Total aerial count of elephants, Grevy'szebra and other large mammals in Laikipia-Samburu-Marsabit Ecosystem in (November 2012)

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MIKE
Monitoring the illegal killing of elephants

GREVY'S ZEBRA TRUST

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ABBREVIATIONS

AWF	African Wildlife Foundation
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
GZT	Grevy's Zebra Trust
KWS	Kenya Wildlife Service
LWC	Lewa Wildlife Conservancy
LWF	Laikipia Wildlife Forum
MES	Mwalunganje Elephant Sanctuary
MCA	Mountain Conservation Area
MCT	Marwell Conservation Trust
MIKE	Monitoring Illegal Killing of Elephants
NCA	Northern Conservation Area
NRT	Northern Rangelands Trust
STE	Save the Elephants
TET	Tsavo Elephant Trust

Species codes used in recording data

Code	Species
BN	Baboon
BF	Buffalo
BB	Bushbuck
CH	Cheetah
CM	Colobus monkey
CC	Crown cranes
DD	Dikdik
DK	Duicker
ED	Eland
EL	Elephant
F	Elephant carcass fresh
O	Elephant carcass old
R	Elephant carcass recent
VO	Elephant carcass very old
FE	Fish eagle
FX	Fox
GN	Gerenuk
GR	Giraffe
GG	Grants gazelle
HP	Hippo
HR	Hirola
HY	Hyaena
IM	Impala
JK	Jackal
KL	Klipspringer
KG	Kongoni/Hartebeest
KB	Kori bustard
LK	Lesser kudu
LN	Lion
OX	Oryx
OS	Ostrich
RB	Reedbuck
SC	Secretary bird
TG	Thomson gazelle
TP	Topi
VM	Vervet monkey
WH	Warthog
WB	Waterbuck
WD	Wild dog
WL	Wildebeest
ZB	Zebra Common
ZG	Zebra Grevy

Acknowledgements

This aerial census would not have been successful without the financial support of the donors, including the Grevy's Zebra Trust (GZT), MarwellWildlife (MW),African Wildlife Foundation (AWF), the Northern Rangelands Trust (NRT) and the MIKEsecretariat; we thank them all for their financial support. Special thanks go to Savethe Elephant (STE), Lewa Wildlife Conservancy (LWC), Laikipia Wildlife Forum (LWF), PeterZannetti of Mwalunganje Elephant Sanctuary (MES), Space for Giants, Boran Ranch, Tsavo Trust (TT) for providing aircrafts, pilots, crew andflying time, which resulted to the success of this aerial count. We also thank the IUCN African Elephant Specialist Group (AfESG) for supporting and providing an observer during the exercise. The teams showed a lot of enthusiasm resulting to completion of the survey area within the planned time period. Special thanks go to all the observers, data entry crew, and the staff of Sarova Shaba Lodge for working tirelessly to ensure the census was successful. Special thanks go to the management of County Council of Isiolo (CCI) for waiver of the reserve entry fees during the exercise. To the Director, Kenya Wildlife Service (KWS), The Deputy Director, Biodiversity Research and Monitoring, The Senior Assistant Director, Species conservation and Management, Assistant Directors of Eastern Conservation Areas, we thank you all for your support during the planning and execution of the aerial census. Many other people contributed to the success of this exercise (e.g., drivers, rangers, aircraft attendants among others not mentioned herein), we thank them all for their contribution to ensure the aerial census was undertaken successfully.

Chapter 1

General Introduction

This chapter was developed by:

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1. General Introduction

1.1 Background

Wildlife managers can only effectively manage wildlife resources for posterity using sound scientific data. Aerial counts of large mammals are major source of these data.In Kenya, the counts have been carried out in various ecosystems since the 1960's (Thoulesset *al*., 2008). As of 2002, Kenya Wildlife Service (KWS) began undertaking aerial counts of elephants and other large mammals in key ecosystems (e.g., Tsavo, Samburu-Laikipia-Marsabit, Maasai Mara, Amboseli, and Meru) after every three years (Thoulesset *al*., 2008; Litorohet *al*., 2008; Ngeneet *al*., 2011; Mwangiet *al*., 2007; Kiambiet *al*., 2010). Therefore, the 2012 aerial count of elephants, Grevy's zebra and other large mammals in Laikipia-Samburu-Marsabit ecosystem is part of the 3 years' monitoring cycle adopted by KWS.

Five factors made the 2012 aerial count in Laikipia-Samburu-Marsabit ecosystem important. First, the impact of the 2009 severe drought needed to be assessed. Second, there was need to establish the impact of increased poaching of elephantsbetween 2008 and 2012 on the ecosystem's population status. Third, notably also is habitat loss emanating from sedentary settlements around major elephant migratory corridors and former elephant rangeswhich has compressed the elephant range. This is a key elephant conservation and management issue in the ecosystem. Fourth, human-elephant conflict is currently the greatest problem associated with loss of elephant range as a result of land use change and increasing settlements in formerly unsettled areas. Fifth, currently, the area has the second largest elephant population and the largest (about 90%) in-situ Grevy's Zebra population in the world. It is therefore important to continue to monitor the population of elephants and Grevy's Zebra in the ecosystem to provide continuous long term data for sound management. The aerial count was undertaken by staff (research scientists, pilots, GIS officers, research assistants, and drivers) from different conservation agencies.

The 2012 aerial count wascarried out by staff from KWS, LewaDown Wildlife Conservancy, Laikipia Wildlife Forum, Northern Rangeland Trust (NRT), African Wildlife Foundation (AWF), Mpala Research Center (MRC), OlPejeta Conservancy (OPC), Space for Giants (SG), OlJogi Game Ranch, Borana Ranch, Department of Resource Surveys and Remote Sensing(DRSRS) andMwaluganje Elephant Sanctuary, Tsavo Elephant Trust, International Union for Conservation of Nature (IUCN), and Save the Elephants.

1.2 Goal and objective

The goal of this aerial count was "*to sustain the long term aerial monitoring of elephants, Grevy's Zebra and other large mammals in Laikipia-Samburu-Marsabit ecosystem*". This goal was achieved through the following specific objectives:

(a) Determining the present status of elephant population
(b) Establishing elephant poaching levels through observation of carcasses within the ecosystem
(c) Detailing changes in the elephant population size and their distribution since the last aerial survey of 2008
(d) Determining population status and distribution of Grevy's zebra

(e) Identifying trends in the Grevy's zebra populations by locations

(f) Establishing a baseline for Grevy's zebra for future surveys in Kenya

(g) Documentingnumbers and distributionof other animal species such as the buffaloes

(h) Documenting numbers and spread of anthropogenic activities across the e.g. settlements, logging and livestock.

1.3 Justification

a) Monitoring of species trends in numbers and distribution is essential in order to:

i. Assess their survival prospects by establishing their population dynamics
ii. Learn more about their ecology and survival chances in the face of various pressures
iii. Establish human-elephant conflict pressure points
iv. Establish elephant carcass distribution in the survey area as this will help pinpoint areas of high mortalities and cause. This will enable appropriate intervention management strategies to be put in place.

As a long term monitoring process, the survey data and information is valuable for the effective management of the entire Laikipia,Samburu and Marsabit ecosystem as it continues to experience pressures from human population growth and consequent changes in land use practices.

b) Human-elephant conflicts and poaching

Since the banning of trade in ivory by CITES in 1989, the elephant population in Kenya has continued to rise as a result of enhanced security and protection. It is estimated that the population has been increasing at a rate of about 1000 individuals per year with estimated increase from 5,447 to 7,415 in Laikipia-Samburu and Marsabit Ecosystem. After the partial lifting of ivory trade by CITES in 2007, incidences of poaching in Kenya and MCA have increased. This threatens the gains made after the banning of ivory trade. Overall, because of the increase in elephant numbers, incidences of habitat destruction and conflicts with people have also continued to increase. Conflicts between elephants and people have significantly continued to increase as they compete for the limited resources in this complex mosaic. The monitoring process has been able to allow KWS and other officers to easily predict places and times of conflicts and hence take mitigating measures in time.

c) National Importance

The ecosystem is a host to priority Grevy'szebra population in the world and the second largest elephant population in Kenya. Monitoring of these species is important because it provides valuable information that allows for comparisons over a period of years. Interpretation of such data in regard to elephant numbers and distribution will provide an insight into best management options for the study area. The information and data can also be used to model the distribution of elephants and other large mammals as well as predict the probability of poaching. Such information may be replicated in other elephant ranges.

1.4 Study area

The survey area lies astride the entire Laikipia and Samburu counties and some parts of Isiolo, Meru and Marsabit counties. The survey covered an area of over 55,000km² in northern Kenya. This included over 100 ranches and conservancies, vast areas of community trust-land outside protected area, severalNational Reserves (Laikipia, Losai, Buffalo Springs, Samburu, Shaba and Marsabit)Marsabit National Park, as well as the proposed Laikipia National Park. The survey area included about40blocks which were covered in about 5 days using 13 aircrafts. Figure 2-1 below shows the map of the area covered during the aerial survey.

1.5 Outline of the report

This report consists of a collection of unpublished papers derived from results of the November 2012 aerial survey of large mammals in Samburu-Laikipia-Marsabit ecosystem. The report is organized into four chapters.

Chapter 1 presents the general introduction on why managers require data on wildlife numbers. The goal, objectives, and justification of the aerial survey are outlined. Subsequently, the study area and outline of the report are introduced.

Chapter 2 describes and outlines the population status, trend and distribution of elephants and elephant carcasses in the Samburu-Laikipia-Marsabit ecosystem. The census effort is outlined and compared with past census efforts. Spatial analysis was used to visualize the distribution of elephants and elephant carcasses. The reasons for observed elephant population decline are presented.

Chapter 3 aims to provide an insight on the population status, distribution, and trends of Grevy's zebra in Northern Kenya. Appropriate spatial analysis is used for data visualization. The mortality of Grevy's zebra against rainfall is explored. Areas of overlap, census effort, and comparison of ground and aerial counts are presented. Appropriate recommendations to management are outlined. The reasons of the observed population stats and trend are presented. Appropriate recommendations are outlined in this chapter.

Chapter 4 describes the population status, distribution and trends of other large mammals (buffalo, eland, giraffe, lion, ostrich, gerenuk, Thomson's gazelle, Grant's gazelle, hartebeests, rhino, impala, waterbuck, oryx, Buchell's zebra), and distribution of human activities, shoats, camel, donkey, and cattle in Laikipia-Samburu-Marsabit ecosystem.

Chapter 2

The population status of elephants in Laikipia-Samburu-Marsabitecosystem

This chapter was developed by:

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2. Aerial Count of Elephants in Laikipia-Samburu-Marsabit Ecosystem, Northern Kenya

Summary

We summarize the population size and trend of elephants in the Laikipia-Samburu-Marsabit ecosystem. Data was acquired through aerial survey of the ecosystem using 13 fixed wing aircrafts. The average scanning intensity for all blocks was 209km^2/hr.The aerial survey recorded 6,365 elephants in Laikipia-Samburu ecosystem and 89 within the Marsabit ecosystem. This represents about 14% (n = 1,050) and 72% (n = 302) decline in four years, translating to an approximate annual loss of 263 and 76 elephants in Laikipia-Samburu and Marsabit ecosystems respectively. However, the long-term population trend of elephants in Laikipia-Samburu ecosystemshowed an increase between 1992 and 2012. The population increased from 2,969 elephants in 1992 to 6365 elephants in 2012, a 114% (n = 3,396) increase in 20 years. This represents an annual increase of about 170 elephants, translating to an annual growth rate of 0.04. Elephants were commonly sighted in Colcheccio/Kisima (block 23), Segera (block 28), ADCMutara (block 29), Mpala/El Karama/Oljogi (block 14) and Olpajeta/Solio (block 27). Other areas where concentrations of elephants occurred included Lewa (block 20), OlJogi/Borana (block 18), E. Barsalinga/Mukokodo (block 17), W. Isiolo/Samburu (block 7), OlDonyoSabacha (block 5), Serolevi (block 3), and DoinyoUasin (block 2). In addition, elephants concentrated within the protected areas in the areas (i.e., Shaba, Samburu and Buffalo Springs National Reserves). In Marsabit, the elephants were found in Marsabit 1, south of Marsabit Mountain (block 36).It is evident that elephants were concentrated in the protected areas of Samburu-Buffalo Springs National Reserves, Sera Community Conservancy, to the East of Mathews Range and in the private ranches in the heart of Laikipia.Approximately 190 elephant carcasses were sighted during the survey. Most of these carcasses were old (57%; n = 109) and very old (30%; n = 57). There were few recent carcasses (12%; n = 22) and very few fresh carcasses (1%; n = 2). The elephant carcasses were more common at Serolevi (block 3), Ewaso (block 4), W. Isiolo/Samburu, and BiliqoBulessa Area B (block 16). The proportion of illegally killed elephants (PIKE) has been adopted as a measure of the severity of illegal killing since the demonstration that it is not significantly auto correlated to any land use. The average carcass ratio for the MIKE site for the 11 years period is 3.5%. The survey confirms earlier concerns that the elephant population is declining. The severe drought in 2009 compounded with increased levels of illegal killing is believed to be major factors contributing to the decline. To keep track of the population dynamics of this second largest population of elephants in Kenya, it is imperative to continue the existing MIKE monitoring programme.

2. 1 Introduction

The Laikipia-Samburu-Marsabit ecosystem has the second largest population of elephantsin Kenya after the Tsavo ecosystem. The ecosystem is an important elephant range as it currently harbors the largest population of elephants outside protected areas in the country (Omondi*et al.,* 2002).Long-term monitoring of elephant numbers offers the most comprehensive method for recording elephant population change in the country. Such efforts to record the number and distribution of elephants in the ecosystem have been going on in the past. For example, Thouless*et al.* (2008) provides details of historic information on elephant numbers and distribution in the ecosystem.

In the 1970s, Kenyas second largest population sought refuge in the vast private ranches in Laikipia from intense poaching in the north (Thouless, 1990). This escalated management problems and the government through Kenya Rangelands Environmental Monitoring Unit (KREMU), currently the Department of Resource Surveys and Remote Sensing (DRSRS) conducted a number of sample counts. The private ranches provided security, sufficient food and water. The ration of live to dead elephants for Laikipia and Samburu districts were 41: 1 and 1:3.1, which indicates the severity of poaching in northern Kenya (Thouless 1990).

Total aerial counts that aimed at enumerating entire populations of elephants were initiated in the Laikipia-Samburu ecosystem in 1990 and have continued since then (Thouelesset *al.*, 2008). The population was estimated at 2312 in 1990 (Thouless, 1990), 2969 in 1992 (Thouless, 1992), 3436 in 1999 (Kahumbu*et al.*, 1999), 5447 in 2002 (Omondi*et al.*, 2002), and 7415 in 2008 (Litoroh*et al.*, 2010). Results from these aerial surveys suggest that the population has increased over the years. The area covered over the years has also increased as more resources were allocated to the surveys and new knowledge of elephant range became available (Thouless*et al.*, 2008). This could have been the reason for the recorded increase over the years. An unknown number of elephants are believed to be in the forests and mountain ranges that are never surveyed.

The 2008 survey included the Marsabit ecosystemduring which about 319 elephants were recorded within the ecosystem. Literature on the number and distribution of elephants in Marsabit before 2008 are scanty. However, Thouless*et al.* (2008) provides a summary of past information in Marsabit elephants with Litoroh*et al* (1994) estimating about 297 elephants around Marsabit forest. The elephants are also known to utilize the western parts of Marsabit forest. This area was not covered during the 2008 and 2012 aerial surveys due to its characteristic strong winds that make it difficult for aircrafts to fly through (Captain Muchina*pers. comm.*, 2012). They also located at BuleMarmar, which is about 90km north-west of Marsabit forest. The 2008 and 2012 census covered this area but previous total aerial surveys did not cover the BuleMarmar area (Litoroh, 1994; Litoroh*et al.*, 2008).

Together with the Laikipia-Samburu ecosystem, the Marsabit ecosystem has experienced changes of land use within former elephant range and migratory corridors (Omondi*et al.*, 2002; Ngene, 2010; Litoroh*et al.*, 2010). The land use changes are because of increase of human population (Litoroh*et al.*, 2008), changes of land tenure systems, and practice of agro-pastoralists by former nomadic pastoralists (Ngene, 2010). In addition, this 2012 survey was conducted notably after unusually high level of elephant mortality due to illegal killings from 2008 and a drought in 2009 (KWS Security Database, 2012). The one-off sale approval by Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 2007 has fuelled demand for ivory from 2008 resulting to increased cases of illegally killed elephants (CITES, 2010a). The 2009 drought was part of the impacts of climate change to Kenya. Mostly elephants died during the drought due to lack of forage and water. This affected the new borne, young animals as well as adults who could not access these resources.

The censuses incorporate the international system for Monitoring Illegal Killing of Elephants (MIKE), instituted under the (CITES). Monitoring mortality in the Laikipia-Samburu MIKE site has been consistent since 2002 (Kahindi*et al.*, 2009, Douglas-Hamilton *et al.*, 2010). Detailed analysis of elephant mortality in the ecosystem is provided by Thouless*et al.* (2008), whereas raw data is available at KWS Security Database (2012).

The goal of the aerial survey was to sustain the long term monitoring of elephants in Laikipia-Samburu-Marsabit ecosystems. This consistent monitoring programme began in 1992 and has been going on since then. This census aims to establish the impacts of the 2009 drought and illegal killings of elephants on their population status and distribution. The specific objectives of the aerial survey were to: determine the present status of elephants in the Laikipia-Samburu-Marsabit ecosystems. The results were compared with those of previous surveys to establish the elephants' population trends; establish the number and distribution of elephant carcasses; and, document the distribution of livestock in relation to elephants. The information generated from this survey will be used to make sound management decisions regarding continued existence of elephants in this fragile ecosystem.

2.2 Materials and Methods

2.2.1 Study Area

Laikipia-Samburu-Marsabit ecosystem covers approximately 55,000km^2. The ecosystem is bounded by coordinates 0.5S, 3N, 36E and 39E (Figure 2-1). The southern half of the ecosystem is the Laikpia Plateau which lies between the highlands of Mt. Kenya and the Aberdares ranges. Most of the region is typically dry savanna, hot and dry for most of the year with highly variable and erratic bimodal rainfall, 90% of which falls in April and November (Barkham and Rainy 1976). In the drier northern extent of the study area, rainfall drops to less than 500mm per year except in the mountains where variations may reach high of 1250mm per year (Kahindi*et al.*, 2009). Laikipia lies on the leeward side of Mount Kenya and the weather is thus affected by the rain shadow of the mountain (Kahindi*et al.*, 2009). It has a high diversity of habitats ranging from the lowland, xeric scrub bush lands comprising *Acacia* and *Commiphora*species to the highland, mesic cedar and camphor forests (Barkham and Rainy 1976). Ewaso River and its tributaries is the lifeline for wildlife providing dry season food resources in the dry season (Barkham and Rainy 1976).

Major land uses through the census area include national reserves, community conservation areas, undeveloped government-owned trust land, forest reserves, private ranches and sanctuaries and agricultural settlement (Kahumbu*et. al.,* 1999). Much of Laikipia consists of the private ranches. Samburu is mainly a low lying pastoral grazing land with forested ranges (Kirisia/Leroghi/Mathews). The County has three protected areas; Samburu, Buffalo Springs and Shaba National Reserves. Several Community Wildlife Conservancies; Namunyak, Kalama, Meibae and Il Ngwesi were included in the survey area.

Most of Laikipia is marginal for farming. Efforts to drive the elephants from the private ranches in 1978 and 1979 were unsuccessful prompting a recommendation to build a fence across Laikipia separating the settlements and ranches. Some of the private ranches build internal fences which elephants constantly break and invade farms. As such the human elephant conflict problem is perennial in that part of the elephant range.

The private ranches in Laikipia host a lot of resident wildlife populations that either have been confined by fencing or are free ranging. The fencing influences movement patterns of wildlife. Subdivision of some of the ranches and the subsequent settlement in the western and southern parts of the County has led to intense human-wildlife conflicts as the migratory corridors have been blocked. OlPajeta, OlJogi, Lewa and Solio Conservancies host rhinos. The count was focused on the designated MIKE survey sites and extended to the known Grevy's zebra range.

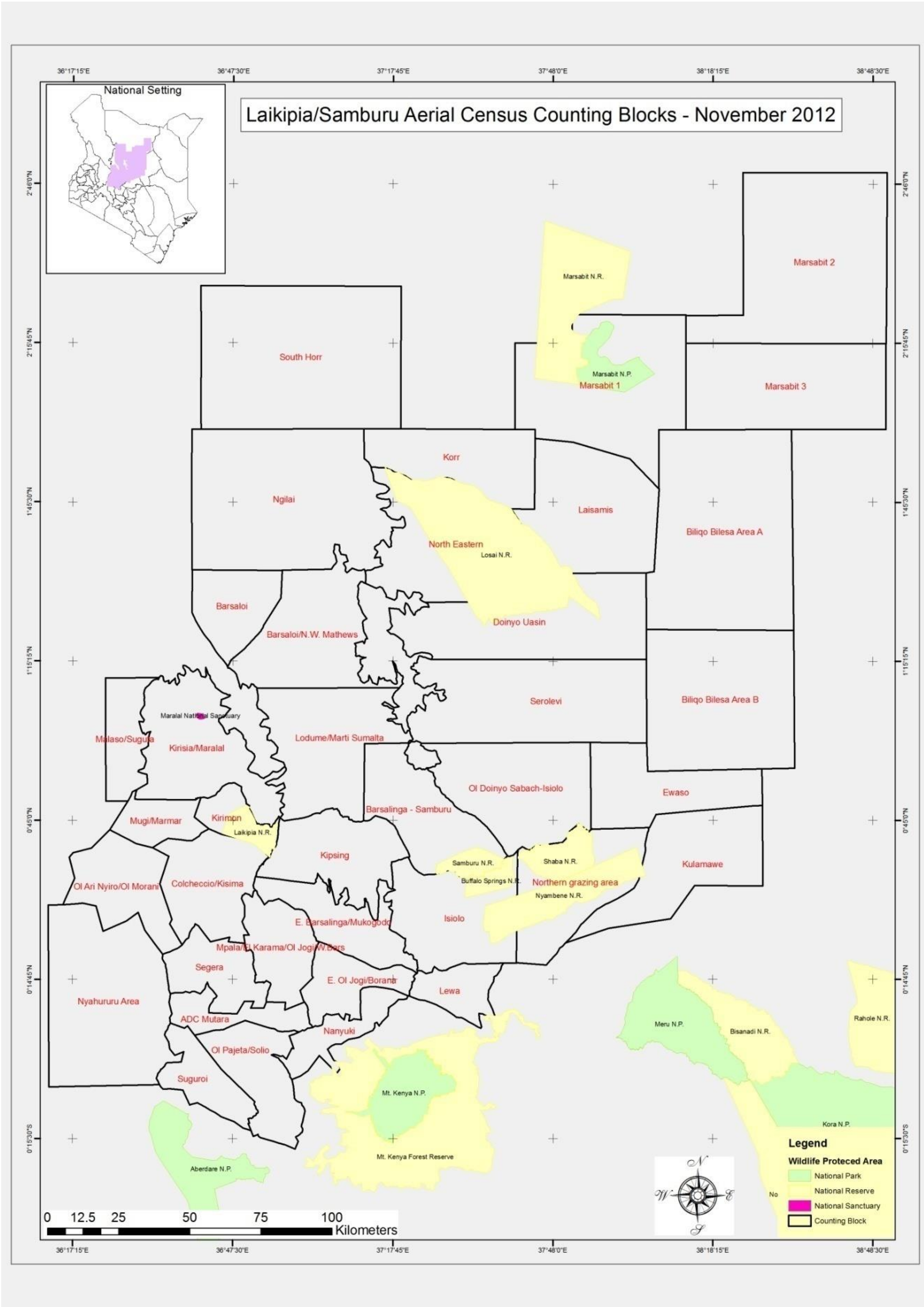

Figure 2-1: Laikipia-Samburu-Marsabit counting blocks. Only one National Park is found within this study area while the rest are National Reserves, however most of the study area is communal and private land.

2.2.2 Aircrafts, flight paths and crew

The census event benefited from pilots and crew highly experienced and most of them having participated in numerous similar exercises. A total of 13 aircrafts were used in the count. The method adopted for the 2012 total aerial count for wildlife and livestock was as described by Douglas-Hamilton *et al.* (1994) and Douglas-Hamilton (1997).

All observations made were saved in hand held GPS receivers as referenced waypoints with the geographical location and were used in producing species distribution maps. Repeat counts along block boundaries were corrected before data analysis. The exercise started every morning at 7.30am and ended late in the evening. Breaks were taken during refuelling of the aircrafts and at lunch. Fuelling sites were strategically distributed in the survey area to cut down on ferrying time. Each survey crew consisted of 1 observer and a pilot for 2 seater aircraft and a pilot, 1 FSO and 2 Rear Seat Observers (RSO) for a 4 seater aircraft.

The interval between the flight lines varied between one and two kilometres depending on the visibility and terrain, but constancy in direction and interval was observed whenever possible for each block (Figure 2-2below). The wider spacing of flight lines was predominantly towards the northern part of the census area. These flight paths varied in length to conform to block delineations and topography. Fifteen wildlife species and livestock and elephant carcasses were counted. Where the visibility was good, the flight line intervals were increased from one to two kilometres. Some big blocks were jointly surveyed by two teams who in such a case commenced from opposite directions till they overlapped by at least one flight line.

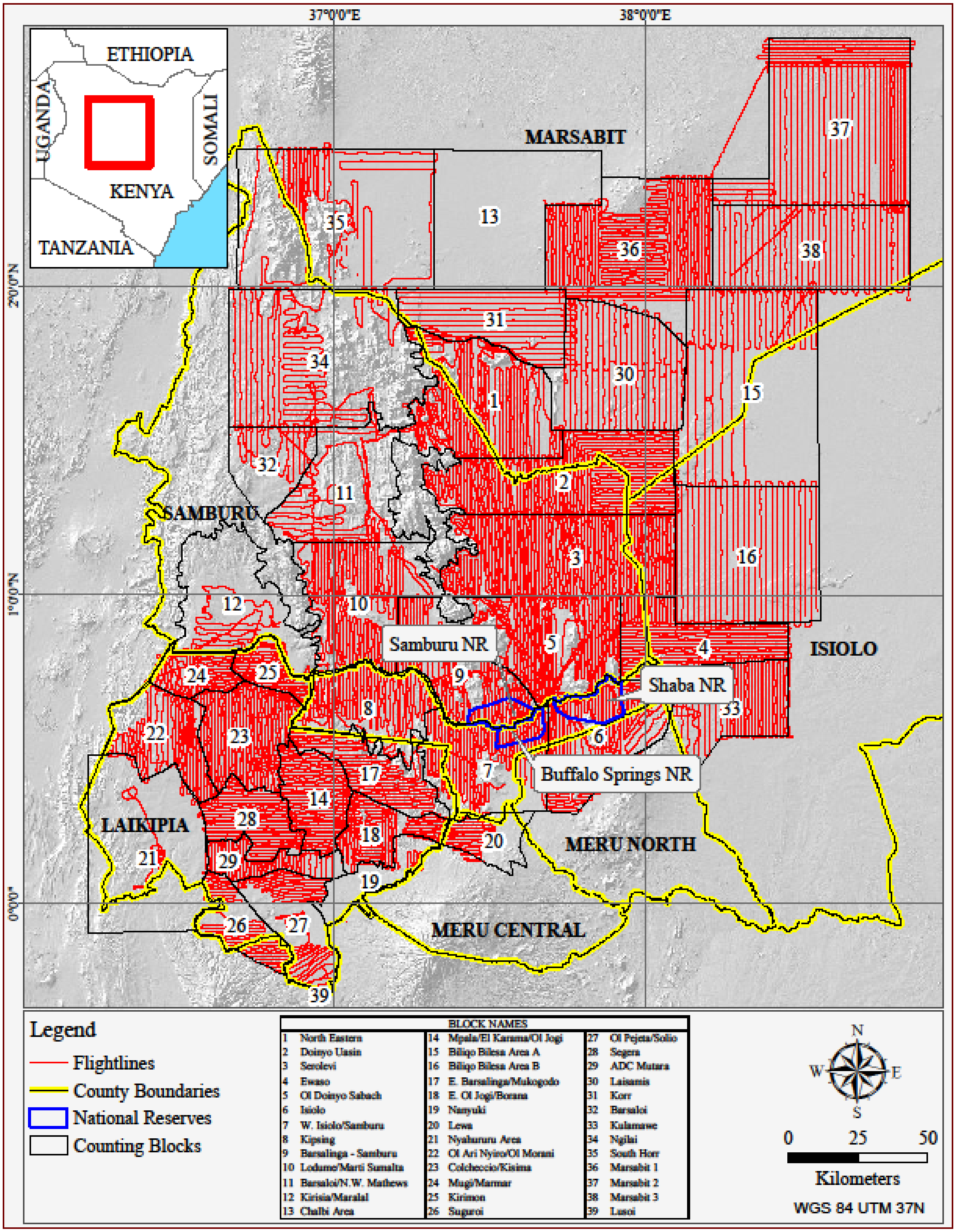

Figure 2-2: The map of the study area showing the blocks used during the aerial survey and aircraft flight paths

2.2.3 Data recording

Data was recorded on hard copy datasheets by FSOs. The FSO also saved and recorded the waypoints taken for any sighted species or human activity using a hand held Geographic Positioning System (GPS) unit. The crews were very experienced and this reduced potential errors especially in counting complex herds. When necessary, pilots circled large and complex elephant herds as the observers counted. Fewphotographs were taken. Standard datasheets described in detail by Douglass-Hamilton (1996) and used in the past census activities were used for recording observations.

The dead elephants were divided into four categories as defined by Olindo*et al.* (1988). These were:
(i) 'Fresh', in which carcasses have fresh skin giving the rounded appearance, scavengers probably present. These are carcasses estimated to be less than three weeks old.
(ii) 'Recent', in which carcasses less than one year and may be distinguished by a rot patch around the body which has killed vegetation.
(iii) 'Old', in which carcasses have usually decomposed to a skeleton and vegetation is beginning to grow. This applies to dead elephants that have died more than a year ago.
(iv) 'Very old', in which the bones have began to turn grey. These no longer stand out and are hard to distinguish from air.

2.2.4 Experimental blocks

To check on the accuracy of observers, two aircrafts i.e., 5Y KTP and 5Y KWB flew in Isiolo West and Samburu-Barsalinga blocks respectively, an experimental mini block comprising of Samburu and Buffalo Springs National Reserves was double checked by a ground crew backed up by a separate air craft 5Y STE (Figure 2-3). The aerial teams communicated with the ground crew who counted various herds encountered and recorded their numbers separately. The results were mapped and the sizes of various herds were later compared to assess possible disparities. The ground team from Save the Elephants has been studying individual elephants and has a database of known elephants from which they could identify individual elephants crossing river and possibly double counted by aerial crew.

2.2.5 Post flight procedures

After landing and reporting to base station, the FSOs corrected their notes for typos made while flying. They further liaised with the data entry clerks to ensure that their data was fed into the computer accordingly. The GPS data was downloaded into ArcGIS program (ESRI, 2011). Spatial joins between the way points and field data were created and the batch converted into a shapefile. Another team of GIS personnel checked through the records especially zone boundaries where pilots overlapped for possible double counts. These double counts were cross checked with field notes and FSOs and then rectified as need was. The flight times were logged in from take off to start of counting and stop. The crew computed the time spent in each block after landing.

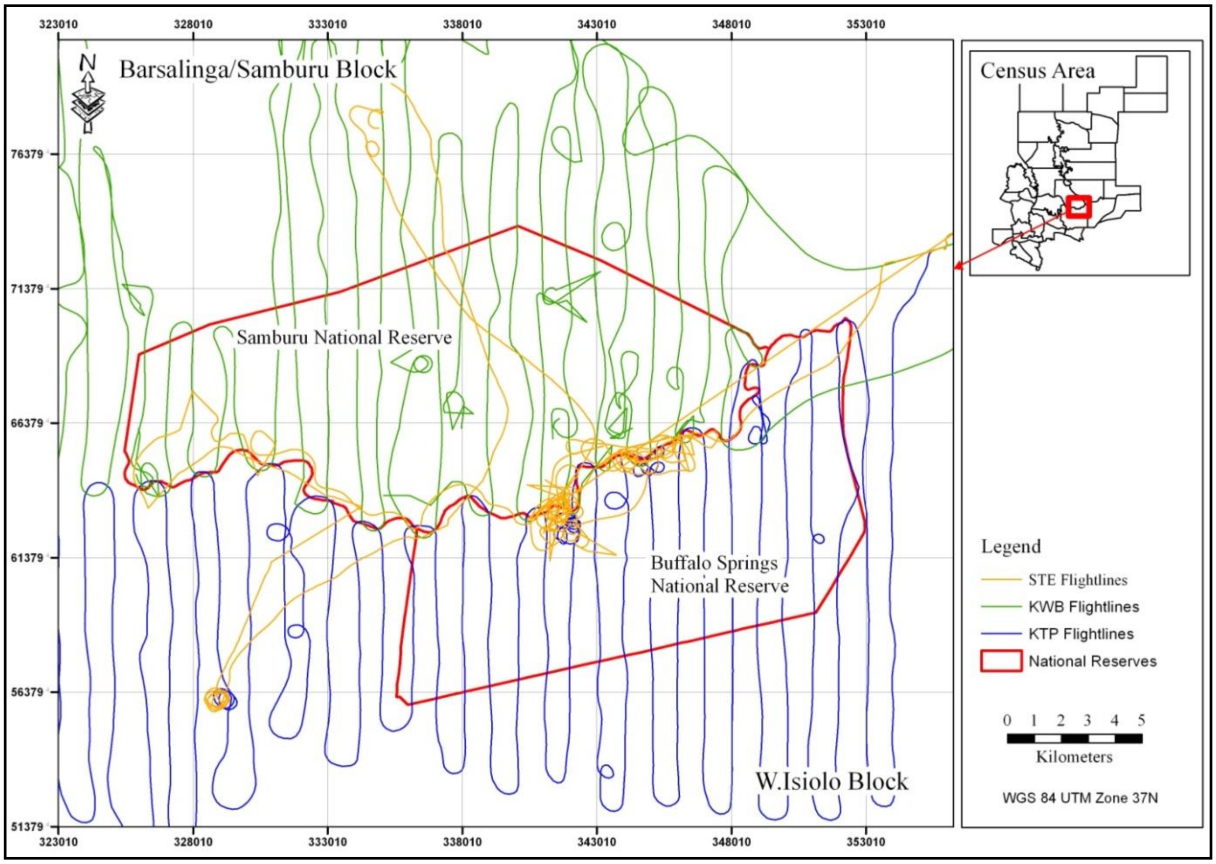

Figure 2-3: Flight lines of 5Y-STE in orange through along the river boundary separating Samburu and Buffalo Springs National Reserves where two other teams, 5Y-KWB and 5Y-KTP surveyed as part of the 2008 elephant count

2.2.6 Analyses

The data files from each flight were compiled into one permanent GIS record of observations for analyses purposes. Data on each species were summarized by block. These were then expressed as densities per block after dividing by the block area. The ferrying times were computed as time from take off to arrival at specific blocks. Total counting times were added up in cases of more than one flight sessions having been undertaken. The number of carcasses were verified as well and summarized by block.

Scanning intensity was measured as km^2 searched per hour for each block. The average scanning intensity was recorded and compared with those from past aerial census to discern any significance differences. Chi-square tests were used to establish whether the observed and expected scanning intensity were significantly different in different years (Zar, 1996).

For regression analysis of the trends of population increase, data was used for areas that were consistently surveyed using the same method from 1992 to 2012. These areas included Laikipia and Samburu. The regression analysis followed the procedures described by Zar (1996). Third order polynomial analysis was used to get the line of best fit during the regression analysis (Zar, 1996).

The observed rate of population increase over the years ($\bar{r}$) was calculated from the natural logarithms of the totals number of elephants counted in 1992 and 2012 using the formula (Caughley, 1977):

$\bar{r} = log_e N_t - log_e N_0$

Where $\boldsymbol{Log_e}$ *= Natural logarithm;* N_t *= Total number of elephants counted in 2012;* $\boldsymbol{N_0}$ *= Total number of elephants counted in 1992 and 2008*

Carcass ratios we calculated as number of carcass/(live + dead). The study area falls under the designated LaikipiaSamburu MIKE site, where detailed records of systematic monitoring of mortality are available. Carcass ratios were calculated using the ground carcass records.

2.3 Results

2.3.1 Aerial Census effort

The number of hours flown by each crew in each block was added up in the case of blocks surveyed by more than one plane. The scanning intensity was measured as kilometers searched per hour (Douglas-Hamilton, 1996). The average scanning intensity for all blocks was 209km^2/hr. The table of scanning rates per block is provided in appendix 2-1.

2.3.2 Status and trends of elephants

The aerial survey recorded 6,365 elephants in Laikipia-Samburu ecosystem and 89 within the Marsabit ecosystem, representing approximately 14% (n = 1,050) and 72% (n = 302) decline in four years. This translates to an approximate annual loss of 263 and 76 elephants in Laikipia-Samburu and Marsabit ecosystems respectively, which is equivalent to an annual growth rate of -0.04 for the Laikipia-Samburu ecosystem. The decline of elephants between 2008 and 2012 was statistically significant ($X^2 = 80$; df = 1; $p < 0.05$).

However, for the Laikipia-Samburu ecosystem, the long-term population trend of elephants showed an increase between 1992 and 2012 (Figure 2-4). The population increased from 2,969 elephants in 1992 to 6365 elephants in 2012, a 114% (n = 3,396) increase in 20 years. This represents an annual increase of about 170 elephants, translating to an annual growth rate of 0.04.

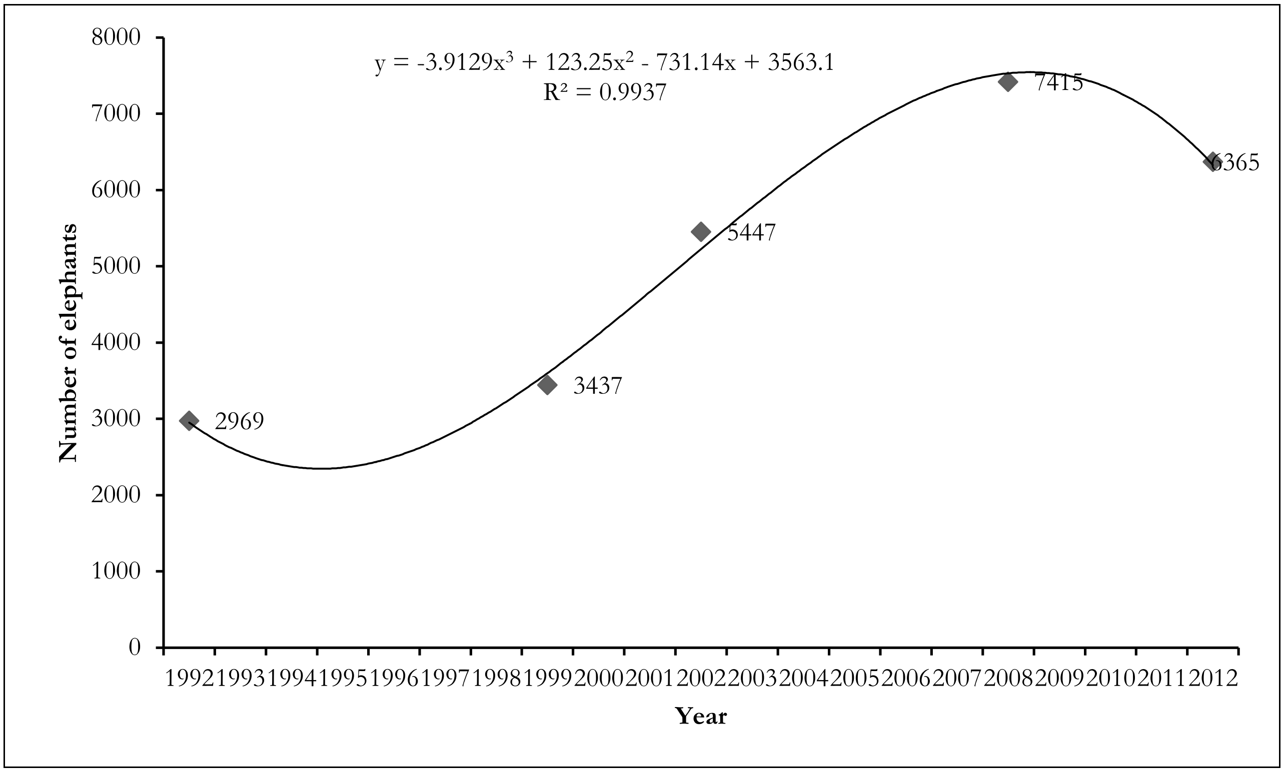

Figure 2-4: The population trend of elephants in Laikipia-Samburu ecosystem, Northern Kenya (1992-2012)

2.3.3 The distribution and density of elephants

About six areas of elephant concentration were observed during the survey. Elephants were commonly sighted in Colcheccio/Kisima (block 23), Segera (block 28), ADC Mutara (block 29), Mpala/El Karama/Oljogi (block 14) and Olpajeta/Solio (block 27; Figure 2-5). Other areas where concentrations of elephants occurred included Lewa (block 20), E. OlJogi/Borana (block 18), E. Barsalinga/Mukokodo (block 17), W. Isiolo/Samburu (block 7), OlDonyoSabacha (block 5), Serolevi (block 3), and DoinyoUasin (block 2; Figure 2-5). In addition, elephants concentrated within the protected areas in the areas (i.e., Shaba, Samburu and Buffalo Springs National Reserves; Figure 2-5). In Marsabit, the elephants were found in Marsabit 1, south of Marsabit Mountain (block 36; Figure 2-5).

It is evident that elephants were concentrated in the protected areas of Samburu-Buffalo Springs National Reserves, Sera Community Conservancy, to the East of Mathews Range and in the private ranches atthe heart of Laikipia.

2.3.4 The number and distribution of elephant carcasses

Approximately 190 elephant carcasses were sighted during the survey. Most of these carcasses were old (57%; n = 109) and very old (30%; n = 57). There were few recent carcasses (12%; n = 22) and very few fresh carcasses (1%; n = 2). Figure 2-5 below shows the distribution of different classes of elephant carcasses sighted during the aerial survey. The elephant carcasses were more common at

Serolevi (block 3), Ewaso (block 4), W. Isiolo/Samburu, and BiliqoBulessa Area B (block 16; Figure 2-6). The proportion of illegally killed elephants (PIKE) has been adopted as a measure of the severity of illegal killing since the demonstration that it is not significantly auto correlated to any land use (CITES, 2010b, Kahindi*et al* 2009). The average carcass ratio for the MIKE site for the 11 years period is 3.5% (Table 2-1).

Table 2-1: The carcass ratios, number of live elephants from aerial surveys and dead elephants from ground patrol over the last three censuses

		2002		2008		2012		Average			
Land Use	**Area Km²**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**	***Live***	***Dead***	***CR (%)***	***PIKE (%)***
Community - Conservation	11457	938	54	2384	62	2293	113	*1872*	*76*	*3.9*	*48.8*
Forest Reserve	3299	778	24	68	40	374	45	*407*	*36*	*8.2*	*54.9*
National Reserve	533	216	1	1093	8	496	13	*602*	*7*	*1.2*	*29.9*
Private Ranches & Sanctuaries	4418	2835	35	2749	63	2372	110	*2652*	*69*	*2.5*	*40.5*
Settlements	5707	137	8	8	15	75	3	*73*	*9*	*10.6*	*37.9*
Trust Land	8403	488	40	1111	47	755	17	*785*	*35*	*4.2*	*50.9*
Total	33815	5447	162	7413	235	6365	301	*6409*	*233*	*3.5*	*46.2*

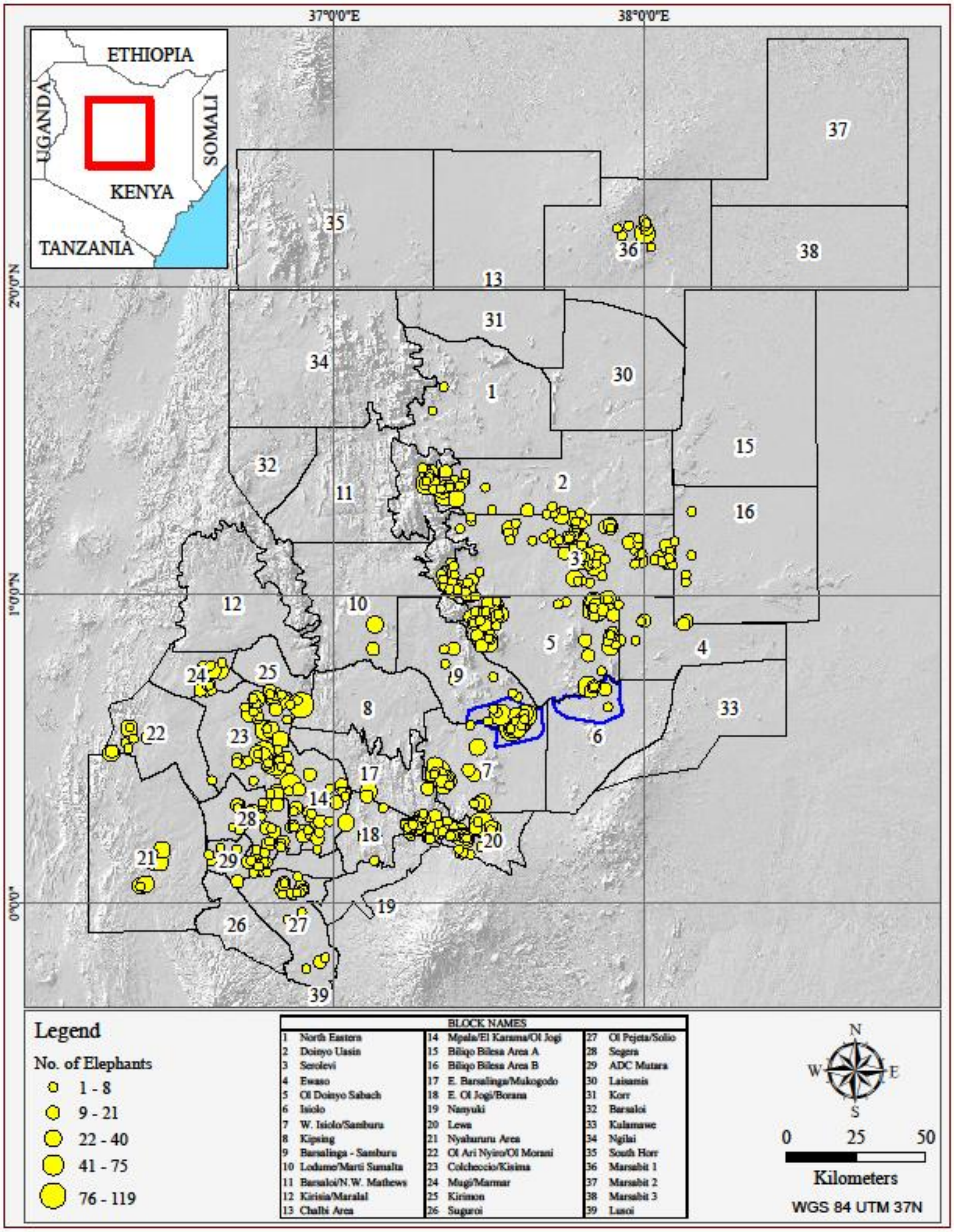

Figure 2-5: The distribution of elephants in Laikipia, Samburu and Marsabit ecosystem in late November 2012

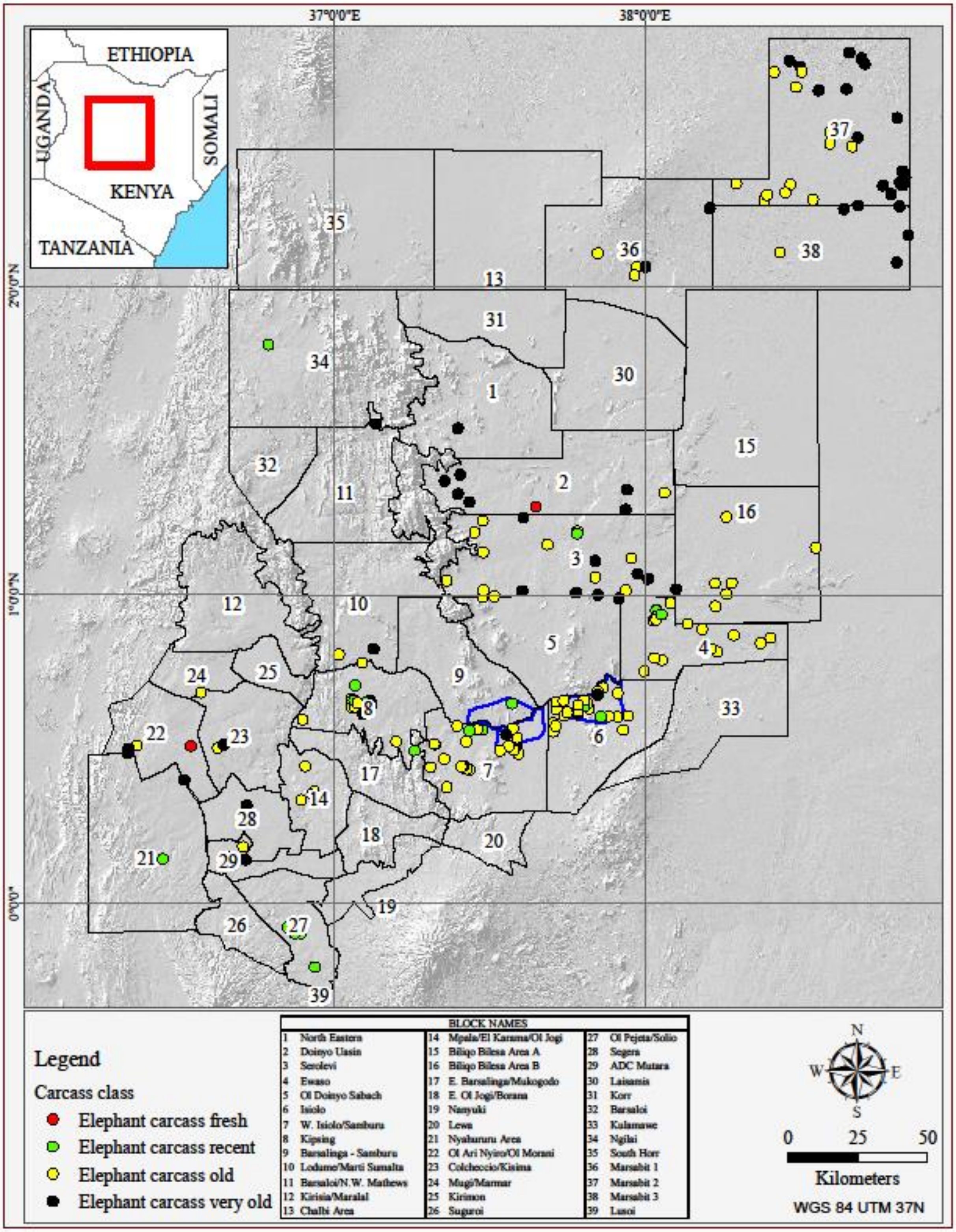

Figure 2-6: The distribution of different categories of elephant carcasses in Laikipia, Samburu and Marsabit ecosystems in late November 2012

Under the routine MIKE monitoring, the ecosystem is subdivided into smaller management units. The survey data was assigned to these smaller units and the average carcass ratios calculated from the 2002, 2008 and 2012 calculated for each. Elephant densities for the same units were calculated too. Areas with higher carcass ratios tended to have lower elephant densities (Figure 2-7).

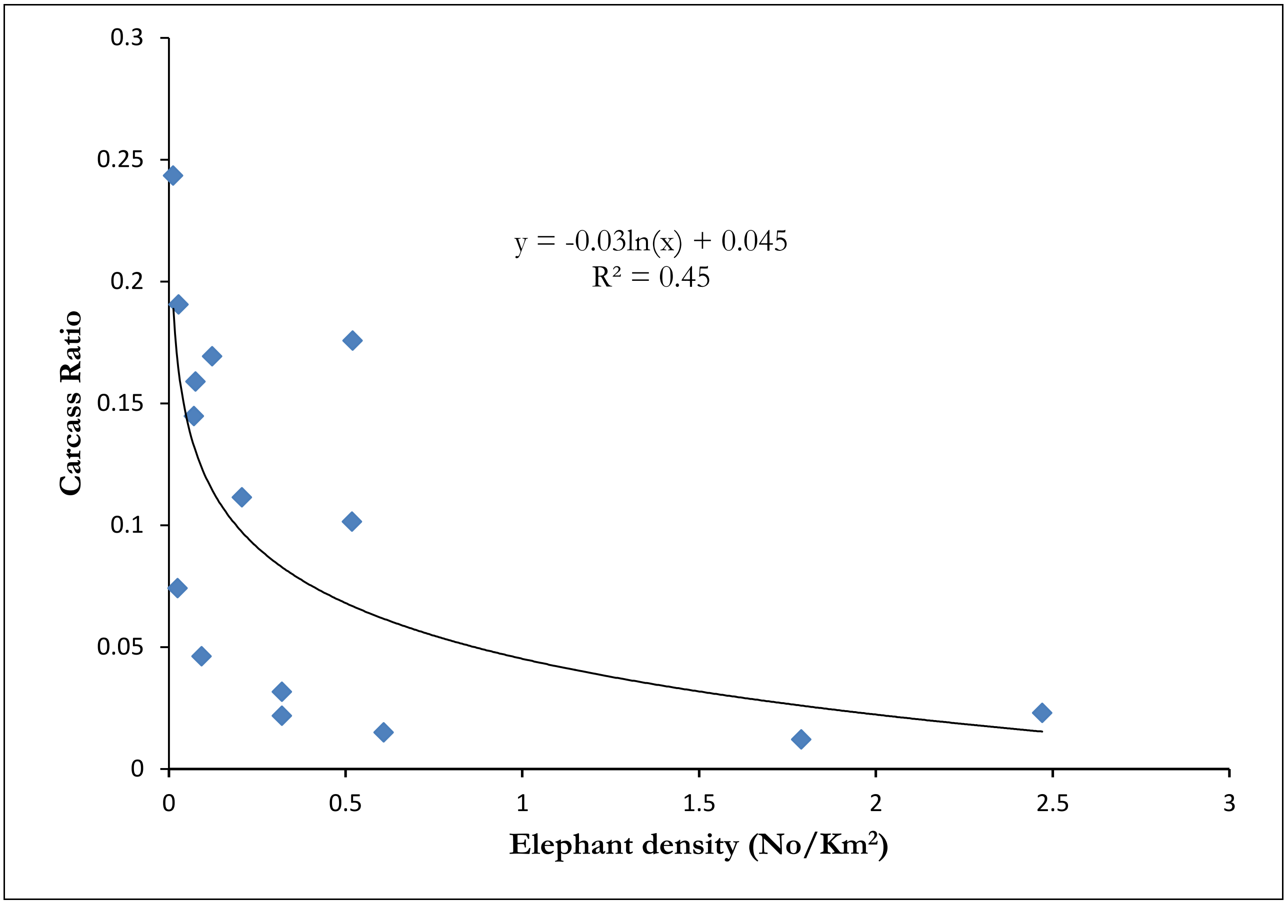

Figure 2-7: Relationship between elephant density and carcass ratio across various sub units of Laikipia-Samburu MIKE site.

2.4 Discussion

The results divulged that the Laikipia-Samburu and Marsabit ecosystems support at least 6,365 and 89 elephants respectively during the survey period. The 2008 aerial census recorded about 7,415 and 319 elephants in the respective ecosystems. The current population represents approximately 14% (n = 1,050) and 72% (n = 302) decline in four years within the Laikipia-Samburu and Marsabit ecosystems respectively. Four reasons are advanced to explain the observed decline of elephant population in the last four years (2008-2012). First, death of elephants due to natural causes was high (n = 504) between December 2008 and October 2012. Most of these elephants (67%; n = 338) died due to the 2009 drought (KWS Security Database, 2012; Figure 2-8). Droughts have been known to reduce the population of wildlife including elephants in other ecosystems. For example, about 2000 elephants died due to droughts in 1970 and 1971 in the Tsavo ecosystem (Corfield, 1973). Second, trophy poaching also contributed to the decline of elephants. For example, between 2008 and

November 2012, approximately 389 elephants were killed through trophy poaching within the survey area (KWS Security Database, 2012).

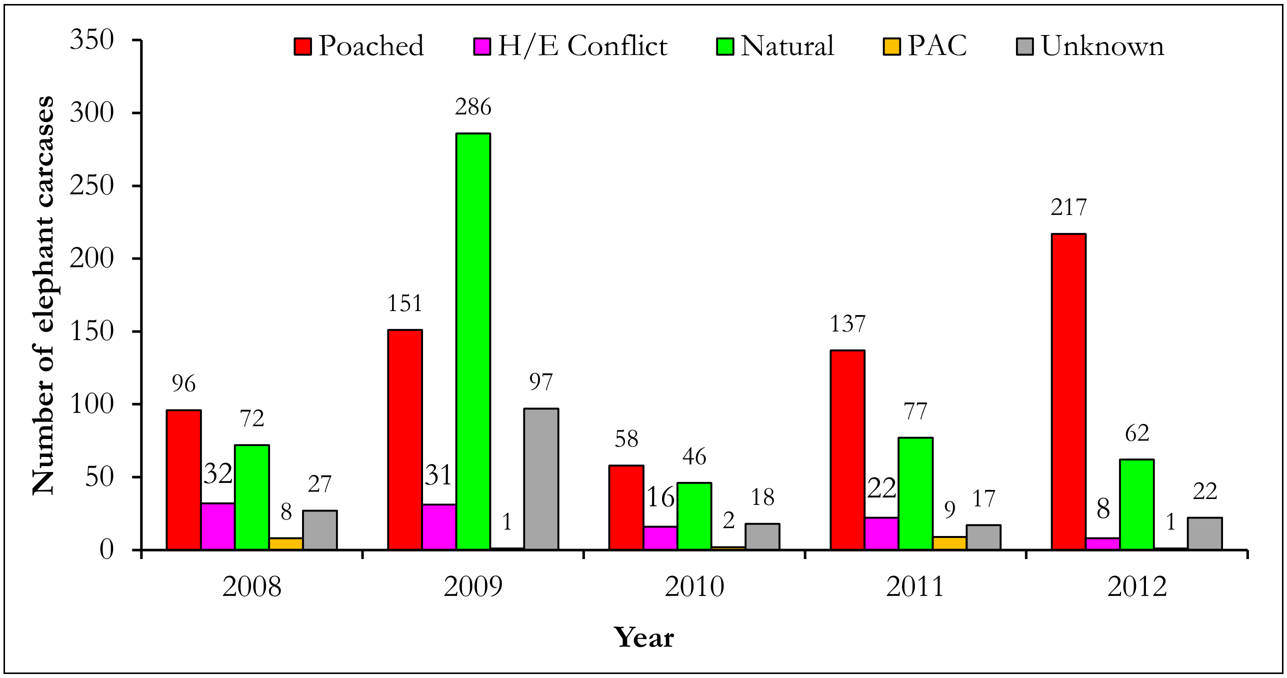

Figure 2-8: Mortality of elephants in Laikipia-Samburu MIKE site ecosystems due to different reasons (January 2008 to 2012).

Longer term trends reveal a cyclic change in elephant numbers initially estimated to be approximately 14500 in 1970 (Jarman, 1973; Figure 2-9). Jarman, 1973 further noted that 9000 (62%) of these elephants were in Samburu and the rest in Laikipia. The distribution of elephants between Samburu and Laikipia has undoubtedly flipped with the latter hosting the majority of the elephants in the Laikipia-Samburu ecosystem. The flip in this elephant distribution in favor of Laikipia came as a result of elephants seeking refuge from the intense poaching in the late 1970s', and several attempts to drive the elephants back north in 1978 were unsuccessful (Woodley and Snyder 1978). Despite the evident importance of Laikipia in conservation of the elephants, it is worrying that the unpublished levels of illegal killing in these ranches and private conservancies in general has been rising steadily from a low of 22% in 2002 to an all time high of 76% in 2012 (KWS Security Database).

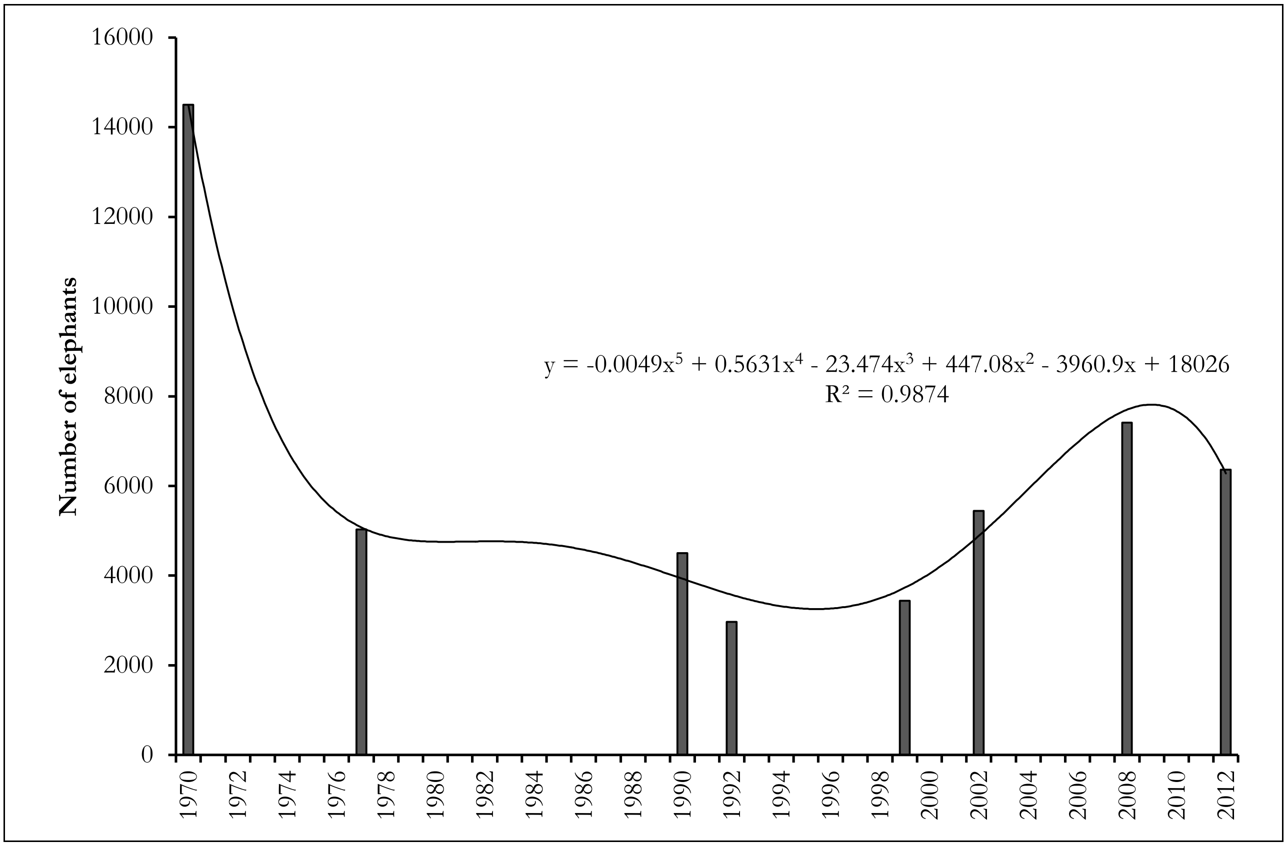

Figure 2-9: Trends in elephant numbers in LaikipiaSamburu ecosystem from sample counts from 1970 to 2012. Prior to the 2002 counts, they were all sample counts. **Source:** Jarman (1973), Douglas-Hamilton (1980), Thoulesset *al.* (2008) and Litoroh*et al.* (2010).

Poaching has been resulted to decline of elephants in Kenya and other African elephant range states in the past (Blanc *et al.*, 2007). Today, poaching is a threat to elephant populations in other elephant ranges in Africa in general and Kenya in particular. A comparison between the 2002 and 2008 elephant numbers had revealed an annualized growth rate of around 6% between the two counts (CITES, 2010b).

Our results showed that about 263 elephants were lost each year between 2008 and 2012, representing an annual growth rate of -0.04. If this annual loss of elephants continue, then elephants will be locally extinct from the ecosystem in the next 25 years (i.e., by 2037). For the population to start increasing again, efforts should be enhanced to reduce mortality factors that can be prevented (e.g., illegal killing, problem animal control, among others). To mitigate mortality arising from droughts, it is important to provide water resources within the protected area, wildlife conservancies (community and private).

Comparison of aerial and ground carcass sightings

The census area falls within the Laikipia-Samburu MIKE site where systematic monitoring of mortality has been in place since 2002. It was estimated that carcasses of elephants spotted from air could have died in the years 2011 and 2012. From the MIKE ground monitoring, 264 and 310 carcasses were recorded in the years, respectively. The ‘Fresh’, ‘Recent’ and ‘Old’ carcasses spotted from air within the MIKE site boundary were 105, 18.3% of the expected ground sightings. This illustrates the unreliability of aerial surveys for MIKE work. For this reason, the ground patrol data was used to calculate carcass ratios. The carcass ratio from the 2012 census was 5%, up from 3% for each of the earlier two censuses, 2002 and 2008. Figure 2-10 below shows the distribution of elephant carcasses during the 2012 aerial count and from the ground carcass sightings.

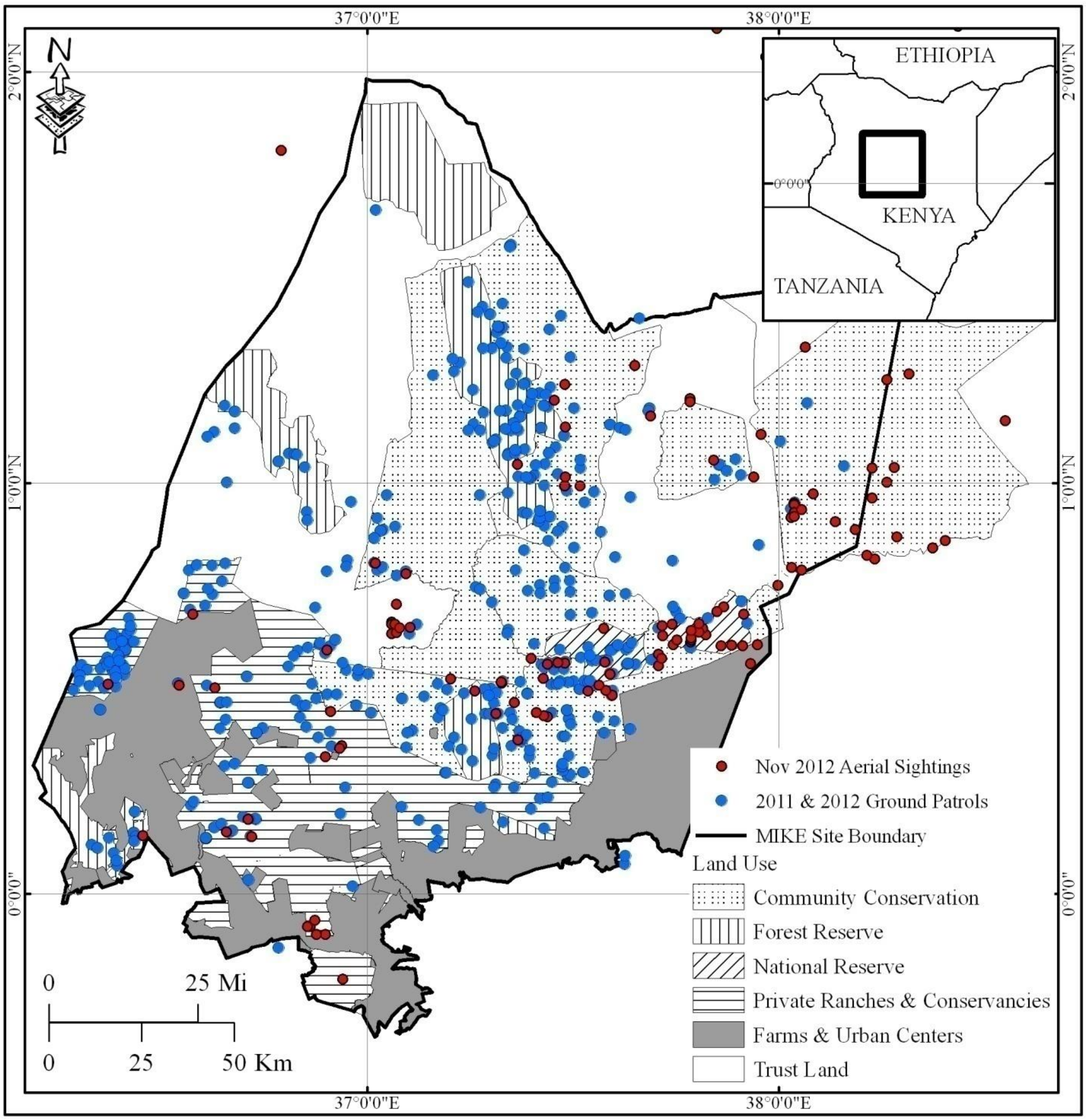

Figure 2-10: Distribution of carcasses recorded from air during the 2012 census and those from ground MIKE monitoring in 2011 and 2012

Throughout the elephant range, there has been a continuing increase in levels of illegal killing since 2006 with 2011 displaying the highest levels (CITES, 2010c). In the just ended year 2012 when this survey was conducted, the levels of illegal killing is at an all time high since the last poaching crises in the 1970s, probably an indication of trends in other sites (KWS Security Database, 2012). It is not certain how the intensity of poaching changed after 1975, but carcass ratio data from KREMU suggest that it was lower in the 1980s than in the 1970s (Douglas-Hamilton, 1980). The first KREMU sample counts were conducted in 1977 after the initial period of heavy poaching, giving a population of 5032 ± 1981 live elephants and 3601 ± 587 carcasses for Isiolo, Laikipia and Samburu districts combined (Thouless*et al.*, 2008).

2.5 Conclusions

The survey confirms earlier concerns that the elephant population is declining. The severe drought in 2009 compounded with increased levels of illegal killing is believed to be major factors contributing to the decline. To keep track of the population dynamics of this second largest population of elephants in Kenya, it is imperative to continue the existing MIKE monitoring programme.

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Appendix 2-1: The scanning rates and density of elephants in Laikipia-Samburu-Marsabit ecosystem

Name	*Block Area (Km^2)*	*Area flown (Km^2)*	*count time (Hours)*	*scanning rate (Km^2/hr)*	*Number of Elephants*	*Density (No/Km^2)*
Ol Doinyo Sabach	1683	1514	7.85	192.91	1124	0.742
Serolevi	2345	2345	20.25	115.79	875	0.373
W. Isiolo/Samburu	1448	1448	10.62	136.37	863	0.596
Colcheccio/Kisima	1072	1072	4.68	228.96	676	0.630
Doinyo Uasin	2131	2131	12.77	166.91	446	0.209
Mpala/El Karama /Ol Jogi/W.Bars	727	727	7.05	103.13	380	0.523
E. Ol Jogi/Borana	586	586	7.57	77.43	368	0.628
Lewa	444	444	2.30	193.04	344	0.775
Segera	681	681	9.10	74.84	200	0.294
Barsalinga - Samburu	1263	1137	7.02	161.97	197	0.173
Nyahururu Area	2433	122	1.18	102.79	190	1.562
Ol Pajeta/Solio	876	657	4.83	135.86	154	0.235
Mugi/Marmar	421	421	3.53	119.14	152	0.361
Ol Ari Nyiro/Ol Morani	956	812	4.05	200.58	93	0.114
Marsabit 1	2566	2310	6.09	379.03	86	0.037
ADC Mutara	443	443	3.47	127.86	84	0.190
E. Barsalinga/Mukogodo	830	830	2.58	321.31	68	0.082
Lodume/Marti Sumalta	1674	1507	15.85	95.07	50	0.033
Ewaso	1167	1167	9.42	123.97	47	0.040
Biliqo Bilesa Area B	2541	2541	5.73	443.18	33	0.013
Isiolo	1442	1442	7.15	201.71	17	0.012
Kirimon	355	355	3.47	102.45	4	0.011
North Eastern	1954	1954	10.03	194.71	3	0.002
Barsaloi	742	371	0.62	601.75	0	0.000
Barsaloi/N.W. Mathews	1547	464	3.17	146.53	0	0.000
Biliqo Bilesa Area A	1024	1024	8.82	116.18	0	0.000
Kipsing	1140	1140	4.67	244.36	0	0.000
Kirisia/Maralal	1537	307	2.82	109.17	0	0.000
Korr	1207	1207	6.27	192.62	0	0.000
Kulamawe	1464	1172	6.02	194.71	0	0.000
Laisamis	1932	1932	3.17	610.13	0	0.000
Lusoi	27	0	0.00	0.00	0	0.000
Marsabit 2	3210	3210	14.18	226.32	0	0.000
Marsabit 3	2114	2114	3.68	573.98	0	0.000

Appendix 2-1 (Cont.)

Name	*Block Area (Km^2)*	*Area flown (Km^2)*	*count time (Hours)*	*scanning rate (Km^2/hr)*	*Number of Elephants*	*Density (No/Km^2)*
Mathews Ranges	742	0	0.00	0.00	0	0.000
Nanyuki	443	0	0.00	0.00	0	0.000
Ngilai	3215	1607	5.53	290.47	0	0.000
Rumuruti	672	671.8022	0.00	0.00	0	0.000
South Horr	3518	528	6.05	87.22	0	0.000
Suguroi	573	487	3.55	137.16	0	0.000
Totals	**55,144**	**42,881**	**235.13**		**6454**	

Chapter 3

Aerial Count of Grevy's Zebra in Laikipia-Samburu-Marsabit Ecosystem

This chapter was developed by:

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3. Aerial Count of Grevy's zebra in Laikipia-Samburu-Marsabit ecosystem, Northern Kenya

Summary

This report presents the results of the Kenyan national survey for Grevy's zebra, carried out in November 2012. Kenya Wildlife Service (KWS) with partners in the Grevy's Zebra Technical Committee lead the planning of the regular surveys to count the Elephants, Grevy's zebra and other large mammals in Laikipia, Samburu, Isiolo and Marsabit Counties. The report begins with a description of the conservation status of Grevy's zebra and past efforts to survey them. The aerial survey methods used in this survey are presented alongside a detailed description of the survey area. Results are divided into three distinct sections. In thefirst, Grevy's zebra numbers are presented in terms of management zone and land use type.In the second, aerial survey results are compared to ground survey data collectedsimultaneously. In the third, the distribution of Grevy's zebra is compared to a range ofhuman and environmental variables. Finally, recommendations are made for future surveys.

The goals of the survey were to: Determine the distribution and provide an estimate of any change in numbers of Grevy's zebra across Kenya; develop a trend analysis for the Grevy's' zebra population utilizing all available population estimates, and standardizing this going forward on regular aerial survey count data, augmented by ground based surveys and datasets; provide data from which to identify locations where populations have declined and those where populations have increased; develop analyses describing factors influencing the survival of Grevy's zebra in Kenya; assess the suitability of aerial surveys for monitoring population trends over the long term and to institutionalize a periodic count of Grevy's zebra in Kenya.

The survey used a standardised minimum count methodology to count Grevy's zebra within the survey area. The methodology for 2012 was largely similar to that applied in 2008, however the, 2012 survey covered a larger area, further north, appending some eastern territories and extending the southern areas covered in Laikipia. In comparison, 2012 survey covered 9700km^2 more than 2008 survey. In 2008 a total of 46 391Km^2 were surveyed, while in 2012 the total area was 56 300 Km^2. The standardized area used for trend analysis was reduced to 40 100Km^2. The 2012 National Survey counted 1897 Grevy's zebra in the total survey area. This represents 510 fewer animals than were detected in 2008. Results showed that similarly to the 2008 survey the Wamba and Laikipia zones accounted for the most sightings (89%), however this was 3% lower than in 2008 for the same area. The number of individuals counted outside of the management zones was again 2%. Laisamis and Elbarta management zones held the lowest numbers of 8% and 1% respectively.

Land use analysis revealed substantial changes in the type of habitat that Grevy's zebra were found in when compared with the 2008 distribution. The majority of Grevy's zebra were found distributed between community conservation areas and private ranches and Government Land, representing 88% of the population. The proportion of Grevy's zebra on private ranches has increased by 12%, while community conservancies have lost population share by 10% when compared to 2008. 9% were found in settlement areas in 2012, up 3% on the 2008 survey figure. 1% of observations fell outside of any management areas in 2012 compared to 4% in 2008. Community land accounted for a further 14%, down 4% from 2008, while only 2% were observed in protected areas, similar to 2008.

The precision and/or accuracy of a minimum count such as this cannot be determined without some form of multiple sampling, or a measure of detectability. Carrying out ground counts in some blocks has enabled comparisons between methods.

The Grevy's Zebra Technical Committee recommends modification of the management zones to include Grevy's zebra that were counted in areas outside the current zone boundaries. Assessment of population health is also possible by determining age structure during an aerial survey and should be undertaken during the next count in light of the threats to Grevy's zebra recruitment that have been identified by previous research. We also recommend improving the survey method including using a 1km transect interval across all areas in order to avoid missing Grevy's zebra, determining a detection factor for Grevy's zebra in each survey block and correcting results for this, and investigating the option of sample surveys. In future surveys a more systematic ground survey should be employed in parallel with the aerial survey to more fully explore the accuracy of this method. Finally, we recommend that local experts be used as spotters to improve the accuracy of counts and promote local involvement in the survey.

3.1 Introduction

3.1.1 Background

The current *Conservation and Management Strategy for Grevy's Zebra in Kenya* (KWS, 2012) emphasizes population monitoring as a key objective. Monitoring will provide baseline data on the distribution and numbers of Grevy's zebra within Kenya. Such data will enable the assessment and prioritization of appropriate actions for Grevy's zebra conservation and will be used to update their IUCN conservation status and range map. Furthermore, the national strategy emphasizes the importance of developing standardized methods for surveying Grevy's zebra throughout their range and at regular intervals in the future. Without effective accounting of Grevy's zebra numbers, we cannot know whether conservation efforts are successful. Also, we cannot effectively plan future conservation actions without knowing the current status of Grevy's zebra in Kenya.

Grevy's zebra (*Equusgrevyi*) numbers have declined rapidly in recent times (Nelson, 2003; Rowen& Ginsberg, 1992). Population estimates of 15,000 in the late 1970s (Grunblatt*et al*, 1989) compare with estimates of between 1,700 and 2,100 animals more recently (Nelson,2003; Williams *et al*, 2003).The range of Grevy's zebra has also dramatically reduced in size. This species once ranged over large tracts of south western Somalia and northern Kenya, as well as large areas of Ethiopia through to northern Djibouti and southern Eritrea. Furthermore, a stakeholder workshop held in 2007 suggested that the number of Grevy's zebra in Kenya was between 1,838 and 2,319 (Mwasi&Mwangi, 2007), which would have suggested marginal increase in Grevy's zebra numbers from the previous estimate of 2004.This represented a maximum decline of 85% over the last 27 years However in 2008 an aerial census detected 2407 Grevy's zebra (Low *et al.*, 2008). A meeting of Grevy's zebra specialists and stakeholders from Kenya and Ethiopia estimated that approximately 2800 animals were present in managed and monitored populations between Kenya and Ethiopia in 2012 with 93% of the population residing in Kenya. This gave rise to the hope that the population was more abundant than previously thought.

The decline of the species from prehistory to the present day has been speculated upon and agonized over, and is generally believed to be largely as a result of human population expansion and competition for scarce water and forage resources, and predation. Undoubtedly these are important factors, however, Faith *et al*., 2013 reported on fossil history of Grevy's zebra indicating population decrease during the Pleistocene-Holocene era transition due to loss of arid grasslands. Current environmental conditions might suggest that this theory is still proximal to the cause of declining Grevy's zebra populations in the modern day. Global warming and human population expansion alone may be impacting the quality and quantity of arid land grasses available for this highly dry adapted species. Recent years have seen a dramatic oscillation between drought and flood as rainfall patterns become more unpredictable in Grevy's zebra rangelands. Drought conditions have been documented as increasing mortality amongst Grevy's zebra populations (GZT, unpublished data), while the ensuing heavy rains and flooding in Northern Kenya may produce poor conditions for the production of arid land grass species. This scenario of change followed by change without respite for historically normal arid conditions may represent a double edged sword driving deep below the surface of the Grevy's zebra's finely tuned resilience to arid conditions which have been stable within their limits for millennia.

In the last ten years, conservation efforts for this species have been intensified particularly in communal lands which have been reported to have over 50% of the population of wild Grevy's zebra in Kenya (Low *et al*., 2008). Attitudes of the local people living within Grevy's zebra habitat are positive towards conservation (Lelenguya, 2012), potentially providing a productive social environment for the adoption of conservation practice and the entrenchment of positive attitudes toward the species. Taken together these conditions of precarious population decline and positive sentiment toward wildlife mean that there is an increasing urgency for information, which can be used to develop recommendations, guidelines and actions for the conservation of Grevy's zebra and other wildlife in northern Kenya.

Working with partners in the Grevy's Zebra Technical Committee and the Kenya Wildlife Service (KWS) lead the planning of the regular surveys to monitor the Illegal Killing of Elephants (MIKE) in Laikipia, Samburu, Isiolo and Marsabit Counties.The MIKE elephant survey area overlaps significantly with the core area of Grevy's zebra range (Figure 3-1). For this reason, combinedeffortto carry out a joint survey for Grevy's zebra and elephants in the Laikipia-Samburu ecosystem was found to be applicable. For purposes of improving the survey design for Grevy's zebra several new areas were included in the survey area for 2012 (Figure 3-1).

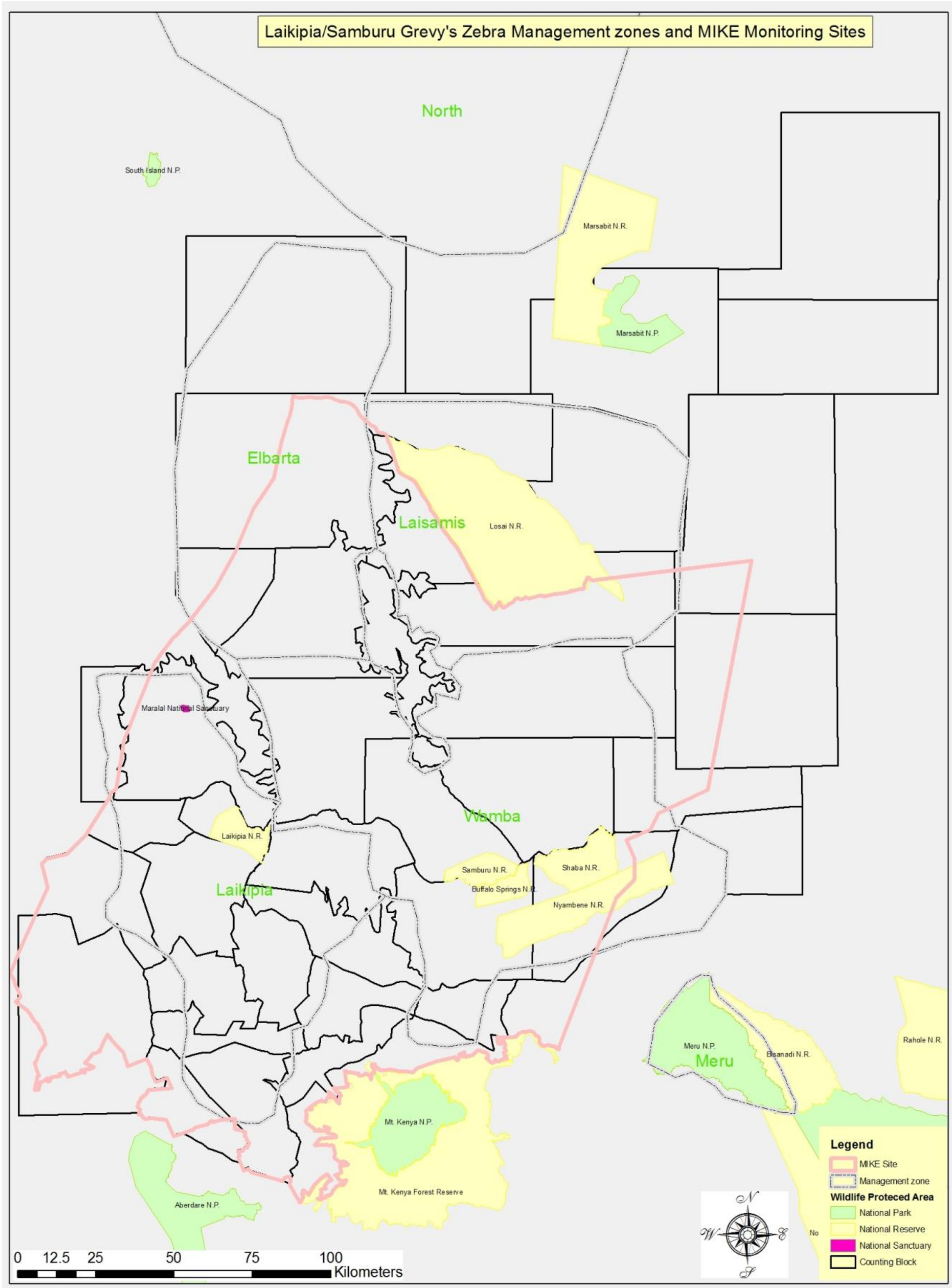

Figure 3-1: Overlay of MIKE survey zones and Grevy's zebra management zones indicating overlapping.

It is anticipated that collaboration with other partners will institutionalize the national survey for Grevy's zebra and will ensure it is repeated at four year intervals. The survey was carried out in November 2012 using standard aerial survey methods and coordinated by KWS in collaboration with African Elephant Specialist Group, Ministry of Environment and the Department for Research Surveys and Remote Sensing (DRSRS) and the Grevy's Zebra Technical Committee (GZTC).

The Grevy's Zebra Technical Committee is a collaboration of seven organizations including: African Wildlife Foundation, Denver Zoo, Princeton University, Grevy's Zebra Trust, Kenya Wildlife Service, Lewa Wildlife Conservancy, Marwell Wildlife and Northern Rangelands Trust. These organizations are committed to conserving Grevy's zebra. The Technical Committee has since evolved into the National Grevy's Zebra Steering Committee (NGZSC) in line with the coordinating framework defined in the reviewed second edition of Conservation and Management Strategy for Grevy's zebra (KWS, 2012). The NGZSC's mission is to deliver pragmatic, management oriented initiatives to strengthen Grevy's zebra conservation action within Kenya. The NGZSC coordinates and implements conservation, research, education, and management activities in line with the objectives of Conservation and Management Strategy.

3.1.2 Goals

The goals of the Grevy's zebra survey were to:

a) Determine the distribution and provide an estimate of any change in numbers of Grevy's zebra across Kenya.

b) To develop a trend analysis fo the Grevy's zebra population utilizing all available population estimates, and standardizing this going forward on regular aerial survey count data, augmented by ground based surveys and datasets.

c) Provide data from which to identify locations where populations have declined and those where populations have increased

d) Develop analyses describing factors influencing the survival of Grevy's zebra in Kenya.

e) To assess the suitability of aerial surveys for monitoring population trends over the long term

f) Institutionalize a periodic count of Grevy's zebra in Kenya

3.1.3 Specific outputs

a) To produce a minimum count of Grevy's zebra by area for the country. This represents the second comprehensive count of Grevy's zebra in Kenya since the year 2008.

b) To derive population trends over time to produce a map with detailed information on the distribution of Grevy's zebra across Kenya.

c) To prioritize conservation resources and provide information to assess conservation initiatives such as the newly established community conservancies.

d) To provide the count data to IUCN authorities so that the global conservation status of Grevy's zebra may be updated.

e) To illustrate and discuss environmental factors which may be impacting the Grevy's zebra populations in the survey areas.

f) To illustrate and discuss different land use in the survey areas, to determine the extent and spread of human activities in the ecosystem

g) To identify threats to wildlife conservation in the Laikipia-Samburu-Marsaitecosystem

3.2 Materials and methods

3.2.1 Study area

Laikipia-Samburu-Marsabit ecosystem covers approximately 60,000km^2. The ecosystem is bounded by coordinates 0.5S, 3N, 36E and 39E (Figure 3-2). Most of the region is typically arid savanna, hot and dry for most of the year with highly variable and erratic bimodal rainfall, 90% of which falls in April and November (Figure 3-3) (Barkham and Rainy 1976). Between 2005 and 2012 however, while the bimodal norm has been maintained, rainfall has become increasingly erratic when with extreme peaks and troughs producing severe drought and flooding alternately (Figure 3-4). In the dryer northern extent of the study area, rainfall has historically dropped to less than 500mm per year except in the mountains where variations may reach high of 1250mm per year (Bronner, 1990). Laikipia lies on the leeward side of Mt Kenya and the weather is thus affected by its rain shadow (Berger, 1989). Samburu is mainly a low lying pastoral grazing land with forested mountain ranges (Kirisia/Leroghi/Mathews). It has a high diversity of habitats ranging from the lowland, xeric scrub bush lands comprising *Acacia* and *Commiphora*species to the highland, mesic cedar and camphor forests. Ewaso River and its tributaries is the lifeline for wildlife providing dry season food resources.

The major land uses in the census area include national reserves, community conservation areas, undeveloped government-owned trust land, forest reserves, private ranches and sanctuaries and agricultural settlement (Kahumbu*et al.,* 1999). The following land use categories' were used:

Community Conservancy: Community conservancies are legally-recognized and formed by communities who have united to manage and benefit from wildlife and other natural resources (Weaver and Skyer, 2003). Examples of community conservancies include: Westgate, Meibae, Kalama in Samburu county as well as Melako Wildlife Conservancy in Marsabit county.

Private Ranch: This is a large farm, especially where cattle or other animals are bred. Thus, a ranch is an area of landscape, including various structures, given primarily to the practice of ranching, the practice of raising grazing livestock such as cattle or sheep for meat or wool. Examples of private ranches include: OlJogi and Segera ranches.

Community Land: Community land also referred to as common land is land owned collectively or by one person, but over which other people have certain traditional rights, such as to allow their livestock to graze upon it and collect firewood (Radkau, 2008). Communal land is a mostly rural territory in possession of a community, rather than an individual or company. Examples of community lands include: Oldonyiro and Kisima plains in Samburu County as well as Laisamis plains in Marsabit County.

Government Land: This refers to some land that is held by central or local governments for a specific use. These lands are also referred to as public land and an example is land set aside as livestock corridors for example of Mugwooni cattle track in Laikipia County.

Settlement: Settlement is a general term used to refer to a permanent or temporary community in which people live or have lived, without being specific as to size, population or importance. A settlement can therefore range in size from a small number of dwellings grouped together to the largest of cities with surrounding urbanized areas.

Large Scale Farm – Agriculture: Large-scale farming takes advantage of economies of scale to produce safe, wholesome food at relatively low cost to hundreds of millions of people worldwide. Africa, with available arable land for lease and ready domestic market, has become a hot spot for local and foreign companies looking into large-scale agriculture farm investment (Sapp, 2010). Examples include, large scale wheat farming in OlPejeta Conservancy.

Protected Area: Protected areas are areas set aside to maintain functioning natural ecosystems, to act as refuges for species and to maintain ecological processes that cannot survive in most intensely managed landscapes. Protected areas in Kenya include National Parks, National Reserves, National Monuments, and Wildlife Sanctuaries enhance conservation of species (Lisa *et al.*, 2005). Examples include: Laikipia, Samburu, Buffalo Spring, Shaba and Losai National Reserve.

Forest Reserves: A forest reserve is a specific term for designating forests and other natural areas which enjoy judicial and / or constitutional protection under the legal systems of many countries. Thus, a forest reserve is used to denote forests accorded certain degrees of protection. Example includes: Mukogodo Forest Reserve.

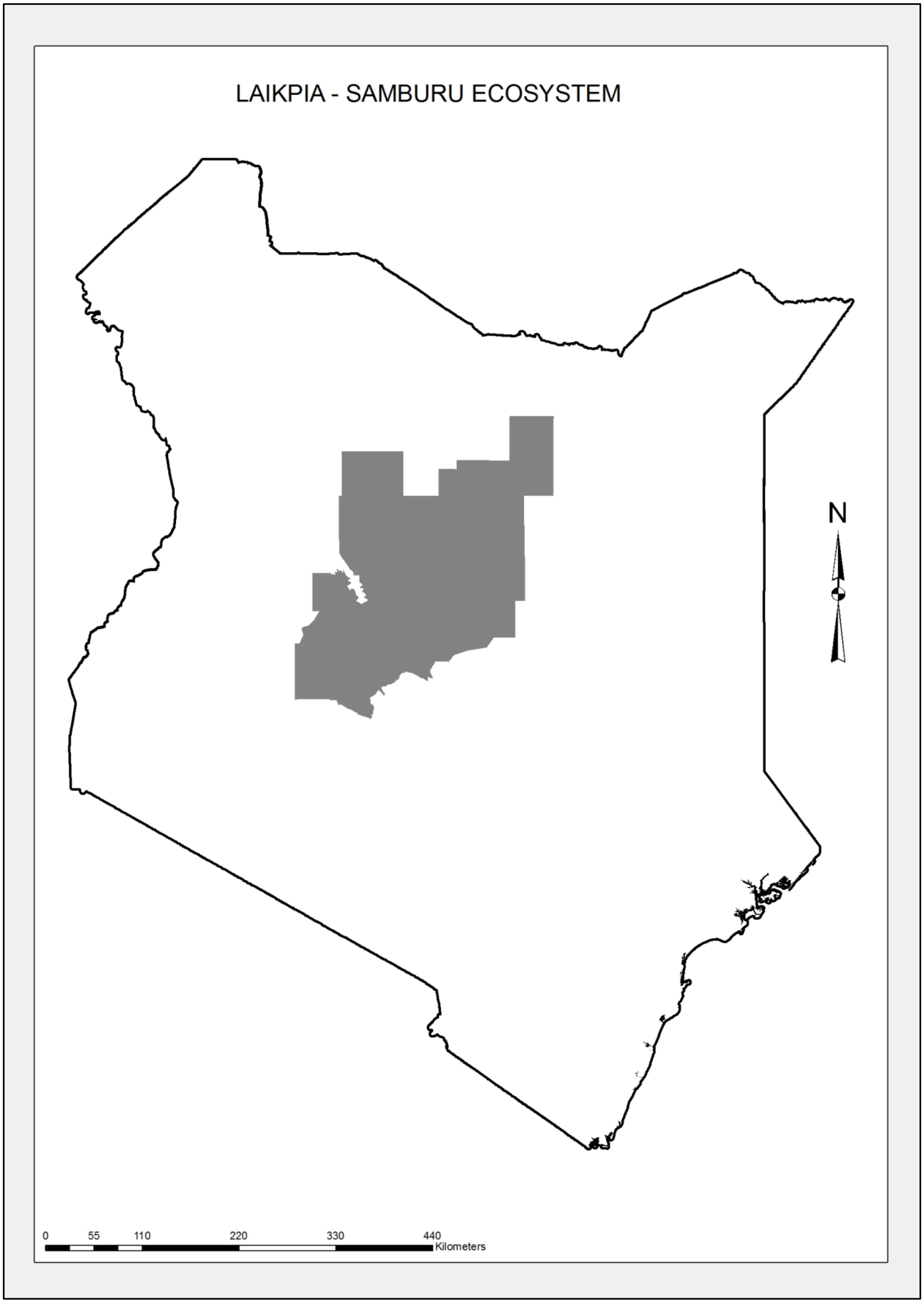

Figure 3-2: Map demarcating area surveyed in 2012 in Kenya

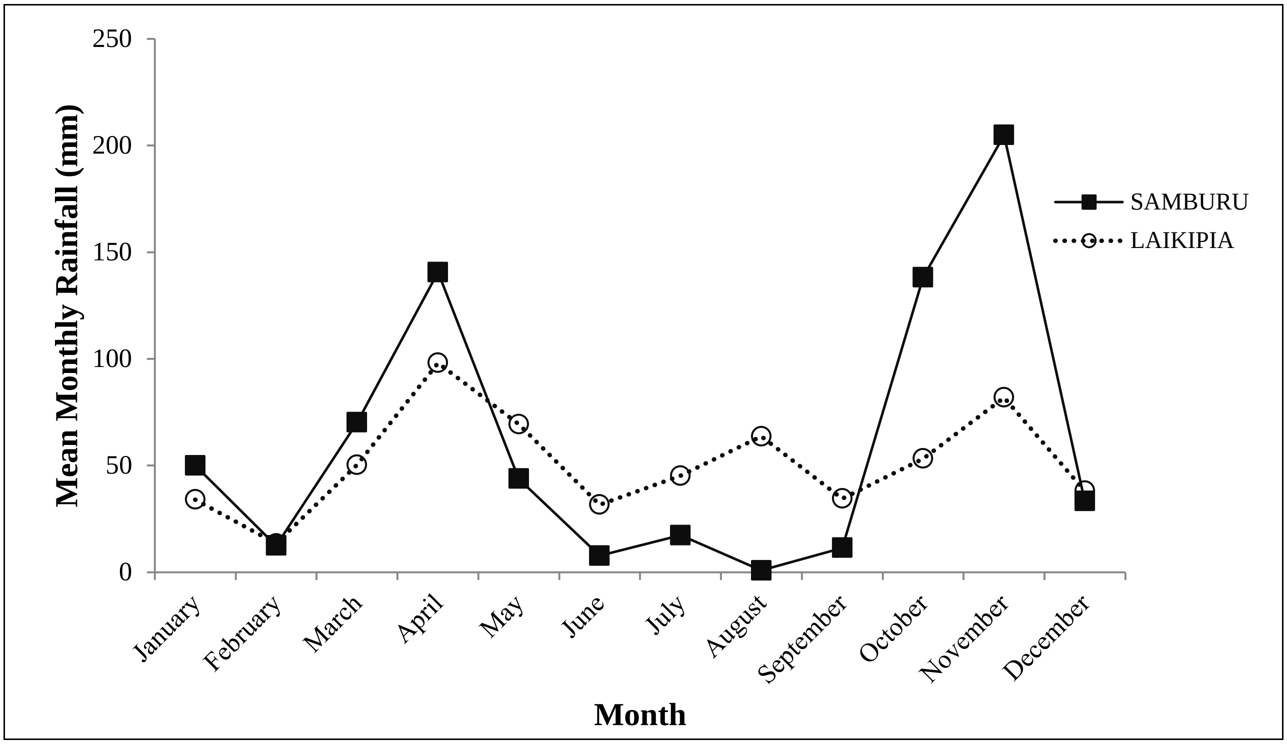

Figure 3-3: Mean monthly rainfall derived from ten years (2003-2012) of Laikipia and Samburu counties. (Source data; *AWF Samburu Heartland, Earthwatch Samburu, Mpala Research Center, OlPejeta Conservancy*)

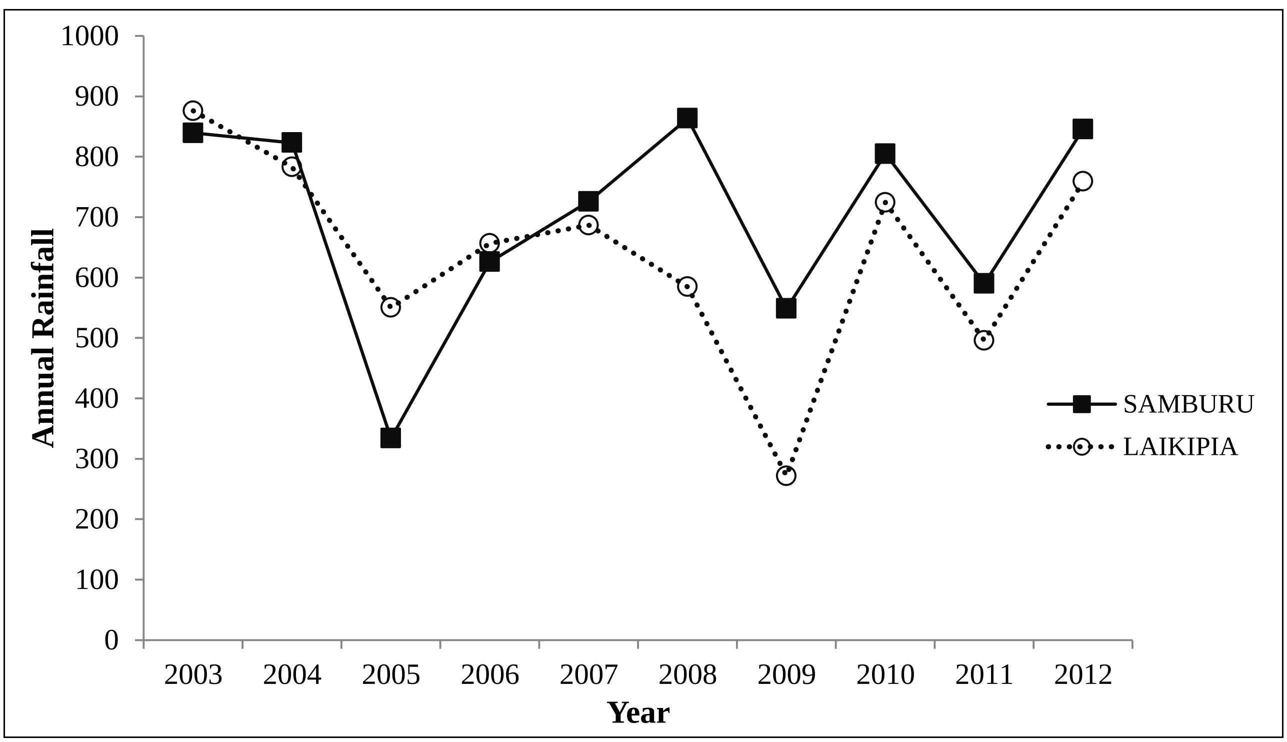

Figure 3-4: Representation of annual rainfall in Laikipia and Samburu counties between 2003 and 2012. (Source data; *AWF Samburu Heartland, Earthwatch Samburu, Mpala Research Center, OlPejeta Conservancy*)

3.2.2 Survey methods

The methodology for 2012 was largely similar to that applied in 2008, however the, 2012 survey covered a larger area, further north, appending some eastern territories and extending the southern areas covered in Laikipia. In comparison, 2012 survey covered 9700km^2 more than 2008 survey (Figure 3-5). A total of 13 aircraft were used in the survey. Each survey crew consisted of 1 observer and a pilot for the 2 seater aircraft, 1pilot, 1 FSO and 2 Rear Seat Observers (RSO) for the 4 seater aircraft.

The survey started every morning at 7.30am and ended at 6.00 p.m. Breaks were taken during refueling of the aircraft and at lunch. Fueling sites were strategically distributed in survey area at Laisamis, Kisima and Shaba NR to cut down on operational costs and maximizing on surveying time. The flight lines intervals varied between one and three kilometers depending on the visibility and terrain, but constancy in flight direction and interval was maintained whenever possible for each block (Figure 3-5). The wider spacing of flight lines was predominantly towards the northern part of the census area due to suitable open terrain. These flight paths varied in length to conform to block delineations and topography. Some big blocks were jointly surveyed by two teams with overlap of at least one flight line to ensure that complete coverage was achieved.

3.2.3 Data collection and management

All observations made were geo-referenced using standardized hand held Garmin 72 GPS. These data were used in producing species distribution maps. Repeat counts along block boundaries and overlapping efforts were corrected before data analysis. Standard datasheets (Douglass-Hamilton, 1996) were used in data collection. All data was recorded by front seat observer. In addition the FSO also saved and recorded the waypoints taken for any sighted species or human activity. After landing and reporting to base station, the FSOs corrected their notes for typos made while flying. All observation on datasheets was entered on MS Excel spreadsheet for management while GPS data was downloaded into ArcGIS 10 (ESRI, 2010). Spatial joins between the way points and field data were created and the batch converted into a shape file. A separate team of GIS personnel checked through the records for possible double counts. Any double counts were cross checked with field notes and FSOs and then rectified. The crew computed the time spent in each block after landing using logged flight times and survey data records.

3.2.4Grevy's zebra total count trend methods

Area surveyed and coverage of survey blocks was not similar between 2008 and 2012. This was because the survey area was expanded based on recommendations from the 2008 survey. In the execution of the survey some blocks were found to be devoid of wildlife and decisions taken to discontinue counting in these areas. In others the transect width varied and was increased from 1km to 2km and in some cases 3km to allow these areas to be completed in the time available. These adjustments were made by survey crews as they flew and based on the incidence of wildlife sightings where very low encounter rates or open terrain with good visibility suggested that survey effort could be reduced.

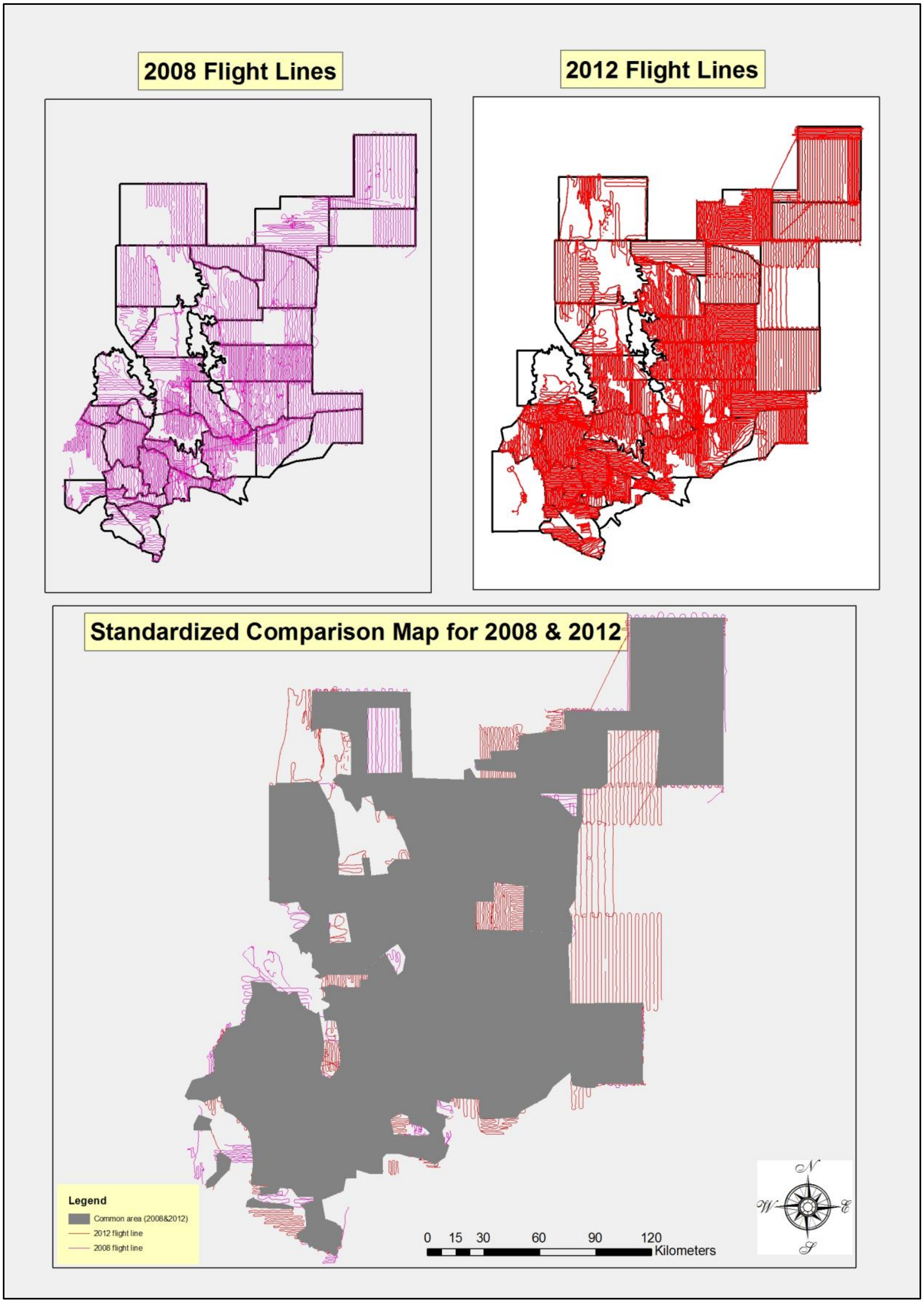

Figure 3-5: Map of the study area showing the blocks and aircraft flight paths used during the aerial survey conducted in November 2012

This being the case, Grevy's zebra datasets from the 2008 and 2012 MIKE surveys were combined to produce compatible samples (Figure 3-5 above). Flight lines from the two years were projected together in ArcGIS 10 and an overlap analysis performed to reveal all areas that had coverage for both years. A new survey area shape was produced, excluding all areas which displayed no coverage, and areas for which there was only a single year's coverage. The resulting shape file was then clipped independently to the species distribution data from each year to provide a distribution and density projection specific to the new shape for each survey. The total counts in these clipped datasets were then used to analyze the trend in numbers.

3.2.5Comparing Grevy's zebra ground and aerial counts

Three sources of data have been collated to provide some expectation of what the November 2012 survey would detect in different areas. Stripe identification, scout based wildlife sightings and annual aerial count data have been used with standard capture recapture methods where possible, or as raw data from total counts where applicable, to obtain general estimates for specific properties. While these estimates do not always coincide with the timing of the 2012 survey, they are the best available data for ground based confirmation of this aerial census.

Stripe Identification is a method using digital photography and bespoke software to extract a unique identification code for each individual captured. Daily scout sightings data is provided by NRT and GZT scouts based permanently in the areas being surveyed. Furthermore, ground based counts were carried out over the survey period by AWF and Earthwatch volunteers in Westgate conservancy (NgutukOngiron) and Meibae conservancy which was divided into two sampling areas; Ngaroni and Barsalinga. Data was collected by driving through the sampling areas with two observers guided by a local scout. Systematic off-road routes were driven where driving terrain was favorable, and as such is considered a minimum count. A similar procedure is followed by a mobile scout in Westgate and Meibae every month using a motorbike. Some properties, such as Lewa Wildlife Conservancy, OlJogi and Mpala, run an annual census of wildlife numbers. All these observations have been used in comparison with the 2012 total count as a means of confirming both the expected distribution and numbers of Grevy's zebra.

3.2.6 Correction factor for ground and aerial count data

Comparison of ground and aerial survey data for five areas (Wamba, Laikipia, Laisamis, outside management zones, and Elbarta)was undertaken. Data was comprised of surveys conducted in the same areas within seven days pre and post the aerial survey and from data provided by field research stations. We assumed that ground survey teams accurately counted all Grevy's zebras in each area they surveyed over time but the aerial survey team missed some individuals. This can occur because small groups are harder to see from the air or some individuals could have been concealed by habitat or terrain obstructions (Jachmann, 2002). Conversely however, aerial counts covered larger areas unreachable by ground crew due to unfavorable terrain thereby possibly increasing probability of detection of isolated populations of Grevy's zebras. We thus applied a*correction factor* by dividing the aerial census count with the ground count. Correction factor larger than 150% was treated as an outlier.

3.3 Results

3.3.1 Minimum counts of Grevy'szebra

In 2008 a total of 46391km^2 were surveyed, while in 2012 the total area was 56300km^2. The standardized area used for trend analysis was reduced to 40100km^2. The 2012 National Survey counted 1897 Grevy's zebra in the total survey area. This represents 510 fewer animals than were detected in 2008 (-21.1%). The standardized method applied to both datasets increased this separation to 630 animals. This represents a 26% decrease in population size detected in a comparable area with similar effort.

Similarly to the 2008 survey the Wamba and Laikipia zones accounted for the most sightings (89%), however this was 3% lower than in 2008 for the same area. The number of individuals counted outside of the management zones was again 2% (n=41). Laisamis and Elbarta management zones held the lowest numbers of 8% (n=153) and 1% (n =25) respectively (Table 3-1).

Table 3-1: The sightings and number of Grevy's zebra per management zone (2008 and 2012)

Management zone	Sightings per zone	No. of Grevy's zebra per zone	Percentage	
			2012	**2008**
Wamba	93	1,036	55%	54%
Laikipia	86	642	34%	38%
Laisamis	13	153	8%	4%
Outside Mngt Zones	7	41	2%	2%
Elbarta	3	25	1%	1%
	199	1,897	**100%**	**100%**

3.3.2 Survey effort

Total flight time was 227 hours, covering 42209km^2. Scanning rates were calculated at a mean rate of 209km^2/hr (Appendix 2-1 in Chapter 2). Means of daily counting time per aircraft are provided in Table 3-2 below.

Table 3-2: A summary of the effort during the 26-30 November aerial census in Laikipia-Samburu-Marsabit ecosystem

Date	Aircrafts Used	Total Flights	Total Count Time (Hrs)	Mean Count Time (Hrs)/Aircraft	SD
26-Nov-12	11	23	59.6	5.4	1.3
27-Nov-12	12	27	59.8	5.0	1.7
28-Nov-12	10	22	48.3	4.8	2.5
29-Nov-12	8	19	52.9	6.6	3.1
30-Nov-12	2	2	4.1	2.1	1.3

3.3.3 Grevy's zebra sightings and land-use

Land use analysis revealed substantial changes in the type of habitat that Grevy's zebra were found in when compared with the 2008 distribution (Figure3-6). The majority of Grevy's zebra were found distributed between community conservation areas and private ranches and Government Land, representing 88% of the population (Table 3-2). The proportion of Grevy's zebra on private ranches has increased by 12%, while community conservancies have lost population share by 10% when compared to 2008. 9% were found in settlement areas in 2012, up 3% on the 2008 survey figure. 1% of observations fell outside of any management areas in 2012 compared to 4% in 2008. Community land accounted for a further 14%, down 4% from 2008, while only 2% were observed in protected areas, similar to 2008 (Table 3-3).

Table 3-3: Percentage of Grevy's zebra per land use area for the 2012 & 2008 national surveys

Land Use Cat.	Sightings in 2008	Sightings in 2012	% in Cat. 2008	% in Cat. 2012
CCA	44%	643	44%	34%
Cattle tracks	22	0	1%	0%
Community Land	436	264	18%	14%
Forest Reserve	0	0	0%	0%
Government Land	0	0	0%	0%
Large Scale Farm	0	0	0%	0%
Private Ranch	689	769	29%	41%
Protected Area	49	45	2%	2%
Settlements	148	176	6%	9%
Swamp	0	0	0%	0%
Urban Center	0	0	0%	0%
	2407	**1897**	**100%**	**100%**

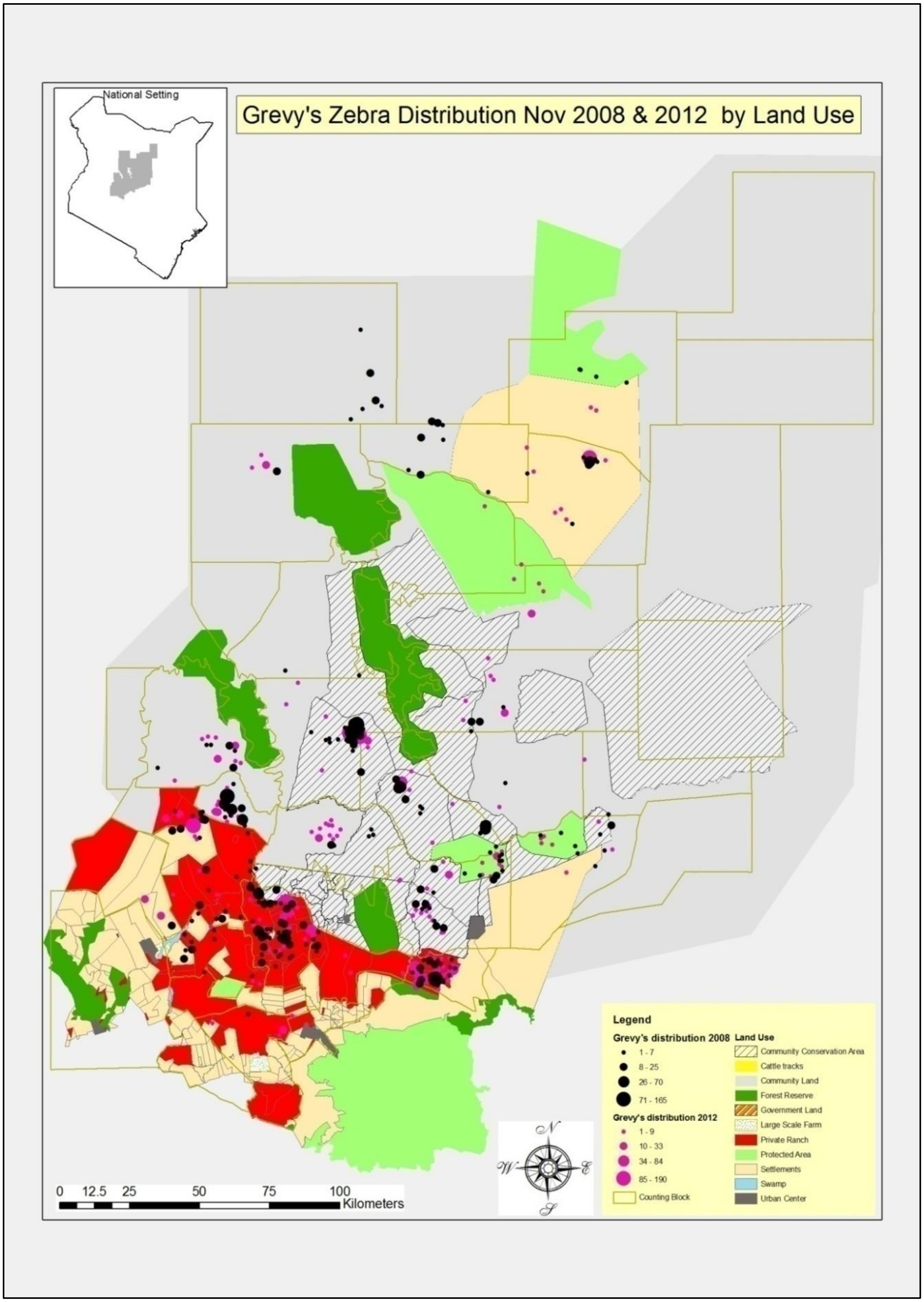

Figure 3-6: Map showing Grevy's zebra numbers and distribution across different land use types

3.3.4 Overlap analysis

Kernel densities of the 2012 and 2008 data revealed that while there was overlap between the distributions of Grevy's zebra in the two counts (Figure3-7.) overlap between core areas represented by 50% kernels was very low (Table 3-4). Overall the two samples were spatially overlapped by 31% (95% isopleths). 75% Kernels representing areas more frequently utilized by Grevy's zebra overlapped by 11%, while 50% kernels overlapped by 3% (Table 3-4).

Table 3-4: Overlap matrix for 50%, 75% and 95% kernel distributions for Grevy'szebra locations for the 2008 and 2012 surveys

		2012			
Overlap	**Search radius**	**50%**	**75%**	**95%**	**Total**
2008	50%	3%	5%	6%	15%
	75%	5%	11%	16%	32%
	95%	7%	16%	31%	53%
	Total	**15%**	**32%**	**53%**	**100%**

3.3.5 Comparing ground and aerial counts

Grounds counts between 2008 and 2012 provided distributions for Grevy's zebra across the management zones with population size estimates for specific properties. Ground count data illustrated areas where Grevy's zebra were expected to be found against which to verify aerial count data (Figure 3-7). Density distributions of ground and aerial count data found that Grevy's zebra were detected in the expected areas and with proportionally similar frequencies of occurrence. A comparison of ground and aerial count population estimates reveal that ground count methodologies provided higher estimates of population size than did Aerial total counts in all but one case (Table 3-5).

Table 3-5: Comparison of aerial and ground count data of six conservation areas surveyed in 2012

	Aerial count 2012		**Ground counts**		
Area	**Date**	**No.**	**Date**	**No.**	**Source**
WestGate Community Conservancy	27-Nov-12	89	14-Nov-12	155	Muoria*et al*. (2012)
			23-Nov-12	143	Muoria*et al*. (2012)
			27-Nov-12	106	GZT
MeibaeCommunity Conservancy	27-Nov-12	463	21-Nov-12	59	Muoria*et al*. (2012)
			30-Nov-12	23	GZT
			7-Dec-12	307	GZT
Lewa Wildlife Conservancy	26-Nov-12	165	31-Mar-12	378	LWC
Mpala Research Center	26-Nov-12	31	22-Nov-12	33	Betts*et al*. (2012)
OlJogi	28-Nov-12	94	31-Mar-12	223	Tupper *et al*. (2012)
Pyramid	27-Nov-12	0	8-Nov-12	22	Tupper *et al*. (2012)

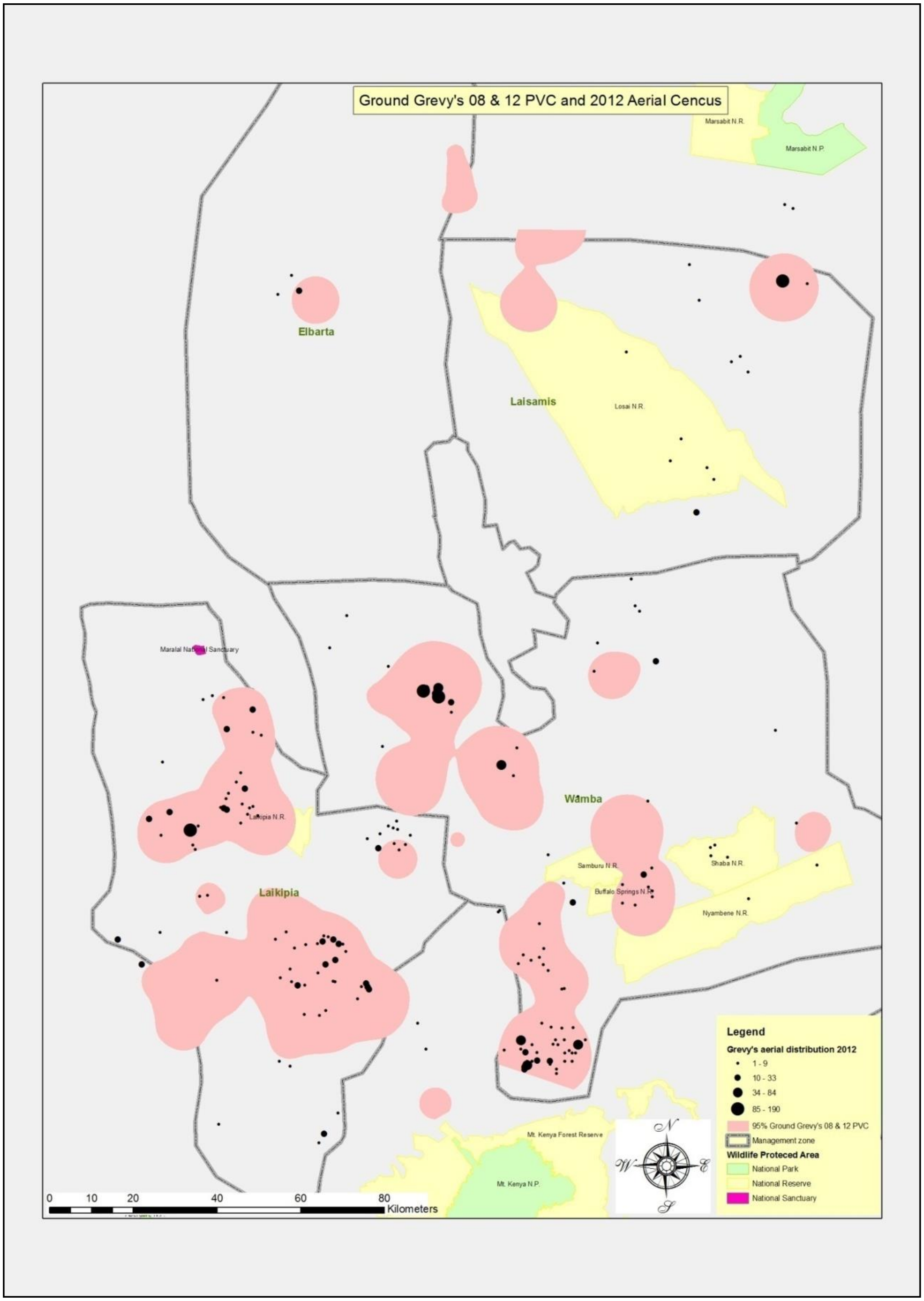

Figure 3-7: Map displaying the 95% kernel extent of ground count data overlaid with aerial survey data of Grevy's zebra total counts in GZTC Management Zones.

3.3.6 Ground based correction factors

A mean correction factor of 0.76±0.38 was formulated. Using this correction factor a total Grevy's zebra population lower limit was derived to be 2229 individuals while the upper limit was 3458.

3.3.7 Spatial distribution of pastoral communities, livestock and Grevy's zebra

Kernel density distributions (Percent Volume contour: PVC) of occupied and abandoned bomas (Manyattas or Homesteads) are presented in Figure 3-8. Abandoned boma sites dominated the northern and eastern quadrants of the survey area and were concentrated in the Laisamis andElbartaGrevy's zebra management zones. Occupied bomas were more prevalent in the southern and western quadrants and were more concentrated in the western Wamba and western Laikipia management zones. Occupied bomas were also found spread out along a north east to south west distribution line across the Elbarta and Laisamis management zones. Occupied boma sites were visible outside of the management zones between the Laisamis and Northern zones in the areas surrounding Marsabit National Park and Reserve.

Similar kernel distributions are shown for livestock including Cattle and shoats (Sheep and Goats), which mirror and expand the area impacted by occupied bomas(Figures 3-8). Nestled between these impacted areas are the distributions of Grevy's zebra. Core areas represented by their 50% and 75% kernel isopleths seldom overlap the occupied boma core isopleths (Figure 3-8). In the more northerly areas Grevy's zebra distributions are often well separated from occupied boma sites. Grevy's zebra thus appear to avoid areas where sedentary, if temporary, human habitation is found.
While there is considerable overlap with the more transitory livestock distributions, core areas are still separated at the 50% isopleths indicating spatial avoidance.

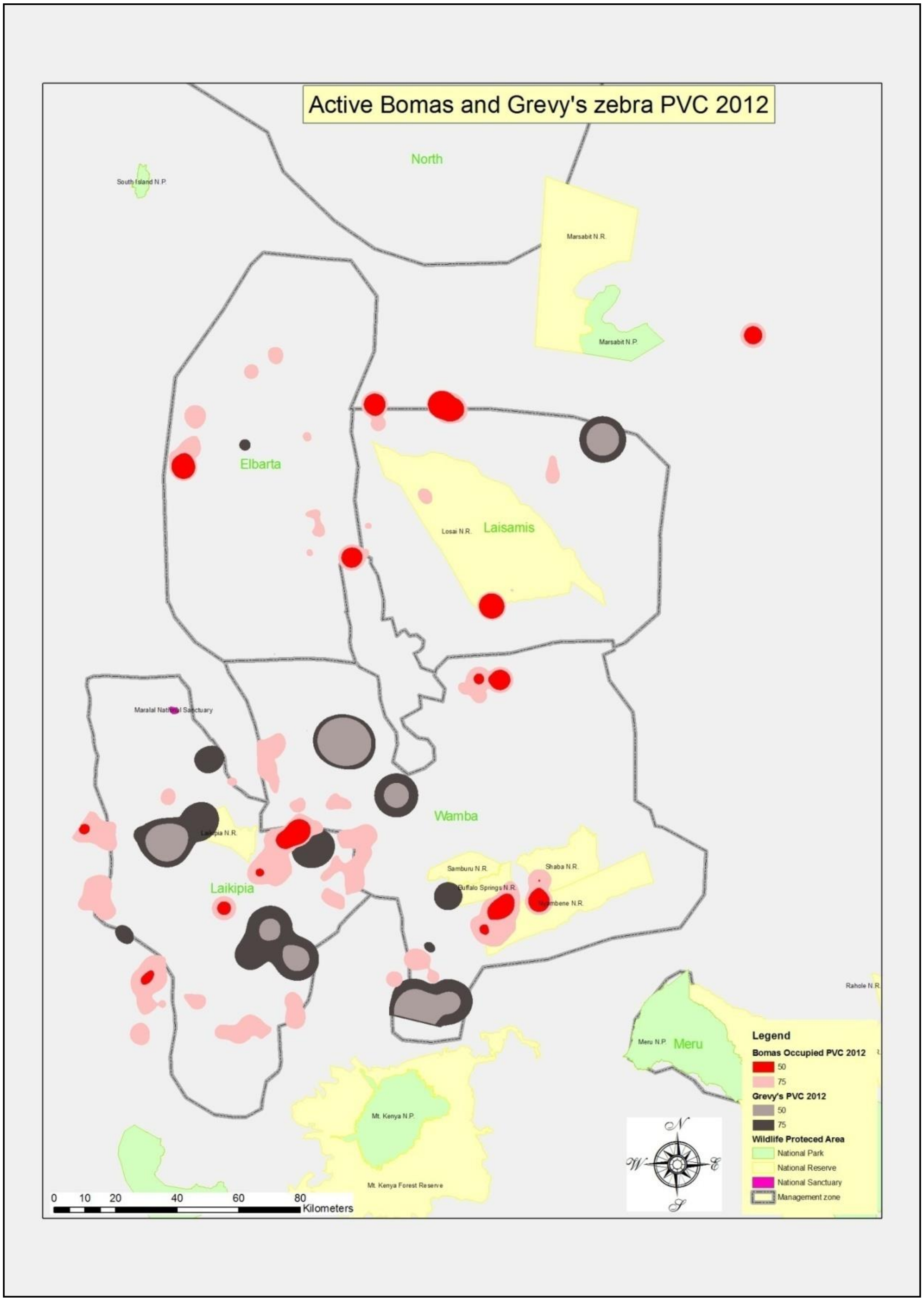

Figure 3-8: Map displaying the separation of core kernel densities at 75% and 50% distributions for active bomas and Grevy's zebra in the GZTC Management Zones.

3.3.8 Grevy'szebra mortality

Mortality figures between 2008 and 2012 have decreased from a high of 97 in 2008 to 22 in 2012. A total of 220 Grevy's zebra mortalities were recorded over this period. Mortality appears to be heaviest in the adult class for all years except 2011. Mortality rates appear to be dependent on rainfall as the highest levels of mortality occurred in the lowest rainfall years (Figure 3-9).

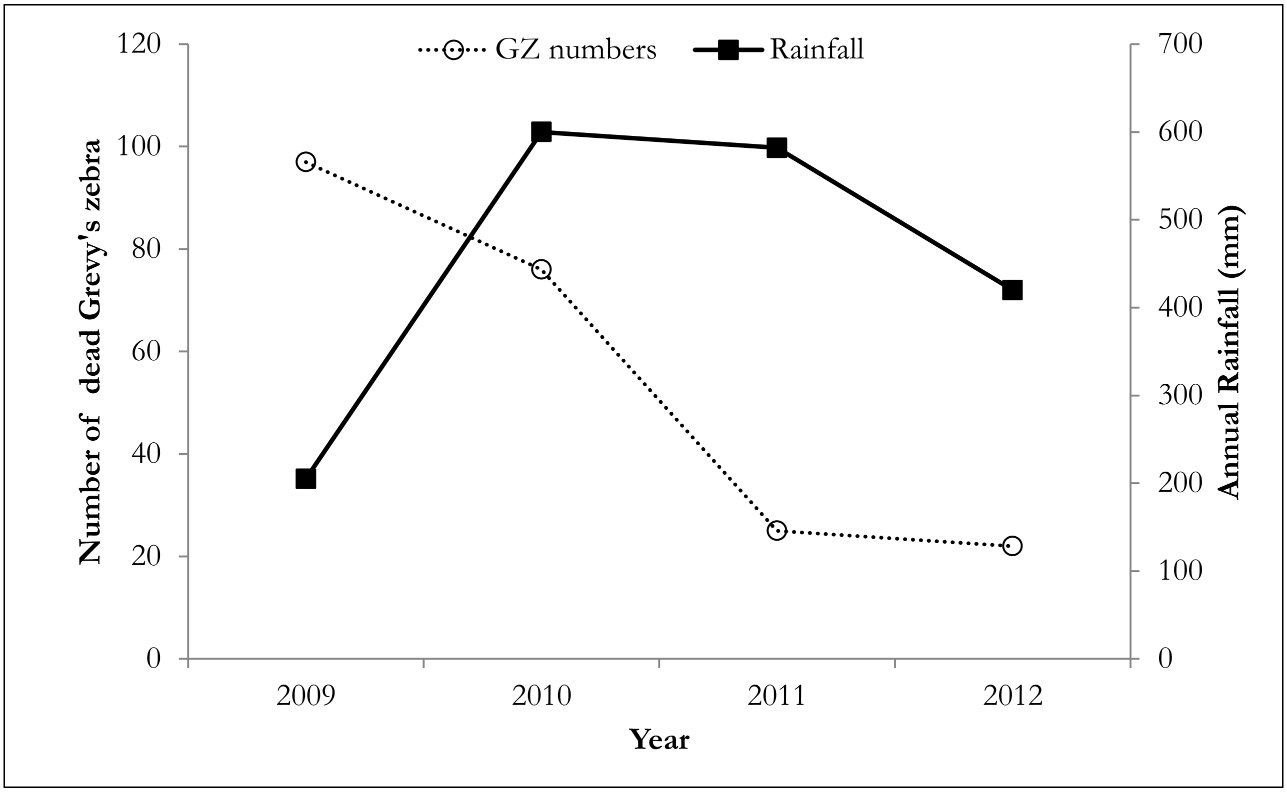

Figure 3-9: Comparison of Grevy's zebra mortality with annual rainfall (Source: Grevy's Zebra Trust)

3.4 Discussion

3.4.1 The population trend

These results suggest that between a fifth and a quarter of the population has been lost over the past three years. While this represents fewer animals counted in a larger area than previously surveyed, several factors need to be discussed in order to determine the significance of this result. Elements such as weather and visibility, timing of survey seasonally and during the day, visibility differences between airplane types, wind and turbulence, glare from the sun, pilot skill, and observer skill amongst others have all impacted the surveys execution. The main factors contributing to variability in the MIKE total count surveys are the differences inherent between different types of aircraft and the skill level of pilots and observers. Generally speaking, MIKE survey pilots have a high standard of operation and are consistent both between surveys and over the duration of each survey. Front Seat Observers (FSO's) are also very consistent with only one change between two planes in 2012 which did not include a new observer, only a swap between planes. Observers do however vary.

Several rear seatobservers were interchanged between planes and some new observers were used for the first time on some flights.

Flight durations were longer than is ideally recommended, the average being approximately 5 hours (± 2), with crews taking an average of 1.5 hours (±0.5) break during the course of the day. While this is not uncommon for Kenyan survey crews which typically have to cover extremely large survey blocks, two counting periods of two hours each, timed for the time of day in which optimal visibility can be expected might possibly improve the detection of species. Despite the intensity of this effort, the survey was still truncated and areas were not surveyed (e.g.,Chalbidesert and parts of BeliquoBulesa). Additionally transect widths were increased in areas where time was becoming critical andsome areas that had inconsistent data or absent coverage when compared to the 2008 survey.

Several ground based long term monitoring efforts have suggested that animals were not sighted from the air in areas where sightings had been made recently from the ground. This included camera trap data for the dates of the survey in the North Eastern, Kor and South Hoar blocks. This is not however a damning criticism of the survey results. Ground visibility in these areas is hampered by tree canopy density and mountainous terrain and animals would have been missed as a matter of course.

With these factors in mind, we have standardized total count effort based on flight lines and produced a "like for like" analysis comparing the 2008 and 2012 survey data. This provides a simple sampled approach and yet still represents a total count result for a common area, derived from comparable effort. We have only used the sub-sample for the total count trend analysis. For all other analyses we have used the entire survey area and all animals counted.

3.4.2 Grevy's zebra population size and distribution

Despite the shift in population share between community conservancies and private ranches, there does not appear to have been any migration of the population fromthe one area to the other. Populations on private ranches appear to be stable and in some cases isolated (Davidson *pers. comm.*). Thus the shift is a change in proportional composition only and so may support the decrease in the number of animals detected. Furthermore, there has not been an increase in predation levels in conservancies where predators and Grevy's zebra mortality are monitored (e.g., Westgate). Analysis of anthropogenic factors acting in the Laikipia and Samburu landscape provide some rationale for both the possible decline in population size and the shift in territories observed.

3.4.3 Grevy's zebra population dispersal

Large mammals typically exploit key resources located in fixed locations within core territories in their geographic range. These areas include permanent water sources and areas where good foraging is available. This is particularly true for territorial animals, and the Grevy's zebra does display territoriality amongst males of the species. Any shift in the spatial distribution of these core areas may indicate a trend toward increased dispersal and hence fragmentation of the population.

The overlap analysis performed between the 2008 and 2012 surveys is a strong indicator that the population has to adapt to competitive pressures for scarce water and forage resources, particularly in the north of its Kenyan range. Several areas identified as 95% and 75% kernels in land use in 2008 were absent from the 2012 distribution. Additionally the overlap o 50% kernel was low, suggesting that core areas and hence important territories, have been lost or have had to shift to alternate areas. Further habitat analysis is required to disentangle the reasons for this shift. These may be owing to the encroachment of human settlement on historic Grevy's zebra territory or the overexploitation of resources by an ever more confined wildlife population and expanding human and livestock populations amongst others.

3.4.4 Spatial distribution of pastoral communities, livestock and Grevy's zebra

The distribution of occupied and abandoned bomas taken together with the distribution of livestock suggests a displacement of people from the north east of the survey area to the south west. This may have occurred in recent times coinciding with the severe drought conditions experienced between 2005 and 2010. Occupied Bomas explain the distribution of Livestock well and when viewed against the distribution of Grevy's zebra appear to support the suggestion that anthropogenic activities are responsible for displacing them in the central Wamba and Laisamis management zones. This being the case it would appear that a primary reason for the decline in Grevy's zebra numbers between 2008 and 2013 is that human populations and their livestock have increased and occupied their ranges in these areas. The resultant competition for water and grazing combined with lack of access to secure habitat would produce a strong negative pressure on foal survival and recruitment to the adult population.

3.4.5 Grevy's zebra population decrease

Analyses of ground based Grevy's zebra counts and aerial count suggests that aerial counts were detecting zebra in the majority of locations that they were expected to be found. However, generally speaking, the group sizes detected from the air were smaller than those detected from the ground.

Aerial carcass counts are not possible for Grevy's zebra. However long term ground based efforts are able to collect representative mortality data for the species. Mortality data for this survey has been provided by the Grevy's Zebra Trust. Over the period between the 2008 and 2012 surveys mortality from all sources has been relatively low and this is unlikely to be a major contributor to adult mortality. Unfortunately reproductive success and recruitment are still poorly understood for wild Grevy's zebra populations and it is not clear what the primary cause of a negative population growth rate might be. Studies on micronutrient availability in soil samples have revealed sub-optimal levels for lactation in Lewa Wildlife conservancy but this does not translate well to the wider population where habitat type varies considerably (Tupper et al. 2011). Despite the lack of biological information available to explain population decrease, human population expansion and competition of scarce resources in Grevy's zebra rangelands is still the most compelling cause. This may be acting through population fragmentation, making detection of remaining groups of Grevy's zebra more difficult, or through senescence without replacement by reproduction and recruitment to the adult population.

3.5 Recommendations

New survey zones for Grevy's zebra: All current sightings should be incorporated into the nearest management zone by expanding the boundaries to encompass all sightings. Before this is done, all sightings should be buffered at 10km distance in order to incorporate not only the location where the Grevy's zebra were sighted, but also the habitat immediate surrounding each sighting. 10 km buffer is used because it accounts for mean daily ranging patterns of Grevy's zebra

Determining the age structure of Grevy's zebra populations*:* The age structure of a population is critical information for management because it indicates population health. By counting the number of Grevy's zebra foals during the next aerial survey it will be possible to identify which populations are breeding and those which have a high proportion of adults. This information can inform further investigation on the ground to determine what the limiting factors are to a healthy breeding population and provide a baseline for future evaluation of conservation efforts focused on increasing foal survival. Differentiating adults and foals from the air is straightforward but it will require further training for the spotters to ensure they are familiar with identifying foals of Grevy's zebra and it is strongly recommended that this component of the count be incorporated into the next survey.

Transects at 1km intervals:In 2008 census, for several outlying blocks of the survey area, transects were spaced at 2km distance. This was initially the case for Meibae conservancy, which yielded results that were far lower than expected by local experts. As a result a second survey was scheduled, this time with 1km spacing. This survey presented a much higher number of Grevy's zebra, a figure in closer keeping with the expectations for the conservancy. Unfortunately the ground counts did not cover the entire area and so it was not possible to verify the results of the second survey. However, it is almost certain that the 1km transect results are more accurate, given the assumption that a wider transect width leads to a lower rate of detection. For future Grevy's zebra surveys using a minimum count methodology, it is recommended that all blocks are surveyed with a 1km interval between transects. In addition we must standardize all operational parameters in the survey such as height above ground, transect width, and strip width (Jachmann, 2002).

Detectability:Currently there is no measure of detectability incorporated into the minimum count methods used in this survey. Detectability is an important consideration: essentially it is the measure of how detectable a Grevy's zebra is in different habitats. One would expect it to be more difficult to locate Grevy's zebra in thick bush as opposed to open grassland. Therefore, it is reasonable to assume that in survey blocks with thicker bush, a greater percentage of Grevy's zebra will go undetected, as opposed to a block with open grassland. Where detectability is not accounted for in a survey, there is a greater likelihood of undercounting to occur and it is also difficult to ascertain the accuracy of surveys.

It is possible to calculate the detectability of different survey blocks, and to use the resulting detection factor to correct the number of Grevy's zebra counted. To give a simplified example: if a certain block returned a correction factor of 0.8 this would mean that on average 80% of Grevy's zebra were detected, and 20% were not. The count for this block would be increased by 20% in order to account for the Grevy's zebra that were missed. Detectability can be calculated for different habitat types across the entire study area if all blocks are counted in the same standardized way. The simplest method would be the 'double observer', the details of which are presented by Cook and Jacobson (1979).

Sample surveys:For areas with known Grevy's zebra population assessed through ground survey, sample surveys can be conducted to extrapolate the population size of the area (See Parker G. *et al.*, 2010). This will provide opportunity to reducing operational cost by 60%.

Grevy's zebra survey experts:It is recommended that in all future surveys that Grevy's zebra field research experts are included in the survey This should increase the accuracy of Grevy's zebra counts and reduce the risk of confusion between plains and Grevy's zebra. It also engages those on the ground in being actively involved in the survey.

Ground Counts:In this survey ground counts provided one way to verify the accuracy of the aerial survey methods. However, there were issues with timing and coverage of the ground surveys. This method should be used in all future surveys, by ensuring ground and aerial blocks are matched, and ground survey teams cover the entire area.

Other recommendations include:Standardizing aircrafts for the survey will be appropriate for uniformity in aircraft speed and flight heights; Pilots briefing on the standard methods before the beginning of survey assuring on flight direction, speed and flight heights; Pre-survey observer training should be planned where all observers are trained to identify species from the air as well as improving their resilience for flying; Need to incorporate Ethiopia Wildlife Conservation Authority (EWCA) for a transboundary survey effort. One of the aims of the GZ strategy will be to strengthen regional links with Ethiopia. This will not only steer a regional landscape approach to Grevy's zebra conservation but also synergize Kenya and Ethiopia on conservation matters; Taking cognizance of the fact that Grevy's zebra are only found in Kenya and Ethiopia in their natural range, it is very important to establish a collaborative transboundary framework to effectively manage transboundary population areas and their habitats.

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Chapter 4

The population status of other large mammals in Laikipia-Samburu-Marsabit ecosystem

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4. The population status of other large mammals in Laikipia-Samburu-Laikipia ecosystem

Summary

This chapter presents the results of other opportunistically observed large mammal species within the Laikipia-Samburu-Marsaibit ecosystem. It also presents human activities observed and recorded which included among others logging, farming and livestock estimates within the ecosystem. Five species, waterbuck, impala, ostrich, giraffe and oryx recorded population growth in numbers of between 7.1% and 86%, while seven species including among others Grant's gazelle and eland recorded a downward growth in population of between 2.2% and 31% compared to the 2008 count. Distribution of these animals showed that settlements, private ranches and community lands as areas of preference. One avian species, the ostrich recorded an 11% increase since 2008 census.A total of 1333 cultivated plots were estimated in the entire surveyed area. Most of the farming activities were predominant in the west and south western parts of Laikipia (642) as well the Southeastern boundary of Marsabit National Reserve (641) and were scattered across Samburu county presumably due to rainfall patterns. Out of 742 770 livestock estimated, Marsabit county recorded the highest (220,737) followed by Laikipia (197,026) and Samburu at 164,625 animals. Charcoal burning was highest in Laikipia (n=251) concentrated in central and north western parts of Laikipia. More charcoal production activities were recorded in the western parts of Samburu (n=54) and within the cultivated plots in Marsabit (n=11) as well as around the Nyambene, Shaba and Buffalo springs national reserves. Mining activities were prevalent in Samburu where 16 sand mines were recorded in similar locations as farming and charcoal production activities. These human activities can hinder migratory species such as Gerenuks, grant's gazelles and oryx and therefore an assessment is required to assess their impacts. Whereas some human activities e.g. livestock showed some coexistence with wildlife existence the dangers of zoonotic disease spread renders such a relationship unhealthy and therefore proper land use policies need to be identified by the respective County Governments.

4.1 Introduction

Apart from elephants and Grevy's zebra, other large mammals such as giraffes, gerenuk, oryx, buffalo, eland, waterbuck, impala, grant's gazeele, Thomsons gazelle, common zebra, giraffe, ostrich, hartebeest, and livestock occur in the Laikipia-Samburu-Marsabit ecosystem. Their occurrence is affected by human activities (farms, settlements, and roads). The mammals have been counted alongside the elephants and Grevy's zebra over time (Thoulless*et al.*, 2008). Past results shows the ecosystem holds a high concentration of other large mammals outside protected area, which makes it the focus of considerable conservation interest in Kenya (Omondi*et al.*, 2002: Litoroh*et al.*, 2010). Information on the number and range of other large mammal is important for their effective conservation and management. Since the 2008 survey, this information had not been updated. The ecosystem experienced a severe drought in 2009 that affected large mammals and livestock. We hypothesized that other large mammals population in the ecosystem may have declined due to the 2009 drought and illegal killings for bush meat trade. Therefore, the 2012 total aerial count in Laikipia-Samburu-Marsabit ecosystem aimed to determine the current status of other large mammals in the ecosystem and map out the threats to this northern Kenya population and their distribution.

The following specific questions were addressed: (1) what is the current population size and distribution of other large mammals such as giraffes, gerenuk, oryx, buffalo, eland, waterbuck, impala, Grant's gazelle, Thomsons gazelle, common zebra, giraffe, ostrich, and hartebeest (2) how is the distribution of human activities that may be threatening the other large mammals through blockage of migratory corridors and dispersal areas?

4.2 Materials and Methods

4.2.1 Study area

The aerial survey was undertaken in Laikipia-Samburu-Marsabit ecosystem. A detailed description of the study area is provided in chapter 2 of this report.

4.2.2 The aircraft, flight paths, crew, and data recording

The aerial survey followed procedures described by Douglas-Hamilton (1996). Chapter 2 of this report provides a detailed description of the aircrafts, flight paths, crew, and data recording. These were used to collect data on other large mammals within the survey area.

4.2.3 Data analysis

The observeddata were tabulated and the results compared with the 2008 census to establish trends and changes in wildlife population estimates. They were calculated across the county boundaries, across different land use systems and the entire survey area. GIS based distribution maps were generated to depict the spatial extent and distributions of various wildlife, human activities and livestock. Analysis of trends for select wildlife species and areas was undertaken for 2008 and 2012 census.

4.3 Results

4.3.1 Population status of different species of large mammals

The results presented here are the numbers estimated from the tally sheets used during the survey. It is important to note that by the very nature of the aerial counts, the numbers might have been underestimated, as some of them are not easily detectable from the air, while others are active during night. The results will present data for 11 mammalian and 1 avian species recorded during the count (Table 4-1a). Burchell'szebra (*Equusburchelli*) was the most abundant wild species followed by Grant's gazelle (*Gazellagranti*) and impala (*Aepycerosmelampus*). Others included buffalo (*Synceruscaffer*), giraffe (*Giraffacamelopardalis*), Oryx (*Oryx gazella*), eland (*Taurotragusoryx*), ostrich (*Struthiocamelus*), hartebeest (*Alcelaphusbuselaphusjacksoni*), rhinos and water buck (Table 4-1a and 4-1b). The least counted species were waterbucks (n=333), hartebeests (n=365) and gerenuks (n=461). Out of the twelve species of the population recorded in this year's survey, only five recorded an upward change in population while more than half recorded a decline with eland and zebras recording a 31% and 28% declines respectively reference to the survey conducted in the year 2008 (Table 4-1b). Overall, there was a 15.6% decline in the number of animals counted in 2012 compared to 2008 (Table 4-1b).

Table 4-1: Summary of wildlife species numbers counted in the surveyed area (a); and the changes in numbers counted compared to the 2008 census (b)

Species counted	Total count	%	Species	2008	2012 *	Change (%)
B. zebra	21800	48	Waterbuck	179	333	86.0
G. Gazelle	5887	13	Impala	3915	5525	41.1
Impala	5525	12	Ostrich	792	943	19.1
Buffalo	4069	9	Giraffe	2557	2839	11.0
Giraffe	2839	6	Oryx	1509	1616	7.1
Oryx	1616	4	Grant's Gazelle	6020	5887	**-2.2**
Elands	1061	2	Gerenuk	490	461	**-5.9**
Ostrich	943	2	Hartebeest	416	365	**-12.3**
Gerenuk	461	1	Rhinos	178	140	**-21.3**
Hartebeest	365	0.8	Buffalo	5331	4069	**-23.7**
Waterbuck	333	0.7	B. zebras	3045 2	2180 0	**-28.4**
Rhino	140	0.3	Elands	1541	1061	**-31.1**
Total	**45039**		**Overall**	**5338 0**	**4503 9**	**-15.6**

***:**The 2012 census covered a wider area compared to 2008 hence these comparisons are only made for common blocks in the two censuses.

4.3.2 Wildlife estimates and distribution

A total of 21,800 Burchell's zebras were estimated to occur in the survey area at the time of this survey representing 48.4% of the total species counted (Table 4-1a. The population estimate indicated a significant fall in zebra population compared to that of year 2008 (Table 4-1b). Out of the total estimate of 45, 039 animals, 5,887 were Grants gazelles which accounted for 13%; 5,525 (12.3%) were impala; and 461 (1%) were gerenuks(Table 4-1a). Compared to the 2008 estimates, the gazelles and gerenuks recorded decline in population estimated by 2.2% and 5.9% respectively while impala recorded a 19.1% positive change in population estimate (Table 4-1b). All the three wildlife species were observed predominantly on Private ranches and community land. However gerenuks also showed preference for settlement areas (Figure 4-1). Among the seven land use types, zebras occurred prominently in private ranches (11,715), community land (5,306) and areas of settlement (4,475; Table 4-2).

Eland, oryxand waterbucks were predominantly observed on private ranches and settlement areas in central Laikipia, south western parts of Marsabit and western parts of Samburu counties (Figure 4-32). Accounting for 2.4%, 3.6% and 0.7% of the entire estimated population, eland, oryxand waterbuck recorded significant changes in the estimated populations compared to the 2008 census figures. Eland recorded a decline in estimated population of 31% (from 1541 to 1061) while waterbuck recorded the highest increase in population of 86% representing a change from 179 animals in 2008 to 333 animals in 2012. Some 4,069 buffalos, 2839 Giraffes and 365 hartebeests were recorded in the survey area. The only avian species recorded, the ostrich accounted for only 2% of the total count. Between 2008 and 2012, the number of ostriches increased by 19%. Similarly, there was an 11% increase in estimates for the giraffes in 2012 in reference to the 2008 census. However, the buffalos and hartebeest recorded a 23.7% and 12.3% decline in population estimates respectively. Zebras were predominantly recorded in Laikipia County with a few animals occurring in the north western parts of Samburu County (Table 4-3; Figure 4-1).Figures 4-1, 4-2, 4-3, 4-4, 4-5, 4-6 below shows the distribution of Buchell's zebra, impala, gerenuk, Grant's gazelle, eland, oryx, waterbuck, giraffe, buffalo, hartebeests, and ostrich respectively.

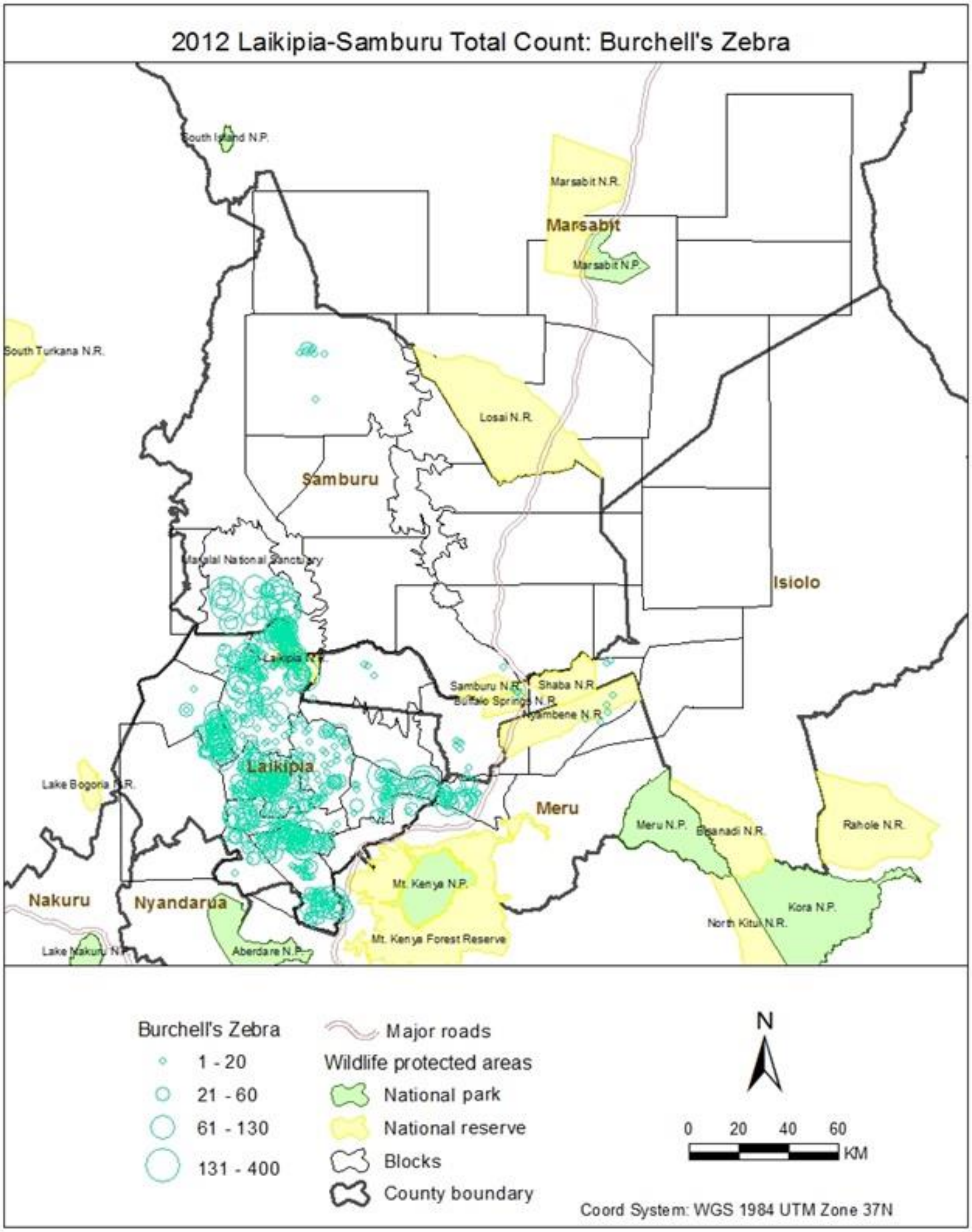
Table 4-2: Summary of the number of other large mammals counted in different land- use types within the Laikipia-Samburu-Marsabit ecosystem in 2012

Speci es	**Com munit y**	**Com munit y**	**F o r**	**La rg e**	**Pr iva te**	**Prote cted Area**	**Settleme nt**
Buffal	20	19	3	14	40	3	2
B.	98	5306	0	89	11	578	4475
Eland	20	34	0	0	98	23	63
Gere	95	161	0	0	11	75	50
Giraff	696	594	3	0	15	150	153
G.	530	2640	0	0	12	888	1201
Harte	0	39	0	5	29	1	35
Impal	76	79	0	11	49	198	198
Oryx	150	257	0	0	57	157	527
Ostri	131	539	4	4	94	82	214
Rhino	0	0	0	0	14	0	0
Water	3	0	0	7	31	11	6
Total	**1819**	**9668**	**1**	**23**	**26**	**2166**	**6924**

Table 4-3: The number of different species of other large mammals counted in Samburu-Laikipia-Marsabit ecosystem by county

Species	**Laikipia**	**Samburu**	**Meru**	**Isiolo**	**Marsabit**	**Total**
Buffalo	3906	37	198	6	0	4147
B. Zebras	19039	2379	713	130	0	22261
Eland	948	20	117	20	16	1121
Gerenuk	126	93	13	93	165	490
Giraffe	1495	768	108	391	368	3130
G. Gazelle	1438	486	331	908	3381	6544
Hartebeests	347	16	0	0	12	375
Impala	5117	92	209	215	0	5633
Oryx	872	146	147	246	257	1668
Ostrich	150	284	18	117	499	1068
Rhinos	107	0	33	0	0	140
Waterbuck	301	6	24	8	0	339
Total	**33846**	**4327**	**1911**	**2134**	**4698**	**46916**

Figure 4-1: The distribution of Burchell's zebras in Laikipia-Samburu-Marsabit ecosystem in 2012


2012 Laikipia-Samburu Total Count: Burchell's Zebra
South Island N.P.
Marsabit N.R.
Marsabit
Marsabit N.P.
South Turkana N.R.
Losai N.R.
Samburu
Maralal National Sanctuary
Isiolo
Laikipia N.R.
Samburu N.R.
Shaba N.R.
Buffalo Springs N.R.
Nyambene N.R.
Laikipia
Lake Bogoria N.R.
Meru
Meru N.P.
Bisanadi N.R.
Rahole N.R.
Mt. Kenya N.P.
Kora N.P.
Nakuru
Nyandarua
North Kitui N.R.
Mt. Kenya Forest Reserve
Lake Nakuru N.P.
Aberdare N.P.
Burchell's Zebra
1 - 20
21 - 60
61 - 130
131 - 400
Major roads
Wildlife protected areas
National park
National reserve
Blocks
County boundary
N
0 20 40 60
KM
Coord System: WGS 1984 UTM Zone 37N

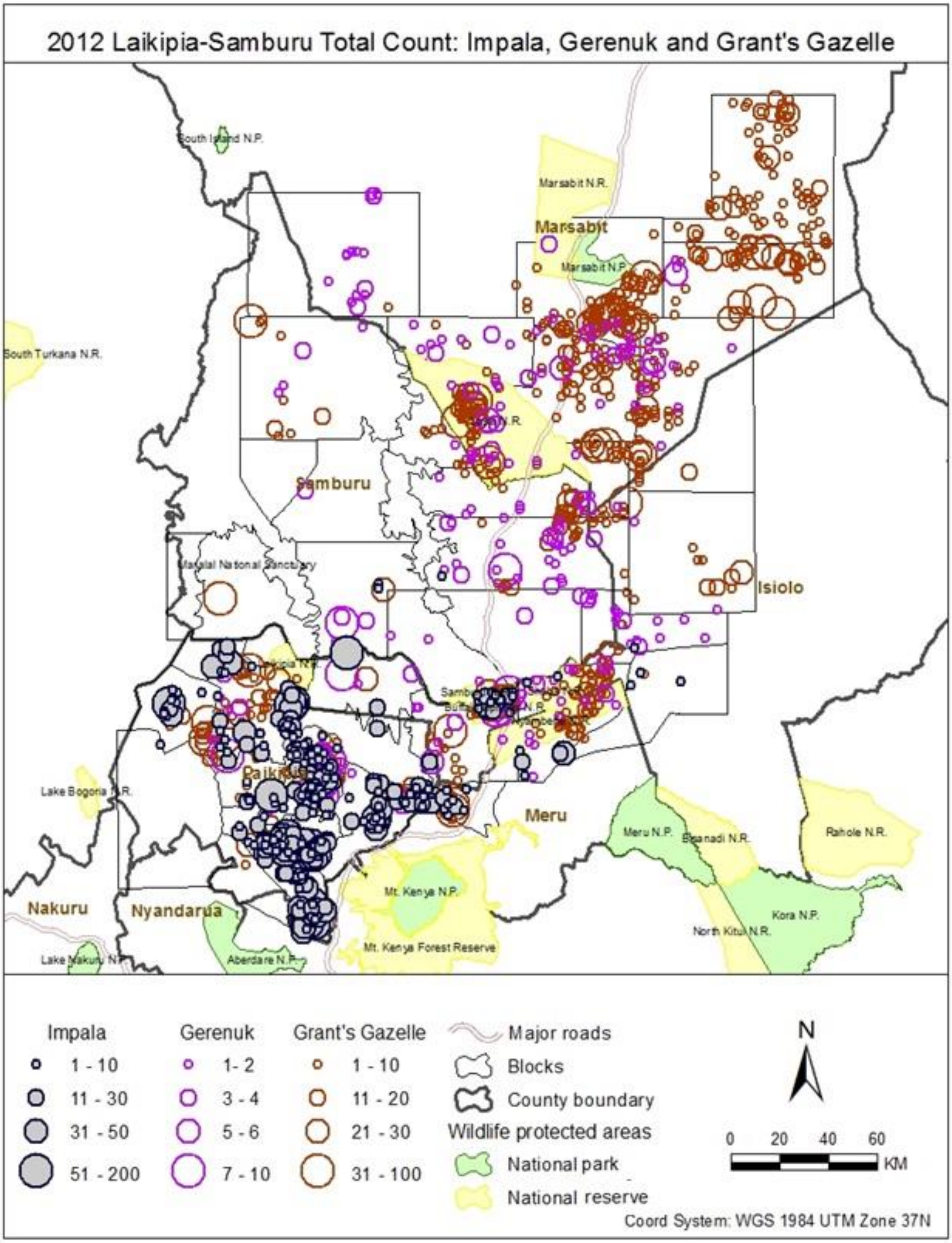


Figure 4-2: The distribution of Impala, Gerenuk and Grant's gazelle in Laikipia-Samburu-Marsabit ecosystem in 2012

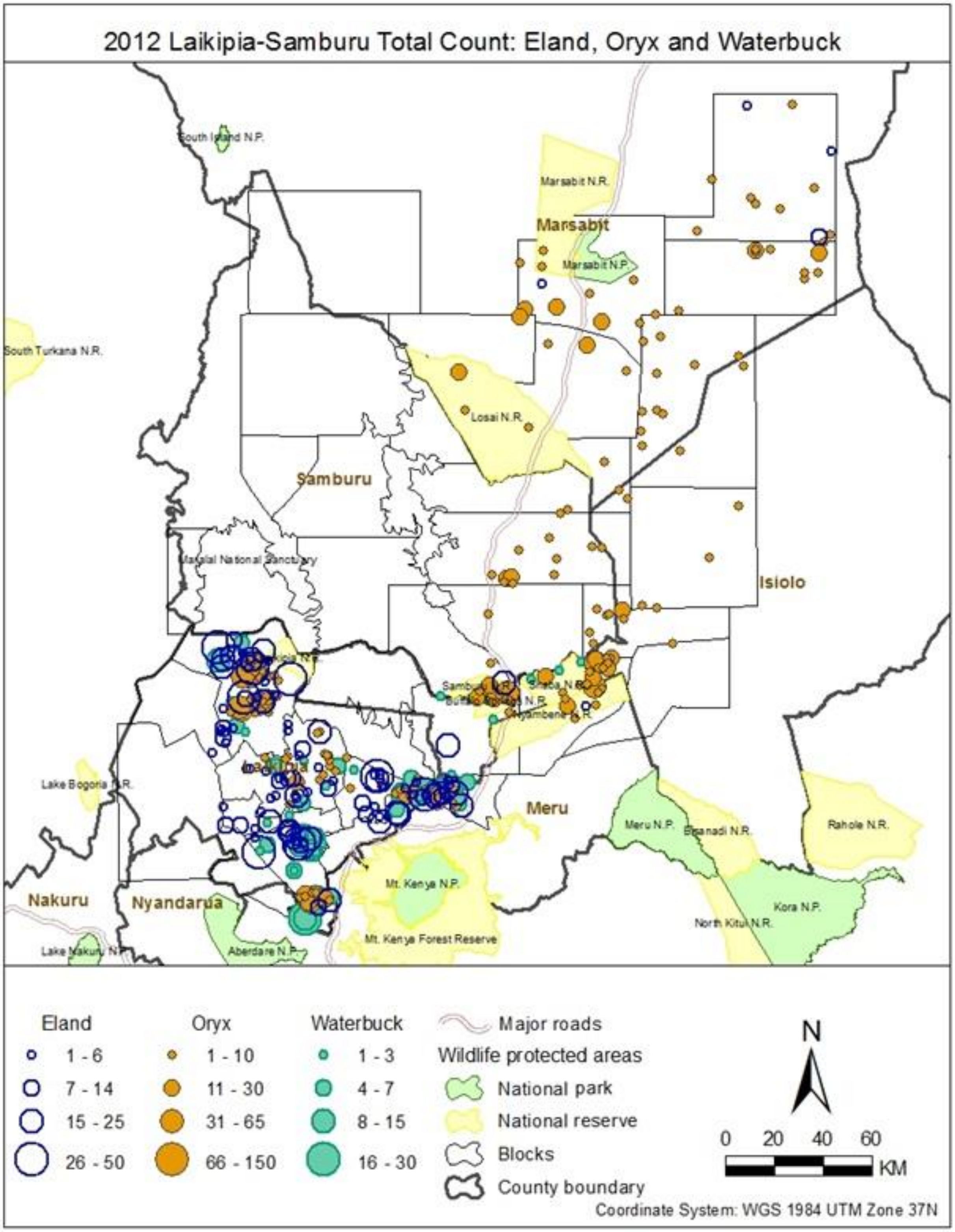


Figure 4-3: The distribution of Eland, Oryx and Waterbucks in Laikipia-Samburu-Marsabit ecosystem in 2012

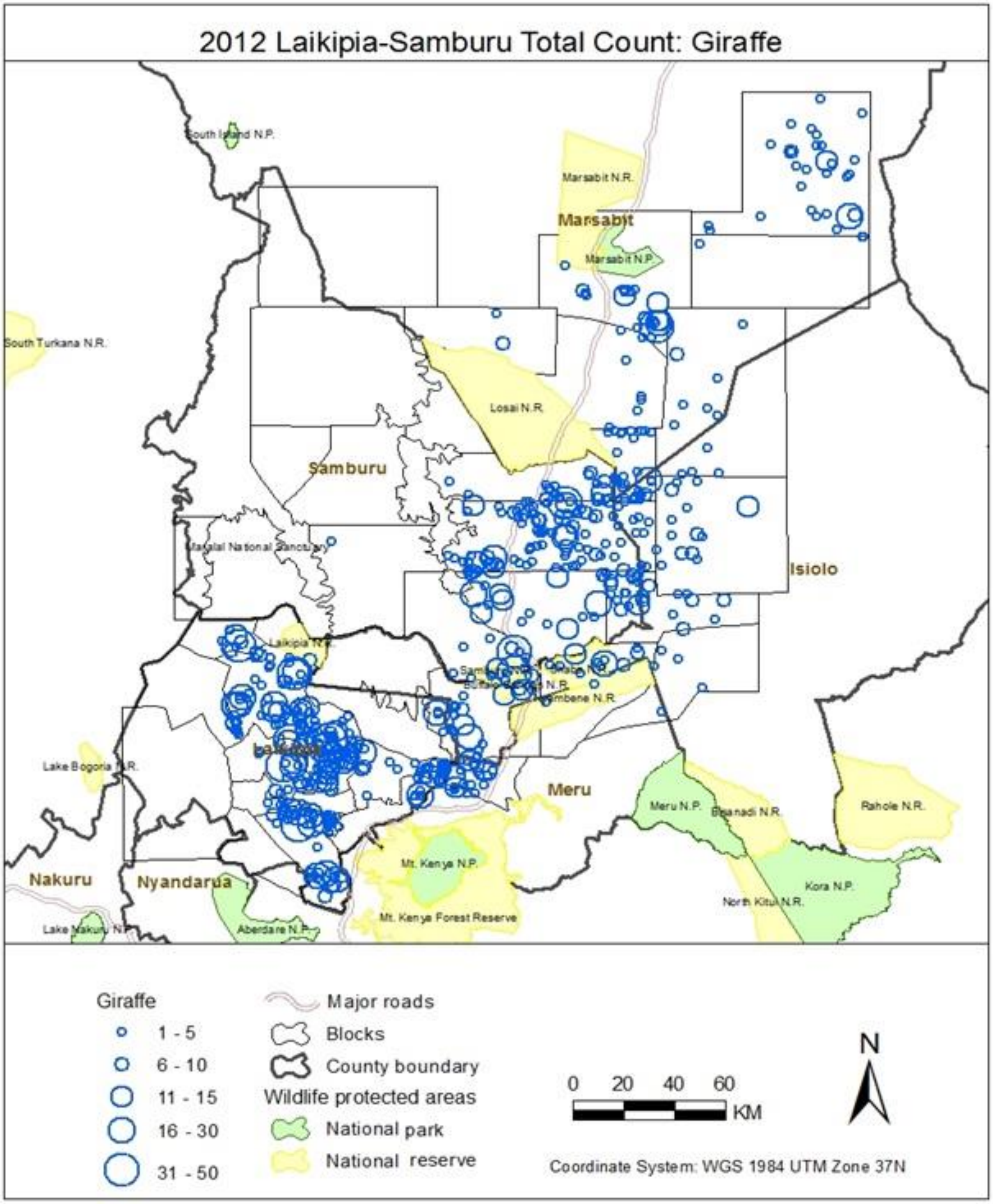


Figure 4-4: The distribution of Giraffe in Laikipia-Samburu-Marsabit ecosystem in 2012

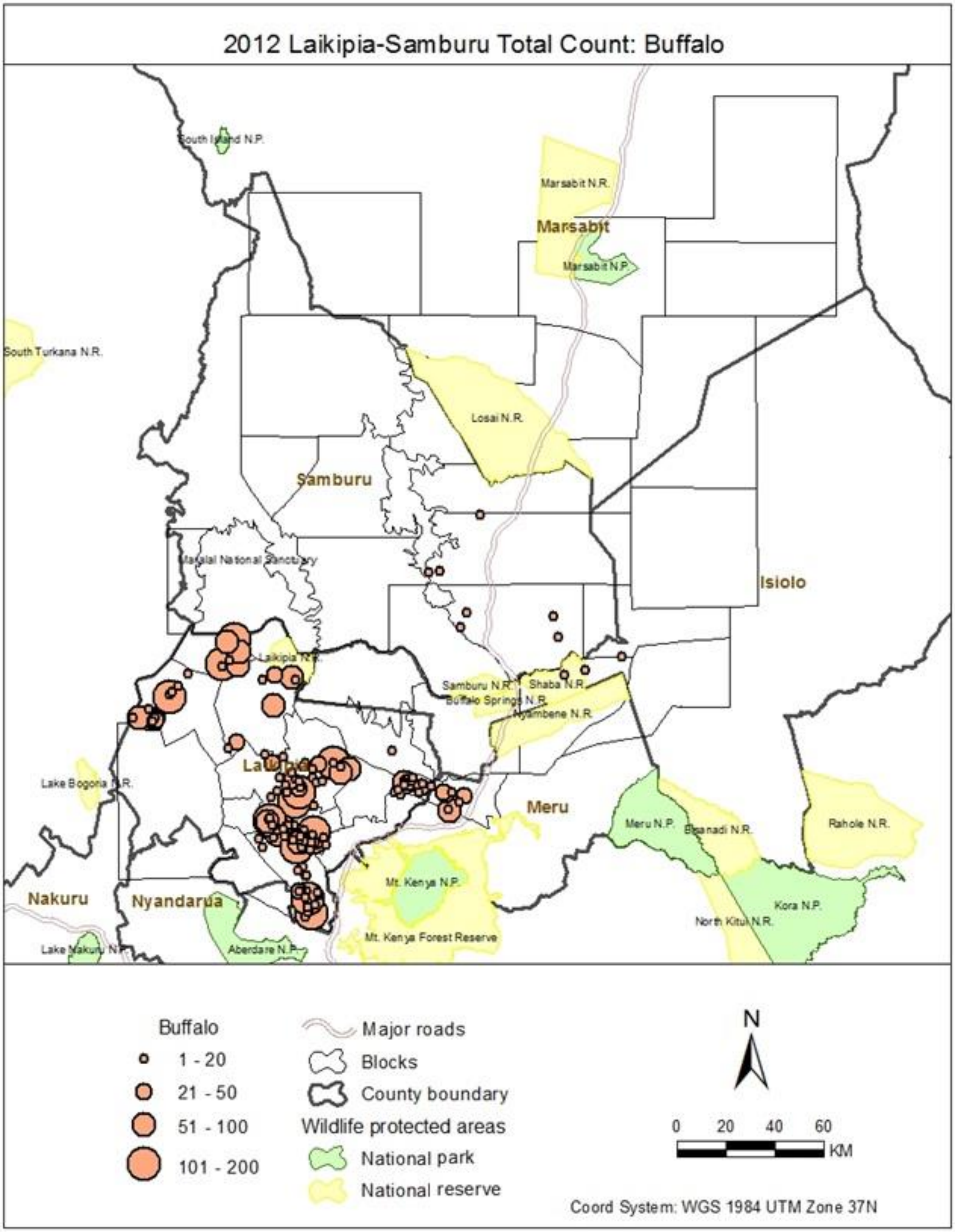


Figure 4-5: The distribution of Buffalo in Laikipia-Samburu-Laikipia ecosystem in 2012

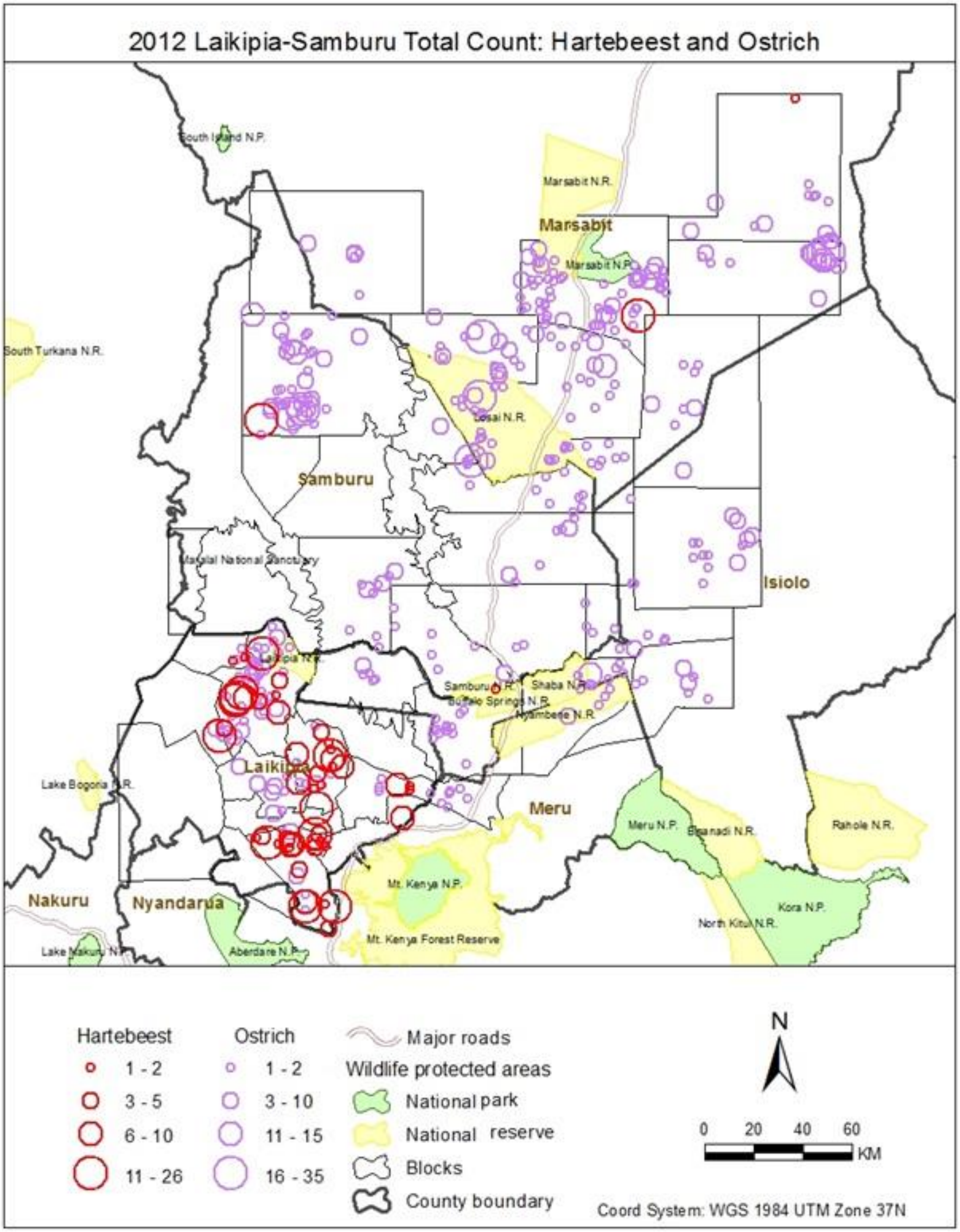


Figure 4-6: The distribution of hartebeests and ostrich in Laikipia-Samburu-Marsabit ecosystem in 2012

4.3.3 Human activities estimates and distribution

Human activities recorded in this survey included livestock (sheep, goats, cattle and camels), human settlements, cultivation, charcoal production and artificial water provisions. Human settlements included structures such as schools, churches, shopping centers and homesteads (Table 4-4).

Table 4-4: Estimates of number of human activities by county within the Laikipia-Samburu-Marsabit ecosystem in 2012

Activity	Laikipia	Samburu	Meru	Isiolo	Marsabit	Total
Settlement	1352	4166	498	2924	7551	**16491**
Mining	1	16	0	2	3	**22**
Farming	642	45	0	5	641	**1333**
Charcoal	251	54	78	80	11	**474**
Livestock	197026	164625	61016	99366	220737	**742770**
Total	**199272**	**168906**	**61592**	**102377**	**228943**	**761090**

A total of 1333 cultivated plots were estimated in the entire surveyed area (Table 4). Most of the farming activities were predominant in the west and south western parts of Laikipia (642) as well the Southeastern boundary of Marsabit National Reserve (641) and were scattered across Samburu county (45; Table 4; Figure 4-7). Out of 742 770 livestock counted, Marsabit county recorded the highest (220,737) followed by Laikipia (197,026) and Samburu at 164,625 animals (Table 4; Figure 4-7).

Charcoal burning was highest in Laikipia (n=251) where they were concentrated in central and north western parts of Laikipia. More charcoal production activities were recorded in the western parts of Samburu (n=54) and within the cultivated plots in Marsabit (n=11) as well as around the Nyambene, Shaba and Buffalo springs national reserves. Mining activities were prevalent in Samburu where 16 sand mines were recorded in similar locations as farming and charcoal production activities (Table 4; Figure 4-7).

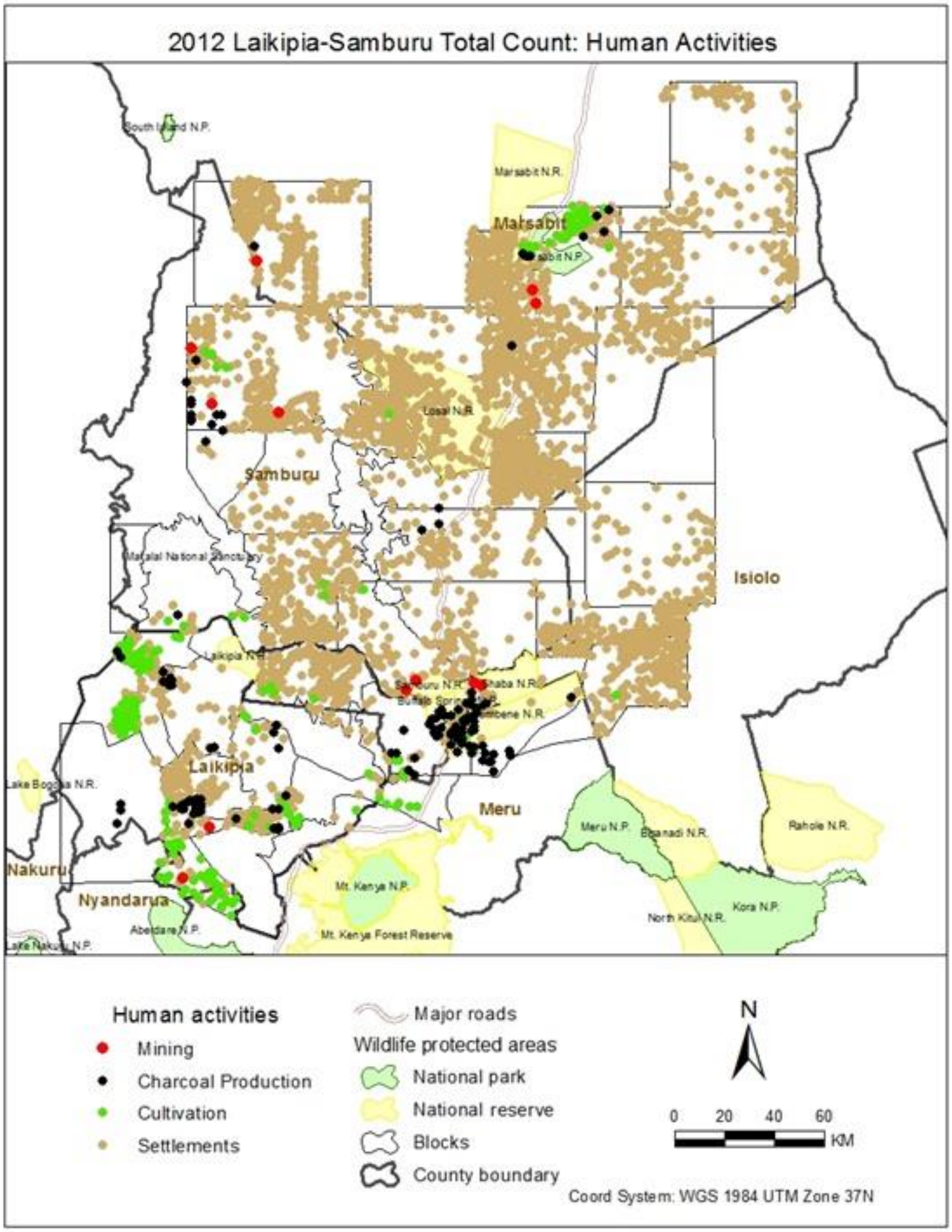


Figure 4-7: The distribution of human activities recorded in Laikipia-Samburu-Marsabit ecosystem in November 2012

4.4 Discussion

4.4.1 Population status and distribution

The entire survey area forms an important conservation unit comprised of Laikipia, Samburu, Isiolo and MarsabitCounties that are ecologically and hydrologicaly interlinked. Wildlife move across and within the entire area with respect to prevailing seasonal weather changes. In addition, the entire ecosystem depicts an erratic rainfall pattern which affects wildlife and livestock movements and distribution as human activities in the area.

The results of this survey showed that other wildlife species are widely distributed in the ecosystem. This can be attributed to the different land use patterns ranging from community conservancies to settlements. Most wildlife species were found in areas that offered security (both from predators and humans), water sources and low forage competition. More wildlife species were recorded on private ranches and community lands as opposed to the numbers recorded on forest reserves and large scale farms. It is widely expected that ranches and community areas engage in livestock farming and pastoralism which offers little competition with wildlife especially the zebras and buffalos. Artificial water points are also readily available in such areas offering attraction to wildlife.

The current study highlights the effects of the 2009 drought on the population of both wildlife and livestock species. Results indicate that there was a 15% decline in the number of other species counted between the year 2008 and the year 2012 (Table 4-1b). This decline can be attributed to the prolonged drought experienced in the area. In comparison to the 2008 census report for the same spatial coverage, wildlife species that were predominant on private ranches and community lands, suffered massive population declines, for example, elands declined by about 31% from 1541 to 1069 individuals, zebra declined by 28.4% from 30,452 to 21, 860 animals while buffalo declined by 23.7% from 5331 to 4069 individuals (Table 4-1b). In contrast however, Waterbuck and Impala appeared to have increased comparatively by 86% from 179 to 333 and 41.1% from 3915 to 5525 animals respectively during the same period (Table 4-1b).

While the scope of our analysis could not clearly show a major impact of the occurrence of crop farming, charcoal burning and mining activities on the distribution of wildlife species, there is a strong possibility that with a finer level analysis, some relationships could be deduced. This is deemed possible since such activities tend to reduce available graze/browse for livestock and wildlife. Furthermore, charcoal burning in the area has detrimental effects through loss of browse for species such as giraffe and further leads to habitat degradation. Similarly wildlife and settlements are mutually exclusive due to displacement effects. Increased proliferation of human settlements in wildlife areas leads to habitat fragmentation, habitat loss and associated human-wildlife conflicts such as crop raiding by wildlife. This is more likely to impact on the distribution of wildlife prone to completion with livestock and people for resources.

4.4.2 Marsabit blocks

Surveyed in 2008 only after having been surveyed in 1994, Marsabit blocks were surveyed in 2012 also and encompassed Marsabit National Park and part of Marsabit National Reserve (Table 4-5; Figure 4-8).

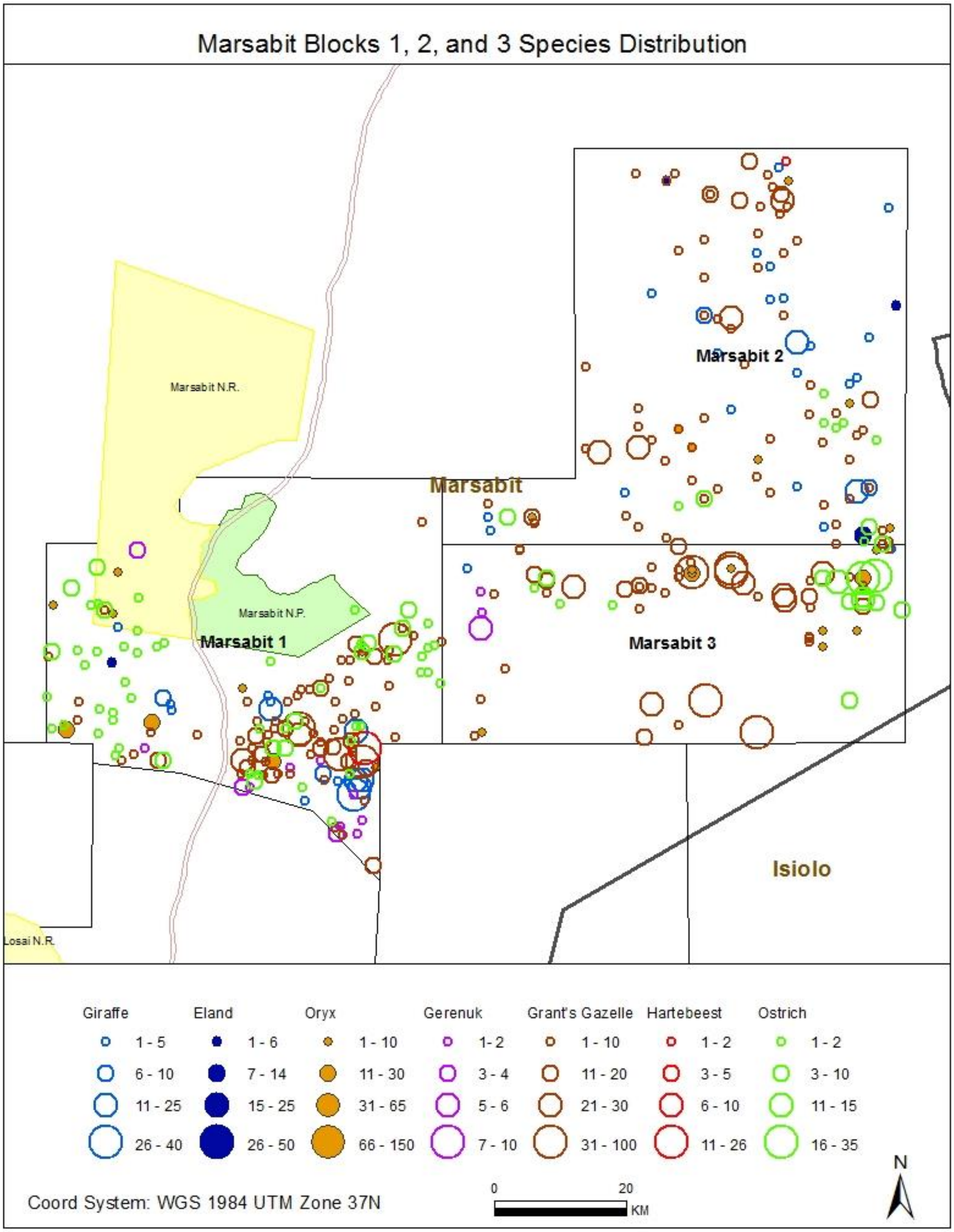


Figure 4-8: The distribution of different species of wildlife within Marsabit counting blocks in November 2012

Table 4-5: Comparison of wildlife estimates in Marsabit ecosystem in 2008 and 2012 according to counting blocks in Marsabit

Block Number	**Marsabit 1**		**Marsabit 2**		**Marsabit 3**	
Species	**2008**	**2012**	**2008**	**2012**	**2008**	**2012**
Grants Gazelle	566	725	347	420	4351	706
Oryx	20	80	5	15	344	67
Greater Kudu	4	0	0	0	0	0
Lesser Kudu	3	0	2	0	0	0
Gerenuk	2	21	1	0	7	9
Giraffe	0	166	0	107	0	8
Ostrich	0	126	0	22	0	118
Hartebeests	0	11	0	1	0	0
Eland	0	1	0	15	0	0
Overall	**595**	**1130**	**355**	**580**	**4702**	**908**

There was a general increase in the number of Grants gazelle and oryx counted in Marsabit 1 and 2 blocks. Grants gazelle increased from 566 to 725 in Marsabit 1 and from 347 to 420 in Marsabit 2, while that of oryx increased from 20 to 80 in Marsabit 1 and from 5 to 15 in Marsabit 2. However, there was a significant decrease in the number of both Grants gazelle and oryx in Marsabit 3 (i.e., from 4351 to 706 and 344 to 67) respectively.

4.4.3 Laikipia county

Human elephant conflict in particular the problem of crop-raiding, in the Laikipia County is probably the worst in Kenya (Graham *et al.*, 2010) and is considered the major cause of food insecurity, illegal killing of elephants and political tension between those who tolerate elephant conservation and those who suffer the costs of living with elephants (Thouless 1994; Gadd 2005; Graham 2007). The Laikipia County has a huge population of wildlife including elephants and hence when conservation of elephant is threatened, then the other species are affected. To forestall a possible assault on conservation of species due to HEC, the Laikipia Wildlife Forum, (LWF) in collaboration with the Kenya Wildlife Service (KWS) and local landowners, through funding provided by the Kenya Government and Royal Netherlands Embassy, initiated the West Laikipia Fence (WLF) project. The project aimed to construct a 163km electrified fence from OlPejeta Conservancy in south-central Laikipia, to the Laikipia Nature Conservancy in west Laikipia to help reduce crop raiding by elephants on arable smallholder land Southwest of Laikipia thereby minimizing the number of elephants killed in PAC. The first section of this fence was completed in 2008 and was completed done by mid-2010.

Of the key species recorded in Laikipia during the 2012 survey, only zebras appeared to have strayed outside this fence (Figure 4-9). These were sported around three sections around ADC Mutara ranch, Lombala ranch, and Ngurare ranch. The majority were however recorded around Ngurare ranch boundary near the UwasoNarok swamp.

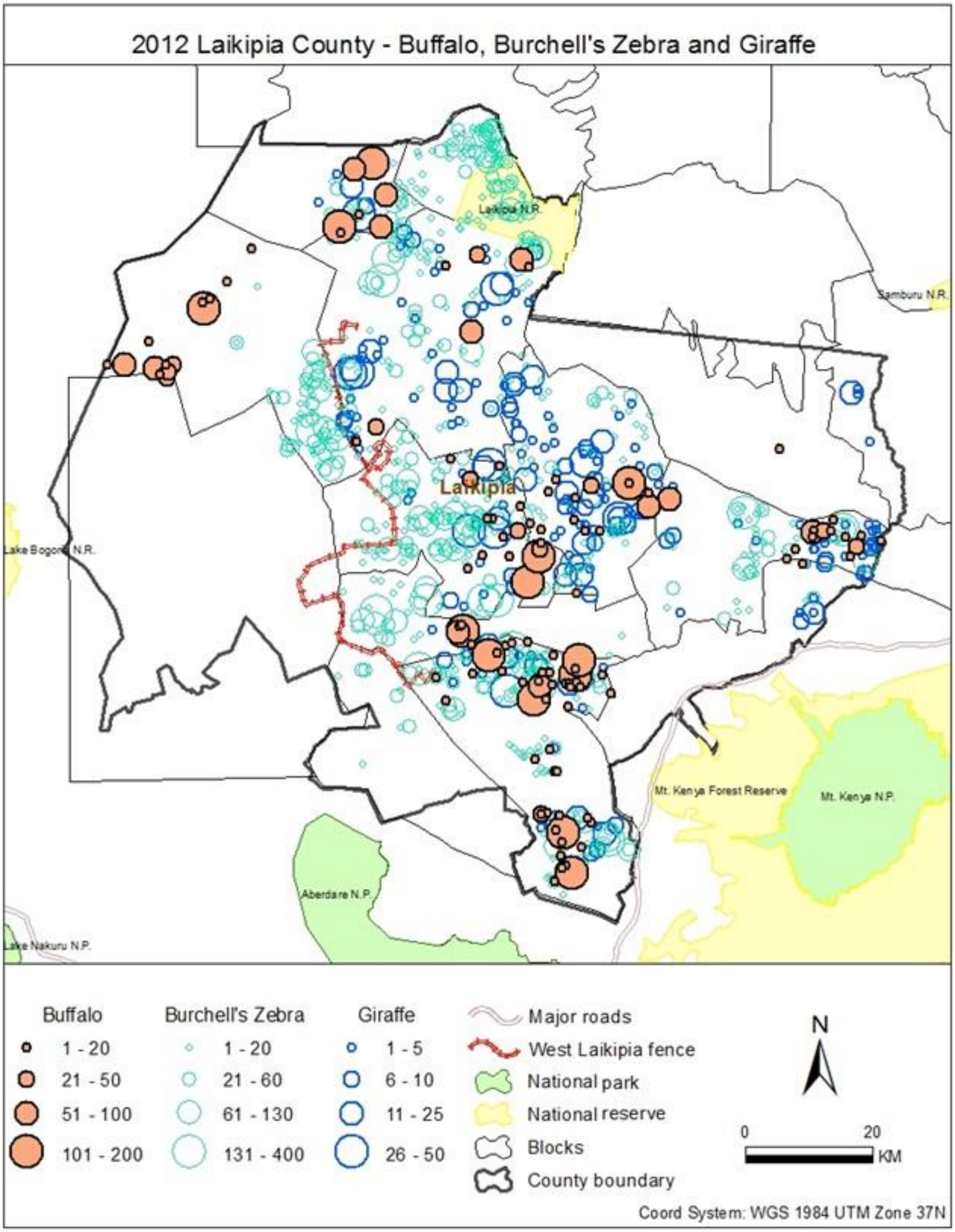


Figure 4-9: The distribution of buffalos, zebras and giraffes relative to the West Laikipia Fence

4.5 Conclusion

While much of the wildlife species were found in the Laikipia County, there is evidence of high connectivity in terms of wildlife movement in the entire survey area. Migratory species such as gerenuks, Grant's gazelles and oryx move within and across the four counties.

The 2009 drought is suspected to have had a significant effect on the populations of wildlife species leading to a significant decline, especially on elands (31%), Burchell's zebra (28%) and buffalos (23%). However, the species still recorded significant populations and were fairly well distributed hence a high possibility of recovery. Closer study of species numbers is required to monitor recovery of the populations.

The widespread distribution and occurrence of human activities such as livestock keeping, farming, mining and illegal charcoal production are known to have impacts on the distribution and occurrence of wildlife species. While some species would co-exist with livestock, others are inadvertently displaced whereas other species especially crop raiders cannot live near human settlement and agriculture. In addition the existence of charcoal production and farming activities around national reserves in Meru, Samburu and Marsabit pose a great threat to continued existence of wildlife in these reserves. This will further lead to human wildlife conflicts, and hence retaliatory killing of wildlife as well as in PAC.

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