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Contraction of Wildlife Dispersal Area and Displacement by Human Activities in Kimana Group Ranch Near Amboseli National Park, Kenya

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Abstract: Kimana Group Ranch area is a critical area for Amboseli, Chyulu, Tsavo West national parks, and community sanctuaries in the Tsavo – Amboseli Ecosystem. However, growing human populations and associated activities are causing range contraction and wildlife displacement in this dispersal area. This study investigated the contraction of wildlife dispersal area through field mapping and spatial analysis. Human activities displaced wildlife from 140.01 km² (55.74%) of KGR, leaving only about 44% of the land for wildlife. The actual area occupied by these activities was 57.83 km^2 (23% of KGR). Wildlife kept 0.23 ± 0.04 km from Maasai homes, 0.18 ± 0.02 km from roads, 0.07 ± 0.04 km from electric fences, and 0.21 ± 0.02 km from livestock. No wildlife was seen close to agricultural areas, which covered 0.89 km^2, 0.27%. Kimana and Namelok electric fences covered 52.98 km² (21.10%), but displaced wildlife from 69.29 km² (27.61%). Although Maasai homes covered only 0.24 km² (1.09%), they displaced wildlife from 28.11 km² (11.19%). Spatially, clusters of human activities were cutting off Amboseli and KCWS, forcing the wildlife to find alternative routes with Tsavo / Chyulu. Therefore, Kimana is diminishing as wildlife dispersal area and this will affect the viability of protected areas.

Keywords: Corridors, Kenya, Kimana Group Ranch, Tsavo-Amboseli ecosystem, Wildlife dispersal areas, Wildlife displacement.

INTRODUCTION

Insularization of protected areas and habitat fragmentation lead to the extinction of species, directly reducing biodiversity [1-3]. Isolation reduces the effective size of an area by limiting movement of species and causing faunal relaxation [4]. If the protected areas have no dispersal areas, genetic drift and inbreeding may occur, leading to population instability, loss of ecological integrity and possibly local extinction [5]. Isolation can be caused by various factors such as roads or fences, areas of agriculture or dense human population [6].

The threat of biodiversity loss is an eminent one for East African protected areas as they become increasingly insularized by the growing human population in surrounding areas outside protected areas, human activities such as settlement, agricultural cultivation, and active elimination of wildlife on land adjacent to parks [6, 7]. In the Amboseli area, attributes associated with rapid population growth and land use changes threaten to completely isolate protected areas from each other [7]. It is likely that protected areas will lose a significant proportion of their large mammal fauna if they become completely insularized [10].

But the frequency of human wildlife conflict can be inversely related to human density and land use changes on lands adjacent to protected areas [8]. Also human population density has been a major indicator and predictor of large mammal local extinctions. An increase in human population and human associated activities decreases wildlife population space and dispersal and leads to an increase in human – wildlife conflicts [9]. These human-wildlife conflicts create frustration and animosity towards wildlife and may result in retaliation killings [7, 10].

This study aimed to establish the contraction of Kimana Group Ranch (KGR) as a wildlife dispersal space. The specific objectives were to:

i) Determine what human structures and activities reduce dispersal area in KGR.

ii) Determine spatial location and distribution of these human structures and activities and implications for wildlife dispersal.

iii) Determine displacement effects of these human structures and activities, including livestock presence on wild mammals

iv) Explore potential mitigation measures and the way forward for conservation in this critical dispersal area.

THE STUDY AREA

Kimana Group Ranch (KGR) is located in the Tsavo – Amboseli Ecosystem (Fig. **1**). KGR is 251 km^2 in area. The group ranch supports free ranging wildlife. Therefore, Kimana Community Wildlife Sanctuary (KCWS) was established by the community in 1996 [11]. It provides a dry season concentration area just like Amboseli Park [12].

Amboseli National Park was designated as a national game reserve in 1948 with an area of 3260 km2, and managed by local Kajiado County Council. However, the mismanagement of the park (loss of revenue and overgrazing by Maasai cattle) led the government to designate a small

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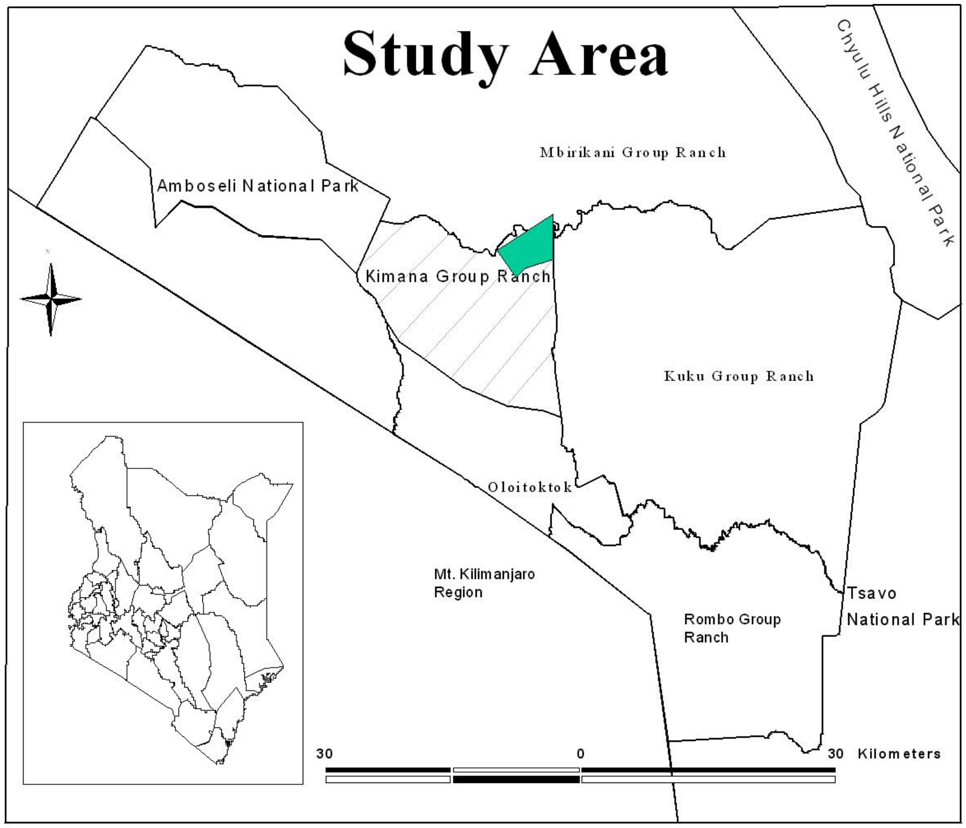

Fig. (1). The six group ranches between Amboseli National Park and Tsavo / Chyulu Parks form critical wildife dispersal areas and migration routes between protected areas. Chyulu / Tsavo West Natonal Parks are to the east of Mbirikani and Kuku Group Ranches.

area of 392 km^2 as a national park in 1974, and the rest of the area given to Maasai for settlement and pastoralism. This is the land comprised of the six group ranches and which is communally owned by the Maasai. Because Amboseli National Park is not fenced, Maasai communal lands around Amboseli are critical as mainly wet season dispersal area for Amboseli National Park. This land is not just a dispersal area for wildlife, but have resident wildlife herds which share water, space and pasture with Maasai cattle throughout the year [12].

Amboseli Area is a semi-arid and arid rangeland with a bimodal rainfall, as it occurs in the rain shadow of Mt. Kilimanjaro. Long rains occur from March to early June and the short rains occur in October and November. KGR receives 210 mm annually, with 30% received during the short rains and 45% in the long rains [13].

The Kimana rangeland has dense and open shrubland, bushland, and woodland habitats. The dominant vegetation in the riverine habitat is *Acacia xanthophloea* and the drier regions are dominated by *Acacia tortillis* and *Acacia mellifera* (Irigia, 1995). Soils are shallow but fertile volcanic, and are saline and alkaline. Only swamps and riverine areas are suitable for agriculture while the entire range is suitable for wildlife and pastoralism [14].

METHODS AND MATERIALS

Spatial location, area and wildlife displacement effects were assessed for Maasai homesteads (*bomas*), roads, markets, electric fences, public institutions, and agriculture. Research was done in two wet season (the first in November 2004 and the second in April 2005) when wildlife is dispersing in group ranches.

Wildlife Sightings in Relation to Human Activities and Livestock

All wild large mammals (larger than a Kirk's Dik-dik *Madoqua kirkii*, and all primates) in KGR outside electric fences and close to human structures / activities were mapped whenever they were sighted. Once wildlife was spotted, their exact location was recorded using Global Positioning Systems (GPS, Version III Plus, Germin Corporation, 1999). Further, the species, number of individuals in each group, and general habitat type (open grassland, Open woodland / shrubland, dense woodland / shrubland, and riverine) were noted. The distance to livestock and any human structure / activity nearby was recorded using a rangefinder (Bushnell® Laser Rangefinder, Yardage Pro™ 400, Bushnell Corporation USA). This distance that wildlife kept away from human structures / activities was regarded as an index of the "displacement effect".

Spatial Locations of Human Structures / Activities

Maasai homesteads (bomas), public institutions, electric fences, market centers, Kimana Community Wildlife Sanctuary (KCWS) and agricultural fields were mapped using a GPS. To obtain the location and dimensions of human structure / activities, GPS points were taken at central and along the perimeter. Multiple GPS coordinates along the perimeter were taken always for larger structures / activities.

For markets, all facilities (shops, social areas, and residential areas) associated with market were considered part of the market infrastructure. After mapping, areas close by were scanned by standard binocular to spot any large wild mammals (including primates) present and distance from human structures / activities.

Road Network and Area Mapping

To establish location and area of roads, GPS points were taken every one kilometer along main roads, and every half kilometer on minor or feeder roads, and at every curve of more than 30^0. All roads in Kimana Group Ranch were mapped. The length of each road segment was determined with a vehicle odometer, while the width was recorded at every GPS point using tape measure or a rangefinder.

Every road segment was noted as main, minor or feeder roads. The name of the road from places being linked was given. The mean widths and total length was used to compute the area and road network. The entire road reserve was included in width determination. Further, along the roads during this work, surrounding areas were scanned for large wild mammals (including primates) present and distance from the road.

Data Analysis

The network and average area covered by all human structures / activities were calculated from measured parameters (radius, lengths and widths) using standard arithmetic techniques. All Global Positioning System (GPS) coordinates were entered into a Geographical Information System (GIS) Using ARC - View® software (Version 3.3, Environmental Systems Research Institute, Inc., 2000 for spatial analysis and generation of maps.

An average distance of each large mammal species to livestock and human activities / structures was determined. This distance was added on measured parameters (radius, length, widths) of human structures / activities to estimate the area of wildlife displacement for that activity / structure. The displacement area was first determined for each unit (such as a single boma, road type, fence) and then for total units of that activity / structure (such as total bomas, fences, agriculture etc).

RESULTS

Area and Wildlife Displacement by Livestock and Human Structures / Activities

All human structures and activities displaced wildlife (actual and displacement area) from a total area of 140.01 km² (55.74%), leaving about 44% of KGR available for wildlife and livestock (Table **1**). However, only 57.83 km^2 (about 23%) was actually taken by all human activities /structures. Public institutions covered a small actual area, but displaced wildlife from a total of 5.2 km² (2.07%) with a

Table 1. Actual Area Occupied by Human Structures as well as Associated Wildlife Displacement Area in Kimana Group Ranch

Human Structures and Activities in Kimana Group Ranch	Perimeter (km)	Area of KGR Actually Taken (km^2)	Proportion (%) of Total KGR Area	Area of KGR Actually Taken Inclusive of Wildlife Displacement Area (km^2)	Proportion (%) of Total KGR Inclusive of Wildlife Displacement Area
Amboseli Sopa Lodge	3.02	0.11	0.04	5.2 (all institutions together)	2.07 (All institutions together)
SFS Center for Wildlife Management Studies	1.52	0.14	0.06		
Kimana Secondary school	1.67	0.14	0.06		
Commercial Cultural *Manyattas* (three at Amboseli, Sopa Lodge and KCWS)	0.5	0.03	0.01		
Churches	6.21	0.19	0.08		
Schools	4.28	0.28	0.11		
Government offices	2.08	0.12	0.05		
Bomas	-	0.24	1.09	28.11	11.19
Agriculture	-	0.69	0.27	No wildlife sighted closer	-
Other Institutions	0.37	0.002	0.0006	-	-
Electric Fences	-	52.98	21.10	69.29	27.61
TOTAL of all human structures and activities	-	57.83[1]	23.02	140.01	55.74
Kimana Community Wildlife Sanctuary (KCWS)	21.85	24.04	9.57	-	-

[1]Adjustment to areas was done to eliminate double counting for structures and activities within electric fences. No wildlife was therefore seen in human activities enclosed within electric fences (markets, institutions). No wildlife was seen close to agriculture found outside electric fences.

Table 2. Area of Roads and Electric Fences Including Wildlife Displacement Effect in Kimana Group Ranch

Type of Road (all were Marrum Roads)	Total Length (km)	Average Width (km)	Total Area (km^2)	Percentage (%) of Group Ranch	Road Area and Displacement (km^2)	Percentage (%) of Group Ranch with Displacement
Isinet - Kimana main road	16.28	0.019	0.30	0.12	3.06	1.22
Amboseli road (off main Kimana – Oloitoktok road)	21.60	0.008	0.18	0.07	3.84	1.53
Major roads	113.58	0.008	0.94	0.37	20.20	8.04
Feeder roads	67.74	0.004	0.27	0.10	11.11	3.00
Total	**219.20**	**0.010**	**1.69**	**0.47**	**38.22**	**13.79**
The electric fence location	Perimeter (km)		Area (km^2)	Percentage (%) of KGR	Displacement area (km^2)	Displacement Percentage (%) of KGR
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**	**21.10**	**69.29**	**27.61**

*Area and perimeter within Kimana Group Ranch. Total Namelok Fence was 18.11 km^2 and total perimeter was 21.15 km as covers part of Mbirikani and Ololorashi group ranch.

0.18 ± 0.06 km of wildlife displacement distance (Table **3**). *Bomas* also took a small total actual area (0.24 km², 1.09%), but the area increased to 28.11 km² (11.19%) for wildlife displacement, and a displacement distance of 0.23 ± 0.04 km.

Kimana Community Wildlife Sanctuary had the largest area (24.04 km^2, 9.57%) of community / public institutions within the group ranch (Table **1**). Besides KCWS, only 34.89% of land available after wildlife displacement effects, but about 67.43% of KGR assuming no additional wildlife displacement.

Roads had a network of 219 kilometers (Table **2**) and covered an actual area of 1.69 km² (0 .47% of KGR). But this area increased to a wildlife displacement area of 38.22 km² (13.79%). Wildlife kept off roads an average distance of 0.18 ± 0.02 (Table **3**), with the Maasai giraffe (*Giraffa camelopardalis)* keeping off further (0.19 ± 0.05km) but the African elephant (*Loxodonta africana)* the least (0.17 ± 0.05 km).

The electric fences covered the largest total actual area (52.98 km^2, 21.09%) in KGR (Table **1**). This area increased to a wildlife displacement area of 69.29 km^2 (27.58%), with displacement distance of 0.07 ± 0.04 km (Table **3**). Kimana fence had an actual area of 42.39 km^2 (16.88%) but a displacement area of 53.07 km^2 (21.12%), while Namelok had an actual area of 10.59 km^2 (4.22%) but a displacement area of 16.22 km^2 (6.46%).

Markets covered only 0.58 km^2 (0.23%), with the two largest markets: Kimana (0.48 km^2, 0.19%) and Namelok (0.06 km^2, 0.02%) being the main markets (Table **3**). The majority of institutions and markets were inside Kimana and Namelok electric fences. Therefore, no wildlife was sighted closer to markets and most institutions. Similarly, agriculture was mainly located inside the electric fences, with a very small proportion outside the fence (0.89 km^2 (0.27%). No wildlife was sighted in close proximity to these agricultural areas.

The displacement of wildlife by livestock was 0.21 ± 0.02 km. Shoats (sheep and goats together) displaced wildlife the most (0.20 ±0.03 km). Cattle displaced wildlife next (0.18 ± 0.03 km), but donkeys the least (0.05 ±0.03 km).

Spatial Relationships of Human Structures and Activities and Wildlife

Most human structures /activities clustered mostly inside and around electric fences, and associated with roads, rivers and market centers (Fig. **2**). However, wildlife was distributed all across the group ranch, but had higher numbers closer to protected areas, water sources and areas without or with little human activities / structures (Fig. **2**).

Spatially, human structures and activities seemed to occur in clusters and were blocking the south western wildlife entry into KCWS. Electric fences run longitudinally in a north – south direction, thereby preventing most wildlife access to Kimana Sanctuary (Fig. **3**). There were only five kilometers between the two fences at the entry to KCWS. The southern boundary of KCWS was blocked almost completely by Kimana fence, and about half of the western boundary by Namelok fence. The remaining corridor between Namelok fence and *boma* clusters was 1.82 km, and only 111.75 meters between *boma* clusters and Kimana fence near KCWS (Fig. **2**).

DISCUSSIONS AND CONCLUSIONS

The threat to wildlife dispersal areas and corridors in Kimana is both spatial and actual area taken by human activities. Over half of KGR been taken over by human structures, and wildlife greatly displaced by especially *bomas*, roads, electric fences and agriculture. The fact that we could not see any wildlife close to agricultural areas is evidence for agriculture's high wildlife displacement potential [15]. People persecute wildlife to push them away from farms to reduce crop raiding. Further, the people who farm spend lots of energy guarding their crops day and night using noise, fire and other crude weapons which further scare, intimidate and displace wildlife. Many farm attendants

Table 3. 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[1] 0.16 ± 0.05[2] **0.17 ± 0.05[3]**	0.40 ± 0.06[1]	0.09±0.03[1] 0.25*[2]	0.40*[1]	0.075*[1]	-	0.24 ± 0.05 0.20 ± 0.07 **0.17 ± 0.05**
Bat-eared Fox (*Otocyon megalotis*)	0.08*[1]	-	-	-	-	-	**0.08*[1]**
Black-backed Jackal (*Canis mesomelas*)	0.01*[2]	-	-	-	-	-	**0.01*[2]**
Common Duiker (*Sylvicapra grimmia*)	0.004*[1]	-	-	-	-	-	**0.004*[1]**
Common Eland (*Tragelaphus oryx*)	0.04 ± 0.02[1]	0.01*[1]	-	0.5*[2]	0.20*[1]	-	**0.19 ± 0.11**
Grant's Gazelle (*Gazella granti*)	0.11 ± 0.02 0.22 ± 0.10 **0.15 ± 0.03**	0.24±0.16[1]	0.25*[1]	0.14 ± 0.04 0.25 ± 0.06 **0.19 ± 0.04**	0.20*[1]	0.17±0.07[1]	0.14 ± 0.02 0.26 ± 0.02 **0.24 ± 0.05**
Impala (*Aepyceros melampus*)	0.07 ± 0.01 0.24 ± 0.12 **0.13 ± 0.05**	0.40*[1]	0.28 ± 0.11[1]	0.10* 0.19 ± 0.04 **0.18 ± 0.04**	0.002 ± 0.25[1]	0.10*[1]	0.13 ± 0.03 0.22 ± 0.02 **0.22 ± 0.006**
Kirk's Dik-dik (*Madoqua kirkii*)	0.03 ± 0.01 0.04 ± 0.02 **0.03 ± 0.009**	0.13±0.09[1]	0.42 ± 0.09[1]	0.45 ± 0.18 0.20* **0.13 ± 0.08**	0.41 ± 0.20[1]	-	0.09 ± 0.03 0.12 ± 0.08 **0.08 ± 0.04**
Maasai Giraffe (*Giraffa camelopardalis*)	0.13 ± 0.03 0.24 ± 0.06 **0.19 ± 0.05**	1.80±0.70[1]	0.17 ± 0.14[1]	0.14 ± 0.07 0.31 ± 0.17 **0.25 ± 0.12**	-	0.25*[1]	0.26 ± 0.09 0.28 ± 0.04 **0.27 ± 0.07**
Plains Zebra (*Equus burchelli*)	0.02 ± 0.01 0.19 ± 0.05 **0.13 ± 0.02**	0.05±0.05[1]	0.01* 0.01* **0.22 ±0.08**	0.005* 0.25 ± 0.05 **0.22 ± 0.04**	0.008± 0.003[1]	0.01 ±0.008[1]	0.02 ± 0.01 0.16 ± 0.05 **0.20 ± 0.03**
Savanna Baboon *(Papio cynocephalus)*	0.11 ± 0.02[1]	0.73±0.59[1]	0.23 ± 0.05[1]	0.16± 0.02[1]	-	0.15±0.03[1]	**0.18 ± 0.05**
Sykes Monkey *(Cercopithecus mitis)*	0.03*[1]	-	-	0.005*[1]	-	0.005*[1]	**0.01 ± 0.01**
Thomson's Gazelle (*Gazella thomsonii*)	0.09 ± 0.02 0.19 ± 0.13 **0.13 ± 0.04**	0.17 ± 0.16 0.01 ± 0.07 **0.11 ± 0.10**	0.17 ±0.03 0.35 ±0.07 **0.25 ±0.05**	0.32 ± 0.02 0.17 ± 0.40 **0.21 ± 0.05**	-	0.42± 0.08[1]	0.15 ± 0.03 0.18 ± 0.07 **0.18 ± 0.06**
Vervet Monkey (*Cercopithecus aethiops*)	0.04 ± 0.02 0.08 ± 0.04 **0.06 ± 0.02**	0.025*[1]	0.14 ±0.03 0.45 ±0.05 **0.21 ±0.06**	0.18 ± 0.09 0.06 ± 0.04 **0.13 ± 0.07**	0.30±0.20[1]	0.07 ±0.04[1]	0.10 ± 0.02 0.20 ± 0.13 **0.14 ± 0.05**
Total Wildlife Displacement	0.08 ± 0.007[1] 0.17 ± 0.02[2] **0.18 ± 0.02[3]**	0.44 ± 0.15 0.008 ± 0.07 **0.07 ± 0.04**	0.17 ±0.02 0.31 ±0.07 **0.23 ±0.04**	0.17 ± 0.03 0.22 ± 0.03 **0.21 ± 0.02**	**0.18 ±0.06[1]**	0.10 ± 0.03 0.25 ± 0.05 **0.20 ± 0.05**	0.14 ± 0.02 0.20 ± 0.02 **0.19 ± 0.01**

*Indicates that there was only one sample for that category.
[1]November 2004, [2]April 2005, [3]Average (in bold), respectively.

from over–utilization of plant resources around bomas [16] that degrade and reduce wildlife habitat quality. Further, various activities associated with *bomas* such as livestock grazing, human presence, children playing noisily and even smoke emission from cooking also displace wildlife. This is also especially threatening to wildlife because the density of bomas will inevitably increase with the increasing human population. As more adults leave to establish new *bomas* to make room for new families, the number of bomas in the group ranch will inevitably increase, further displacing wildlife.

In a similar way, roads displaced wildlife because of their collective destruction of habitat in road network as well as noise and potential harm in accidental and deliberate deaths from vehicle and human traffic. Roads also have great fragmentation effect because of their relatively huge network that keep changing because of poor conditions. This degrades and destroys wildlife habitats and fragments the dispersal areas which may not be useful, even if available.

Livestock contribute to wildlife displacement through competition for resources and space. Sheep and goats were the cause of the most displacement of wildlife. This may be due to their large group size and feeding strategy; they compete with both wild grazers and browsers. Further, the seasonal migration patterns and foraging strategies of wildlife and livestock are similar such that their competition for pasture and water occurs throughout the year [17]. This suggests that there is direct competition for resources between wildlife and livestock, often leading to intense human – wildlife conflicts [18] displacement of wildlife, especially in the dry season when forage and water are scarce [7, 19].

Confining human structures / activities inside the electric fences may be a useful strategy to contain expansion of human settlements to one location where wildlife has already been displaced anyway. The problem with this is that it is not consistent with the Maasai's pastoral lifestyle, and the land inside the fence can not support all people, and has already been subdivided into individual ownership [20, 21]. However, most of the land outside the electric fence can still have defined land uses in a comprehensive integrated plan with neighboring wildlife protected areas that will incorporate people, livestock and wildlife. The challenge with this approach is lack of efficient and effective legal instruments and institutions for enforcement, especially in regards to environmental management.

The second option would be to have the remaining identified functional corridors, especially used by keystone and long raining species such as the elephant [22] and negotiate 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 [23] 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 seasons.

The third option is to encourage landowners to pool together land (as seems to be now happening) and form communal and 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 [23], but will have to still be linked to each other by viable corridors and migration routes to avoid insularization.

In conclusion, similar work should be in other group ranches surrounding Amboseli National Park to establish both area and spatial orientation threats of human activities on wildlife movements. This will provide information for critical conservation action and monitoring purposes. Stakeholders and government should now urgently initiate conservation programs to address land use changes and potential impacts to wildlife dispersal in the area.

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