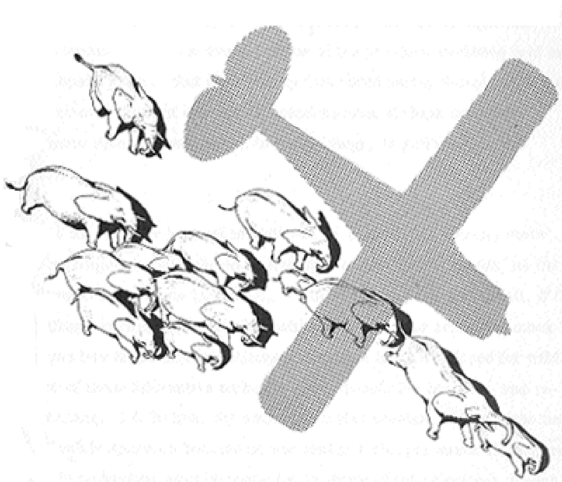
AERIAL TOTAL COUNT

AMBOSELI – WEST KILIMANJARO AND MAGADI - NATRON CROSS BORDER LANDSCAPE

WET SEASON, APRIL 2013



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EXECUTIVE SUMMARY

The Amboseli-West Kilimanjaro/Magadi – Natron cross- border landscape comprises various ecologically important areas in Kenya and Tanzania and supports a high wildlife population. In order to understand the status of the wildlife population, a wet season total aerial count was conducted across this landscape from 22nd – 26th April 2013. The census covered an area of 25,623 km^2 including 9,214 km^2 of the Amboseli ecosystem, 6,348 km^2 of the Namanga-Magadi areas in south-western Kenya, 3,013 km^2 of the West Kilimanjaro and 7,047 km^2 of the Natron areas in North Tanzania.

The objectives of the census were to: (i) determine wildlife populations and distribution (ii) determine the extent and spread of human activities; and (iii) identify threats to wildlife conservation in the landscape. The count made use of 9- light aircrafts fitted with observer calibrated streamers. Data was captured by observers in the aircrafts using GPS and digital voice recorders. The census aircrafts comprising of mostly 4-seater and a few 2-seater planes, were flown along established transects at altitudes between 300-400ft above ground across 31 predetermined counting blocks spread in Kenya and Tanzania. Total counts of elephants, elephant carcasses, buffalo, giraffe, wildebeest, elands and other wildlife species were made.

During the survey, 28 wild mammalian and 1 avian species were recorded. Zebra with a population of approximately 29,867 individuals was the most numerous wildlife species followed by Grant's gazelle (17, 509), Common wildebeest (14,728), Maasai giraffe (7,627), Eland (5,035), Maasai ostrich (2,010), African elephant (1,930), Impala (3,644), Thomson's gazelle (2,699) and Coke's hartebeest (550). There was a general increase in the number of large herbivores between the years 2010 and 2013. Elephant population increased from 1420 to 1,930 while elephant carcass ratio declined from 3.7% to 1.8%. Wildebeest increased by over 100% from 7,240 to 14,728. Similarly, zebra numbers more than doubled from 13,740 to 29,867 while buffalo population increased by about 72% from 334 to 575. These populations' increases can be attributed largely to the recovery of the populations after the severe drought experienced in the area between 2007 and 2009 and to a lesser extent the increase in survey area more specifically for elephants

In addition to counts of wildlife species, some human activities mainly livestock numbers were also recorded in this survey. Shoats (Sheep and Goats) numbering 530,358 were the most abundant and widely distributed livestock followed by cattle (211,701), donkey (5,648) and camel (1,677). Natron area had the highest abundance of shoats (159,281) followed by Magadi (151,501), Amboseli (138,059) and West Kilimanjaro (81,517).

This survey exposes the need for a landscape approach in conservation planning in cross- border landscape area. We recommend that future wildlife studies/surveys should focus in assisting wildlife managers to better understand the large-scale wildlife movement dynamics in this landscape.

LIST OF ACRONYMS AND ABBREVIATIONS

AGL	Above Ground Level
ASL	Above Sea Level
ASTER	Advanced Spaceborne Thermal Emission and Reflection
ATE	Amboseli Trust for Elephants
AWF	African Wildlife Foundation
CIMU	Conservation information and Monitoring Unit
DEM	Digital Elevation Model
DNR	Department Natural Resources
FSO	Front Seat Observer
GCA	Game Controlled Area
GIS	Geographical Information Systems
GPS	Global Positioning System
KINAPA	Kilimanjaro National Park
KWS	Kenya Wildlife Service
NP	National Park
RSO	Rear Seat Observer
SPSS	Statistical Package for Social Scientist
SRF	Systematic Reconnaissance Flight
TANAPA	Tanzania National Parks
TAWIRI	Tanzania Wildlife Research Institute
TC	Total Count
TWCM	Tanzania Wildlife Conservation Monitoring
UTM	Universal Transverse Mercator
WD	Wildlife Division (Tanzania)

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INTRODUCTION

Kenya Wildlife Service (KWS) and Tanzania Wildlife Research Institute (TAWIRI) conducted a wet season total aerial count in the Amboseli-West Kilimanjaro and Magadi –Natron cross-border landscape from 22nd to 26th April 2013. The count was a follow up to similar counts conducted in wet and dry seasons in the year 2010. These counts are aimed at deepening the understanding of spatial and temporal variations in distribution and abundance of wildlife populations as well as some selected human activities in the landscape.

The landscape comprises protected areas of different status; National Park, Game controlled area, Open area and ranches that are ecologically important in Kenya and Tanzania. The survey area comprises two ecologically linked cross-border ecosystems, as described in KWS & TAWIRI (2010). The landscape-wide wildlife population studies and monitoring in the northern part of the landscape has been well studied over the past 40 years (Western 1973; Western & Van Praet, 1973; Lindsay 1994; Kikoti, 2009). Most of these studies have, however, focused on smaller portions of the linked ecosystems, mainly confined within national administrative boundaries in the two countries. Consequently, the wider picture of the Amboseli-West Kilimanjaro and Magadi –Natron cross-border landscape in terms of wildlife population monitoring has not been adequately investigated. With increasing knowledge of animal movements within the landscape and observations of fluctuating animal numbers within the various constituent areas, it has become necessary to have a broader survey in both wet and dry seasons every three years in order to study the changes within the whole area as a unit. Furthermore, adaptive management and conservation of natural ecosystems require effective monitoring of biodiversity, including regular surveys of wildlife abundance and distributions (Lindenmayer & Likens, 2009). The first ever combined survey between Kenya and Tanzania was conducted during wet season in March 2010 (KWS & TAWIRI, 2010).

Historically, there have been a number of aerial surveys conducted in different parts of these inter-linked ecosystems, with spatial-temporal and design differences. Other surveys conducted within the Amboseli-West Kilimanjaro ecosystem are summarized in table 1. These differences are attributed to differences in the objectives of the surveys between individual researchers in the area and differences in the survey methodologies used between the two countries. This (April 2013) wet season count is the third cross-border survey that covered the larger portion of the Amboseli- West Kilimanjaro and Magadi –Natron ecological area that used a common methodology for both countries.

Purpose and Objectives of the Survey

The purpose of this survey, therefore, was to gather comprehensive wet season data on various wildlife species and human activities and compare the same with previous surveys conducted in the year 2010, following the catastrophic drought of 2007, 2008 and 2009. The specific objectives of the survey were to:

1. Determine wildlife populations abundance and distribution in the landscape
2. Determine the extent and spread of human activities in the landscape
3. Determine the wildlife population trends and distribution changes over the landscape as compared to previous studies
4. Identify threats to wildlife conservation in the landscape
5. Suggest strategies for effective wildlife management across the landscape

Table 1: Aerial surveys conducted in Amboseli and West Kilimanjaro areas, 1997 – 2013

Notice the significant differences in the areas covered and the harmonized area from 2010 when Kenya and Tanzania begun a collaborative effort to count wildlife as a team.

Year	Month	Season	Survey Technique	Name of area surveyed	Area (km²)	Source
1997	June	Wet	SRF	West Kilimanjaro	2,537	TWCM (1998)
2000	January	Wet	TC	Amboseli	4,035	KWS (2000)
2001	May	Wet	SRF	West Kilimanjaro	2,537	CIMU (2002)
2002	August	Dry	TC	West Kilimanjaro	6,909	TAWIRI (2003)
2002	August	Dry	TC	Amboseli	5,736	KWS (2002)
2007	May	Wet	TC	Amboseli	5,542	KWS (2007)
2009	March	Dry	SRF	West Kilimanjaro	2,558	TAWIRI (2009)
2010	March	Wet	TC	Amboseli, West Kilimanjaro, Namanga-Magadi, Natron	24,108	KWS & TAWIRI, 2010
2010	October	Dry	TC	Amboseli-West Kilimanjaro and Namanga-Magadi, Natron	24,788	KWS & TAWIRI, 2010
2013	April	Wet	TC	Amboseli, West Kilimanjaro, Namanga-Magadi, Natron	25,623	This report

MATERIALS AND METHODS

Study Area

Amboseli-West Kilimanjaro and Magadi- Natorn Landscape covers portions of Southern Kenya and Northern Tanzania between latitudes 1^0 37′ and 3^0 13′ South and longitude 35^0 49′ and 38^0 00′ East (Figure 1). This ecosystem comprises Amboseli and Namanga-Magadi areas in Southern Kenya, and West Kilimanjaro and Natron in Northern Tanzania. The survey covered approximately 25,623 km^2 and extended from the foot of Chyulu hills to the east, Arusha National Park to the south, Lake Natron to the west and Lake Magadi to the North. Mt. Kilimanjaro lies to the south eastern boundary of the survey area. For purposes of this census, the survey area has been divided into four broad areas namely: Namanga-Magadi (also labeled as Magadi on Maps and Tables), Amboseli, Natron and West Kilimanjaro areas.

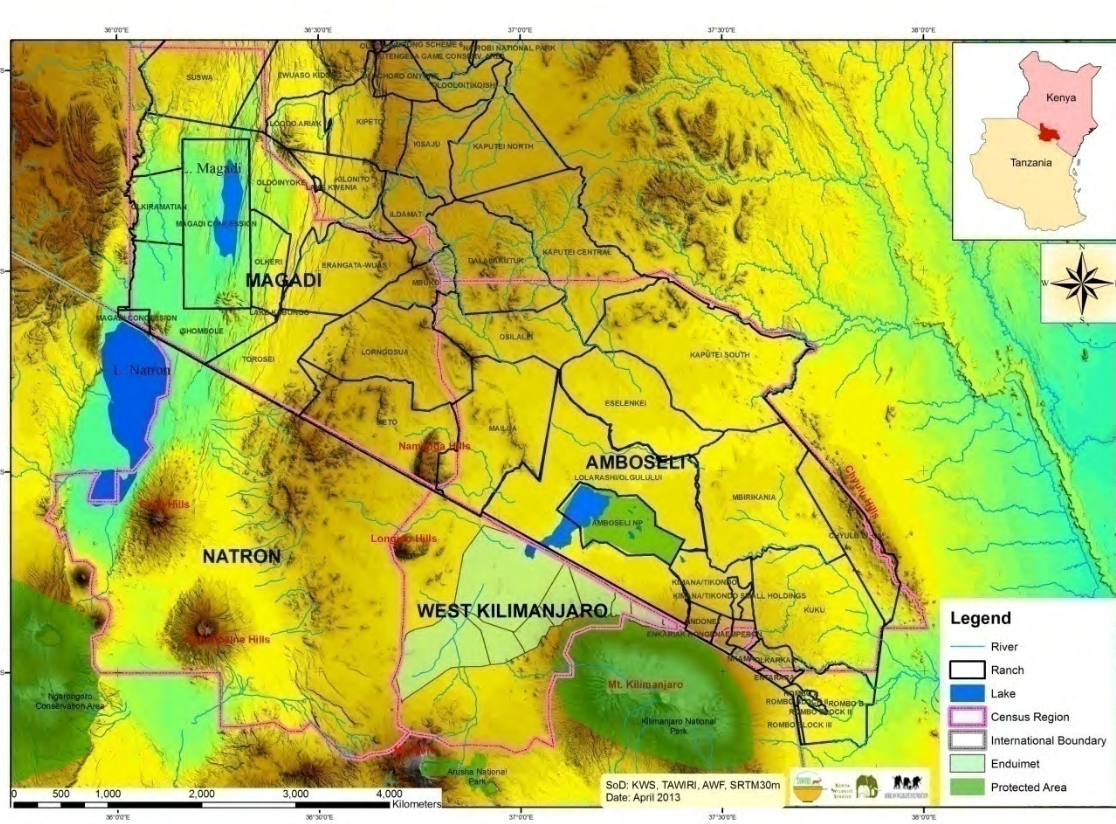

Figure 1: Map of the survey area showing the four broader census areas in Kenya and Tanzania.

Amboseli Area

Amboseli area covers an area of about 9214 km^2 and consists of Amboseli National Park and the surrounding group ranches namely; Kimana/Tikondo, Olgulului/Olararashi, Selengei, Imbirikani, Osilalei, Mailua, Kaputei south and Kuku. It also includes the former 48 individual ranches located on the lower slopes of Kilimanjaro along the Kenya –Tanzania international border, westwards from Loitoktok , that are now under crop production, mainly rain fed agriculture.

The area consists of basement plains, saline plains with fresh water swamps and the volcanic slopes of the Kilimanjaro. The vegetation is mainly that of a semi-arid environment. Quaternary volcanic soils on the northeastern Kilimanjaro slope dominate in the southeastern area (Pratt and Gwynne, 1977), encouraging rain-fed agriculture while basement rock soils cover most of the rest of Olgulului, making only pastoralism possible

The Amboseli area lies in ecological zone VI in the agro-climatic zone map and is generally arid to semi- arid savanna environment with low agricultural potential (Croze et al., 2006).The area is characterized by spatial and temporal variation in hydrology. Surface water is only found in the few permanent rivers (Kimana, Elselenkei-Kiboko and Loiterish river,) whereas streams and the existing water resources are predominantly as a result of the influence of Mt. Kilimanjaro water which flows under gravity and emerges from underground in form of springs. These springs together with rainfall feed the rivers, streams and swamps in the area (Engong narok and Longinye in the Amboseli N. P., Namelok, Engum, Ol makau and Isnet at the intersection between Kimana, Olgulului and Mbirikani group ranches and Olngarua Lenker in Kuku).

There is scarcity of water in the area surrounding the Park, particularly in Olgulului/Olorarashi group ranch especially during the dry season. The group ranch depends mostly on a series of boreholes and dams, and the 65 km Amboseli National Park water pipeline to water livestock and for domestic use.

The dominant vegetation types are open grasslands towards the north and northeast to the Chyulu Hills; *Acacia* dominated bush land to the south until the forest belt of Kilimanjaro. Throughout these main vegetation types, there are patches of swamp and swamp-edge grassland and Acacia woodland following a roughly northwest-southeast line along the park's long axis, with wooded and bush grassland found wherever there is seasonal accumulation of water. There have been changes in *Acacia xanthophloea* and *A. tortilis* woodlands along the swamps and to the southeast of the National Park, but such changes – though visually striking – must be seen in the context of the long-term, non-equilibrium behavior of arid ecosystems that are by nature highly variable, unpredictable and surprisingly resilient (Croze et al., 2011).

Namanga-Magadi Area

The Namanga-Magadi area (6348 km^2) comprises of Meto, Torosei, Mbuko, Elangata Wuas, Olkiramatian, Lorngosua and Shompole ranches. For most parts, the topography of Meto and Torosei Group Ranch area is a combination of gently undulating plains and outstanding hilly landscape and the Great Rift Valley. The soil is "black clayey" (grumosolic soils) and consist of a range of "black cotton" soils including the calcareous and non calcareous variants (Pratt and Gwynne, 1977).

Uaso Ngiro is the only permanent river; however there are several seasonal rivers like the Namanga and Esokota Rivers which originate from Namanga and Meto hills. The other main seasonal river is the Ol Kejuado that originates from Ilemelepo hills to the north west of Ibisil town and drains into river Kiboko. Minor seasonal rivers are Nosikitok, Nendanai and Ngatataek. Namanga (Ol donyo Orok) hill is a crucial water catchment. The other important water resources in the area are boreholes and artificial water dams that are either publicly or privately owned. These artificial water sources are the principle sources of water for humans, wildlife and livestock in many of the group ranches.

The diverse physical features have led to spatial and temporal variation in distinct habitat types. The dominant tree species include a variety of Acacias, *Commiphora* and *Balanites glabra*. The major grasses include *Chloris roxburgiana, Pennisetum stramenium, Pennisetum mezianum, Digitaria sp, Cynodon dactylon and Eragrostis sp.*

Rainfall received in this area is low, bimodal and highly variable, ranging between 400 - 600 mm. This low rainfall has rendered the area to be of marginal agricultural potential and therefore, most of the area is under pastoralism by Maasai people (Kioko, 2008). Limited irrigation and rain fed agriculture is practiced in a few areas, mostly along Maili Tisa-Namanga road, along the main rivers and Uaso Ngiro. Quarrying of building stones is practiced mainly along the Kajiado-Namanga road while sand harvesting occasionally occurs in the dry river beds impacting potential damages to the environment

West Kilimanjaro Area

The West Kilimanjaro area (3013 km^2) is within the Longido District of Arusha Region in the United Republic of Tanzania. The northern extent of the area is the Tanzania-Kenya border from Namanga south eastward to Irkaswa. The eastern border is defined by the boundary of Kilimanjaro National Park extending southward to near the community of Sanya Juu. The southern extent of this study area extends west from Sanya Juu to the northeast corner of Arusha National Park, continuing along the northern park border to the Arusha-Nairobi Road that also defines the western extent of West Kilimanjaro area.

The area is a complex mosaic of diverse natural communities, extensive grazing lands, and large agricultural fields at lower elevations of Mt. Kilimanjaro. There are traditional, agro-pastoral Maasai communities that graze cattle and other livestock as well as growing subsistence crops. In addition, there are five other medium-sized agricultural communities in the region. There are several protected areas in the region, including Kilimanjaro NP (755 km2) on the eastern boundary, Arusha NP (137 km^2) to the south, and Amboseli NP (392 km^2) in southern Kenya, 20 km north of the Tanzania-Kenya border. Additionally, there are two private conservation areas, West Kilimanjaro Ranch (303 km^2), Endarakwai Ranch (44 km^2); as well as, Longido Game Controlled Area (GCA, 1,700 km^2), and Ngasurai Open Area (544 km^2) that provide important habitats for wildlife.

Although the area varies in elevation (1,230 to 1,600 m ASL), the predominant ecological zone is semi-arid savannah (Pratt et al. 1966) interspersed with woodlands. There are extensive agricultural fields along the lower western flank of Mt. Kilimanjaro and lowland forests within the boundary of Kilimanjaro National Park (KINAPA) Distribution of rainfall is unpredictable, especially at lower elevations, and highly variable from year to year. Rainfall amounts average 341 mm/yr in semi-arid lower elevations (Moss 2001) and 890 mm/yr in agricultural areas at lower elevations on Mt. Kilimanjaro and at Mt. Meru and Monduli areas in the southern portion of the survey area.

Natron Area

The Natron area (7,047 km^2) is to the west of the West Kilimanjaro area with its northern extent defined by the Tanzania-Kenya border, extending from the border town of Namanga on the east and continuing northwest along the border to the northern terminus of Lake Natron. The western extent is along the east side of Lake Natron continuing south along the eastern border of Ngorongoro Conservation Area. The southern boundary extends from the southeast corner of Ngorongoro Conservation Area eastward to the northwest corner of Arusha National Park.

The area is a mosaic of diverse natural communities and extensive grazing lands. There is a unique Maasai grazing area extending westward from the Kiserian-Mriata Ridge (on the eastern side of the study region) extending westward encompassing the grasslands adjacent to Gelai (2,942 m) and Kitumbeine (2,858 m) mountains. This area is characterized by well-drained savannah grasslands and woodlands where Maasai graze their cattle during the dry season and no permanent human settlements are allowed.

Within this study region, traditional Maasai communities graze their livestock and practice subsistence agriculture. The entire region is included within the Natron GCA and the northern portion of the Monduli GCA where wildlife is managed primarily for hunting. The predominant ecological zone is semi-arid savannah interspersed with open acacia woodlands (*Acacia sp* and *Commiphora sp*), especially on the western side of the Kiserian-Mriata Ridge. Distribution of rainfall is unpredictable and highly variable from year to year, but rainfall is typically less than 350 mm/yr.

Data collection Protocols

For a long time Kenya wildlife Service has been undertaking total aerial counts of large herbivores using methods as described by Douglas-Hamilton (1994) and Norton–Griffiths, (1978). This technique aimed at systematically covering the entire area of the defined census zone and recording every mammal species being counted and its location in UTM coordinates. Such total aerial counts rely heavily on the experience of both the pilot and the flight crews (Douglas-Hamilton et al., 1994). In Kenya a substantial set of data have been generated from this method and have provided trends for understanding the dynamics of wildlife populations in the country.

Census techniques modifications and its rationale

In the 2013 census, a series of data collection procedures were modified to enhance accuracy and efficacy of the counts without radically changing the data to an extent that they were incompatible with previous long term data. The objectives of the modification were three fold, to;

a. Explore how data can be collected in a way that sampling can be integrated within total counts in a sort of 'hybrid' manner. This would enable comparison of recent total counts with past sample counts. The use of the streamers coupled with determination of heights above ground provides a way that data can be analyzed as a sample count. This may have an additional benefit if in the event that future total counts would be hard to fund, then a way to smoothly transition to sample counts would have been explored.
b. Provide an opportunity for estimating errors in total counts
c. Enhance acceptability and reliability of reports for scientific publications and further modeling

By surveying over the entire study area while still capturing survey parameters that would meet the requirements of a sample survey design, this current design provides the opportunity of exploiting the strengths of both total and sample design strategies. The advantage comes from the opportunity that by flying 1- KM transects across the whole survey area a very large data samples are generated yet still by disregarding the streamers, the data can also be analyzed as a total count.

The following were the modifications /improvements added to the usual total count method:

Census Blocks Modification

The counting blocks were modified and reshaped to ensure that:

- Rivers were not boundaries of the blocks. Normally rivers are places of concentration of animals hence using them as a boundary for census blocks is a potential source of errors.
- Blocks were rectangular or square in shape. This eased navigation for pilot and FSO and allowed more time for observations. With rectangular blocks, the entire pilot needed to know was the GPS reading at start and end of each block.
- Blocks were made small enough to be counted by a single plane in a single day. This size was determined to be about 900KM^2 .The situation where a block needed to be counted in two days was thus avoided.
- Areas of no wildlife or features of interest such as heavily settled areas (towns and market centers), and large scale farms and agricultural areas, mountains were not included in the blocks. These areas were determined based on observation from previous censuses. This was done to enable economy of fuel and resources
- Blocks boundaries did not cut across areas of high wildlife density as determined by kernel densities of previous counts.

The modification of block shapes and sizes in the survey area resulted in 31 discrete counting blocks (Figure 2) with most blocks (25 out of 31) being flown in a south-north direction (Figure 3)

Use of streamers and Calibrations

To improve the quality of data collected on wildlife populations, the crew were trained on data capture, species identification and data handling. Both crew and planes were calibrated to aid in estimation of distance for subsequent calculation of observable strip width. Streamers were mounted on either side of the aircraft wings to create two strip categories, the inner and outer (Figure 4). Inner category was defined as the region from the farthest one could see from the belly of the plane to the lower streamer. Likewise the outer category was defined as the region between the lower and the upper streamer (within the streamers).

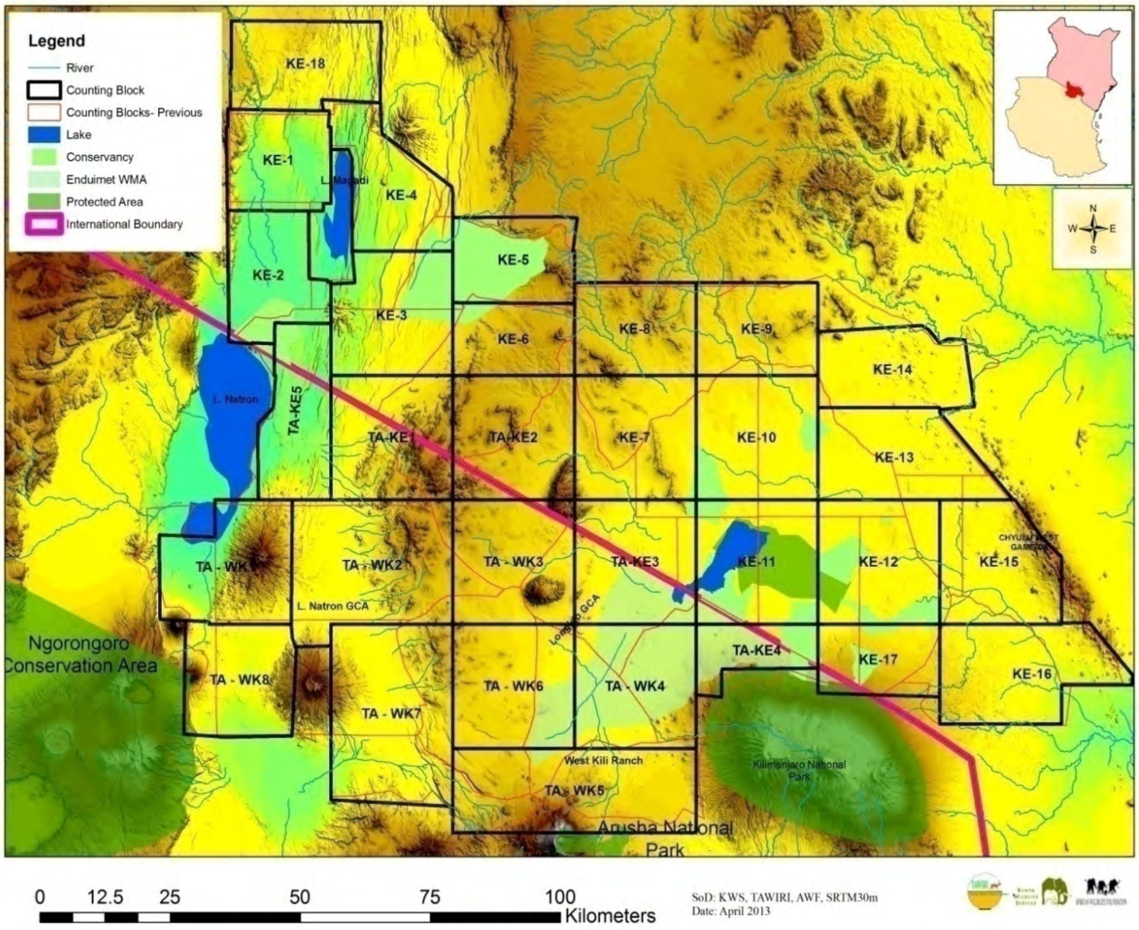

Figure 2 Map of the study area showing modified survey blocks

Calibration for observers entailed adjusting the angle of view of the streamers to correspond to 500M and 250 M on the ground for a set altitude of 300 Ft AGL for the upper and lower streamer respectively. This was done by use of clinometers. The Rear Seat Observers (RSO's) were each calibrated and observer specific and plane specific metrics for each calibration recorded according to an individual's physique. The metrics comprised measurements from various reference points on the air craft such as low and high eye mark on the aircraft window, upper and lower streamer mark on wing strut and plane fuselage. In addition, Front Seat Observers (FSO's) and pilots the were also calibrated for the purpose of assisting the RSO's to determine whether or not the counted animals are within the strip width.

For each calibration made, test flights were conducted at the set altitude for streamers (300 Ft AGL) to determine how well the streamers fit to the desired strip width on the ground. This was achieved by creating a flight line at 500M and 250M from a very straight and long (5KMs) section of a road. When the aircrafts flew on this line, the road was either 500M or 250M from the plane and this allowed for evaluation of the streamers.

To asses inter observer variability in estimation and enhance species identification, all observers were independently subjected to count a portion of the same block with different species of known numbers in mock flights.

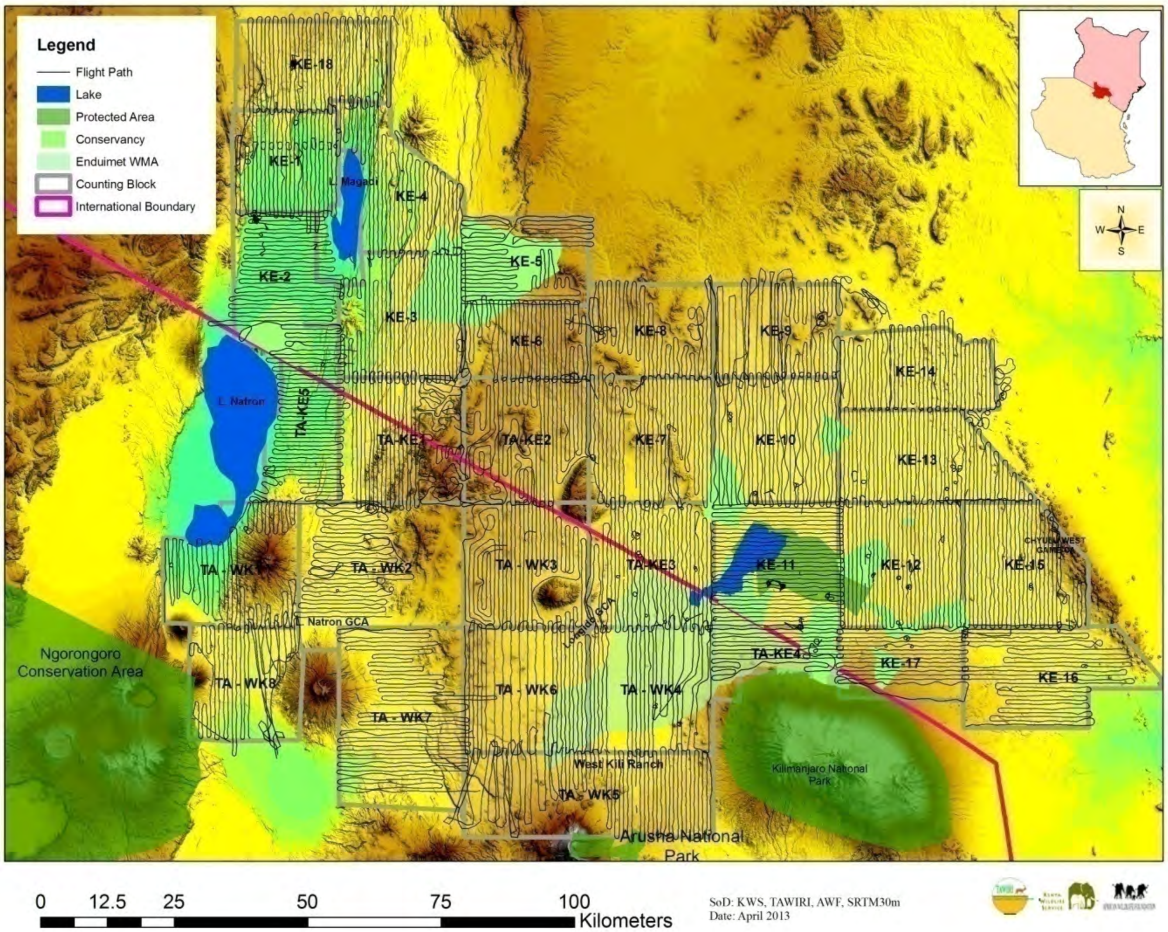

Figure 3: Map of the study area showing the flight paths

Estimation of height above ground

Most of the aircrafts used in this census did not have radar altimeters and hence we had to find an alternative way of estimating AGL. Handheld GPS units in combination with a Digital Elevation Model (DEM) were used for this purpose by utilizing elevation functionality of the GPS units. Prior and after each flight the GPS were calibrated for elevation from a reference point with known elevation. A 30m ASTER Digital Elevation Model (DEM) for the entire survey area was downloaded from the internet (*g**dem**.ersdac.jspacesystems.or.jp*)). Heights above ground were then later calculated.

Figure 4 Photo demonstrating the fixing of streamers on an aircraft

Use of digital voice recorders and data sheets

To enhance efficiency in data collection, digital voice recorders were used to capture observation data. The observers upon spotting an observation of interest, shouted onto the voice recorder the species, estimate, the side (left or right), the streamer category (inner or outer) as well as the GPS waypoint number of the observation. In a four seater- aircraft, the FSO also recorded data using data sheets. However, in a two- seater aircraft, the FSO collected all the information using the voice recorder and a GPS receiver only.

In addition to wildlife data, other information of interest was human activities that that were presumed to pose a threat to the ecological integrity of the ecosystems in the surveyed area. These included anthropogenic activities namely livestock grazing, clearing of vegetation for development activities, roads and infrastructure. These parameters are believed to be the key drivers in ecosystem changes and degradation that results in loss of conservation areas (Ngene et al., 2009).

Data handling and analyses

On landing, the ground crew downloaded the data recorded in GPS units and records captured in digital voice recorders. Once downloaded, the voice records were processed digitally to remove background noises to enable the data to be clearly heard. A team of transcribers listened to these records transcribed the data onto data sheets. This process produced datasheets for two seater planes and an additional data sheet for the four seater planes. For the four seater planes, the transcribed data sheet was compared to the original FSO data sheets. Where there were discrepancies, these were verified, corrected and reconciled. All data were then entered into a spread sheet.

Double counts especially on flight lines that were overlapping or very near each other were visually searched and eliminated in a GIS environment. At the end of count session the GPS flight paths (as tracks) and waypoints were down loaded using DNR-Garmin /MapSource software. Flight path and way point data were processed using ArcGIS 10.1 software to develop wildlife distribution maps. A process of data validation and quality control was thereafter done to eliminate any data entry errors and ensure completeness of data.

To obtain the height above ground for each observation, the following formula was used $HAG_p = G_p - D_p - (D_r - G_r)$

Where

$HAGL_p$ = Height Above ground at a particular observation point

G_p = GPS elevation value and a particular observation point

D_p = DEM value at a particular observation point

D_r= DEM value at the reference location

G_r= GPS elevation value at the reference location

Population density and carcass ratio

The population density of each wildlife species was computed as the number of individuals divided by area in square kilometer. The carcass ratio was computed as the proportion of dead elephants to summation of all live and dead elephants and as recommended by Douglas-Hamiton & Hillman (1981), and the ratio was used as an index of relative elephant mortality.

RESULTS

Wildlife Abundance

A total of 28 mammalian and one avian species were counted in the Amboseli-West Kilimanjaro and the Lake Natron landscape (Table 2). Common Zebra (*Equus burchelli)* was the most abundant wild species (**29,867)** followed by Grant's gazelle (*Gazella granti*) (**17,509)** and common wildebeest (*Connnochaetes taurinus*) (**14,728).** Other abundant species included Maasai giraffe (*Giraffa camelopardalis*), Cape eland (*Taurotragus oryx*),), impala (*Aepyceros melampus*), Thomson's gazelle (*Gazella thomsonii*), Maasai ostrich (*Struthio camelus*) and the African elephant (*Loxontoda africana*) while the least abundant species included the Bat eared fox (*Otocyon megalotis*), spotted hyena (*Crocuta crocuta*) and the Dikdiks(Madoqua).

Table 2: Summary of wildlife species numbers counted during the wet season count of April 2013 in various areas during the census survey

SPECIES	**AMBOSELI (9214.44 KM²)**	**MAGADI (6348.32 KM2) KM²)**	**NATRON (7047.26 KM²)**	**W. KILIMANJARO (3013.18 KM²)**	**Grand Total**
COMMON ZEBRA	12,159	7,378	8,067	2,263	**29,867**
GRANT'S GAZELLE	8,180	5,319	2,878	1,132	**17,509**
COMMON WILDEBEEST	3,894	2,389	7,487	958	**14,728**
MAASAI GIRAFFE	3,470	1,577	1,767	813	**7,627**
CAPE ELAND	3,302	991	623	119	**5,035**
IMPALA	1,549	1,452	241	402	**3,644**
THOMSON'S GAZELLE	1,064	592	574	469	**2,699**
MAASAI OSTRICH	910	438	523	139	**2,010**
AFRICAN ELEPHANT	1,281	449	63	137	**1,930**
CAPE BUFFALO	325	107		143	**575**
COKE'S HARTEBEAST	541	9			**550**
FRIDGE EARED-ORYX	187	191	89	66	**533**
GERENUK	114	37	45	66	**262**
LESSER KUDU	112	25	14	60	**211**

BABOON	8	30	81	70	**189**
WARTHOG	47	42	18	24	**131**
SILVERBACKED JACKAL	2	33		2	**37**
ELEPHANT CARCASS	14	1	3	18	**36**
COMMON WATERBUCK	13	17			**30**
HIPPOPOTAMUS	18				**18**
BUSHBUCK	4	8			**12**
LION	4			5	**9**
CHEETAH	6				**6**
GREATER KUDU				6	**6**
REED BUCK	4	2			**6**
BAT EARED FOX			5		**5**
SPOTTED HYENA	3		1		**4**
DIKDIK			1		**1**
Total					**87,670**

Species abundance, densities and their Distributions

Common Zebra

There were **29,867** zebras recorded in the entire survey area (Table 2). The species was widely distributed across the entire survey area, with most concentrations in areas east and south of Amboseli, Lake Natron game control area and in Kaputei south, Eselenkei and Maelua areas (Figure 5). Among the four survey areas Amboseli had the highest density (1.32/km^2), followed by Natron (1.145/km^2), Magadi (0.80/km^2) and West Kilimanjaro (0.751/km^2) (appendix 1). The population has more than doubled since the last wet season count of 2010.

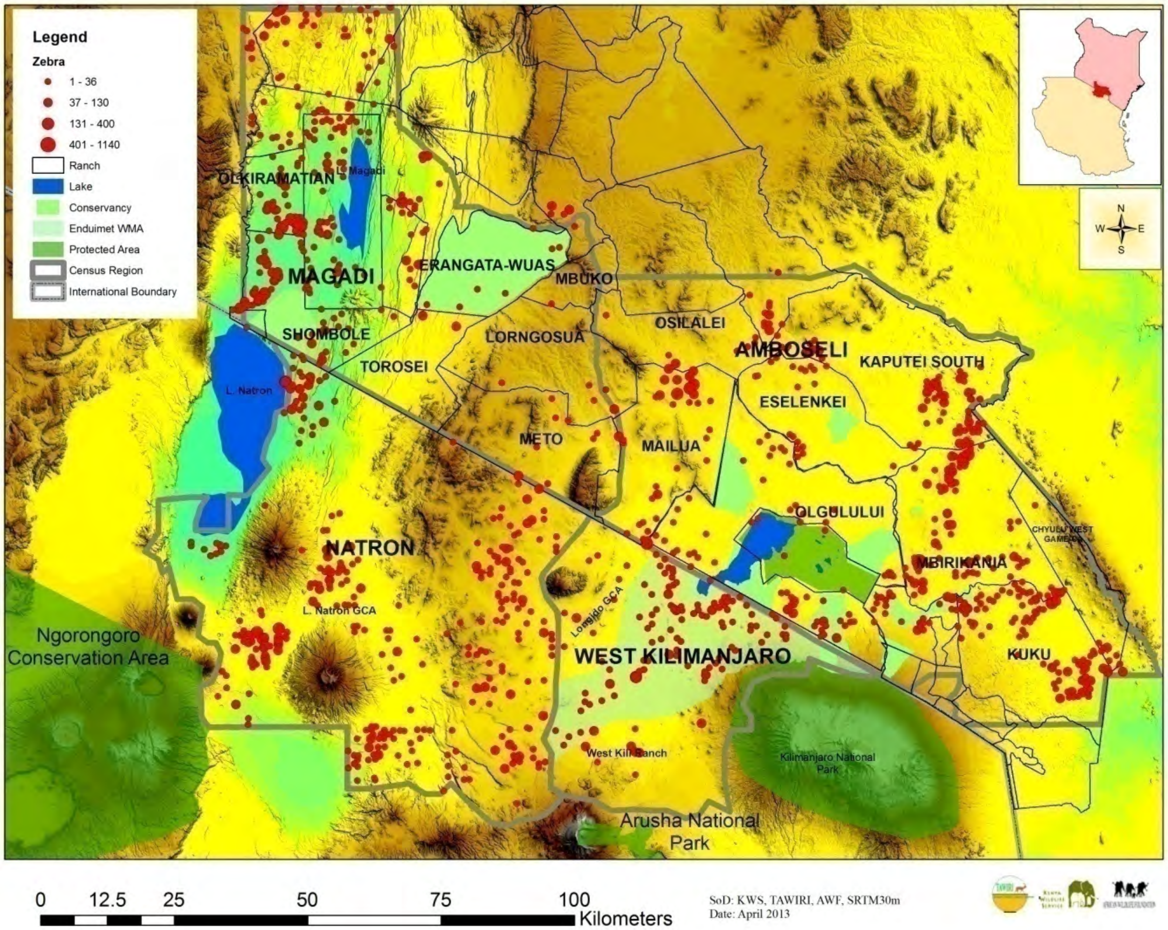

Figure 5: Distribution of common zebra in the study area in April 2013.

Grant's gazelle

Grant's gazelles, with a population abundance of 17, 509 individuals was the second most abundant species in the surveyed area. The population has doubled as compared to 8,362 individual recorded in the last wet season census carried out in the year 2010. The Amboseli and Namanga-Magadi areas had the majority of Grant's gazelles (8,180 and 5,319, respectively). Natron area had 2878 individuals while, 1132 individuals were found in the West Kilimanjaro area. This species was ubiquitously distributed (Figure 6) with the highest density recorded in the Amboseli area ($0.888/km^2$) and the lowest in West Kilimanjaro ($0.376/km^2$) (Table 2 and appendix 1)

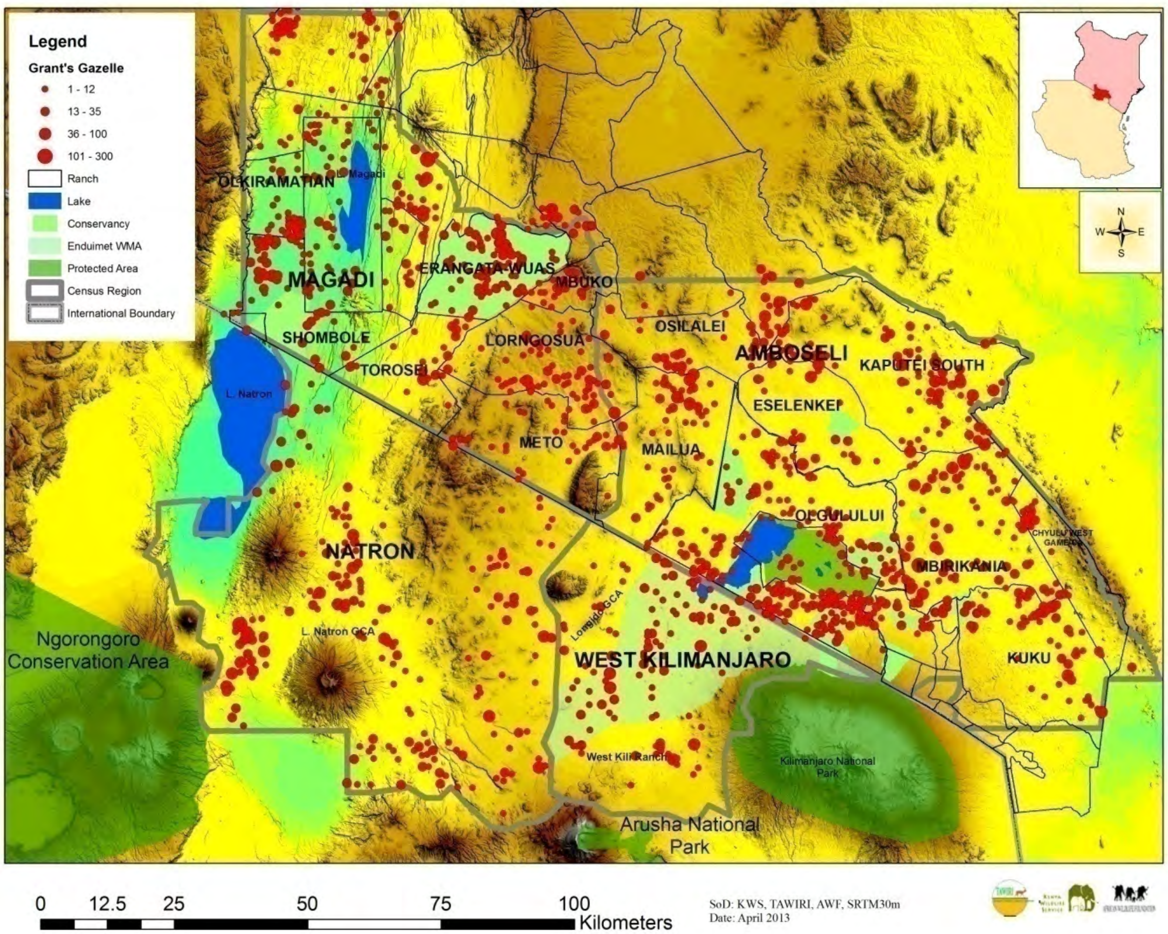

Figure 6: Distribution of Grant's gazelle in the study area in April 2013

Common Wildebeest

Wildebeest was the third most abundant wildlife species recorded in the surveyed area with a total number of 14728 individuals. Most of the wildebeest were in the Lake Natron, Amboseli and Lake Magadi areas and were remarkably absent in blocks situated in Meto-Longoswa and few individuals were recorded in West Kilimanjaro ranch (Figure 7). The highest density was recorded in the Natron region (1.06/km^2), followed by Amboseli area (0.423/km^2). In the Namanga-Magadi area, wildebeest had a density of 0.376/km^2 while in the West Kilimanjaro their density was 0.318/km^2 (Table 2 and appendix 1).

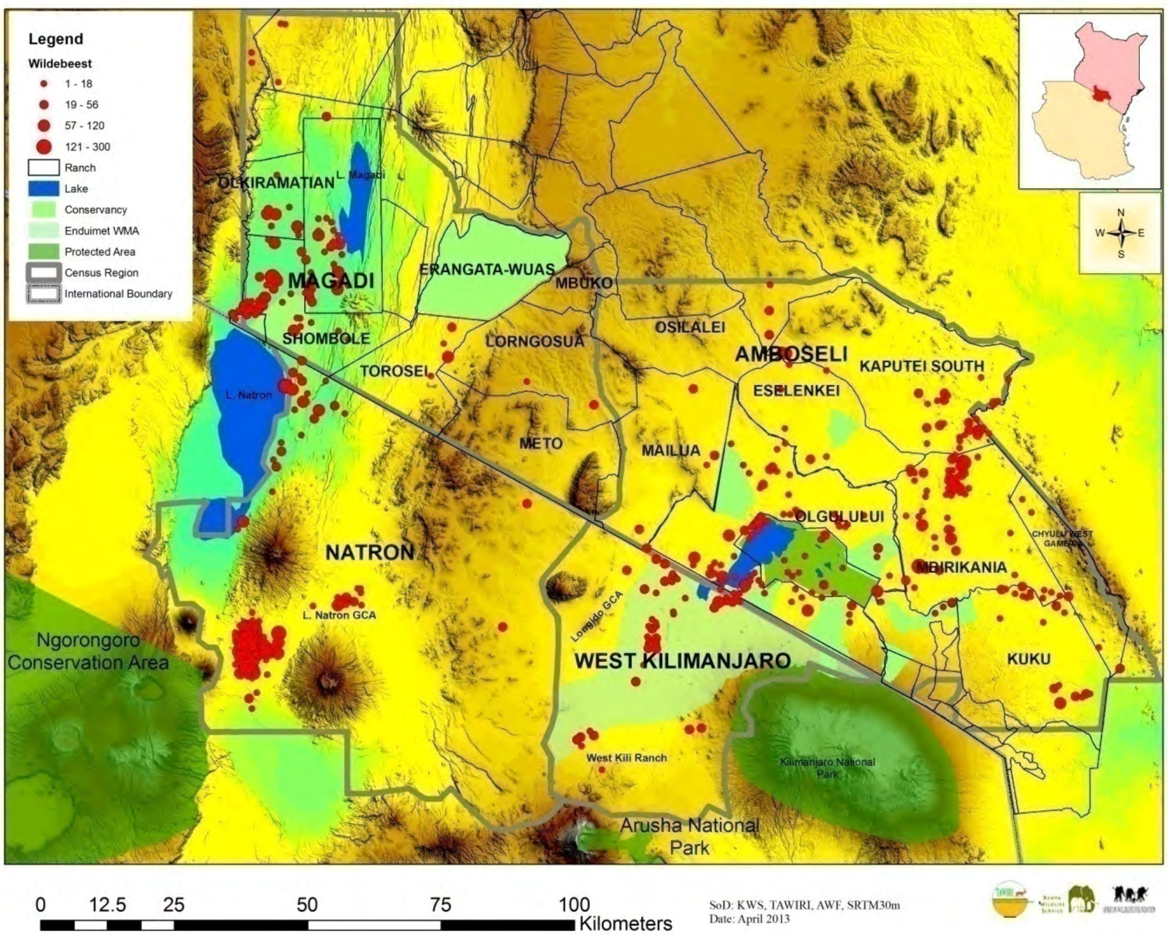

Figure 7: Map of the study area showing distribution of wildebeest, April 2013

Maasai Giraffe

Giraffes were widely distributed in the entire ecosystem. They occurred in all the surveyed blocks with major concentrations due south of Lake Natron, Lake Magadi and in the east and west of Amboseli (Figure 8).The highest number recorded was in Amboseli (3,470) followed by Natron (1767), Magadi (1577) and were least in West Kilimanjaro (813) (Table 2). However, there were no major variations in densities between areas, with Amboseli recording densities of 0.38/km², Magadi 0.25/km², Natron 0.25/km² and West Kilimanjaro 0.27/km² (Appendix 1).

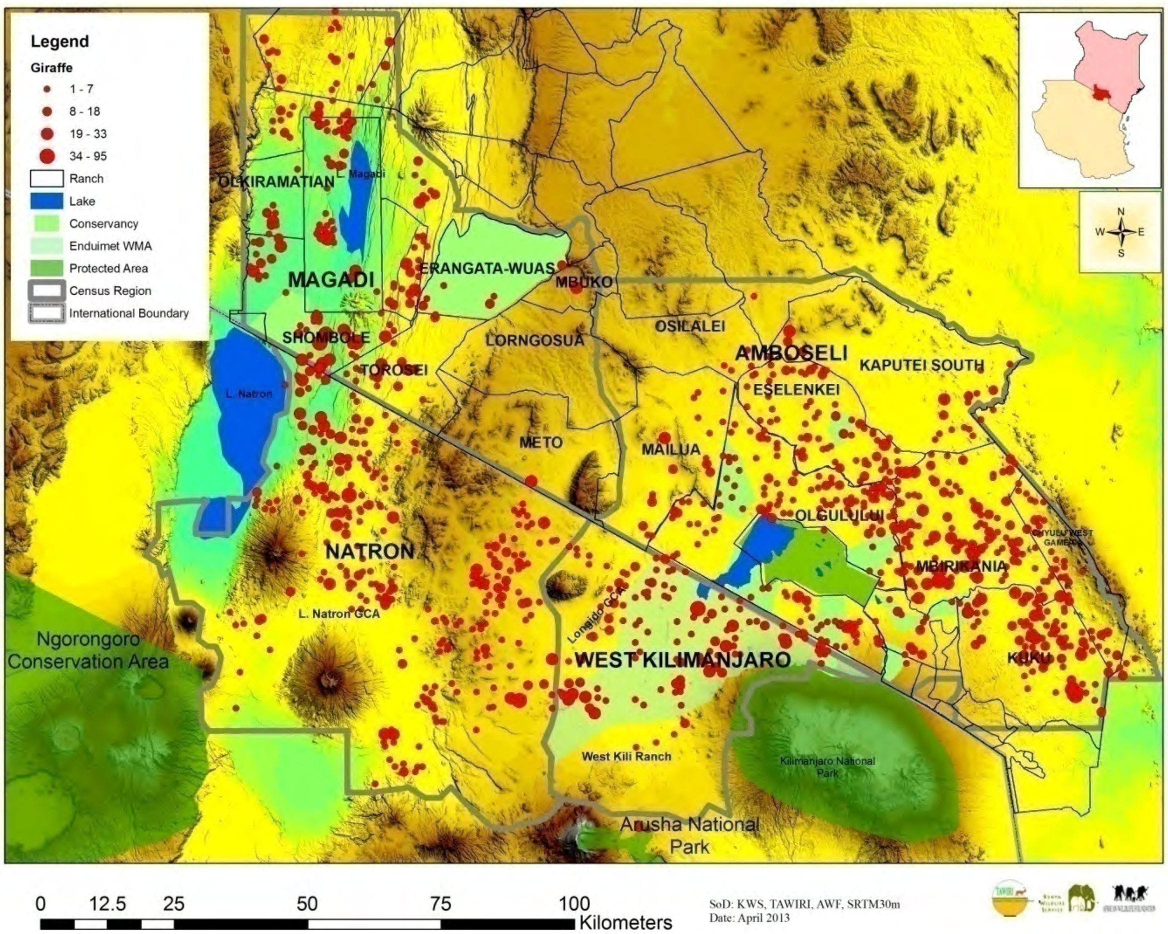

Figure 8: Distribution of Maasai Giraffe in the study area in April 2013

Cape Eland

Population of eland recorded in the study area was 5035 individuals. These were widely distributed in the survey area with the exception of areas near Meto-Olongosua where there were no Elands recorded (Figure 9). Interestingly, no elands were recorded in the Amboseli National Park. Elands were mainly concentrated to the east and north east outside Amboseli National Park and in areas north of Lake Magadi. The highest density was recorded in the Amboseli area (0.358/km²) followed by Magadi (0.156/km²) and Natron (0.088/ km²). West Kilimanjaro had a density of 0.039/km² (Appendix 1).

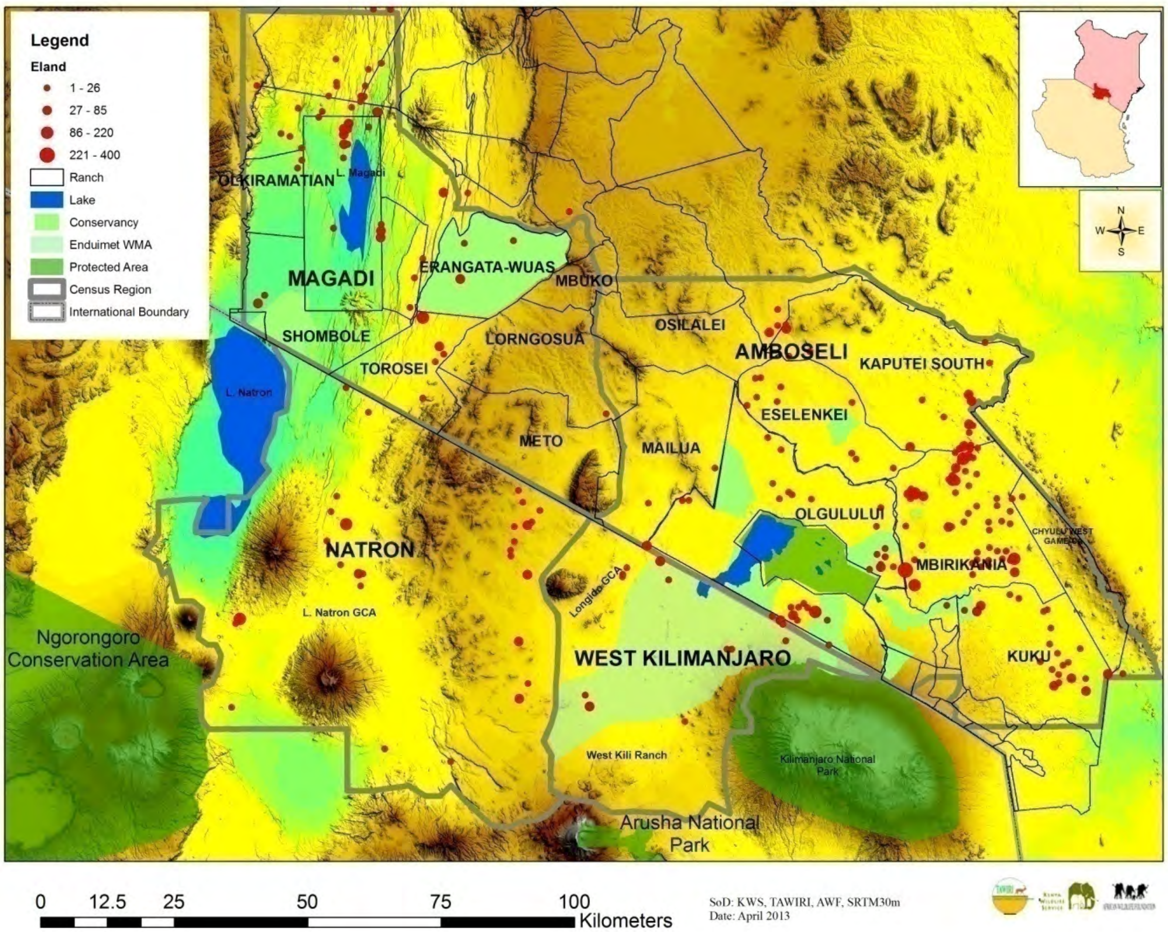

Figure 9: Distribution of Eland in the study area in April 2013

Maasai Ostrich

Two thousand and ten (2, 010) Ostriches were recorded during the census, and they were sighted in almost all the blocks counted (Figure 10). However, most of the Ostriches were recorded in the Amboseli area with a density of 0.099/km^2; Namanga-Magadi area with density 0.069/km^2, while West Kilimanjaro and Natron had densities of 0.046/km^2 and 0.074/ km^2, respectively (appendix 1).

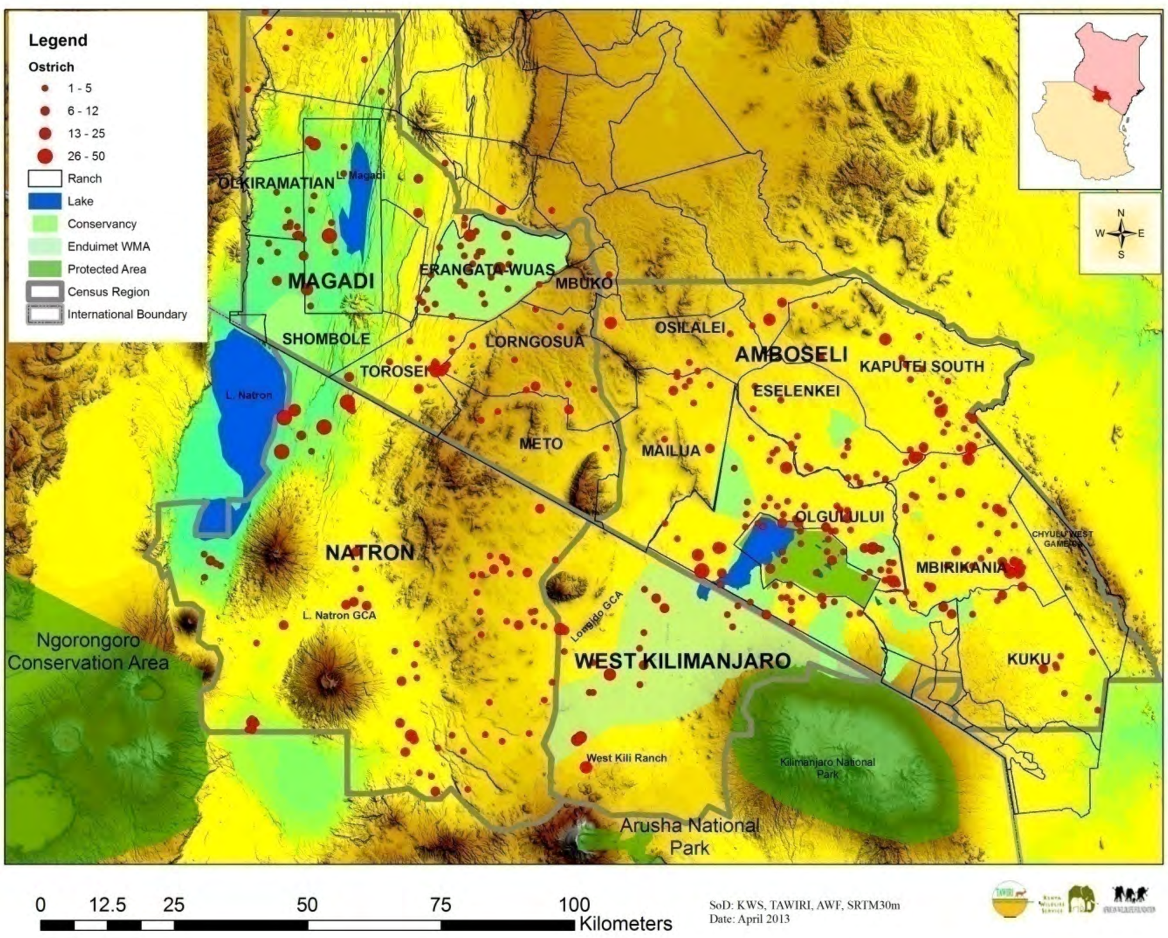

Figure 10: Distribution of Ostrich in the study area in April 2013

African Elephant

During the survey, most of elephants (1281 or 66.4% of the total) were found inside and areas adjacent to Amboseli National Park (Figure 11). This translates to a density of 0.14/km2. Magadi block that includes Namanga, Natron and West Kilimanjaro had 23.3%, 3.3% and 7% respectively. Magadi, Natron, and West Kilimanjaro had 449, 63 and 139 elephants respectively. The densities for Magadi, Natron and West and Kilimanjaro were 0.07/km2, 0.01/km^2 and 0.05/km^2 respectively (appendix 1)

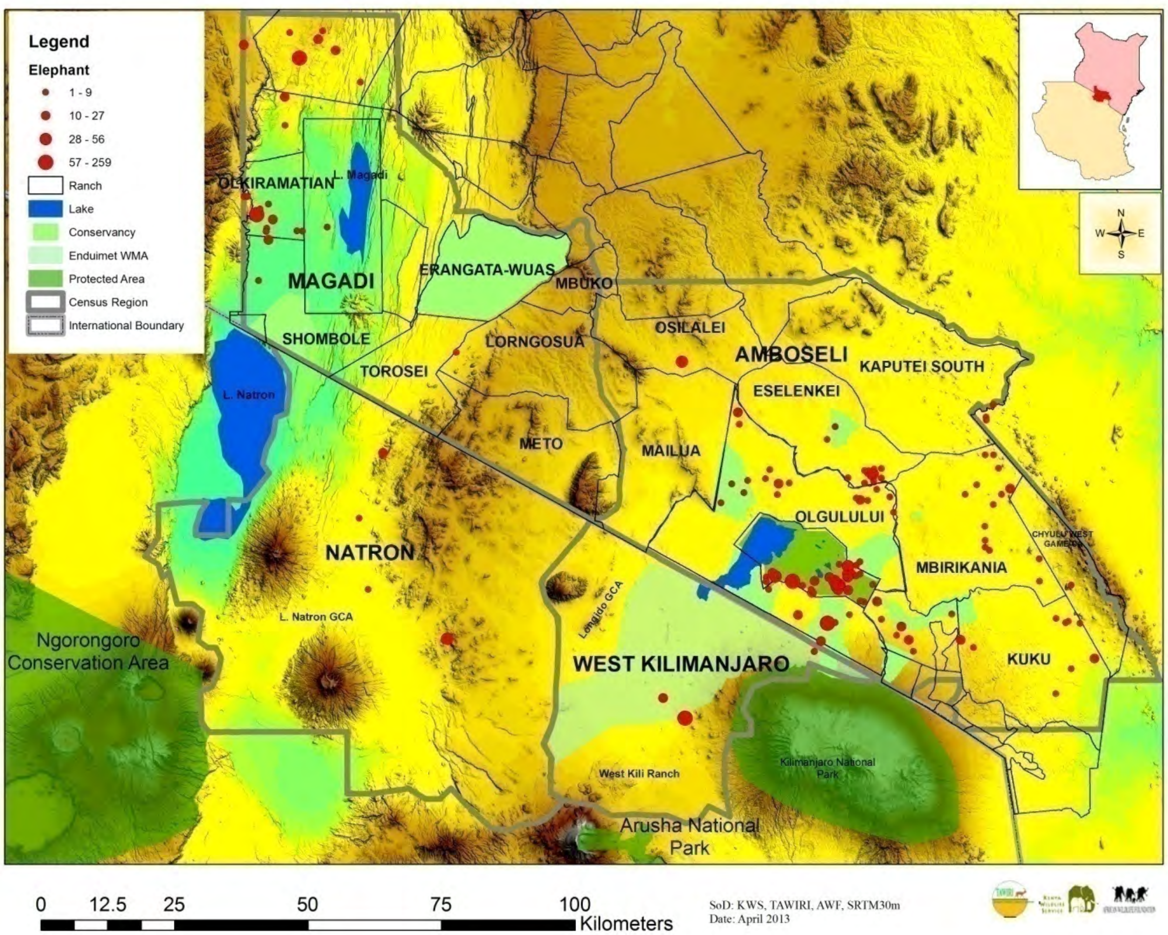

Figure 11: Distribution of Elephants in the study area, April 2013

Elephant carcasses

A total of 36 elephant carcasses were recorded in the entire ecosystem. Majority of them (19) were old while 17 were classified as very old. 50 % of all the carcasses were in West Kilimanjaro block. Amboseli block had the next highest number (39%) of carcass, Magadi and Natron had one and three carcases respectively (Figure 12.).

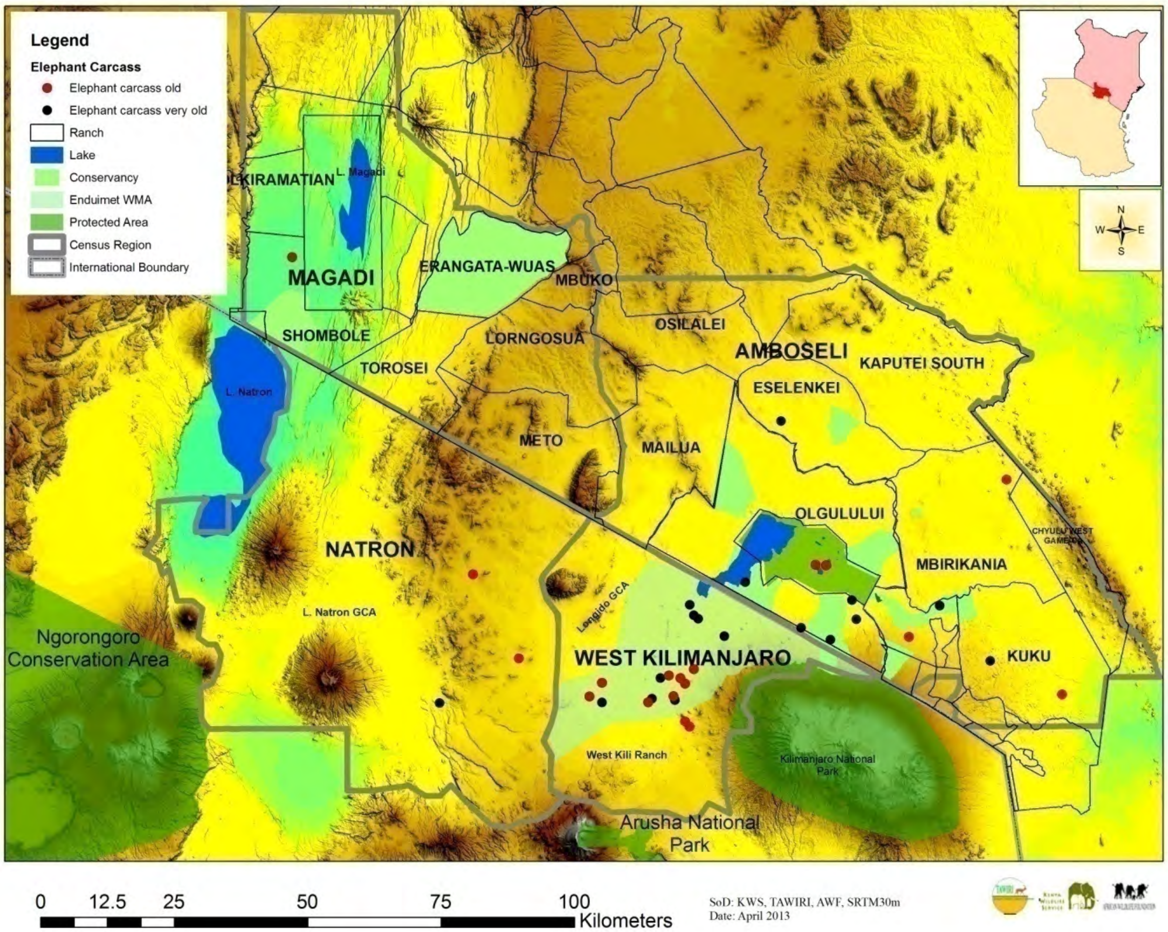

Figure 12: Map of the study area showing distribution of elephant carcasses, April 2013

Impala

The population of Impala in the study area was 3644 individuals (Table 2). The West Kilimanjaro area though having the lowest population (241) had the highest percentage increase (90.5%) with a density of 0.13/km^2. Amboseli recorded the highest number (1549 and a density of 0.17/km^2). Magadi with a density of 0.23/ km^2 had 1452 impalas. With a density of 0.03/ km^2, the Natron area recorded population of 402. In the order of distribution, Amboseli had the highest concentrations, followed by Magadi, Natron and West Kilimanjaro respectively. Most of the impalas in Amboseli were found outside the national park in the south eastern and north western parts of the block. In Magadi most of the population was to the west and north of the lake as well as to the south eastern areas bordering Amboseli. (Figure 13).

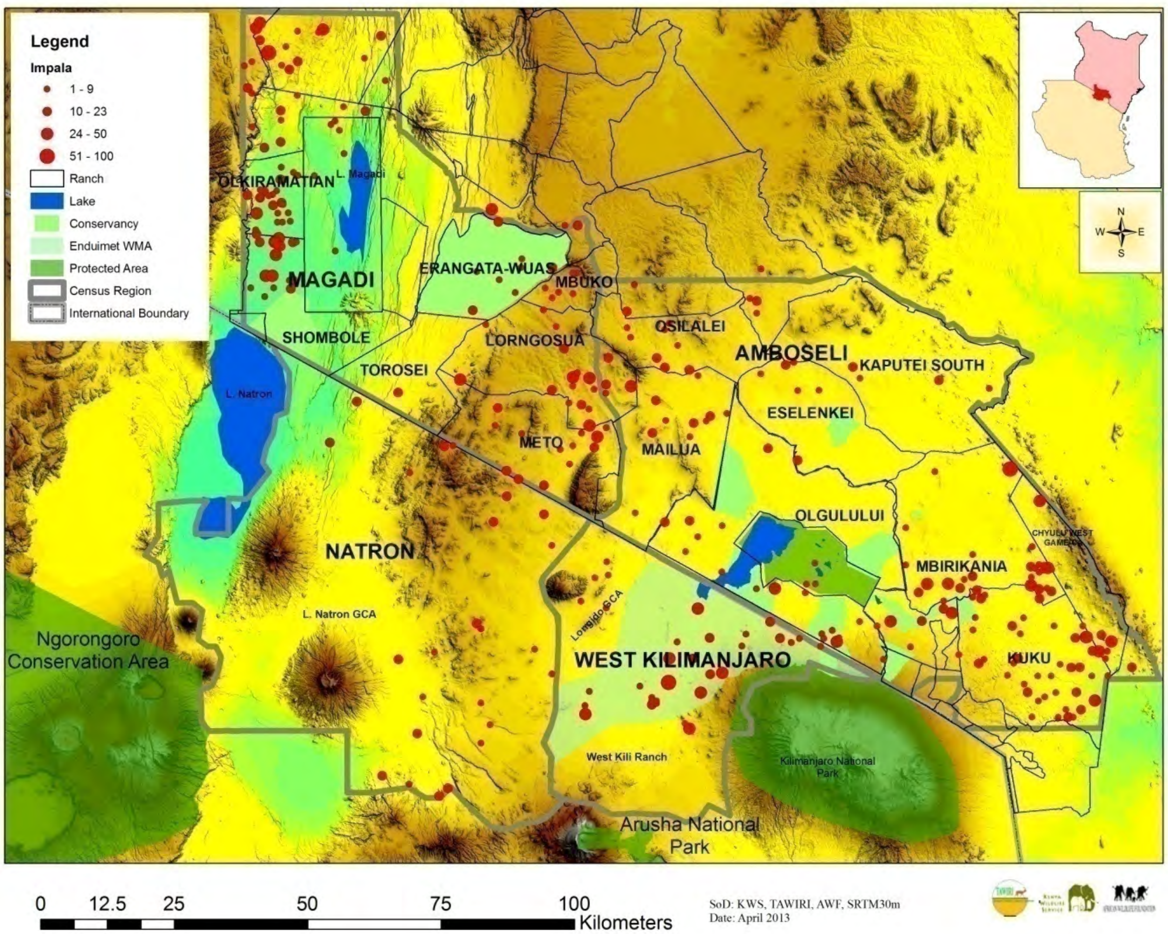

Figure 13 Distribution of Impalas in study area

Thomson's Gazelle

Thomson's gazelles were widely distributed in the study and 2699 individuals were counted. Magadi recorded 592 individuals with a density of 0.09/ km². Amboseli had the highest concentration of 1064 individuals with a density of 0.12/ km². West Kilimanjaro recorded 469 showing an increase of 54.6% and a density of 0.16/ km². Natron (574 individuals) had a density of 0.08/ km² (Table 2 and appendix 1). The overall density of Thomson's gazelle in the study area was 0.11/ km².

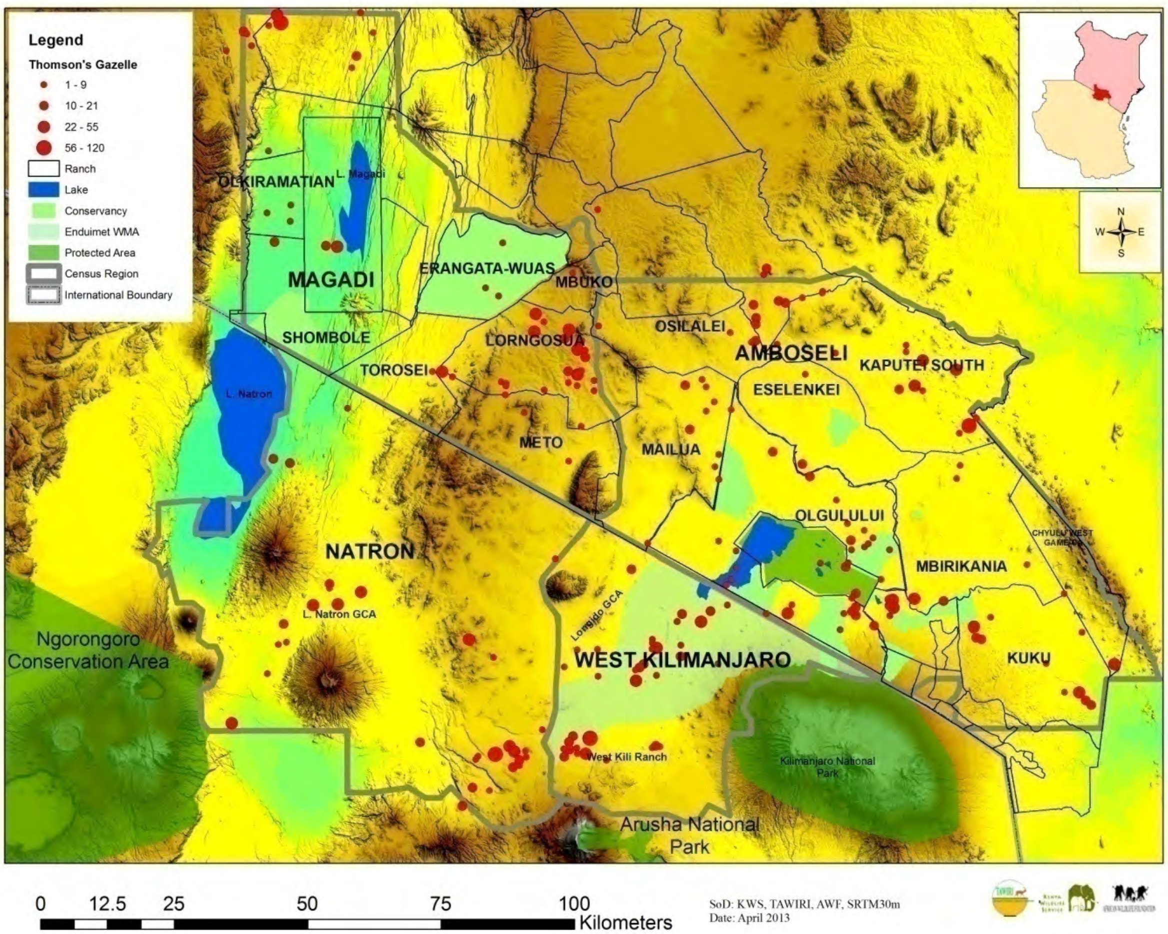

Figure 14: Distribution of Thomson's Gazelles in the study area, April 2013

Coke's Hartebeest (Kongoni)

During the survey 550 individuals of coke's hartebeest were recorded. Amboseli area had the highest number of 541 with a density of 0.06/km2. Most of these animals were found outside the park on the slopes of Chyulu hills (Figure 15). West Kilimanjaro and Natron recorded no hartebeest. The overall density was 0.02/km^2. Magadi area recorded only 9 individuals (Table 2 and figure 12).

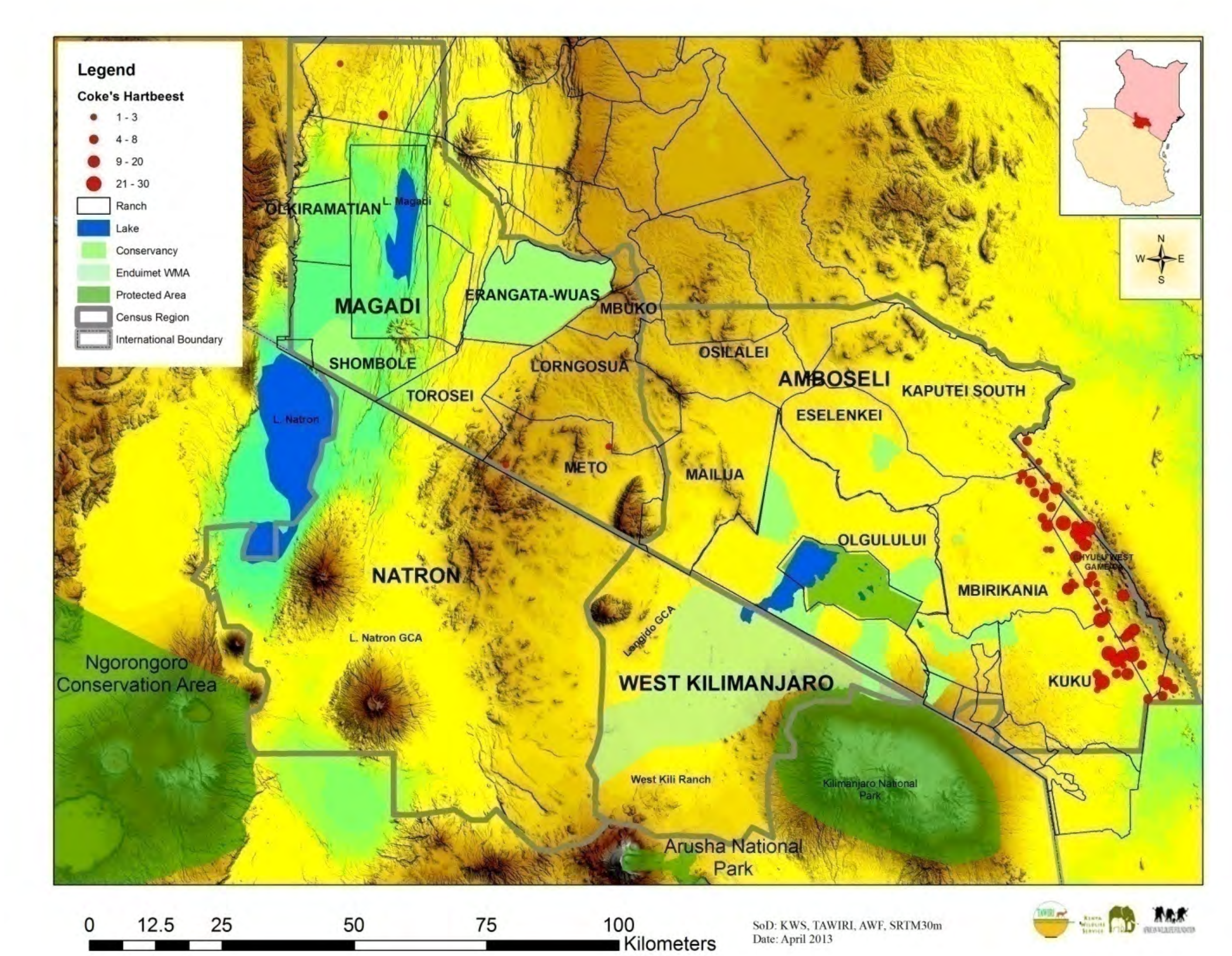

Figure 15: Distribution of Coke's Hartebeest in Study Area

Cape Buffalo

A total of 575 buffaloes were recorded during the census and their density was highest in Amboseli (0.04/km²). Over all the increase of buffaloes in entire area was 41.9% since the last count. This was followed by West Kilimanjaro which had 143 individuals with a density of 0.05/ km². Magadi area, recorded 62 buffaloes leading to a density of 0.02/ km² while in the Natron area, no buffalo was recorded. The overall density was 0.02/ km². (table 2 and appendix 1). Figure 16 below gives a spatial distribution of buffalo across the entire area.

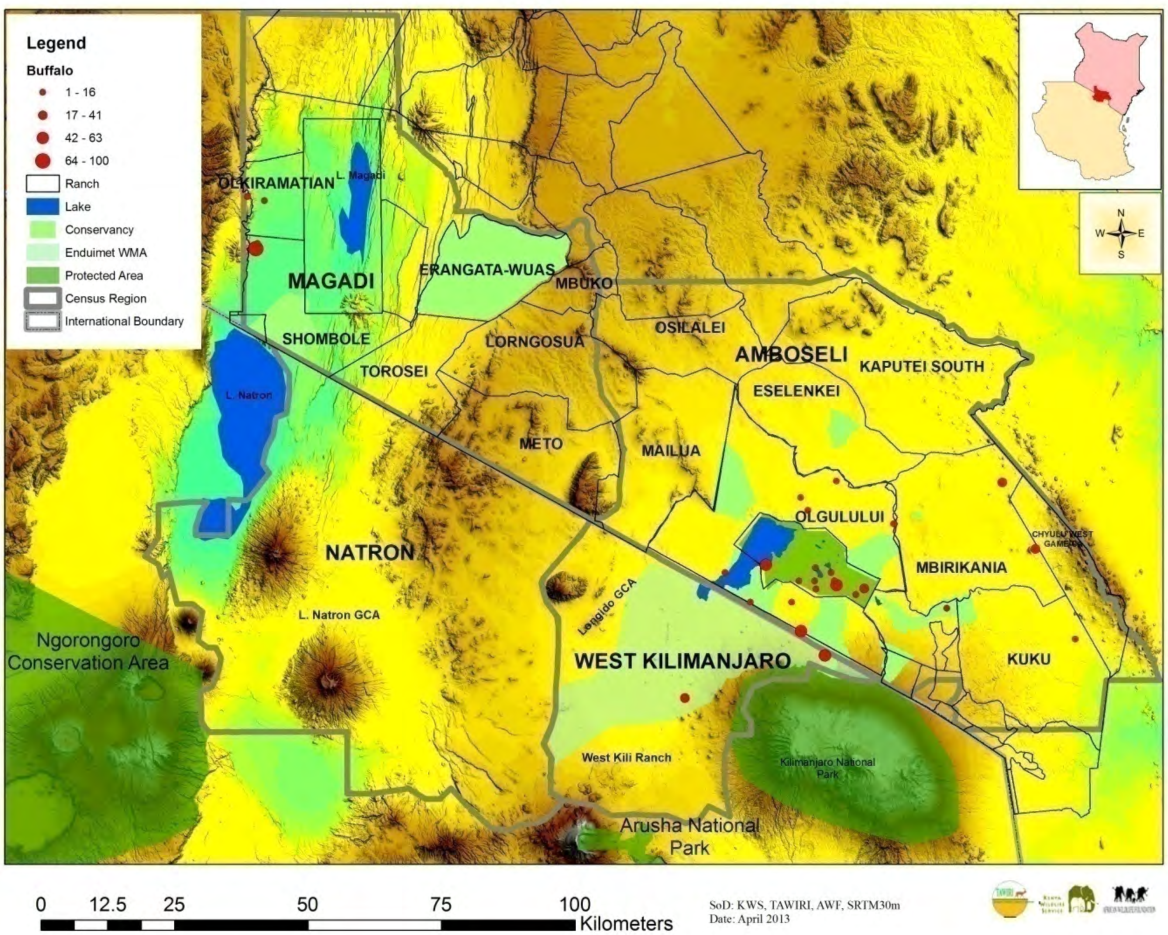

Figure 16: Distribution of Cape buffalo in the study area

Fringe-Eared Oryx

A total of 533 Fringe-eared Oryx individuals were recorded giving an overall density of 0.02/km². Magadi recorded the highest number of individuals (191). The density here was 0.03/km². In West Kilimanjaro, the density was 0.02/km². The Natron area recorded a total of 89 individuals with a density of 0.01/km². Amboseli had a density of 0.02/km²(Figure14 table 2 and appendix 1).

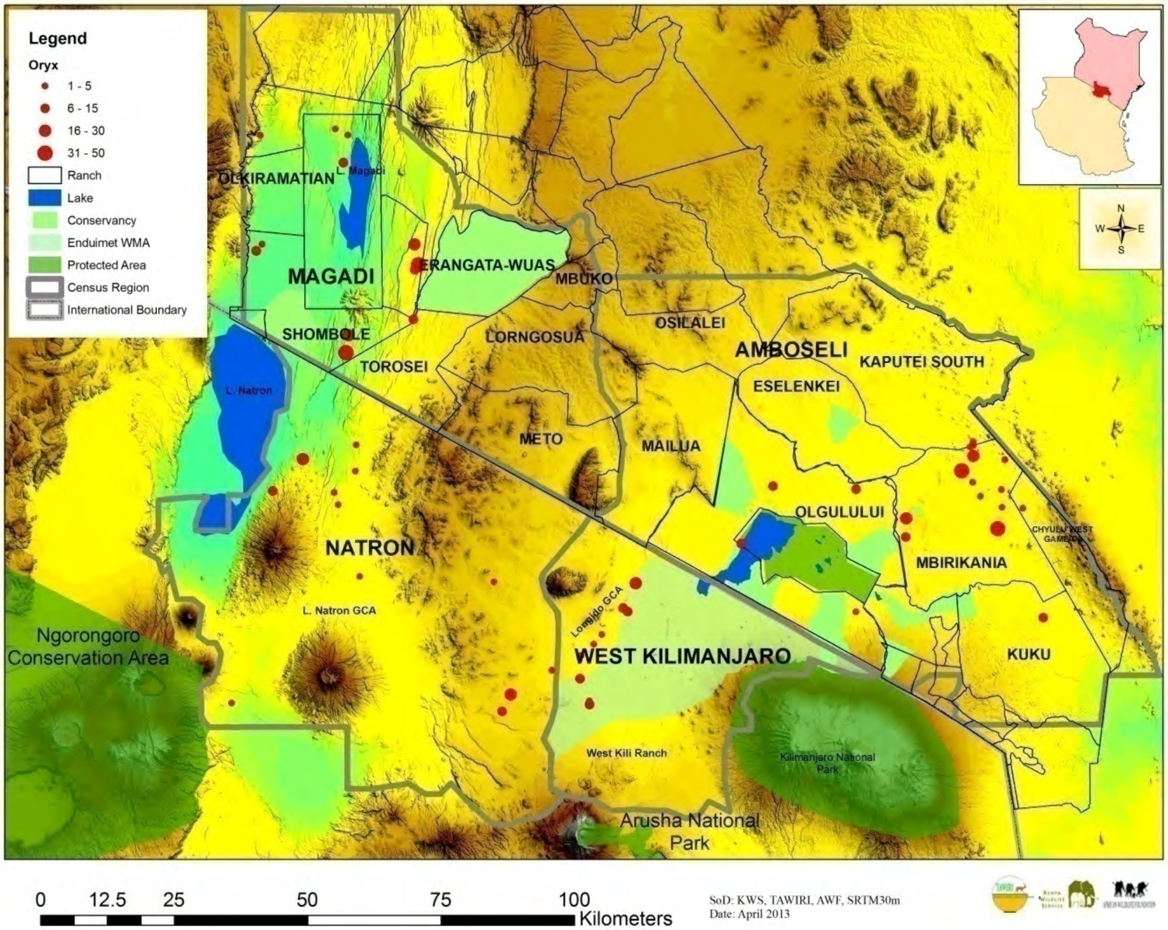

Figure 17: Distribution of Fringe Eared Oryx in Study area

Lesser Kudu

A total of 211 Lesser Kudu (density of 0.008/km²) were counted. Amboseli had 112 individuals and a density o f 0.012/km². Magadi recorded 25 individuals and a density of 0.004/km². West Kilimanjaro had 60 individuals with a density of 0.02/km². The Natron area had 14 lesser kudus with a density of 0.002/km² (Table 2). All the Lesser Kudus in Amboseli were outside the National Park and occurred in areas towards the north and south east. Lesser kudu appear to be dispersed outside protected areas (Figure 18)

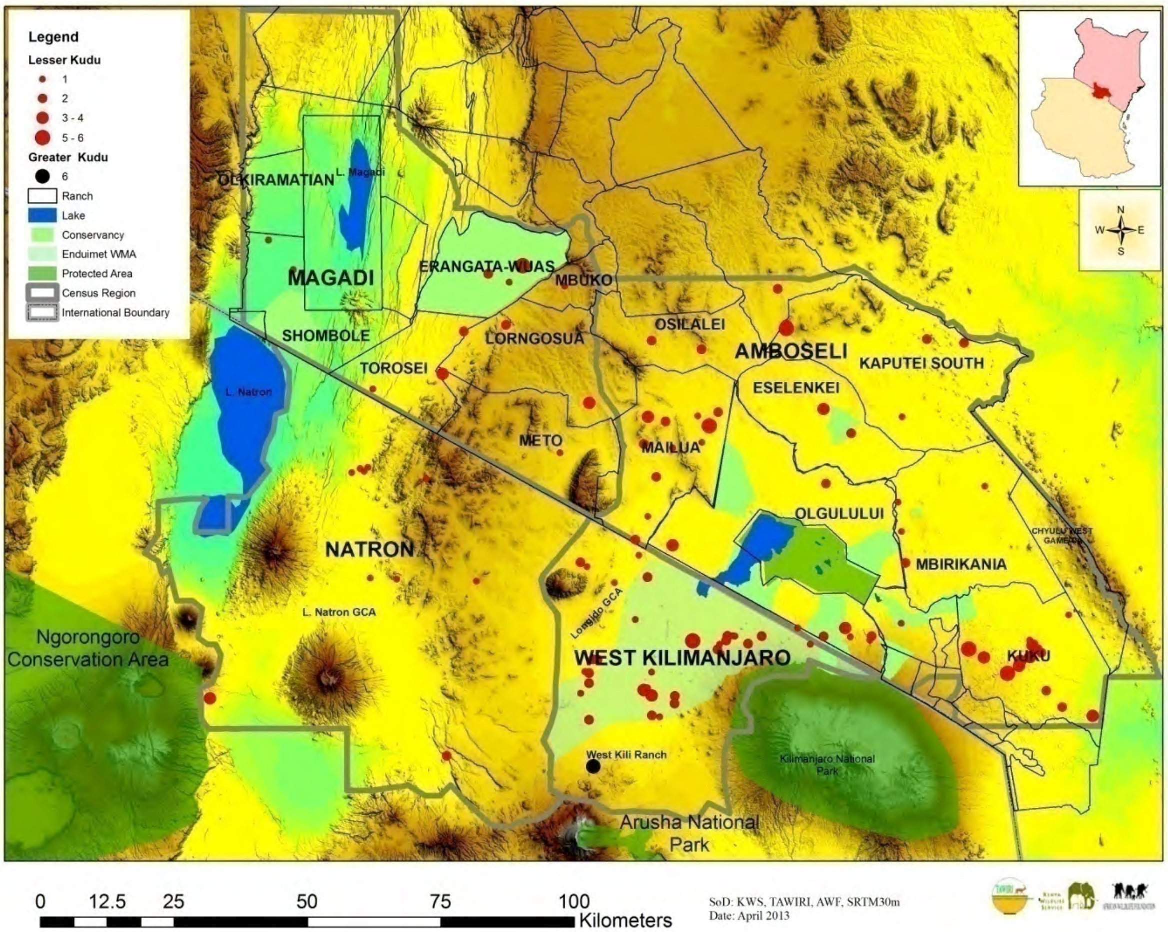

Figure 18: Distribution of Lesser Kudu in the study area

Gerenuk

During the survey, 262 gerenuks were recorded and were widely distributed in the ecosystem (Figure 19). The overall density was 0.01/km². Amboseli block had 114 individuals with a density of 0.012/km². West Kilimanjaro had 66 individuals and a density of 0.02/km². The Natron area had the least population (45) with a density of 0.002/km² while Magadi had a density of 0.006/km²(Table 2 and appendix 1)

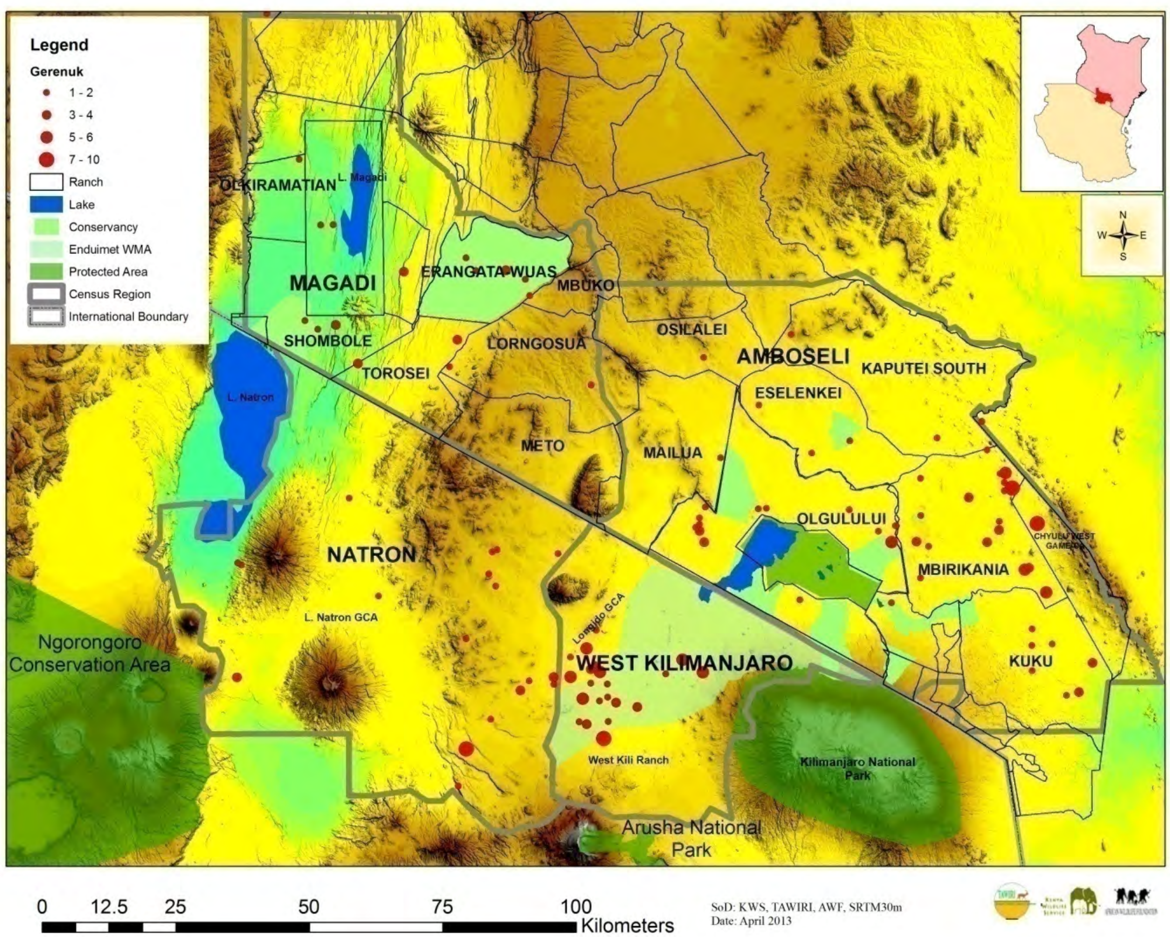

Figure 19: Distribution of Gerenuks in the Study Area in April 2013

Other species

Other wildlife species recorded during the census and their abundances in brackets included: Baboon (189), Bushbuck (12), Dikdik (1), Warthogs (131), Hyena (4), Duiker (9), Cheetah (6), Hippopotamus (18) and Lions (9), Silverbacked jackal (37), Bat eared fox (5) and Greater Kudu (6). Their distribution is summarized in Figure 20. Most hippopotamus were confined to the Amboseli swamps for obvious reasons while the warthogs were almost uniformly distributed across the survey area. The results from this survey are likely to be an under count for these species as some of them have poor detestability from the air while others are nocturnal (e.g. Lion) and some live in a confined environment (e.g. hippopotamus). Species under this category require other appropriate census techniques.

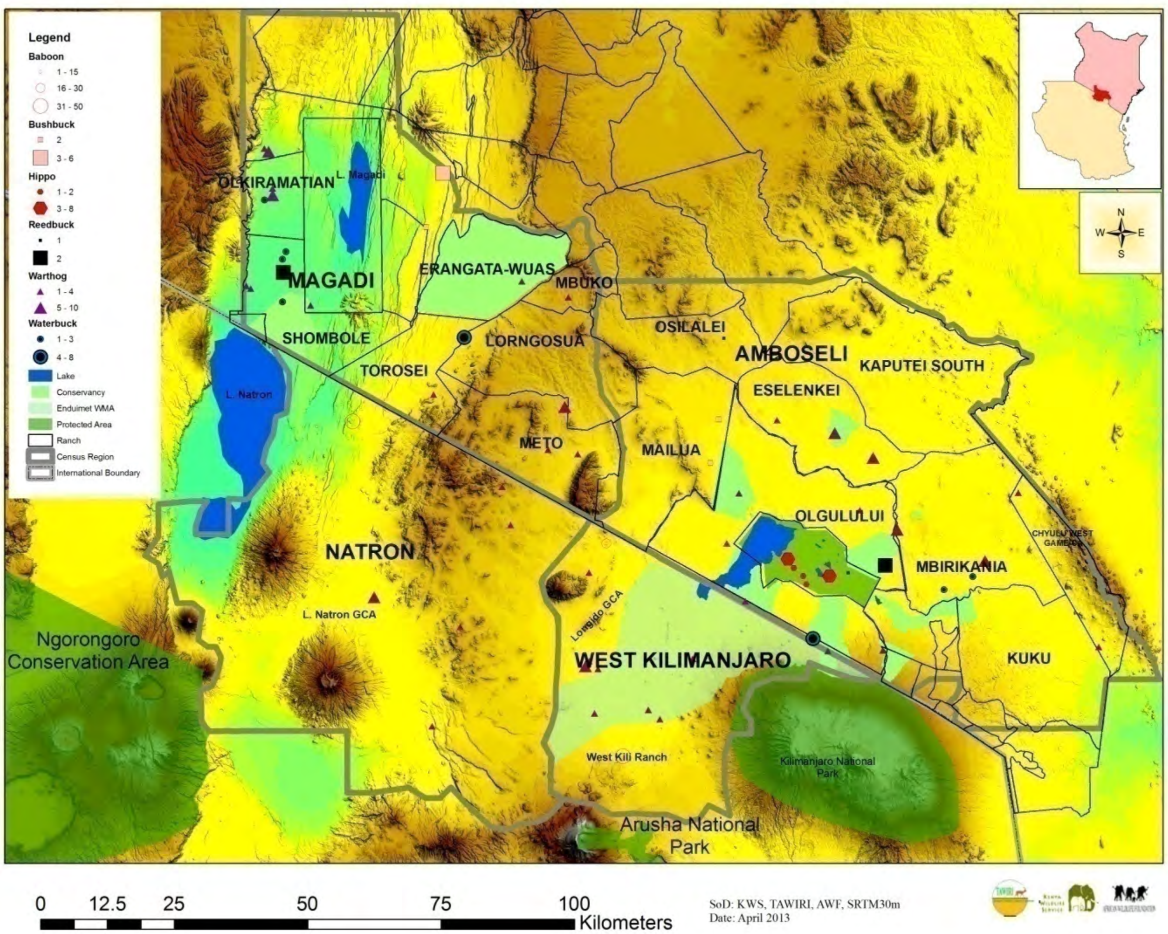

Figure 20: Distribution of other wildlife species recorded in the study area in April 2013

Human activities

Human activities recorded in this survey included livestock; shoats (530,358, cattle (211,701), donkey (5,648) and camel (1,677) (Table 3). The Natron area had the highest shoats abundance (159,281) followed by Magadi (151,501), Amboseli (138,059) and West Kilimanjaro (81,517) (Table 3). Shoats were widely distributed in the entire area with the highest density in the southern part of Natron and West Kilimanjaro, and in central and northern part of Amboseli area (Figure 21). The highest abundance of cattle was recorded in the Amboseli (63,813) followed by Natron (55,486), Magadi (50,448) and West Kilimanjaro (41,954) (Table 3, Figure 22). Most of the donkeys (2331) and camels (1209) were concentrated in Magadi (Table 3, Figure 23)

Table 3: Human activities recorded in the study area

	SPECIES	AMBOSELI (9214.44 KM²)	MAGADI (6348.32 KM²)	NATRON (7047 KM².26)	WEST KILIMANJARO (3013.18) KM²)	Grand Total
1	SHOATS	138,059	151,501	159,281	81,517	530,358
2	CATTLE	63,813	50,448	55,486	41,954	211,701
3	DONKEY	797	2,331	1,382	1,138	5,648
4	CAMEL	435	1,209	21	12	1,677

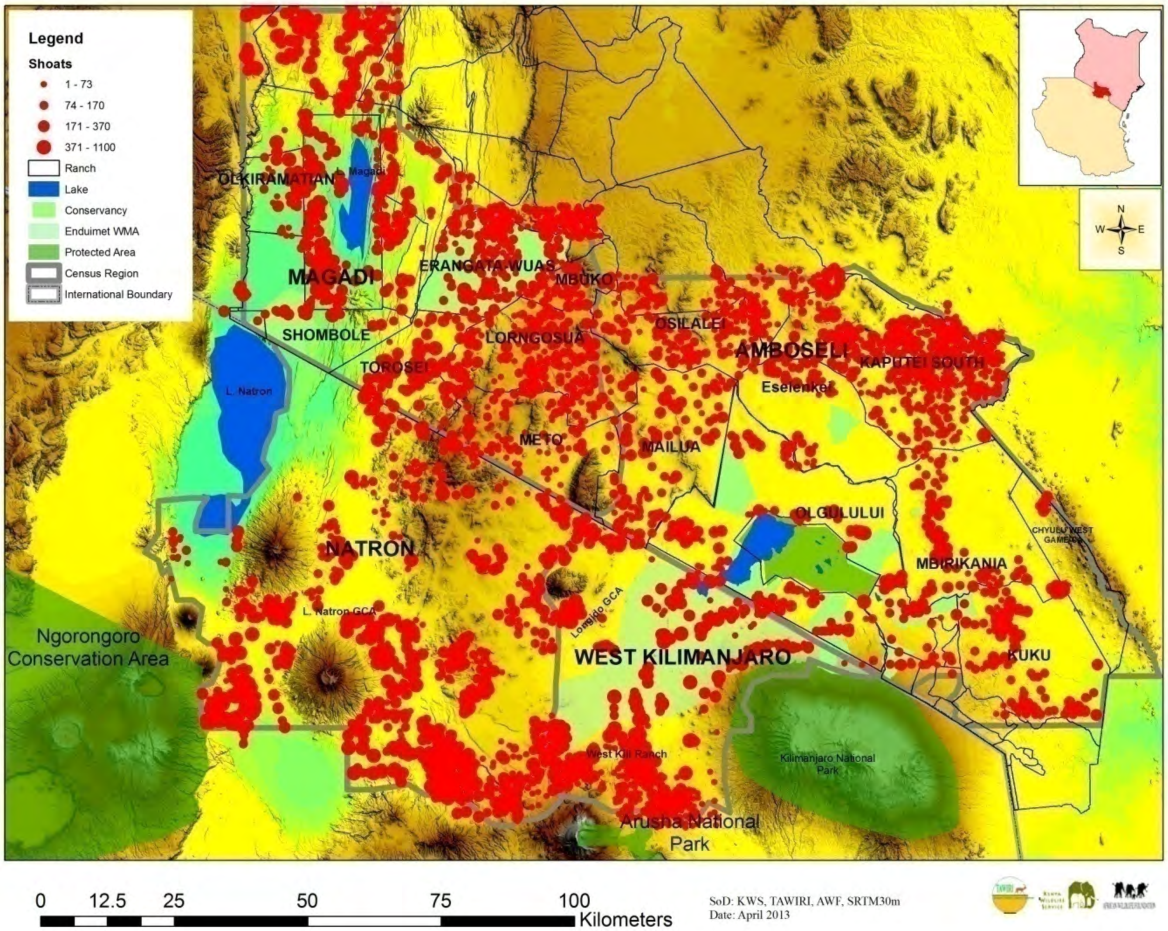

Figure 21: Shoats abundance and distribution in the study area in April 2013

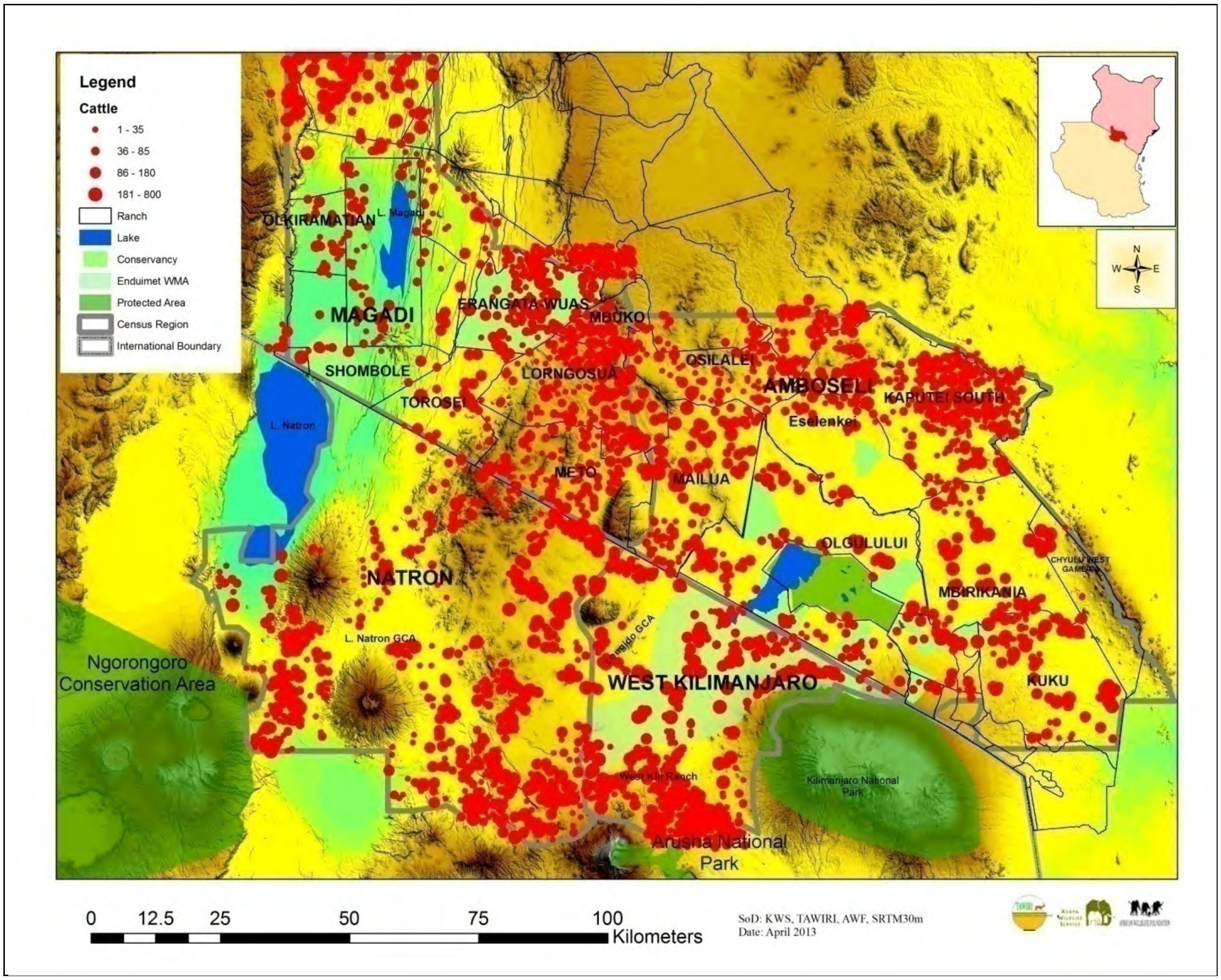

Figure 22: Cattle abundance and distribution in the study area in April 2013

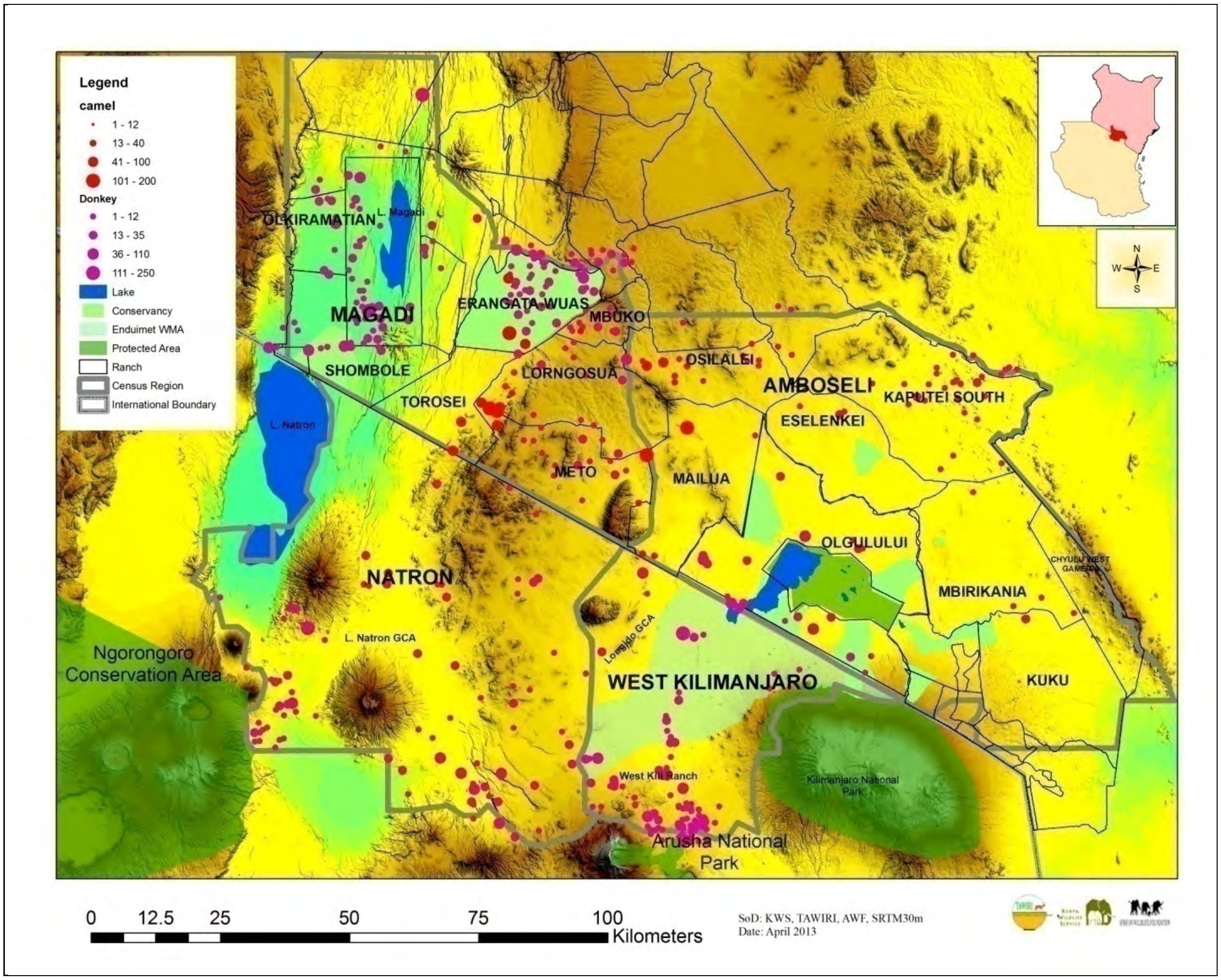

Figure 23: Camel and donkey abundance and distribution in the study area in April 2013

DISCUSSION

This survey is the third of its kind in the Amboseli- West Kilimanjaro/ Magadi –Natron cross-border landscape and covered a total area of 25,623 Km². A total of 28 mammalian and 1 avian species were counted. The major wildlife species including the elephants,, Zebras, wildebeests, giraffes and the cape eland showed a remarkable increase in their population compared to the wet season counts of March 2010 (Appendix 2). The marked increase in these populations could be attributed to the recovery of the populations after the catastrophic drought of 2007 to 2009. Between 2010 and 2013, areas in the surveyed landscape have not experienced such droughts (had normal rainfall (Appendix 3)) the situation that could have influenced massive range regeneration and improved foliage for wildlife. Other species like the giraffes population growth which was not affected by the drought of 2009 remained steadily stable over the three-year period.

The African elephant which has been facing immense poaching and poaching threats in African range states also showed a steady increase in its population in the survey area (Appendix 2). Their population increase is driven by reduced mortalities attributed to enhanced anti-poaching initiatives, including improved patrols mounted by conservation agencies like TANAPA, Wildlife division, Kenya Wildlife Service and community rangers. This has reduced elephant mortalities and in effect stabilized the populations. On the other hand, before the year 2010, the drought had some effect on the elephant populations though the population was resilient enough to still record an increase as other wild animals had their population drop by up to 70% (KWS and TAWIRI, 2010b). The absence of severe drought conditions and flooding could have further improved the range in favour of the elephants. The range resources are not uniformly distributed across any landscape (Ngene et al., 2009), and as such movement of large mammals to certain areas in Amboseli, Magadi and Natron areas could probably have been influenced the distribution of this resources.

The Amboseli Elephant population is a subject of long term studies (Western 1973; Western & Lindsay, 1984; Moss, 2001; Kioko et al., 2006). Trends from continuous monitoring show an increasing population since 1990s. Recent surveys show that the elephant population is relatively stable (1087 in 2000, 1090 in 2002 and 967 in 2007, 1420 in 2010), compared to the present population numbers of 1930 counted in the survey areas. The inclusion of a portion of the area near Magadi and which had been ignored initially has also influenced the present numbers in Magadi area. Past studies on elephant ranging patterns revealed that elephants move widely in the ecosystem (Poole & Reuling, 1997). Elephants in Amboseli make seasonal movements in and out of the park (Western & Lindsay, 1984; Moss, 2001). Although there may be no direct evidence linking the Magadi- Nguruman population with the Amboseli population, recent studies of collared elephants indicate that the Amboseli elephants wander to most of the

West Kilimanjaro area and further into lake Natron area which is also utilized by elephants from Magadi-Nguruman area (Kikoti, 2009). These studies suggest that there are more interactive elephant movements within the greater Amboseli-West Kilimanjaro ecosystem and that elephant numbers in one area need to be evaluated in the context of numbers within other areas. It is also possible that the slight fluctuations in elephant numbers recorded in previous counts could be accounted for by elephant movements since most of the previous counts focused on relatively smaller areas of the ecosystem.

As compared to the same period in 2010, the elephant population in Amboseli area appeared stable with a marginal decrease of 0.85%. In 2010, Magadi area had only 48 elephants, however, in this count the population increased by 89 %. In Natron area, which had 19 individuals in 2010 the population increased by 27.7%. West Kilimanjaro had 61 in 2010 but this increased by 55.47% in 2013. The increase in elephant numbers mostly in Magadi area could also be attributed to increase in area of coverage especially taking into consideration the additional block north of Lake Magadi.

The number of carcasses (36) recorded in this count compared to (54) in 2010 represented a decline of 40% of the observed of carcasses. The carcass ratio was 1.8% as compare to 3.7% in 2010 and could be a true reflection of human-wildlife conflicts and poaching-related mortalities in the survey area. Though, Hamilton & Burril (1991) recommended that carcass numbers be evaluated using narrower transects of about 200 Meters and preferably during dry seasons when carcasses are less likely to be hidden in vegetation, this assertion may not be applicable since intensive patrols in many areas would reveal such incidences. The elephant carcasses recorded were concentrated more on Amboseli-West Kilimanjaro area which also recorded high population density.

The need to consider the entire study area as a conservation unit is apparent as the areas that compose the cross-border landscape namely; Amboseli, West Kilimanjaro, Namanga-Magadi and Lake Natron are ecologically and hydrologically interlinked. Wildlife move across and within the entire area with respect to prevailing seasonal weather changes. In addition, due to an erratic rainfall pattern and the existence of two distinct rain seasons, forage and surface water availability vary that in turn affecting wildlife and livestock movements and distribution. Moreover, Mt. Kilimanjaro has a profound effect on the rainfall and water distribution on most parts of the surveyed area.

The results of this study showed that wildlife species are widely distributed in the landscape. Most of the wildlife species recorded during the census in the Amboseli area occurred outside Amboseli National Park. Obare (2007), Ndambuki & Kioko (2009) reported that past animal counts show high concentrations of wildlife around the swamps within the park during the dry season. The extensive distribution of wildlife species observed in the present census underscore the importance of the areas outside the park as wet season dispersal ranges for wildlife. This can be attributed to the predominant land-use that has remained largely pastoral thus allowing relative coexistence between humans, livestock and wildlife. In areas where crop farming and urban areas existed, the wildlife densities were low for example the Longido-Namanga area and the upper slopes of Mt. Kilimanjaro. Further, being a wet count, water and forage are ample and widely distributed and therefore wildlife finds little utility in clustering.

The current study highlights the effects of the 2007 - 2009 drought on the population of both wildlife and livestock species. Results indicate that there was a dramatic decline in a number of large herbivore species between the year 2007 and the year 2010. This decline can be attributed to the prolonged drought experienced in the area (Ndambuki and Kioko, 2009). Compared to the year 2007 census results (Ngoru and Mwangi, 2007), and 2010 census results almost the same spatial extent as the 2013 census showed a general rise in population numbers. In the Amboseli area for example, Zebra and wildebeests numbers doubled (apendix 1 and table 2) from 13740 to 29,867 and 8362 to 17509, respectively. Similar trends were observed in the populations of Grant's gazelle, Maasai giraffes and Cape elands, which have been known to be hardy species that can survive drought conditions (Estes, 1991; Stuart and Stuart 2006).

The present census showed that the Amboseli-West Kilimanjaro and Magadi Natron landscape is extensively utilized for livestock herding. The livestock numbers increased in most parts of the survey area probably due to favourable weather conditions experienced in many parts of the survey area. In 2010, the livestock numbers in the same areas were low due to drought-related mortalities between 2007 and 2009 (KWS & AWF, 2010). In general, the cattle numbers cumulatively increased in the entire study area.

The population of baboons and other small mammals like Dikdik and Duickers might have been underestimate as it is hard to detect the species from the air. The 189 baboons recorded in this survey may be a small proportion of the baboon population that is part of a larger extended population of baboons in southern Kenya and northern Tanzania that roam widely within the survey area (Loisel et al., 2006). The method too underestimated the lion population as well as hyena due to crepuscular and/or nocturnal nature of their behavior.

CONCLUSIONS AND RECOMMENDATIONS

The current survey reveals the importance of the Amboseli- West Kilimanjaro and Magadi –Natron cross-border landscape as a wildlife conservation and dispersal area. While much of the wildlife species were found in the Amboseli area, there is evidence of high connectivity in terms of wildlife movement in the entire study area as shown by the species distribution figures. Migratory species such as elephants, wildebeest, zebra and eland move within and across the various constituent areas of the landscape hence data from a particular area need to be evaluated in the context of the broader landscape
While the years 2007-2009 droughts had significant effects on the populations of wildebeest, zebra and buffalo, most these populations have recovered remarkably in the year 2013. The populations of Zebras and wildebeests have doubled over the three year period while other species like the elephants have remained fairly stable over the same period and maintained and utilized the Amboseli National Park as an important drought period refuge, although they make long range movements outside the park during wet seasons.

Recommendation

- ✓ There is need for a dry season aerial count in 2013, to establish seasonal changes in numbers and distribution of wildlife
- ✓ Regular total aerial surveys to monitor wildlife populations in the region preferably a dry and a wet count once in every three years to be up held.
- ✓ Continued collaboration and information exchange among conservation stakeholders across the border.
- ✓ Collaborative and improved law enforcement to prevent wildlife crimes including poaching and wanton habitat destruction, for instance charcoal burning and a check on uncontrolled developments in areas that harbor wildlife.
- ✓ Coordinated ecosystem wide research and data sharing among the stakeholders
- ✓ There is need for harmonized wildlife management policies between Kenya and Tanzania
- ✓ The governments to initiate land acquisition outside the National Parks so as to secure wildlife dispersal areas.

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To the Pilots, survey observers, Ground crew and support personnel without whom the survey would not have been smooth, we applaud their effort and dedication. Finally, to all those who participated in anyway and have not been mentioned, we thank you for your contribution in making this exercise a success.

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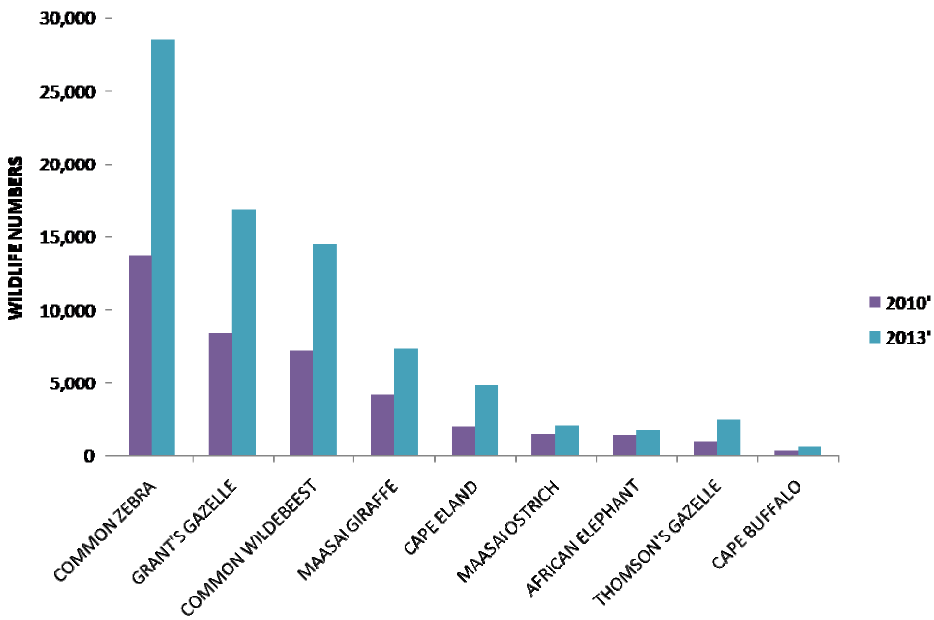
Appendices

Appendix 1: wildlife densities per areas square kilometer

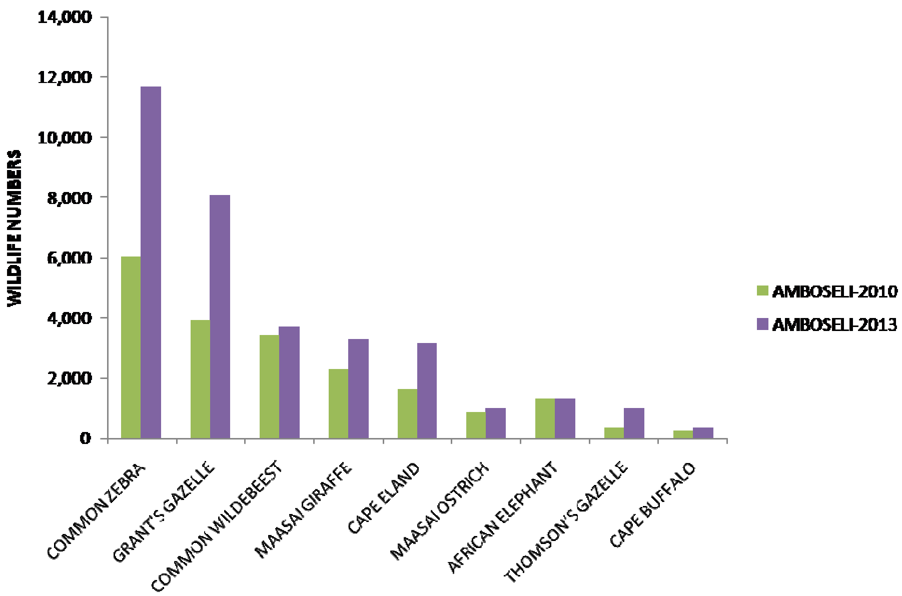
SPECIES_NAME	Overall (25623 km²) density per km²	Amboseli (9214.44 km²) density per km²	Magadi (6348.32 km²) Density per km²	Natron (7047.26 km²) density per km²	West Kili (3013.18 km²) Density per km²
COMMON ZEBRA	1.166	1.320	1.162	1.145	0.751
GRANT'S GAZELLE	0.683	0.888	0.838	0.408	0.376
COMMON WILDEBEEST	0.575	0.423	0.376	1.062	0.318
MAASAI GIRAFFE	0.298	0.377	0.248	0.251	0.270
CAPE ELAND	0.197	0.358	0.156	0.088	0.039
IMPALA	0.142	0.168	0.229	0.034	0.133
THOMSON'S GAZELLE	0.105	0.115	0.093	0.081	0.156
MAASAI OSTRICH	0.078	0.099	0.069	0.074	0.046
AFRICAN ELEPHANT	0.075	0.139	0.071	0.009	0.045
CAPE BUFFALO	0.022	0.035	0.017	0.000	0.047
COKE'S HARTEBEAST	0.021	0.059	0.001	0.000	0.000
FRIDGE EARED-ORYX	0.021	0.020	0.030	0.013	0.022
GERENUK	0.010	0.012	0.006	0.006	0.022
LESSER KUDU	0.008	0.012	0.004	0.002	0.020
BABOON	0.007	0.001	0.005	0.011	0.023
WARTHOG	0.005	0.005	0.007	0.003	0.008
SILVERBACKED JACKAL	0.001	0.000	0.005	0.000	0.001
ELEPHANT CARCASS	0.001	0.002	0.000	0.000	0.006

SPECIES_NAME	Overall (25623 km²) density per km²	Amboseli (9214.44 km²) density per km²	Magadi (6348.32 km²) Density per km²	Natron (7047.26 km²) density per km²	West Kili (3013.18 km²) Density per km²
COMMON WATERBUCK	0.001	0.001	0.003	0.000	0.000
HIPPOPOTAMUS	0.001	0.002	0.000	0.000	0.000
BUSHBUCK	0.000	0.000	0.001	0.000	0.000
LION	0.000	0.000	0.000	0.000	0.002
CHEETAH	0.000	0.001	0.000	0.000	0.000
GREATER KUDU	0.000	0.000	0.000	0.000	0.002
REED BUCK	0.000	0.000	0.000	0.000	0.000
BAT EARED FOX	0.000	0.000	0.000	0.001	0.000
SPOTTED HYENA	0.000	0.000	0.000	0.000	0.000
DIKDIK	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000
DOMESTIC ANIMALS	0.000	0.000	0.000	0.000	0.000
SHOATS	20.699	14.983	23.865	22.602	27.053
CATTLE	8.262	6.925	7.947	7.873	13.924
DONKEY	0.220	0.086	0.367	0.196	0.378
CAMEL	0.065	0.047	0.190	0.003	0.004

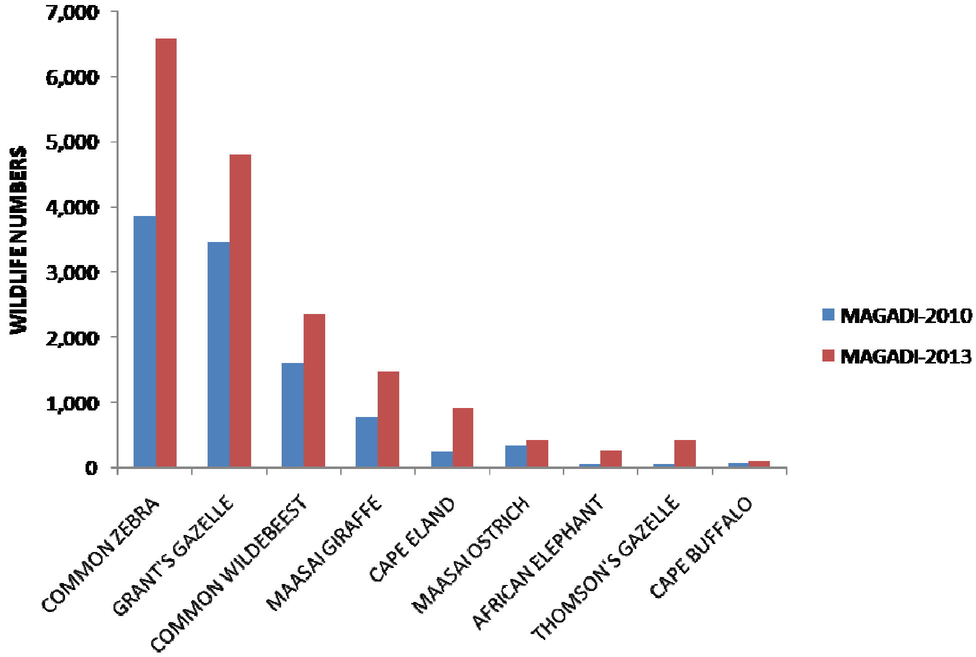
Appendix 2; Wildlife population trends



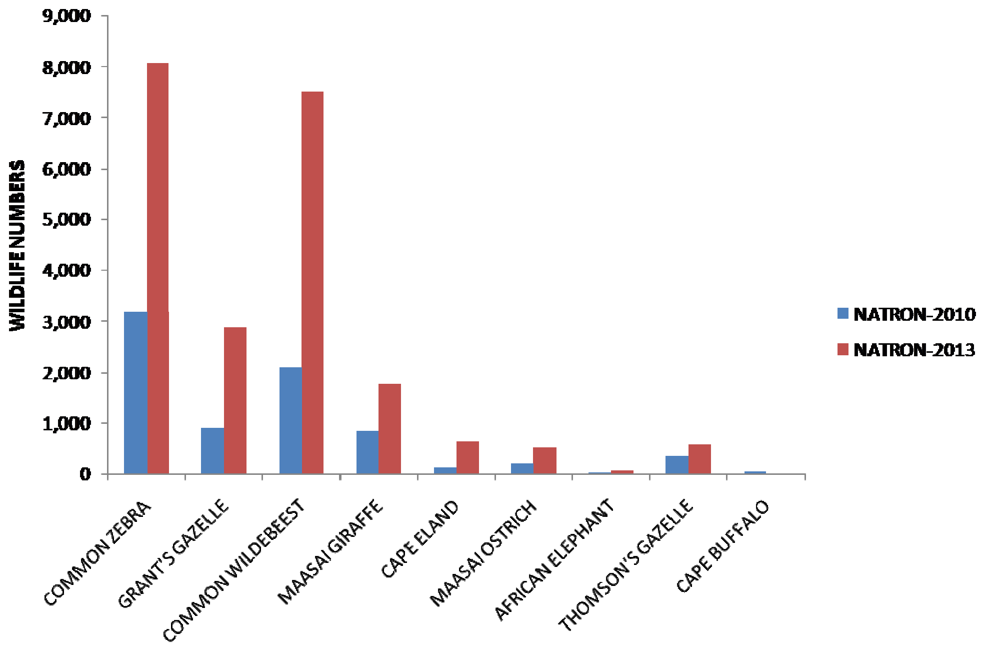
1a -Wildlife number comparison all area



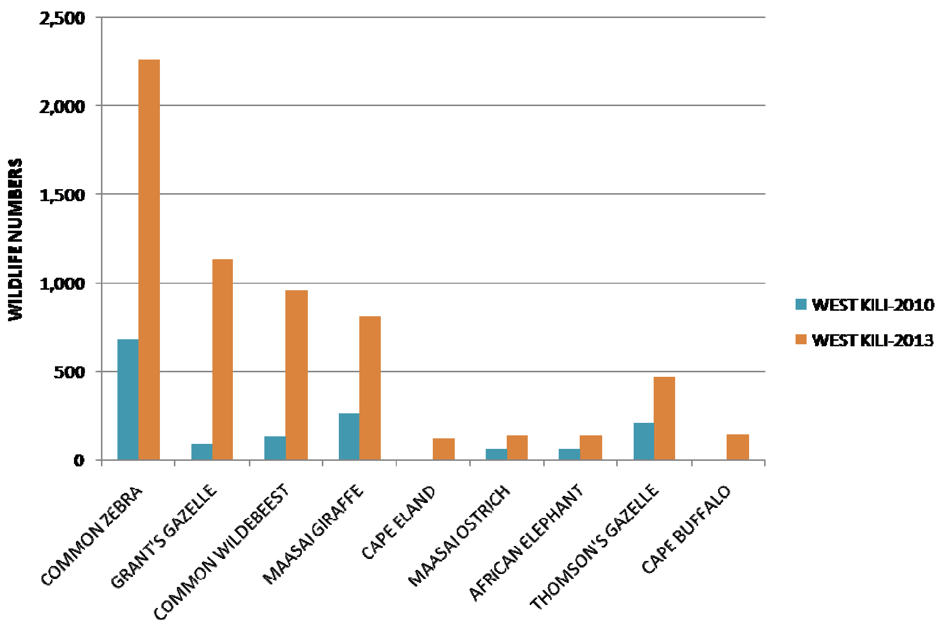
1b-Wildlife number comparison Amboseli region



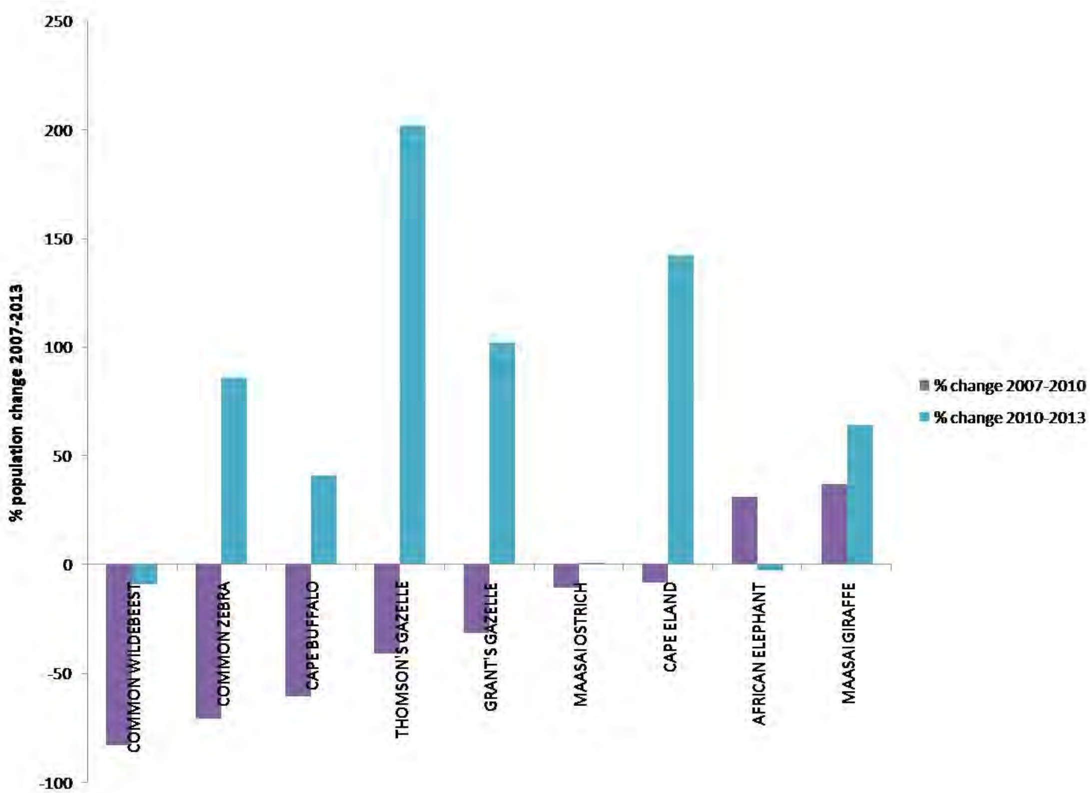
1c-Wildlife number comparison Magadi region



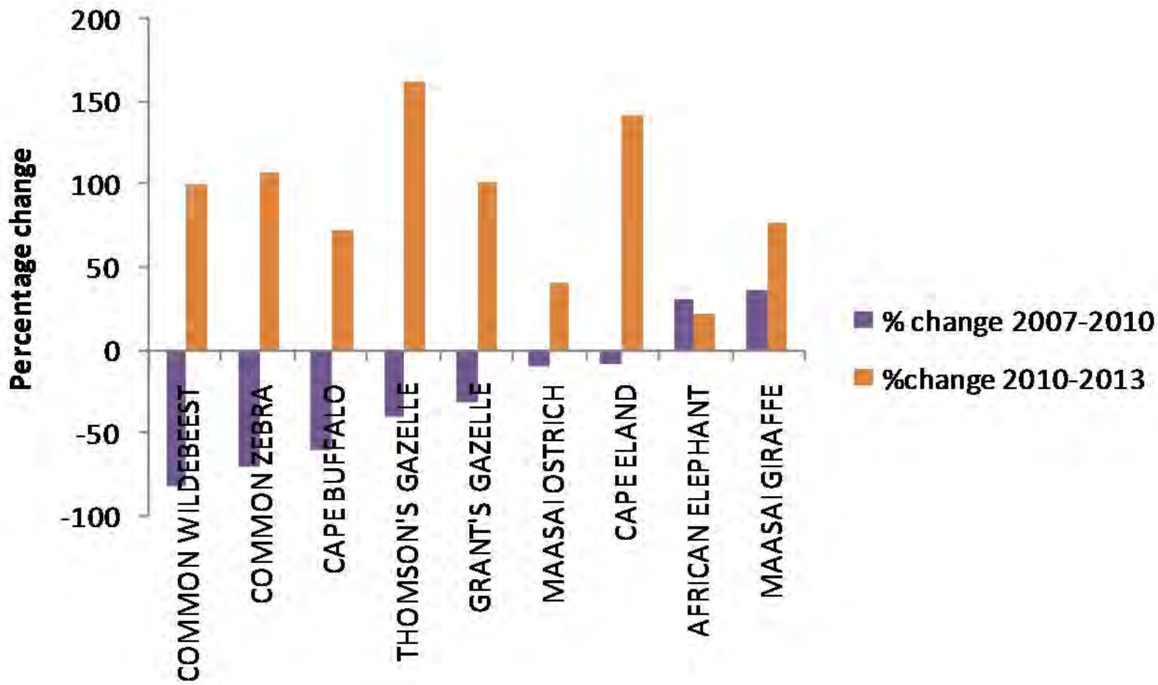
1d-Wildlife numbers comparisons at Natron region



1e-Wildlife number comparison West Kilimanjaro region



1f-Population change using old and smaller (2007) Amboseli census area (5,700 Km^2)



1h-Population change using 2007 census area-07/10 and 2010 census area-10/13

Appendix 3; Average rainfall pattern in over (calendar year) Amboseli area since 1977.