KENYA WILDLIFE SERVICE

TSAVO – MKOMAZI TOTAL AERIAL CENSUS

For

Elephants and Large Animals

April, **2014**

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Executive Summary

The census report gives update to the status and distribution of elephants as well as other large mammals in Tsavo-Mkomazi ecosystem. The census was carried out by 15 light aircrafts for a period six days in the month of February 2014 and in total it took 339.5 hours to cover over 48,600sq km. Search effort was 143.15 square kilometers per hour.

The blocks were redesigned to address challenges previously encountered, regular counting blocks that are easily navigable were established. The average block size was set at 900km□ which was calculated to be the average area a plane would comfortably survey within six hours at maximum. There were 68 blocks in total, each block was assigned to one aircraft with crew comprising of the pilot, front seat observer, and two rear seat observers in the case of four seater light aircraft and a pilot and an observer for two seat light aircraft. Streamers were fitted to wing struts of each plane to define transect widths, a concept borrowed from SRF (Systematic Reconnaissance Flight) to aid observers in distance estimation. The streamers were calibrated for each Rear Seat Observers (RSO) at a flight height of 91.2m (350 ft) above ground level. In-flight data was captured in both GPS and voice recorders. Digital cameras were also used to capture large herds which enabled the census team to undertake photo corrections on the results.

General distribution patterns and distribution of herd sizes were analyzed for elephants, buffalo, giraffe and zebra. Comparison and polynomial regression analysis was only done for data pooled for areas that have been counted consistently over the years from 1988 to 2014. We tested for the general distribution patterns of the four species using the Getis-Ord general G statistic. The distribution of different herd sizes were mapped using the Hot-Spot analysis (Getis-OrdGi* statistic) and implemented using ArcGIS 9.3. The Z-score statistics were used to aid interpretation of results. Correlation analysis was done to determine the relationship between elephant distribution to water points, livestock, charcoal production and mining.

A total of 11, 217 elephants were counted in the entire Tsavo-Mkomazi conservation area which was a drop of 10.34% compared to 2011 elephant results. Most of the elephants were counted inside protected areas with a population of 9,605 (85.63%) showing an increase of 9.81% as compared to 8,747 elephants counted in 2011. A total of 857 elephant carcasses were counted in Tsavo-Mkomazi ecosystem in 2014. This is an increase of 51.15% compared to 567 elephant carcasses recorded in 2011. Other key species such as the Buffalo also showed a decline of about 20% with estimated buffaloes to be 5,912 from 7,406 individuals recorded in 2011. Giraffe and Zebra however showed an increase 40.68% (n = 2,891) and 33.91% (n = 9,007) respectively from 2011 census.

Concentrations of cattle were recorded in the ranches (Taita, Galana, Kulalu), West of Chyulu NP, Rombo and South Kitui; the Shoats followed the same distribution pattern as those of cattle. Camels and donkeys were also counted in the ecosystem high concentrations were recorded in South Kitui Game reserve with few sparsely distributions in Galana, Taita and Rombo regions. The mining activities observed in 2014 were apparently fewer and more clustered than those documented in 2011. High concentrations of charcoal burning were recoded is in South Kitui National in the ranches however there was a significant reduction of charcoal productin when compared to 2011 especially in Rukinga, Sagala and Maungu areas.

It's recommended that measures needs to be put in place to stop the further decline of elephants in the Tsavo-Mkomazi Ecosystem. Studies to understand the declining buffalo population as well as the carnivore populations especially the wild dogs and hyenas needs to carried out

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List of acronyms

AEF	African Elephant Fund
CCA	Coast Conservation Area
CRCA	Central Rift Conservation Area
DEM	Digital Elevation Model
DRSRS	Department of Resource Survey and Remote Sensing
DSWT	David Shedrick Wildlife Trust
ECA	Eastern Conservation Area
ESRI EA	Environmental Systems Research Institute East Africa
FSO	Front Seat Observer
GIS	Geographical Information System
GPS	Global Positioning System
HAG	Height above Ground
HQs	Headquarters
IFAW	International Fund for Animal Welfare
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for Conservation of Nature
KWS	Kenya Wildlife Service
MCA	Mountain Conservation Area
MIKE	Monitoring Illegal Killing of Elephants
NP	National Park
NR	National Reserve
REDD	Reducing Emissions from Deforestation and Degradation
RSO	Rear Seat Observer

SCA	Southern Conservation Area
STE	Save the Elephants
TANAPA	Tanzania National Park
TAWIRI	Tanzania Wildlife Research Institute
TCA	Tsavo Conservation Area
UTM	Universal Traverse Mercator

1.0 Introduction

1.1 History of Tsavo census

Aerial counts of large mammals in Tsavo ecosystem have been carried out since the 1960's (Thouless *et al.*, 2008). For example, an aerial count that was undertaken in September 1962 estimated the population of elephants to be about 10,799 and 4,804 animals in the protected area and outside respectively (Glover, 1963). Laws estimated that in 1967, the population of elephants was about 35,000 individuals (Laws, 1969). A severe drought between 1970 and 1971 resulted to death of about 6,000 elephants (Corfield, 1973). Due to increase of poaching, the population of elephants reduced to about 12,000 animals by 1981 (Ottichilo, 1981). Only about 5,400 elephants remained in the ecosystem in 1988 (Olindo *et al.*, 1988). With the establishment of KWS in 1989, efforts to reduce poaching pressure on elephants were initiated which resulted to an increase of elephants in the ecosystem. The anti-poaching efforts were felt in that 6,763 elephants were counted in the ecosystem in 1991; 7,371 in 1994; 8,068 in 1999; 9,284 in 2002; 10,397 in 2005; 11,696 in 2008, and 12,573 in 2011 (Ngene *et al.*, 2011; Omondi *et al.*, 2008, Omondi and Bitok 2005; Thouless *et al.*, 2002). These counts have provided vital information to policy makers and park managers, facilitating sound management of elephants in the ecosystem. The decline of poaching and increase of elephant population have resulting in other management and conservation challenges.

Habitat loss due to compression of the elephant population emanating from sedentary settlements around major migratory corridors and former elephant range is a key elephant conservation and management issue in the Tsavos. Human-elephant conflict is currently the greatest problem associated with loss of elephant range as a result of increasing settlements in formerly unsettled areas (Low, 2000; Mcknight, 2004). Communities surrounding protected areas in the Tsavo ecosystem are practicing crop farming, therefore competing for land with wildlife. The area is home to many other wildlife species and is an important tourist destination famed for the presence of the big five. Currently the area has the largest population of elephant population in Kenya (Blanc et al., 2007; Ngene et al., 2013). Therefore, it is important to continue to monitor the population of elephants and other mammals in the ecosystem to provide the long term data required by park managers and policy makers to make decisions necessary for comprehensive management of this vital and fragile ecosystem.

1.2 Review of census methods and equipment used

Tsavo-Mkomazi elephant counts have been done since 1962 (Ngene et al., 2013) with modification of the methods used. In 1973, a total aerial count was conducted where the area was covered visually as thoroughly as possible with an aid of four aircrafts and elephant sightings and numbers were recorded on a 1:250000 maps (Leothold and Sale, 1973).

In 1988, census crew (Pilot and scientists) were selected based on the years of experience not only on flying and aerial counting but also conversant of Tsavo (Olindo et al., 1988). Aircrafts were flown 400-700 feet above ground at speeds of 130 – 170 km/h depending on type. Flight paths were marked on a map and the locations of animals were marked and recorded serially on data sheets (Olindo et al., 1988). Circling and photography was also used especially if the animal group was about 25 and more (Olindo et al., 1988).

IUCN elephant group in 1976 adopted both sample and total count (IUCN, 1976). Total count was limited to specific species and small areas. The areas covered were divided into sections where each section was covered by flying parallel transects spaced such that the rear seat observer can scan on one pass contiguous with that covered on the subsequent pass (IUCN, 1976). Circling of large herds was done until a consensus number was got or sufficient photographs for further counting were obtained (IUCN, 1976). Sample counts on the other hand, was done on large areas and count on a variety of species within a limited flying time (IUCN, 1976). The aircraft flies at regular spaced straight line transect across the census blocks. Animals were counted within the streamers which were placed on the struts of the aircraft and calibrated using fixed scale along the runway. Also radar altimeters and tape recorders were used to control on the flying height and record animal sightings respectively (IUCN, 1976). Species location were indicated on maps based on the transect subdivisions.

The 1994 census changed the methodology a bit. The crew was mostly KWS employees and had done census before especially in 1991, 1989, 1988 or earlier (Douglas-Hamilton et al., 1994). Flight crew were briefed on roles according to protocol laid down in the briefing notes which had evolved from what had been written by Norton-Griffins (1978). It is during this year when use of hand held GPS (Global Positioning System) receiver was used in the survey (Douglas-Hamilton et al., 1994). The GPS handset was used to record species sighting points as a waypoint which was downloaded later on into a Geographical Information System (GIS) database. A Trimble Pathfinder-Plus Model was used to track the flight paths for each aircraft. This was an innovation, since it was the first time when a detailed and accurate map of real flight lines of counting aircraft was made (Douglas-Hamilton et al., 1994).

For censuses carried out in 2002, 2005, 2008 and 2011, methods used in 1999 were adopted with slight modifications despite the census being a total count. GPS receivers were used in navigation, to record species points inform of waypoints and tracking of flight lines which were then downloaded and used to prepare species distribution maps and flight lines respectively (Omondi et al., 2002). In case of large herds, photographs were taken for further counting and verification.

However, use of these methods has been faced with challenges which include estimation of the 500 meter distance from each side of aircraft, flying at recommended height and on intended

flight line, recording of data in the air, block design and sizes and block boundaries. Solutions have been proposed but they come with financial challenges and therefore changing these methods has not been easy. Use of streamers (rods) and radar altimeters have been used before (IUCN, 1976). These are important so as to assist in 500 meter strip and maintain the flying height and thus avoid double counting or miss a sighting. Despite an improvement on flying on proposed flight lines, more training needs to be done on pilots so as to make it acceptable. The more the pilots fly on the flight lines, the more they get used to it and thus their accuracy improves.

Counting of animals from the air is a tedious job and thus the roles of the observers should be limited to counting. For years, observers are required to (i) assist in navigation especially on flight lines, start and end of flight line (ii) observe and count (iii) take GPS point (iv) record data in a data sheet. All this is done and if not done as quickly as possible, probability of missing a sighting will be high.

Most of the blocks for counting in Tsavo-Mkomazi have been used since 1962 for the sake of comparison over years. However, the number of the blocks has changed over time. The number of blocks is not an issue but the boundaries of the blocks are. The block boundary demarcation is by use of rivers, roads, hills and ranch/park/reserve/international boundaries (Omondi et al., 2008; Ngene et al., 2013). Use of these recognizable features was used in 1960's to help in navigation especially turning points since GPS's were not available.

Counting crew experience has also been pointed out. In early years of counting, the crew had to be experienced in counting, flying and also familiar of Tsavo (Olindo et al., 1988). Since then, briefs and test flights has been introduced so as to increase staff accuracies (Douglas-Hamilton et al., 1994; Omondi et al., 2008; Ngene et al., 2013). This might not be enough but an attempt has been done. Crew should be trained continuously and be allowed to do rehearsals as much as possible and if necessary, examination to be done to ascertain on the crew performance level. A total aerial count is an expensive exercise hence its not right taking things for chance. High level of counting animals is required where the crew should be able to be a good spotter, familiar with species, quick in counting numbers and of course able to have endurance in flying.

1.3 Tsavo census blocks and sizes

In 1988, a total of 34 blocks were counted. This include 27 blocks which covered Tsavo East and Tsavo West and environs of Machakos, Tana River, Taita Taveta, Kilifi and Kwale Counties, 5 blocks in Galana ranch and 2 blocks in Mkomazi Game Reserve targeting 40,000 km^2 of the proposed Tsavo Ecosystem (Olindo et al., 1988). Same blocks were counted in 1989 though block 2 was omitted but an extra blocks added to west of Chyullu adjacent to block 1 and sisal

field close to block 8 (Douglas-Hamilton et al., 1994). For 1991, the 34 blocks were counted with block 1 omitted but block 2 included once again (Douglas-Hamilton et al., 1994).

For 1994, 36 blocks were covered with an area of 38,200 km^2. However, block 1 and 2 were omitted since no elephants were sighted in the last 3 counts but a block in Rombo area was included where elephants had been reported before census (Douglas-Hamilton et al., 1994). Block 13 to 17 were redesigned but maintained the original blocks as it was developed by Sheldrick (Douglas-Hamilton et al., 1994).

In the year 2002, 39 blocks were counted with block 1 and 2 omitted (Bitok et al., 2002). The area of coverage in 2005 was 46,437 km^2 where 42 blocks were counted (Omondi and Bitok, 2005). Same number of blocks was used in 2008 (Omondi et al., 2008). For the most recent census that was carried out in 2011, 44 blocks were covered totaling an area of 48,319 km^2 (Ngene et al., 2013).

1.4 Justification

The Tsavo elephants are thought to be remnants of a once large population whose range originally extended to Amboseli to the west, Shimba Hills to the south, and Kitui, Mwingi, Garissa, and Meru to the north and north east respectively. The Tsavos are currently the most important wildlife-attraction based tourism in Kenya and accounts for about 50% of Kenya's elephant population. The area was least affected by the poaching menace of the 70's and 80's hence the elephant has impacted on the ecology of the area especially in controlling woodlands. This has contributed to the great diversity of wildlife in the area. Apart from the elephants, the Tsavo has always had the highest number of buffalo in the country. In the 1960s, the population of buffalo in the protected areas was low as captured by the monitoring exercise in 1965 (4,697 buffalo), 1988 (3,891 buffalo), 1991 (6,850 buffalo). However in 1994 onwards, the population of buffalo in the protected areas was higher (e.g., 1994 = 10,842 buffalo; and, 2005 = 8,506 buffalo) but the numbers declined to 6,514 buffalo in 2008 (Douglas-Hamilton et al., 1994; Omondi et al., 2002, 2005 & 2008). However, between 2008 and 2011 buffalo increased from about 6,514 to about 7,402 an increase of about 12% (Ngene et al., 2011).

Monitoring of species trends in numbers and distribution in the Tsavo Mkomazi Ecosystem is essential in order to assess the survival prospects of species, learn more about their ecology and survival chances in the face of various pressures, establish human-elephant conflict pressure points, establish elephant carcass distribution in the survey area as this will help pinpoint areas of high mortalities and their 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 Tsavo ecosystem as it continues to experience pressures from

poaching (especially between 2011 and 2013), human population growth and consequent changes in land use types.

1.5 Survey Objectives

The Tsavo Mkomazi census aims at sustaining the long term aerial monitoring of elephants and other large mammals in Tsavo ecosystem by closely and accurately monitoring the status and trends. The specific objectives include;

I. To establish the current elephant and other large mammals population sizes and distribution and compare these results with the results of past aerial counts.
II. To determine the number and distribution of elephant carcasses.
III. To determine the impact of poaching on the elephants population in Tsavo-Mkomazi ecosystem.
IV. To understand the distribution of elephants in relation to distribution of water sources.
V. To map human activities inside and outside the protected areas (e.g. logging, settlements, farming, and charcoal burning).
VI. To document the distribution and numbers of livestock in relation to elephants and other large mammals in the ecosystem.
VII. Interpret the information obtained and deduce sound management decisions to guide management of elephants and other wildlife in this fragile ecosystem.

2.0 Study Area

2.1 Location

The 2014 Tsavo-Mkomazi large mammal aerial census covered an area of about 48,600Km². The Tsavo-Mkomazi ecosystem is the largest in Kenya, and is constituted of the Tsavo Conservation Area (TCA) and the Mkomazi National Park in Tanzania (figure 2.1). The TCA is located in southeastern Kenya and northeastern Tanzania between latitudes 4°35'S and 1°36'S and longitudes 37°25'E and 39°59'E . The ecosystem lies 70 to 250 Km from the coast and comprises of arid bush land at an altitude of 200 to 1000m above sea level. The Tsavo ecosystem is defined as the area in which the major terrestrial animal populations find their home range on a yearly basis and is about 43,000Km² (Cobb, 1976). The core of the Tsavo ecosystem is approximately 21,000Km² comprised of Tsavo East and West National Parks. The ecosystem is bound in the northwest by densely populated parts of Ukambani, to the southwest by the Kilimanjaro, Pare and Usambara and to the southeast by the moderately densely populated coastal hinterland (Wijngaarden, 1985). Over the years the survey area has changed as more adjacent were included and therefore the 2014 Tsavo-Mkomazi survey area was about 48,600km² (Figure 2.1).

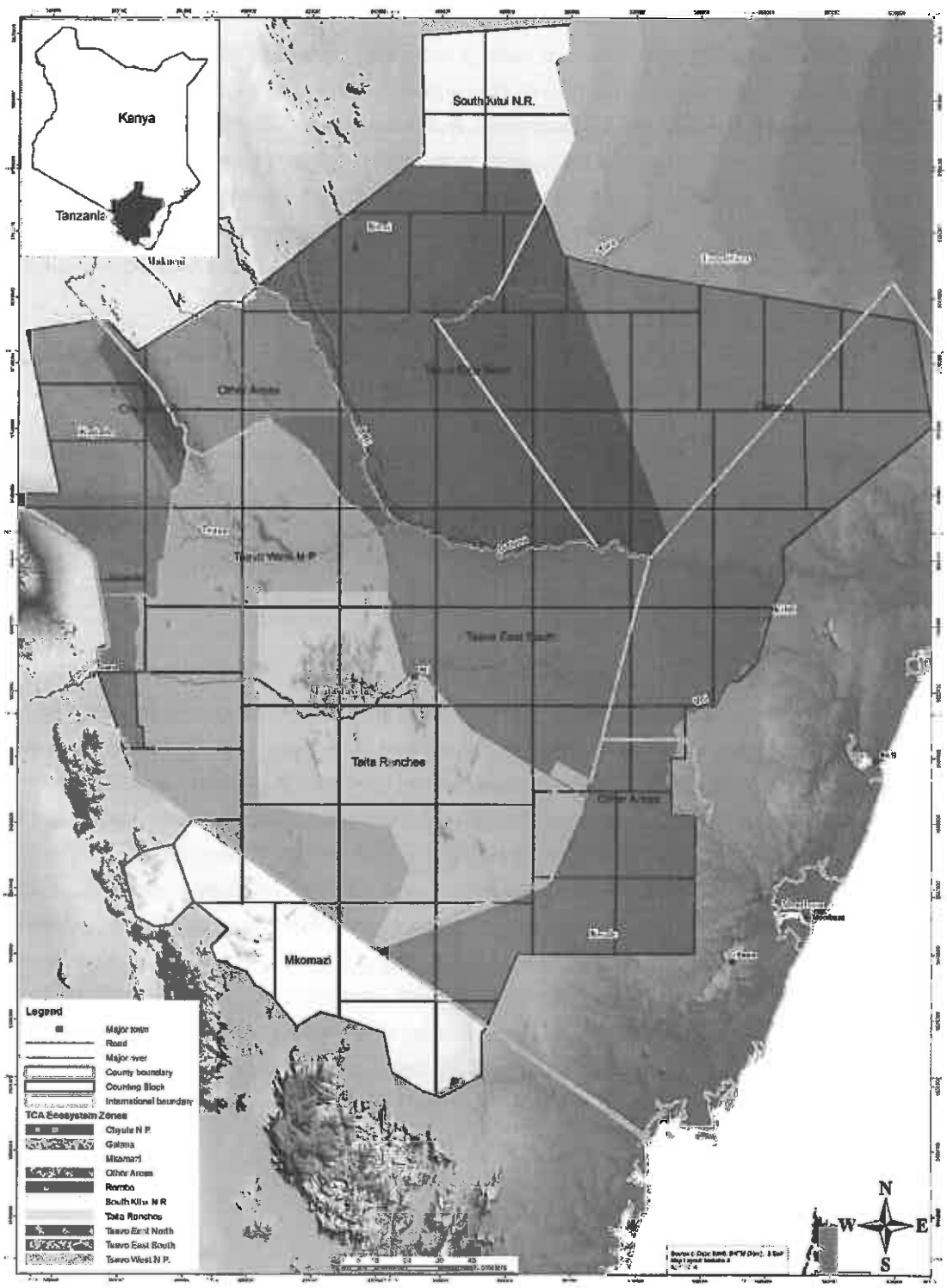


Figure2.1: Map of the Tsavo-Mkomazi survey area

2.2 Climate

The rainfall regime in the Tsavo ecosystem is roughly related to the movement of the Inter-tropical Convergence Zone (ITCZ), (Wijngaarden, 1985). Climate in Tsavo area is semi-arid, with an

unpredictable, bimodal rainfall distribution of between 200 and 700 millimetres per annum (Wijngaarden, 1985; Kasiki, 1998). The long rainy season is experienced in the months of March - April/ May and the short rain season in November - December. The short rains are generally considered to be more reliable and less erratic than the long rains. Rainfall in Tsavo West is generally higher and usually less erratic in spatial and temporal distribution than in Tsavo East (Wijngaarden, 1985; Leuthold and Sale, 1973). Although the seasons described above are usually well defined, rainfall varies considerably in its spatial and temporal distribution. Average normal daily temperatures range between 20°C and 30°C. The temperatures are slightly higher in the dry season than in the wet season with a general decrease in temperature with increasing altitude.

2.3 Topography and soils

Most of the Tsavo ecosystem has a gentle east-west slope from the generally low-lying plains in the east about 300m above sea level to the erosion prone plains in the west lying at about 600m above sea level. The project site is about 577 meters above sea level. The soil in this area is reddish in colour and of sandy loams. A detailed description of the soils and geology of the Tsavo-Mkomazi survey area is provided by Ngene, et al 2011.

2.4 Fauna

The Tsavo ecosystem has been defined as the total area used seasonally by the Tsavo elephant population (Cobb, 1976). The ecosystem is considered a priority area in the conservation of the elephant population in Kenya. The major herbivores are elephant (*Loxodonta africana*), African buffalo (*Syncerus caffer*), eland (*Taurotragus oryx*), fringe-eared oryx (*Oryx beisa*), coke's hartebeest (*Acelaphus buselaphus cokii*), burchell's zebra (*Equus burchelli*), grevy's zebra (*Equus grevyi*), impala (*Aepyceros melapus*), giraffe (*giraffe camelopadalis)*, black rhinoceros (*Diceros bicornis*), hippopotamus (*Hippopotamus amphibius*), common warthog (*Phacochoerus africanus)* and Grant's gazelle (*Gazella grantii*). The common primates are the yellow baboon (*Papio cynocephalus*), vervet monkey (*Cercopithecus aethiops pygerythrus*). The silver-backed (black-backed) jackal (*Canis mesomelas*), bat-eared fox (*Otocyon megalotis*), wild dog (*Lycaon pictus*), ratel/honey badger (*mellivora capensis*), dwarf mongoose (*Helogale parvula*), banded mongoose (*Mungos mungo*), white-tailed mongoose (*Ichneumia albicauda*), spotted hyaena (*Crocuta crocuta*), aardwolf (*Proteles cristata*), leopard (*Panthera pardus*), lion (*Panthera leo*), cheetah (*Acinonyx jubatus*), aardvark (*Orycteropus afer*) and rock hyrax (*Procavia johnstoni*) among others.

2.5 Flora

The vegetation is dominated by a mixture of the perennial grasses *Digitaria macroblephara, Chlorisrox burghiana,* and *Bothriochloa radicans* and the annual legumes *Tephrosia subtriflora* and *Tephrosia villosa* (Belsky *et al.* 1987). The tree component includes *Acacia tortilis, Adansonia digitata, Delonix elata* and *Melia volkensii* surrounded with distinct patches of under storey species. The grasslands are dominated by the perennial grasses *Cenchrisciliaris, C. roxburghiana, Digitaria macroblephara* and *Eragrostis caespitosa*. Herbaceous-layer vegetation under tree canopies is dominated by the

stoloniferous perennial grass *Cynodon dactylon* and *Panicum maximum*. These under storey species, along with *Aneilema johnstonii*, *Cocciniami crophylla*, and *Commelina benghalensis*, are replaced at or near the edge of the canopy zone by a more species-rich mixture dominated by *Bothriochloa radicans*, *Chlorisrox burghiana*, *Digitaria macroblephara*, and *Eragrostis caespitosa*, among other species. The under storey species also occur away from the trees in association with small shrubs but at lower cover values. Other frequent species (> 5% cover) in the open grasslands include the dicots, *Cassia mimosoides*, *Commelina africana*, *Portulacao leraceae*, *Solanum incanum*, *Momordica boivinii*, *Heliotropium steudneri*, *Ipomoea obscura* and *Hibiscus micranthus*, and the grasses *Cenchris ciliaris*, *Microchloa kunthii*, *Sporobolus pellucidus*, *Aristida adscensionis*, and *Sporobolus fimbriat* (Belsky*et al.*, 1989).

2.6 Economic Activities

Most of the Tsavo land is unsuitable for crop farming (Adanje, 2002) except the Taita Hills and Njukini-Rombo areas where crop farming is done depending on rain or irrigation respectively. Despite the unfavorable weather conditions, the locals practice small scale crop farming which in most cases end up being unproductive. Fruit plantation farming is widely practiced along west of the Athi river where mangoes, oranges and vegetables are grown under irrigation.

Livestock ranching is a viable economic activity and is widely practiced in areas surrounding the national parks. The ranches are either government owned through Agricultural Development Cooperation or individually (Private or group ranches) (Adanje, 2002). Sisal farming is also done in Taita and Voi ranches, farms in Taru, Samburu, Kibwezi and Ziwani areas. Mining has been practiced in the area but by privately owned companies. This is usually in areas of Kanjaro, Kasigau and adjacent areas. Charcoal production is done for subsistence by the local community which has lead to vegetation destruction in most of the areas (McKnight, 2004).

Recently Wildlife Works, a for-profit conservation organization, has initiated a conservation scheme known as Reducing Emissions from Deforestation and Degradation (REDD) (Wildlife Works, 2014). Through the sale of verified carbon credits, which the shareholders receive a portion of and which are generated by the forest and verified by two standardizing bodies, the ranches have been able to make an income from the land by protecting it.

3.0 Materials and Methods

3.1 Census Design

This total aerial census used survey principles as described by Norton–Griffiths (1978) and Douglas-Hamilton (1996). To enhance survey accuracy, however, other additional survey parameters were included. They included fitting streamers on the aircraft wing struts on either side of the plane to limit observer distance to 500m at about 350ft above ground. Maintaining the average standard flight height above ground was ensured by running calibration flights in which a 10km straight cutline running north-south was flown. This was meant to guide the observers in distance estimation in order to ensure that double counts and other survey errors associated with distance estimation were minimized.

There was a two-day intensive training that took place on February 3rd and 4th 2014. It involved 16 planes among them eight four-seater planes and eight two-seater planes. At the completion of the training exercise one four-seater plane could not meet requirements and therefore 15 aircrafts were used during the February 5th to 11th 2014 survey exercise.

Unlike previous censuses in Tsavo-Mkomazi ecosystem in which data capture was done by filling printed datasheets, in-flight voice recorders were used to capture the data. This enhanced wildlife spotting by ensuring that observers spent their time counting animals instead of writing down observations on paper. All Voice recorders and cameras were set to optimize data capture while all hand held GPS receivers were set to Universal Transverse Mercator (UTM) coordinate system for ease of distance estimation and standardization.

3.2 Block Design and Flight Plan

In the past, Tsavo-Mkomazi total aerial census, like other parts of the country has been based on irregular counting blocks defined by physical features such as rivers, ridges and roads (figure 2.2). These blocks have been difficult and taxing to navigate both for the pilot and the Front Seat Observer (FSO). In addition, the irregular blocks defined by physical features meant that such physical features became the turning points of each survey transect. In a dry and semi arid ecosystem like Tsavo-Mkomazi where water is a limiting factor, animals tend to concentrate their activities along these boundaries like river courses especially during dry season and therefore increasing chances of double counts.

The probability of introducing errors in the survey with these kind of blocks is high. To address these challenges previously encountered, we designed regular counting blocks that are easily navigable using GPS (Global Positioning Technology) technology (Figure 2.3). The average block size was set at 900km^2 which was calculated to be the average area a plane would comfortably survey within six hours at maximum. The regular block design also took into consideration known areas of elephant concentration based on past censuses such that the survey blocks do not cut across such populations. A total of 68 blocks were surveyed covering an area of 48,656 km^2. This survey area was similar to that covered in 2011 census aside from a small search area done around Lake Jipe in this census.

The regularized blocks were overlaid with 1km UTM grids on a topographical sheet, printed and issued to flight crew (Figure..). North-South transects were recommended for counting to avoid sun glare. However, in areas where the topography was rugged and difficult to navigate through (like hill tops and deep valleys), transects were flown in the most suitable manner that ensured safety of the participants and the planes without compromising the survey quality and objectives. Elephant herds with more than ten individuals were circled to ensure all individuals were counted, while for other wildlife species their numbers were estimated along transects. In areas whose land use has been adversely changed over time due to changing human activities and lifestyles, and where past censuses have established that wildlife has already been displaced, transect spacing was set at 2km interval but was not encouraged.

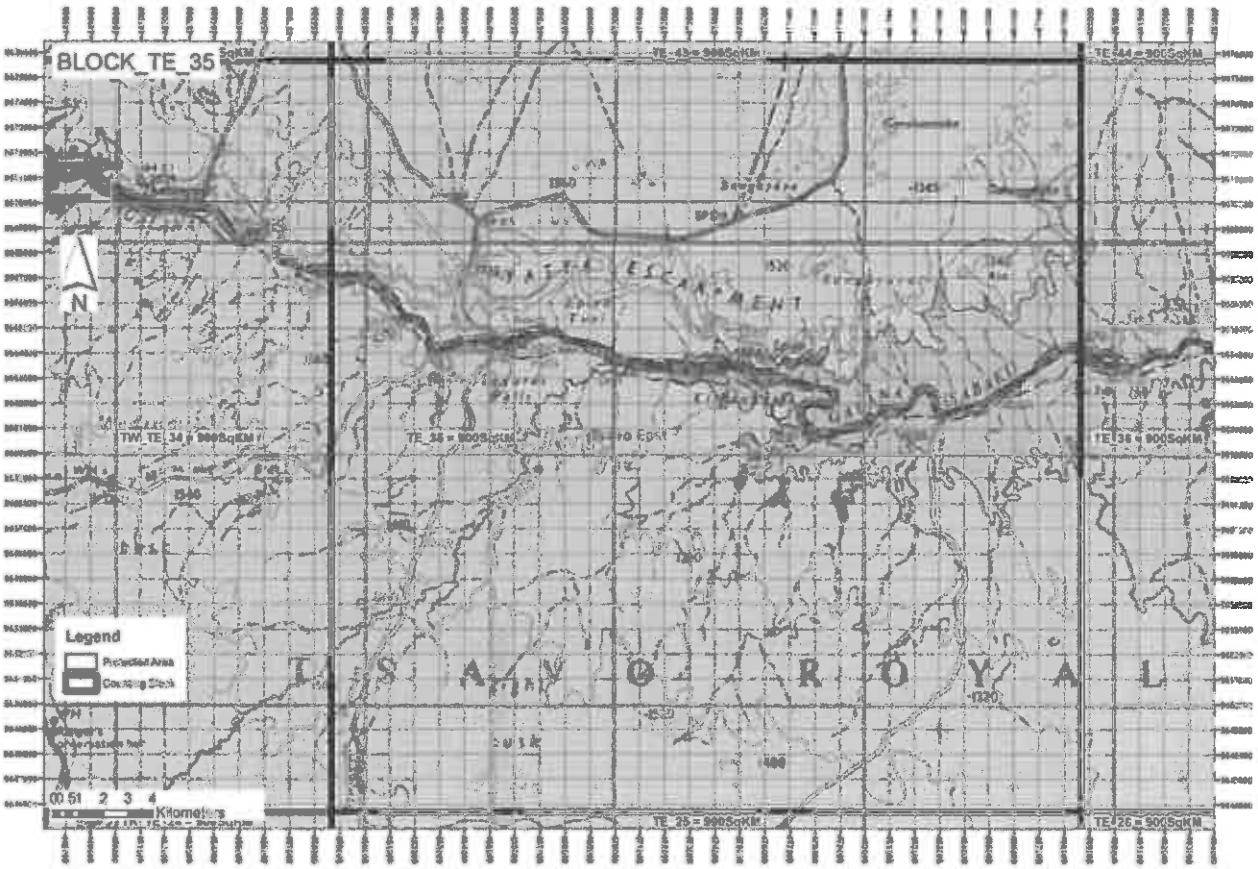


Figure 2.2: Sample block used by crew during 2014 survey

Note: The survey block transcends Galana river previously used as a block boundary

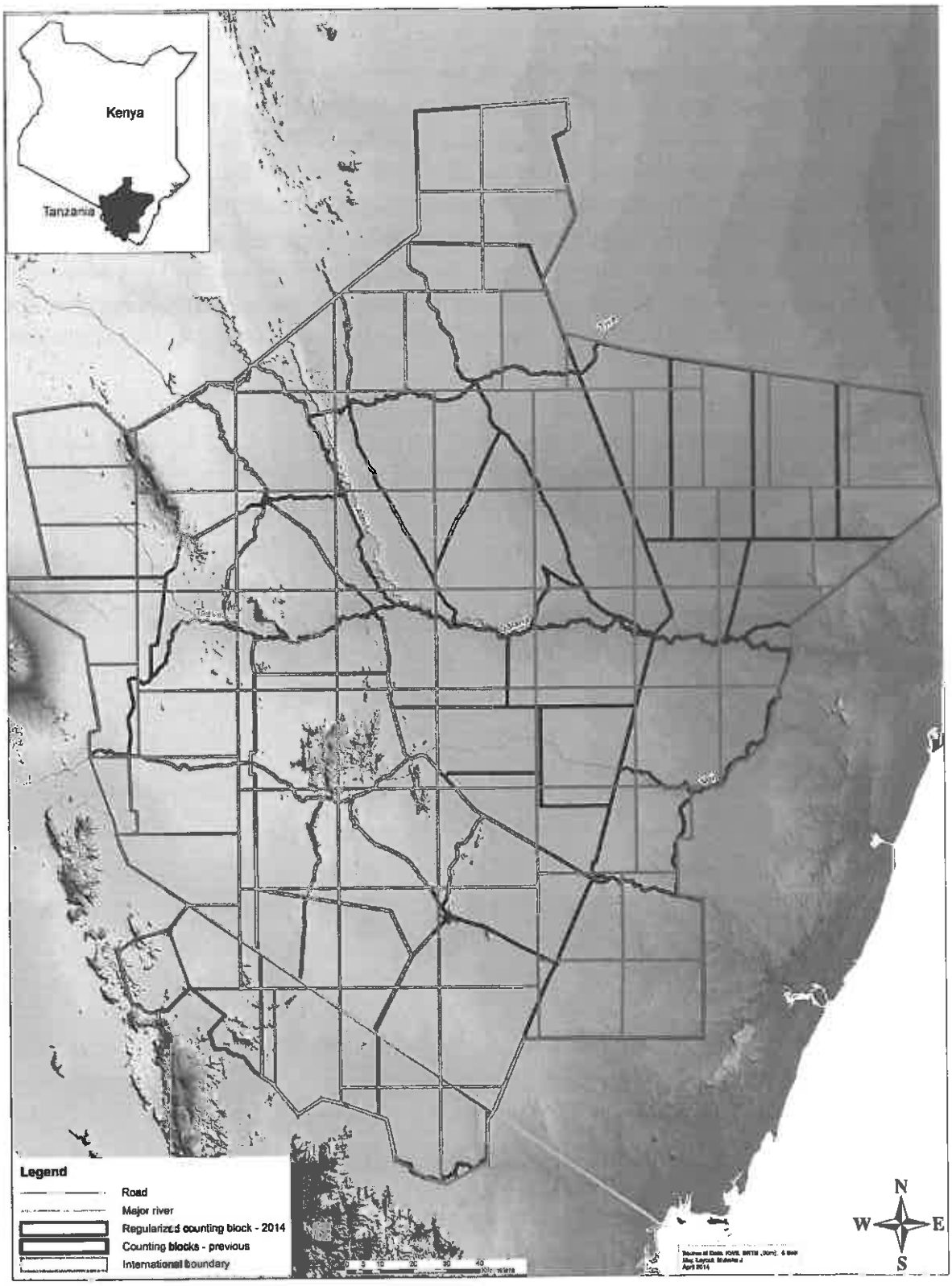


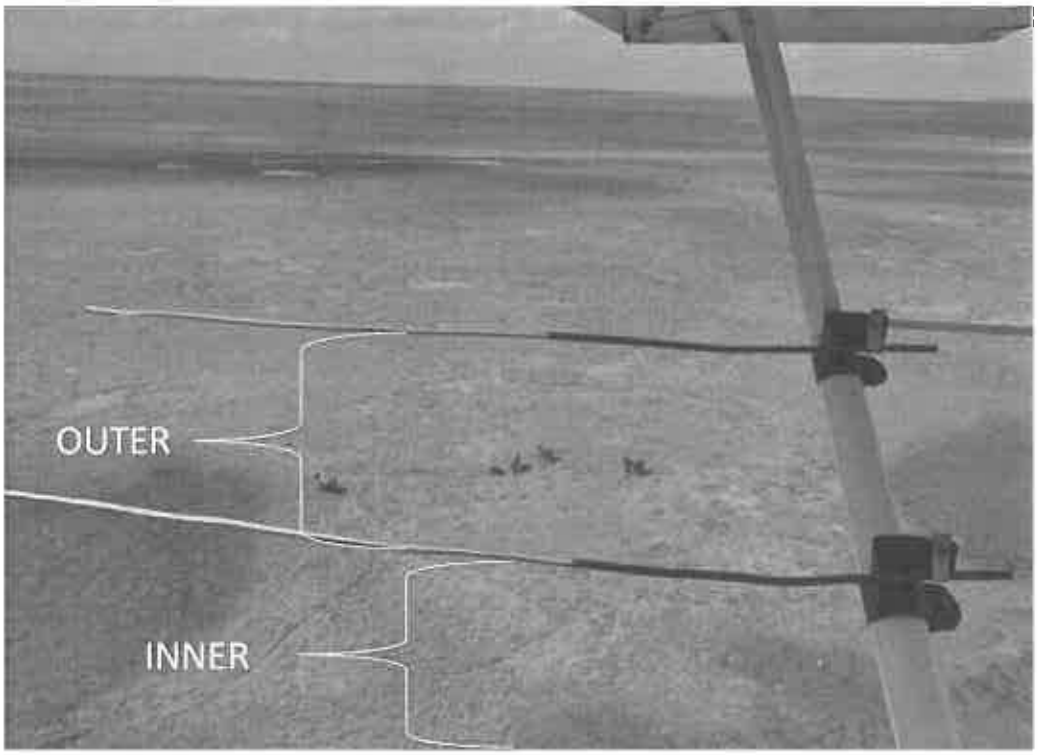
Figure 2.3: Map showing old blocks and 2014 regularized block

3.3 Aircraft calibration and data collection

Data quality on wildlife populations was enhanced by undertaking a two-day training of all survey participants on use of various counting and estimation techniques, use and handling of equipment (GPS receivers, voice recorders and cameras), plane navigation, species identification and estimation, elephant carcass aging. Practical training sessions and test flights were included as rehearsal for the actual census. The test flights involved the different flight crews flying the same mock transects at different intervals while maintaining same orientation in order to assess inter-observer variability in species detection, estimation and identification.

Streamers were fitted to wing struts of each plane to define transect widths, a concept borrowed from SRF (Systematic Reconnaissance Flight) sample count method Norton–Griffiths (1978) to aid observers in distance estimation (Plate 2.1). The streamers were calibrated for each Rear Seat Observers (RSO) at a flight height of 91.2m (350 ft) above ground level. The outer streamer was set to limit the extent of observation to the maximum transect width of 500m on either side of the plane; inner streamers were set at half that width. This provided a way of subdividing transects into two band strips (inner and outer). Observations were then apportioned to either of the bands (inner or outer) as they were sighted. The idea was to collect data that is consisted and comparable with past total aerial census data and at the same time providing an opportunity for the data to be analysed as a sample count in the future should funding for total count become limiting. It also allows for the potential correction of the total count data by comparing densities of observations within the two bands.

In-flight data was captured in both GPS and voice recorders. Digital cameras were also used to capture large herds which enabled the census team to undertake photo corrections on the results.



3.4 Data capture and handling

The ground crew was trained in data handling and data processing protocols. They were trained on use of species codes, in putting data in a MS Access database. They were also trained to use various audio software to transcribe audio data from flight crew onto datasheets. Data collected in-flight in GPS were downloaded using DNR Gamin® software set to UTM Zone 37S. These data included both waypoints for observed events and tracks for flight lines. Voice records were downloaded, transcribed and entered into an MS Access database. The waypoints data were imported into the database where they were joined with the transcribed data. The joined data were exported to dbase file which was used to create an ESRI shapefile in ArcGIS 10. Double counts due to flight overlaps were identified and removed.

3.5 Data analysis

Comparison and polynomial regression analysis was only done for data pooled for areas that have been counted consistently over the years from 1988 to 2014. This has been taken as a caution in that the censuses have been carried out using varying methodologies, counting effort and climatic conditions between the years (Ngene et al., 2013). The areas that qualified for cautious comparison include Tsavo East (north), Tsavo East (south), Tsavo West, Mkomazi National Park, Galana, and Taita Ranches. Simple percentages were used to analyze variation of species abundance and elephant carcasses.

Distribution and density maps were prepared using ArcGIS 10. The orientation of the geographic distribution and the centre of the elephant concentration were analyzed for elephants only using the standard deviational ellipse and mean centre (ESRI, 1997; Mitchell, 2009). General distribution patterns (random, dispersed or clustered) and distribution of herd sizes were analyzed for elephants, buffalo, giraffe and zebra. We tested for the general distribution patterns of the four species using the Getis-Ord general G statistic as described by Mitchell (2009). The distribution of different herd sizes were mapped using the Hot-Spot analysis (Getis-OrdGi* statistic) and implemented using ArcGIS 9.3 (ESRI, 2007; Mitchell, 2009). The results were interpreted as described by Mitchell (2009). The *Z-score* statistics were used to aid interpretation of results as outlined by Mitchell (2009).

Further correlation analysis was done to determine the relationship between elephant distribution to water points, livestock, charcoal production and mining. Significance levels were set at p= 0.05.

4.0 Results

4.1 Census Effort and Survey Parameters

The Tsavo-Mkomazi total aerial census was carried out by 15 light aircrafts, lasted for six days (5th February – 10th February 2014) and in total it took 339.5 hours (Table 4.1) to cover about 48,600sq km. The survey maintained north-south 1 km transects for most of the area (Figure 4.1)

Table 4.1: Total count time for aircrafts

Aircraft Registration	Seat capacity	Count time (hrs)
BCA	4	12.82
LLJ	4	13.33
KWL	2	15.85
KWC	2	16.88
STP	2	21.22
BWX	2	22.12
WRB	2	23.98
KWY	2	24.65
KWB	2	24.82
PHT	4	25.83
ACE	2	26.40
DTP	2	26.75
DHS	4	26.97
BZA	4	27.72
STE	4	30.17
Total Count Time (hrs)		**339.50**

Search effort (scanning rate) = Total ecosystem area / Total count time for all aircrafts

= 48600 sqkm/ 339.5 hrs

143.15 sqkm/hr

The 2014 Tsavo-Mkomazi aerial census search effort was therefore 143.15 square kilometers hourly. This is the highest mean search rate recorded for Tsavo-Mkomazi aerial count compared to other previous count efforts (Table 4.2). A four seater plane flown by Save the Elephant (STE) flew the highest total hours (30.17hrs) while another four seater owned by KWS flew the minimum number of hours (12.82hrs). Search effort has been increasing over the years as KWS finds more willing support from stakeholders. For instance the number of aircrafts assembled during this census was 16 while in 2011 they were nine.

Table 4.2: Search effort for some recent total counts

Year	Search effort (km^2/hour)	Total elephants counted
2014	143.15	11217
2011	191	12573
2008	213	11733
2005	224	11742
2002	242	9284
1994	210	8032
1991	247	8407
1989	276	6999
1988	321	6399

Search efforts during aerial counts determine the number of large mammals counted during the exercise (Douglas-Hamilton, 1994). The term search effort refers to the area (km^2) covered by the aerial count crew in one hour (km^2/hour; Douglas-Hamilton *et al.*, 1994). High and low search efforts result to higher and lower numbers of the large mammals being counted respectively (Douglas-Hamilton *et al.*, 1994). The 2014 aerial survey recorded a search effort of 143km2/hr, the highest so far for recent aerial censuses. However, it is during this census that a drop in elephant population was recorded in recent years. One major reason that can be attributed to a higher search effort during the 2014 survey was the consistent use of 1km transects as opposed to previous counts when areas like the Galana, South Kitui and others were surveyed using 2km transects. Studies indicate that however, number of elephants increases with increase of search effort (Ngene *et al, 2011*). The 2014 census elephant population drop contradicts this, and therefore other variables should be examined to explain this drop.

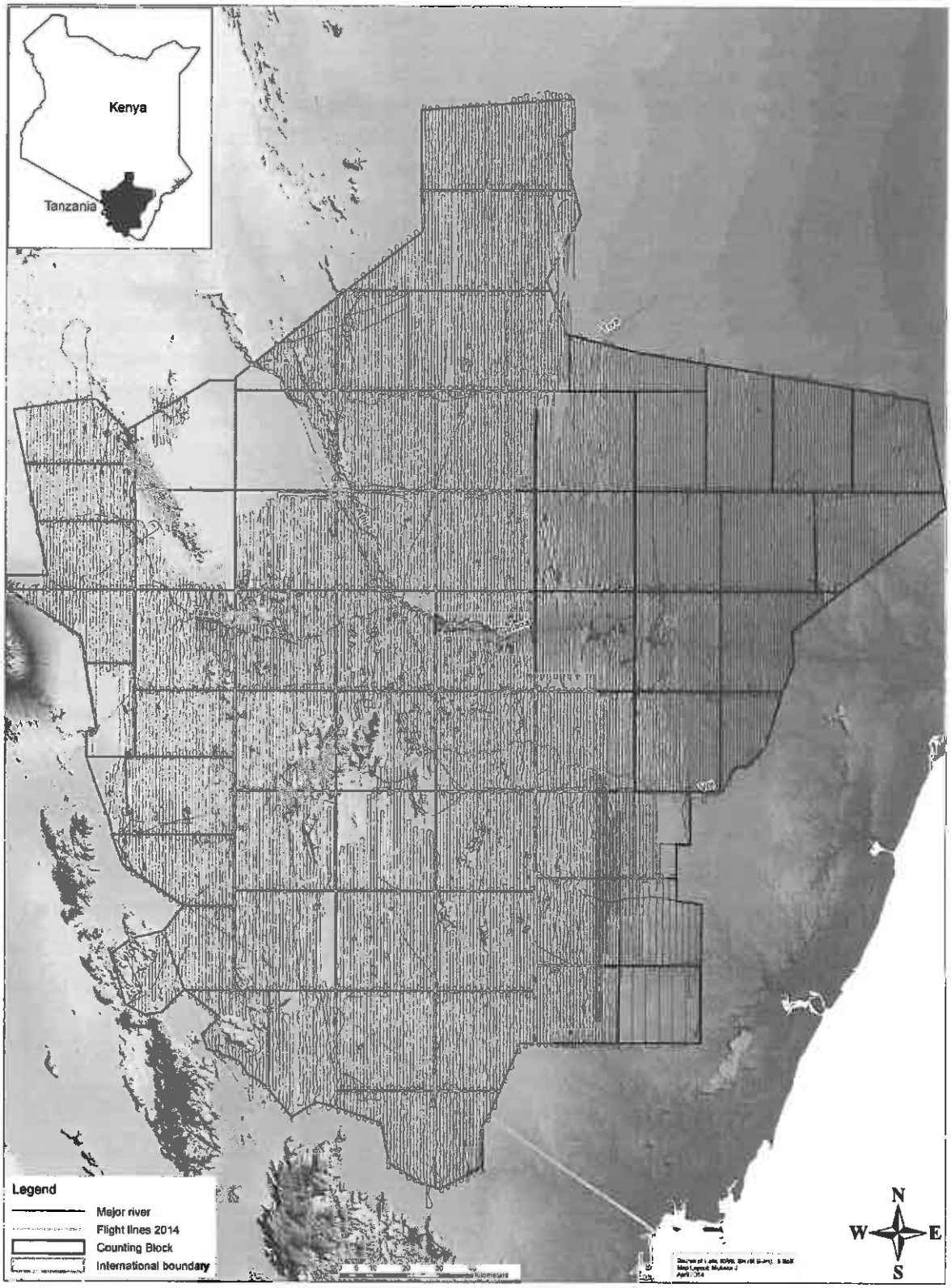


Figure 4.1: Flight lines during 2014 Tsavo-Mkomazi aerial census

Note: Hilly areas were not over-flown and the area east of Chyullu Park was not counted because it is completely settled.

During the census, streamers had been fitted and calibrated to fly at average height above ground of 350 feet. We extracted values from a 30 digital elevation model (DEM), and got the difference between the GPS generated altitude to get Height Above Ground (HAG). The mean HAG flown by all the aircrafts was 383 ft with a standard deviation of 141.

The mean HAG of 383ft falls within the recommended limits of aerial census of between 300 and 400 ft above ground (Douglas-Hamilton 1996). The large standard deviation however, also indicates that at times the pilots would fly at heights not recommended. The implication for too low and too high flying using the streamers is observation strip is significantly reduced and increased respectively. With too low flying, lower numbers will reported while at too high flying, double counting chances increase.

4.2 Status of Wildlife Populations

4.2.1 Wildlife Abundance

Thirty four (34) wildlife species were documented during the 2014 census. They include 29 mammalian species of which four were carnivores, 4 avian species and one reptile species (Table 4.3). The most abundant species were elephant (11,217), common zebra (9,007), buffalo (5,912), eland (3,166) and giraffe (2,891). Other species with over 1,000 individuals counted were Oryx (1,991), grant gazelle (1,530), kongoni (2,102) and impala (1,010).

Table 4.3: Summaries of wildlife species counted in various region in Tsavo-Mkomazi ecosystem in 2014

Species	Chyulu West NP	Galana	Mkomazi	Other Areas	Rombo	South Kitui NR	Taita Ranches	Tsavo East North	Tsavo East South	Tsavo West NP	Grand Total
Baboon		12	30	63		117	72	63		95	**452**
Buffalo		51	308	130	8		1082	540	2007	1786	**5912**
Bushbuck				5			3	3			**1**
Cheetah				1		1			4	1	**7**
Crocodile								2			**2**
Crowned crane				1							**1**
Dikdik		25	8	17		10	30	24	8	11	**133**
Duiker		1		1			3	1			**6**
Eland	24		551	245	172	2	605	243	295	1029	**3166**
Elephant	42	12	59	31	149		1420	1257	5329	2918	**11217**
Fish eagle								4			**4**
Gerenuk		34	5	24	2	9	24	40	11	42	**191**
Giraffe	88	95	184	461	187	17	315	235	428	881	**2891**

Grants gazelle	30	16	15	244	219	19	69	159	195	564	**1530**
Greater kudu										2	**2**
Grevy Zebra							19				**19**
Hippo		16						18	99	31	**164**
Hirola									15		**15**
Hyena							1		3	2	**6**
Impala	35		96	143	76		81	87	308	184	**1010**
Jackal		2					1	21		4	**28**
Klipspringer				1		1	2				**4**
Kongoni/Hartebeest	28		114	60			42	46	327	585	**1202**
Lesser kudu		28	72	157	2	23	97	58	19	112	**568**
Lion	7	2					1			4	**14**
Oryx		96	94	186	1	23	210	470	328	583	**1991**
Ostrich		20	39	66		12	77	64	139	172	**589**
Rhino										1	**1**
Secretary bird				1				5		1	**7**
Thomson gazelle	21			135			12	2	1	46	**217**
Topi				4					32	15	**51**
Vervet monkey								1			**1**
Warthog		61	51	75		17	115	41	107	192	**659**
Waterbuck	5	3	9	36	2		6	21	35	38	**155**
Wild dog								4			**4**
Wildebeest				439	36	5			11	85	**576**
Zebra common	187	63	460	1085	974		733	584	2096	2825	**9007**

4.2.2 Status of Elephant Population

In 2014 a total of 11, 217 elephants were counted in the entire Tsavo-Mkomazi conservation area which translates to a decline of 10.34% compared to 2011 elephant results. On average, 433 elephants have been lost every year since 2011. Most of the elephants were counted inside protected areas with a population of 9,605 (85.63%) showing an increase of 9.81% as compared to 8,747 elephants counted in 2011. On the other hand, 1,612 elephants were counted outside protected areas in 2014 that represents a decline of 57.87% of 3,826 elephants counted outside protected areas in 2011. Comparing regions, some of them have experienced a decline or an increase in elephant numbers (Table 4.4). For the previous two counts, Rombo did not have elephants but the 2014 count recorded 149 elephants.

Table 4.4: Comparison and distribution of elephant numbers counted in various regions in 2014 and 2011

Region	2014		2011		% decrease/increase
	n	%	n	%	
Tsavo East NP North	1257	11.21	2094	16.65	-39.97

Tsavo East NP South	5329	47.51	4120	32.77	29.34
Tsavo West NP	2918	26.01	2142	17.04	36.23
Chyulu NP	42	0.37	135	1.07	-68.89
South Kitui NR	0	0.00	0	0.00	0.00
Galana	12	0.11	398	3.17	-96.98
Taita	1420	12.66	2751	21.88	-48.38
Mkomazi NP	59	0.53	256	2.04	-76.95
Others	31	0.28	509	4.05	-93.91
Rombo	149	1.33	0	0.00	N/A
Total	**11217**		**12573**		

4.2.2.1 Elephant Density and Distribution

The elephants cluster distribution exhibited in 2011 was not significant for the 2014 ($Z= 1.373$, $P>0.05$) instead a random distribution was evident in most of the areas (Figure 4.2). This distribution varied depending on the regions, where they occurred as individuals or groups of 1-160 (Mean herd size = 10±15) (Figure 4.3) which is not much different from that of 2011 where they existed in groups of 1-189 elephants (Mean herd size = 9±12). The mean herd sizes was significantly different in the regions ($F= 2.239$, $df=7$, $P<0.05$; note Galana was not included in the Post hoc analysis since it had only one case) where large herd sizes were in Taita ranches, south of Tsavo West NP and South of Tsavo East NP south of Galana River (Figure 4.4).

More concentration of elephants was between Voi and Galana rivers but was distributed away from park boundary bordering Kulalu ranch (Figure 4.3). Galana ranch was also avoided though a small group of 12 was counted in one area (Table 4.5). Avoidance of the park boundary was also replicated in Northern Tsavo east but small concentrations are evident along or close to Tiva River. Kibwezi, Chyulu National Park and west of Chyulu has elephants but are sparsely distributed in small groupings. However, Kamboyo and Mzima springs have large concentration of elephants but Oza, Kishushe and Manyani areas have small concentrations. Ziwani, Maktau and Salaita areas also have small concentrations of elephants. A random distribution of elephants was recorded in areas between Taita sanctuary and Lake Jipe. In Taita ranches, large elephant concentrations were sighted in Taita, Rukinga, Bura and Lualenyi ranches where supplemented water has been provided for livestock.

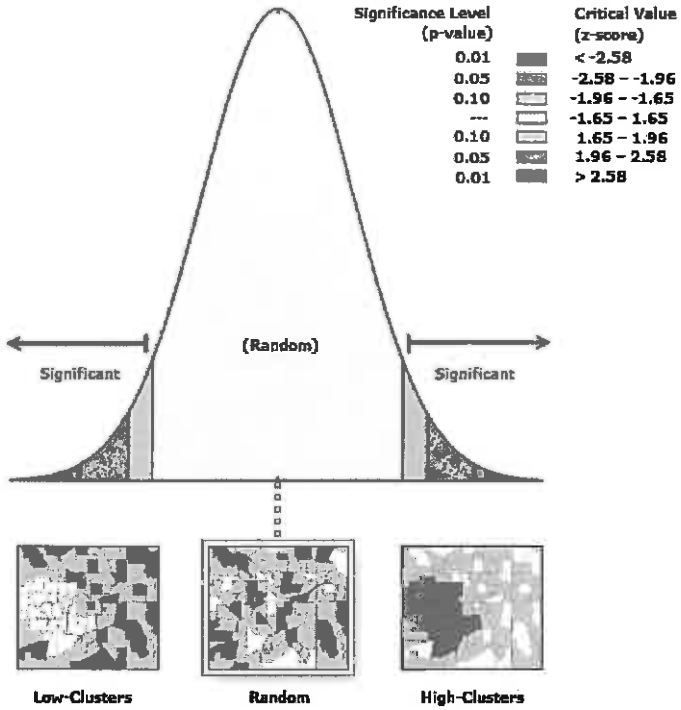


Figure 4.2: Overall elephant distribution in the entire Tsavo-Mkomazi ecosystem (Febuary 2014).

The elephant densities varied depending on the regions where Tsavo East South of Galana river had a density of 1.279 elephants per km^2 while Tsavo West NP, Mkomazi and each of Taita, Rombo, Tsavo East North and Chyulu had 0.447, 0.0185 and 0.0983-0.237 respectively (Figure 4.5). Based on the kernel density analysis, areas around Tsavo East park headquarters had the highest elephant population densities (Figure 4.6). This has varied compared to 2011, where parts of Galana, Ziwani and south east of Taita Ranches had concentrations of elephants but in 2014 most of these areas no or few elephants were counted (Figure 4.7).

Table 4.5: Elephant mean herd sizes in various regions of the Tsavo-Mkomazi ecosystem, 2014.

Region	n	Mean	Minimum	Maximum
Chyulu NP	4	10.5	2	33
Galana	1	12	12	12
Mkomazi NP	6	9.3	1	22
Other areas	6	5.2	1	11
Rombo	7	21.3	1	126
Taita Ranches	99	14.3	1	122
Tsavo East NP North	77	10.5	1	160
Tsavo East NP South	524	10.2	1	85
Tsavo West NP	311	9.4	1	120
Total	**1116**	**10.1**	**1**	**160**

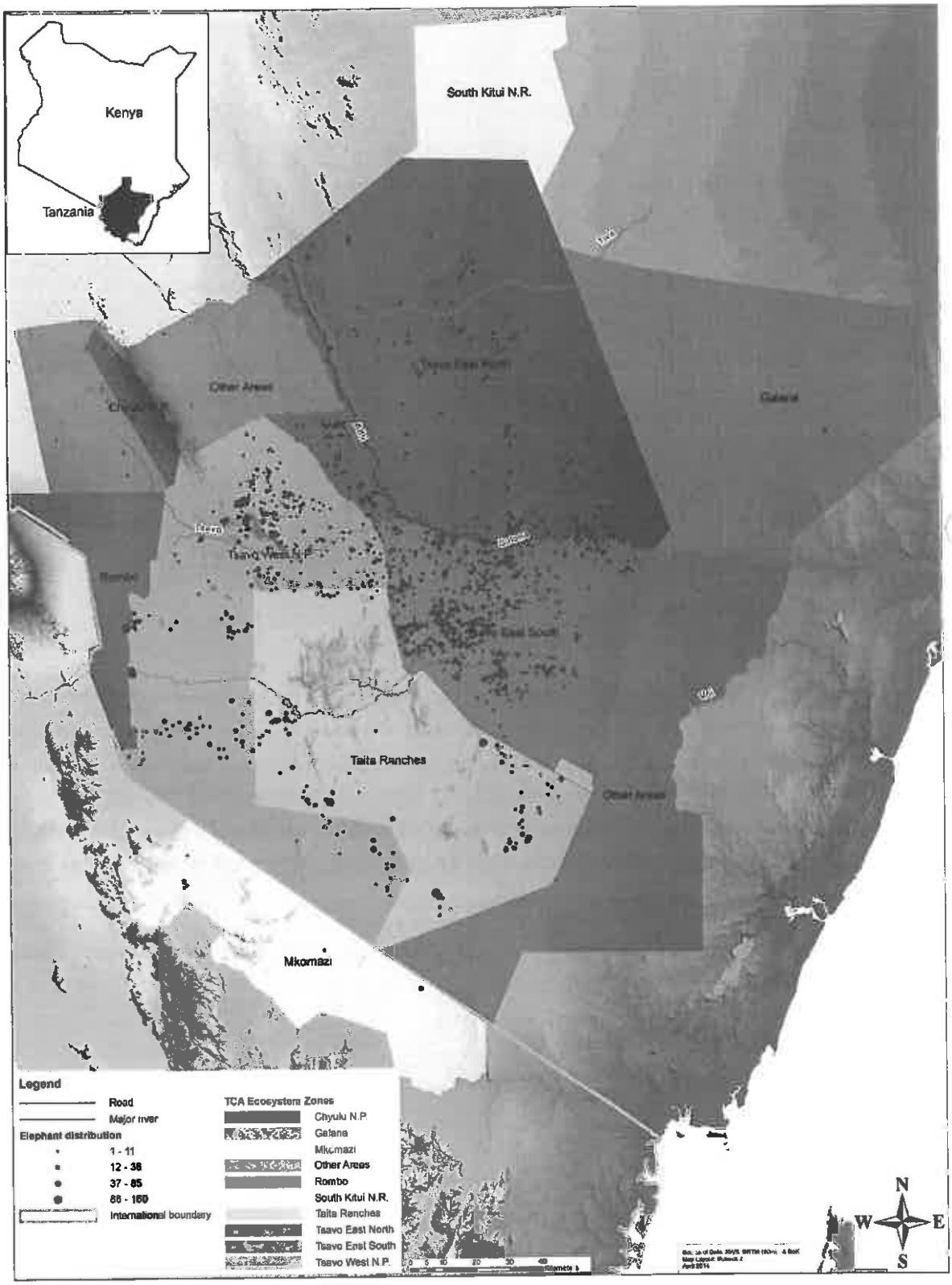


Figure 4.3: Elephant distribution in Tsavo-Mkomazi ecosystem based on the 2014 aerial census total count.

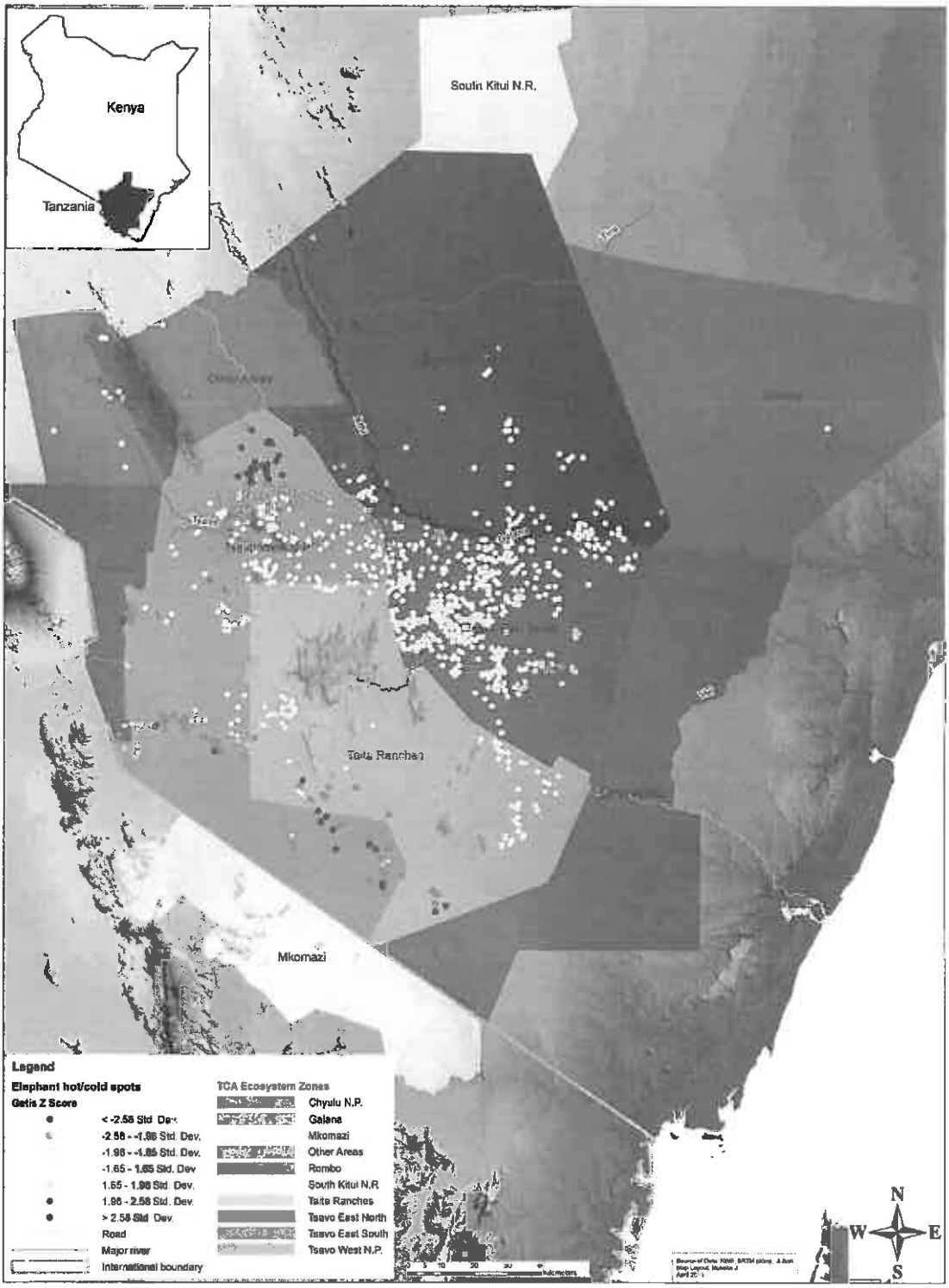


Figure 4.4: Hot/cold spot map for 2014 elephant aerial survey

NOTE: Red dots denote hot spots while blue indicate cold spots. Hot spots are areas of large groups found together while cold spots are areas where small groups exist.

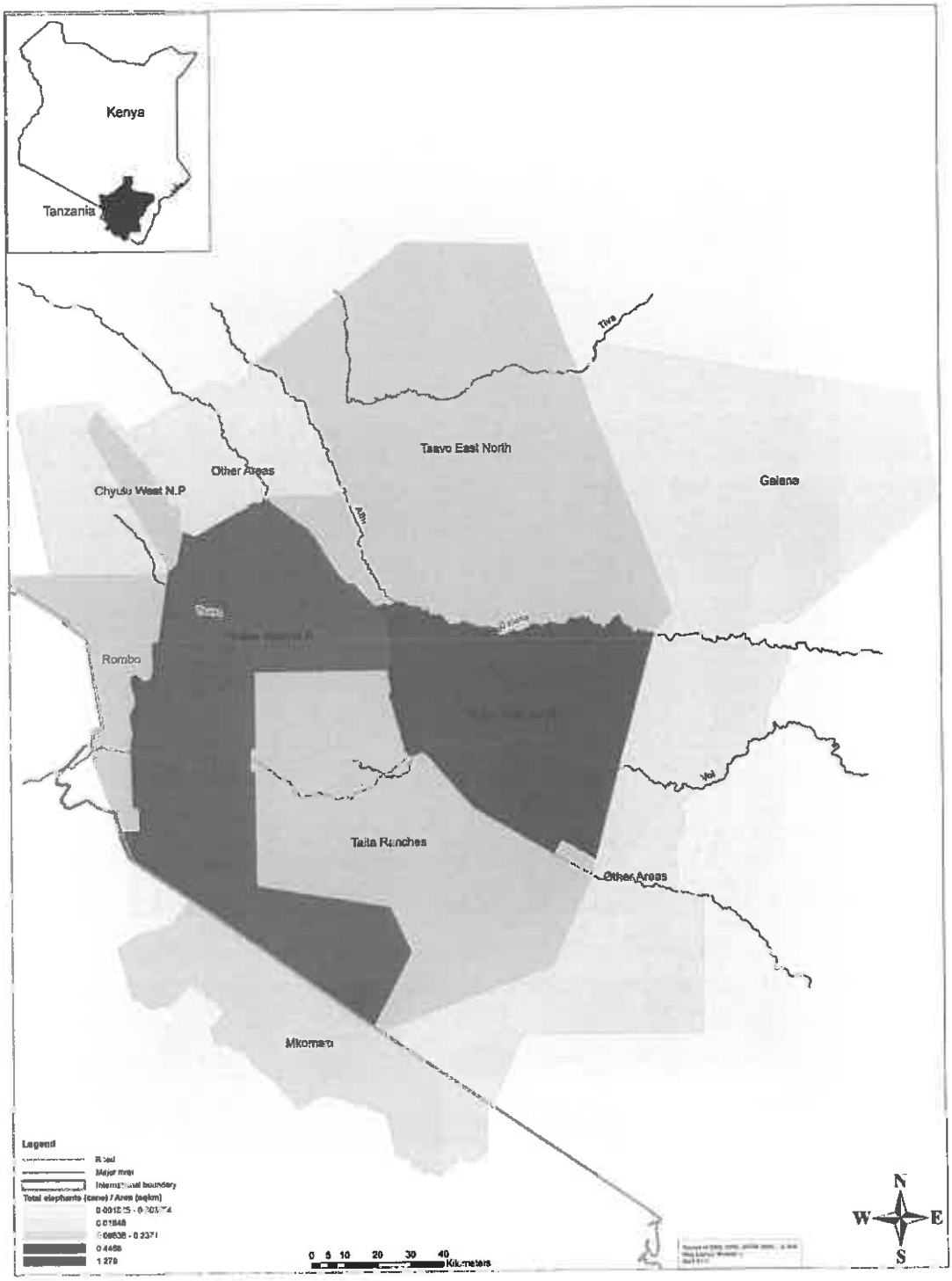


Figure 4.5: Regional Elephant density variations in Tsavo-Mkomazi ecosystem using 2014 survey.

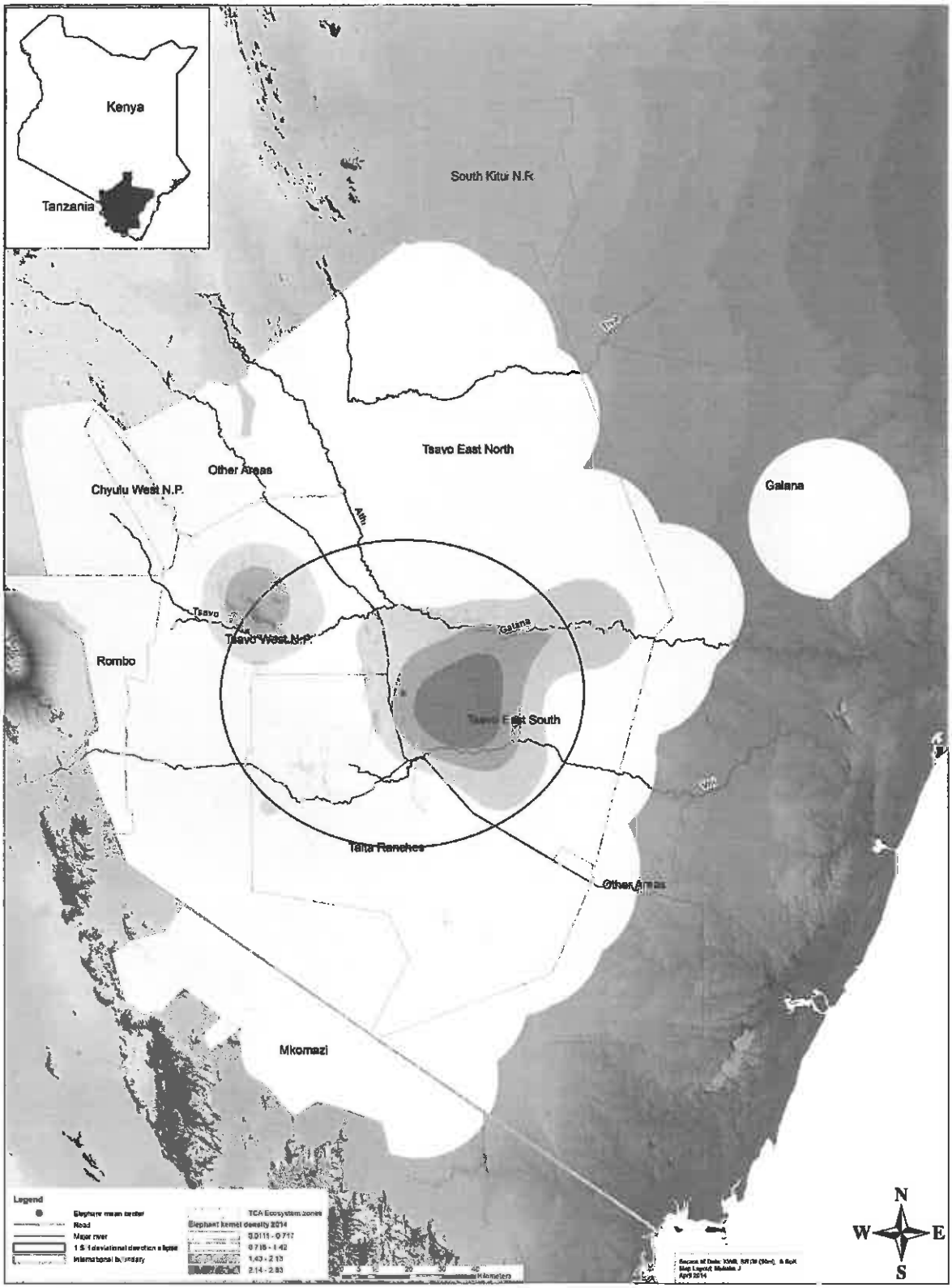


Figure 4.6: The kernel distribution density and deviational ellipse map of elephant distribution in Tsavo-Mkomazi ecosystem 2014.

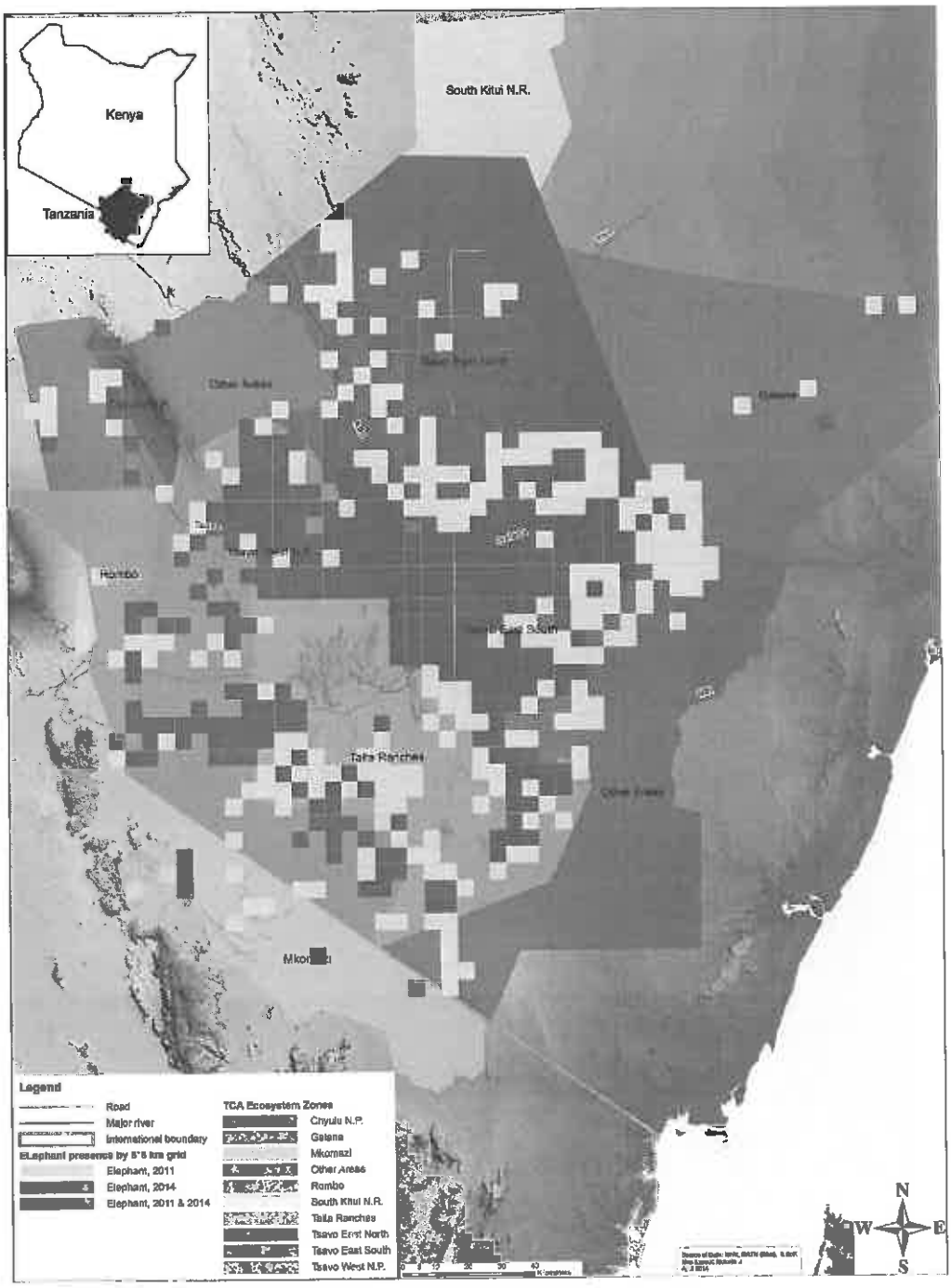


Figure 4.7: A 5*5km grid map showing 2011 and 2014 elephant distribution

Note the difference in 2011 and 2014 elephant distribution, where yellow indicates elephant presence in 2011 only and shrinkage in 2014 occupance

4.2.2.2 Elephant Carcass Distribution and Carcass ratio

A total of 857 elephant carcasses were counted in Tsavo-Mkomazi ecosystem in 2014. This is an increase of 51.15% compared to 567 elephant carcasses recorded in 2011(Table 4.6). Based on the carcasses counted, there has been a mixed change in elephant mortalities in various regions. Mkomazi NP, Taita ranches and other areas (Kulalu, West of chyulu) have experienced a drastic increase in elephant mortalities of 833.33%, 200.00% and 800.00% respectively (Table 4.6). On the other hand Chyulu NP (-50.00%) and areas outside TCA (-25.00%) have recorded a decline in number of elephant mortalities. Out of the 857 carcasses, 89.61% represented old carcass, 9.33% was recent carcass and 1.05% fresh carcass. The 2014 carcass ratio is 7.10% per the three year period.

Most of the elephant deaths occurred in Tsavo West NP (23.34%) and Tsavo East North of Galana River (21.35%). Tsavo East NP south of Galana, Taita ranches, Galana, Mkomazi NP and Chyulu NP recorded 17.62%, 15.05%, 5.13%, 3.27% and 0.23% of the elephant carcasses respectively. Out of the 9 fresh carcasses counted, 2 were in TsavoEas NP south of Galana (each in Galana and Voi Rivers), 3 in Taita Ranches, 3 in Mkomazi and 1 in Chyullu NP. Most of the elephant deaths were recorded close to protected area boundaries or rivers (Figure 4.8).

Table 4.6: The number of elephant carcasses counted in Tsavo in 2014 and 2011. The comparison column shows the percentage change in number of carcasses from 2011 to 2014.

	2014			2011			Comparison
LOCATION	Old	Recent	**Total**	Old	Recent	**Total**	**% change**
Tsavo East NP North	170	13	**183**	151	14	**165**	**10.91**
Tsavo East NP South	134	17	**151**	149	9	**158**	**-4.43**
Tsavo West NP	180	20	**200**	119	11	**130**	**53.85**
Chyulu NP	1	1	**2**	4	0	**4**	**-50.00**
South Kitui NR	0	0	**0**	0	0	**0**	**0.00**
Galana Ranch	43	1	**44**	43	4	**47**	**-6.38**
Taita Ranches	104	25	**129**	31	12	**43**	**200.00**
Mkomazi NP	23	5	**28**	3	0	**3**	**833.33**
Other Areas	110	7	**117**	13	0	**13**	**800.00**
Outside TCA	3	0	**3**	4	0	**4**	**-25.00**
Total	**768**	**89**	**857**	**517**	**50**	**567**	**51.15**

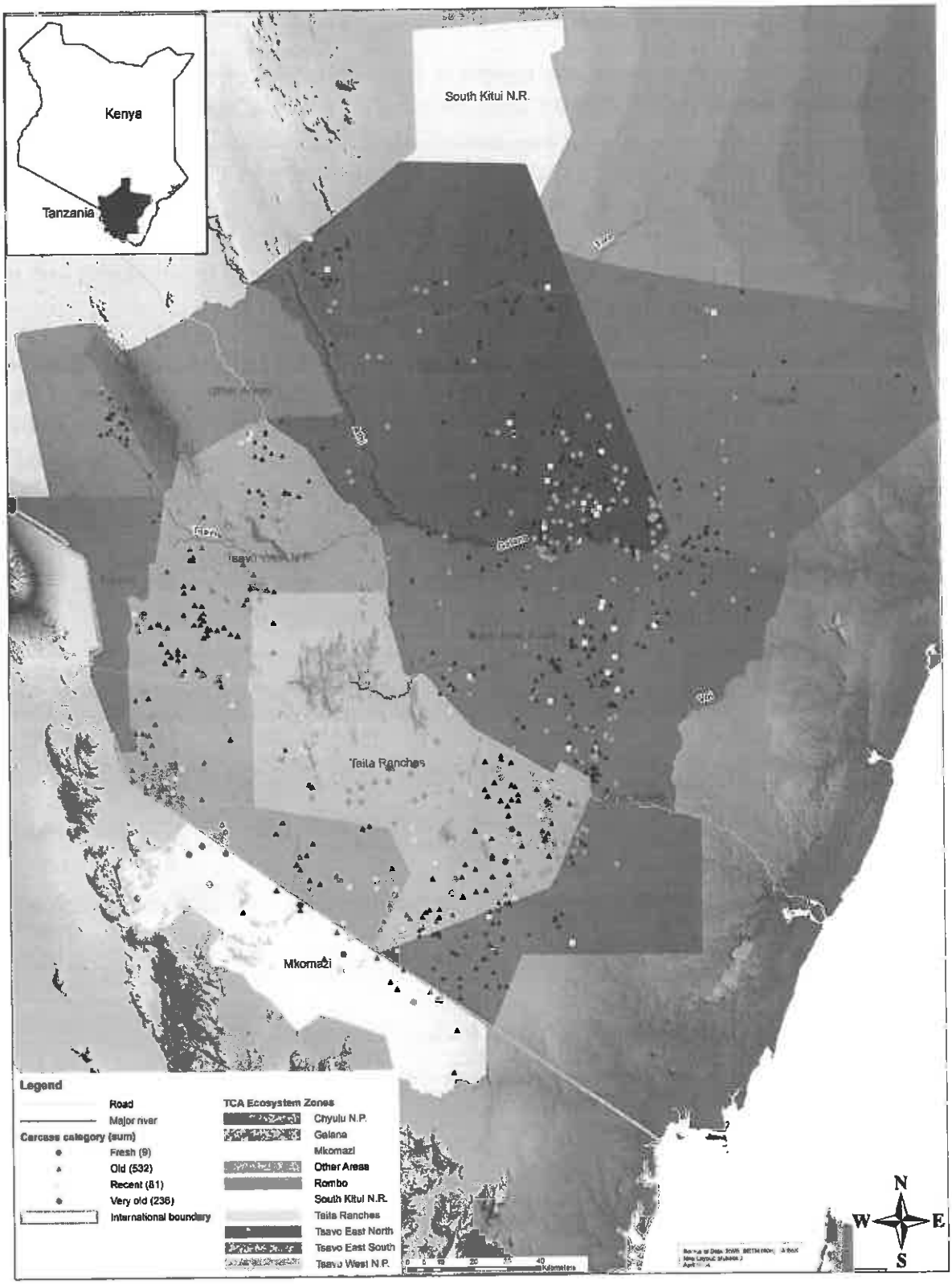


Figure 4.8: Elephant carcasses based on categories for 2014 Tsavo-Mkomazi survey

4.2.3 Status and Distribution of Buffalo

Large buffalo concentrations were observed scattered in both Tsavo East and Tsavo West N. Parks except the central sector of Tsavo East NP (Figure 4.9). Other populations were documented in Taita and Galana ranches as well as Mkomazi NP. However, the buffalo populations appear to have spiraled downwards in Tsavo East NP during the 2014 census compared to 2011 census; the biggest decline being witnessed in the northern sector of the park (Table 4.7). Tsavo West and Mkomazi NP as well as other areas like Rombo experienced a remarkable increase in buffalo population. Taita and Galana ranches too experienced an increase in buffalo population between 2011 and 2014 albeit slight. However, Chyulu NP and South Kitui National Reserve had no buffaloes observed during both 2011 and 2014 censuses. Overall, buffalo population in Tsavo-Mkomazi landscape declined by about 20%. The herd sizes seem to be the same in all regions except Galana and adjacent areas (Figure 4.10).

Table 4.7: Buffalo regional population and change in 2014 and 2011

Region	**2014**		**2011**		**% decrease/increase**
	n1	**%**	**n2**	**%**	
Tsavo East NP North	540	9.13	2613	35.28	**-79.33**
Tsavo East NP South	2007	33.95	3142	42.43	**-36.12**
Tsavo West NP	1786	30.21	641	8.66	**178.63**
Chyulu NP	0	0	0	0	**0.00**
South Kitui NR	0	0	0	0	**0.00**
Galana	51	0.86	44	0.59	**15.91**
Taita	1082	18.3	797	10.76	**35.76**
Mkomazi NP	308	5.21	121	1.63	**154.55**
Others	138	2.33	48	0.65	**187.50**
Total	**5912**	**100**	**7406**	100	**-20.17**

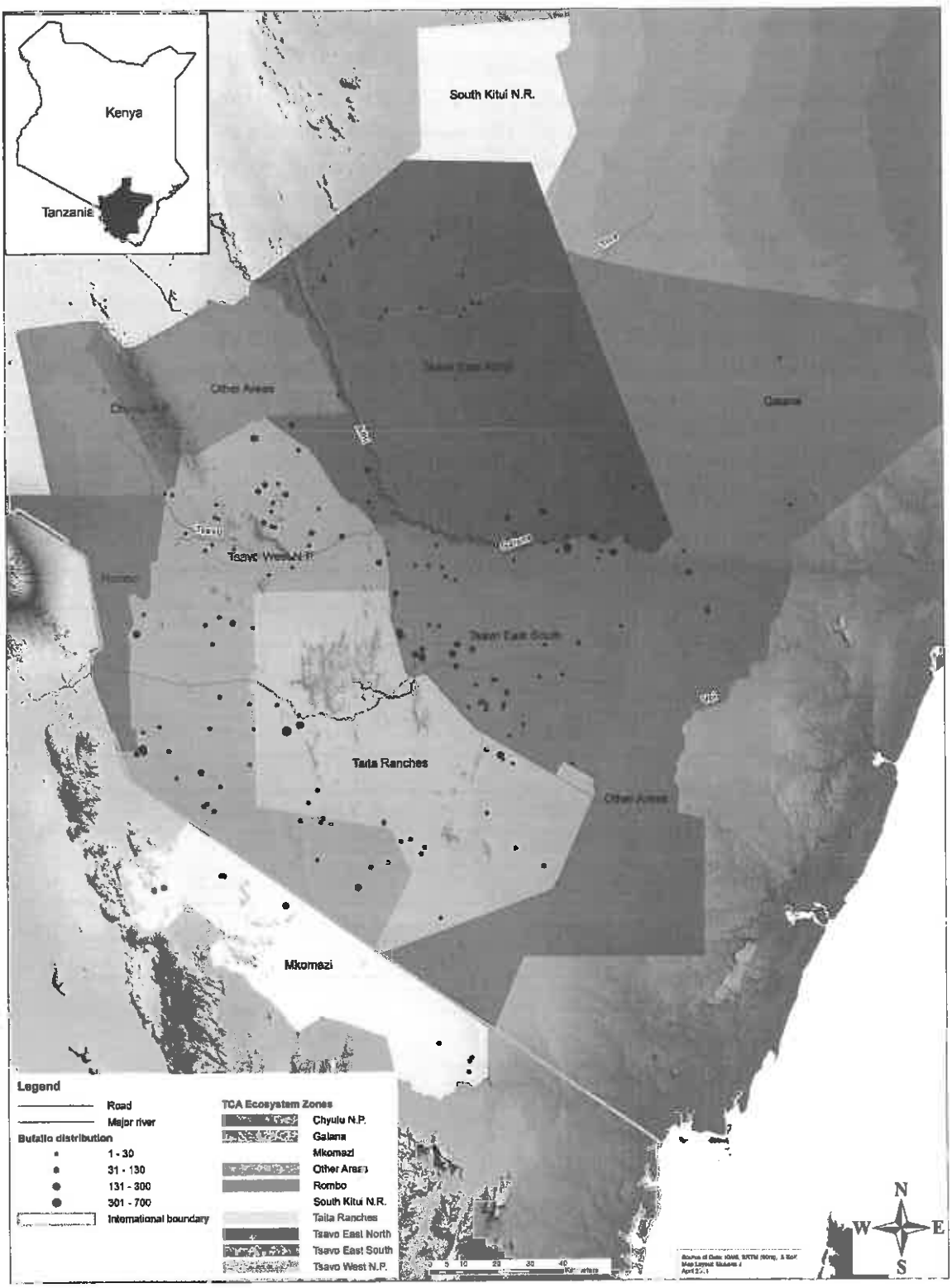


Figure 4.9: Buffalo distribution in Tsavo-Mkomazi ecosystem

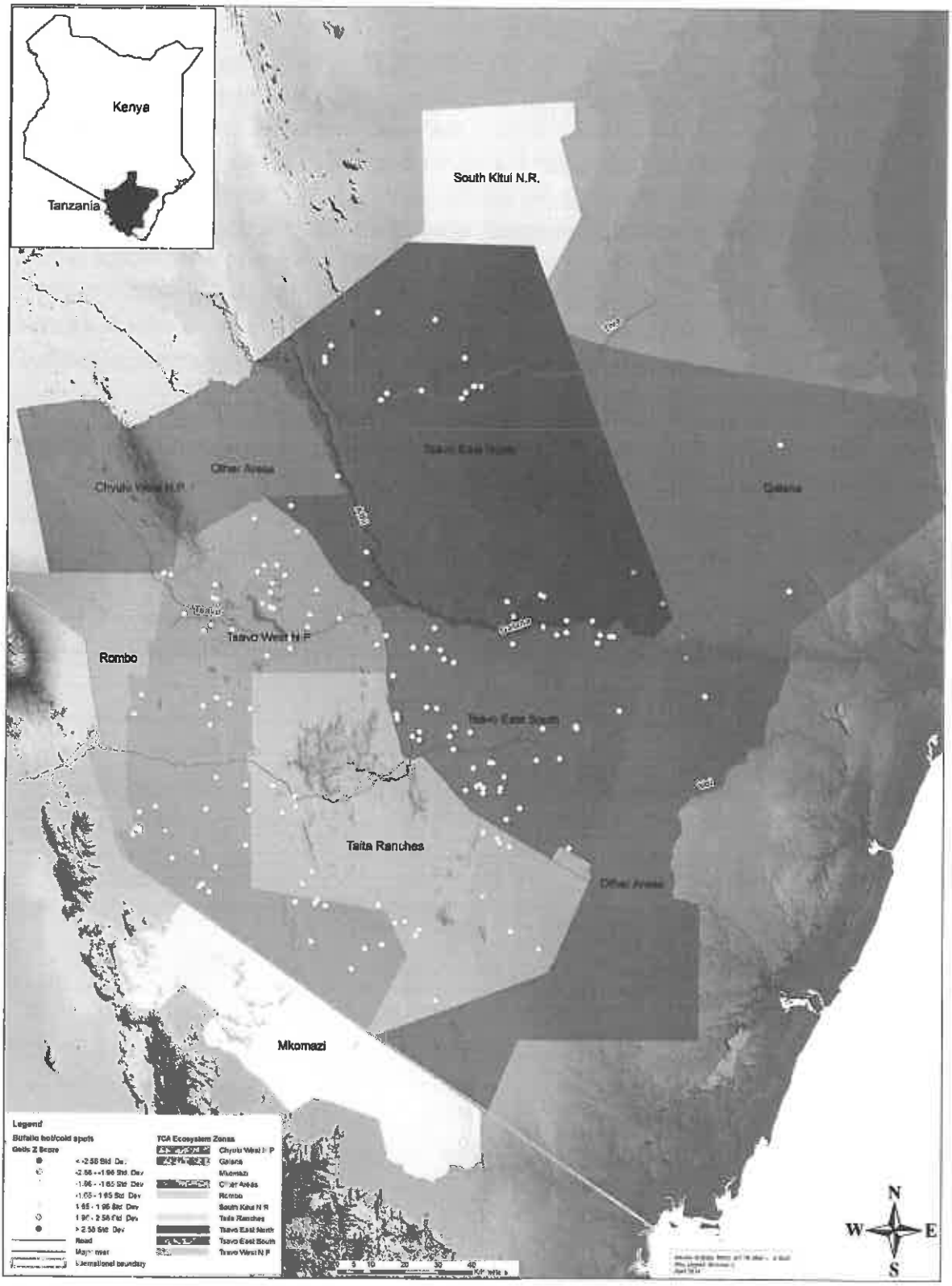


Figure 4.10: Buffalo hot and cold spot analysis.

4.2.4 Status and Distribution of Giraffe

The ecosystem supported a large number of giraffes based on the 2014 census (n=2891) as compared to n=2055 in the 2011 census. Large group sizes of up to 70 individuals were recorded in 2014 (Figure 4.11). Figure 4.12, shows large group sizes in the areas west of the Chyulu hills (area under outside region of the survey blocks), Chyulu NP and the Irima area in Tsavo East NP south.The results indicate that the ecosystem is still critical for the species with the highest number of giraffes counted on the areas of the ecosystem other than protected areas (Table 4.8). The 2014 census results indicated the highest decline of 81.72% in Galana ranches and the highest increase of 88140.45% on regions other than protected areas. Tsavo East NP north and south reported 48.24% and 57.21% decrease in giraffe numbers since 2011. Mkomazi NP population almost doubled while South Kitui N. Reserve recorded impressive population increase compared to 2011 census; overall, the giraffe population in Tsavo-Mkomazi landscape increased by 40.68%.

Table 4.8: Comparison of giraffe population in the ecosystem in 2014 and 2011 and population changes in respective regions.

Giraffe	2014		2011		
Region	n1	%	n2	%	%Increase/decrease
Tsavo East NP (N)	88	3	170	8.27	-48.24
Tsavo East NP (S)	95	3.3	222	10.8	-57.21
Tsavo West NP	184	6.4	691	33.63	-73.37
Chyulu NP	461	15.9	292	14.21	57.88
South Kitui NR	187	6.5	6	0.29	3016.67
Galana	17	0.6	93	4.53	-81.72
Taita	315	10.9	282	13.72	11.70
Mkomazi NP	235	8.1	120	5.84	95.83
Other areas	1309	45.3	179	8.71	88140.45
Total	2891	100	2055	100	40.68

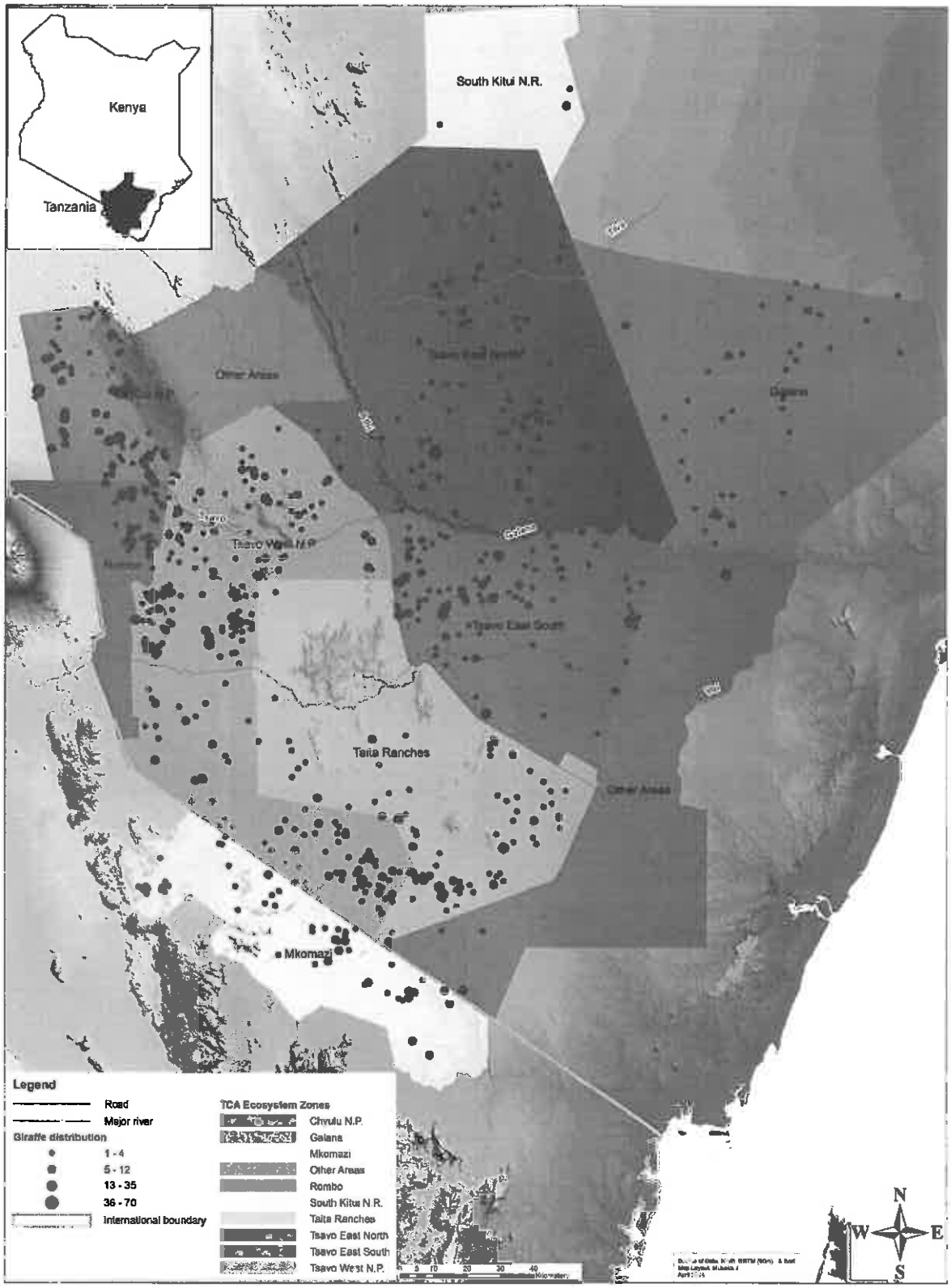


Figure 4.11: Giraffe distribution 2014

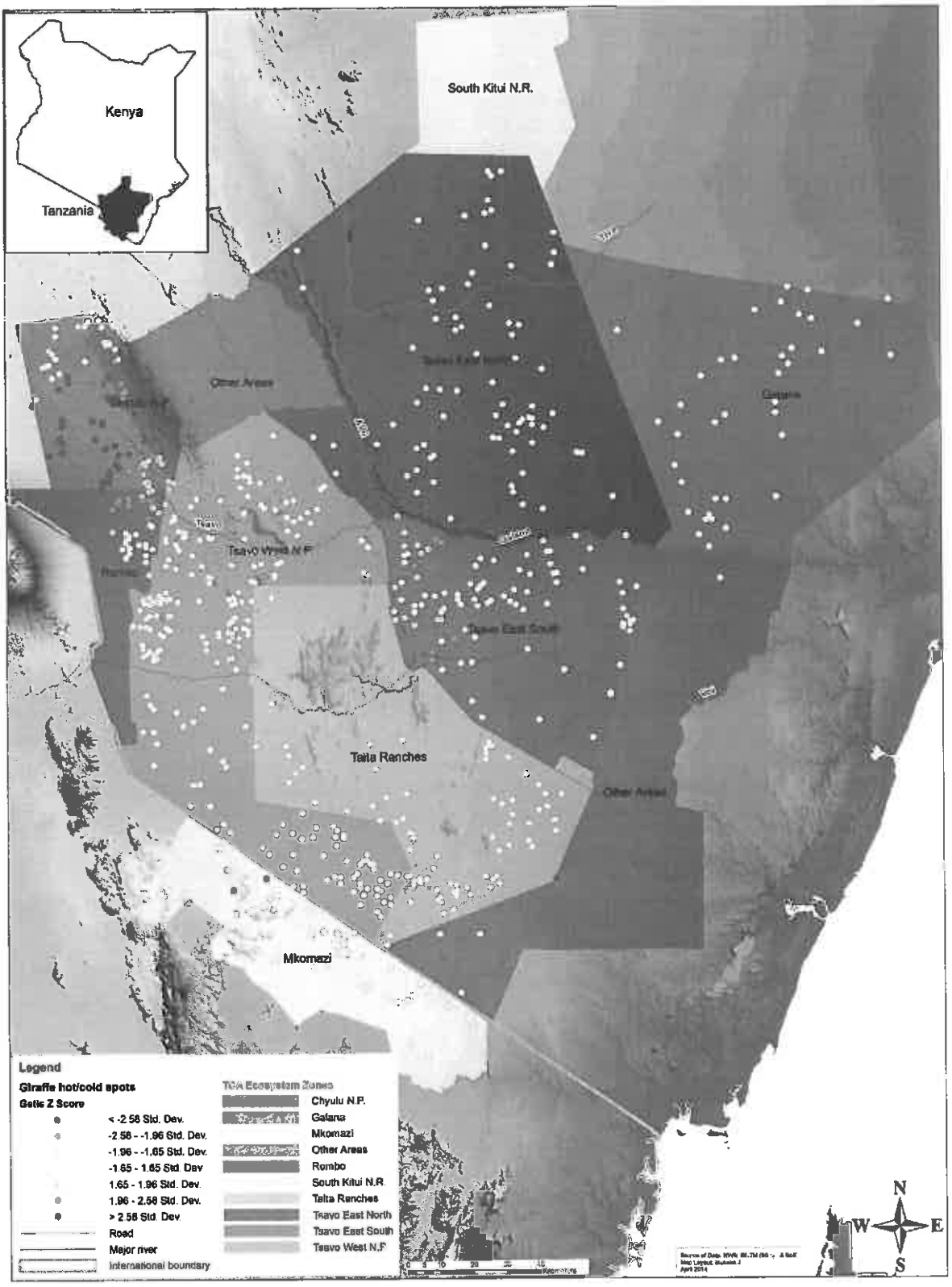


Figure 4.12: Map of hot/cold spots for giraffe 2014

4.2.5 Status and Distribution of Common Zebra

The common zebra numbers in 2014 indicated a 33.91% increase (n=9007) from 2011 observations (n= 6726) (Table 4.8). The highest numbers were recorded in Tsavo West NP and southern sector of Tsavo East NP with 2825 and 2096 individuals counted respectively (Figure 4.13) which coincides also with the large herd sizes (Figure 4.14). In the northern sector of Tsavo East NP, zebras occurred, only along Galana and Tiva rivers though widespread in the southern sector. There were no common zebra observations made in South Kitui NR in 2014 just as in the previous year.

Table 4.8: Status of common zebra in comparison of 2014 and 2011

	2014		2011		
Location	**n**	**%**	**n**	**%**	**%Increase/decrease**
Tsavo East NP North	584	6.48	494	7.34	**18.22**
Tsavo East NP South	2096	23.27	955	14.2	**119.48**
Tsavo West NP	2825	31.36	2248	33.42	**25.67**
Chyulu NP	187	2.08	890	13.23	**-78.99**
South Kitui NR	0	0	0	0	**0.00**
Galana	63	0.7	124	1.84	**-49.19**
Taita	733	8.14	960	14.27	**-23.65**
Mkomazi NP	460	5.11	195	2.9	**135.90**
Other areas	2059	22.86	860	12.78	**139.42**
Total	**9007**	**100**	**6726**	**100**	**33.91**

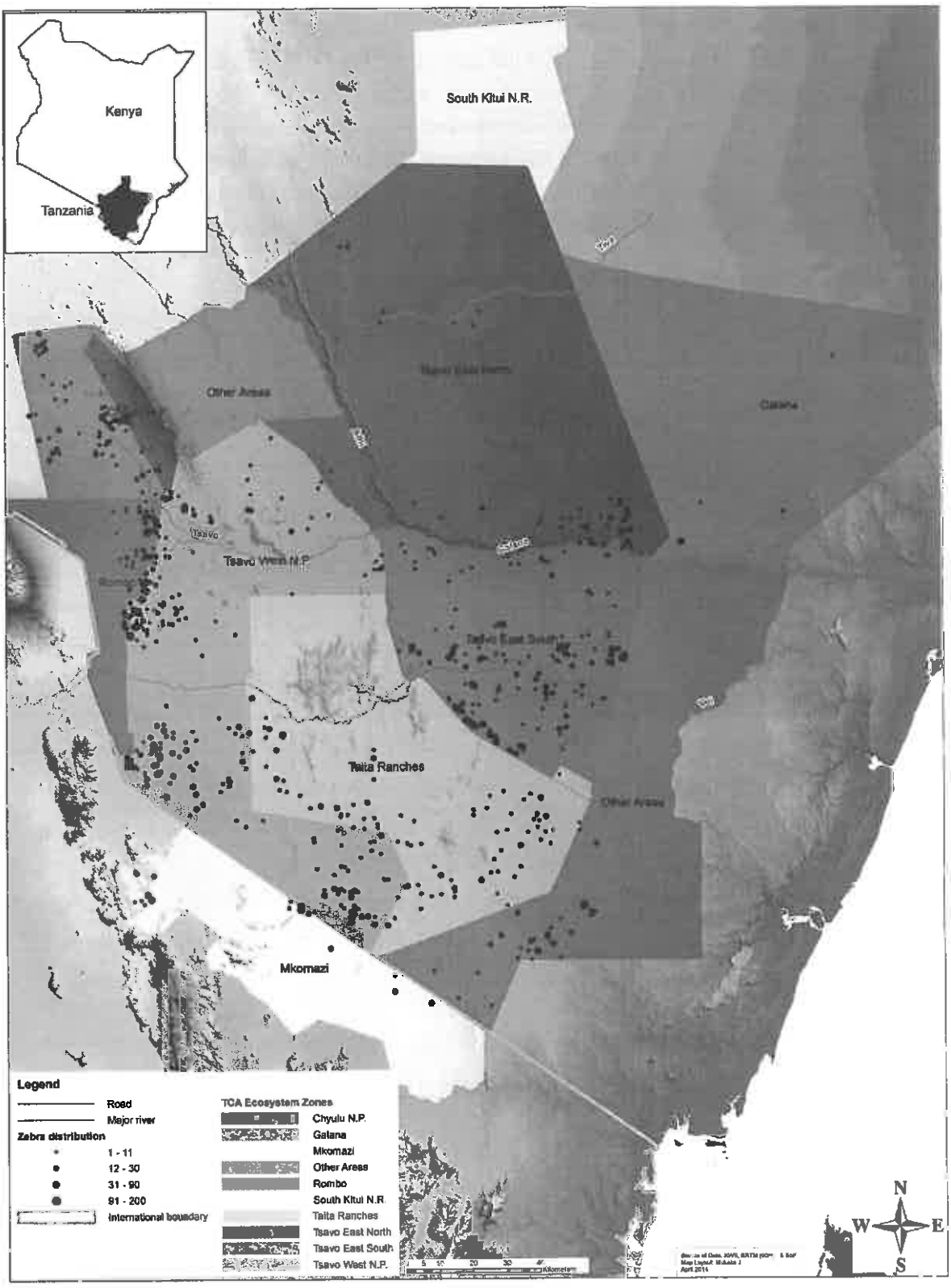


Figure 4.13: Common zebra distribution for year 2014

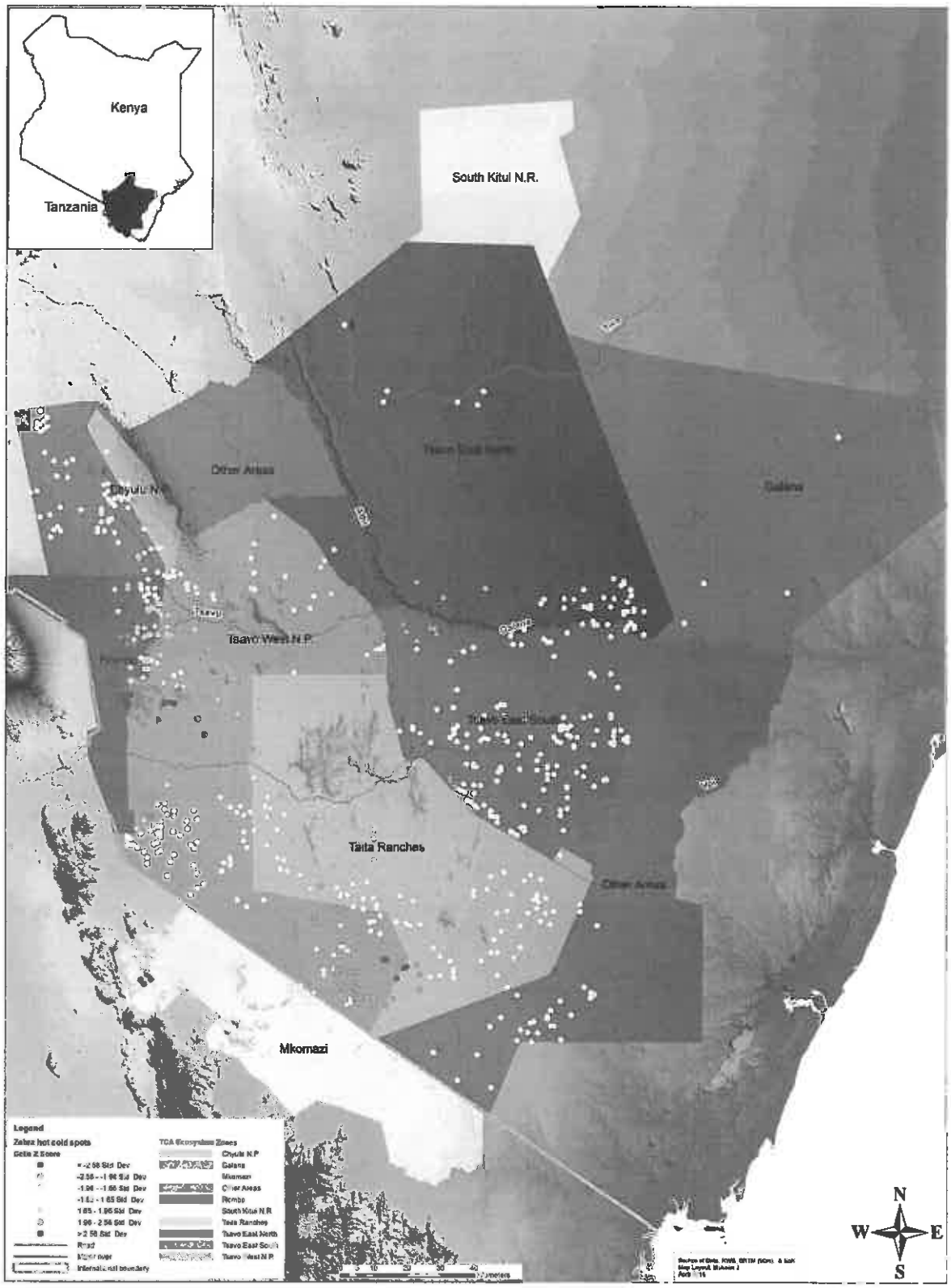


Figure4.14: Hot/cold spot analysis for common zebra 2014

4.2.6 Status and Distribution of Grant Gazelle, Gerenuk and Lesser Kudu

The 2014 census results recorded Grants gazelles and gerenuks in all the regions included in the survey (Figure 4.15). A total of 1530 Grants gazelles and 191 gerenuks were counted in the 2014 census. A total of 568 lesser kudu were observed in eight of the nine regions included in the survey with Chyulu NP recording no individuals of the species.

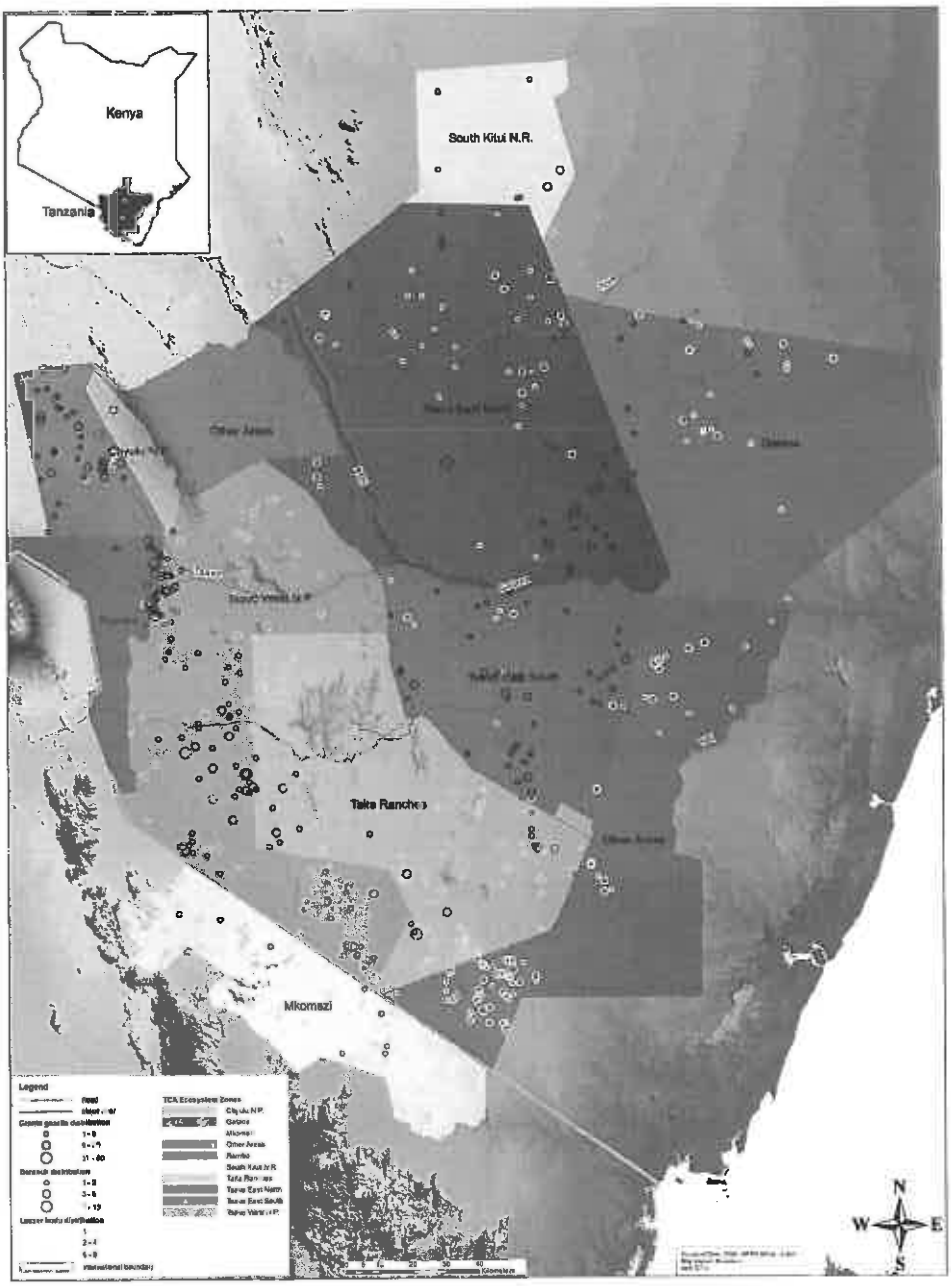


Figure 4.15: Distribution of grant gazelles, Gerenuk and lesser Kudu in Tsavo-Mkomazi ecosystem

4.2.7 Status and Distribution of Ostrich

A total of 589 ostriches were sighted during the census. These were found Tsavo East North (n = 64), Tsavo East South (n = 139), Tsavo West National park (n = 172), Galana (n = 20), Taita Ranches (n = 77), South Kitui National Reserve (n = 12) and other areas (n = 66). Chyulu West including Chyulu National Park and Mkomazi National Park did not have any sightings. Most of the ostriches were counted in Tsavo West National Park followed by the Southern part of Tsavo East National Park respectively (Figure 4.16). In general there was a decline of 11.38% in the ostrich numbers when compared with the 2011 numbers.

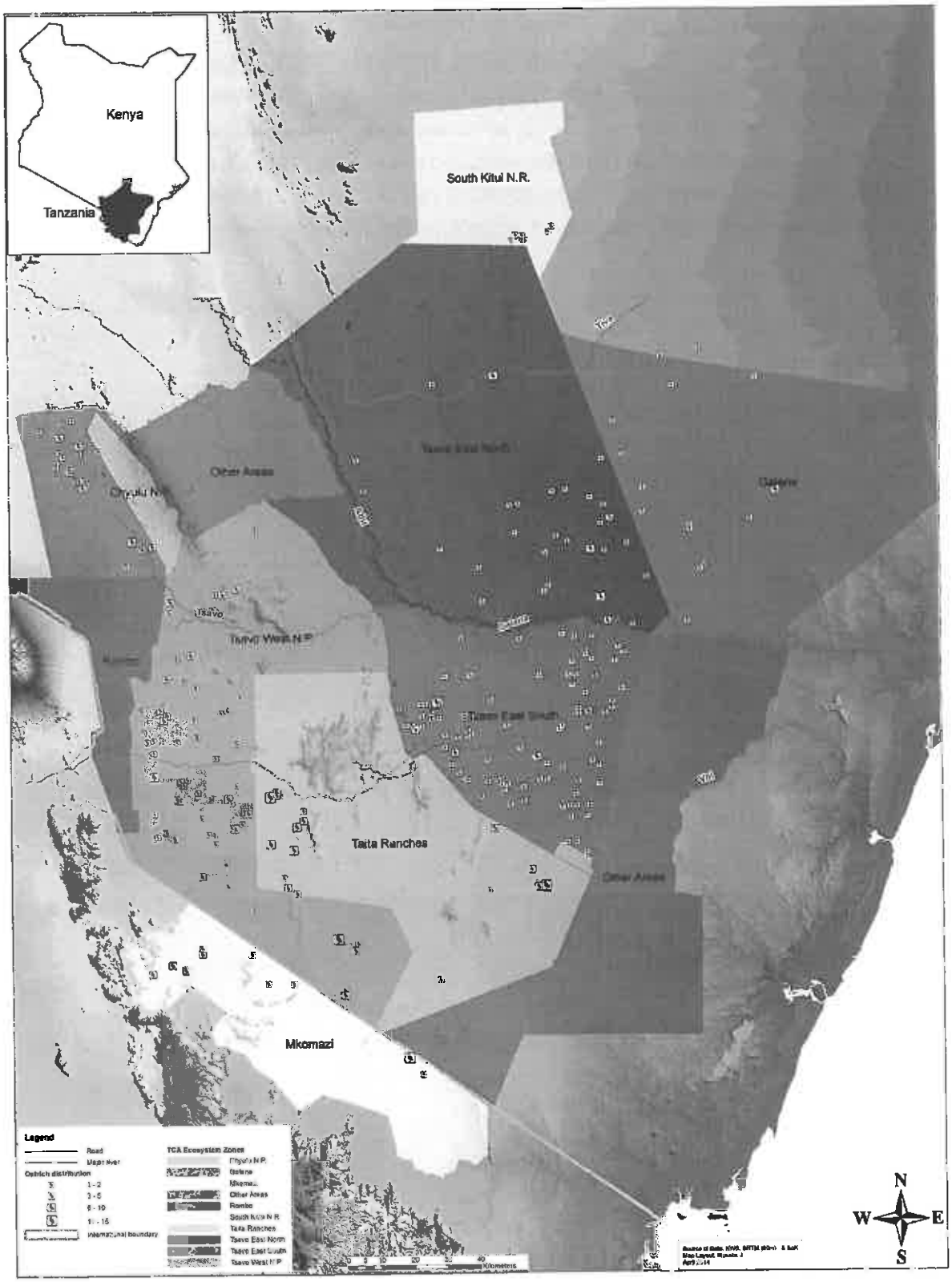


Figure 4.16: Ostrich distribution in the entire ecosystem of Tsavo-Mkomazi

4.2.8 Status and Distribution of Impala, Wildebeest and Kongoni

Impala, Wildebeest and Kongoni were opportunistically counted during the 2014 census. Figure 4.17, shows the distribution of the three species counted in the ecosystem. Impalas were sighted in Tsavo East North (n = 87), Tsavo East South (n =308), Tsavo West (n=184), Chyulu National Park (n =35), Taita Ranches (n=81), Mkomazi National Park (n=96) and the other areas (n=219). The largest number of Impalas was recorded in Tsavo East south (30.5%) followed by the other areas (21.68%). Wildebeest was sighted in four areas only, Tsavo East North (n=85), Tsavo east South (n=11), South Kitui(n=5) and the other areas including Rombo(n=35). The highest number of wildebeest was recorded in the other areas (75.52%) followed by Tsavo East North (14.76%). Kongoni were sighted in Tsavo East North (n=46), Tsavo East South (n=327), Tsavo West (n=595), Chyulu National Park (n=28), Taita Ranches (n=42), Mkomazi National Park (n=114) and the other areas (n=60). The largest numberofKongoniwere recorded in Tsavo west (48.67%) followed by Tsavo east South (27.2%).

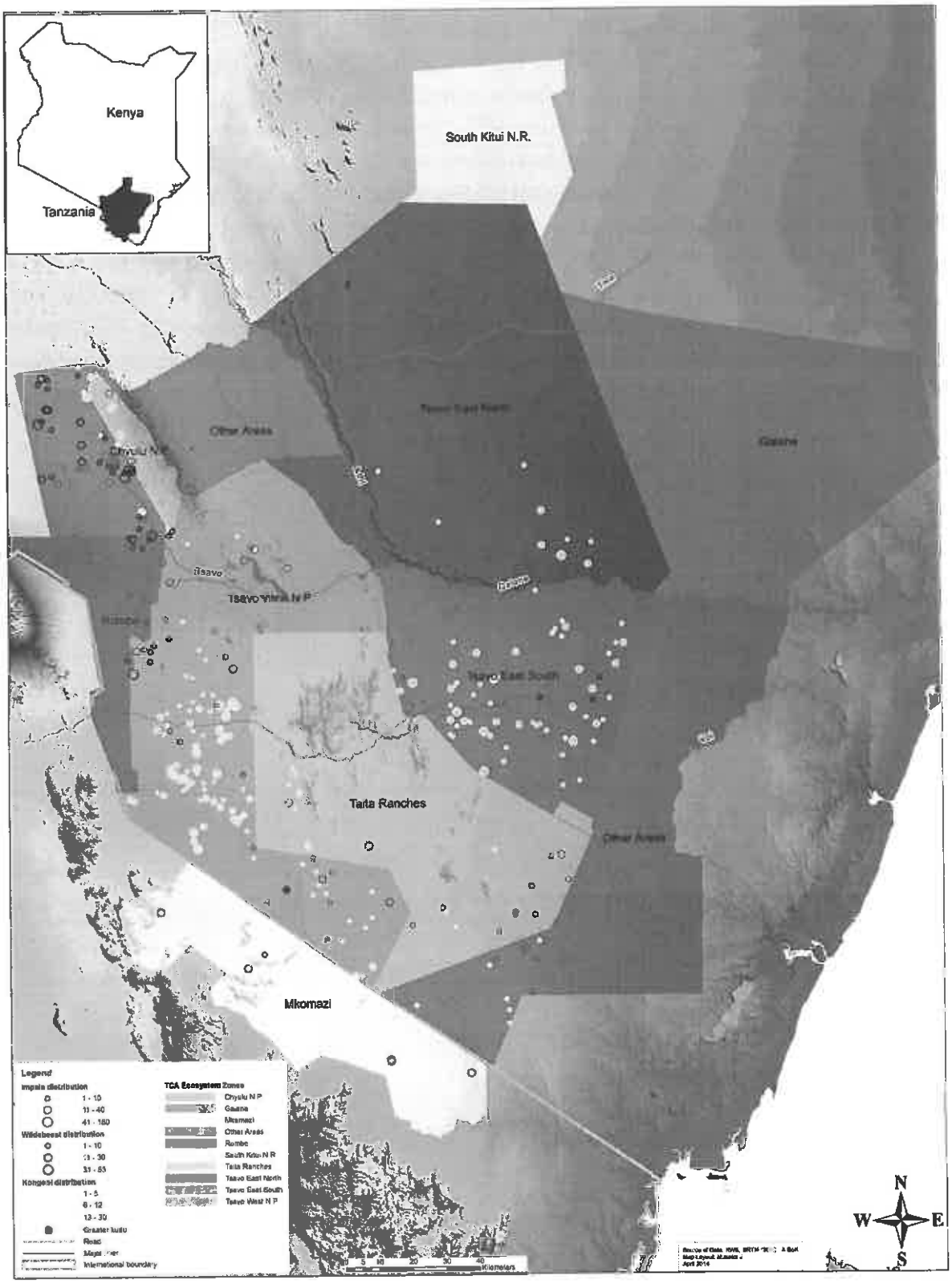


Figure 4.17: Map showing distribution of impala, Wildebeest and Kongoni

4.2.9 Status and Distribution of Eland, Oryx and Hirola

The 2014 Tsavo-Mkomazi census indicated an estimated 110% growth in eland population from 1508 in 2011 to 3166 in 2014 (Figure 4.18). The results indicate that the highest numbers in 2014 were in Tsavo West NP, Taita ranches, Mkomazi NP with 32.5 % (n=1029), 19.1% (n=605) and 17.4% (n=551) respectively. On the other hand, a total of 1588 Oryx were counted with 38% (n=606) of these were in Tsavo West NP, 25% (n=397) in Tsavo East North and 13% (n=209) in Tsavo East South. Hirola antelope a species introduced to Tsavo East NP from Ijara recorded a total of 15 individuals in the 2014 census. The 15 individuals were all counted in Tsavo East South in an area that is a known hirola range.

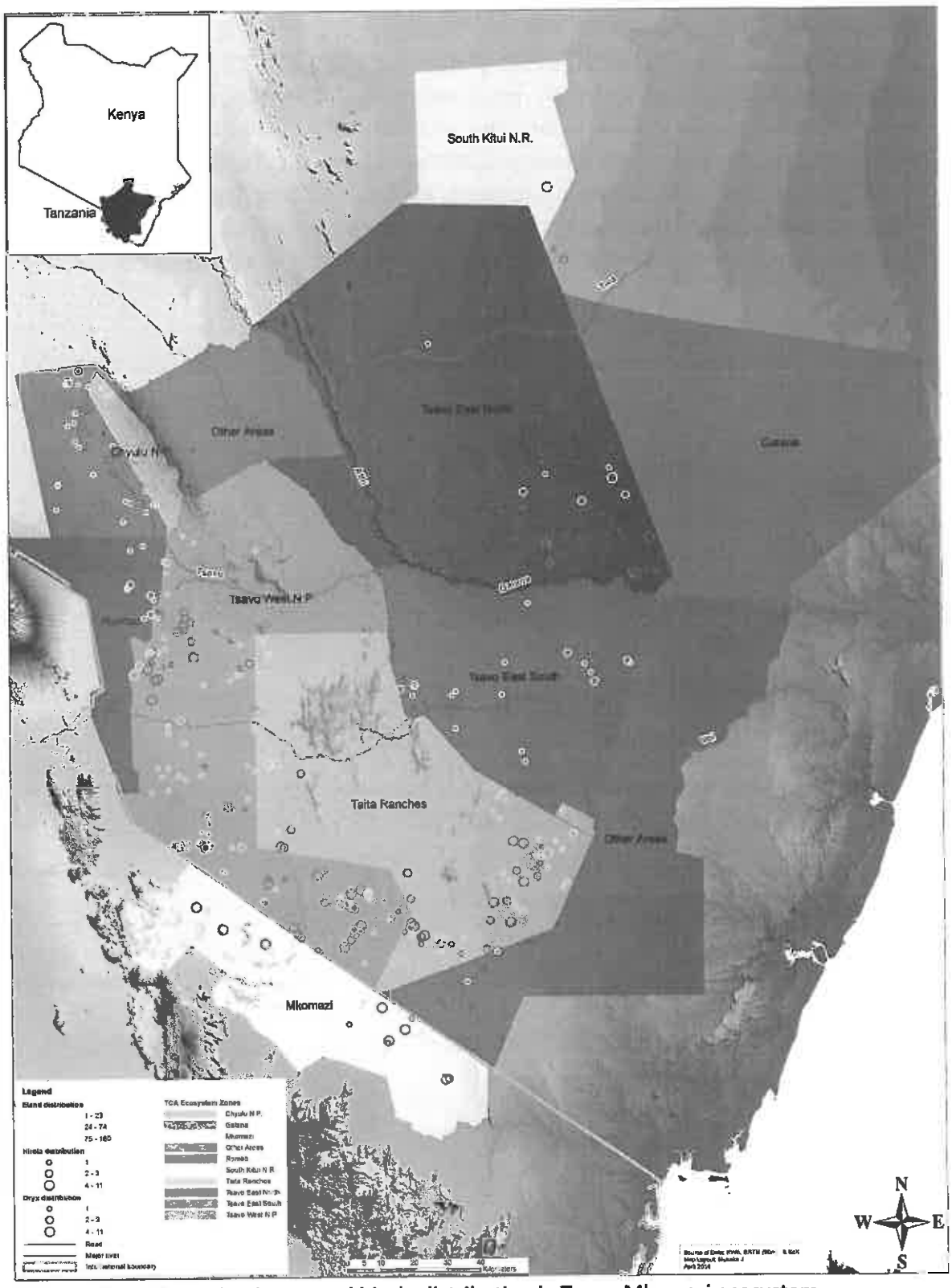


Figure 4.18: eland, oryx and hirola distribution in Tsavo-Mkomazi ecosystem.

4.2.10 Status and Distribution of Carnivores

The methodology used for the census is not suitable for determining carnivore numbers and distribution. Through opportunistic sightings however, the carnivore sightings results were able to indicate their presence in Tsavo Conservation MkomaziArea. During the 2014 Tsavo – Mkomazi census, 14 lions were sighted Tsavo East North (n = 7), Tsavo West (n = 4), Galana (n= 2) and Taita Ranches (n= 1) (Figure 4.19). Fewer wild dogs (n = 4) were sighted compared to 2011 when 38 wildogs were sighted. Hyenas were sighted in Tsavo East North (n=3), Tsavo East South (n=2) and Taita Ranches (n=1). Jackals were sighted in Tsavo East North (n=21), Tsavo West (n=4), Galana (n=2) and Taita Ranches (n=1). In 2011 only four Jackals were recorded in Tsavo East South, Chyulu and Galana.

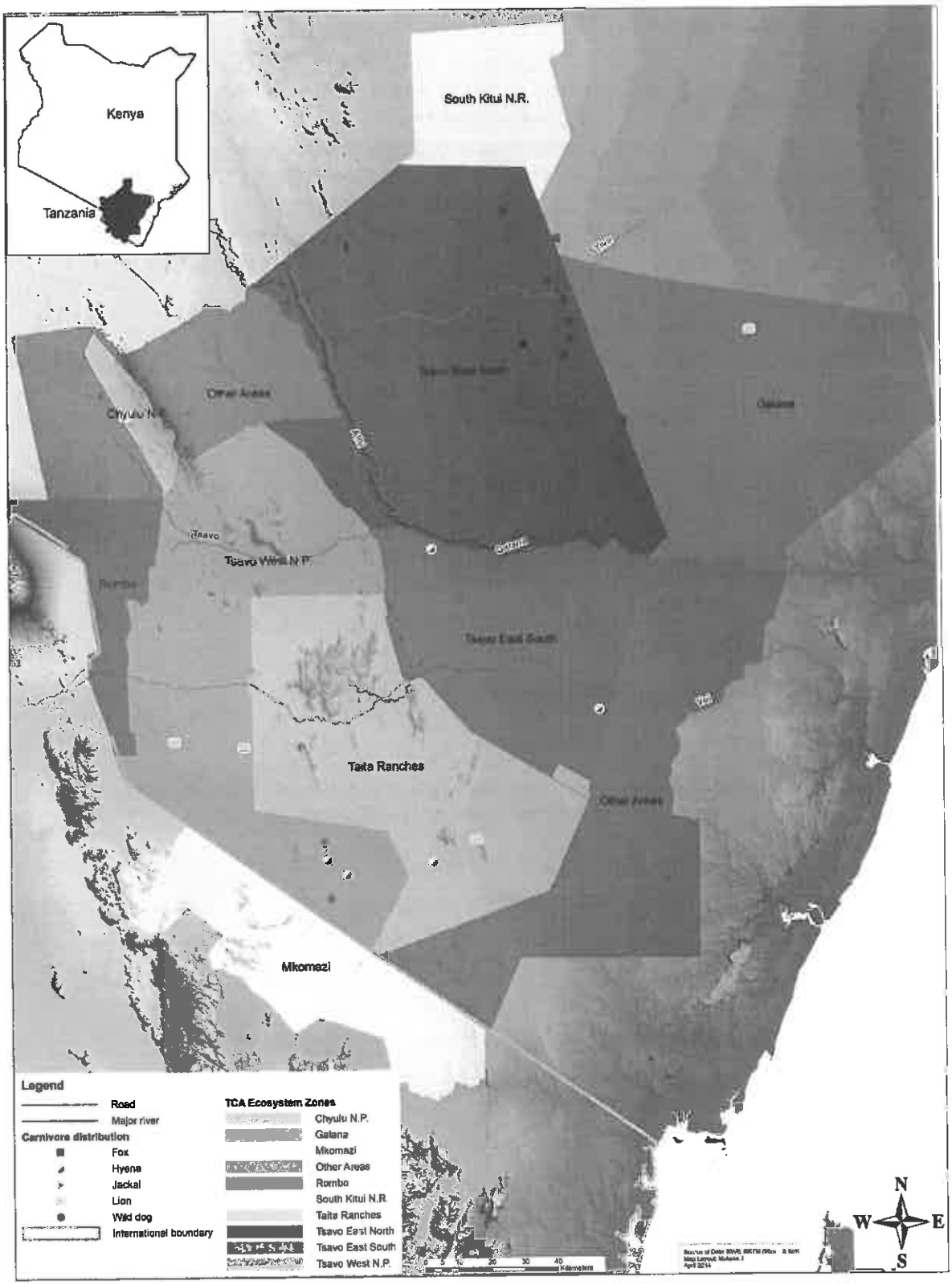


Figure 4.19: Carnivore distribution in the ecosystem.

4.2.11 Status and Distribution of other Species

Other important species counted during the census include the endangered grevy zebra, topi, warthog, waterbuck, hippo, Thomson gazelle and dik dik (Figure 4.20). Nineteen grevy zebras were counted in 2014 compared to 47 seen in 2011. All the 19 were observed in Taita ranches compared to 29, 3 and 15 seen in the northern Tsavo East National park, southern Tsavo East National Park and Taita ranches respectively in 2011.

Fifty one topis were counted in 2014. They were mainly concentrated in the southern sector of Tsavo East National park (32), Tsavo West National Park (15) and Taita ranches (4). In 2011 however, only two topis were observed in the northern Tsavo East National Park sector.

Warthogs were widely distributed within Tsavo-Mkomazi ecosystem except in Chyulu National Park. A total of 659 individuals were enumerated in 2014 compared to 272 counted in 2011. The 2011 warthog distribution was similar to that observed in 2014.

Just like warthogs, waterbucks exhibited wide distribution within the ecosystem with a similar pattern witnessed in 2011. However, a small number of individuals (155) were counted in 2014 census compared to 468 observed in 2011.

Hippos were observed along permanent water courses of Athi, GalanaRivers in Tsavo East national Park and along Tsavo River as well as Lake Jipe and Chala in Tsavo West National Park. A total of 164 hippos were counted in 2014 compared to 119 counted in 2011.

Thomson gazelles were mainly concentrated in the central part of Tsavo West NP, southern sector of Tsavo East NP, around Chyulu NP and a few seek in Taita ranches. A total of 217 individuals were counted compared to 108 seen in 2011. A similar population distribution pattern documented in 2014 was also observed in 2011.

Though dik diks were counted in most parts of the ecosystem, curiously very few were seen in the central sector of Tsavo East NP. Curious too is the fact that none were documented in the 2011 census. A total of 133 individuals were observed in 2014.

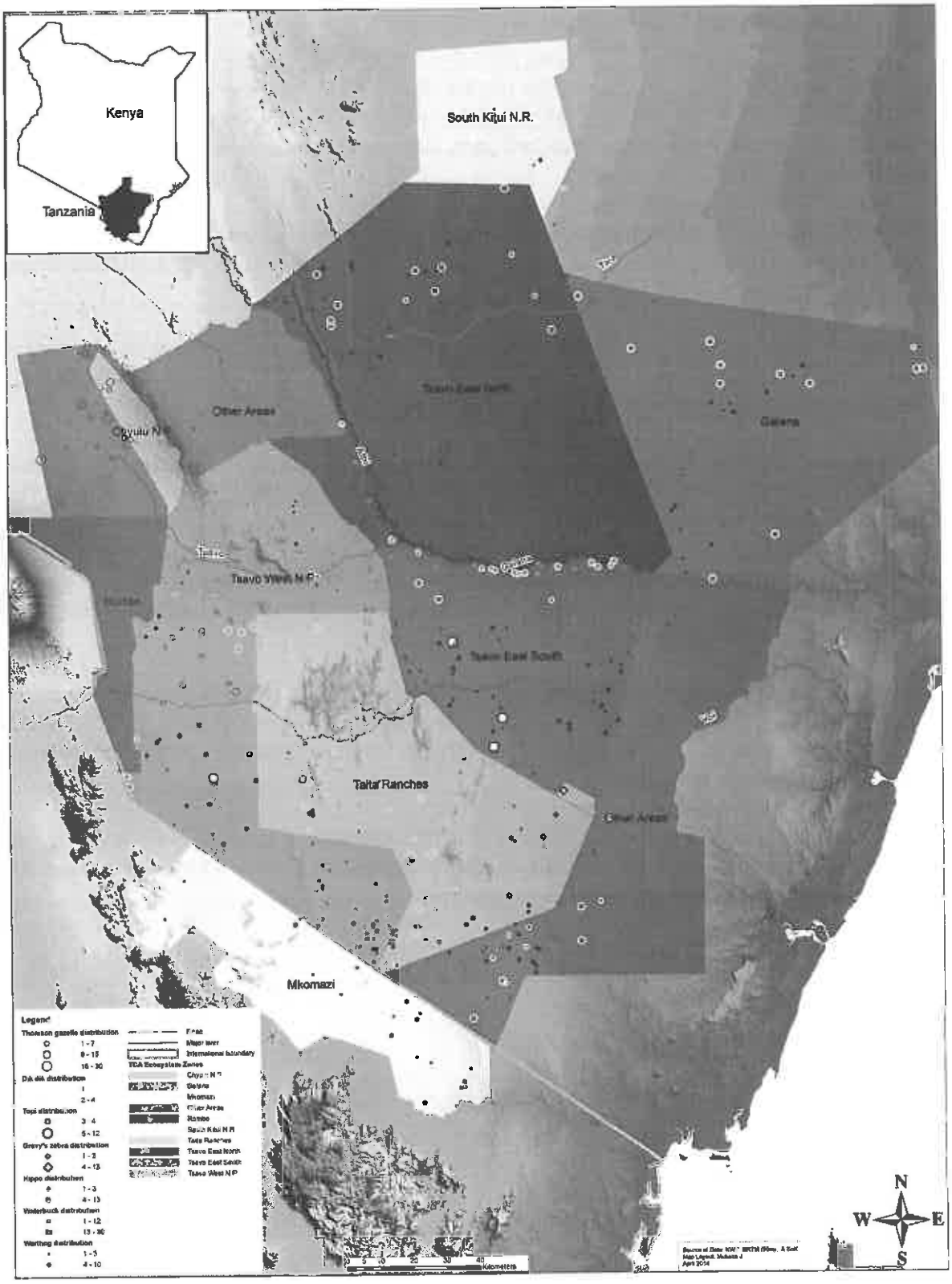


Figure 4.20: Distribution of other wildlife species in the ecosystem.

4.3 Status of Wildlife Habitats

4.3.1 Distribution of Sources of Surface Water

Tsavo-Mkomazi ecosystem is served by three types of surface water namely rivers (permanent and Seasonal), artificial (man-made) and natural points (natural collection of water) and underground water in form of boholes. Distribution of these water bodies determines the distribution of wildlife. During the 2014 census, artificial and natural water were documented (Figure 4.21). A total of 195 artificial water points were counted in the ecosystem where 67.69% were inside protected areas. Out of this, 98.48% were with water while the rest were dry. Slightly more than a half (55.57%) of the artificial water points outside the protected areas was found with water. However, natural water points were almost fifty-fifty inside (50.21%, n= 707) and outside (49.79%, n= 701) the protected areas. 60.91% of the natural water points found outside protected areas were wet.

Chyulu NP, Rombo and Tsavo East NP north of Galana River are not supplied with artificial water points but depend mostly on natural water points. South Kitui NR and Galana regions were supplied with less wet watering pointscampared to Taita ranches, Tsavo West NP and other areas. High concentrations of watering points are in south east of Taita Ranches, south and south East of Tsavo East NP south of Galana River and Kamboyo area North of Tsavo West NP (Figure 4.21)

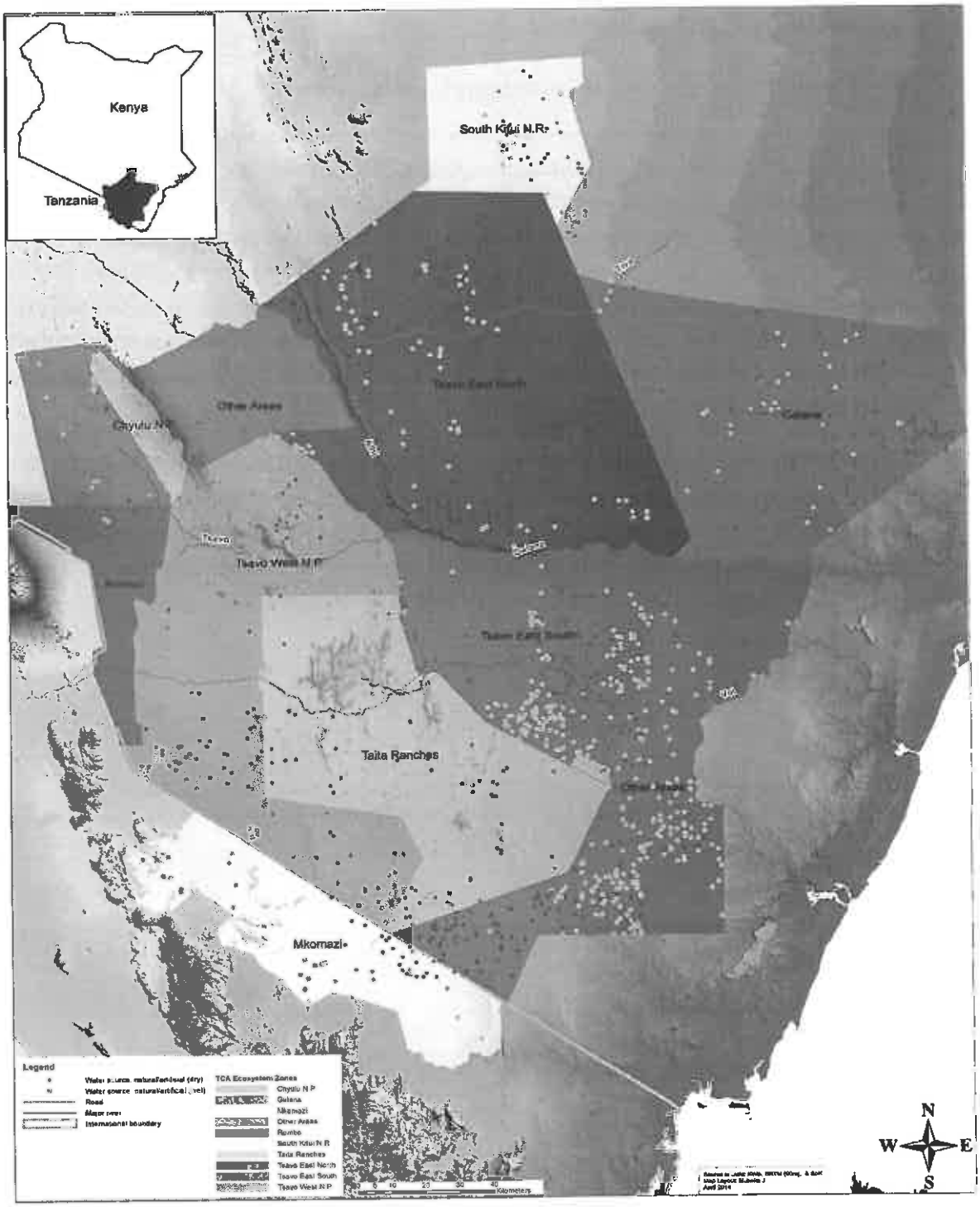


Figure 4.21: Distribution of water sources in the ecosystem including wet and dry water points.

4.4 Human Activities

4.4.1 Status and Distribution of Cattle

Tsavo Protected areas are surrounded by ranches and community lands which are set aside for livestock ranching and settlements. During the 2014 census, an approximate of 170,049 cattle was counted compared to 115,798 counted in 2011 (46.85% increase). Large concentrations were recorded in the ranches (Taita, Galana, Kulalu), West of Chyulu NP, Rombo, South Kitui and southern part of the study area (Figure 4.22). However, some of the protected areas have cattle especially in south and west of Tsavo west NP and East of Tsavo East NP north of Galana River within Ndiandasa area. Notably, cattle concentrate in areas along the park boundaries.

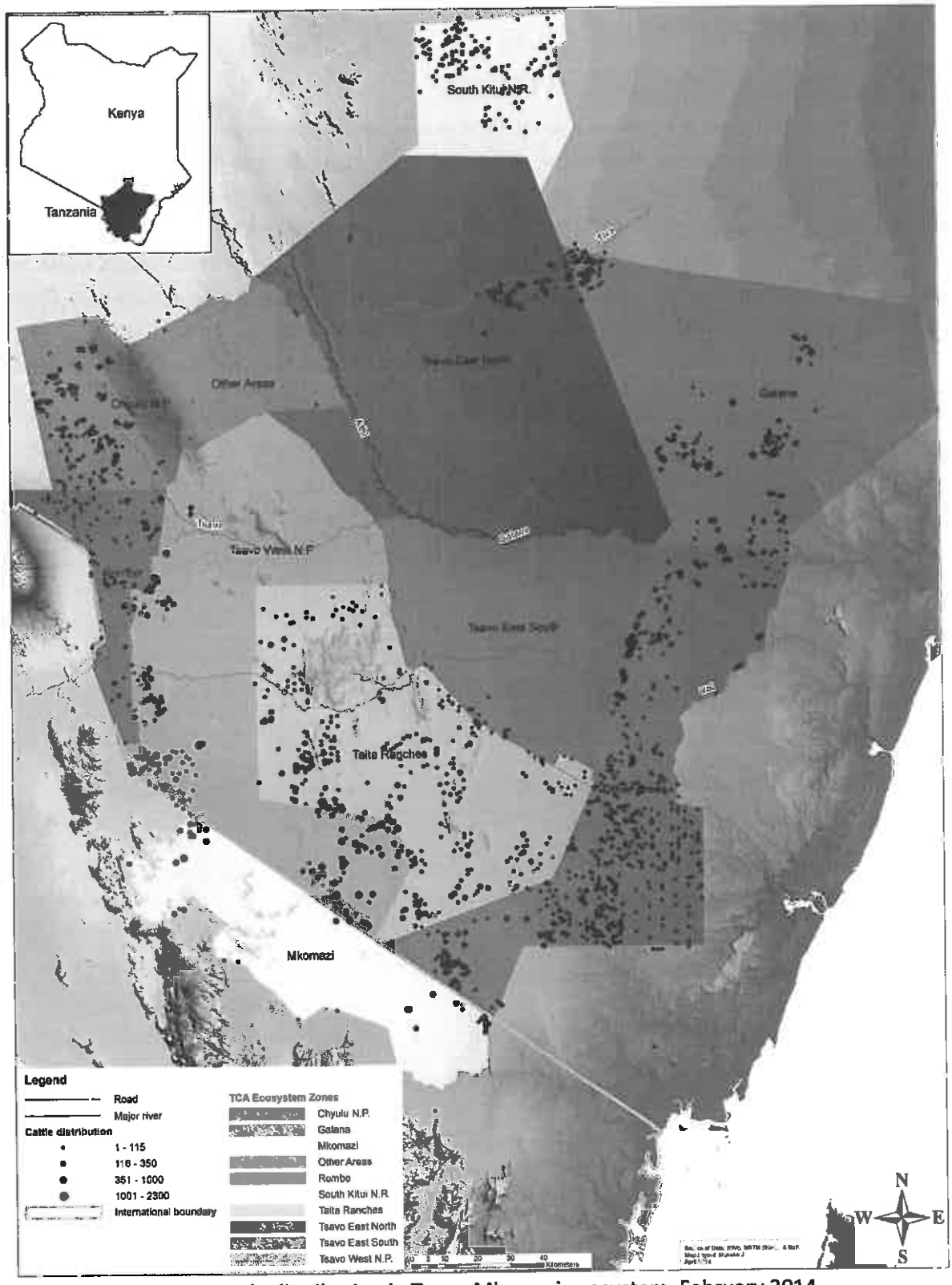


Figure 4.22: Cattle distribution in Tsavo-Mkomazi ecosystem, February 2014