KENYA WILDLIFE SERVICE

Wet Season Aerial Count of Large Herbivores in Masai Mara National Reserve and the Adjacent Community Areas

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1.0 Executive summary

The wet season Mara aerial wildlife census was conducted from 6th to 12th June 2010. The survey covered an area of 4,713km², as part of the long-term annual ecological monitoring, aerial census undertaken since 1984. The survey was conducted using a Cessna 4 seater air craft at a 1km grid flight line assuming an east-west orientation.

A total of 3,071 elephants, 4,649 buffaloes, 1,619 giraffe and 1,283 elands were counted. Other species counted were impala 15,031; Grant gazelle 5,133; Thomson gazelle 14,414; zebra 36,487 and wildebeest 18,825. This census recorded a 32.52% and 2.7% increase in Elephant and buffalo population respectively in the last 3 years.

Of the total livestock encountered in the ecosystem 12.76% were inside the Masai Mara National Reserve (MMNR), signifying illegal livestock incursion.

The study identifies the community owned land adjacent to the reserve as a crucial wildlife dispersal area and calls for pragmatic measures to be adopted to enhance its (the dispersal area) conservation.

The study also recommends joint trans-boundary ventures with Tanzanian counterparts in ecological monitoring activities in the Serengeti-Mara ecosystem

2.0 Acknowledgement

This Survey was conducted as part of the ongoing ecological monitoring activities within the Mara ecosystem. Funding was provided by Kenya Wildlife Service. We are greatly indebted to the Head Ecological Monitoring Department Mr. Erastus Kanga and the Deputy Director Biodiversity Research and Monitoring Dr. Samuel Kasiki for providing resources and giving timely advice. Big thank you to the team from headquarter that assisted in data cleaning and GIS expertise. We applaud Captain Obrien excellent navigation that allowed the count to be completed within the stipulated time. We are indebted to Mr. Patrick Omondi for review of this report. To all those mentioned and assisted in one way or the other we say thank you.

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3.0 Introduction

Knowledge on the status and trends of wildlife populations is fundamental to Kenya Wildlife Service's ability to manage and conserve its wildlife. Ecological Monitoring is a key component in the Service's strategy to provide scientific data and information needed for management decision-making and education. Ecological Monitoring also contributes information needed to understand and to measure performance regarding the condition of ecosystems and biological communities to ensure ecological integrity.

Monitoring data help to define the normal limits of natural variation in biodiversity resources and provide a basis for understanding observed changes and possible management connections. Understanding the dynamic nature of ecosystems and the consequences of human activities is essential for management decision-making aimed to maintain, enhance, and/or restore the ecological integrity of ecosystems and to avoid, minimize, or mitigate ecological threats to these systems.

The Mara wildlife aerial census is a long term ecological monitoring program which was started in 1984. It was a bi-annual event conducted during the wet and dry seasons from 1984-2007. Since then; the exercise was rescheduled to take place once every three years. Initially elephant and buffalo were counted; later giraffe and eland were included in the counts. Species of special concern like large cats and black rhino are counted opportunistically, although this method might not be suitable for such species.

The Mara ecosystem has undergone considerable changes in terms of land cover, land use and land tenure. The major land use changes started in the early 1960s. At this time the ecosystem was less populated and the land was exclusively used for nomadic pastoralism, livestock and wildlife grazing. Subsequently, slowly the emigrants from the agricultural communities started entering into the ecosystem. They leased land from the Masai landowners and slowly human settlements, agriculture and livestock production started expanding (Gachugu. 1997). All these have had an impact either to the wildlife or their habitat.

4.0 Objectives

1. To establish current wildlife numbers, their densities ,distribution, humans settlements and livestock distribution within the Mara ecosystem,
2. To determine the influence of livestock, settlements and rivers to the distribution of wildlife.
3. To determine spatial and temporal patterns of wildlife within the Mara ecosystem

5.0 Methodology

5.1 Study area

The area covered has remained the same in all the counts including Masai Mara National Reserve, the adjacent pastoral lands (Lemek, Koyiaki and parts of Siana Group Ranches). This is an area of about 4,761km^2.

The study lies within grids 37693000 - 981000 and 37693000 - 981000 and 37693000 - 988700 to the west and extends to 37790000 - 981000 and 3779000 - 9888000 the east.
The study area is divided into counting blocks that have been maintained in this and all previous counts.

5.2 Methods

The count was conducted from 6th to 12th of June 2010. The survey area constituted of Masai Mara National Reserve, adjacent community land and Lamai wedge with traditional 5km overlap zone in Tanzania. The method used was total counts as described by Norton Griffins (1978) and have been standard in count since the inception of count in 1984. This involved use of a fixed upper wing Cessna 182 four seater aircraft. The GPS was used for navigation and marking waypoints of species counted. The count was done at 1km interval following east west orientation and maintained a flying height of 100m. This was to increase precision in counting due to the undulating landscape. The pilot was responsible for navigation and safety with help of the front seat observer (FSO). He would keep flight paths and circle over huge elephant herds to allow for accurate counting. The FSO was responsible for registering waypoints on GPS, recording the counts on pre-designed data forms and also recording the corresponding waypoint numbers as well. Some portions in the northern part of the ecosystem were not over-flown since they are under wheat farming. Wild animal species, in exception of wildebeest, large buffalo herds and Thompson's gazelles were counted while livestock species were estimated. Animals counted twice were screened and therefore were not included in the results.

5.3 Data analysis

- Descriptive
- Kernel density analysis at 5km search radius to determine spatial concentrations of various census parameters
- Proximity analysis for determine relationships between various census parameters such as distance of wildlife to rivers, settlements, livestock etc

6.0 Results

A total of 4950 observations were made during the survey where more than 62% were wild animal encounters. Livestock and other human activities constituted 22% and 14% respectively.

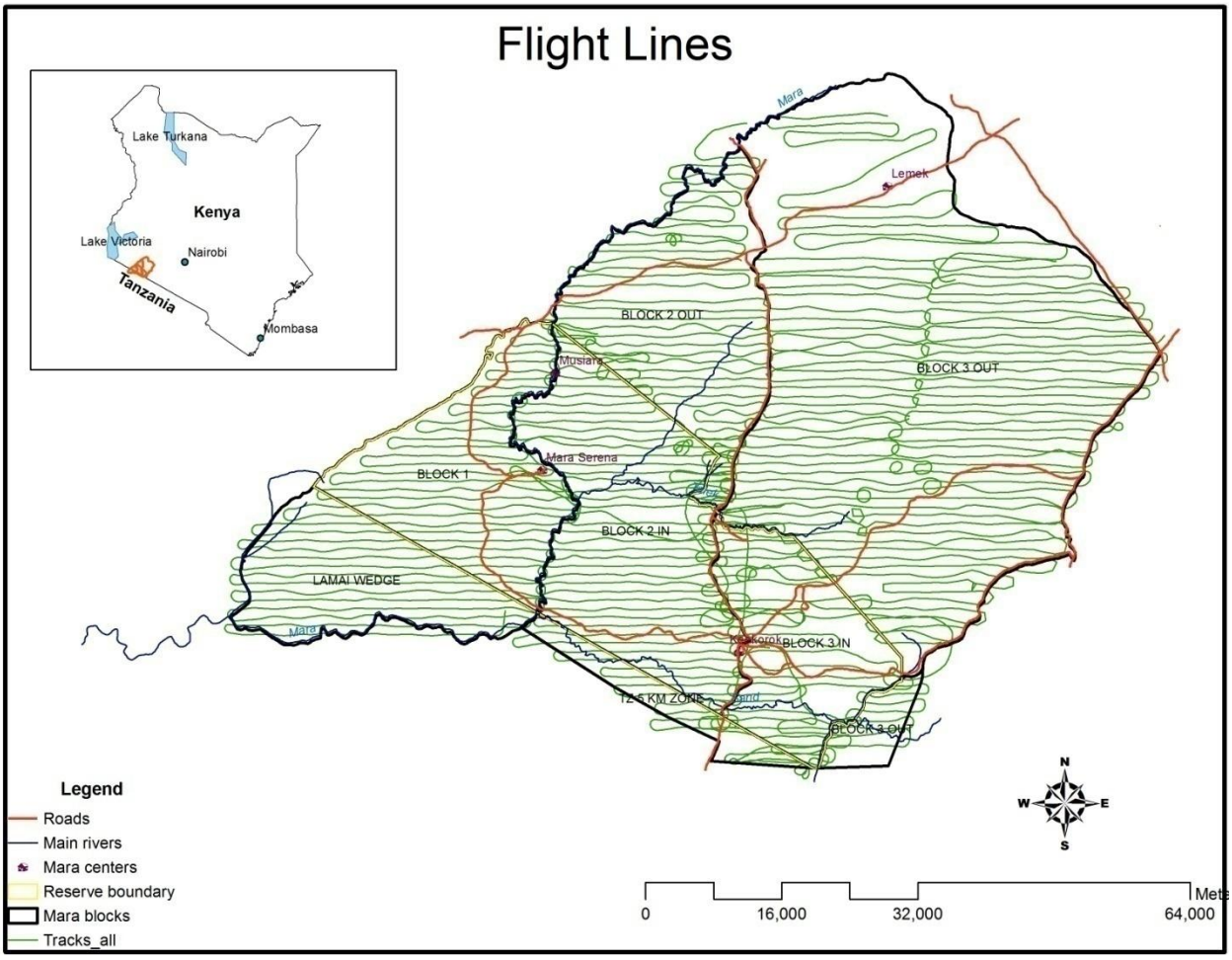


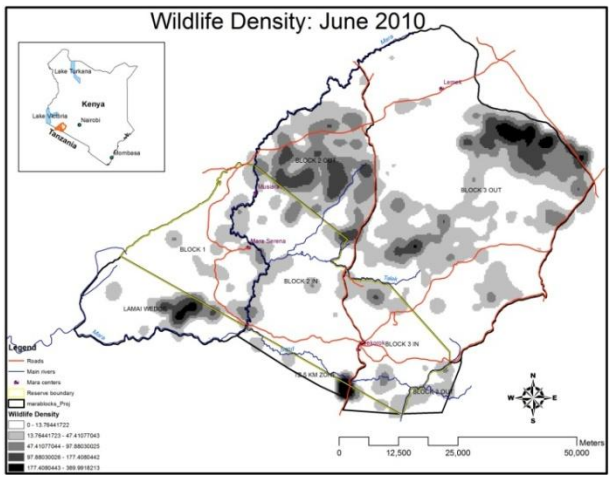
Figure 1. The Mara ecosystem aerial survey area indicating the survey blocks and flight lines as at the June 2010 aerial census

The common zebra, wildebeest and impala were the most abundant wild mammalian species counted.. Of the 4 livestock species encountered during the survey, 55.2% and 44.7% was shoats and cattle respectively.

Table 1. Wildlife abundance per block in the Mara ecosystem as at June 2010, where 5KM TZ and Lamai wedge are the Tanzania overlap, Blocks 1, 2IN and 3IN are inside the reserve and Blocks 2OUT AND 3OUT are in the adjacent community owned dispersal area

Block name/Area (km²) SPECIES	***5KM TZ***	***LAMAI WEDGE***	***Block 3 IN***	***BLOCK 1***	***Block2 OUT***	***Block 2 IN***	***Block3 OUT***	***TOTAL***
Zebra	5	94	1760	2421	9953	3697	18557	36487
Wildebeest		10	763	825	1374	230	15609	18811
Impala	141	365	1078	1191	6030	1175	5051	15031
Thomson gazelle	53		257	1207	4057	1224	7616	14414
Topi	205	27	60	2268	1537	1593	1078	6768
Grants gazelle			80	583	2963	271	1236	5133
Buffalo	215			1694	351	1095	1294	4649
Elephant	2		372	919	223	478	1077	3071
Hartebeest	11	34	451	577	206	43	587	1909
Hippo		203		648	42	825		1718
Giraffe	2	4	134	175	529	169	606	1619
Eland		35	170	399	325	41	313	1283
Waterbuck	7	2	3	167	10	151	31	371
Warthog	2	3		132	29	127	2	295
Ostrich	2	4	27	58	37	61	94	283
Lion			1	5	3	17	19	45
Hyena					2	1	13	16
Baboon			1		1		10	12
Rhino	1			1		4	1	7
Crocodile				5				5
Dik dik					1			1
Total	646	781	5157	13275	27673	11202	53194	111928

There was a high wild animal denisty in blocks 2 out, block 1 and block 3 out with 49.64, 27.24 and 24.35animals/km² respectively, figure 2 below. Both blocks 2 out and 3 out represent blocks outside the Reserve (PA), in the adjacent community owned dispersal land, while block 1 is the western, wetter side of the reserve.



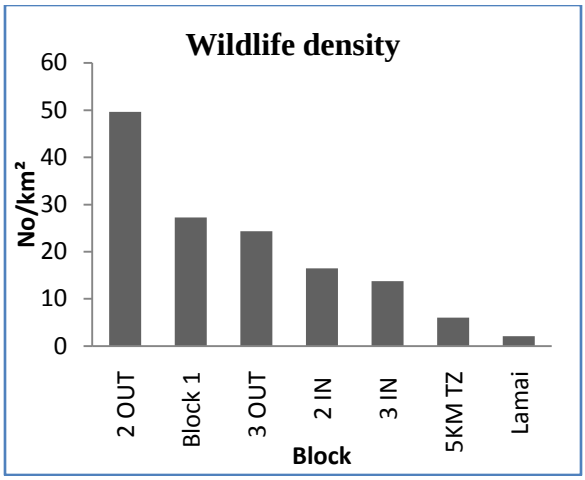


Figure 2 Wildlife density in different counting blocks in the Mara ecosystem

6.1 Wild mammal distribution and abundance

6.1.1 Common zebra

The most abundant species during the survey was , zebra, with a total of 36,487 individuals (table 1), . They were mostly distributed in the community land to the North of the reserve (figure 2). Only 21.6% were within PA (appendix I (l)). A total of 623 herds were counted with herd sizes ranging from 1 to 1500 with an average of 58.6 individuals.

6.1.2 Wildebeest

Wildebeest was the second most abundant species and was encountered in the community owned land (figure 4 (g)). Of the 18,811 individuals counted, 90.3% were in community land (appendix I (k)). This represents a 9.6wildebeest/km² density. Only one herd with 10 individuls was encountered in the Tanzania overlap. There was a larger herd size in the dispersal area as compared to reserve with a mean of 69.6±101.2individuals/herd in the dispersal area, as compared to a mean of 58.6±73.7individuals/herd in the reserve.

6.1.3 Buffalo

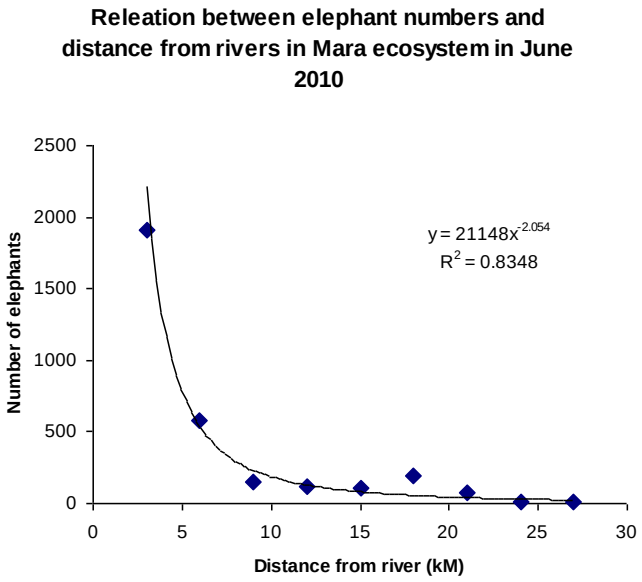
As in the previous count, buffaloes were concentrated inside the protected area, with few individuals outside the reserve. 59.9% of the buffalo were in MMNR comprising of 23 herds in the dispersal area and 78 herds in the reserve. There was a significant difference in herd sizes in the three management blocks, P=0.0434, F= 53.671, n=102, with the largest herd size in dispersal area, with 71.52±87.1 individuals/herd, as compared to 35.76±69.6 individuals/herd in the reserve. The Tanzania overlap had a mean herd size of 107.5±80.1 individuals/herd, but only 2 herds were encountered.

6.1.4 Elephant

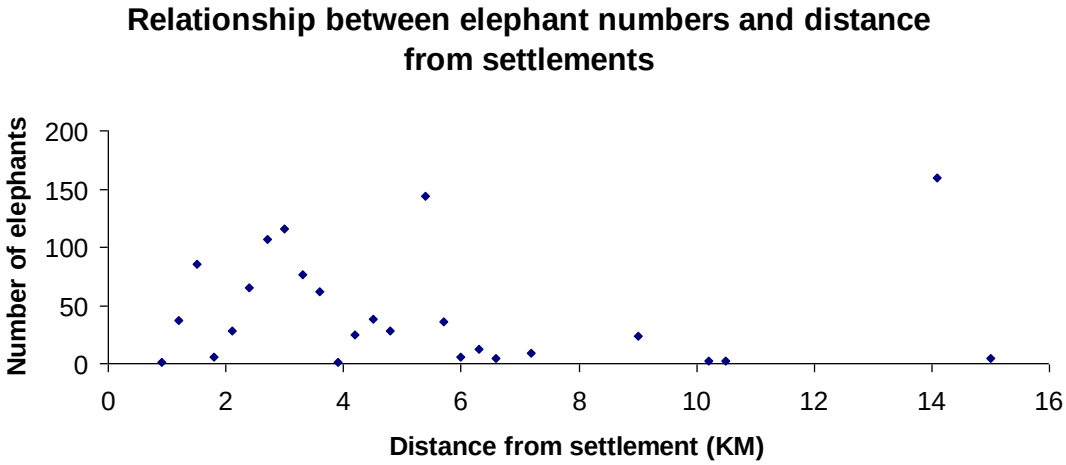
A total of 3, 071 elephants were counted during the survey period, with 57.6% of the total within MMNR reflecting a density of 1.15elephants/km² in MMNR and a density of 0.47elephnats/km² in the dispersal areas.

There was no difference in the overall elephant herd size across the three management blocks, P=0.0747, F=2.623, n=234, but there was a difference in the mean elephant herd sizes between the reserve and the adjacent dispersal area P=0.0273, n=234, where the dispersal area had higher herd sizes compared to MMNR with 17.3±23.5 individuals/herd and 11.3±18.0 individuals/herd for dispersal area and MMNR respectively. The largest herd with 160 individuals was in the dispersal area.

There was a positive relation between elephant spatial distribution and water availability (figure 3(a)), and with human settlement (figure 3 (b)) with more than ¾ of the encountered elephants being within a 5 km and 6km belt, from water and human settlement respectively



a)



b)

Figure 3 Relation between elephant numbers and distance from water sources (a) and human settlement (b)

From a census conducted by KWS in 2007, same period, there has been a 10.84% annual increase in elephant populations in the Mara ecosystem. This high increase could be due to emigration from Serengeti due to reported illegal activities or the counter's error and should be treated with caution!

6.1.5 Giraffe & eland

A total of 1619 giraffe were counted during the survey with more than 70% of the total being encountered outside MMNR in the community owned community land. This reflects a density of 0.41individuals/km² and 0.31individuals/km² for the dispersal area and MMNR respectively.

Of the total 1,283 elands counted, 49.73% were encountered in the community owned dispersal area. There were larger clusters inside the reserve as compared to outside, at 14.18±13.16individuals/cluster and 19.67±26.31individuals/cluster for the dispersal area and MMNR respectively.

6.1.6 Waterbuck and warthog

Though the count was conducted towards the end of wet season, when water scarcity shouldn't be an issue in any of the management blocks, 86.5% and 87.9% of the total waterbucks and warthog encountered, respectively, were inside the reserve, with a majority being in the western side of Mara triangle. There were only 6 herds in the dispersal areas, as compared to 27 inside the reserve. The average sounder size for warthog was higher in the reserve as compared to the dispersal area at 4.46±6.98individuals/sounder and 3.1±3.25individuals/sounder for reserve and dispersal area respectively.

6.1.7 Impala, Grant's and Thompson's gazelle

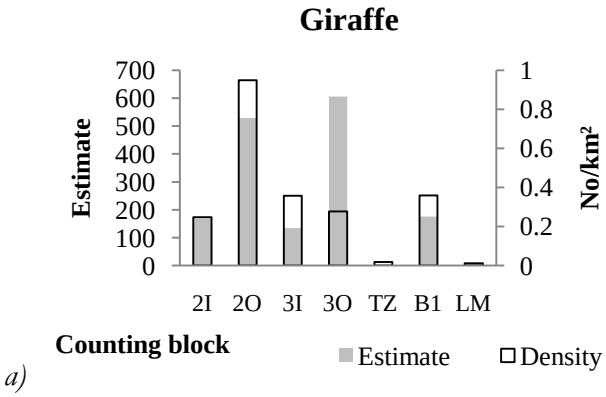
Of the three antelopes, impala was most abundant with a total of 15,031 counted; Grant's gazelle was least abundant with 5,133 counted. In the survey area, 77.95% of the three species encounters were in the community owned dispersal area adjacent to the reserve. No Grant's gazelles were encountered in the Tanzania overlap, (figure 4(i)). With exception of Impala, where there was no difference in mean herd sizes, P=0.4951, F= 0.704, n=429, inside and outside the reserve, but there was a difference in herd sizes for Grant's and Thompson's with bigger herds inside the reserve.

6.1.8 Topi and hartebeest

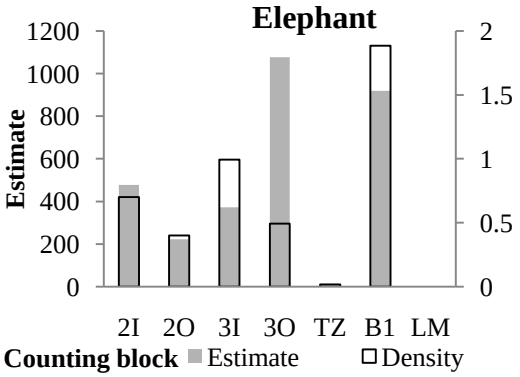
There were 8677 and 1909 topi and hartebeest counted respectively during the survey. The two species were more abundant in the reserve as compared to outside. Proportionally, there was a 56.1% and 57.9% of the total encounters of hartebeest and topi, respectively, inside the reserve. Within the reserve, there was a higher density of topi in the western side of the reserve, (figure 4 (e)).

6.1.9 Carnivores

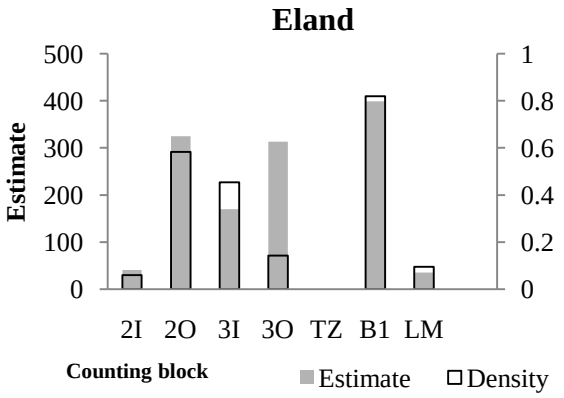
Only two carnivore species were encountered during the survey period, i.e. hyena and lion with 16 hyenas and 45 lions counted during the survey. Lions had no distribution preference in regard to protection status, with almost a 50-50% distribution in MMNR and the adjacent community owned dispersal area, while on the other hand, 93.8% of the total hyenas encountered were in the dispersal areas adjacent to the reserve.


Giraffe
Estimate
No/km²
2I 2O 3I 3O TZ B1 LM
Counting block
Estimate
Density

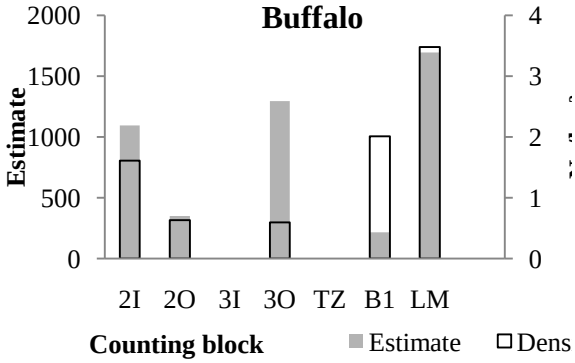
a)


Elephant
Estimate
2I 2O 3I 3O TZ B1 LM
Counting block
Estimate
Density

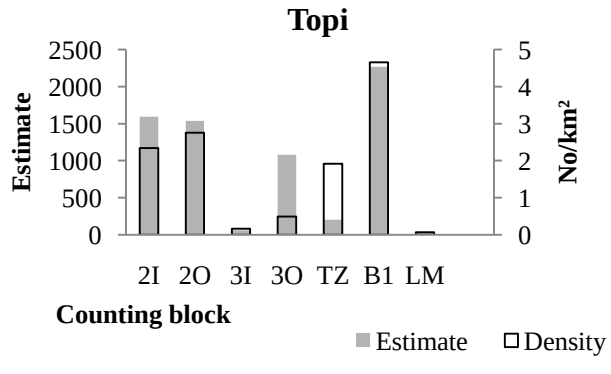
b)


Eland
Estimate
2I 2O 3I 3O TZ B1 LM
Counting block
Estimate
Density

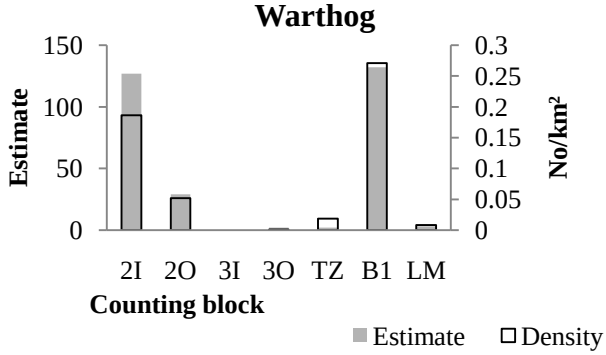
c)

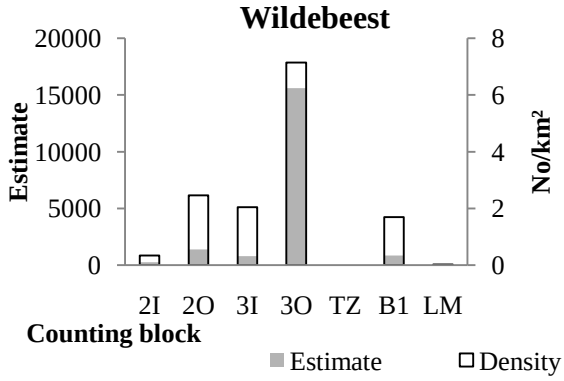

Buffalo
Estimate
2I 2O 3I 3O TZ B1 LM
Counting block
Estimate
Dens

d)

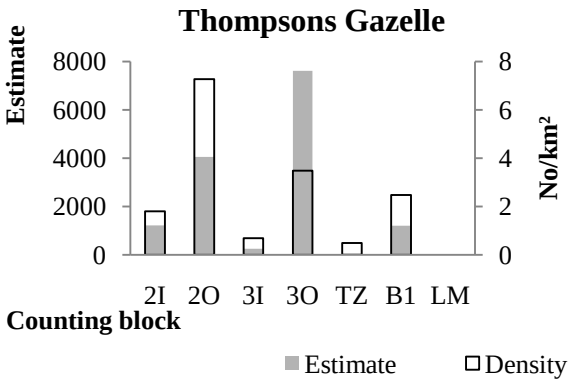

Topi
Estimate
No/km²
2I 2O 3I 3O TZ B1 LM
Counting block
Estimate
Density

e)


Warthog
Estimate
No/km²
2I 2O 3I 3O TZ B1 LM
Counting block
Estimate
Density


Wildebeest
Estimate
No/km²
2I 2O 3I 3O TZ B1 LM
Counting block
Estimate
Density

f)


Thompsons Gazelle
Estimate
No/km²
2I 2O 3I 3O TZ B1 LM
Counting block
Estimate
Density

g)

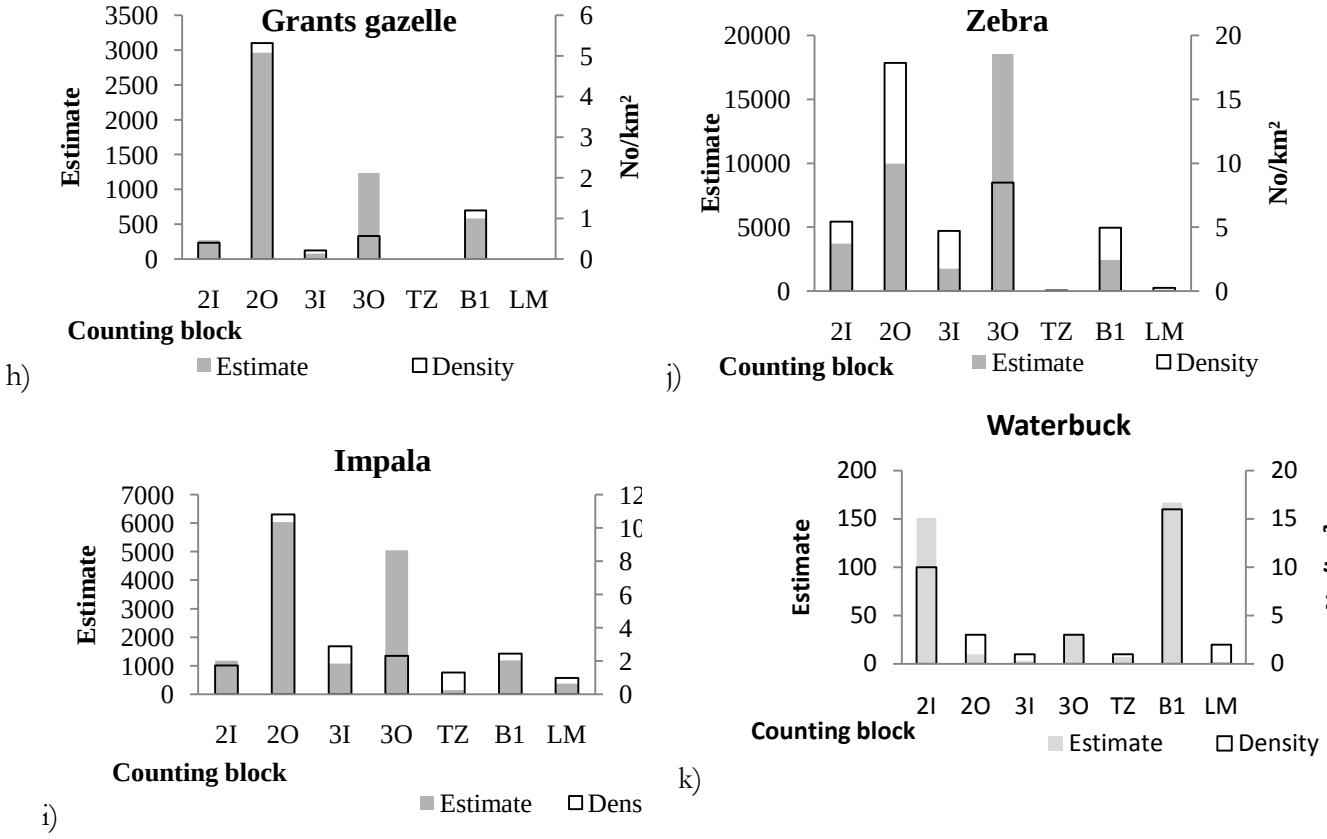


Figure 4 Series of graphs comparing estimated numbers and densities for different wild mammal species in the 7 counting blocks of the Mara ecosystem, where 2I is Block 2 In, 2O is Block 2 Out, 3 I is Block 3 In, TZ is 5 kilometer Tanzania border overlap, B1 is Block 1 and LM is Lamai wedge in Tanzania. 2I, 3I and B1 were sampling bocks inside MMNR, 2O and 3O were blocks outside MMNR in adjacent community owned land, while TZ and LM were overlapping blocks in Tanzania

6.2 Human activity

6.2.1 Livestock distribution and abundance

Four livestock species were estimated during the survey i.e. camel, cattle, donkey and shoats, where shoats include goats and sheep. Shoats were most abundant followed by cattle with 55.2% and 44.7% of the total encounters for shoats and cattle respectively. Only one camel was encoutered. 12.8% of the livestock was encountered inside the reserve (figure 5), especially in the eastern side.
Livestock had the highest density in the dispersal areas with a density of 63.21 individuals/km², while inside the reserve, livestock density was at 16.38 individuals/km².

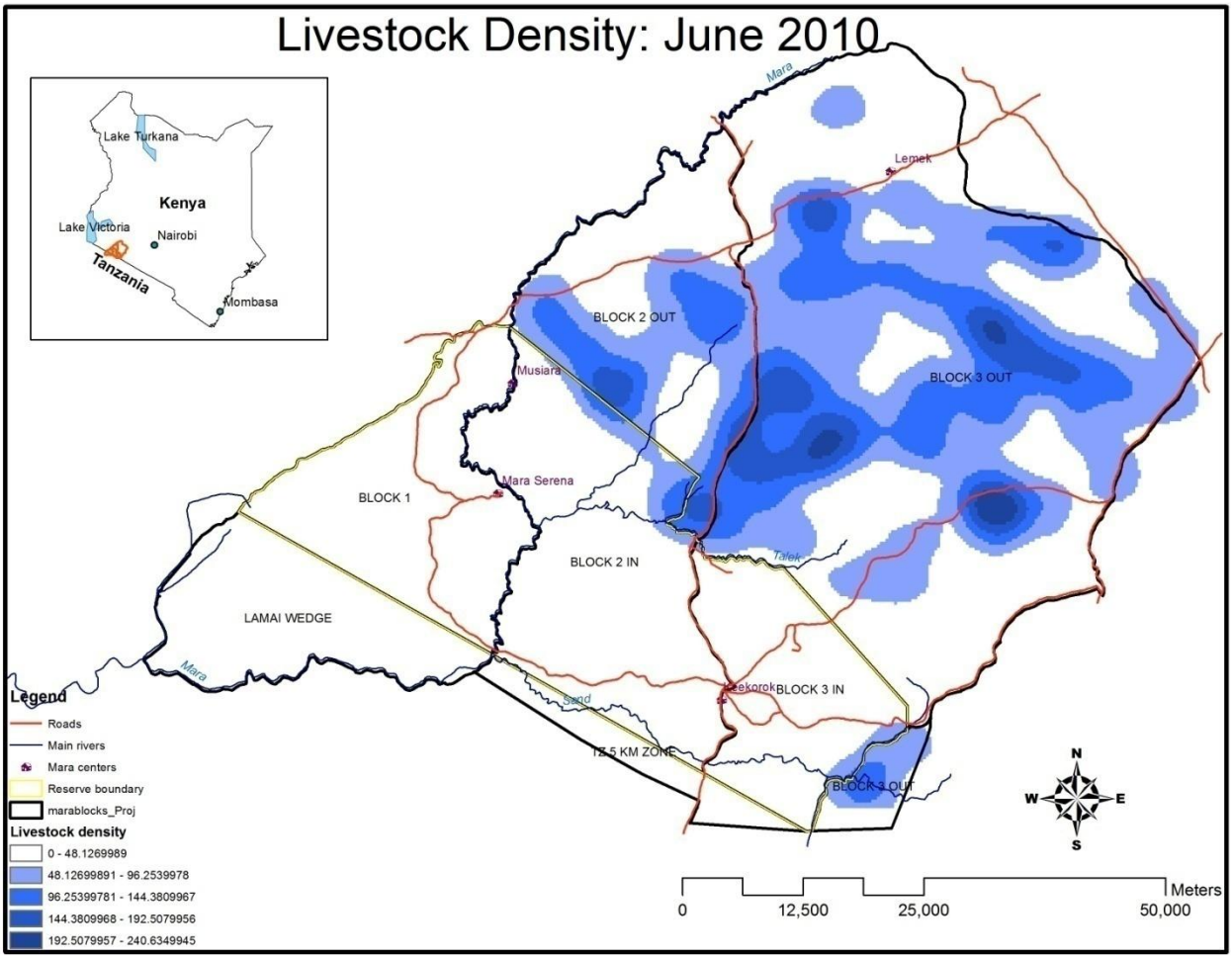


Figure 5 Livestock spatial distribution and densities in the Mara ecosystem

Cattle grazing intensity in the reserve was higher than any other livestock species with 13.8% of livestock grazing in the reserve, while shoats had a 11.9% preference for the reserve. Both cattle and shotas had higher herd sizes inside the reserve as compared to outside, with mean herd sizes being 144.2±136.35 individuals/herd and 199.65±179.49 individuals/herd for cattle and shoats, respectively, outside the reserve, as compared to a mean herd size of 200.66±193.59 individuals/herd and 251.58±213.97individuals/herd for cattle and shoats, respectively, inside the reserve.

6.2.2 Human settlement

1427 human settlement structures were encountered, and constituted manyattas, lodges/hotels, tented camps and settlements. Settlements were the most abundant with a 57.3% of the encounters.Manyattas constituted 37.4% of the total human settlements with a density of 0.47manyattas/km² in the dispersal areas (figure 6), below.

Most human settlements were concentrated in block 3 out with 82% of the total human settlement encounters, constituting a density of 0.33settlements/km² as compared to a density of 0.04settlements/km² in block 2 out.

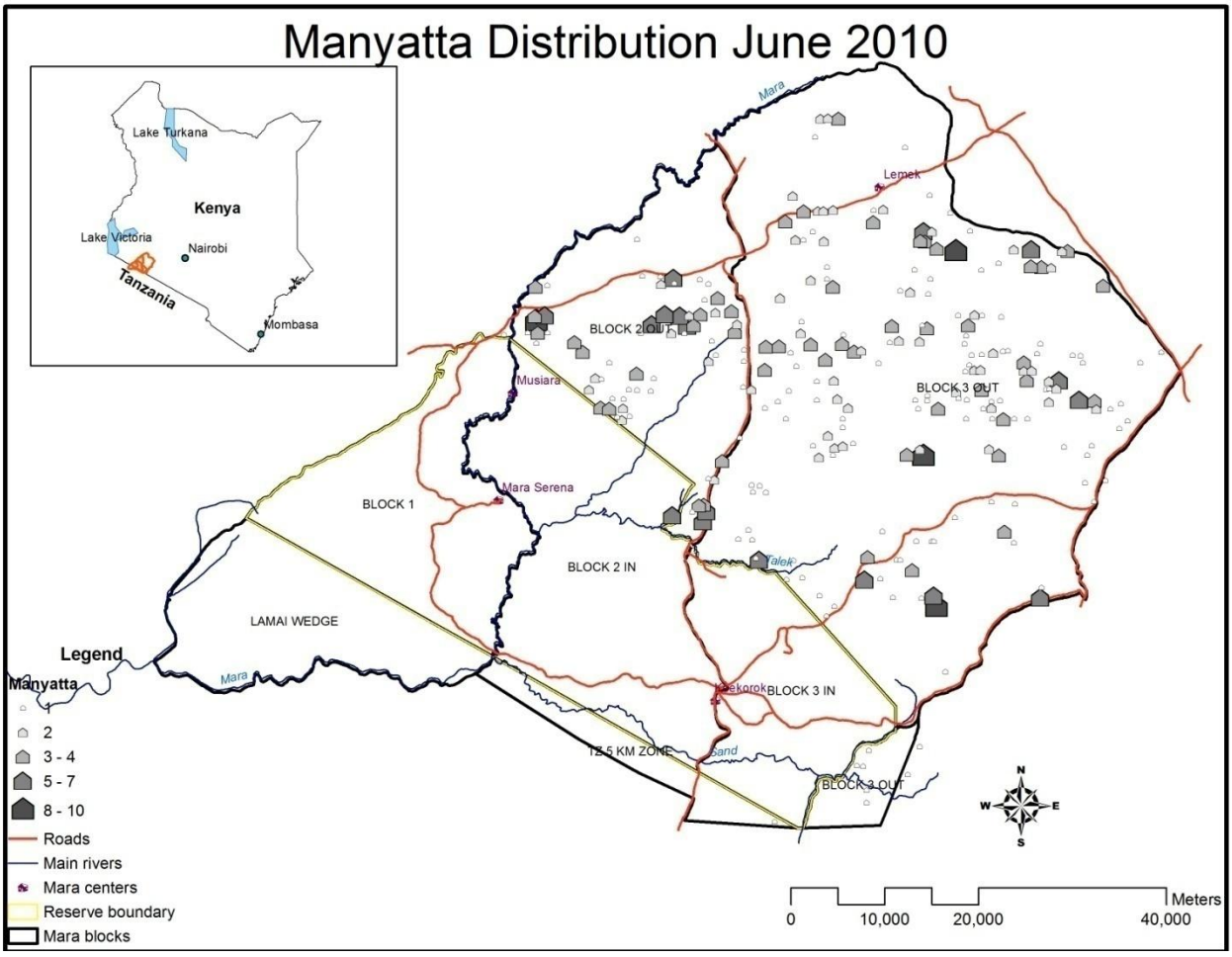


Figure 6 Spatial manyatta distribution in the June 2010 aerial total count

Of the total tourist facilities i.e. lodges/hotels and tented camps 33.3%, making a total of 14 facilities, were encountered inside the reserve.
Hotel facilities outside the reserve were concentrated in a 10km zone along the reserve boundary, especially in riverine drainage lines.

6.2.3 Cultivation

A total of 168 farms were encountered in the survey area during the study period. The farms were in the north most part of the survey area (figure 7), with only one encounter in block 2 out. All other farms were in block 3 out. There were 3.03 farms encoutered in every observation.

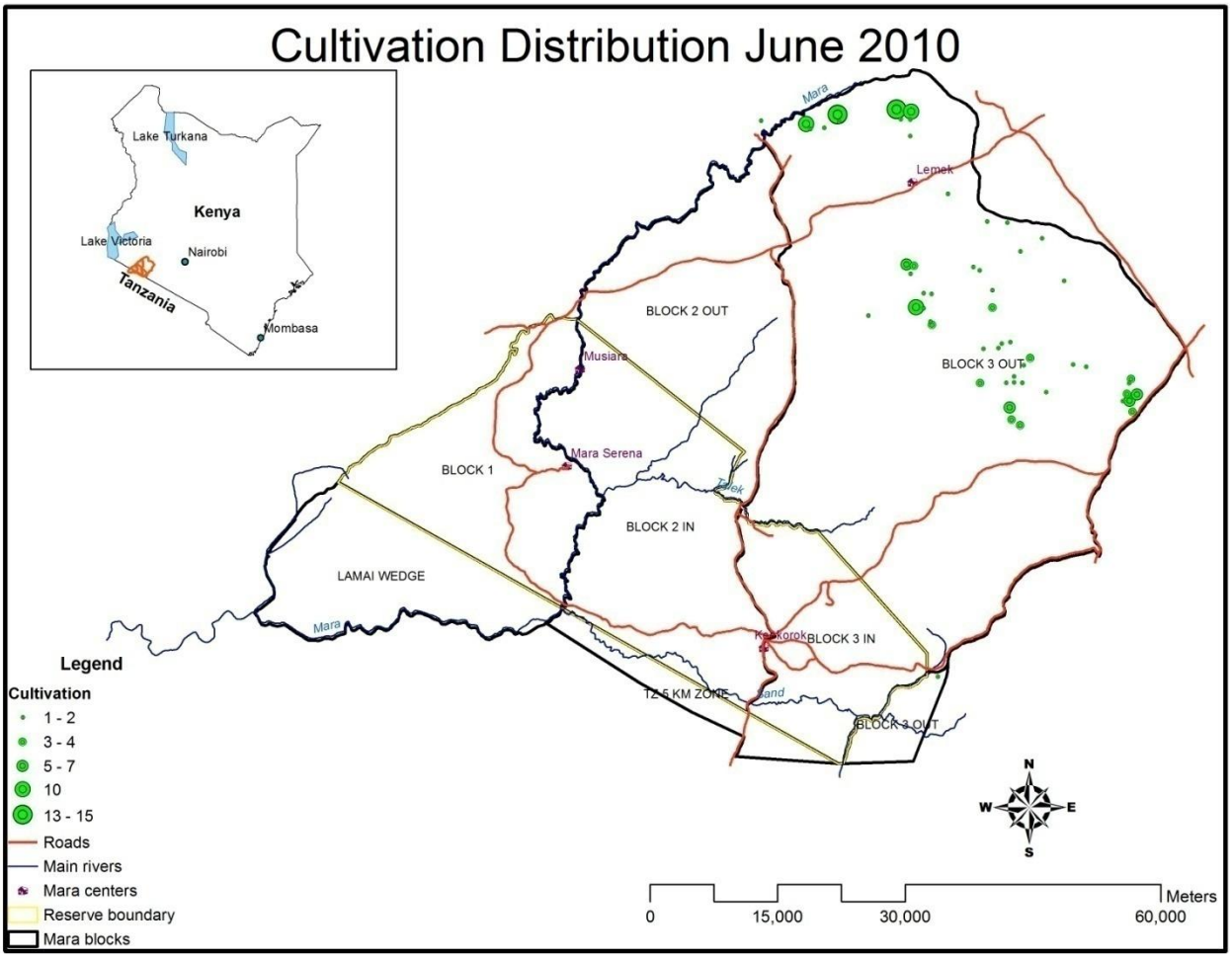


Figure 7 Spatial cultivativation distribution as at the 2010 wet season aerial survey

7.0 Discussions

The high wildlife density outside the reserve can be explained, in that during the wet season grass in the reserve, which is predominantly *Themeda triandra* and *Hyperrhenia sp,* can grow to approximately one meter high (KWS unpublished data). This makes the reserve biomass less available to smaller ungulates, who mostly prefer the swords. Grass height too poses a security threat to predation to the smaller bodied ungulates. The ungulates therefore range outside the community owned land, where the grass lawns are maintained short by the high grazing pressure from livestock. In addition, the resident wildebeest, zebra and other associated species of the annual Serengeti-Mara migration, range in Loita plains, outside the reserve.

The census recorded low elephant and buffalo densities in the dispersal areas but with a higher herd size in the dispersal area. Increase in human population and settlement, change in land tenure and land use, and the subsequent change in land cover has led to shrinkage of habitats could explain the low densities in the dispersal areas. Using elephant as the key wildlife species, in regard to human

wildlife conflict, and livestock distribution as an index of human activity, there is a high level of human-wildlife interaction in the community owned dispersal area (figure 8). This and the fact that carnivores, especially hyenas had a preference of the community owned dispersal area adjacent to the reserve, where pastoralism is the major land use for communities adjacent the reserve, might explain the heightening of conflict in the form of predation, human injury, human death, obstruction and destruction of installation within the dispersal areas.

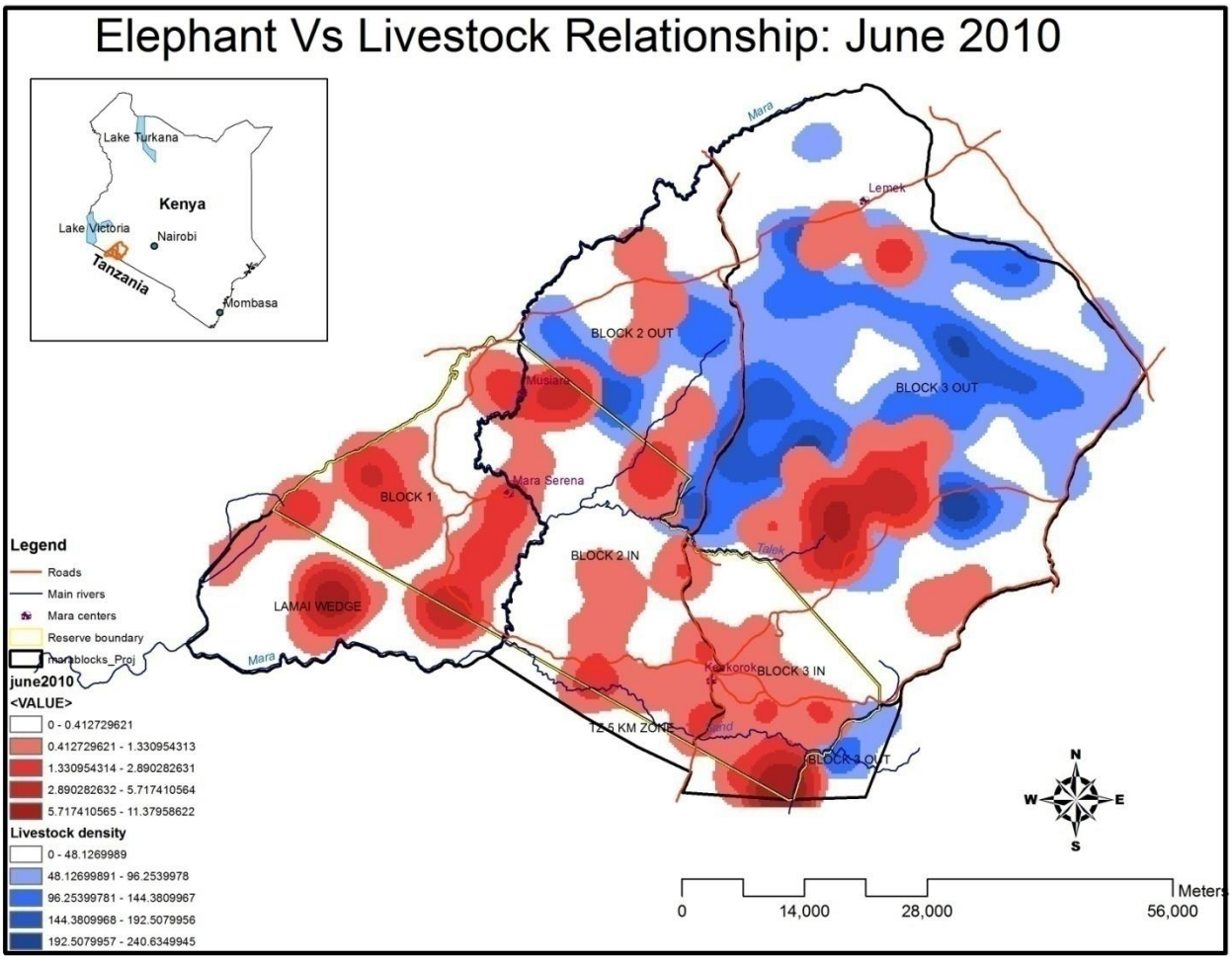


Figure 8 Human wildlife interactions, as depicted by the spatial distribution of livestock and elephants as indexes to human activity and wildlife in regard to human wildlife conflict.

A 10.84% annual population growth rate of elephants in the Mara over the last 3 years is far much higher than the documented, 4-5%. This might mostly be explained by elephant emigration from the neighboring Serengeti National Park in Tanzania and Trans-Mara district, or disparity in counters estimation error.

Majority of the browser species, especially giraffe and eland, were encountered outside protected area. In addition, contrary to other larger wild ungulates, elands had higher group sizes in the reserve as compared to the dispersal area. Frequent wild fires and habitat modification by elephants, inside the reserve has led to gradual change in land cover type in MMNR from closed canopies to opens

grasslands, reducing the browse biomass, hence the less browser species density, and influencing individuals to converge to hill tops and drainage lines, the only woodlands in the reserve.

Waterbuck and warthog are high water dependent mammals, living next to permanent water sources for a green biomass supply throughout the year and for wallowing. In the Mara ecosystem, permanent water sources are restricted inside the reserve, in marshes, mostly adjacent to the Mara River and hence the higher densities of the two species inside the reserve.

High livestock densities in the community owned land adjacent to the reserve, which act as a dispersal area to wildlife from the reserve, has led to high grazing pressure to grass biomass leading to its limitation and availability. This has in-turn triggered illegal livestock incursion into the reserve, mainly in search for pasture. This can be explained by the 16.38 livestock/km² encountered in the reserve during the survey period.

There is a northwest to southeast decreasing rainfall gradient in the Mara ecosystem. Cultivation is gradually extending to the south of the ecosystem from the larger Narok district. Crop farming is an incompatible land use with wildlife conservation. The change in land use to crop farming in the dispersal area adjacent to MMNR is gradually displacing wildlife (figure 9), from their original ranges.

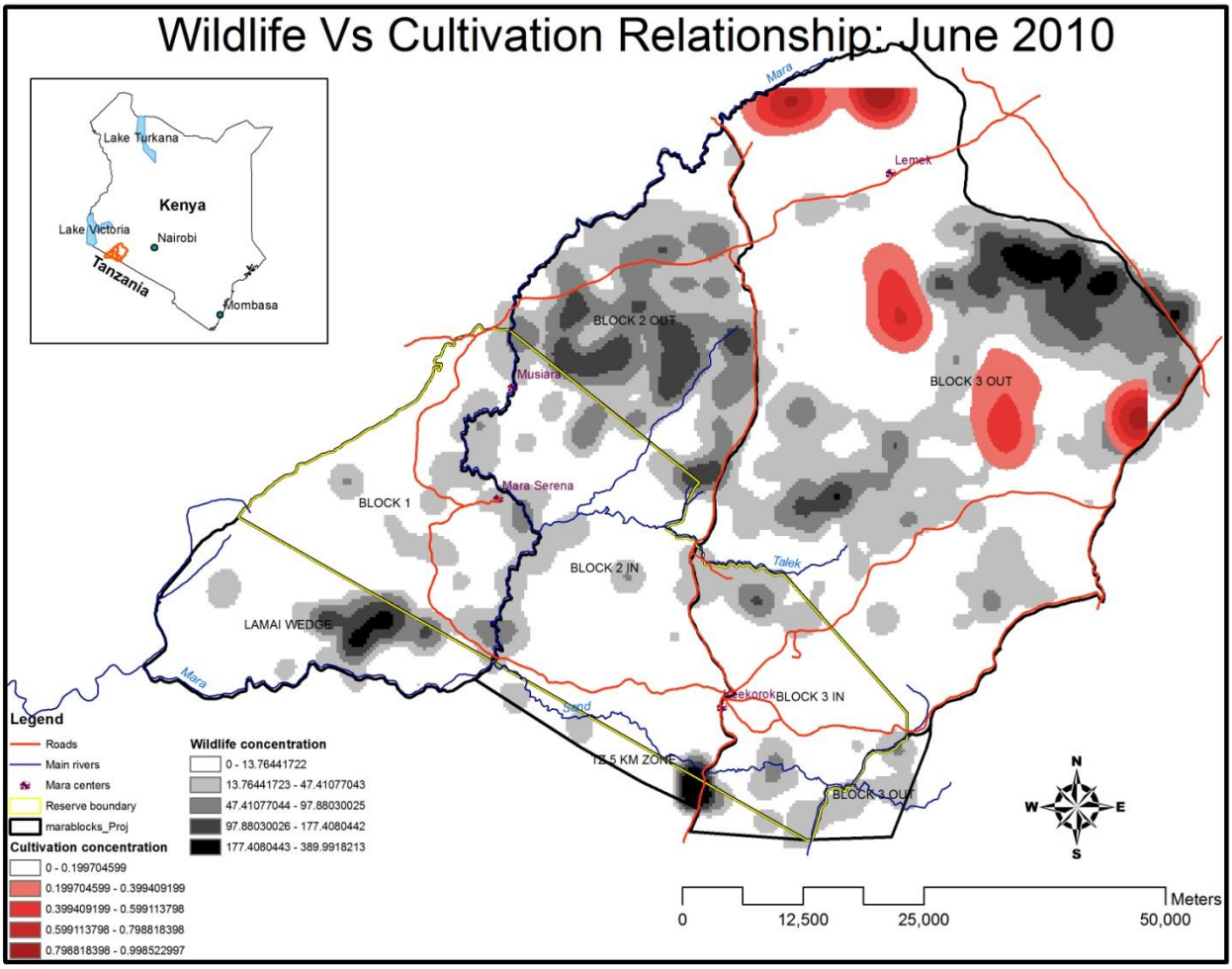


Figure 9 Wildlife distributions in relation to crop farming in the Mara ecosystem

8.0 Conclusion and recommendations

Masai Mara National Reserve, being only a quarter of the Greater Mara Ecosystem is highly dependent on the adjacent community owned land. For sustainability of wildlife conservation in greater Mara ecosystem, therefore, the ecological integrity of the dispersal areas of MMNR has to be maintained. Human population increase, settlement and change in land use in the dispersal area will affect wildlife conservation in the greater ecosystem. In addition, unchecked increase in livestock numbers, poor livestock husbandry regimes is not only degrading the dispersal area, but leading to livestock incursion into the reserve.

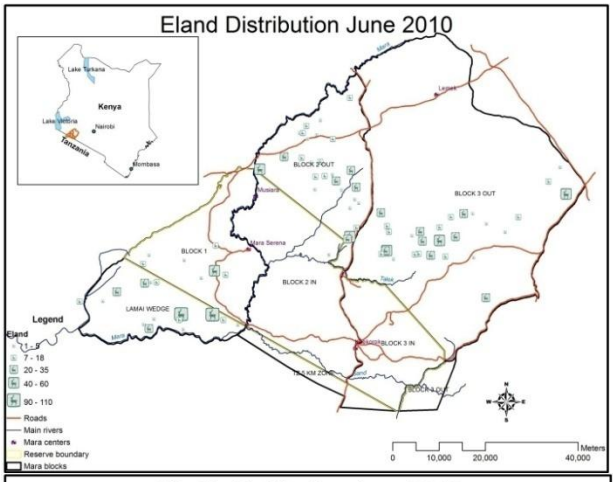
For sustainable wildlife conservation in the Mara ecosystem, therefore, the survey recommends that;

1. There is need for management structures to be put in place for protection and management of the community owned land adjacent to the reserve e.g. through community owned conservancy development, proper livestock husbandry systems.
2. Due to the increasing human wildlife interaction, pragmatic measures that may include predator proof bomas should be put in place to prevent human wildlife conflict, especially predation.
3. A formal management plan for the reserve, including management of the adjacent community owned land should be developed and implemented. The plan should explore possible enhanced benefit to the local communities that leave their land for conservation.
4. Formal recognition of the community's conservation effort should be emphasized.
5. To understand wildlife population dynamics, especially elephant, detailed studies of the species should be conducted. In addition, trans-boundary collaboration in ecological monitoring of the ecosystem e.g. through joint aerial surveys should be emphasized.
6. Kenya Wildlife Service should identify and adequately train a group of expert in aerial counts to minimize estimation error and enhance consistency.

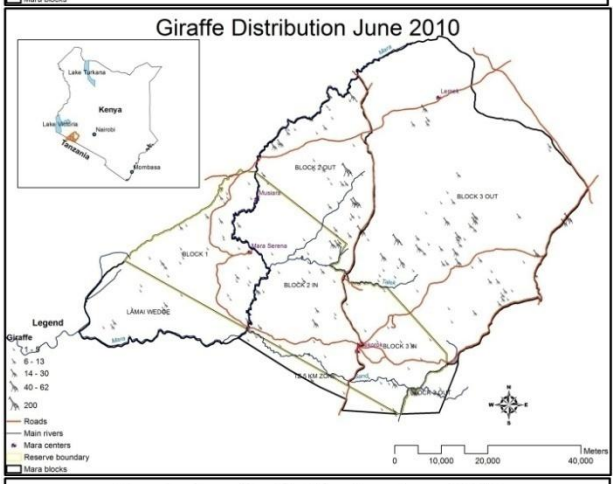
10.0 Appendices

10.1 Appendix I: Spatial distribution

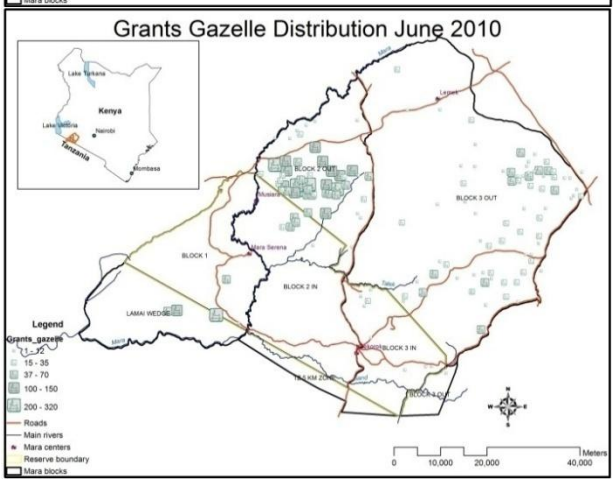
a)



b)



c)



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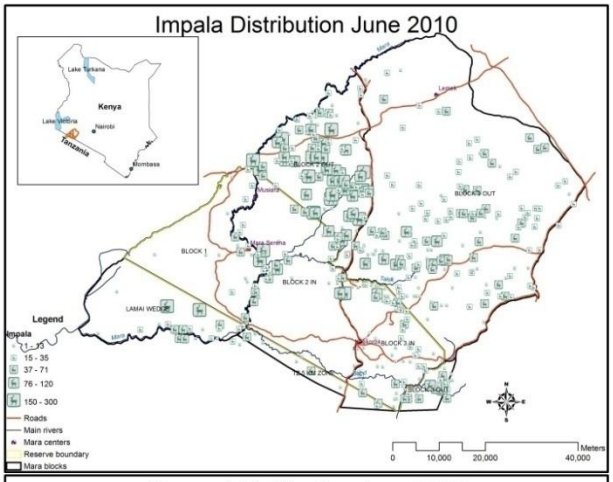
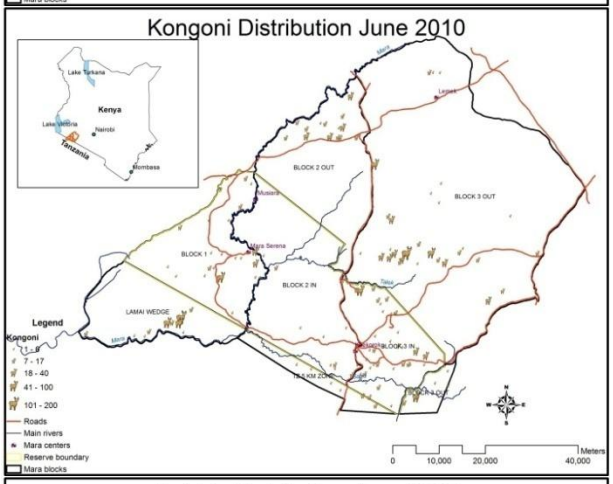
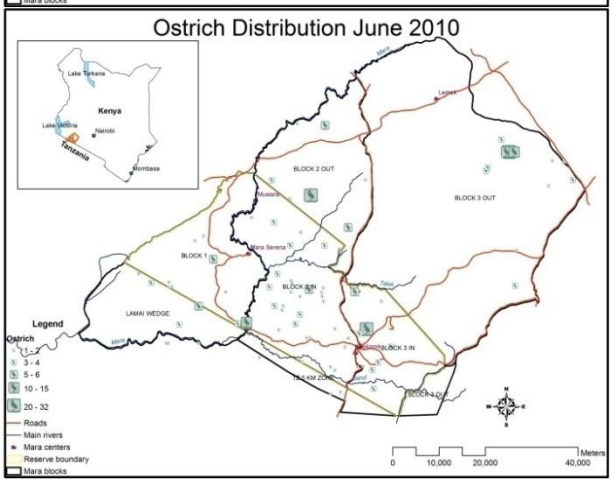


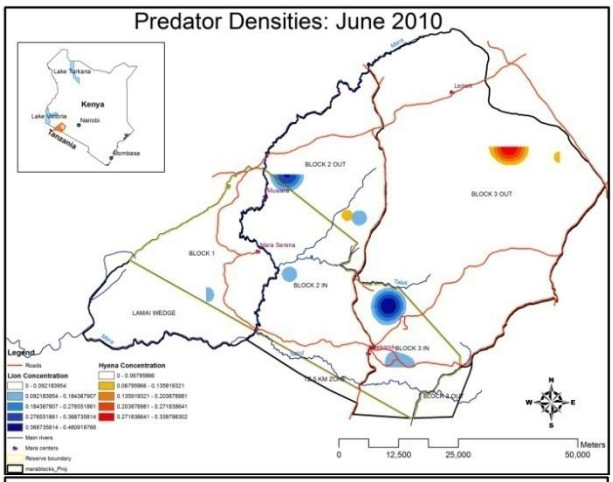
e)



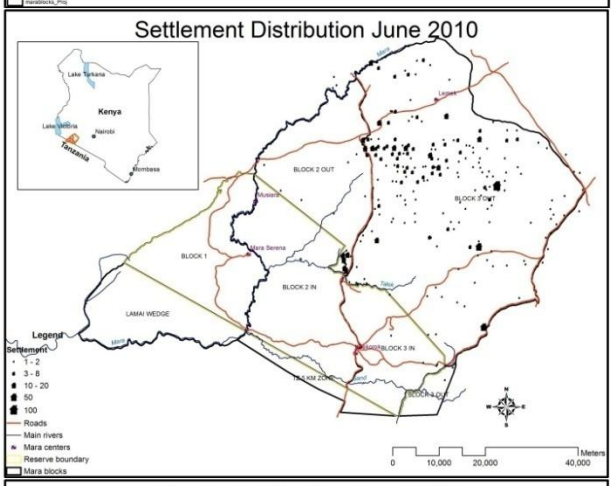
f)



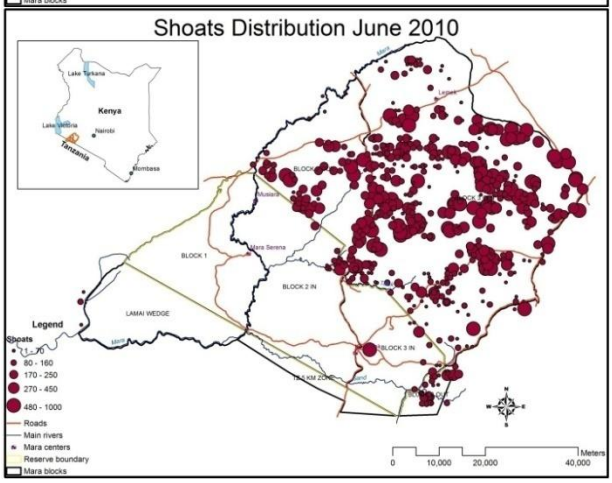
g)


Predator Densities: June 2010
Kenya
Lake Turkana
Lake Victoria
Nairobi
Tanzania
Mombasa
BLOCK 2 OUT
BLOCK 3 OUT
BLOCK 1
BLOCK 2 IN
BLOCK 3 IN
BLOCK 4 OUT
LAMAI WEDGE
Mara Serena
Legend
Roads
Lion Concentration
Hyena Concentration
Main rivers
Mara centers
Reserve boundary
marablocks_Proj
0
12,500
25,000
50,000
Meters

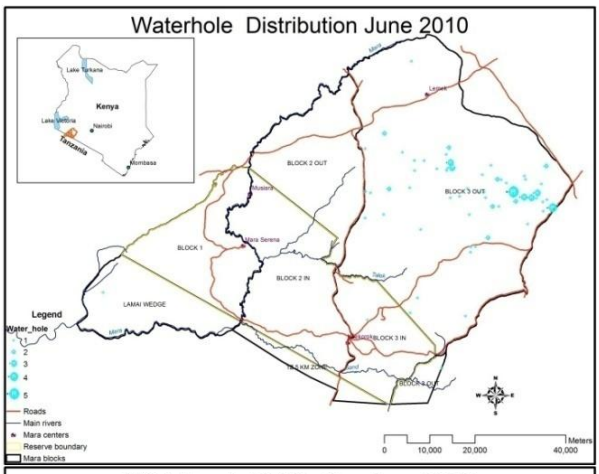
h)


Settlement Distribution June 2010
Kenya
Lake Turkana
Lake Victoria
Nairobi
Tanzania
Mombasa
BLOCK 2 OUT
BLOCK 3 OUT
BLOCK 1
BLOCK 2 IN
BLOCK 3 IN
BLOCK 4 OUT
LAMAI WEDGE
Mara Serena
Legend
Settlement
1 - 2
3 - 8
10 - 20
50
100
Roads
Main rivers
Mara centers
Reserve boundary
Mara blocks
0
10,000
20,000
40,000
Meters

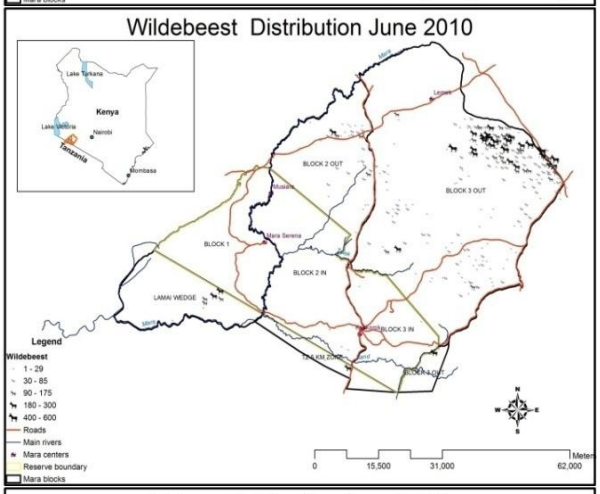
i)


Shoats Distribution June 2010
Kenya
Lake Turkana
Lake Victoria
Nairobi
Tanzania
Mombasa
BLOCK 1
BLOCK 2 IN
BLOCK 3 IN
LAMAI WEDGE
Mara Serena
Legend
Shoats
1 - 20
80 - 160
170 - 250
270 - 450
480 - 1000
Roads
Main rivers
Mara centers
Reserve boundary
Mara blocks
0
10,000
20,000
40,000
Meters

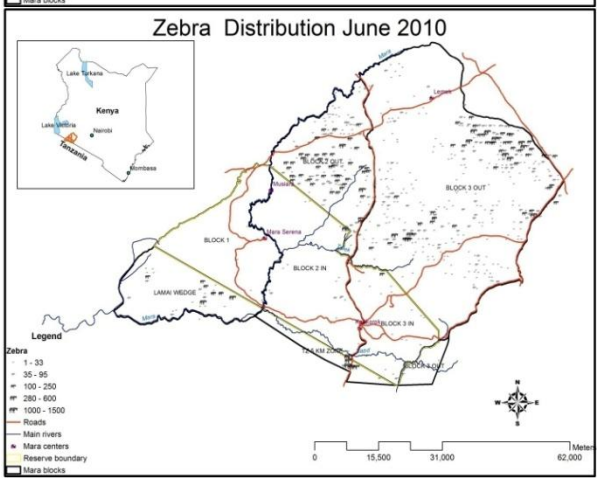
j)


Waterhole Distribution June 2010
Kenya
Lake Turkana
Lake Victoria
Nairobi
Tanzania
Mombasa
BLOCK 2 OUT
BLOCK 3 OUT
BLOCK 1
BLOCK 2 IN
BLOCK 3 IN
BLOCK 4 OUT
LAMAI WEDGE
Mara Serena
Legend
Water_hole
2
3
4
5
Roads
Main rivers
Mara centers
Reserve boundary
Mara blocks
0
10,000
20,000
40,000
Meters

k)


Wildebeest Distribution June 2010
Kenya
Lake Turkana
Lake Victoria
Nairobi
Tanzania
Mombasa
BLOCK 2 OUT
BLOCK 3 OUT
BLOCK 1
BLOCK 2 IN
BLOCK 3 IN
BLOCK 4 OUT
LAMAI WEDGE
Mara Serena
Legend
Wildebeest
1 - 29
30 - 85
90 - 175
180 - 300
400 - 600
Roads
Main rivers
Mara centers
Reserve boundary
Mara blocks
0
15,500
31,000
62,000
Meters

l)


Zebra Distribution June 2010
Kenya
Lake Turkana
Lake Victoria
Nairobi
Tanzania
Mombasa
BLOCK 1
BLOCK 2 IN
BLOCK 3 IN
BLOCK 3 OUT
BLOCK 4 OUT
LAMAI WEDGE
Mara Serena
Legend
Zebra
1 - 33
35 - 95
100 - 250
280 - 600
1000 - 1500
Roads
Main rivers
Mara centers
Reserve boundary
Mara blocks
0
15,500
31,000
62,000
Meters

10.2 Appendix II: Spatial relations