AERIAL CENSUS
in the
SERENGETI ECOSYSTEM
WET SEASON, 2010

Conducted by
TANZANIA WILDLIFE RESEARCH INSTITUTE
CONSERVATION INFORMATION AND MONITORING UNIT

in collaboration with
FRANKFURT ZOOLOGICAL SOCIETY AND
TANZANIA NATIONAL PARKS

Requested by
Tanzania National Parks
& Frankfurt Zoological Society
SUMMARY

- A Systematic Reconnaissance Flight (SRF) survey was carried out in the Serengeti ecosystem from February 6th to 12th, 2010 covering 26,827 km$^2$.
- Twenty eight wildlife species were recorded, including 25 mammals, an ostrich, one large reptile (crocodile) and four elephant carcasses.
- None of the species showed declining trend, five species showed increasing trend when compared to the 2006 census results. These included Grants gazelle that increased from 35,707 (±5564 SE) to 119,707 (±26450 SE). Giraffe population increased from 5,246 (± 871 SE) to 12,078 (± 1645 SE) while hartebeest increased from 7,204 (± 1440 SE) to 15,908 (± 2434 SE). Other species were eland which increased from 17,957 (± 3898 SE) to 36,297 (± 619 SE) to 11,273 (± 1823 SE) in this census.
- Censuses analysis showed that there was no significant difference in population estimates of 12 species for the year 2010 (d=test < 1.69) when compared to year 2006 results. This suggests that the populations of these species are stable and they hippo (1,306 ± 1,068SE), impala (74,837 ± 9,106SE), reedbuck (1,545 ± 1,342SE), Thomson’s gazelle (165,973 ± 34,218SE), topi (38,497 ± 12,856SE), waterbuck (2,567 ± 1,083SE), wildebeest (41,759 ± 10,823SE), zebra (207,166SE), ostrich (5,419 ±1,135SE), lion (936 ± 290SE) and hyena (392 ± 246SE).
- Buffalo and Elephant occur in large herds and therefore are not evenly distributed in the area. The species populations are better estimated by total count technique and therefore the data for buffalo and elephants presented in this report are from the TC survey conducted in the Serengeti Ecosystem in the year 2009.
- Pastoralism was the main human activity in the Serengeti ecosystem estimated at 116,070 (± 20,190SE) cattle, 87,612 (± 19,509SE) sheep and 19,366 (± 5,310 SE) goats. Agriculture was the second important human activity in the ecosystem.
- Other human activities recorded included settlements with an estimate of 5,006 (± 1,552SE) thatch roofed huts, 1,741 (± 850SE) iron sheet roofed huts/houses, 4,134 (± 1,839SE) occupied bomas while 1,154 (± 296SE) were abandoned bomas.
• The analysis also has revealed that some human activities recorded in the year 2010 were significantly less than those recorded in the year 2006. These were abandoned bomas, cattle population and cultivated plots (d-test = 3.89, 2.60 and 5.09) respectively. However, there was no statistical significance difference for other human activities recorded in the ecosystem when compared to the results of the year 2006 (d-test < 1.69).

RECOMMENDATIONS

• There is a need of assessing the impact of increasing livestock numbers and human settlements in the NCA and LGCA on wildlife populations due to potential for competition with wildlife for forage and water and hence conflicts.

• There is also need of taking action to address the problem of livestock grazing and human settlements near the park and Game Reserve on the western boundaries that may lead to encroachment that could threaten the integrity of these wildlife conservation areas.

• Agricultural activities that are conducted close to the National Park and Game Reserves in western and southwestern boundaries of the ecosystem pose a threat to wildlife because of possibilities of human-wildlife conflicts.

• The decline of some of the major human activities such as livestock numbers and farming plots is a good sign for sustainable conservation. However this needs to go with improved livestock keeping and agricultural practices in order to avoid increased poverty to the people living in and around the ecosystem.
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<thead>
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<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>Conservation Area</td>
</tr>
<tr>
<td>CIMU</td>
<td>Conservation Information and Monitoring Unit</td>
</tr>
<tr>
<td>FSO</td>
<td>Front Seat Observer</td>
</tr>
<tr>
<td>FZS</td>
<td>Frankfurt Zoological Society</td>
</tr>
<tr>
<td>GCA</td>
<td>Game Controlled Area</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>GR</td>
<td>Game Reserve</td>
</tr>
<tr>
<td>GGR</td>
<td>Grumeti Game Reserve</td>
</tr>
<tr>
<td>IGR</td>
<td>Ikorongo Game Reserve</td>
</tr>
<tr>
<td>LGCA</td>
<td>Loliondo Game Controlled Area</td>
</tr>
<tr>
<td>NCA</td>
<td>Ngorongoro Conservation Area</td>
</tr>
<tr>
<td>NCAA</td>
<td>Ngorongoro Conservation Area Authority</td>
</tr>
<tr>
<td>NP</td>
<td>National Park</td>
</tr>
<tr>
<td>PA</td>
<td>Protected Area</td>
</tr>
<tr>
<td>RSO</td>
<td>Rear Seat Observer</td>
</tr>
<tr>
<td>SE</td>
<td>Standard Error</td>
</tr>
<tr>
<td>SISTA</td>
<td>Survey Information Systems at TAWIRI</td>
</tr>
<tr>
<td>SRF</td>
<td>Systematic Reconnaissance Flight</td>
</tr>
<tr>
<td>TANAPA</td>
<td>Tanzania National Parks</td>
</tr>
<tr>
<td>TAWIRI</td>
<td>Tanzania Wildlife Research Institute</td>
</tr>
<tr>
<td>TC</td>
<td>Total Count</td>
</tr>
<tr>
<td>TWCM</td>
<td>Tanzania Wildlife Conservation Monitoring</td>
</tr>
<tr>
<td>WD</td>
<td>Wildlife Division</td>
</tr>
<tr>
<td>WMA</td>
<td>Wildlife Management Area</td>
</tr>
<tr>
<td>WWF</td>
<td>World Wide Fund for Nature</td>
</tr>
<tr>
<td>°C</td>
<td>Degrees Centigrade</td>
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INTRODUCTION

This report provides results of SRF survey of the Serengeti Ecosystem that was carried in February 6th to 12th 2010. The census was conducted four years after a similar census carried out in April 4th to 9th, 2006. The objectives of this survey were:

- To estimate the abundance of large ungulates in the Serengeti Ecosystem
- To estimate the abundance of human activities in the Serengeti Ecosystem
- To determine trends and distribution of large ungulate populations and human activities in the ecosystem.

The Serengeti ecosystem in northern Tanzania is composed by the Loliondo Game Controlled area (LGCA) and Ngorongoro Conservation Area (NCA) to the east, Maswa Game Reserve (MGR) in the south west, Serengeti National Park (SNP) with its western corridor extending to Lake Victoria with Grumeti Game Reserve (GGR), the Ikorongo Game Reserve (IGR) to the west and also extends to Masai Mara in Kenya.

The main features of the Serengeti Ecosystem include:

- Serengeti National Park - a World Heritage Site and a Biosphere Reserve
- Habitats within the ecosystem range from savannah grasslands and woodland to riverine vegetation and swampy area. *Acacia* woodlands dominate the area with extensive grass plains in the southern part of the ecosystem.
- High biological diversity with over 1000 plant species, over 400 bird species and over 20 species of large mammals and reptiles. Little is known about the diversity of small flora and fauna.
- Serengeti harbours the largest concentration of migratory ungulates than elsewhere in the world. These include wildebeest, zebra and Thomson’s gazelle, over 2 million in total.
- The major drainage systems include the Mara, Orangi-Grumeti and Mbalageti Rivers.

The wet season SRF census was conducted in February 2010 as part of the long term monitoring program of this famous and well studied ecosystem in order to obtain
information on the populations, densities, distribution and trends of major wildlife species and human activities.

Result of this census was compared with similar censuses conducted in the ecosystem since 1989. The ecosystem experiences maximum temperatures between 24-27°C and minimums of 15-21°C with mean annual rainfall ranging from 1,050mm in the northwest to 550mm in the southeast of the Serengeti (Sinclair et al. 2000, Sinclair & Arcese 1995). The long rains peak between March and May. The Serengeti Ecosystem is famous in harboring species of international importance due to their abundance. They include about 1.3 million wildebeests, 200,000 plains zebra and 400,000 Thomson’s gazelles (Campbell & Borner 1995, WCMC 2001). Others species include waterbuck, eland, Coke’s hartebeest, topi, impala, Grant’s gazelle, and buffalo (Stuart et al. 1990). Although the ecosystem may be large enough to ensure sustainable conservation, increasing human settlement and agricultural expansion outside core protected areas and in NCA and Loliondo GCA pose a threat to wildlife populations in the ecosystem. Consequently monitoring is important in order to provide information that can be used to guide conservation planning.

Table 1: Wildlife Surveys in the Serengeti Ecosystem, 1989 - 2010

<table>
<thead>
<tr>
<th>Year</th>
<th>Season</th>
<th>Area covered*</th>
<th>Area (km²)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>Dry</td>
<td>Serengeti Ecosystem</td>
<td>27,541</td>
<td>TWCM (1989)</td>
</tr>
<tr>
<td>1991</td>
<td>Wet</td>
<td>Serengeti Ecosystem</td>
<td>26,084</td>
<td>TWCM (1991)</td>
</tr>
<tr>
<td>1996</td>
<td>Dry</td>
<td>Serengeti Ecosystem</td>
<td>27,992</td>
<td>TWVCM (1996)</td>
</tr>
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<td>2001</td>
<td>Wet</td>
<td>Serengeti Ecosystem</td>
<td>26,870</td>
<td>TWCM (2007)</td>
</tr>
<tr>
<td>2006</td>
<td>Wet</td>
<td>Serengeti Ecosystem</td>
<td>27,113</td>
<td>TAWIRI (2008)</td>
</tr>
<tr>
<td>2010</td>
<td>Wet</td>
<td>Serengeti Ecosystem</td>
<td>26,827</td>
<td>This Report</td>
</tr>
</tbody>
</table>
METHODS

Study Area

The Serengeti Ecosystem is located in northern Tanzania between 34° 45’ - 35° 50’ E and 2° – 3° 20’ S (Figure 1). The areas covered in this census included the Serengeti National Park, Maswa Game Reserve, Ikorongo-Grumeti Game Reserves, the Ngorongoro Conservation Area, Loliondo Game Controlled Area and adjacent areas (Figure 2).

Field Work

The SRF survey was conducted by employing the methodology of Norton Griffiths (1978), using a light aircrafts with four crews (Appendix I). Similar surveys carried out in the Serengeti Ecosystem in the past years are listed in Table 1.

The study area (26,827 km²) was systematically searched along 89 established transects spaced 5 km apart except for Ikorongo-Grumeti GRs where transect were spaced at 2.5 km (Table 2 & Figure 3).

Pilots recorded the beginning and end points of each transect by using Geographical Positioning System and flight lines were drawn on maps in ArcView, with coordinates written out for pilots to follow mark as completed. Each transect was divided into sub-units defined by thirty-second flying time, which is approximately 1.8 km long on the ground. At the beginning of each sub-unit the front seat observer (FSO) announced the change of sub-unit and recorded the radar altimeter to the nearest 10ft. Rear seat observers (RSOs) recorded onto cassette recorders the sub-unit identification with all counts of large mammals, birds and human activities sighted within each of the sub-units. These recordings were transcribed onto data sheets after each flight. Wildebeest on the plains were not counted as they were considered to be migrant animals, and therefore are usually estimated using another censuses technique (Arial Point Surveys).
Laboratory Work

Census data were entered in computers and analyzed using software (SISTA) developed at CIMU specifically for SRF surveys. Population estimates were calculated using Jolly’s Method of 2 unequal sized units (Jolly 1969). The d-test (Cochran 1963, Norton Griffiths 1978) was used to detect population changes. The species distribution maps were created using Arc View®.

Figure 1: Map of Tanzania showing location of the Serengeti (pointer) and other wildlife protected areas
Figure 2: Protected areas within the Serengeti Ecosystem
Figure 3: Survey blocks in the Serengeti Ecosystem showing flight transects, February 2010
Table 2: Survey Parameters of the SRF census conducted in the Serengeti Ecosystem, February 2010

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>5H-ZGF</th>
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</thead>
<tbody>
<tr>
<td>Number of Transects</td>
<td>89</td>
</tr>
<tr>
<td>Total Sub Units</td>
<td>3271</td>
</tr>
<tr>
<td>Area in km²</td>
<td>26,827</td>
</tr>
<tr>
<td>Average altitude (ft)</td>
<td>328</td>
</tr>
<tr>
<td>Median altitude (ft)</td>
<td>340</td>
</tr>
<tr>
<td>Most used altitude (ft)</td>
<td>350</td>
</tr>
<tr>
<td>Max altitude (ft)</td>
<td>500</td>
</tr>
<tr>
<td>Min altitude (ft)</td>
<td>150</td>
</tr>
<tr>
<td>Strip width (Left) (m)</td>
<td>131</td>
</tr>
<tr>
<td>Strip width (Right) (m)</td>
<td>99</td>
</tr>
<tr>
<td>Combined strip width (m)</td>
<td>230</td>
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</tbody>
</table>

RESULTS AND DISCUSSION

Wildlife

Twenty eight wildlife species were recorded in this census and twenty of them appeared to be the most abundant. These included zebra (207,166 ± 37,638), Thomson gazelle (165,973 ± 34,218), Grants gazelle (119,707 ± 26,450), impala (74,837 ± 9,106), and buffalo (32,001). Other species recorded in the area were wildebeest (41,759 ± 10,823), topi (38,497 ± 12,856), eland (36,297 ± 6,169), hartebeest (15,908 ± 2,434) and giraffe (12,078 ± 1,645) warthog (11,273 ± 1,822), elephant (3680), baboon (5,897 ± 1,707), ostrich (5,419 ± 1,135), waterbuck 2,567 ± 1,083), reedbuck (1,545 ± 1,342), and hippopotamus (1,306 ± 1,068). However nine species had less than 30 individuals counted in the SRF therefore it was not possible to determine their population estimates due to small sample sizes. Species with small sample sizes were hyaena (18), bat eared fox (14), roan antelope (13), duiker (10), jackals (7), greater kudu (5), cheetah (3), bushbuck (1) and crocodile (1). We also counted four elephant carcasses (Table 3 & Appendix II). Species distribution maps were created using Arc View. When we
compared the present analysis with that of the year 2006, it was found that no species showed a declining trend, five species had increasing trends, 18 remained stable and 8 showed no clear trends (Table 5).
Table 3: Wildlife population estimates for the Serengeti Ecosystem, February 2010

<table>
<thead>
<tr>
<th>Surveyed area</th>
<th>26,827 km²</th>
<th>Species name</th>
<th>Counted</th>
<th>Observations</th>
<th>Estimates</th>
<th>S.E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Buffalo*(TC, 2009)</td>
<td>32,001</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Baboon</td>
<td>271</td>
<td>17</td>
<td>5897</td>
<td>1707</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bat-eared Fox</td>
<td>14</td>
<td>3</td>
<td>306</td>
<td>175</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duiker</td>
<td>10</td>
<td>1</td>
<td>217</td>
<td>213</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elephant Carcass</td>
<td>4</td>
<td>4</td>
<td>86</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eland</td>
<td>1,668</td>
<td>127</td>
<td>36,297</td>
<td>6,169</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elephant</td>
<td>506</td>
<td>56</td>
<td>11,012</td>
<td>2430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grants Gazelle</td>
<td>5,501</td>
<td>271</td>
<td>11,9707</td>
<td>26,450</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Giraffe</td>
<td>555</td>
<td>115</td>
<td>12,078</td>
<td>1,645</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hippo</td>
<td>60</td>
<td>3</td>
<td>1,306</td>
<td>1,068</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hyaena</td>
<td>18</td>
<td>7</td>
<td>392</td>
<td>246</td>
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<tr>
<td></td>
<td></td>
<td>Impala</td>
<td>3,439</td>
<td>210</td>
<td>74,837</td>
<td>9,106</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kongoni/Hartebeest</td>
<td>731</td>
<td>114</td>
<td>15,908</td>
<td>2,434</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ostrich</td>
<td>249</td>
<td>62</td>
<td>5419</td>
<td>1,135</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reedbuck</td>
<td>71</td>
<td>7</td>
<td>1,545</td>
<td>1,342</td>
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<tr>
<td></td>
<td></td>
<td>Roan Antelope</td>
<td>13</td>
<td>2</td>
<td>282</td>
<td>257</td>
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<tr>
<td></td>
<td></td>
<td>Thomson Gazelle</td>
<td>7,627</td>
<td>273</td>
<td>165,973</td>
<td>34,218</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Topi</td>
<td>1,769</td>
<td>158</td>
<td>38,497</td>
<td>12,856</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waterbuck</td>
<td>118</td>
<td>22</td>
<td>2567</td>
<td>1083</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Warthog</td>
<td>518</td>
<td>137</td>
<td>11,273</td>
<td>1822</td>
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<tr>
<td></td>
<td></td>
<td>Wildebeest</td>
<td>1,919</td>
<td>83</td>
<td>41,759</td>
<td>10,823</td>
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<tr>
<td></td>
<td></td>
<td>Zebra</td>
<td>9520</td>
<td>514</td>
<td>20,7166</td>
<td>37,638</td>
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</tbody>
</table>

Others included bushbuck (1), crocodile (1), cheetah (3), greater kudu (5), and Jackals (7) with total individuals counted in brackets

*(Results presented in a separate census report, TAWIRI, 2010

**WILDLIFE ESTIMATES PER ADMINISTRATIVE AREA**
The Serengeti ecosystem is composed of six administrative areas namely Serengeti National Park, Ngorongoro Conservation Area, Grmeti Game Reserves, Ikorongo Game Reserve, Maswa Game Reserve and Loliondo Game Controlled Area. The following table show the wildlife estimates per administrative areas.
Table 4: Wildlife population estimates per administrative areas in the Serengeti Ecosystem, February 2010

<table>
<thead>
<tr>
<th>Common name</th>
<th>Counted</th>
<th>Observations</th>
<th>Estimates</th>
<th>S.E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serengeti NP 12,930 km²</td>
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<td></td>
<td></td>
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Table 5: Wildlife population estimate trends in the Serengeti ecosystem, 1996-2010

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Species with declining populations

Buffalo (*Syncerus caffer*)

Buffalo is one of the species that tend to congregate in large groups and therefore TC is the most reliable method for determine the population number of such species. According to TC survey conducted in Serengeti Ecosystem in October 2009, the buffalo population was 32,001 individuals. This number is less by 2.8% when compared to 32,919 individuals recorded in April 2008. However, Norton-Griffith (1978) suggested a 10% correction factor (*not applied in this results*) for under count caused by missing animals, especially calves hidden behind or under adults, or animals hidden under tree canopies or deep gullies. Under such ground, the buffalo population numbers of the two consecutive years; 2008 and 2009 are the highest in the Serengeti Ecosystem for the past 14 years (Figure 4). Most of the buffalo were recorded in the Serengeti National Park (Figure 5).

![Buffalo population estimate trends in the Serengeti Ecosystem, years 1986 to 2010](image)

**Figure 4:** Buffalo population estimate trends in the Serengeti Ecosystem, years 1986 to 2010
Species with increasing populations

Grants Gazelle
Grants gazelle was another species that appeared to be most abundant in the area. Analysis showed that there were 119,707 ± 26,450 SE individuals in the area and also suggest a significant increase (Table 5) ($d$-test = 3.11) when compared to 35,537 ± 5,564 SE individuals recorded in the year 2006. The distribution of grants gazelle indicate high concentrate in the central plains of the ecosystem and dispersed into the remaining plains throughout the ecosystem except Maswa GR which had very few grants gazelle found on the southeastern part, a border to NCA and SNP (Figure 6).

Figure 5: Density and distribution of buffalo in the Serengeti ecosystem, February 2010
Figure 6: Density and distribution of grant gazelle in the Serengeti ecosystem, February 2010
Figure 7: Grants gazelle population estimate trends in the Serengeti Ecosystem, 1996 – 2010

Giraffe (Giraffa camelopardalis)

Other most abundant species recorded in the ecosystem was Giraffe. The species population increased significantly (almost double) from 5,246 ± 871 SE in the year 2006 to 12,078 ± 1,645 SE giraffe in 2010 (Table 5) \((d = 3.67)\). Giraffe were recorded in all administrative areas but more abundant in the Serengeti National Park, Maswa Game Reserve and Loliondo Game Controlled Area (Figure 8).
Figure 8: Density and distribution of giraffe in the Serengeti ecosystem, February 2010
Hartebeest (Kongoni) were also abundant in the area estimated at 15,908 ± 2,434 SE. This was significantly higher ($d = 3.08$) when compared to 7,204 ± 1,440 SE recorded in the year 2006 census (Table 5). The population trend of the hartebeest in the ecosystem shows that this estimate is common as almost the same was recorded in the year 2003 (Figure 11). Hartebeest were recorded in all administrative areas of the ecosystem with higher density in the Serengeti National Parks, more particularly in the Serengeti plains (Figure 10) probably because the species prefer open and light bush habitat.
Figure 10: Density and distribution of hartebeest in the Serengeti ecosystem, February 2010
Eland (*Taurotragus derbianus*)

Eland were also found to be among the abundant species in the area estimated at 36,297 ± 6,169 SE individuals. The species indicated a significant increase ($d = 2.51$) as compared to 17,957 ± 3,898 SE individuals recorded in the year 2006 (Table 5). This is the highest population ever recorded in the Serengeti Ecosystem in the past 14 years (Figure 13). Such sharp increase suggests that there was immigration of large group from elsewhere where outside the surveyed area. Eland were mostly distributed in the plains of the Serengeti, Ngorongoro and the Maswa Game Reserve (Figure 12).
Figure 12: Density and distribution of eland in the Serengeti ecosystem, February 2010
Figure 13: Eland population estimate trends in the Serengeti Ecosystem, years 1996 to 2010

Warthog (*Phacochoerus porcus*)

The survey results showed significant increase of warthog ($d = 4.10$) from $3,370 \pm 619$ SE in the year 2006 to $11,273 \pm 1,823$ SE individuals in the year 2010 (Table 5). Analysis showed that the population estimated in this survey is the highest ever recorded in the ecosystem in the past 14 years. Such increase is so sharp and is not a normal increase within four years. This estimates should therefore taken with caution unless compared with the next similar census. Warthogs were found throughout the western half of the surveyed area with the highest concentrations in the western part of the Serengeti national park (Figure 14).
Figure 14: Density and distribution of warthog in the Serengeti ecosystem, February 2010
Species with stable populations

Elephant (*Loxodonta Africana*)

As for buffaloes, elephant population numbers in the Serengeti ecosystem are better estimated by using TC surveys due to their behavior of congregating into large herds habitat selection. A total of 3,680 elephants were counted in the TC survey conducted in the Serengeti Ecosystem in October, 2009. The results suggest that the elephant population number has increased by 0.78% as compared to the population number determined in the area in the survey of the year 2008. This is the highest number ever recorded in the area in the past 23 years (Figure 16). Highest population density of elephant was recorded in the Serengeti National Parks followed by the Maswa Game Reserve (Figure 17).
Figure 16: Elephant population trends in the Serengeti Ecosystem, years 1986 – 2009

Figure 17: Density and distribution of elephant in the Serengeti ecosystem, February 2010
Thomson’s gazelle

Thomson’s gazelle was also among the most abundant species in the surveyed area. As compared to the previous survey, Thomson’s gazelle population has decreased from 214,308 ± 50,088 SE in the year 2006 to 165,975 ± 34,218 SE in the year 2010. However, the decrease is not statistically significant (Table 5) ($d = 1.24$) and this suggest that the population of Thomson’s gazelle in the ecosystem is stable. (Table 3 & Figure 19). Thomson’s gazelle was mostly recorded in the plains of the Serengeti national park, Ngorongoro conservation area and Loliondo game controlled area (Figure 18).

Figure 18: Density and distribution of Thomson’s gazelle in the Serengeti ecosystem, February 2010
Figure 19: Thomson’s gazelle population estimate trends in the Serengeti Ecosystem, years 1996 - 2010

**Impala (Aepyceros melampus)**

The population of impala was estimated at 74,837 ± 9,106 SE individuals. The estimates indicates no significant different from the year 2006 estimates that stood at 72,159 ± 12,887 SE individuals (Table 5 & Figure 21) ($d = 0.17$). Impalas were recorded almost everywhere in the ecosystem but in less dense at the plains of Ngorongoro, Serengeti and Loliondo Game controlled area (Fig.20) probably because they prefer acacia savanna and light woodland (Dorst & Dandelot, 1993).
Figure 20: Density and distribution of impala in the Serengeti ecosystem, February 2010
Figure 21: Impala population estimate trends in the Serengeti Ecosystem, years 1996 - 2010

**Topi (Damaliscus lunatus)**

Population estimate of topi was 38,497 ± 12,856 individuals excluding large groups of topi found in the plain of the Western Serengeti namely Nyasirori and Msabi. The estimate is slightly higher than that of the year 2006 survey that estimated 35,044 ± (10,085 SE) individuals (Table 3 & Figure 23). Nevertheless, there is no significant difference between the two estimates (Table 5) \( (d-test = 0.21) \). This suggests that topi population in the Serengeti ecosystem is stable.

In addition to SRF survey estimates, total count survey carried out in the same survey period in part of the western Serengeti (Nyasirori, Ndoha and Msabi) determined topi population number of large herds found in the area to be 8715 individuals. High densities of topi were found in the Serengeti National Park, at the northern part and western corridor (Figure 22).
Figure 22: Density and distribution of topi in the Serengeti ecosystem, February 2010
Figure 23: Topi population estimate trends in the Serengeti Ecosystem, years 1996 - 2010

Waterbuck (*Kobus ellipsyprimmus*)

The survey results estimated 2,567 ± 1,083 SE waterbuck, and that is slightly higher than 1,085 ± 428 SE individuals estimated in the year 2006 census. Analysis showed that there was no significant difference in population size estimates for the two surveys (Table 5) (\(d_{test} = 1.27\)). These results suggest that population of waterbuck has remained stable in the area (Table 3 & Figure 25). Waterbuck were mainly found in western part of the ecosystem probably because these areas have more water sources/rivers (Figure 24).
Figure 24: Density and distribution of waterbuck in the Serengeti ecosystem, February 2010
Figure 25: Waterbuck population estimate trends in the Serengeti Ecosystem, years 1996 to 2010

Ostrich (*Struthio camelus*)

Population size of ostrich was estimated at 5,419 ± 1,135 SE individuals which is slightly less when compared to 6,019 ± 1,125 SE estimated in the year 2006. However, this is not significantly different (Table 5) ($d$-test = 0.38), and suggesting that the species population is stable (Table 3 & Figure 26). Ostrich were widely distributed in the ecosystem except in the southeastern part of Ngorongoro Conservation Area (Figure 25).
Figure 26: Density and distribution of ostrich in the Serengeti ecosystem, February 2010
Other species recorded in the area that indicated stable population included Reedbuck (*Redunca redunca*) 1,545 ± 1,342 SE, Hippopotamus (*Hippopotamus amphibius*) 1,306 ± 1054 SE, Hyena (*Crocuta crocuta*) 392 ± 246 SE, Wildebeest (*Connochaetes taurinus*) 4141,759 ± (10,823 SE), Zebra (*Equus burchelli*), 207,166 ± 37,638 SE, and Baboon (*Papio cynocephalus*) that has 5,897 ± 1,707 SE individuals (Table 3).

**Species with unclear population estimates**

There were eight species that their population trends could not be determined due to lack of consistence in the data from previous surveys and also insufficient data to allow robust statistical analysis. These species included roan antelope greater kudu, cheetah, bushbuck, duiker, dikdik, bat eared fox and crocodile
Human activities

We recorded 11 types of human activities which included occupied bomas (4,134 ± 1,839 SE) and (1,154 ± 296 SE) abandoned bomas. Huts/houses with iron sheet roof were 1,741 ± 850 SE, thatch roof (5,006 ± 1,552 SE), cattle (113,070 ± 20,190 SE), sheep and goats (shoats) (87,612 ± 19,509 SE) and donkeys (349 ± 260). We also recorded 22 villages, a poacher’s camp and 33 access roads and tracks (Table 6).

Table 6: Estimates of human activities in the Serengeti Ecosystem, February 2010

<table>
<thead>
<tr>
<th>Common name</th>
<th>Counted</th>
<th>Observations</th>
<th>Estimates</th>
<th>S.E</th>
</tr>
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<tbody>
<tr>
<td>Boma Abandoned</td>
<td>53</td>
<td>36</td>
<td>1154</td>
<td>296</td>
</tr>
<tr>
<td>Hut with Mabati roof</td>
<td>80</td>
<td>20</td>
<td>1741</td>
<td>850</td>
</tr>
<tr>
<td>Masai Boma – Occupied</td>
<td>190</td>
<td>74</td>
<td>4134</td>
<td>1839</td>
</tr>
<tr>
<td>Cattle</td>
<td>5196</td>
<td>102</td>
<td>113070</td>
<td>20190</td>
</tr>
<tr>
<td>Agriculture / Cultivation</td>
<td>890</td>
<td>103</td>
<td>19366</td>
<td>5310</td>
</tr>
<tr>
<td>Donkey</td>
<td>16</td>
<td>3</td>
<td>349</td>
<td>260</td>
</tr>
<tr>
<td>POACHERS CAMP</td>
<td>1</td>
<td>1</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Access, roads and tracks</td>
<td>33</td>
<td>33</td>
<td>719</td>
<td>143</td>
</tr>
<tr>
<td>Sheep and Goats</td>
<td>4026</td>
<td>64</td>
<td>87612</td>
<td>19509</td>
</tr>
<tr>
<td>Hut with Thatched Roof</td>
<td>230</td>
<td>45</td>
<td>5006</td>
<td>1552</td>
</tr>
<tr>
<td>Village</td>
<td>22</td>
<td>17</td>
<td>478</td>
<td>205</td>
</tr>
</tbody>
</table>

Cattle

Cattle were found mainly in the peripheral of the National Park, and Game Reserves while in the LGCA, they were inside the PA and in NCA were found mainly in southwestern part of the conservation area. In Maswa GR there was a group of cattle found far inside the reserve. The estimated population of cattle in the ecosystem decreased significantly (d-test = 2.60) (Table 7) indicating a decline of cattle population in the ecosystem since year 2003 (Figure 29).
Figure 28: Density and distribution of cattle in the Serengeti ecosystem, February 2010
Figure 29: Cattle population estimate trends in the Serengeti Ecosystem, years 1996 - 2010

**Shoats**

Shoats (sheep and goats) were restricted to the areas outside the National Park, Game Reserves. However they were found in relatively high densities inside NCA and LGCA (Figure 30). Although the estimate indicated a stable population compared to the year 2006 ($d$-test = 1.14) (Table 7), there appear to be a steady decline since the year 2003 census (Figure 31).
Figure 30: Density and distribution of shoats in the Serengeti ecosystem, February 2010
Donkey

Donkeys were restricted to LGCA and NCA where pastoralists are allowed (Figure 32). The population size of donkeys in the ecosystem has remained stable ($d$-test = 1.26) when compared to year 2006 census results (Table 7), although it appears to fluctuate over time (Figure 33).
Figure 32: Density and distribution of donkey in the Serengeti ecosystem, February 2010
Human Settlements

Settlements (bomas and thatch/iron sheet roofs) were restricted to areas outside the National Park, and Game Reserves with high concentrations in the periphery of Maswa Game Reserve and Grumeti Game Reserve and were found more scattered throughout western NCA and LGCA (Figure 34).
Figure 34: Density and distribution of settlements in the Serengeti ecosystem, February 2010

Cultivation
Cultivated plots were found outside or adjacent to the Game Reserves, NCA and the National Park and some inside its western corridor. Other cultivated plots were adjacent to MGR GGR. However, in the LGCA cultivation were recorded inside the Game Controlled Area (Figure 35). The number of cultivated plots in the ecosystem has declined when compared to 2006 survey ($d$-test = 5.09) (Table 7) (Figure 36).
Figure 35: Density and distribution of cultivation in the Serengeti ecosystem, February 2010
**Figure 36**: Cultivation plots population estimate trends in the Serengeti Ecosystem, years 1996 - 2010
Table 7: Human activities population estimate trends in the Serengeti ecosystem, 1996-2010

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>Boma Abandoned</td>
<td>1562 (219)</td>
<td></td>
<td>1094 (223)</td>
<td></td>
<td>363 (59)</td>
<td></td>
<td>2615 (231)</td>
<td></td>
<td>1154 (29)</td>
<td></td>
<td>296 (3.89)</td>
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<tr>
<td></td>
<td>Cattle</td>
<td>199393 (19962)</td>
<td></td>
<td>215121 (40874)</td>
<td></td>
<td>237591 (38984)</td>
<td></td>
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<td>2.60 (1.61)</td>
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<td>Agriculture / Cultivation</td>
<td>72465 (11850)</td>
<td>25769 (5673)</td>
<td>11082 (1277)</td>
<td>67058 (7727)</td>
<td>19366 (5310)</td>
<td>5.09</td>
<td></td>
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<td>Hut with Mabati roof</td>
<td>2179 (907)</td>
<td>3151 (1136)</td>
<td>2740 (386)</td>
<td>3783 (976)</td>
<td>1741 (850)</td>
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<td></td>
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<td>Masai Boma - Occupied</td>
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<td>547 (175)</td>
<td>2195 (222)</td>
<td>7518 (1019)</td>
<td>4134 (1839)</td>
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<td>Donkey</td>
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<td>1161 (695)</td>
<td>2422 (845)</td>
<td>5231 (3869)</td>
<td>349 (260)</td>
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<tr>
<td></td>
<td>Sheep and Goats</td>
<td>106</td>
<td>128780 (10993)</td>
<td>112927 (10741)</td>
<td>87612 (19509)</td>
<td>1.14</td>
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<tr>
<td></td>
<td>Hut with Thatched Roof</td>
<td>13121 (1764)</td>
<td>12785 (3483)</td>
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<td>4162 (378)</td>
<td>5006 (1552)</td>
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</tr>
<tr>
<td></td>
<td>Village</td>
<td>1139 (157)</td>
<td>182 (70)</td>
<td>45 (25)</td>
<td>510 (45)</td>
<td>478 (505)</td>
<td>0.06</td>
<td></td>
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CONCLUDING REMARKS

- Concentration of livestock and human settlements in the NCA and LGCA appear to be a major threat to conservation as it increases potential for competition for forage and water between wildlife and livestock.

- Proximity of livestock and human settlements to the (NP and GRs) western boundaries may lead to encroachment that could threaten the integrity of these wildlife conservation areas.

- Agricultural activities found close to the national park and game reserves in western and southwestern boundaries of the ecosystem is a potential source of human-wildlife conflicts.

- This census results suggests healthy populations of the major wildlife species in the ecosystem even after the major drought between 2007-2009 that affect this ecosystem and its surrounding areas such as the Amboseli – West Kilimanjaro – Lake Natron.

- Declining trend of some of the major human activities such as livestock numbers and farming plots may a good sign for sustainable conservation but this need to go with improved livestock keeping and agricultural practices in order to avoid increased poverty to the people living in and around the ecosystem.
ACKNOWLEDGEMENTS

We are grateful to the Director of Wildlife, Director General of Tanzania National Parks the Conservator of Ngorongoro Conservation Area for allowing us to conduct the census, the Frankfurt Zoological Society for releasing their aircraft and pilot to conduct the census and all individuals, staff institutions that in one way or another made this exercise a success.

Special thanks go to the survey crew and to all those who provided assistance in the field. Funding, personnel and logistical support were provided by the Frankfurt Zoological Society, Tanzania National Parks and Tanzania Wildlife Research Institute. Many thanks.
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TAWIRI 2005: Aerial Census in the Serengeti Ecosystem, Wet Season 2001
## APPENDIX I: PARTICIPANTS

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>Initials</th>
<th>Name</th>
<th>Role</th>
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<td>Pilot</td>
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<td>5H-ZGF</td>
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<td>Hamza Khalid Kija</td>
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<td>5H-ZGF</td>
<td>HTM</td>
<td>Honori Thomas Maliti</td>
<td>Coordinator</td>
</tr>
</tbody>
</table>

Data entry: Hadia Hajji - TAWIRI

Data verification and analysis: Honori T. Maliti & Hamza K. Kija - TAWIRI

# APPENDIX II: Species list

## Mammals:
- Bat eared fox: *Otocyon megalotis*
- Buffalo: *Syncerus caffer*
- Baboon: *Papio cynocephalus*
- Bushbuck: *Tragelaphus scriptus*
- Cheetah: *Acinonyx jubatus*
- Duiker: *Sylvicapra grimmia*
- Eland: *Taurotragus oryx*
- Elephant: *Loxodonta africana*
- Grant’s Gazelle: *Gazella granti*
- Giraffe: *Giraffa camelopardalis*
- Hippo: *Hippopotamus amphibius*
- Hyaena: *Crocuta crocuta*
- Impala: *Aepyceros melampus*
- Jackal: *Canis adustus & mesomelas*
- Hartebeest: *Alcephalus buselaphus*
- Lion: *Panthera leo*
- Reedbuck: *Redunca redunca*
- Thomson’s Gazelle: *Gazella rufifrons*
- Topi: *Damaliscus lunatus*
- Wildebeest: *Connochaetes taurinus*
- Waterbuck: *Kobus ellipsyprimmus*
- Warthog: *Phacochoerus aethiopicus*
- Zebra: *Equus burchelli*

## Birds:
- Marabou Stork: *Leptoptilos crumeniferus*
- Ostrich: *Struthio camelus*