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Full Length Research Paper

The contraction of wildlife dispersal areas by human structures and activities in Mbirikani Group Ranch in the Amboseli Ecosystem, Kenya

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The Amboseli ecosystem in Kenya has some of the largest concentrations of free-ranging large mammals in the country. National parks depend on the surrounding group ranches for wildlife dispersal. Mbirikani group ranch [MGR] is a key dispersal area for the Amboseli ecosystem, but it is not known exactly what area remains for wildlife dispersal or where that is. Data was collected using global positioning system (GPS) units to map roads, water points, *bomas*, institutions and human activities, including herds of livestock and agricultural farms. The distribution of wildlife was then spatially analyzed using geographic information systems (GIS). Eight human settlement clusters of multiple human activities were located mainly along roads and water sources, covering 20.43% of the group ranch. The actual area covered by all human structures and activities was 1.37%, leaving over 98% open for wildlife dispersal. The actual area covered by human structures and activities increased to 22.97% of the group ranch, leaving about 77% available to wildlife dispersal. Even though MGR had a large portion of area remaining for wildlife, the spatial orientation of human settlement was blocking wildlife migration corridors. In order to mitigate this, a negotiated land use plan in the context of compensation for the land owners is urgently needed.

Key words: Amboseli, Dispersal areas, Kenya, Mbirikani group ranch.

INTRODUCTION

Some of Kenya's highest concentrations of large mammal species are found at the southern border with Tanzania (Sinclair, 1995), near Amboseli and Tsavo protected areas. This area has a large concentration of wild large mammals, but also supports an expanding human population dominated by the Maasai people. The government of Kenya reported in its most recent census (2001) that the human population was growing at a rate of 3% (Worden et al., 2003). Similarly, some of the wildlife populations such as elephants are also growing at an annual rate of over 4% (Cynthia Moss pers. Comm.). The rise in human populations and associated demand for natural resources is causing competition for land and other resources such as water and pasture between people, wildlife and livestock.

The survival of wildlife in the protected areas and Maasai group dispersal areas in this region depends on the ecological and environmental integrity of these dispersal areas and migration corridors that allow mammals to move seasonally in response to the rainfall patterns. The Amboseli ecosystem is a rangeland in which rainfall is patchy and affects productivity, hence wildlife and livestock distribution and use of the rangeland is in response to rain and associated primary productivity in pasture and water availability (Western, 1975). However, land tenure and land-use changes in these group ranches threaten the future of wildlife conservation by effectively reducing available dispersal areas (Campbell et al., 2000; Okello, 2005; Kiringe et al., 2007).

The Maasai in the area have been living in communal group ranches established after independence in 1963. Under this policy the Maasai could own and manage land available (Campbell et al., 2003b) communally to improve pastoralism practices and also prevent their land from being taken by other communities or by the government as idle land. Although the communal land tenure system was widely accepted at first due to its compatibility with pastoralism, later it seems to have failed due to exploitation of the large community by its leaders and community elites, leaving the rest of the community with little access or tangible benefits from the communal land and its resources. Therefore in recent years, there has been a growing demand for individual ownership and land use changes (especially adoption of agriculture), leading to the rampant group ranch subdivision in progress in many Maasai group ranches (Fratkin, 1997). Other key factors that have influenced a land use change in the ecosystem include a growing population, weak communal leadership and the desire for land title for collateral for loan applications from commercial banks (Campbell et al., 2000; Campbell et al., 2003b). Combined, these factors create resource competition and eliminate traditional wet and dry season grazing patterns (Ntiati, 2002). These land use changes and increasing competition are not only leading to severe resource use competition, but converting former wildlife range into human settlement and activities.

The changes in land tenure have influenced the types of land use practiced in the group ranches. Nomadic pastoralism is quickly being overtaken by agro-pastoralism as the Maasai herders are realizing that agriculture brings higher direct household economic benefits than pastoralism or current wildlife conservation initiatives (Fratkin, 1997). Wishitemi and Okello (2003) noted that over 89% of those living in the Amboseli region are involved in both pastoral and agricultural land uses, demonstrating the trend towards permanent settlements. Agriculturalists have caused competition for resources between the farmers and pastoral Maasai, especially for limited land and water. Increased human population and loss of grazing land has quickly prompted pastoralists to become sedentary (Fratkin, 1997). Because of the high concentration of cultivation practiced around swamps and along rivers, access to these water sources is increasingly curtailed for both pastoralists and wildlife access (Campbell et al., 2000).

Most agriculture practiced in Amboseli ecosystem is not rain-fed agriculture. Irrigation agriculture in the area has undergone rapid expansion since 1973. This has been accompanied by increased river diversions, thereby limiting the accessibility of water resources for both pastoralists and wildlife, especially downstream. Agriculture also has adverse negative effects on the water quality and quantity of the Amboseli ecosystem. Githaiga et al. (2003) found that while irrigation diverts water, lessening amounts of water available downstream, agriculture also decreases water quality from agro-chemical contamination. A more recent expansion in agriculture activities occurred between 1994 and 2000 with increased cultivation because of the establishment of irrigation schemes and electric fencing of these agricultural schemes in the ecosystem (Campbell et al., 2003b). This has further encouraged sedentary lifestyle among the Maasai, leading to further pressure on and settlements near critical resources (such as water and rivers). Natural vegetation has continued to be cleared to pave the way for irrigated agriculture, especially in riverine habitats and conversion of critical swamps for Maasai livestock dry season grazing and also wildlife dry season refugia (Wishitemi and Okello, 2003; Campbell et al., 2003a).

Human encroachment on protected areas and land use changes in dispersal areas are effectively turning protected areas in the Amboseli ecosystem (Amboseli, Chyulu and Tsavo West) into ecological “islands” through fragmentation of this once continual conservation block, and actual blocking of key migration routes between these protected areas using the Maasai group ranches as dispersal areas. The majority of the wildlife within the Amboseli ecosystem utilizes a total dispersal area of 5000 km^2, which is profoundly larger than the 392 km^2 set aside for Amboseli National Park (Western[a], 1982). Larger habitats are critical in facilitating gene transfer, reducing inbreeding depression, extending the habitat available for species with large home ranges, and increasing resilience to stochastic events (Mech and Hallett, 2001). As the displacement areas become more fragmented and isolated, the local extinction rates of the wildlife populations and species will increase (Newmark, 1996; Mech and Hallett, 2001).

Over 80% of wildlife leaves Amboseli national park during the wet season to disperse into the group ranches after more pasture and water become available (Okello and Kiringe, 2009). Because the group ranches are used by the majority of wildlife, these areas need to be open for dispersal and critical migration routes and dispersal areas conserved for wildlife movements between the protected areas. Not only do human establishments in the dispersal zones cause insularization of the national parks and protected areas, but they also cause the loss of wildlife habitats and resources, producing a crescendo in human-wildlife conflicts (Worden et al., 2003).

Human-wildlife conflicts are becoming more prevalent among herders and small-scale cultivators in the dispersal areas of the Amboseli ecosystem. Carnivores such as lions (*Panthera leo*) and hyenas (Crocuta crocuta) that follow migrating herbivores often kill livestock for an easier meal. Dispersing wildlife competes for pasture and water with livestock, and proximity leads to transmission of diseases to livestock, hence heavy economic losses for the Maasai. Farmers also incur high costs through crop raiding and trampling (Okello and Kiringe, 2004). Agriculture as a land use encourages human wildlife conflicts in many wildlife dispersal ranges.

However, these landowners shoulder those costs without receiving any of the benefits that the government receives from protected areas, such as money from wildlife-based tourism (O’Connell-Rodwell et al., 2000). Left to bear the burdens of wildlife without receiving benefits, the residents of these group ranches have

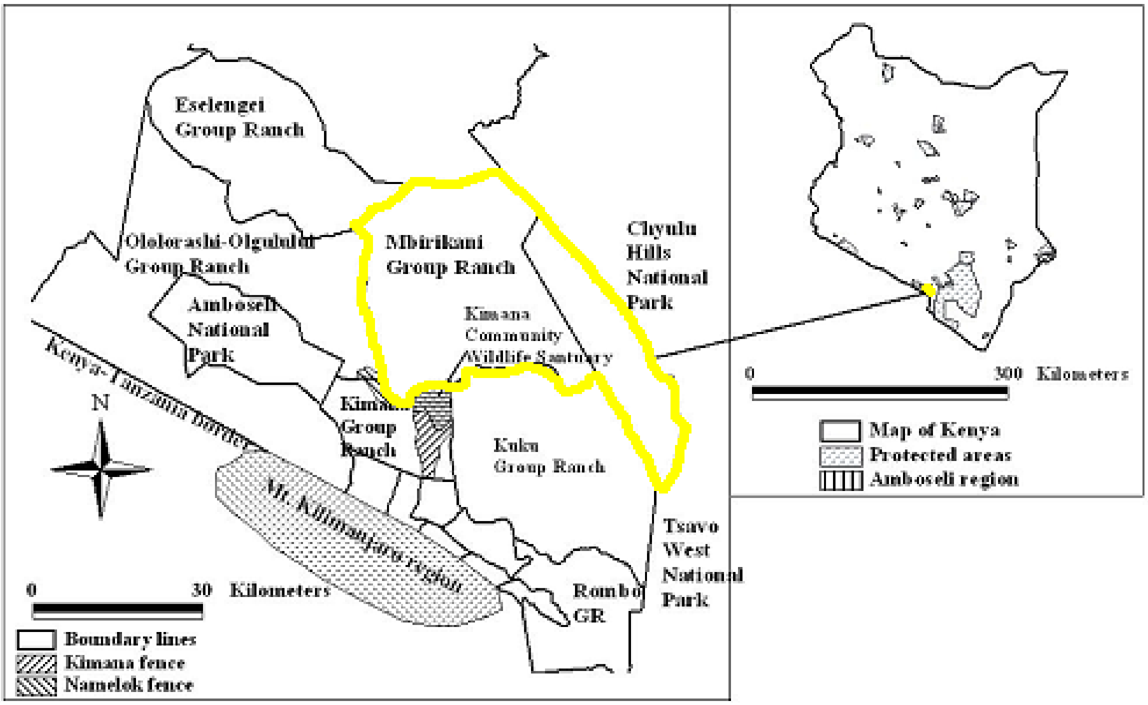

Figure 1. Tsavo-Amboseli ecosystem showing the six group ranches and the three national parks.

developed negative attitudes toward wildlife. Frustrations toward wildlife by communities lead to retaliatory poaching and bushmeat activities, which decreases wildlife viability outside protected areas and compromises conservation efforts (Westerna, 1982). With human populations growing in wildlife dispersal areas, competition for the same diminishing resources will result in more frequent human-wildlife conflicts that pose threats to both local livelihoods and wildlife conservation efforts (Okello and Kiringe, 2003). The establishment dispersal areas still remaining and actually used by wildlife in group ranches from expansion of human structures and activities is critical in helping elaborate areas where migration corridors and community conservation areas can be established outside Amboseli park.

This study was conducted to provide such information for Mbrikani group ranch near Amboseli, which is one of the key wildlife resident and dispersal areas in Maasai communal lands. Specific objectives were to:

Identify large mammal wildlife species and their distribution in Mbirikani Group Ranch.
Determine the actual area that human structures and settlements occupy, and thus the amount of actual land that remains for wildlife use, and where it is spatially located.
Establish the minimum distance that wildlife stay away from human structures and activities, which can be used as an index of wildlife displacement from human activities and structures.

Determine the extent of wildlife displacement by the presence of humans and livestock. Establish broad wildlife – habitat associations to establish areas of potential competition between livestock and wildlife.

STUDY AREA

The study was conducted on the Mbirikani group ranch in the Loitokitok District of southern Kenya. This land is one of the six Maasai group ranches in the Amboseli ecosystem (Figure 1), with an area of 1,228.93 km^2 (Campbell et al., 2003b). The group ranch borders Kuku and Kimana group ranches to the south, Chyulu Hills national park to the east, and Eselenkei and Ololorashi-Olgulului group ranches to the north and west, respectively. This study was conducted in November 2006, April 2007 and November 2007 (the time of rainy season when wildlife leave the park and disperse into group ranches because of plenty of water and pasture available during this time outside the park). Mbirikani group Ranch is located between Amboseli National Park on the east and Tsavo and Chyulu Hills national parks on the west, and contains a high concentration of resident and migrating wildlife. Because of its location between the three protected areas, it is an important area for wildlife dispersal from protected areas (Campbell et al., 2003b).

The human population of the group ranch has grown rapidly since its inception in 1981. The group membership increased from 922 members in 1987 to 4,585 members in 2001 (Campbell et al., 2003b). The average population density for Loitokitok District is 43 people per km^2 (Githaiga et al., 2003). The population is rapidly growing due in part to large numbers of immigrants into the area, particularly of Kenyan Kikuyu and Kamba ethnicities as well as Tanzanians (Ntiati, 2002). The people in this area are predominantly Maasai and mainly practice pastoralism; their livelihoods are based primarily on natural resources (Campbell et al., 2003b).

Mbirikani group ranch is arid or semi-arid land, classified into agroclimatic zones V and VI Groom, 2005). There are often unpredictable and periodic droughts which make cultivation difficult (Campbell et al., 2003a). The rains come in bimodal patterns with long rains from March to May and short rains from October to December. The amount of rain ranges from 500 to 800 mm per year and is dependent on the altitude. The high altitude areas of Chyulu Hills receive about 800 mm of rain per year (Campbell et al., 2003b). The lowland areas receive only 500 mm of rain per year due to the rain-shadow effect from Mt. Kilimanjaro and Chyulu Hills (Ntiati, 2002).

The soil of the group ranch also depends on the altitude. The Chyulu soils are volcanic and fertile enough to support woodland vegetation. The lower elevation areas have basement complexes and alluvial soils in the swamps. The vegetation is predominantly grassland in the low areas, and woodlands or wooded grasslands are prevalent in Chyulu Hills (Githaiga et al., 2003). Recently, Mbirikani group ranch has experienced decreased woodland vegetation and soil fertility and increasing soil erosion (Campbell et al., 2003a). This rangeland degradation is a result of overgrazing of livestock and wildlife, and the increasing sedentarization of a traditionally nomadic pastoral Maasai (Western and Finch, 1986).

MATERIALS AND METHODS

Global positioning system (GPS) units (eTrex® Vista 3.60, 1999, Garmin limited technology, Olathe, KS, USA) were used to record spatial location of all human structures and activities (Maasai homesteads (*bomas*); public institutional structures such as schools, government offices, public offices, infrastructure, etc.; roads; and agricultural areas) and free-ranging large wild mammals. GPS units were used to measure perimeters of structures, lengths of roads, and locations of livestock and wildlife using the universal transverse mercato (UTM) system. Measurements were taken to determine large wild mammals' distance from the nearest distinctive type of human structure, livestock, and road using rangefinders (Yardage Pro, Bushnell Corporation, Overland Park, KS, USA). All surveys were taken on foot except for the measurement of roads, which were taken by vehicle. This work was done between 2006 and end of 2007 during the wet season when pasture and water are plenty, and wildlife large mammals are widely dispersing between group ranches and protected areas in the ecosystem.

Maasai homesteads

Maasai homesteads (*bomas*) were defined as traditional Maasai living complexes consisting of more than one to more housing units fenced off in a circular pattern with an inner corral for livestock. The perimeter of the *bomas* was mapped using the GPS units, and so were the radius, length and width depending on the shape of the boma. The number of housing units within each *boma* was also counted and recorded, being classified as permanent, semi-permanent, temporary, or incomplete based on occupancy. *Bomas* were also classified based on the construction materials used for its construction: Permanent (with stone, concrete, and/or brick with a tin or iron roof); Semi-permanent (with timber or mud wall with a iron roof); and temporary (with mud or dung walls, and grass roof). Incomplete *bomas* were those still in the process of construction. *Bomas* were also classified based on occupancy status such as "new" which were under construction, "occupied" being those currently in use, and "abandoned" being those no longer in use by the Maasai who have moved to a new site.

Public institutions, and agriculture clusters

The location and area of all public and private institutions (except *bomas*) included churches, schools, markets, businesses, health clinics, and agricultural fields. Institutions where human influence covers a large area, such as markets, were measured around the outermost perimeter of influence. Relevant dimensional measurements (radius, or length and width) were taken to later determine the area occupied depending on the shape of the institution property (fenced off or marked otherwise).

Wildlife distributions and group size

All mammal species larger than a Kirk's dik dik (Madoqua kirkii) and all primate species observed were identified and counted to establish their spatial location, group size, relationship with human structures and activities, and the habitats used. Wildlife sightings were actively searched from hilltop and along transects that traversed the entire group ranch and any other vantage points using binoculars in sectors that covered the entire group ranch during the day in entire group ranch. When seen, the place where they were first located was recorded using GPS units. The habitat in which a species was sighted was also recorded based on a classification by the dominant vegetation height. The habitat categories were grassland, shrubland (less than six meters), bushland (between six and ten meters), and woodland (greater than ten meters). The density of shrubland, bushland and woodland habitats was also recorded, with open habitats having a visibility over 100 m and dense habitats having a visibility under 100 m. The minimum distance wildlife stayed away from (the nearest, within a kilometer) human structure and activity was recorded with rangefinders. The type and number of nearby livestock (cattle, shoats, and donkeys) was recorded as well as the habitat in which they were found. The nearest distance to human (predominantly Maasai) presence was also recorded.

Road network and area

The roads were designated according to their destination and classified based on size as main, major or minor depending on their size, quantity of traffic and level of use. Roads were classified according to their width. Roads wider than eight meters were considered main roads. A road was considered major if its width was between two and eight meters. A minor road was about two meters wide. The road width was also measured at every point a

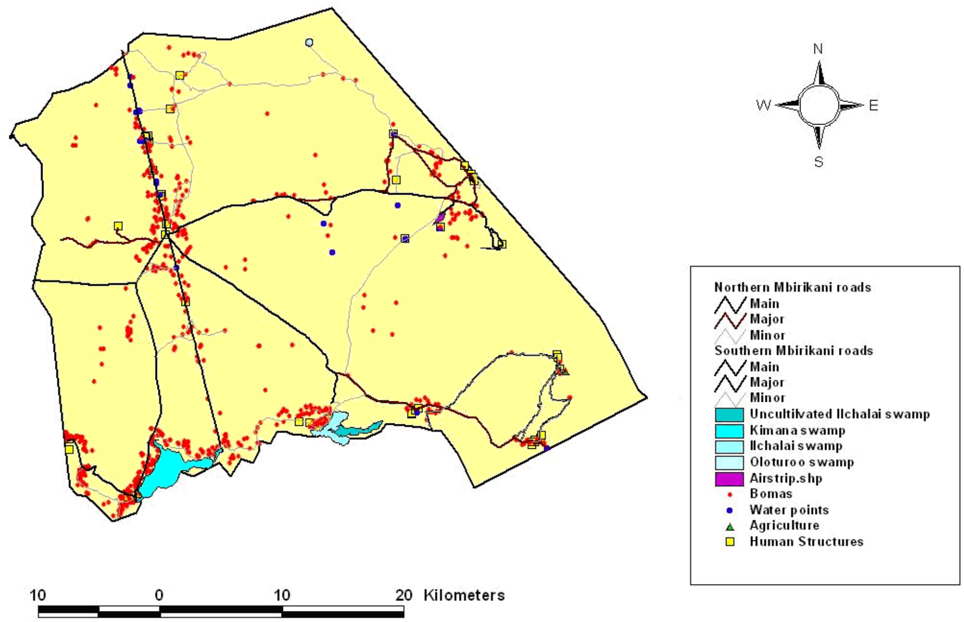

Figure 2. Location of all human structures and activities in Mbirikani group ranch.

GPS point was taken to later determine the average width of each road segment.

Data analysis

Human structures and activities were spatially analyzed using ArcView® geographical information system (GIS, version 3.2 for windows, environmental systems research institute Inc., 2005). Using ArcView®, maps were generated showing the occurrence and spatial distribution of roads, *bomas*, institutions, wildlife, water sources and human activity clusters. The area of human structures was calculated using ArcView® and standard mathematical formulae.

The data were analyzed using SPSS (version 9.0 for Windows, SPSS Inc., 1999) to calculate various sizes of dimensions (average length, width, radius and associated areas) as per standard mathematical formulae. Further, statistical tests between variables (parametric tests) and dependence of sightings and animal numbers on habitats (enumerative statistical tools) were done. ANOVA tests determined the differences in wildlife group sizes among habitats, minimum distances of livestock types from wildlife, and minimum distances of various human structures and activities from wildlife. A chi-square cross – tabulation was used to examine any dependence of wildlife sightings and group size on habitat types. All tests were deemed significant at alpha of 0.05 (Zar, 1999).

Areas of human clusters of activities were delineated using GIS polygons that connected edges of these structures and activities in areas where they concentrated using ArcView® geographical information system and area of delineated area determined using the same software.

RESULTS

Human structures occurred across the entire group ranch (Figure 2), taking up a total actual area of 16.85 km^2 (1.37% of Mbirikani group ranch, MGR) (Table 1). However, when wildlife displacement was taken into account, the area covered by human structures increased by 16.67 times to 282.27 km^2 (22.97 % of MGR). Agricultural clusters covered an actual area of 12.76 km^2 (1.28% of MGR), followed by *bomas* (0.14%), roads (0.12%), airstrips (0.03%), water pipeline points (0.03%), and institutions (0.01%). However, when wildlife displacement was factored in, the road network covered the largest portion of the group ranch (10.43%), followed by *bomas* (10.33%), agricultural areas (1.70%), institutions (0.68%), human / livestock watering points (0.14%) and airstrips (0.05%). Roads also had the largest magnitude of increase from actual to wildlife displacement area (86.57 times the actual area), and the least was airstrips (1.46 times) had the least (Table 1).

Areas with high concentrations of human structures and activities were located in eight clusters of human settlements in MGR (Figure 3). The clusters covered 239.13 km^2 (20.38%) of MGR (Table 2). The largest cluster occurred along the pipeline-main road (128.07 km^2, 11.34% of MGR). This large cluster bisected MGR into nearly half, leaving only a gap of 2.35 km of the main pipeline road open for wildlife migration. The Oldonyo-Wuas Ecotourism Area (43.30 km^2, 3.52%) was the second largest cluster, followed by the Kimana Swamp-Esambu cluster (42.14 km^2, 3.43%), the Ilchalai Swamp cluster (13.62 km^2, 1.11%), the Namelock cluster (7.72 km^2, 0.63%), the Olubili cluster (3.12 km^2, 0.52%), and the Elenkati cluster (0.97 km^2, 0.08%). The smallest group of settlements occurred in the southeast section of

Table 1. Area (m^2) of human structures and activities, and distances wildlife stays away from human structures in Mbirikani group ranch.

Variable	Maasai *Bomas*				Roads[a]				Agriculture	Institutions	Airstrip	Overall
	Overall	Occupied	Abandoned	New	Overall	Minor	Major	Main				
Average minimum distance to wildlife (m) ± SE	237.39 ± 21.92	-	-	-	180.54 ± 10.65	-	-	-	89.50 ± 82.15	333.33 ± 22.10	35.82 ± 7.35	-
Average radius/width (m) ± SE	23.24 ± 0.84	23.90 ± 0.99	19.63 ± 1.03	21.73 ± 2.25	2.82 ± 0.48	7.05 ± 2.51	3.30 ± 0.70	2.63 ± 0.29	Length: 126.5 ± 28.5; Width: 126.0 ± 46.0	Radius: 16.63± 2.84; Length: 82.61± 28.51; Width: 48.89± 12.44	-	- ———
Total area of MGR actually taken (km^2, % of MGR)	1.78 (0.14)	1.64 (0.13)	0.13 (0.01)	0.02 (0.002)	1.48[b] (0.12)	0.55 (0.04)	0.51 (0.04)	0.41 (0.03)	12.76 (1.04)	0.13 (0.01)	0.39 (0.03)	16.85 (1.37)
Total area taken inclusive of wildlife displacement (km^2, % of MGR)	126.90 (10.33)	106.71 (8.68)	17.87 (1.45)	2.32 (0.19)	128.13 (10.43)	44.32 (3.61)	49.03 (3.99)	34.79 (2.83)	16.93 (1.38)	8.30 (0.68) .	0.57 (0.05)	282.27 (22.97)

a Total road network in length was 380.03 km
b Total area of MGR was 1,228.93 km^2 (the total area of Mbirikani Group Ranch

the group ranch (Figure 3) at Elenkati and Lemasusu clusters (0.08% and 0.02% of MGR respectively). These clusters left about 70.62% of MGR open for wildlife and livestock use, and nine potential routes for wildlife dispersal left open in MGR (Figure 6).

The majority of *bomas* in MGR (Figure 4) were occupied *bomas* (73%), but with 14% abandoned, 11% unclassified, and 2% new (Table 3). Occupied *bomas* covered the largest area based on the radius of their compounds (23.90 ± 0.99 m, SE throughout) while the abandoned were the least. The majority of the structures within the *bomas* were temporary (70%), followed by semi-permanent structures (20%), incomplete structures (7%), and permanent structures (3%).

Wildlife was widely distributed in MGR (Figure 5) but was displaced by all structures, especially from clusters. The average minimum distance of all wildlife to all human structures in MGR was 190.29 ± 9.28 m (Table 4). Large mammal species kept the farthest from institutions (326.73 ± 35.28 m), followed by *bomas* (234.84 ± 20.96 m), human / livestock watering points (194.33 ± 75.77) roads (182.17 ± 10.74), agricultural activities (89.50 ± 82.15), and airstrips (35.82 ± 7.35). These distances varied among structures ($F = 3.849$, $df = 4$, $p = 0.004$). The mean minimum distance between wildlife and airstrips was significantly less than between wildlife and *bomas* ($p = 0.037$), and the mean minimum distance between wildlife and airstrips was less than between wildlife and institutions ($p = 0.015$). However, all other differences in the distance wildlife kept off among structures were not significant. (Figure 6). Wildlife kept off an average minimum distance of 329.62 ± 10.89 m from livestock generally (Table 5). Cattle displaced wildlife the most (357.63 ± 14.84 m) and donkeys displaced wildlife the least (161.87 ± 23.43 m), while shoats displaced wildlife at an average distance of 247.17 ± 18.36 m. There was also a

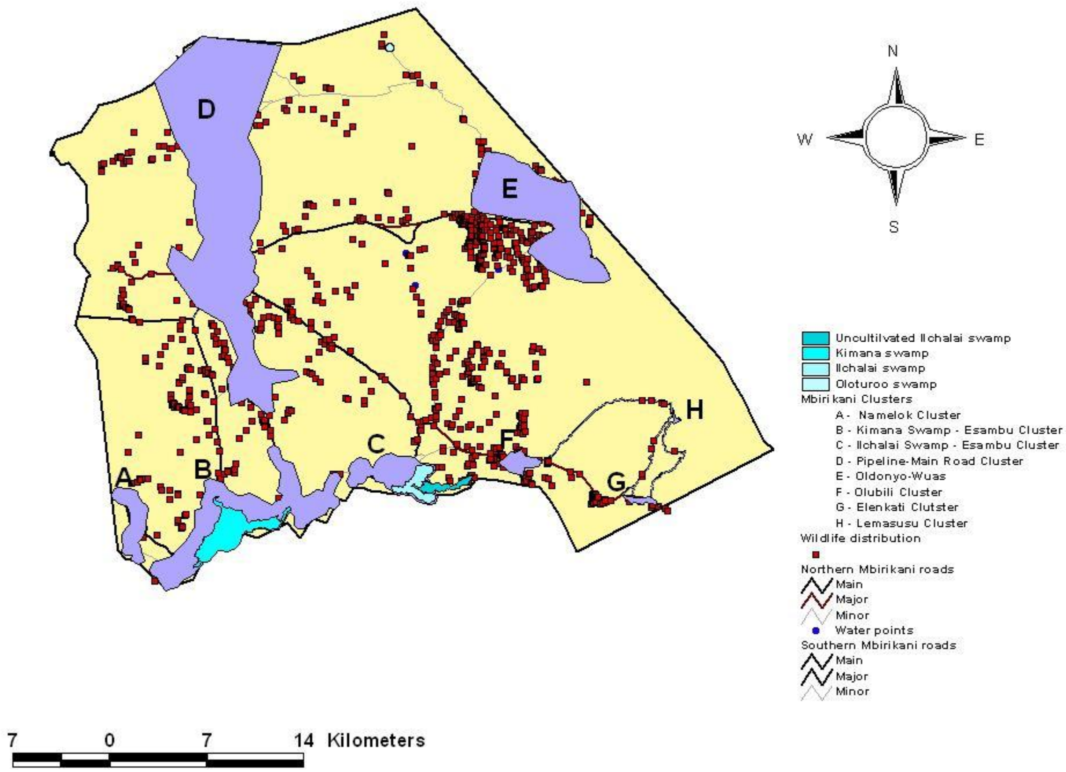

Figure 3. Clusters of multiple human activities and structures in relation to wildlife distribution.

Table 2. Clusters and areas of human settlements and activities in Mbirikani group ranch

Name of human structures / activity clusters	Perimeter (km)	Area (km^2)	Area (%) in Mbirikani group ranch
Namelok cluster (A)	15.26	7.72	0.63
Kimana swamp- esambu cluster (B)	49.39	42.14	3.43
Ilchalai swamp cluster (C)	21.47	13.62	1.11
Pipeline- main road cluster (D)	76.43	128.07	11.34
Oldonyo-wuas ecotourism area (E)	34.93	43.30	3.52
Olubili cluster (F)	7.82	3.12	0.25
Elenkati cluster (G)	6.58	0.97	0.08
Lemasusu cluster (H)	2.67	0.19	0.02
Total	214.55	239.13	20.38

significant and positive correlation between the number of cattle in a herd and the mean minimum distance maintained by wildlife ($r = 0.131$, $n = 277$, $p = 0.030$). Therefore, as cattle group size increases, the mean minimum distances maintained by wildlife increase. There was no significant correlation between the shoats group size and the mean minimum distance kept by wildlife to the herd ($r = -0.167$, $n = 81$, $p = 0.136$), or the donkey group size and the mean minimum distance of wildlife from that herd ($r = 0.435$, $n = 14$, $p = 0.120$).

The average minimum distance of large mammals to humans (Table 5) in MGR was 299.02 ± 11.30 m. The mean minimum distances wildlife kept from structures, livestock and humans differed ($F = 39.734$, $df = 2$, $p < 0.001$). The overall mean minimum distances of wildlife to structures in Mbirikani was less than those from wildlife to livestock ($p < 0.001$) and wildlife and humans ($p < 0.001$).

Among habitats (Table 6), grasslands had the highest wildlife average group size (11.60 ± 0.43 m), followed by dense bushland habitats (9.12 ± 1.82 m), riverine or swamp habitats (7.40 ± 0.35 m), dense shrubland habitats (6.17 ± 0.55 m), and open bushland habitats (5.48 ± 1.02). Across all habitat types, the average group size of all livestock was 89.66 ± 4.81, compared to an

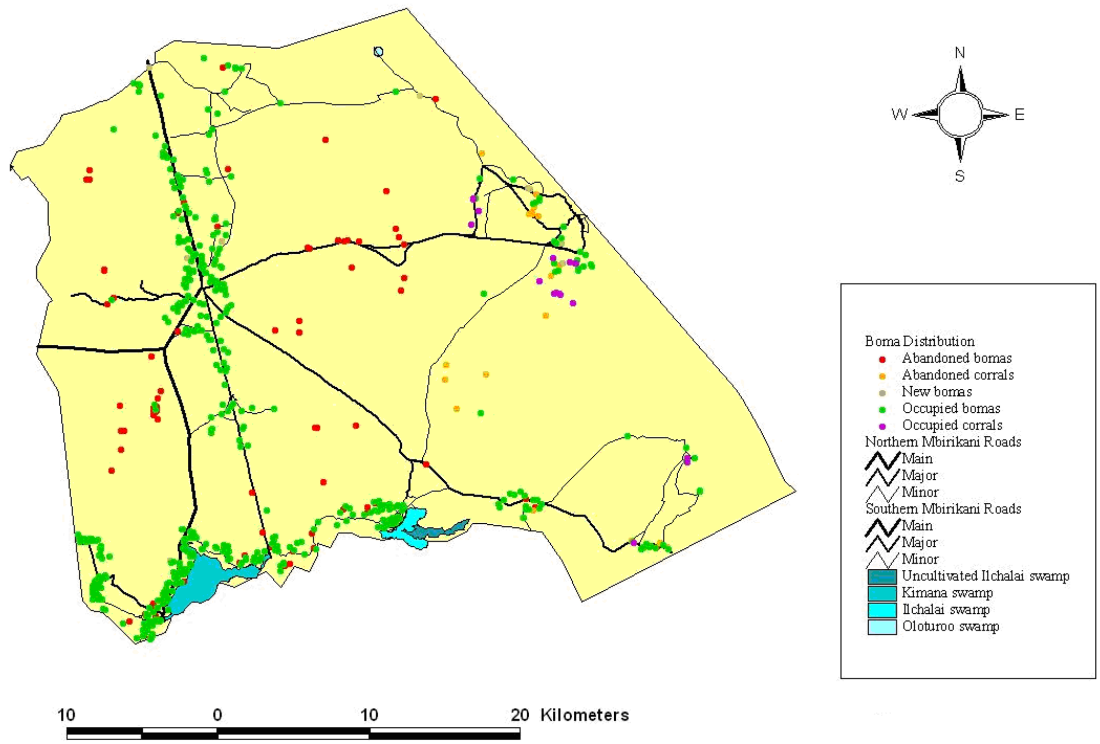

Figure 4. Location of new, abandoned and occupied *bomas* in relation to roads and swamps.

Table 3. Parameters associated with Maasai settlements (*bomas).*

***Boma* occupancy status**	**Mean radius ± SE (m)**
Occupied	23.90 ± 0.99
Abandoned	19.63 ± 1.03
New	21.73 ± 2.25
Overall average	23.24 ± 0.84
Structure type	Number (%)
Temporary	1900 (70%)
Semi-permanent	543 (20%)
Incomplete	191 (7%)
Permanent	77 (3%)
Total number of structures within *bomas*	2711
Boma occupancy status	Count (%)
Occupied	548 (73%)
Unclassified	87 (11%)
Abandoned	106 (14%)
New*	12 (2%)
Total number of *bomas*	754

average wildlife group size of 9.52 ± 0.26 m (Table 6). The average group size of livestock was the highest in grassland habitats (114.25 ± 5.42), followed by open shrubland habitats (62.71 ± 5.59), open bushland habitats (29.00 ± 12.97), and, lastly, dense shrublands habitats (24.86 ± 3.99). Grassland habitats had the highest number of wildlife sightings (Table 7) of wildlife large mammals (53.7%), followed by open shrubland (33.0%), dense shrubland (8.7%), open bushland (2.1%), dense bushland (1.4%), and wetland habitat (1.0%). The

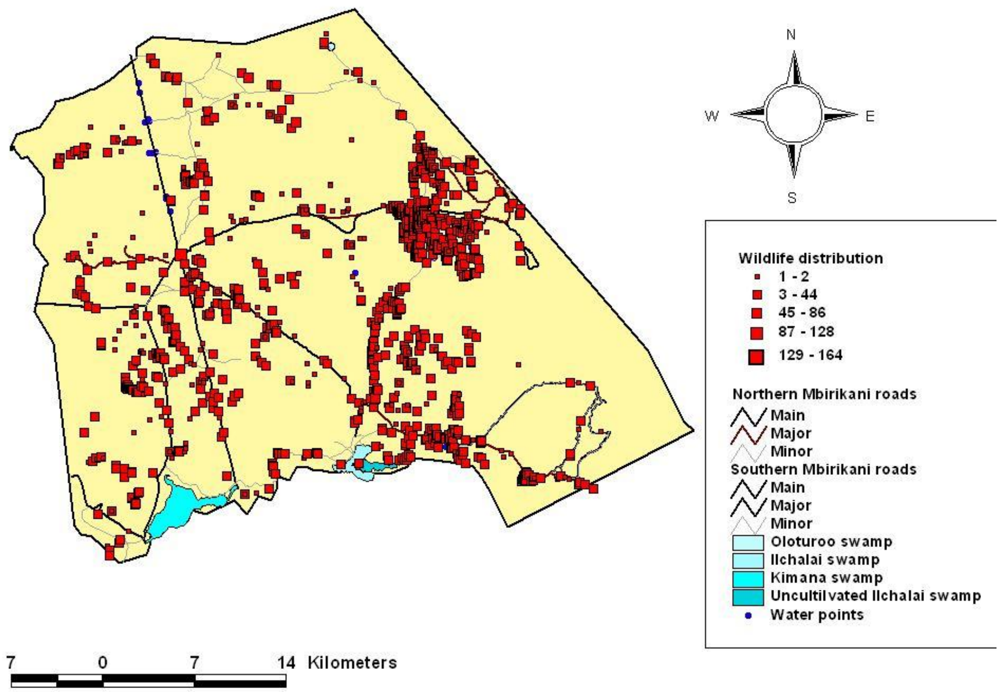

Figure 5. Wildlife distribution and group size in relation to water sources and roads.

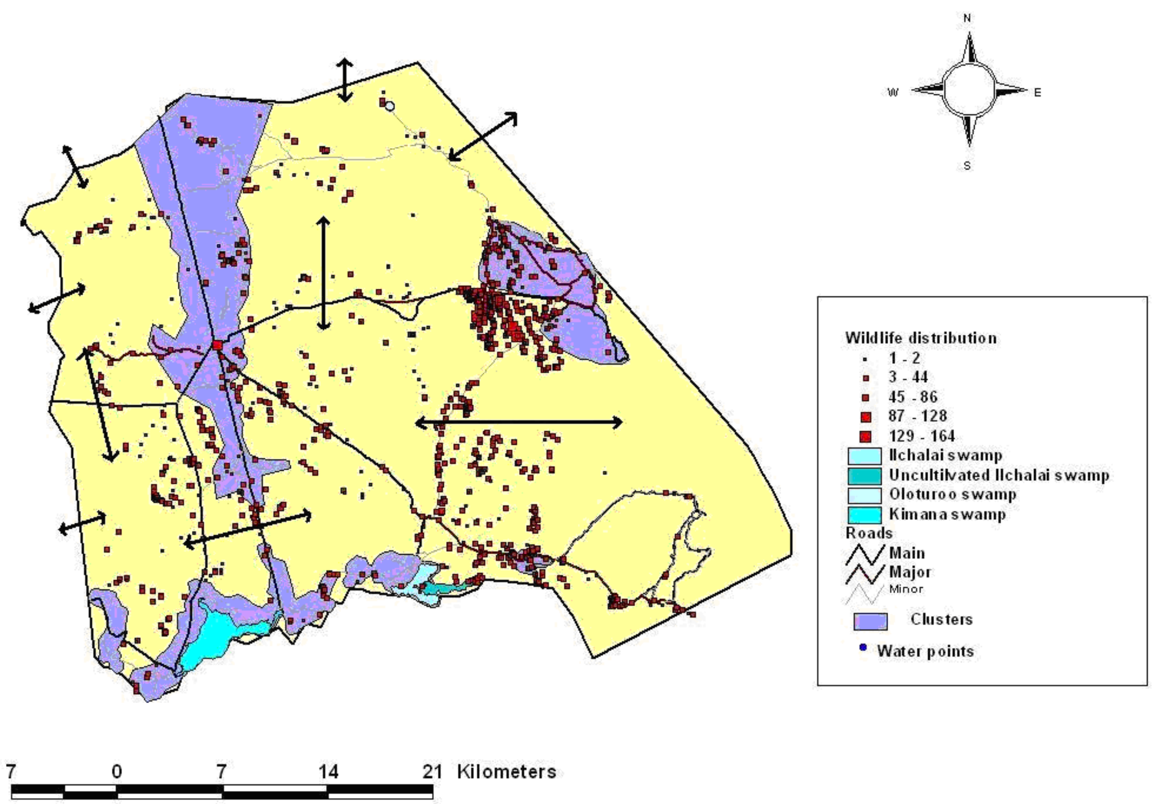

Figure 6. Wildlife distribution and abundance in relation to clusters of human structures/activities and potential wildlife movement routes. The arrows represent potential current wildlife dispersal routes given the prevailing human structures and activities.

Table 4. Average minimum distance (m) [± SE] of human structures to common large mammal species sighted in Mbirikani group ranch.

Species	Roads	*Bomas*	Institutions	Agriculture	Airstrips	All Structures
African elephant	36.67 ± 6.67	-	-	-	-	36.67 ± 6.67
Coke's hartebeest	200.00 ± 56.62	248.66 ± 126.01	-	-	-	218.63 ± 54.07
Common eland	100.10 ± 26.24	340.00 ± 0.00	-	-	-	140.08 ± 34.58
Common warthog	59.40 ± 16.77	-	-	-	-	59.40 ± 16.77
Common wildebeest	236.41 ± 23.57	289.92 ± 54.04	350.00 ± 0.00	126.75 ± 124.42	32.67 ± 3.71	233.22 ± 20.72
Common zebra	225.31 ± 27.00	208.00 ± 63.46	424.50 ± 43.63	-	22.67 ± 11.85	224.13 ± 24.21
Fringe-eared oryx	134.67 ± 37.08	466.67 ± 116.67	-	-	-	245.33 ± 69.06
Gerenuk	120.00 ± 30.11	224.20 ± 75.15	-	-	-	156.89 ± 30.36
Grant's gazelle	167.58 ± 21.67	278.32 ± 43.77	242.50 ± 54.97	-	100	190.94 ± 19.05
Impala	65.21 ± 22.28	50	-	-	-	64.60 ± 21.37
Kirk's dik dik	200	180.00 ± 120.00	-	-	-	186.67 ± 69.60
Maasai giraffe	145.00 ± 42.31	330.83 ± 110.62	-	15.00 ± 5.00	-	168.75 ± 39.25
Thomson's gazelle	144.23 ± 28.04	152.00 ± 18.37	226	-	32.00 ± 4.90	145.76 ± 19.83
Topi	300	-	-	-	-	300
Vervet monkey	250.00 ± 101.24	-	-	-	-	250.00 ± 101.24
Yellow baboon	43.20 ± 19.10	12.33 ± 11.57	-	-	-	33.50 ± 12.92
Overall for all wildlife	182.17 ± 10.74	234.84 ± 20.96	326.73 ± 35.28	89.50 ± 82.15	35.82 ± 7.35	190.29 ± 9.28

Note: Single values indicate the species was sighted only once. Institutions included schools, churches, cattle holding pens, privately owned businesses, and clinics.

Table 5. Average minimum distance (meters) [± SE] of common large mammal species sighted in relation to livestock types in Mbirikani group ranch and presence of human beings (mostly local Maasai).

Species	Cattle	Shoats	Donkeys	All Livestock	Humans**
Black-backed jackal*	100.00	-	-	100.00	239.00
Coke's hartebeest	302.66 ± 42.78	140.00	-	273.09 ± 39.89	274.75 ± 32.46
Common eland	450.25 ± 140.00	30.00	-	366.20 ± 137.20	850.00
Common wildebeest	361.97 ± 24.72	257.59 ± 49.75	-	346.13 ± 22.49	339.58 ± 21.80
Common zebra	372.12 ± 29.93	299.88 ± 51.92	22.50 ± 2.50	353.38 ± 26.37	307.90 ± 24.32
Fringe-eared oryx	759.86 ± 273.60	294.66 ± 152.70	-	620.00 ± 203.80	343.80 ± 113.00
Gerenuk	240.45 ± 40.40	272.00 ± 120.90	250.00	247.40 ± 35.83	261.00 ± 76.00
Grant's gazelle	367.94 ± 33.87	208.71 ± 37.59	177.71 ± 29.28	314.80 ± 26.27	258.52 ± 21.00
Impala	542.00 ± 144.3	191.00 ± 75.37	-	386.00 ± 92.84	275.00 ± 225.00
Kirk's dik dik	192.50 ± 82.80	400.00	-	234.00 ± 76.39	40.00

Table 5. Contd.

Maasai giraffe	176.82 ± 46.48	202.50 ± 50.42	131.00	184.80 ± 32.70	127.20 ± 28.20
Thomson’s gazelle	334.59 ± 27.81	264.50 ± 30.96	189.50 ± 47.29	301.87 ± 20.66	305.60 ± 27.20
Yellow baboon	10.00	-	-	10.00	-
All wildlife	357.63 ± 14.84	247.17 ± 18.36	161.87 ± 23.43	329.62 ± 10.89	299.02 ± 11.30

Single values indicate the species was sighted only once. Sometimes, humans were predominantly seen with livestock; However the distance for humans represents the distance to humans only without (livestock).

Table 6. Average group size [± SE] of common large mammal species among habitats in Mbirikani group ranch.

Wildlife species	Across habitats	Dense bushland	Dense shrubland	Open bushland	Open shrubland	Grassland	Riverine / swamp
Coke's hartebeest	2.85 ± 0.63	8.00	–	–	2.60 ± 1.17	2.57 ± 0.72	–
Common eland	5.56 ± 1.24	8.00 ± 0.00	4.92 ± 1.35	3.00	2.83 ± 0.79	7.80 ± 3.51	–
Common warthog	2.60 ± 0.52	–	1.50 ± 0.22	–	2.80 ± 0.97	3.00 ± 0.58	–
Common wildebeest	15.21 ± 1.12	28.00 ± 22.00	19.88 ± 8.66	5.00	10.14 ± 1.77	16.23 ± 1.33	7.50 ± 3.50
Common zebra	11.86 ± 0.77	3.40 ± 0.81	11.29 ± 2.92	7.25 ± 1.31	9.70 ± 0.86	13.47 ± 1.19	8.63 ± 1.59
Fringe-eared oryx	6.04 ± 1.89	1.67 ± 0.33	10.00 ± 0.00	–	8.56 ± 5.27	3.92 ± 1.86	–
Gerenuk	3.27 ± 0.29	–	3.54 ± 0.96	3.33 ± 0.80	3.24 ± 0.36	3.08 ± 0.67	–
Grant's gazelle	7.34 ± 0.50	5.50 ± 2.50	2.50 ± 0.50	4.71 ± 1.23	7.16 ± 0.66	8.06 ± 0.81	–
Impala	6.87 ± 0.98	22.5 ± 2.75	5.23 ± 1.01	4.00 ± 1.00	5.94 ± 1.21	5.00 ± 3.51	–
Kirk's dik dik	1.57 ± 0.15	2.00 ± 1.00	1.67 ± 0.19	1.00	1.33 ± 0.21	–	–
Lesser kudu	1.25 ± 0.25	–	1.50 ± 0.50	–	1.00	1.00	–
Maasai giraffe	6.22 ± 0.62	6.33 ± 1.86	6.25 ± 0.66	13.00 ± 10.07	5.72 ± 0.75	6.43 ± 2.27	–
Thomson’s gazelle	5.65 ± 0.66	1.22	2.00	1.50 ± 0.50	7.59 ± 2.35	5.49 ± 0.68	3.00
Yellow baboon	10.40 ± 2.96	1.00	–	17.00	12.40 ± 5.21	11.50 ± 1.50	1.00
All wildlife	9.52 ± 0.26	9.12 ± 1.82	6.17 ± 0.55	5.48 ± 1.02	7.36 ± 0.35	11.60 ± 0.43	7.40 ± 1.91
Cattle	88.48 ± 4.80	–	24.57 ± 4.15	29.00 ± 6.00	60.92 ± 8.58	111.31 ± 5.91	24.55 ± 0.55
Donkeys	4.21 ± 0.79	–	2.00	–	3.75 ± 0.95	4.67 ± 1.14	–
Shoats	84.06 ± 6.95	–	–	–	66.05 ± 8.79	102.53 ± 10.10	–
All livestock	89.66 ± 4.81	–	24.86 ± 3.99	29.00 ± 12.97	62.71 ± 5.59	114.25 ± 5.42	24.55 ± 7.40

Note: African civet, African elephant, African wild dog, black-backed jackal, common waterbuck, golden jackal, oribi, spotted hyena, swamp cat, and topi were all observed four times or less and were therefore not included as a commonly sighted animal.

sightings (Table 7) of wildlife species was dependent on habitat type (χ^2 = 381.519, df = 24, p < 0.001). Grassland habitats supported the greatest number (Table 7) of common wildlife mammals (65.6%), followed by open shrubland habitats (25.0%), dense shrubland habitats (5.8%), dense bushland habitats (1.7%), open bushland habitats (1.2%), wetland habitats (0.6%), and open woodland habitats (0.1%). The

Table 7. Total number of common large mammal wildlife species seen* in different habitats in Mbirikani group ranch.

Wildlife Species	Grassland	Open bushland	Dense bushland	Open shrubland	Dense shrubland	Open woodland	Wetland	Number (and %) and frequency (and %)
Coke's hartebeest	36 (14)	0 (0)	8 (1)	13 (5)	0 (0)	0 (0)	0 (0)	57 (0.4); 20 (1.5)
Common eland	78 (10)	3 (1)	16 (2)	17 (6)	64 (13)	0 (0)	0 (0)	178 (1.4); 32 (2.4)
Common warthog	10 (3)	0 (0)	0 (0)	14 (4)	3 (2)	0 (0)	0 (0)	27 (0.2); 9 (.7)
Common wildebeest	4,025 (248)	5 (1)	56 (2)	578 (57)	159 (8)	0 (0)	2 (3)	4825 (36.8); 319 (23.5)
Common zebra	2,747 (204)	29 (4)	17 (0)	1,048 (108)	158 (14)	0 (0)	69 (8)	4068 (30.5); 338 (24.9)
Fringe-eared oryx	47 (12)	0 (0)	5 (3)	77 (9)	40 (4)	0 (0)	0 (0)	169 (1.3); 28 (2.1)
Gerenuk	40 (13)	20 (6)	0 (0)	136 (42)	46 (13)	0 (0)	0 (0)	242 (1.8); 74 (5.5)
Grant's gazelle	1,032 (528)	33 (7)	11 (2)	838 (117)	25 (10)	0 (0)	0 (0)	1939 (14.8); 264 (19.4)
Impala	15 (3)	8 (2)	90 (4)	95 (16)	115 (22)	0 (0)	0 (0)	323 (2.5); 47 (3.5)
Kirk's dik dik	0 (0)	1 (1)	4 (2)	8 (6)	20 (12)	0 (0)	0 (0)	33 (0.3); 21 (1.5)
Maasai giraffe	45 (7)	39 (3)	19 (3)	263 (46)	125 (20)	15 (1)	0 (0)	506 (3.9); 80 (5.9)
Thomson's gazelle	511(94)	3 (2)	2 (1)	129 (17)	2 (1)	0 (0)	3 (1)	650 (5.0); 116 (8.5)
Yellow baboon	23 (2)	17 (1)	0 (0)	62 (5)	1(1)	0 (0)	1 (1)	104 (0.8); 10 (0.7)
Total number (and frequency	8, 609 (738)	158 (28)	228 (20)	3,278 (438)	758 (120)	15 (1)	75 (13)	13,121 (1,358)
Percent (%) of number (and frequency)	65.6 (54.3)	1.2 (2.1)	1.7 (1.5)	25.0 (32.3)	5.8 (8.8)	0.1 (0.1)	0.6 (1.0)	-----

Note: African civet, African elephant, black-backed jackal, African wild dog, golden jackal, lesser kudu, oribi, reedbuck, spotted hyena, swamp cat, topi, waterbuck, and Vervet monkey were all seen very few times and are therefore not included.

abundance (in numbers) of the wildlife species seen was also dependent on habitat type (χ^2 = 4748.348, df = 24, p < 0.001).

DISCUSSION

Protected areas for wildlife conservation without their dispersal areas are becoming ecologically unsustainable islands surrounded by incompatible land uses (Morell, 1996; Western, 1997; Okello and Kiringe, 2004). It is the local people that live on the land that will decide the fate of wildlife conservation (Western, 1982). In order to make a living, the local people in most third world countries, often poor and impoverished, will do what it takes to survive. Therefore, local communities in Amboseli area are increasingly replacing wildlife with livestock and agriculture which have a direct economic value to them (Berger, 1993; Norton – Griffiths and Southey, 1995; Norton – Griffiths, 1996). Money that accrues from wildlife – based tourism benefits mostly the government exchequer, the elitist tourism investors and stakeholders and investors, but significantly less to the local people (Gakahu and Goode, 1992).

If wildlife could be economically useful to local communities, it would gain value and be acceptable for local people to be expected to protect them. Since the government owns wildlife in Kenya, people do not view it as their resource, but as a government property. They view wildlife as enemies from whom they should be protected from. As long as people see wildlife as a competitor for the increasingly limited land and its resources without marching significant benefits, conservation cannot prevail (Sibanda, 1996; Nicholson, 2001; Ogolla and Mugabe, 1996). This partly explains agriculture's rapid expansion and popularity in the Amboseli area (Okello, 2005). The desire for the Maasai to diversify income from the increasingly expensive, uneconomical and unpredictable pastoralism is another strong reason for agriculture expansion

Many Maasai in Amboseli area now believe that agriculture is more productive than pastoralism or wildlife conservation as a land use, however unprofitable or unsustainable it may be. It is for this reason that the majority of people in Amboseli Ecosystem have switched from traditional pastoralists to mixed agro-pastoralism (Pickard, 1998; Campbell et al., 2000; Okello, 2005). Even though the Maasai in this area believe that agricultural expansion is taking away livestock and pastoral lands in the group ranch, but they do not necessarily see it as a problem (Okello, 2005). This is because agriculture reduces their dependence on pastoralism as a source of food, and is mostly confined within the electric fences, along the fertile riverine habitats where wildlife – related damages are minimized, and they use rivers to irrigate their crops throughout the year.

But agriculture is mostly incompatible land uses to the ecology of the Amboseli Area. It heavily relies on irrigation from the few rivers available, thereby affecting water flow and volume in rivers. Agriculture is also leading to rapid conversion of critical wetlands (such as Kimana and Ilchalalai swamps) used by both livestock and wildlife foraging especially in the dry season (and drought) when pasture is limited. This is destroying these rare and critical habitats in the ecosystem and also affecting human use of critical resources (plants, ethno – botanical resources, drinking and domestic water use, and water for livestock) found in these habitats.

Irrigated agriculture poses many direct (habitat loss, pollution from fertilizers and pesticides) and indirect threats (competition for water, human – human conflicts, human – wildlife conflicts) to wildlife conservation in the area. In the area, most rivers are now dry downstream, with diversion of main rivers occurring within a quarter of their causeway from the river sources. This diversion of sometimes entire rivers upstream is not only illegal (but is never enforced by ministry of water resources or National Environmental Management Authority, NEMA) but also denies the majority of people, livestock and wildlife users downstream. This water shortage downstream affects the use of the group ranch, concentrating human activities along river causeways and encouraging degradation water sources (such as swamps, riverine habitats and springs). Irrigated agriculture uses heavy pesticides and herbicides in production of onions, tomatoes, maize and beans. Most of these chemicals percolate into the few existing river systems and are already causing further harm to water users and polluting the environment (Githaiga, 2003).

Most farming areas are also illegal bushmeat hotspots where wildlife is snared and killed for by casual cultivators who stay up late in nights guarding their crops from wildlife raiding. Active illegal killing is also an attempt to reduce the density of wildlife around farms as a way of controlling crop raiding. So even though irrigated agriculture takes a smaller portion of the group ranch, its direct and indirect effects on conservation are many. Therefore, this is possibly why wild mammals kept a longer distance from irrigated agriculture because of harassment, destruction of river nine habitats, snaring and actual harm cultivators subject them to. This has been the reason many wildlife species has been exterminated in former wildlife ranges where agriculture has been established in Kenya (Milton, 2000; Mwale, 2000), and is gradually taking root in Amboseli ecosystem.

Most permanent *bomas* were concentrated around roads and water resources, where distribution of critical resources and services influence people's settlement patterns. Permanent *bomas* and created barriers to wildlife that lead to a lasting loss of wildlife dispersal space. Temporary *bomas* are constructed out of leaves, grass, trees, mud and cow dung, and are traditionally used by the nomadic pastoralists during grazing in unsettled open rangelands. When traditional pastoralists traverse the entire group ranches, their livestock goes with them, spreading the impact of both humans and livestock in the ranch, but such effects of temporary *bomas* help diversify and fertilize the range. Therefore the impacts of temporary *bomas* are less severe and are easily reversed than permanent *bomas,* thereby displacing wildlife less. Nevertheless, this does not eliminate resource competition between livestock and wildlife especially when they occur in preferred habitats that have abundant forage, water and less inhabited by people. Most, *bomas* are also constructed in areas with good soil and drainage conditions (Lamprey and Reid, 2004), and will be abandoned if natural resources in the area declines. Therefore, temporary *bomas* may actually consume more space in the group ranch than the clustered permanent *bomas*, by moving from place to place and consuming resources for their construction more frequently.

Every wildlife species have tolerance levels of human and livestock presence (Bourn and Blench, 1999). Most zebra, wildebeest and gazelles seem to tolerate livestock and will sometimes be seen to graze side by side. However, where competition for forage occurs (like wild browsers and goats) or where livestock is accompanied by much noise and human presence (such as noisy bells hung on goats to establish the location of dispersing ones) displaces wildlife more. Cattle was the cause of the most displacement of wildlife, as cattle are bulk feeders (Bergstrom and Skarpe, 1999) and often grazed in open woodland or shrubland habitats. This may due to their large group size and feeding strategy; they compete with most wild grazers and physically displace wildlife due the noise (from numbers and cowbells) within the herd. They were also most common in dense bush/shrubland, where wildlife occurs in the largest groups outside of riverine habitats. The seasonal migration patterns and foraging strategies of wildlife and livestock are similar that their competition for pasture and water is occurring throughout the year (Berger, 1993). This suggests that there is direct competition for resources between wildlife and livestock, often leading to displacement, especially of wildlife in the dry season when forage and water are scarce (Western, 1975; Okello, 2005).

Another fragmenting land use also associated with much noise and both human and motor traffic are roads. Roads can restrict animal movement since noise and traffic can be extremely alarming to animals and add to the edge effect caused by roads. The restricted movement of animals caused by unplanned network of roads can interfere with wildlife activities such as searching for prey, mates and seeking cover thereby confining them only to ranges where they feel free and safe. In extreme cases, such fragmentation can cause local extinctions (Fahrig, 1997). The continuous soil compaction, caused mainly by vehicle weight, reduces the ability of the soil to recover because of the lack of roots anchorage (Ceballos-Lascurain, 1996). This in-turn creates an increase in surface run-off, which causes erosion and further degradation to the vegetation of the area. Herders of livestock tend to stick close to the roads of the area, which also leads to more wildlife displacement. Vehicles also displace wildlife because of potential harm in accidental deaths from vehicle traffic. The number of road kills may be less in group ranches, but may be significant on main roads that link major towns in the area and elsewhere in Kenya. Further, roads have great fragmentation effect because of their relatively huge network that keeps changing because of poor conditions. This degrades and destroys wildlife habitats and fragments the dispersal areas which may not be useful, even if available.

In Mbirikani group ranch, roads only took up a small actual area of the group ranch, but displaced wildlife the most out of any human infrastructure due to the noise, danger and traffic. The construction of the road network in Mbirikani effectively split the group ranch into six fragmented sections. As the population grows in the group ranches, it is likely that the traffic and noise produced by the roads will also increase further displacing wildlife. If this occurs, the wildlife populations in the group ranch will not be able disperse across Mbirikani, but will return to protected areas of origin, effectively blocking movements between the protected areas. It is important that no more roads are constructed in such a way as to prevent any further truncation of the ecosystem.

Wildlife requires quality habitat and space in order to thrive (Bolen and Robinson, 1999). Range requirements by wildlife include food, proper cover or room to flee and opportunities for reproduction and nurturing of young (Heady and Heady, 1982). Habitats that are heterogeneous and offer many of these will be used more by wildlife. In this study, riverine habitats had few animals because they were in areas of high agriculture and human concentration. Some primates (such as sykes and baboons) prefer this area, but can also be drawn to them for crop raiding or gathering what agriculture produce is left behind after harvesting crops. This intensifies human – wildlife conflicts and can lead to intense persecution and even permanent displacement of wildlife (Siex and Struhsaker, 1999; Hoare and Du Toit, 1999). Open woodland / shrubland offer heterogeneity in terms of browse, grass and cover (thermal, escape and nesting) and hence supported a higher diversity of animals. Grasslands, however, may support large group sizes due to large herd grouping patterns of most plain grazers such as zebra, wildebeests and gazelles (Estes, 1997).

The abundance and frequency of sightings of wildlife were all dependent on habitat type. This could be either because of habitat visibility differences, the time of the day, or simply because certain species prefered certain habitats. For example, animals such as the arboreal sykes monkey (*Cercopithecus mitis*) can only be found in riverine habitats (Estes, 1997) where they feed on fruits and leaves (Estes, 1997). This means that the integrity of certain habitats (especially open wooded or open shrublands, and riverine habitats) is very critical for wildlife viability in dispersal areas. The dispersal areas should offer quality diverse habitats with sufficient supply of shelter, cover, forage and water to remain useful to dispersing wildlife. Otherwise even if the dispersal space is available but the quality of the dispersal areas or migration corridors is low (due to livestock overgrazing, depletion of plant cover by humans or fragmentation by roads and settlements) or unsafe for wildlife, they will not be used (Fahriq, 1997), and the effect will be the same as if the dispersal area and migration corridors had been blocked or converted to alternative uses (Newmark, 1996).

There is indeed a possibility that individual landowners may merge their land into large blocks of land for access to sufficient pasture and water especially in dry season and prolonged droughts. These actions may potentially restore land back to dispersing wildlife. Land owners in known critical wildlife migration routes can be encouraged to begin ecotourism ventures to benefit from wildlife on their land, or they negotiate with conservation NGO's and government agencies to maintain landscapes for pastoralism and wildlife conservation at a concession fee or economic easement programs (Ferraro and Kiss, 2000). This might be easier because negotiations will be with known legal land owners who can easily enter into contracts and reach agreements unlike the current complex management regime where sometimes consensus is difficult to reach and benefits are not distributed equitably among group ranch members (Lichtenfeld, 1998). Therefore group ranch sub – division poses both challenges as well as opportunities for maintaining dispersal areas and migration routes for wildlife.

Even though most of the group ranch is still available for wildlife and livestock in Mbirikani Group Ranch, the spatial placement of the eight clusters in the group ranch has greatly affected the dispersal corridors, and the movement of wildlife. Human settlements tend to concentrate around water resources, which are a scarce resource in the dryland ecosystem (Githaiga et al., 2003). Settlements are also found along the main road from Loitokitok to Emali, and along the pipeline road between Inkisajani and Mbirikani markets that follows the water pipeline to Nairobi (Campbell et al., 2003a). Only nine potential routes were still open for wildlife dispersal (Figure 6). However, these dispersal routes have not been assessed ecologically, for adequate water and forage resources. If the ecological conditions in these areas are poor, the potential routes could be detrimental rather than beneficial to wildlife populations in the area. As immigration and population continue to grow (Thompson and Homewood, 2002), development in the group ranch will expand, further reducing the space available to wildlife. The migration gap left open along the main pipeline road may eventually close and seal off the east-west migration routes that link the Chyulu Hills to Amboseli national park, thus effectively ending migration between the two parks. As Amboseli is too small to support the wildlife populations on its own, species will suffer and possibly go extinct. The ecological integrity of Mbirikani group ranch is critical for the success of wildlife in the region, as the group ranch provides the most direct route for wildlife from Amboseli National Park to Tsavo national park. But the amount of development in the group ranch has cut off wildlife from critical resources. The Namelok, Kimana Swamp-Esambu, and Ilchalai Swamp-Esambu clusters on the southeast end of Mbirikani effectively sealed off the swamps from wildlife, depriving the migrating animals a source of water. These clusters both cut off the swamps and the migration route to the Kimana community wildlife sanctuary, an important dry season grazing and resident area for wildlife. Since water is the limiting factor on the amount of wildlife and livestock that Mbirikani group ranch can support, the loss of swampland habitats will eventually be highly detrimental to the success of many species in the group ranch. The presence of water-independent species such as the eland (*Taurotragus oryx*), fringe-eared oryx (*Oryx beisa callotis*), and gerenuk (*Litocranius walleri*) demonstrate that there were wildlife in the region that are adapted to low water availability, but most species still need access to water resource in order to survive.

Conclusion

The Maasai wildlife dispersal areas between Amboseli and Tsavo parks need a well-defined land use plan that will guide establishment of new agriculture areas, areas of new settlement, markets centers and cluster growth and use of water resources. Collaborative initiatives and consensus building is needed to achieve this. New human activities should be confined within existing clusters, while trying to control expansion into existing wildlife migration routes and key dispersal areas. The spread of agriculture, especially irrigated, needs to be strictly monitored because of the drastic effects it has on the environment. The riverine habitats are essential to the wildlife (also man and livestock) that is dependent on its water resources. The amount of water that farmers can extract from a river should be limited for the protection of wildlife habitats as well as access to water downstream by wildlife, humans and livestock.

More work is needed to establish the exact displacement effects of human structures and activities to wildlife. While this work considers the average distance as an index of such displacement, such distance may be affected by other factors such as habitat quality, animal density and distribution and season of the work. It may be important to evaluate such distances in relation to habitat and distribution variations so as to establish the actual additional displacement of human structures and activities. Further, use of the land may differ between day and night. It is likely that wildlife is less affected at night by human activities and therefore uses a much wider area than that deemed to be displaced. Nevertheless, it's an important first step to addressing wildlife displacement apart from actual area taken away from wildlife as dispersal area.

Another conservation option is to have the identified viable and critical corridors recognized and established (Figure 6). This would involve negotiations with blocks of land owners (where subdivision has already taken place) or group ranch leadership (where land is still under communal ownership) through a lease or compensation program (Ferraro and Kiss, 2000; Galaty, 1992; Hackel, 1999; Alpert 1996; McNeely, 1993; Newmark, 1993; Newmark, 1996; Newmark and Hough, 2000; Western, 1994) from a conservation fund established by stakeholders. Such land would be available for wildlife as priority, but may be used for pastoralism during droughts or long dry season. The other option is to encourage landowners to pool together land (as seems to be now happening) and form privately owned wildlife sanctuaries to tap into the lucrative tourism industry in the area. This would also bring direct benefits from conservation (through establishment of campsites or leasing to ecotourism investors, and money going to known landowners). Such land would also be used sustainably for pastoralism with owners' deliberately reducing livestock stocking density, and ensuring habitat quality and diversity for wildlife. Such private conservation areas would expand range and dispersal area for wildlife from the nearby protected areas as well as economic benefits (Ferraro and Kiss, 2000; Lado, 1992; Lamphry, 2004; Soule' et al 1979), but will have to still be linked to each other by viable corridors and migration routes.

It is apparent, therefore, that it is not only the area of human structures and activities that take away from wildlife in key critical dispersal areas, but also the spatial arrangement and orientation of these structures and activities. Mbirikani group ranch may have most of the wildlife dispersal area still available, but the spatial proximity and orientation clearly block direct wildlife movements and dispersal between the protected areas. The threat is therefore both from the proximity of clustered settlements, the area taken away and the orientation of these clusters.

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