amboseli National Park, Kimana Sanctuary, Tsavo West National Park, and Chyulu Hills are becoming increasingly isolated islands of conservation into which an overabundance of wildlife is compressed, decreasing the biodiversity and wildlife conservation potential of the system (Newmark 1996).

Historically, the highest species extinction rates have occurred on islands (Primack 2000). According to the theory of island biogeography, the survival of a species in an isolated habitat depends on the interaction of colonization and extinction (Newmark 1996). Protected areas are becoming increasingly insularized habitat "islands" as the land surrounding them is lost and fragmented due to human activities such as agricultural expansion, infrastructure development, increased numbers of livestock, and active elimination of wildlife from surrounding areas (Newmark 1996). Studies of large mammal extinctions in Tanzanian protected areas have shown that the more insularized a park is, and therefore the smaller the land area available to wildlife, the higher the rate of extinction (Newmark 1996). Therefore, it makes conservation management sense to create the largest possible area for wildlife to roam because it develops a mixture of niches that can be occupied, encouraging a healthy biodiversity. In other words, smaller conservation areas, such as Amboseli, need to be intensively managed and have connecting corridors, such as Kimana group ranch, in order to decrease faunal relaxation (Young and McClanahan 1996).

Areas of land which link protected areas, known as corridors, ease the threats to the biodiversity of an ecosystem by providing access to important migration routes and otherwise unavailable resources (Newmark 1996, Meffe and Carroll 1997). These resources include habitat space, food, predation cover and breeding sites (Heady and Heady 1982, Newmark 1993). Corridors prevent wildlife from being restricted to protected areas that are slowly becoming encroached and isolated. With the increase in human population and the ensuing encroachment, however, dispersal areas are slowly diminishing. Kimana Group Ranch (along with Kuku and Mbirikani Group Ranches) provides a very important dispersal area for wildlife migrating from Amboseli National Park (dry season) to Kimana Sanctuary and ultimately to the Tsavo National Parks/ Chyulu Hills area (wet season) (Wishitemi and Okello 2003). Potential threats which displace wildlife and lower the integrity of the Kimana corridor are infrastructure development and increasingly sedentary lifestyles; both of which occupy former wildlife habitat and utilize resources once used by wildlife (Mwale 2000, Okello and Kiringe 2004). Due to the importance of corridors, therefore, it is vital to assess the condition of Kimana Group Ranch as a wildlife corridor and to maintain it as an effective dispersal area for free-ranging wildlife in the Amboseli/Tsavo Ecosystem.

The presence of African elephants (*Loxodonta africana*) within wildlife dispersal areas is a valuable indicator of its status. This is because the elephant is a keystone species in African savannas, without which, the health of the rangeland and all those species dependent upon it would collapse (Western 1989). Elephants have been discovered to be vital in creating habitats which support a large diversity of both plant and animal species through their roles as important seed dispersal agents and as creators of grassland gaps in otherwise woodland habitats (Western 1989). Further, due to their size, elephants have a large demand for resources within any habitat which they traverse. Thus, if elephants are present in an appropriate number within a corridor, this can be used as an indication that the land which comprises the corridor has enough resources to be used by wildlife. On the other hand, the absence of elephants from a particular area may indicate that the land has a resource shortage, or that persecution of wildlife by humans has reached a high level.

It is pertinent, furthermore, to observe elephant distributions as a gauge of human-wildlife conflict because elephants are regarded in most developed areas as the number one problem animal (Thouless and Sakwa 1995, Hill 1998). This is because they often migrate through agricultural areas, raiding and trampling crops, destroying property, and sometimes even killing humans (Thouless and Sakwa 1995, Hill 1998). Thus, humans try to keep elephants out of the land surrounding settlements and may resort to measures such as shooting or poisoning problem elephants (Thouless and Sakwa1995, Mwale 2002). Finally, the world renowned status of the elephant as a flagship species makes the presence of elephants within a dispersal area important for wildlife conservation and tourism. When a community can benefit from wildlife by running a conservation area which generates tourism revenue, elephants are a welcomed commodity (Mangat 1994, Thouless and Sakwa 1995). Without elephants, not only will a corridor degrade ecologically, but it will lose the support of the community protecting it if tourism stops and their only source of benefit for conserving wildlife is eliminated.

Similar to the Kimana corridor, the Kuku Group Ranch corridor near Tsavo West National Park is an important dispersal area in the Tsavo/Amboseli ecosystem. Studies have been undertaken analyzing the Kuku corridor size and status, as well as its human activities and their resulting wildlife displacement (Berg 2003, Gooch 2004, and Hale 2004). The results of the studies showed that different human activities had different displacement impacts. The activities studied include agricultural, institutional, road, and livestock areas and their respective displacement impacts. The total actual area of Kuku Group Ranch taken by human structures and activities is 38.31 km^2 (4.00%) (Hale 2004). By combining areas of development into settlement clusters and including the distance that wildlife are displaced by human activities and structures, the total area becomes 234.20 km^2, 24.40% of the group ranch (Hale 2004). Therefore, 75.6% of Kuku Group Ranch is still available for use by wildlife (Hale 2004). The real threat, however, is the spatial location of settlement/agricultural clusters which were found to be expanding towards each other and threatening to isolate Kimana Wildlife Sanctuary from the Tsavo/Chyulu system (Hale 2004).

In conclusion, land use practices are becoming less compatible to wildlife conservation and the human population is rapidly growing and encroaching into the Tsavo/Amboseli dispersal region, as illustrated by the past studies. Thus the purpose of this study was to begin a larger analysis of the status of Kimana Group Ranch as a wildlife corridor.

The objectives of this study were:

1. To determine actual areas of human activities (roads, fences, institutions and markets) as well as their associated wildlife displacement area that contribute to the shrinking of the dispersal area between Amboseli National Park, Kimana Sanctuary, and Tsavo/Chyulu Hills;
2. To establish the locations and extent of roads, fences, institutions and markets, and to map them using GIS;

3. To understand the ability of livestock and wildlife to co-exist by determining displacement distances of wildlife from different species of livestock;

4. To establish wildlife distribution and habitat associations within Kimana Group Ranch, paying particular attention to the distribution of elephants, in order to understand displacement effects in relation to human establishments.

Methods and Materials

Study Area

The study focused on the 251.2 km^2 of Kimana Group Ranch, which, along with Kuku and Mbirikani Group Ranches, forms the main wildlife dispersal corridor between Amboseli National Park and Chyulu Hills/ Tsavo National Parks (Berger 1993, Irigia 1995). Kimana Group Ranch (KGR) is located within the Loitokitok Division of the Kajiado District of the Rift Valley Province. As the largest division, Loitokitok has a total area of 6,090 km^2 and forms part of Kenya's southern border with Tanzania (Berger 1993, GoK 1994). Composed primarily of gentle plains and the occasional volcanic hill, the Loitokitok division has quaternary volcanic soils which are washed down the eastern slopes of Mount Kilimanjaro (GoK 1994). Kimana Group Ranch, specifically, has mainly fine volcanic sandy clay and black cotton soils which are poorly drained and are therefore nutrient-rich (GoK 1994, Irigia 1995).

Despite the nutrient-rich soils, KGR is mostly unsuitable for agriculture because of its low mean rainfall of 210mm/year (Irigia 1995). Strongly influenced by both the InterTropical Convergence Zone and its proximity to Mt. Kilimanjaro, the bimodal rainfall pattern of Kimana Group Ranch is extremely variable and drought is common (GoK 1994, Irigia 1995, Gichohi *et al.* 1996, Kimani and Pickard 1998). KGR, as part of the Loitokitok Division, receives forty-five percent of its annual rainfall during the long rains (October-December) and thirty percent during the short rains (March-May) (GoK 1994, Irigia 1995). Classified in ecoclimatic Zone IV, KGR is a semi-arid and arid rangeland which has very little potential for agriculture (Gichohi *et al.* 1996). The major vegetation types are woodlands and wooded and open grasslands which are dominated by *Acacia* and *Commiphora* species (Stuart *et al.* 1990, Irigia 1995, Gichohi *et al.* 1996). The temperature within the Loitokitok division is just as variable as the rainfall, with the ability to reach up to thirty degrees centigrade and drop down to ten degrees centigrade (GoK 1994). The coolest period is between July and August while the hottest period occurs between November and April (GoK 1994).

Kimana Group Ranch is one of Kenya's richest wildlife areas as it is bordered immediately by Amboseli National Park to its west, contains Kimana Wildlife Sanctuary in its north-eastern corner, and is only one group ranch away from Chyulu Hills/Tsavo West National Park on its eastern boundary (Berger 1993, Irigia 1995). Specifically, Kimana Group Ranch provides immediate corridor from Amboseli National Park to Kimana Sanctuary. Particularly during the dry season, both Amboseli National Park and Kimana Sanctuary are important refuges for wildlife searching for water and food (Berger 1993, Irigia 1995). Due to its permanent water sources such as Kimana Swamp, and its numerous underground springs which constitute Kimana and Isinet Rivers, KGR hosts a variety of wildlife species which become especially abundant during the dry season (Irigia 1995). During the wet season, wildlife is still present in the group ranches as the abundance of resources allow wildlife to disperse outside of small protected areas (Berger 1993, Irigia 1995). As Kimana Group Ranch and the other parts of the dispersal area become more developed, however, the land becomes less effective as a wildlife corridor.

In 1999 the population of KGR was 12,988 individuals (Republic of Kenya 1999). The population growth rate of the Kajiado district was growing at an annual rate of 5.54% in 1989 (GoK 1994, Kimani and Pickard 1998). This high growth rate continues and is concentrated mainly around irrigated agricultural areas such as Kimana where large numbers of immigrant farmers move in to sharecrop mainly horticultural crops with Maasai landowners (Berger 1993, Fratkin 1997, Kimani and Pickard 1998). Historically, the area comprising KGR was the home of the Kisonko Maasai, nomadic pastoralists who co-existed with wildlife for at least four hundred years (Berger 1993). Currently, however, agriculture has become one of the main economic activities within the group ranches (Kimani and Pickard 1998). Cultivation, an unsustainable practice in the arid landscape, uses a large portion of the land once naturally used as a dispersal area for wildlife between Tsavo West and Amboseli. Additional displacement of wildlife occurs as the increasing natural population rate inspires the growth of urban centers that further augment the population through immigration. This amplifies already existing human-wildlife conflict as resources become more limited and thus wildlife must resort to utilization of cultivated land. In addition to decreasing the financial productivity of the land, such conflicts contribute to the ecological collapse of the dispersal area vital for resident wildlife (Berger 1993).

Data Collection

The fieldwork sought to establish the location and area of roads, markets, electric fences, institutions, Kimana Wildlife Sanctuary, wildlife and livestock. This data was compiled with information collected on the displacement distances of wildlife from each type of human activity in order to assess the overall condition of KGR as a wildlife dispersal area and corridor.

Roads

In order to locate roads and find their area, a *Garmin* Global Positioning System (GPS) *III* Plus device (Garmin Corporation 1999) was used to take a reading every one kilometer on straight segments of main roads and every half kilometer on straight segments of side roads. If the road curved at an angle greater than forty-five degrees, a GPS point was taken at the midpoint of each curve. If a road branched, the location of the divergence was noted and subsequently measured upon completion of the current road segment. Furthermore, the width of the road was estimated at every GPS stop to produce an average width of the road segment. Drainage ditches, adjacent foot paths and entire road reserve area was included in the estimated width of the road. Along the total length of every road, each person, bicycle, motorcycle, and vehicle (defined as cars, carts, trucks, and trailers) was counted once as a measure of how busy each road was.

Markets

In order to estimate the area of each market, the market center was determined by judging the highest density of buildings, particularly shops. At that point, a GPS reading was taken. The market radius was then determined by walking from the center point in eight straight transect lines in the four primary (N, S, E, W) and the four secondary compass directions (NW, NE, SE, SW). In each direction, a GPS point was taken on the far side of the last building in order to establish the market radius. If a market contained specifically designated areas for market days, GPS points were taken on the outer perimeter to determine the total area. In addition, any livestock within the market boundaries, including sheep/goats, donkeys and cattle, were counted. Further, each parked bicycle, motorcycle and vehicle (defined as cars, carts, trucks, and trailers) was also noted. These counts were used as indication of how busy a given market was. Finally, the total number and type of structures (stone, tin/timber and mud) were recorded as an indicator of the economic status and permanency of the market center. For analysis, stone structures were considered as permanent, tin/timber as semi-permanent and mud as temporary structures.

Electric Fences

The circumference of Kimana and Namelok electric fences were determined from driving or walking around the entire fence and taking GPS points. At all corners, GPS points were taken as well as at all openings, gates, and curved segments. For each gate or opening, an estimated width was recorded. In addition, GPS points were recorded at locations where the fence had been damaged either by missing poles and/or manipulated or cut wires. If other signs of weakened fence were present, such as segments of loose or twisted wires, it was recorded. At each GPS point, the number and condition of live versus barbed wire was noted. Furthermore, the solar power houses for each fence were mapped and recorded. The perimeter of the power house structure was determined by taking GPS points at the midpoint as well as the four corners in order to determine its total area. It was also noted whether the power house was in operation or if any of its property had been damaged, paying particular attention to the number and condition of the solar panels. Any sections of fence which were suspected to be live were recorded. Finally, all observations concerning the fence and the surrounding area were noted in field notebooks.

Institutions and Kimana Wildlife Sanctuary

All institutions within Kimana Group Ranch, including the conservation area of Kimana Wildlife Sanctuary, which were not included within the market areas were recorded and mapped. Institutions included commercial enterprises such as cultural centers and lodges as well as churches, schools, and government infrastructures (police station, health clinic and district office). First, a GPS reading was taken at the established center of each institution. If the area of the institution was large enough (defined as not being able to see the entirety of the area from the center point), GPS points were taken at the four corners of the institution's perimeter. The Kimana Sanctuary area was mapped using GPS points taken along its entire perimeter. For smaller institutions which could be visually assessed from the center point, an estimation of the area was made either by recording an estimated length and width or an estimated diameter. Areas outside the immediate institution that were part of the institution's land property, such as gardens and playgrounds, were included in the area calculations. For each institution, the number of structures was counted and each was classified according to its building material as stone (a permanent structure), wood/tin (semi-permanent), or mud (temporary).

Wildlife and Elephant Signs

Wildlife were recorded at every sighting throughout the study. In addition, three days at the end of the study were set aside purely to sight and record wildlife within Kimana Group Ranch, especially in areas which were not easily accessible by roads. Any mammal larger than or equal to the size of a Kirk's dik-dik (*Madoqua kirkii*) was recorded upon sighting. All primates were also recorded, regardless of size, because it is important to monitor them as primate numbers are globally declining in all their range. Field guides were used to assure proper identification of animals. The species and number of individuals were noted, as well as their location. A GPS point was then taken at the point where the wildlife was first sighted and recorded. In addition the time of observation, the distinction of being located inside or outside the nearest electric fence, and the habitat (dense woodland/shrubland, grassland, open woodland/shrubland, or riverine) were recorded. The distance of the wildlife from any human activity such as roads, electric fences, *bomas,* livestock, other structures, or people themselves was recorded with the assistance of a Laser Rangefinder (Bushnell Corporation 1999*)* when appropriate. Special attention was given to recording the presence of African elephants (*Loxodonta africana*) as a result of their status as a keystone, conservation flagship, and problem animal species. Thus, GPS points were taken at the location of any elephant sign (dung, tracks, vegetation damage) or live sighting. The age of each sign was categorized and noted as fresh, recent, old, or very old. In addition, the specific type of vegetation damage (such as debarking or uprooting) was recorded. Further, the road segment (when applicable) and habitat in which the elephant sign was found were recorded.

Livestock

Throughout the study, livestock when seen within Kimana Group Ranch were recorded. The main categories which livestock were classified into were sheep/goats (shoats), cattle, and donkeys. The number of individuals was recorded within each group and a GPS point was taken at the center of the occupied area. Furthermore, an estimation of the length and width of the total livestock area was recorded, as well as the distance of the livestock to any wildlife in sight. Other observations such as the time of observation, habitat type (dense woodland/shrubland, grassland, open woodland/shrubland, or riverine), the presence of herdsmen, and the distance of the livestock to any other infrastructure were also noted.

Data Analysis

All data was compiled for analysis into spreadsheets in Excel® 2002 for Windows (Microsoft Corporation, Troy, New York). For all calculations of statistical tests, SPSS® Program (Version 9.0 for Windows) was used. All GPS coordinates were entered into ARCView® software Version 3.3 (Environmental Systems Research Institute, Inc., 2000). Maps were created using Geographic Information Systems (GIS) to show spatial distribution of human activities, infrastructure areas, and group sizes of wildlife and livestock. GIS maps were also used to determine the length of roads as well as the perimeters and areas of markets, fences, institutions, Kimana Wildlife Sanctuary, and the entire group ranch.

In order to understand habitat associations, the mean group size of each species of wildlife observed and the three categories of livestock (shoats, cattle, and donkeys) were determined for each habitat type (dense woodland/shrubland; grassland; open woodland/shrubland; or riverine). In addition, the overall average group size regardless of habitat type was calculated. Chi Square Contingency Table tests (Zar 1999) were then used to determine whether there was a relationship between livestock or wildlife and their habitats. Using total numbers of individuals for each habitat, it was calculated whether there is a dependency between habitat and abundance of wildlife. A second similar test was run using total number of sightings for each habitat to determine whether there is a dependency between habitat and frequency of sightings (Zar 1999).

The distribution of wildlife in relation to electric fences was analyzed. For each wildlife species and then for the overall wildlife total, the number and proportion of individuals, and the number and proportion of sightings both within and outside of electric fences was determined. Two Chi Square Goodness of Fit tests were run to determine whether the abundance and sightings of wildlife inside versus outside the fence were the same. Wildlife distribution was further analyzed by determining mean distances of each species from human activities, categorized as: roads, electric fences, *bomas*, livestock, other structures and institutions, or people. Displacement distances were calculated from the average distance of wildlife sightings from each respective human activity. The total displacement area of each activity was then calculated by adding the displacement distance to each component of the area (usually length, width or diameter), in order to determine the actual area that wildlife is displaced by human activities. There was no sighting of wildlife within eyesight of any market, and thus this displacement distance is not calculated. Displacement from livestock was further investigated. Data was broken into three categories: shoat, cattle, and donkey, and the mean wildlife displacement distance (regardless of wildlife species) was calculated.

In order to determine the area of the road network within KGR, the roads were broken into four categories: Kimana Main Road, Amboseli Main Road, major roads (defined as the majority of the road being greater than three meters wide) and minor roads (the majority of the road having a width less than or equal to three meters). For each road category the actual area and area including wildlife displacement was calculated, as well as the proportions of the entire road network and of the group ranch. Using GIS maps, the perimeter, area, and proportion of KGR were also calculated for institutions, markets, and electric fences. The displacement distance for each structure was then incorporated and the proportion of KGR was determined once again. A portion of the Namelok Fence falls outside KGR, so the total perimeter and area, as well as the perimeter and area within KGR were calculated. In addition, the frequency and percentage of damage incidents (barbed wire, pole missing, live wire loose/ disconnected, live wire twisted/ rock, live wire cut) on each fence was calculated. For this data, the entirety of the Namelok Fence was considered, as damage to any part of the fence lowers the effectiveness of the entire fence. For each of the six markets, the composition of buildings (only stone and tin/wood were observed) was analyzed as an economic and permanency indicator. The number and percentage of both building types was calculated.

Results

The total area taken by all human structures (excluding Kimana Wildlife Sanctuary) analyzed in this study was 56.28 km^2 (22.4%) of the area of Kimana Group Ranch. When wildlife displacement area was added, the total area unavailable for wildlife use within KGR became 108.76 km^2 (43.3%) of the group ranch. Thus, about half of the area of KGR was not available for wildlife dispersal and migration.

The largest occupiers of space, electric fences enclosed a total area of 52.98 km^2 (21.09%) of KGR (table 2). Kimana Fence enclosed an area about four times larger (42.39 km^2, 16.88%) than Namelok Fence (10.59 km^2, 4.22%) and was approximately 2.2 times longer (table 2; figure 4). When the area wildlife were displaced from each fence was added, the total area occupied by electric fences became 69.29 km^2 (27.58%) of KGR (table 2). With displacement, Kimana Fence took up an area (53.07 km^2, 21.12% of KGR) slightly less than four times that of Namelok Fence (16.22 km^2, 6.46% of KGR). The location of the fences was such that the area they occupied inhibited wildlife access to Kimana Sanctuary (figures 1 and 3). The southern boundary of the sanctuary was blocked almost completely by Kimana Fence and about half of the western boundary was blocked by Namelok Fence (figures 1 and 3). Only about five kilometers remained open between the two fences for wildlife to use to enter the sanctuary (figures 1 and 3).

In an analysis of the status of the two electric fences, the combined damage on both Kimana and Namelok fences indicated that the most frequently occurring damage was damage to the barbed wire (37.64% of total damage incidences), followed by missing poles (22.51%), loose/disconnected live wires (16.97%), live wires which were twisted/ held down by rocks (16.24%), and finally cut live wires (6.64%) (table 7). In total, 91.88% of damage incidences occurred on Kimana Fence (table 7). For Kimana Fence specifically, the top three problems were damage to barbed wire (40.56% of damage incidences on Kimana fence), missing poles (24.50%), and loose/disconnected live wires (16.47%) (table 7). Missing poles and cut live wires, which were the most serious types of damage, were counted sixty-one and sixteen times, respectively, on Kimana Fence (table 7). Namelok Fence, however, had no instances of missing poles and only two instances of cut live wire (table 7). The top three problems for Namelok Fence were live wires which were twisted or had rocks placed on them (63.64% of damage incidences on Namelok fence), loose/disconnected live wires (22.73%), and cut live wires (9.09%) (table 7).

Roads occupied the second largest amount of space within Kimana Group Ranch. The total road network of KGR had a length of 213.23 km and took up a total area of 1.73 km^2 (0.69%) of the group ranch (table 4). The largest single road was Kimana Main Road (0.30 km^2, 0.12% of KGR) which comprised 17.54% of the road system (table 4). Amboseli Main Road (0.07% of the road network), had a total area of 0.18 km^2 and took up 0.07% of the group ranch (table 4). The area of all other major roads within KGR (0.94 km^2) comprised 54.19% of the road network and 0.37% of KGR while the area of minor roads (0.31 km^2) were 17.81% of the entire road system and 0.12% of the group ranch (table 4). Considering wildlife displacement area by roads, the road network had a total area of 37.90 km^2 (15.09%) of KGR (table 4). With displacement, Amboseli Main Road occupied the largest area (3.84 km^2, 10.14% of road network, and 1.53% of KGR) (table 4). Kimana Main road followed at 3.06 km^2, 8.08% of road network, and 1.22% of KGR (table 4). Spatially, the densest road cluster occurred within Kimana Fence near Kimana Town (figures 1 and 3). In addition, the Pipeline Road along the eastern boundary of KGR blocked access to Kimana Wildlife Sanctuary along its eastern boundary (figures 1 and 3).

The total area taken by institutions within Kimana Group Ranch (excluding the area of the Kimana Wildlife Sanctuary) was 0.99 km^2 (0.39%)

of the total KGR area (table 1). Kimana Wildlife Sanctuary (24.04 km^2) took up the largest area (9.57% of KGR) of all the institutions within the group ranch (table 1). The remaining institutions took up a very small proportion of KGR when analyzed individually, with primary and nursery schools (0.28 km^2; 0.11% of KGR) and churches (0.19 km^2; 0.08% of KGR) being the largest occupiers of area (table 1). Out of all the human structures analyzed, markets took up the smallest proportion of Kimana Group Ranch, occupying in total 0.58 km^2 (0.23%) (table 3). The two largest markets were Kimana (0.48 km^2, 0.19% of KGR) and Namelok (0.06 km^2, 0.02% of KGR) (table 3; figure 2). In comparing building composition of the six different market areas, Kimana market was shown to be the largest and most permanent with a total of 308 buildings, 18.83% of which were permanent (stone) and 81.17% of which were semi-permanent (timber/ tin) (table 9). Next in size was the Namelok market with 65 structures, 3.08% of which were permanent and 96.92% of which were semi-permanent (table 9). There were no temporary (mud) structures observed in any markets (table 9). The majority of all the institutions and markets analyzed fell inside Kimana and Namelok electric fences (figure 1).

Most wildlife sightings within Kimana Group Ranch occurred outside of the electric fences, with the largest clusters along the road to Amboseli and in between the two electric fences near the southwestern corner of Kimana Sanctuary (figure 6). These same two areas were found to be under current use by elephants (figure 7). Older signs of elephants, however, occurred over the majority of the area of the ranch (figure 8). The mean displacement distance of wildlife (regardless of species) from all human activities (regardless of type) was 0.14 ± 0.02 km (table 5). Of all seventeen species of wildlife seen, the Maasai giraffe (*Giraffa camelopardalis*) was the most displaced across all types of activities with a mean of 0.26 ± 0.09 km (table 5). Following were the African elephant (*Loxodonta africana*) with 0.24 ± 0.05km, Savanna baboon (*Papio cynocephalus*; 0.18 ± 0.05 km), Thomson's gazelle (*Gazella thomsonii*; 0.15 ± 0.03 km), and Grant's gazelle (*Gazella granti*; 0.14 ± 0.02 km) (table 5). Of all the types of human activity, electric fences caused the highest wildlife displacement with a mean of 0.44 ± 0.15 km (table 5). Institutions and other structures have the second greatest mean displacement (0.18 ± 0.06 km), followed by *bomas* (0.17 ± 0.02 km) and livestock (0.17 ± 0.03 km), people (0.10 ± 0.03 km), and finally roads (0.08 ± 0.007km) (table 5).

Overall, wildlife did not appear to be greatly displaced by livestock (figure 5). Shoats (sheep and goats together) displaced wildlife the most with a mean distance to wildlife of 0.17 ± 0.03 km (table 6). The data revealed that cattle follow closely with a mean displacement distance of 0.15 ± 0.00 km and that donkeys displaced wildlife the least (0.05 ± 0.03 km) (table 6).

Wildlife were more abundant both in numbers of individuals and sightings outside of electric fences versus inside (table 8a; figure 6). Outside of electric fences, 86% of total wildlife individuals and 91% of total wildlife sightings were observed for seventeen different species (table 8a). Inside electric fences, there occurred only 14% of total wildlife individuals and 9% of total wildlife sightings (table 8a). Just five species of wildlife were observed inside of electric fences: impala (*Aepyceros melampus*), Kirk's dik-dik (*Madoqua kirkii*), plains zebra (*Equus burchelli*), savanna baboon, and vervet monkey (*Cercopithecus aethiops*) (table 8a). All of those five species, however, were found more frequently (both in the number of individuals and the number of sightings) outside of electric fences (table 8a). The number of wildlife individuals (regardless of species) which were found outside electric fences was significantly more than the number of individuals found within [$\chi^2 = 662.22$; df = 1; $p < .001$],and the number of sightings as well [$\chi^2 = 829.14$; df = 1; $p < .001$] (table 8b).

The average wildlife group size was 5.15 ± 0.31 individuals, while the average livestock group size was 55.55 ± 11.93 individuals (table 10). The habitat that showed the largest wildlife group size was riverine (12.00 ± 2.52 individuals), followed by dense woodland/shrubland (5.90 ± 0.96), grassland (5.40 ± 1.78) and finally open woodland/shrubland (4.87 ± 0.32) (table 10). The habitat in which wildlife were most frequently sighted was open woodland/shrubland, followed by dense woodland/shrubland, grassland, and finally riverine (table 10). Species abundance was determined to be dependent on habitat type [$\chi^2 = 57.922$; df = 6; $p < .001$] while species sightings of wildlife was independent of habitat type [$\chi^2 = 7.488$; df = 6; $p = 0.278$]. Savanna baboons had the largest average group size, regardless of habitat (14.29 ± 2.53), followed by vervet monkeys (7.68 ± 1.26 individuals), plains zebra (6.79 ± 0.60), impala (6.32 ± 1.23), and Grant's gazelle (5.95 ± 0.87) (table 10). Livestock were sighted almost exclusively in open woodland/shrubland habitat with an average group size of 55.61 ± 12.22 individuals across all livestock categories (table 10).

Discussion

Despite having about half of Kimana Group Ranch unavailable as a dispersal area, wildlife are still abundant in a significant area of the group ranch. This indicates that although it is endangered, the Kimana wildlife corridor is a vital area for wildlife dispersal and migration. This is especially evident by the high concentration of wildlife sightings along migratory routes from Amboseli National

Park to Kimana Wildlife Sanctuary. In particular, elephants were sighted almost exclusively in the north-eastern corner of KGR near Kimana Sanctuary. Because of their role as a keystone species, the distribution of elephants in Kimana Group Ranch is an indicator of areas which are important wildlife habitats. Thus, despite increased development around Kimana Wildlife Sanctuary, it is shown to be an important refuge which needs to be protected from further encroachment.

Electric fences caused the highest wildlife displacement distance. This could perhaps be because wildlife have learned to associate the fence with areas of high human concentration, and thus with a less safe environment. In addition, areas inside and surrounding electric fences have a very strong indirect human presence in the form of smells and noises which wildlife probably avoid. Further, wildlife which had a negative experience when the fences were first built may avoid the fences because they associate them with electric shock. Even though the majority of both fences are currently not electrified, research with elephants has proven that the most crucial aspect of electric fences is the first impression that an elephant receives from them (Thouless and Sakwa 1995). If the fence is properly electrified upon first encounter, it will be a much more effective barrier for elephants and other wildlife regardless of the simplicity of its design (Thouless and Sakwa 1995). Thus, complicated fence designs are relatively useless without proper maintenance of electric current.

Hence, the dilapidated condition of KGR's electric fences is cause for concern. If the fences are out of commission for an extended period, elephants and other wildlife new to the area will challenge them and, finding them not electrified, will most likely continue to cross and damage the fences. Kimana Fence, in particular, is in deplorable condition. Despite being only slightly more than twice as long as Namelok Fence, Kimana Fence has more than two times the incidences of damage across all categories. For both fences, the chief problem is human manipulation of wires. This is most typically manifested in the form of cut or loose barbed wire, or live wires closer to the ground being twisted up into higher wires or held down on the ground with rocks. This type of manipulation was observed especially frequently near *bomas*, and is probably done in order to allow livestock, children, and vehicles to pass safely through the fence, as well as to use the wires for making tourist bangles. Although ideally no damage of any type should be found on electric fences in order to ensure the highest rate of effectiveness, this type of damage is easily and inexpensively corrected, and can often occur without disrupting the electricity of the fence. Further, only small wildlife species that are already able to enter the fences through cattle openings are allowed access through these types of damage sites.

The most critical types of damage to the integrity of the electric fences are non-functional powerhouses, missing poles, and cut live wires. Both Namelok and Kimana Fences have several instances of cut live wires; however, this is not a major problem overall as it occurs relatively infrequently. The larger problem is that both fences have a number of powerhouses with no solar panels, and therefore no power in large sections of fences. Further, Kimana Fence has missing poles as its second most frequently occurring damage type. This is a serious concern because not only is it expensive to repair, but also a missing or knocked over pole has the ability to destroy entire segments of fence by pulling down the wires to which it is connected, most likely breaking the electric current.

Despite all the damages which were encountered, this study found both Kimana and Namelok fences to be relatively effective at keeping out wildlife. In fact, there were no live sightings of elephants within either fence, no elephant signs in or near Namelok Fence, and very few elephant signs near the boundary of Kimana Fence. Further, there were significantly fewer wildlife sightings inside the electric fences than there were outside of the fences. Those species which were observed within the fence are all able to enter through cattle openings, regardless of the integrity of the fence as a whole. Further, two of the five species observed were primates (savanna baboon and vervet monkey) who are notorious raiders of crops and garbage associated with human settlements. Thus, Kimana and Namelok fences can currently be considered rather effective wildlife barriers as the access of wildlife inside the fences cannot be directly attributed to areas of fence damage. The future concern, however, is that as new individuals are born or migrate into the area, the fence will be challenged. If it is discovered to still be without electricity, it will probably cease to be an effective wildlife barrier.

The next largest displacers of wildlife, roads, have individually the smallest displacement distance of all the human activities studied. The massive length of the road network, however, creates the second largest area of displacement within KGR. Factoring in displacement area, the roads take up twenty-two times more space than their actual area. During this study, wildlife were often observed not too far from roads or even occasionally crossing roads. While a single road is not too much of a threat to wildlife, it is the dense network of roads which continuously grow around markets that causes problems. Each additional road, no matter how small, brings with it the vehicle, human, and livestock traffic which displaces wildlife. As more roads are formed and begin to cut throughout a habitat, the habitat becomes fragmented and there is not enough space for wildlife to move without encountering humans. Thus, wildlife avoid areas with numerous roads. Further, areas with a dense road network are often prime wildlife habitats because humans usually settle on land with the best natural resources. This becomes a serious threat to the survival of wildlife species when they must abandon prime water, grazing, and shelter resources. As roads continue to expand in KGR, a vital wildlife resource area, there is the threat that its function as a corridor will be fragmented by roads.

Markets in and of themselves take up the smallest proportion of KGR, and the largest two are confined within electric fences. The study was unable to determine specific wildlife displacement distances; however, because most markets are located within electric fences any displacement distance would be confounded by the presence of the fence. As a result, the biggest threat posed by markets to wildlife is not the market structures themselves, but the ever increasing population, infrastructure development, and environmental degradation associated with them. This study found that the two largest markets in KGR, Kimana and Namelok, were both comprised of entirely permanent and semi-permanent buildings. Thus, it can be inferred that the markets are economically important centers which are permanent and, if anything, are continuing to expand. In Kimana market, in fact, there were several observations of buildings under construction. As the markets grow, so do the number of institutions and roads surrounding them. More habitat is then lost and fragmented, unavailable for use by wildlife. The biggest threat of expanding markets occurs when the displacement area of settlements that are scattered throughout a dispersal area begin to overlap, effectively choking out valuable stretches of corridor through which wildlife can no longer migrate. This has already been observed within the Tsavo/Amboseli ecosystem in the Ilchalai and Olorika clusters of Kuku Group Ranch (Hale 2004).

In relation to livestock, wildlife did not appear on GIS maps to be too displaced, but rather appeared to be co-existing. Ecologically, one would expect to see some displacement of wildlife due to livestock because they compete for food and water resources on the rangeland. Further, livestock cause a large amount of vegetation damage through trampling and overgrazing. This soil and vegetation destruction reduces the amount of resources available for wildlife and can even fragment habitats if the rangeland has been so severely overused that it has undergone desertification. It is crucial for the future of wildlife conservation that livestock be kept mobile in order to prevent the rangeland destruction which accompanies sedentary livestock grazing (David Western, personal communication).

In KGR, a small wildlife displacement distance was caused by livestock. The data indicate that shoats caused the greatest displacement distance, followed by cattle, and then donkeys. Shoats, which are very efficient feeders and feed on a wide variety of plants, can out-compete both browsing and grazing wildlife species. Thus, it is expected that they would cause the largest area of displacement. Further, shoats are probably more of a disturbance to wildlife due to the loud noise from the bells often found around their necks, as well as the bleating noises they make when feeding, together with their disruptive climbing of shrubs. Shoats were found the largest average group size, and they displace wildlife from a larger area than a few cattle or donkeys. Cattle, which had the next largest displacement distance, are bulky, slightly selective feeders that can generally be found co-grazing with wildlife. Cattle are less competitive and appear in smaller herd sizes, and thus less displacement of wildlife is observed. The least competitive livestock species is the non-selective, bulky feeding donkey, which, as expected, caused the least amount of wildlife displacement.

Findings established that species abundance was dependent on habitat, but that the number of wildlife sightings was not. Because each habitat type offers resources specific to different species, it makes sense that certain species, and thus certain group sizes, are found in different habitats. Further, the more vegetation cover and resource availability offered by a habitat, the more individuals will be present. The number of sightings, however, is not dependent on habitat type, because the ability to see wildlife is relatively equal in all habitats due to technology such as binoculars. Most wildlife sightings occurred in dense woodland/shrubland, followed by open woodland/shrubland. Because the dominant habitats in KGR are these same two habitats, it would be expected that more sightings would occur in them. Further, there was a greater sampling effort in the open habitat as wildlife viewing was easier, and relatively little sampling in riverine habitats which are typically fenced in. The greatest diversity of wildlife species occurred in the open habitat, presumably because it can support the greatest variety of feeders: browsers, grazers, and mixed feeders. The riverine habitat is where the largest mean group size was observed. This is explained by the fact that the only species seen in riverine habitats were primates, which occur naturally in very large group sizes (Estes 1997). The fact that there were primates, specifically Sykes monkey, observed inside the electric fences illustrates how critical riverine habitats and their associated fruiting trees are to the survival of many wildlife species.

The most critical aspects of fragmentation in KGR were fence and road encroachment, which are cutting off wildlife access into Kimana Wildlife Sanctuary. The western boundary of the sanctuary is bordered by the Namelok electric fence, which blocks the most direct migration route from Amboseli. All access from the south is cut off by the Kimana electric fence. The eastern boundary of the sanctuary is disrupted by the major Pipeline Road which runs parallel to the entire length of the sanctuary boundary. In the remaining small south west corner near Kimana Sanctuary, which is open for migration and dispersal from Amboseli, there are three major roads fragmenting the habitat. And yet, despite all the lost and fragmented habitat, it appears from GIS imaging that many wildlife are still choosing to disperse along the Amboseli Main Road and up into the south-west corner of the sanctuary. However, there has also been increased movement of wildlife outside of KGR: to the north through Mbirikani Group Ranch to Chyulu Hills, or south towards the base of Mt. Kilimanjaro (Okello, personal communication). Evaluation of *bomas* and agriculture size and location in KGR will reveal the full insularization of Kimana Wildlife Sanctuary from wildlife dispersing from Amboseli.

The ability of KGR to serve as an effective wildlife dispersal area and corridor in the Tsavo/Amboseli ecosystem is severely limited by its continually reduced amount of open land. Based on this study, only about half of Kimana Group Ranch is available for wildlife utilization. This data is incomplete, however, as two main human activities, agriculture and *bomas*, have not yet been considered. Past studies of Kuku Group Ranch within the same greater wildlife corridor found that agriculture took up the greatest land area and displaced wildlife the most (Hale, 2004). It is essential, therefore, to determine the area of Kimana Group Ranch under cultivation and the displacement it causes in order to find out how much of the group ranch is still actually available for wildlife dispersal. An additional concern for KGR is that land which still is available for wildlife is relatively resource poor, as prime habitats including water points have mostly been occupied and fenced in by humans.

Kimana Group Ranch must be preserved as a wildlife dispersal area and migration corridor as it is has a critical role in protecting biodiversity in the Tsavo/Amboseli ecosystem by serving as a link between and buffer zone around protected areas (David Western, personal communication). In order to be an effective corridor, there are many factors which must be considered in Kimana Group Ranch. Successful corridors must be wide enough to prevent adverse edge effects, as well as have all the resources which are needed for all its species (Newmark 1993). In addition, it must not be too long, or if it is long, it must have a series of mini-reserves along the way in which wildlife can rest in safety (Newmark 1993). KGR is an excellent corridor linking Amboseli, Kimana Sanctuary, and Chyulu/Tsavo West systems because it is located in an area already used by wildlife and thus must have at one time contained all of the resources and land area required. Further, Kimana Sanctuary acts as a mini-reserve on the long route to Tsavo National Park and Chyulu Hills, and therefore increases the probability of an individual successfully traversing the corridor (Newmark 1993). The integrity of Kimana

Group Ranch as a wildlife dispersal area and corridor has and will continue to decrease, however, as the resources and space available to wildlife disappear with land development and the ensuing habitat loss and fragmentation.

Recommendations

Management

Based on the data which was collected and analyzed, the following management recommendations are made to ensure the survival of Kimana Group Ranch as a viable wildlife corridor and dispersal area:

1. Education must be provided to group ranch members regarding the importance of KGR as a wildlife dispersal area, with emphasis given to maintaining Kimana Sanctuary as a profitable enterprise that provides economic benefits to the people of KGR.

2. Further development and infrastructure construction needs to be kept out of the north eastern corner of KGR, as access to the sanctuary is already almost completely fragmented and blocked. If possible, development must be contained in already existing electric fences to avoid further fragmentation of KGR.

3. Riverine habitats and open habitats need to be preserved especially well because they support the highest diversity and abundance of wildlife. Therefore, agriculture diversion of water should be stopped, minimized, or regulated.

4. Electric fencing needs to be repaired and maintained with particular emphasis put into upholding the electric current. A community financed operator should be put into place at each powerhouse to guard and maintain solar panels. Further, people who live near the fence must be educated as to the greater costs incurred by cutting fence wires and causing other damages, which outweigh the benefits of a shorter path into their *bomas*.

5. In order to preserve the environmental resources upon which humans, wildlife, and livestock depend, efforts should be made throughout the process of sub-division to keep livestock mobile and to keep land open. Alternative land tenure which is compatible with sub-division, such as communal use of private plots, should be encouraged.

6. The road network should be composed of a few well defined and maintained roads rather than an exhaustive web of small back-roads which cause a great amount of degradation and wildlife displacement in KGR.

7. Areas which grant wildlife access to Kimana Wildlife Sanctuary from Amboseli and Chyulu/Tsavo should be established and kept clear so that this sanctuary which brings so much income to KGR can be kept viable.

Research

It is vital to continue to assess the precise status of KGR as a wildlife dispersal area and migratory corridor. There were several limitations to this research which should be corrected in future studies. For one, the study was conducted in only one season, the beginning of the long rains. Most wildlife sampling efforts occurred at the same time of the day, early morning, and were concentrated outside of the electric fences. Some efforts to document wildlife in more remote areas of the group ranch were inhibited by poor road access due to rainy and muddy conditions. Further, not enough sampling of livestock, especially in relation to distance from wildlife, occurred. In mapping the electric fences, the precise areas of damages were not collected, and there were no accurate measures of whether the fence was live or not. Finally, there was not enough time in the study to map and determine the areas of many important human activities and natural resource points. Thus, the following research recommendations are made:

1. Future studies should occur at different seasons of the year to analyze whether there are any changes in wildlife distribution or the effectiveness of KGR as a corridor.

2. Wildlife viewing should be carried out at more varied times of day, particularly at night, and in areas which are further off road in order to document the presence of carnivorous and skittish species.

3. Increased sampling of wildlife should occur within electric fences in order to gain a more accurate picture of their effectiveness.

4. Livestock sampling should also be increased, with specific attention paid to the distance from wildlife, as well as the species and group sizes of both the livestock and wildlife.

5. The electric fences should be re-analyzed in order to determine actual proportions of fence damage and their effectiveness at withstanding wildlife challenges. Each pole, whether missing or present, should be counted. At each damage point, the exact area or length of damage should be recorded. A notation should be made as to whether the damage appears to be due to human manipulation, wildlife destruction, or natural degradation. Distances of damage to any *bomas* should also be noted. Voltage should be measured and recorded along each fence segment. Finally, any wildlife tracks near the fences should be analyzed to determine which wildlife species, and about how many individuals of each, are effectively crossing through the fences.

6. Roads should be quantified according to the amount of activity observed on them (number of vehicles, people, and livestock) and this should be factored into the analysis of road displacement distances.

7. Future studies of KGR should map the areas of agriculture, *bomas*, and water points to determine how they affect wildlife distribution and to gain a more accurate picture of the amount and quality of land within KGR still available for wildlife use.

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Table 1: Perimeters and areas of institutions and wildlife sanctuary within Kimana Group Ranch

Institution	Perimeter (km)	Area of KGR actually taken (km^2)	Proportion (%) of total KGR area
Amboseli Sopa Lodge	3.02	0.11	0.04
SFS Center for Wildlife Management Studies	1.52	0.14	0.06
Kimana Secondary School	1.67	0.14	0.06
Commercial Cultural Manyatta Near Amboseli	0.50	0.02	0.008
Churches	6.21	0.19	0.08
Schools	4.28	0.28	0.11
Government offices	2.08	0.12	0.05
Other Institutions	0.37	0.002	0.0006
TOTAL	**19.94**	**0.99**	**0.39**
Kimana Wildlife Sanctuary	21.86	24.04	9.57

Table 2: Perimeters and areas of electric fences within Kimana Group Ranch

	Perimeter (km)	Area (km^2)	Percentage (%) of KGR	Displacement area (km^2)	Displacement Percentage (%)
Kimana	34.51	42.39	16.88	53.07	21.12
Namelok	16.35*	10.59*	4.22	16.22	6.46
Total	**50.86**	**52.98**	**21.09**	**69.29**	**27.58**

*Area and perimeter inside Kimana Group Ranch. Total area is 18.11 km^2 and total perimeter is 21.15 km.

Table 3: Perimeters and areas of markets within Kimana Group Ranch

Market Name	**Perimeter (km)**	**Area (km^2)**	**Percent (%) of KGR**
Kimana	3.50	0.48	0.19
Namelok	1.05	0.06	0.02
Mbironi	0.72	0.01	0.00
Small Markets	1.74	0.04	0.01
Total	**7.01**	**0.58**	**0.23**

Table 4: Area of roads including wildlife displacement effect in Kimana Group Ranch

	Total Length (km)	Average Width (km)	Total Area (km^2)	Percentage (%) of Road System	Percentage (%) of Group Ranch	Road Area and Displacement (km^2)	Percentage (%) of Road System with Displacement	Percentage (%) of Group Ranch with Displacement
Kimana Main Road	16.28	0.019	0.30	17.54	0.12	3.06	8.08	1.22
Amboseli Main Road	21.60	0.008	0.18	10.46	0.07	3.84	10.14	1.53
Major Roads	113.58	0.008	0.94	54.19	0.37	20.20	53.30	8.04
Minor Roads	61.80	0.005	0.31	17.81	0.12	10.79	28.47	4.30
Total	**213.26**		**1.73**		**0.69**	**37.90**		**15.09**

Table 5: Average distance (km) of wildlife displacement from human and livestock presence in Kimana Group Ranch

Wildlife Species	**Roads**	**Electric Fences**	**Bomas**	**Livestock**	**Institutions and Other Structures**	**People**	**Mean Displacement of Species**
African Elephant (*Loxodonta africana*)	0.19 ± 0.05	0.40 ± 0.06	0.09 ± 0.03	0.40*	0.075*	-	**0.24 ± 0.05**
Bat-eared Fox (*Otocyon megalotis*)	0.08*	-	-	-	-	-	**0.08***
Black-backed Jackal (*Canis mesomelas*)	-	-	-	-	-	-	**-**
Common Duiker (*Sylvicapra grimmia*)	0.004*	-	-	-	-	-	**0.004***
Common Eland (*Tragelaphus oryx*)	0.04 ± 0.02	0.01*	0.01*	-	0.20*	-	**0.05 ± 0.02**
Gerenuk (*Litocranius walleri*)	-	-	-	-	-	-	**-**
Grant's Gazelle (*Gazella granti*)	0.11 ± 0.02	0.24 ± 0.16	0.25*	0.14 ± 0.04	0.20*	0.17 ± 0.07	**0.14 ± 0.02**
Impala (*Aepyceros melampus*)	0.07 ± 0.01	0.40*	0.28 ± 0.11	0.10*	0.002 ± 0.25	0.10*	**0.13 ± 0.03**
Kirk's Dik-dik (*Madoqua kirkii*)	0.03 ± 0.01	0.13 ± 0.09	0.42 ± 0.09	0.45 ± 0.18	0.41 ± 0.20	-	**0.09 ± 0.03**
Lesser Kudu (*Tragelaphus imberbis*)	-	-	-	-	-	-	**-**
Maasai Giraffe (*Giraffa camelopardalis*)	0.13 ± 0.03	1.80 ± 0.70	0.17 ± 0.14	0.14 ± 0.07	-	0.25*	**0.26 ± 0.09**
Plains Zebra (*Equus burchelli*)	0.02 ± 0.01	0.05 ± 0.05	0.01*	0.005*	0.008 ± 0.003	0.01 ± 0.008	**0.02 ± 0.01**
Savanna Baboon *(Papio cynocephalus)*	0.11 ± 0.02	0.73 ± 0.59	0.23 ± 0.05	0.16 ± 0.02	-	0.15 ± 0.03	**0.18 ± 0.05**
Sykes Monkey *(Cercopithecus mitis)*	0.03*	-	-	0.005*	-	0.005*	**0.01 ± 0.01**
Thomson's Gazelle (*Gazella thomsonii*)	0.09 ± 0.02	0.17 ± 0.16	0.17 ± 0.03	0.32 ± 0.02	-	0.42 ± 0.08	**0.15 ± 0.03**
Vervet Monkey (*Cercopithecus aethiops*)	0.04 ± 0.02	0.025*	0.14 ± 0.03	0.18 ± 0.09	0.30 ± 0.20	0.07 ± 0.04	**0.10 ± 0.02**
Waterbuck (*Kobus ellipsiprymnus*)	-	-	-	-	-	-	**-**
Total Wildlife Displacement	**0.08 ± 0.007**	**0.44 ± 0.15**	**0.17 ± 0.02**	**0.17 ± 0.03**	**0.18 ± 0.06**	**0.10 ± 0.03**	**0.14 ± 0.02**

*Indicates that there is only one sample for that category

Table 6: Wildlife displacement by livestock within Kimana Group Ranch

Livestock Type	Mean Distance to Wildlife (km)
Shoat	0.17±0.03
Cattle	0.15±0.00
Donkey	0.05±0.03

Table 7: Types and frequency of damage inflicted upon the European Union electric fences in Kimana Group Ranch

Kimana Electric Fence		
Damage Type	Frequency of Damage	Percentage (%) of Incidence
Barbed wire	101	40.56
Poles missing	61	24.50
Live wire loose/disconnected	41	16.47
Live wire twisted/rock	30	12.05
Live wire cut	16	6.43
Total Damage	**249**	
Namelok Electric Fence		
Damage Type	Frequency of Damage	Percentage (%) of Incidence
Live wire twisted/ rock	14	63.64
Live loose/disconnected	5	22.73
Live wire cut	2	9.09
Barbed wire	1	4.55
Poles missing	0	0
Total Damage	**22**	
Combined Electric Fence Data		
Damage Type	Frequency of Damage	Percentage (%) of Incidence
Barbed wire	102	37.64
Poles missing	61	22.51
Live loose/disconnected	46	16.97
Live wire twisted/ rock	44	16.24
Live wire cut	18	6.64
Grand Total of Damage	**271**	
Incidences on Kimana Fence	249	91.88
Incidences on Namelok Fence	22	8.12

Table 8a: Comparison of wildlife presence inside and outside electric fences in Kimana Group Ranch

	Inside		**Outside**	
Species	**Individuals**	**Sightings**	**Individuals**	**Sightings**
African Elephant (*Loxodonta africana*)	-	-	24	6
Bat-eared Fox (*Otocyon megalotis*)	-	-	2	1
Black-backed Jackal (*Canis mesomelas*)	-	-	3	1
Common Duiker (*Sylvicapra grimmia*)	-	-	1	1
Common Eland (*Tragelaphus oryx*)	-	-	7	6
Gerenuk (*Litocranius walleri*)	-	-	9	3
Grant's Gazelle (*Gazella granti*)	-	-	244	41
Impala (*Aepyceros melampus*)	34 (24%)*	5 (22%)	110 (76%)	18 (78%)
Kirk's Dik-dik (*Madoqua kirkii*)	7 (23%)	4 (22%)	24 (77%)	14 (78%)
Lesser Kudu (*Tragelaphus imberbis*)	-	-	8	4
Maasai Giraffe (*Giraffa camelopardalis*)	-	-	164	39
Plains Zebra (*Equus burchelli*)	43 (33%)	5 (12%)	242 (67%)	37 (88%)
Sykes Monkey (*Cercopithecus mitis*)	-	-	9	1
Savanna Baboon (*Papio cynocephalus*)	27 (15%)	2 (33%)	54 (85%)	4 (67%)
Thomson's Gazelle (*Gazella thomsonii*)	-	-	65	28
Vervet Monkey (*Cercopithecus aethiops*)	55 (38%)	6 (32%)	91 (62%)	13 (68%)
Waterbuck (*Kobus ellipsiprymnus*)	-	-	2	1
Total Wildlife	**166 (14%)**	**22 (9%)**	**1059 (86%)**	**218 (91%)**

*Percentage of species seen within or outside the fence for that particular species

Table 8(b): Chi-square values comparing difference between wildlife inside and outside the fence

	Inside	Outside	Chi-square Test
Numbers Seen	166	1059	$\chi^2 = 662.22$; df = 1; $p < .001$
Sightings	22	218	$\chi^2 = 829.14$; df = 1; $p < .001$

Table 9: Building composition showing permanency of structures in markets of Kimana Group Ranch

Market	Stone (Permanent)		Timber/Tin (Semi-Permanent)		**Total**
Kimana	58	18.83%	250	81.17%	**308**
Namelok	2	3.08%	63	96.92%	**65**
Orkelunyet	-	-	18	100%	**18**
Tikondo	4	25%	12	75%	**16**
Noonkajang'a	-	-	12	100%	**12**
Mbironi Market	-	-	10	100%	**10**
Total	**64**		**365**		**429**

Table 10: Average group sizes of wildlife and livestock within and across habatitats in Kimana Group Ranch

Species	Dense Woodland/ Shrubland	Grassland	Open Woodland/ Shrubland	Riverine	Average in Kimana Group Ranch
African Elephant (*Loxodonta africana*)	1.00*	6.00*	4.25 ± 1.38	-	4.00 ± 1.09
Bat-eared Fox (*Otocyon megalotis*)	-	-	2.00*	-	2.00 *
Black-backed Jackal (*Canis mesomelas*)	-	-	3.00*	-	3.00*
Common Duiker (*Sylvicapra grimmia*)	-	-	1.00*	-	1.00*
Common Eland (*Tragelaphus oryx*)	-	-	1.17 ± 0.16	-	1.17 ± 0.16
Gerenuk (*Litocranius walleri*)	-	-	3.00 ± 1.00	-	3.00 ± 1.00
Grant's Gazelle (*Gazella granti*)	5.50 ± 1.50	3.00 ± 1.00	5.27 ± 1.00	-	5.95 ± 0.87
Impala (*Aepyceros melampus*)	10.53 ± 3.88	-	4.63 ± 0.79	-	6.32 ± 1.23
Kirk's Dik-dik (*Madoqua kirkii*)	1.40 ± 0.25	-	1.69 ± 0.17	-	1.61 ± 0.14
Lesser Kudu (*Tragelaphus imberbis*)	2.00 ± 1.00	-	2.00 ± 1.00	-	2.00 ± 0.58
Maasai Giraffe (*Giraffa camelopardalis*)	2.38 ± 0.53	-	4.68 ± 0.64	-	4.21 ± 0.54
Plains Zebra (*Equus burchelli*)	8.25 ± 1.90	12.00*	6.27 ± 0.59	-	6.79 ± 0.60
Sykes Monkey (*Cercopithecus mitis*)	-	-	-	9.00*	9.00*
Savanna Baboon (*Papio cynocephalus*)	12.67 ± 5.92	-	15.00 ± 2.64	17.00*	14.29 ± 2.53
Thomson's Gazelle (*Gazella thomsonii*)	2.00*	3.00*	2.31 ± 0.37	-	2.32 ± 0.35
Vervet Monkey (*Cercopithecus aethiops*)	7.33 ± 2.73	-	7.13 ± 1.53	10.00*	7.68 ± 1.26
Waterbuck (*Kobus ellipsiprymnus*)	2.00*	-	-	-	2.00*
Average Wildlife Group Size	**5.90 ± 0.96**	**5.40 ± 1.78**	**4.87 ± 0.32**	**12.00 ± 2.52**	**5.15 ± 0.31**
Cattle	-	-	15.60 ± 10.11	-	15.60 ± 10.11
Donkey	-	-	2.00 ± 0.41	-	2.00 ± 0.41
Shoats	-	53.00*	69.13 ± 15.23	-	68.63 ± 14.76
Average Livestock Group Size	**-**	**53.00**	**55.61 ± 12.22**	**-**	**55.55 ± 11.93**

*Species was only seen once in this habitat

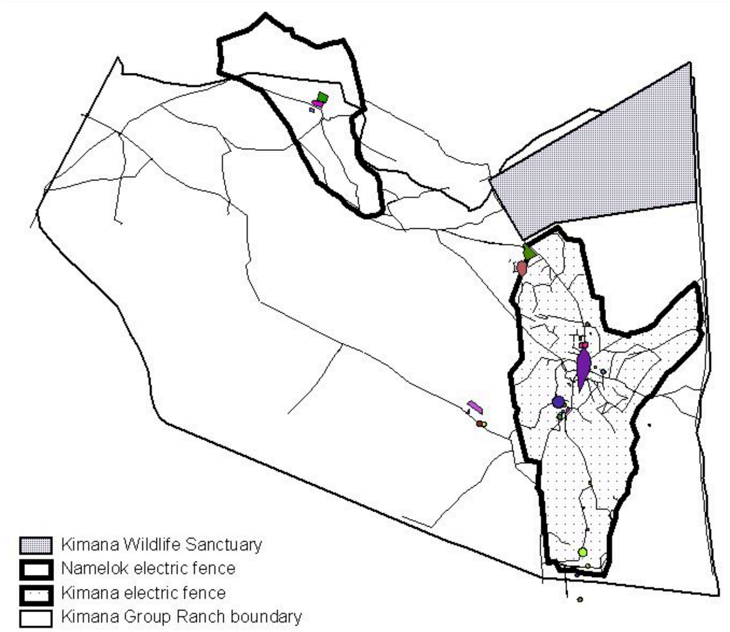

Figure 1: Kimana Group Ranch Electric Fences, Wildlife Sanctuary and markets/institutic

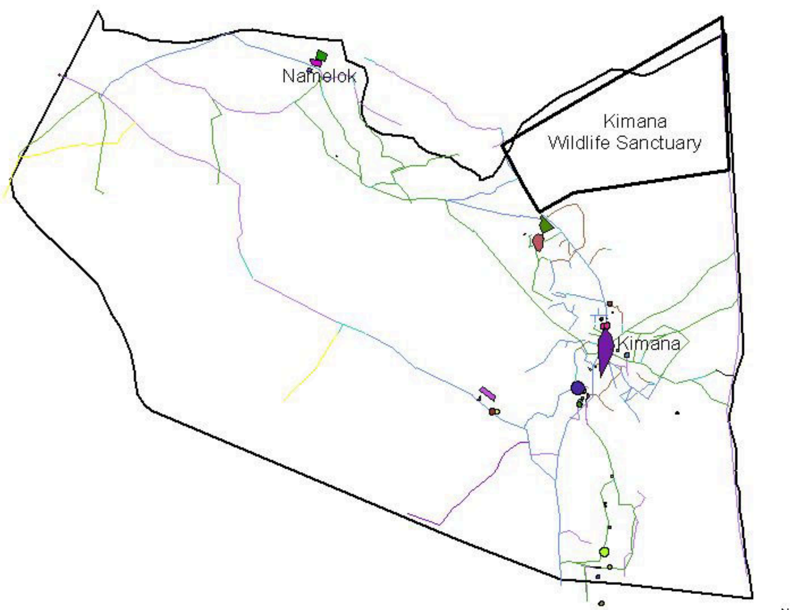

Figure 2: Kimana Wildlife Sanctuary and Kimana Group Ranch Markets/Institutions

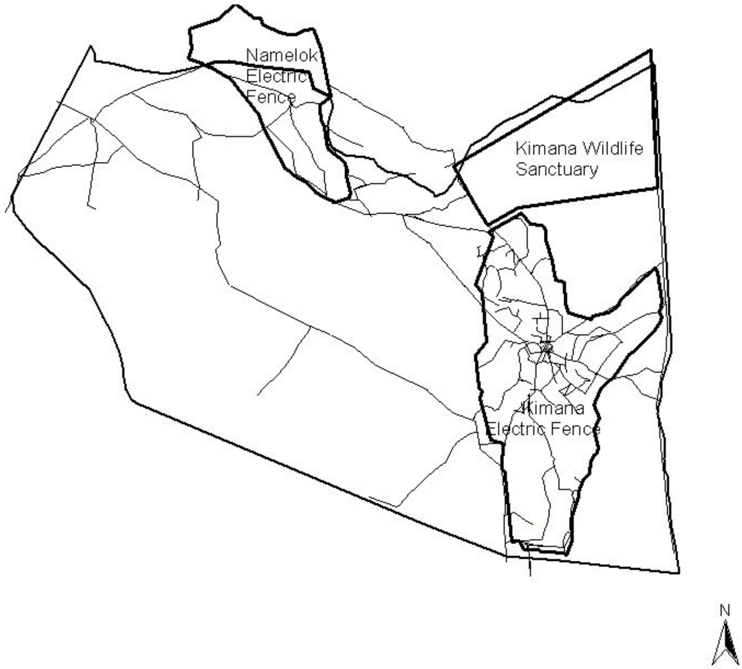

Figure 3: Kimana Wildlife Sanctuary, Electric Fences and Kimana Group Ranch road network

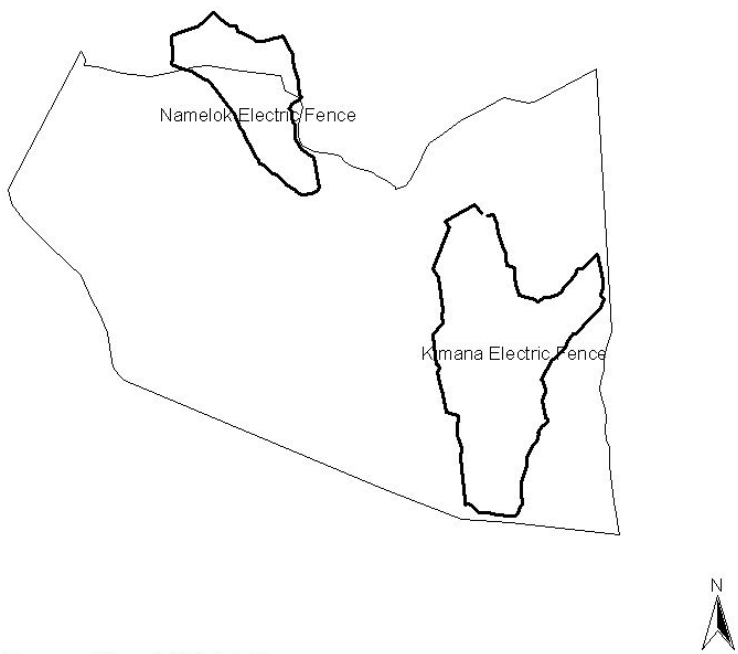

Figure 4: Kimana and Namelok Electric Fences

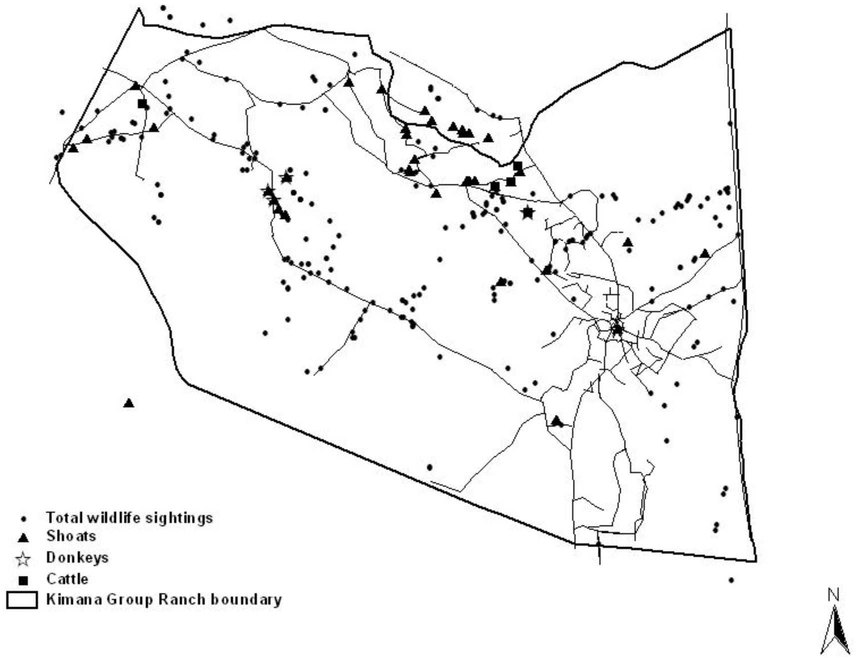

Figure 5: Wildlife sightings in association to livestock sightings

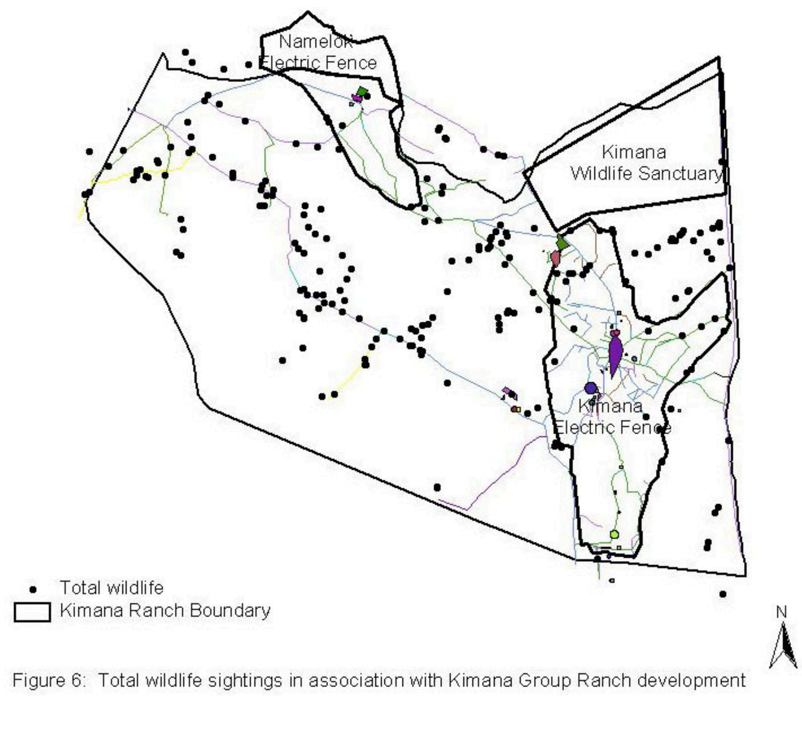

Figure 6: Total wildlife sightings in association with Kimana Group Ranch development

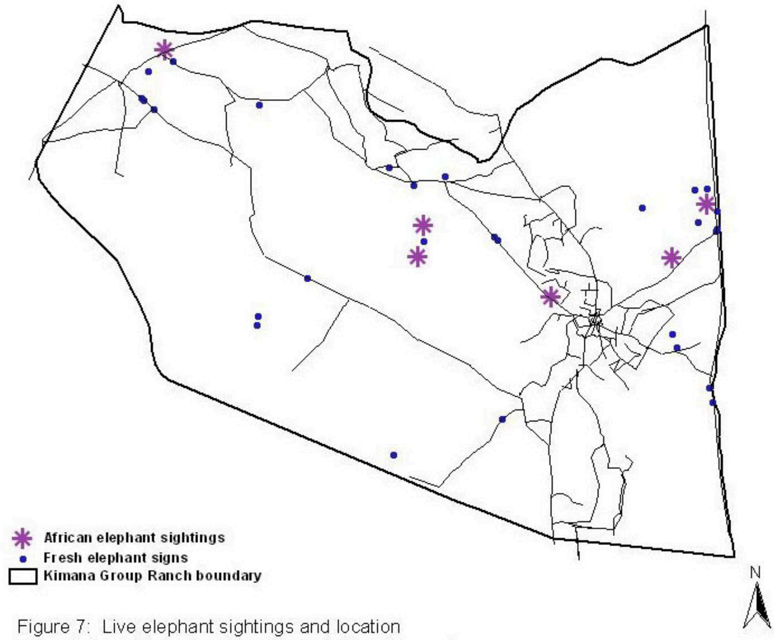

Figure 7: Live elephant sightings and location of fresh signs (dung, tracks and vegetation damage)

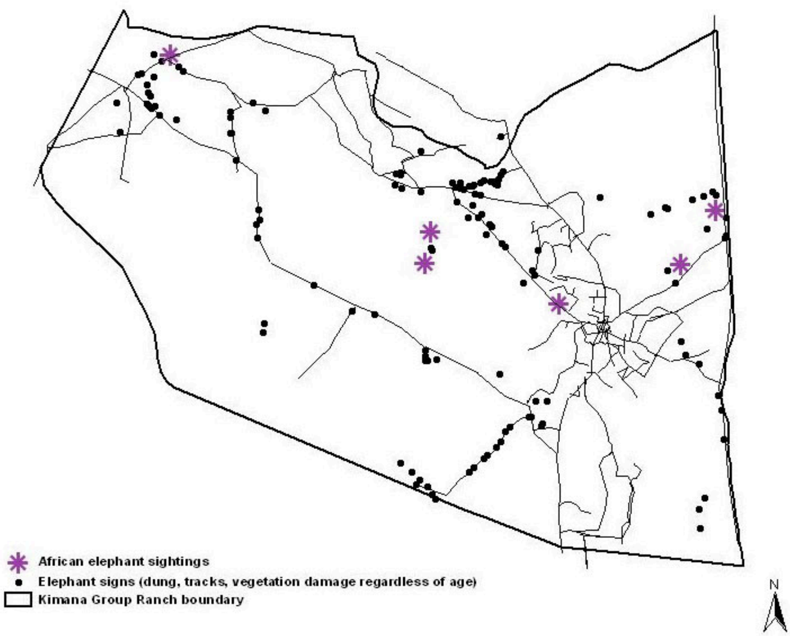

Figure 8: Live elephant sightings with signs of elephant presence

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