# Aerial survey of Hirola (*Beatragus hunteri)* and other large mammals in south-east Kenya

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## SUMMARY

In January 2011, an aerial count of hirola (*Beatragus hunteri*), other wildlife and livestock was carried out over a 12,000 km$^2$ area of south-eastern Kenya, including Ijara and parts of Fafi, Lamu and Garissa districts, encompassing the remaining extent of the hirola's natural range in Kenya. The survey was carried out over a 7 day period using a combination of 4-seater and 2-seater light-aircraft at 1 km transect intervals across the entire area. A total of 245 hirola were observed during the aerial survey.

A comparison of two ground-count and four aerial-count replicates over a 200 km$^2$ sample of the survey area revealed a detection probability of 37.4 % (SD ± 3.0) for hirola in habitats with an average tree cover of 21.6 %. Adjusted estimates for the hirola population in similar habitat (equivalent to 46 % of the survey area) over the entire survey area, combined with a minimum count for denser habitats (54 % of the survey area), gives a revised population estimate of **434 (SD ± 30.19)** with a 95 % confidence interval range of **402 to 466 individuals**.

Low detection probability during the survey may in part be due to the failure of the rains in November and December 2010 which resulted in this being a dry-season rather than wet-season count as intended. The cryptic colouration of hirola against dry bush made observations difficult; detection probability was only determined for one habitat type. The low number of small herds scattered over a wide area makes detection of hirola using aerial surveys problematic, even when carried out at 1 km intervals (equivalent to a 500m counting strip which is considered 'total' coverage of the area). As previously recommended, aerial surveys carried out during the wet season are likely to have higher detection probabilities for hirola than were achieved during this count.

The only concentrations of hirola found were in Ishaqbini Hirola Community Conservancy on the eastern bank of the Tana River Primate Reserve, and Gababa south of Arawale Reserve. Several small herds were found along the north-western edge of the Boni forest; however, throughout the rest of its historic range, hirola were only found in very small, isolated groups.

Comparison with previous population estimates from aerial surveys is difficult since different methods were used and no detection probability was determined for the only other 'total' count that has been conducted (in 1995). However, the dramatic decline of hirola since the 1980s, continued decrease in population size and range over the last 20-25 years and lack of a secure *ex-situ* or captive population means hirola are likely the most endangered antelope in the world. This survey highlights the critical status of hirola within its natural range and reinforces the urgency of targeted conservation interventions to reverse the decline of this species and aid in its recovery.

Estimates of other wildlife in the survey area included over 3,500 buffalo, 1,600 reticulated Giraffe as well as large numbers of lesser kudu, gerenuk and coastal topi. These species are not confined to the survey area and their range extends beyond the survey boundaries, however it gives an indication of the relatively large numbers of wildlife that remain in this part of south-eastern Kenya.

## ACKNOWLEDGEMENTS

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## INTRODUCTION

The hirola (*Beatragus hunteri*) is the only extant member of its genus and is found in a relatively small part of south-eastern Kenya close to the Somali border with a small introduced population also found in Tsavo East National Park. The species is now most likely extinct or extremely rare in Somalia. Conservation efforts date back to the 1960s with attempts to establish *ex-situ* populations in Tsavo East and various zoos. However, the dramatic decline of hirola in the early 1980s from an estimated 13,000 to 1,500 individuals highlighted the critical status and vulnerability of this species. Since then, a second translocation of hirola to Tsavo East was undertaken in 1995 and community engagement in conservation has occurred through development of Ishaqbini Hirola Community Conservancy particularly since 2007. Despite these measures, however, little evidence of recovery of the population has been seen and it is likely still declining in its natural range; no viable zoo populations exist and the *ex-situ* population in Tsavo is also not doing well. The status of hirola up to the present day has been well documented elsewhere (e.g. Andanje 2002[1]; Butynski 2000[2]; Kock *et al.* 2010[3]) and is not covered further in this report.

The last attempts to estimate the hirola population in its natural range were in the 1995/1996 by Kenya Wildlife Service (KWS) and KREMU/DRSRS. Although survey methods used were different and not comparable, the results again highlighted the critically endangered status of this species. In 2010, the Hirola Management Committe of the Kenya Wildlife Service identified the need to establish the current status and distribution of hirola in its natural range as a priority for conservation of the species. The aim of this survey was **to estimate the number and distribution of hirola remaining across their entire natural range in Kenya**. This information will be used to inform targeted conservation interventions by identifying key areas and concentrations of the species as well as providing data for monitoring the impact of conservation on recovery of hirola in future. The survey also estimated numbers of other large mammals, both wildlife and livestock, throughout the survey area.

## METHODS

### 1. Survey area

Selection of the survey area was based on hirola distribution from previous surveys as well as local and expert knowledge on current hirola distribution. The entire survey area covered approximately 12,000 km$^2$ and was divided into blocks, where possible using physical features (roads, rivers) as boundaries (Fig. 1).

The survey encompassed two gazetted protected areas the eastern bank of the Tana River Primate National Reserve, Arawale Reserve and the community conservancy of Ishaqbini; there is no form of protection of the remaining areas which are pastoralist rangelands utilised by local Somali communities.

[1] Andanje S.A. (2002). *Factors limiting the abundance and distribution of hirola (Beatragus hunteri) in Kenya.* PhD thesis, University of Newcastle Upon Tyne, UK.

[2] Butynski T. M. (2000). Independent evaluation of Hirola Antelope (*Beatragus hunter)* Conservation Status and Conservation Action in Kenya. Unpublished report. Kenya Wildlife Service and Zoo Atlanta.

[3] Kock R., Amin R., Andanje S., Rice M., King J., Craig I. & Tear T. (2010). Predator proof fenced sanctuary for the hirola. Unpublished report to the Kenya Wildlife Service.

Major habitat across the survey area was *Acacia* bushland interspersed with more open/lightly bushed grassland areas which are preferred by hirola. The southern extent of the survey area was bounded by woodland/savanna mozaic; this habitat is continuous with the coastal Boni forest. Searching for hirola along the forest edge was carried out by flying off transect into the more open habitat 'fingers' of wooded grasslands.

The survey area was bounded by the Tana River and riverine forest in the west, extended as close to the Somali border as possible in the east, and to the north was defined by local/expert knowledge on current hirola distribution.

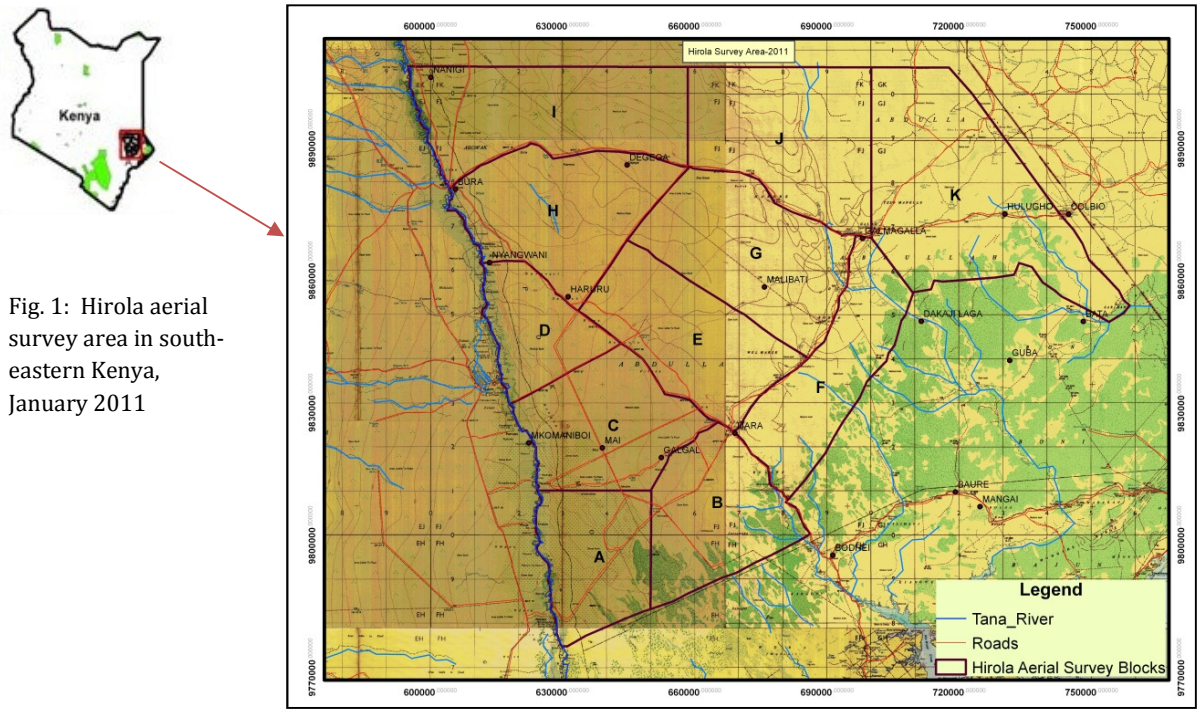



Fig. 1: Hirola aerial survey area in south-eastern Kenya, January 2011

## 2. Survey methods

Aerial survey methods used were for a total count, as described in Douglas Hamilton (1994[4]). This method is preferred by KWS and is standardised for all aerial surveys of large mammals. The survey was conducted over a period of 7 days between 24 - 30 January 2011. Conditions were dry due to the failure of the November/December 2010 rains.

Four aircraft were used for the survey consisting of three 2-seater and one 4-seater light aircraft. Four-seater aircraft had pilot, Front Seat Observer (FSO) and two Rear Seat Observers (RSO); in the 2-seater aircraft the pilot also observed on one side of the aircraft and the passenger served as FSO and observer on the opposite side. All teams were experienced in aerial surveys and were familiar with hirola.

Aircraft tracks were logged using GPS and later downloaded to ensure the entire survey area was covered. All observations made were saved in the GPS as waypoints and species and number/estimate recorded on data sheets by the FSO.

The survey was flown at 1 km linear transects, with an effective strip width of 500 m either side of the aircraft. Counting was restricted to the cooler times of day: 0600-1030 and 1600-1800 hrs. Where possible fuel was transported to airstrips close to the counting blocks to minimize travel time.

[4] Douglas-Hamilton, I. (1997) Counting Elephants from the Air – Total Counts. Chapter 4: African Wildlife Foundation Manual

The ground team, consisting of survey coordinator, GIS and data entry personnel and aircraft technicians were based at Masalani for the duration of the survey. Flight lines for each aircraft were mapped daily and decisions made on allocation of aircraft the following day based on remaining survey areas with emphasis on counting contiguous areas on consecutive days.

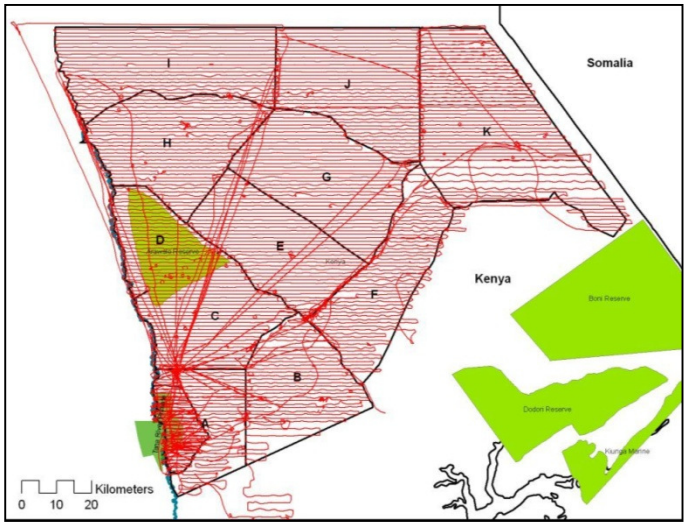



Fig. 2 Flight lines of the completed survey

## 3. Detection probability

To estimate the detection probability of hirola (i.e., the probability that a hirola is seen on an aerial transect, given that it occurs on an aerial transect), a comparison of aerial survey and ground count data for a sample area was carried out within the core area of Ishaqbini Conservancy. It was not possible to do this for other habitat types or areas.

Two replicate ground counts of hirola were conducted on 26th and 28th January by teams of NRT and Ishaqbini rangers. These covered approximately 200 $km^2$ and used both vehicle and foot patrols to find and count hirola groups. Location of groups was based on local knowledge of the area and recent tracks/spoor; the location of all hirola herds was marked with a GPS and the total number in each herd was recorded.

Four replicate aerial surveys were conducted of the same sample area by two different aircraft (the 4-seater and one 2-seater). Surveys were conducted in the early morning or late afternoon on 4 different days during the survey (24th, 25th, 27th and 30th).

Detection probability was calculated as follows:

1. Generated normally distributed data of ground survey with mean ± SD and aerial survey mean ± SD
2. Boostrapped the difference between the two means to calculate detection probability taking ground survey as standard detection probability (%± SD).

The detection probability was corrected for habitat type (% tree cover) across the survey area, assuming that detection probability increases with decreasing tree cover. Detection probability was applied to only the habitat type consistent with or with lower tree density than that found in the sample survey area. A detailed description of analysis of tree cover across the survey area is shown in Appendix 1.

# RESULTS & DISCUSSION

## 1. Hirola population estimate

A raw count of 245 hirola was generated from the aerial survey. However, comparison of replicate ground and aerial count data over the sample survey area were used to determine the detection probability (assuming ground count data was more representative of true population size), since aerial surveys consistently undercounted hirola. Detection probability was calculated as 37.4 % (± 3.0 SD).

Within the sample survey area in Ishaqbini, estimated tree cover averaged 21.63 % ± 6.04 SEM. Within the broader study area, estimated tree cover averaged 35.12 % ± 7.62 SEM. Of the habitat cells randomly sampled across the greater survey area, 54 % has estimated tree cover equal to or greater than that of the sample survey area in Ishaqbini. The detection probability rate (37.4 %) was therefore applied to only the habitats with either equivalent or less tree cover than the sampled area (i.e. 46 % of the survey area).

- 245 hirola x 46 % of the study area = 113 hirola
- 113 hirola / 37.4 % prob detection = 302 hirola in 46 % of the sampling area

Delta method variance = (302^2) * ((0.08^2) + (0.06^2)) = 912

- √912 = 30
- 95% CI = 270-334

It is not possible to estimate the uncertainty around the remaining 132 hirola in 54 % of the study area since detection probability was not determined for habitat types with higher % tree cover than that found in the Ishaqbini sample area.

Therefore, 132 is added to the 95 % confidence intervals above to generate a **<u>conservative</u> estimate** of the population of **434 (± 30 SD)** with a 95 % confidence interval range of **402 to 466 hirola** in their remaining natural range.

## 2. Distribution of hirola

Hirola were unevenly distributed across the survey area (Fig. 3).

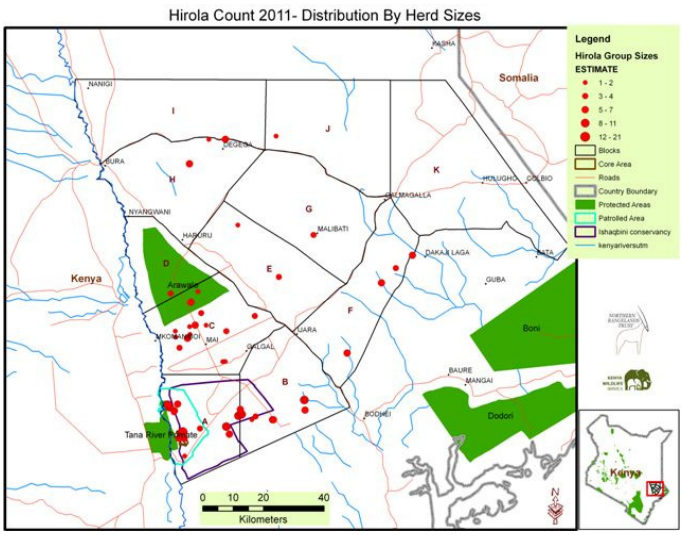



Fig. 3: Distribution of hirola observed during the aerial survey

Concentration areas of hirola were found in Ishaqbini Conservancy on the eastern bank of the Tana River Primate Reserve; east of Ishaqbini within the forest/savanna mozaic along the edge of the boni forest towards Bodhei; and Gababa in the southern part of Arawale Reserve. Other small groups were scattered in the central and south-eastern parts of the survey area. No herds of hirola were seen within 40 km of the Somali border.

## 3. Estimates and distribution of other wildlife

Estimates of other medium-large mammals are shown in table 1. No detection probabilities were determined for these species. The most abundant wildlife species were buffalo, followed by reticulated giraffe and lesser kudu. Additionally lion, African wild dog, leopard, cheetah and other smaller carnivores (jackal and bat-eared fox) were also observed during the survey. Smaller species such as dik-dik, oribi and desert warthog were also observed, however, population estimates for these species are not reliable using aerial survey methods, particularly in bushy areas. Five old elephant carcasses (>1 year) were also seen.

Table 1: Estimates of medium-large wildlife in the survey area:

| Wildlife Species | Total Number |
|---|---|
| Buffalo | 3,543 |
| Giraffe | 1,666 |
| Lesser Kudu | 923 |
| Gerenuk | 757 |
| Topi | 576 |
| Waterbuck | 206 |
| Ostrich | 124 |
| Plains Zebra | 61 |
| Oryx | 42 |
| Grant's Gazelle | 11 |
| Elephant | 2 |

Maps showing the distribution of some species are shown in Annex 2.

Buffalo were largely found in the forest/savanna mosaic adjoining the Boni forest as well as herds in Ishaqbini and the central part of the survey area close to Ijara. Herds numbering several hundred were seen on several occasions particularly at along the edge of the Boni forest. This population is continuous with those buffalo found within the Boni and extending to Lamu district and the Tana Delta.

Reticulated giraffe were scattered throughout the survey area; however, there were none within 40 km of the Somali border. Numbers of giraffe were higher than previously thought and this survey highlighted the importance of this part of south-eastern Kenya, together with other parts of north-eastern province, as a key areas for giraffe.

Lesser Kudu had a similar distribution to giraffe and were scattered throughout the survey area, including areas adjacent to the Somali border.

Waterbuck had a similar distribution to buffalo and were found predominantly along the edge of the Boni forest towards Bodhei as well as Ishaqbini, Galmagala and Sangailu. Common or plains zebra were only found within Ishaqbini with one small herd seen north of Masalani. These zebra are isolated from other populations of zebra and may warrant further study. Beisa oryx and Grant's gazelle were found only in the north-western part of the survey area north and east of Arawale Reserve. Numbers of these species were low.

Only two elephant were counted during the survey, one within Ishaqbini and a second north of Masalani close to the riverine forest of the Tana River. Elephants were previously abundant in this region; however, poaching in the 1970s and 1980s decimated the population. These elephants likely range between the Boni forest and parts of Ijara. Since the conservancy was established, small herds of elephants are frequently seen in Ishaqbini.

## 4. Estimates and distribution of livestock

Numbers of livestock numbers were estimated during the survey, including sheep and goats, camels and cattle.

| Livestock Species | Total Number |
|---|---|
| Sheep & Goats | 64,613 |
| Cattle | 34,911 |
| Camel | 1,367 |

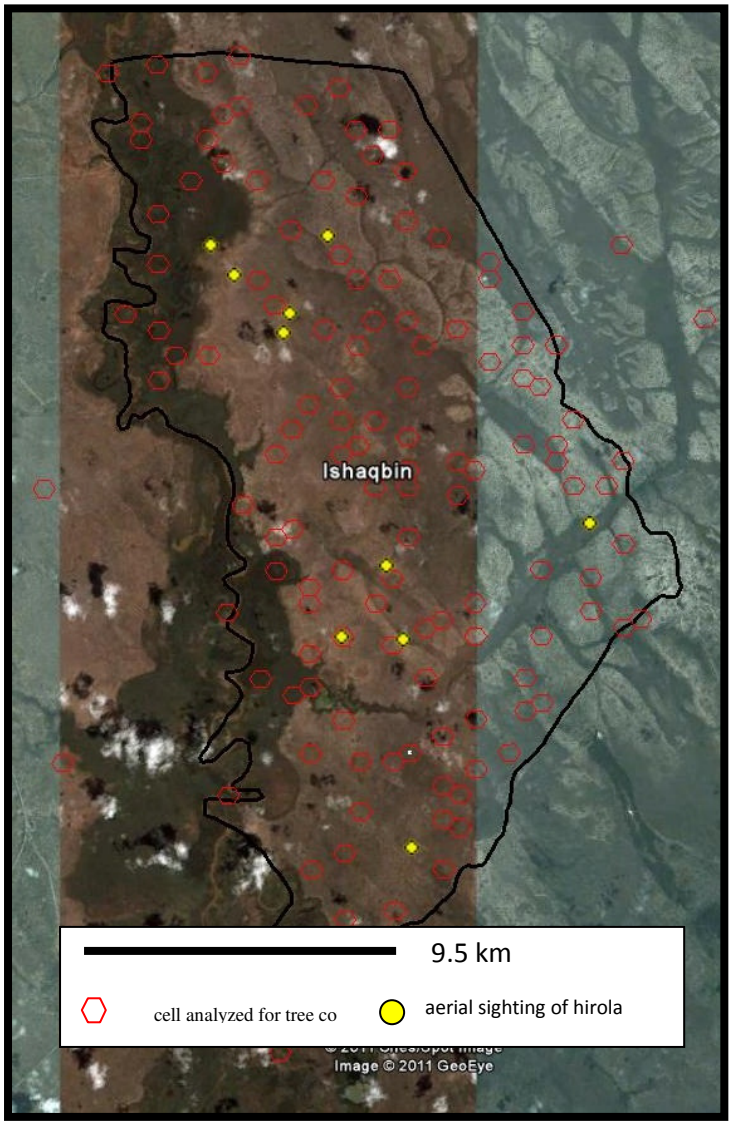
Sheep and goats were almost twice as abundant as cattle. Camel numbers were relatively low. Distribution of livestock is shown in Annex 2. Camels were restricted to the north-western part of the survey area north of Bura. Small stock and cattle were found in large numbers 10 – 20 km within the southern and eastern edge of the survey area and within 20-30 km east of the Tana River. This distribution coincides with the settlement areas/villages and roads between Masalani, Ijara, Galmagala and Hulugo. Livestock were also clustered in the eastern extent of the survey area close to the Somali border. Large herds of cattle were also found in the forest/savanna mosaic leading into the Boni forest.

## Annex 1: Tree cover and hirola sightability in Ijara, Kenya

**Jacob R. Goheen and Abdullahi H. Ali**

In conjunction with this exercise, we constructed two grids in ArcGIS 10.0. The first consisted of 38 ca 40 $km^2$ rectangular grid cells with dimensions 16 x 25 km (the approximate length and width of Ishaqbini) encompassing the entire sampled area (ca 15,000 $km^2$) over which the aerial surveys were conducted, as indicated in the file "survey_hirola_2011". The second consisted of 69,938 ca 22 ha hexagonal cells encompassing the entire sampled area.

Within Ishaqbini, we randomly selected 120 22 ha hexagonal cells in which to estimate tree cover. Within each cell, tree cover was digitized from Ikonos imagery within Google Earth using the ArcGIS extensions KLMer and Arc2Google. **Within Ishaqbini, estimated tree cover averaged 21.63% ± 6.04 SEM.**




Within the broader study area, we randomly selected four 22 ha hexagonal cells within each of the 37 remaining 40 $km^2$ rectangular cells, for a total of 148 hexagonal cells across the 15,000 $km^2$ sampled area. This sampling intensity represents <1% of the sampling area and should be considered a *very rough estimate*. **Within the broader study area, estimated tree cover averaged 35.12 ± 7.62 SEM.**

Of the 37 rectangular cells in which tree cover was estimated over the entire sampling area, 20 had values of estimated tree cover equal to or greater than that of Ishaqbini, amounting to 54% of the sampled area.

If we assume that detection decreases with increasing tree cover, applying the detection probability calculated by Raj Amin to 100-54% = 46% of the sampled area should generate a conservative estimate of population size.

Using Raj Amin's method for calculating standard deviations, we have:

245 hirola x 46% of the study area = 113 hirola

113 hirola / 37.4% prob detection = 302 hirola in 46% of the sampling area

Delta method variance = (302^2) * ((0.08^2) + (0.06^2)) = 912

√1056 = 30

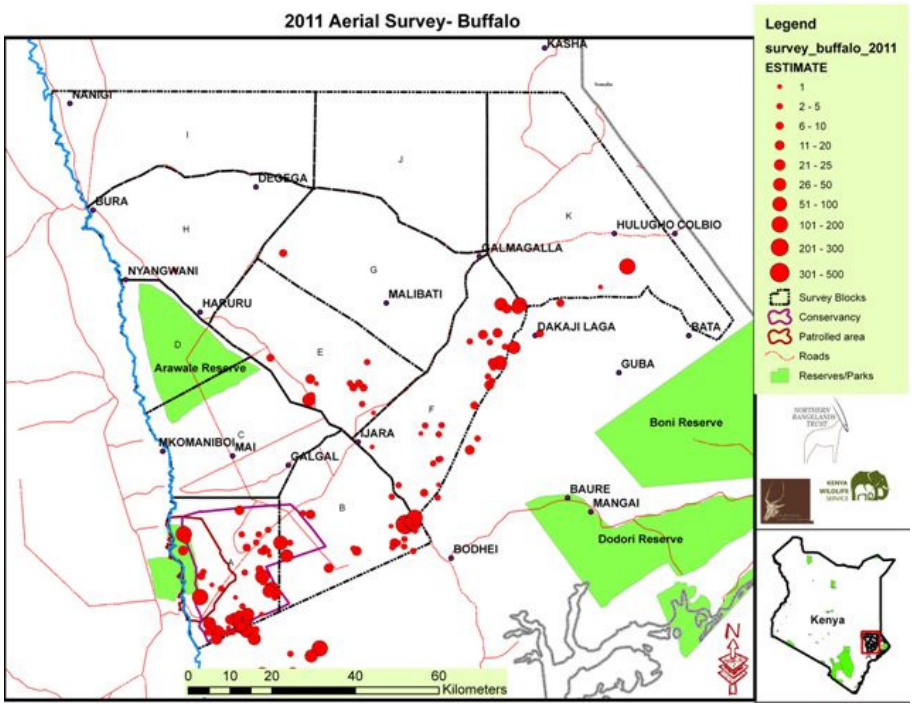
95% CI = 270-334

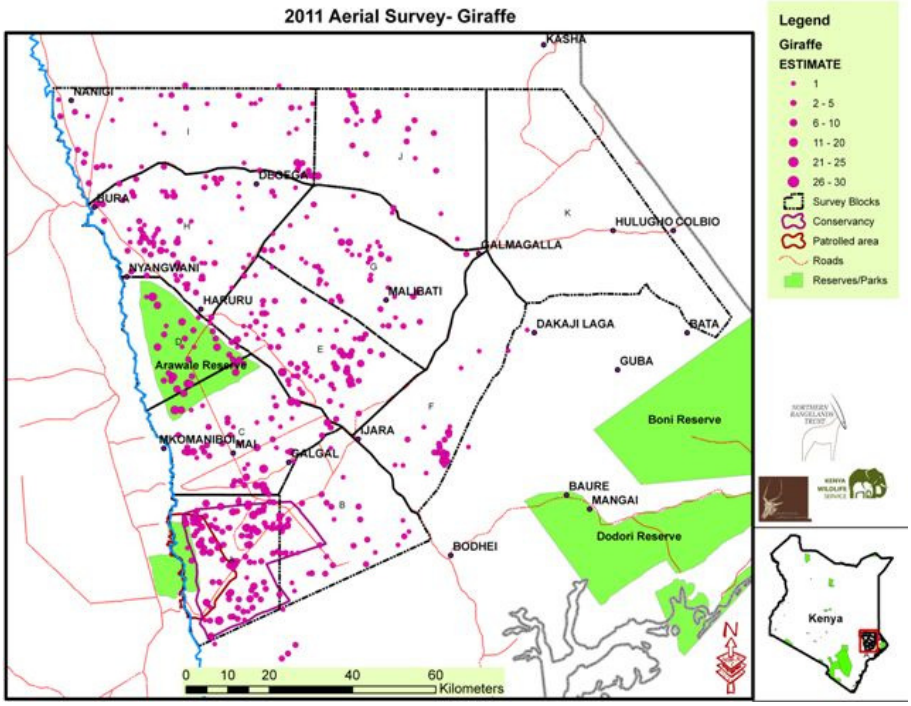
If we are concerned about the relationship between tree cover and detection, it is not possible to estimate the uncertainty around the remaining 132 hirola in 54% of the study area.

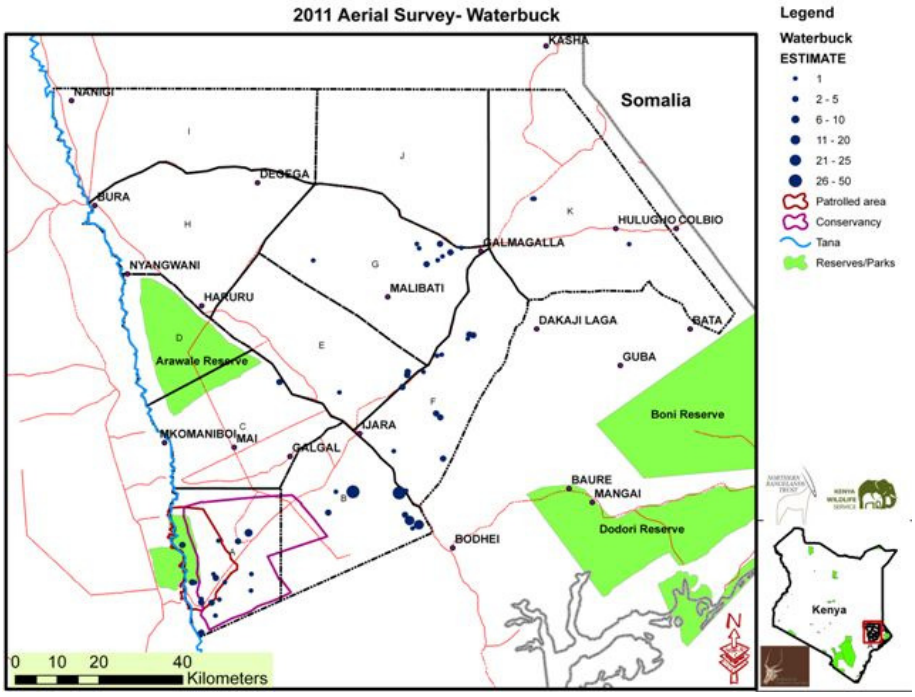
**Therefore, we can simply add 132 to the 95% confidence intervals above to generate a *conservative* estimate of the population from 402-466.**

Depending on if and how detection probability increases with decreasing tree cover, this estimate may stay the same or it may increase. One strategy for addressing this is to conduct a classification of the Ikonos imagery to construct tree-cover specific detection probabilities, which should increase the confidence that we have in our estimates. Our earlier classification of AVHRR imagery was too coarse for this sort of approach. Our future work will assess this issue by using Ikonos imagery.

## Annex 2 Distribution Maps




2011 Aerial Survey- Waterbuck
Legend
Waterbuck
ESTIMATE
1
2 - 5
6 - 10
11 - 20
21 - 25
26 - 50
Patrolled area
Conservancy
Tana
Reserves/Parks
Somalia
KASHA
NANIGI
DEGEGA
BURA
HULUGHO COLBIO
GALMAGALLA
NYANGWANI
MALIBATI
HARURU
DAKAJI LAGA
BATA
Arawale Reserve
GUBA
Boni Reserve
NKOMANIBOI
MAI
IJARA
GALGAL
BAURE
MANGAI
Dodori Reserve
BODHEI
Kenya
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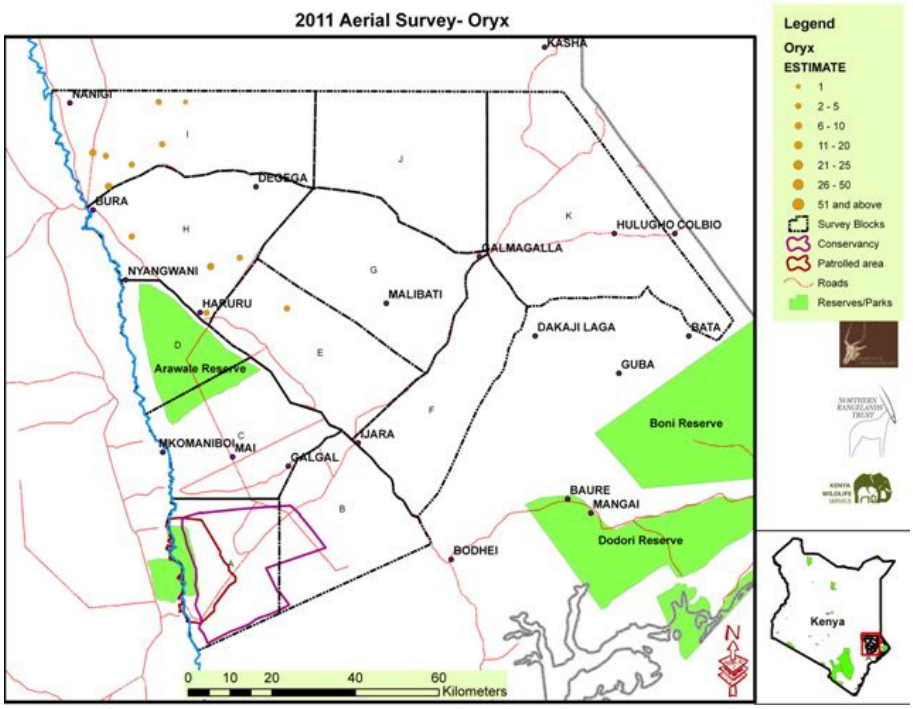
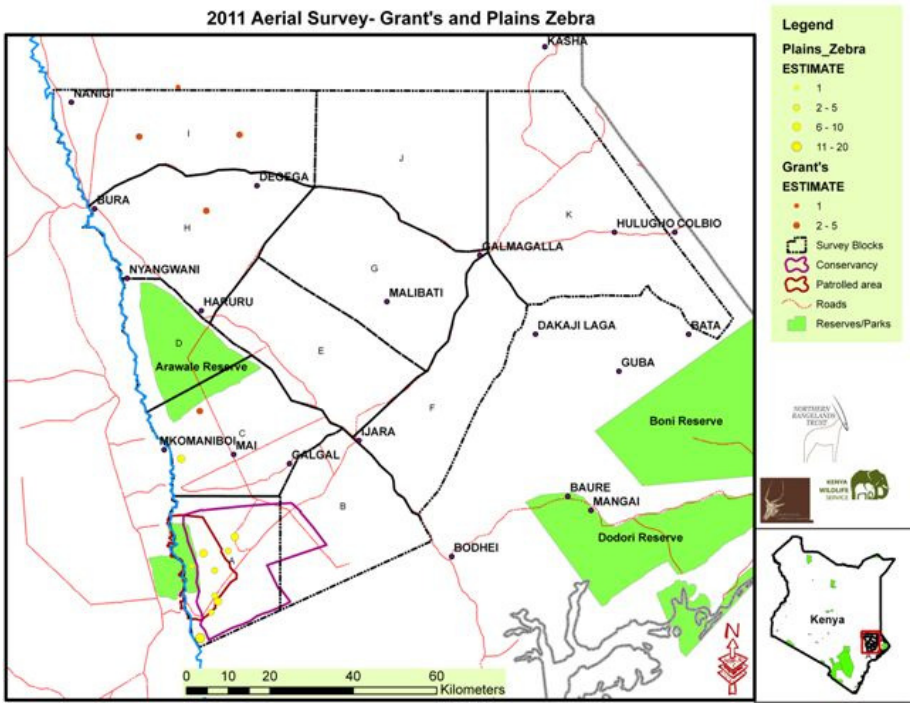
Kilometers


2011 Aerial Survey- Oryx
Legend
Oryx
ESTIMATE
1
2 - 5
6 - 10
11 - 20
21 - 25
26 - 50
51 and above
Survey Blocks
Conservancy
Patrolled area
Roads
Reserves/Parks
KASHA
NANIGI
DEGEGA
BURA
HULUGHO COLBIO
GALMAGALLA
NYANGWANI
MALIBATI
HARURU
DAKAJI LAGA
BATA
Arawale Reserve
GUBA
Boni Reserve
NKOMANIBOI
MAI
IJARA
GALGAL
BAURE
MANGAI
Dodori Reserve
BODHEI
Kenya
0 10 20 40 60
Kilometers


2011 Aerial Survey- Grant's and Plains Zebra
Legend
Plains_Zebra
ESTIMATE
1
2 - 5
6 - 10
11 - 20
Grant's
ESTIMATE
1
2 - 5
Survey Blocks
Conservancy
Patrolled area
Roads
Reserves/Parks
KASHA
NANIGI
DEGEGA
BURA
HULUGHO COLBIO
GALMAGALLA
NYANGWANI
MALIBATI
HARURU
DAKAJI LAGA
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Arawale Reserve
GUBA
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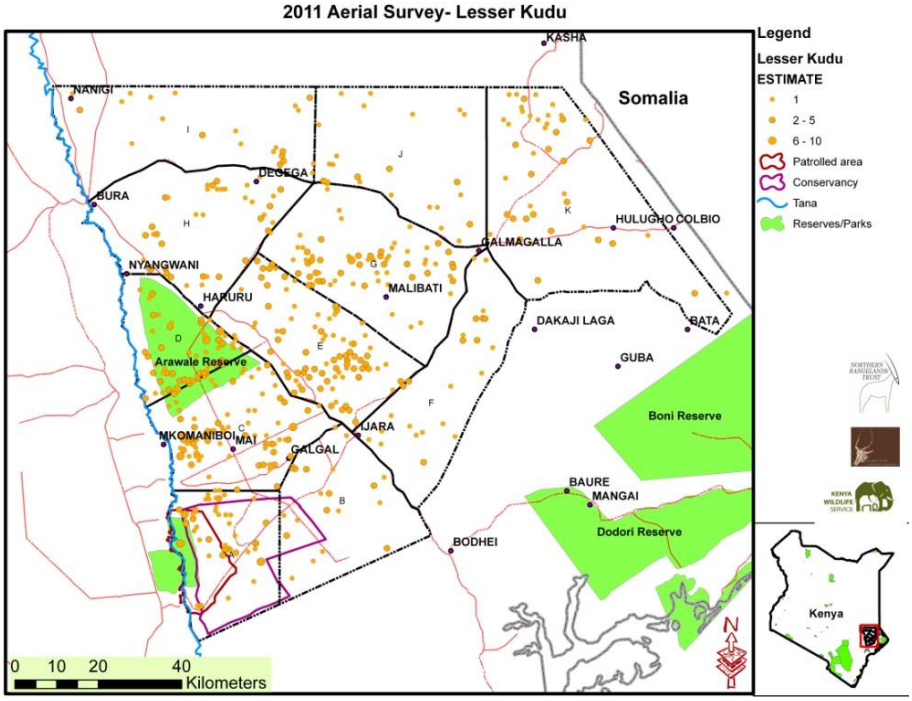
2011 Aerial Survey- Lesser Kudu
Legend
Lesser Kudu
ESTIMATE
1
2 - 5
6 - 10
Patrolled area
Conservancy
Tana
Reserves/Parks
Somalia
KASHA
NANIGI
DEGEGA
BURA
HULUGHO COLBIO
GALMAGALLA
NYANGWANI
MALIBATI
HARURU
DAKAJI LAGA
BATA
Arawale Reserve
GUBA
Boni Reserve
IJARA
MKOMANIBOI
MAI
GALGAL
BAURE
MANGAI
Dodori Reserve
BODHEI
Kenya
0 10 20 40
Kilometers

Distribution of Livestock