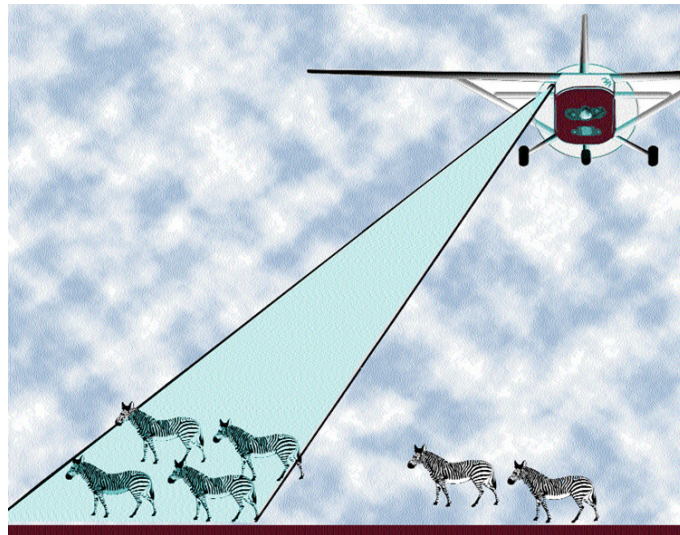


**AERIAL CENSUS**  
**in the**  
**SERENGETI ECOSYSTEM**

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



Tanzania Wildlife Research Institute, 2010  
Aerial Census in the Serengeti Ecosystem, Wet Season, 2010  
TAWIRI Aerial Survey Report

Commissioned by



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## SUMMARY

- A Systematic Reconnaissance Flight (SRF) survey was carried out in the Serengeti ecosystem from February 6<sup>th</sup> to 12<sup>th</sup>, 2010 covering 26,827 km<sup>2</sup>.
- 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 ( $\pm 5564$  SE) to 119,707 ( $\pm 26450$  SE). Giraffe population increased from 5,246 ( $\pm 871$  SE) to 12,078 ( $\pm 1645$  SE) while hartebeest increased from 7,204 ( $\pm 1440$  SE) to 15,908 ( $\pm 2434$  SE). Other species were eland which increased from 17,957 ( $\pm 3898$  SE) to 36,297 ( $\pm 6169$  SE) and warthog from 3,370 ( $\pm 619$  SE) to 11,273 ( $\pm 1823$  SE) in this census.
- Censuses analysis showed that there was no significant difference in population estimates of 12 species for the year 2010 ( $d=\text{test} < 1.69$ ) when compared to year 2006 results. This suggests that the populations of these species are stable and they hippo ( $1,306 \pm 1,068\text{SE}$ ), impala ( $74,837 \pm 9,106\text{SE}$ ), reedbuck ( $1,545 \pm 1,342\text{SE}$ ), Thomson's gazelle ( $165,973 \pm 34,218\text{SE}$ ), topi ( $38,497 \pm 12,856\text{SE}$ ), waterbuck ( $2,567 \pm 1,083\text{SE}$ ), wildebeest ( $41,759 \pm 10,823\text{SE}$ ), zebra ( $207,166\text{SE}$ ), ostrich ( $5,419 \pm 1,135\text{SE}$ ), lion ( $936 \pm 290\text{SE}$ ) and hyena ( $392 \pm 246\text{SE}$ ).
- 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 ( $\pm 20,190\text{SE}$ ) cattle, 87,612 ( $\pm 19,509\text{SE}$ ) sheep and 19,366 ( $\pm 5,310$  SE) goats. Agriculture was the second important human activity in the ecosystem.
- Other human activities recorded included settlements with an estimate of 5,006 ( $\pm 1,552\text{SE}$ ) thatch roofed huts, 1,741 ( $\pm 850\text{SE}$ ) iron sheet roofed huts/houses, 4,134 ( $\pm 1,839\text{SE}$ ) occupied bomas while 1,154 ( $\pm 296\text{SE}$ ) 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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**LIST OF ABBREVIATIONS AND ACRONYMS**

CA	Conservation Area
CIMU	Conservation Information and Monitoring Unit
FSO	Front Seat Observer
FZS	Frankfurt Zoological Society
GCA	Game Controlled Area
GPS	Global Positioning System
GR	Game Reserve
GGR	Grumeti Game Reserve
IGR	Ikorongo Game Reserve
LGCA	Loliondo Game Controlled Area
NCA	Ngorongoro Conservation Area
NCAA	Ngorongoro Conservation Area Authority
NP	National Park
PA	Protected Area
RSO	Rear Seat Observer
SE	Standard Error
SISTA	Survey Information Systems at TAWIRI
SRF	Systematic Reconnaissance Flight
TANAPA	Tanzania National Parks
TAWIRI	Tanzania Wildlife Research Institute
TC	Total Count
TWCM	Tanzania Wildlife Conservation Monitoring
WD	Wildlife Division
WMA	Wildlife Management Area
WWF	World Wide Fund for Nature
<sup>0</sup> C	Degrees Centigrade



## 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<sup>0</sup>C and minimums of 15-21<sup>0</sup>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

<b>Year</b>	<b>Season</b>	<b>Area covered*</b>	<b>Area (km<sup>2</sup>)</b>	<b>Source</b>
1989	Dry	Serengeti Ecosystem	27,541	TWCM (1989)
1991	Wet	Serengeti Ecosystem	26,084	TWCM (1991)
1996	Dry	Serengeti Ecosystem	27,992	TWVCM (1996)
2001	Wet	Serengeti Ecosystem	26,870	TWCM (2007)
2003	Wet	Serengeti Ecosystem	31,157	TAWIRI (2003)
2006	Wet	Serengeti Ecosystem	27,113	TAWIRI (2008)
2010	Wet	Serengeti Ecosystem	26,827	This Report

## 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

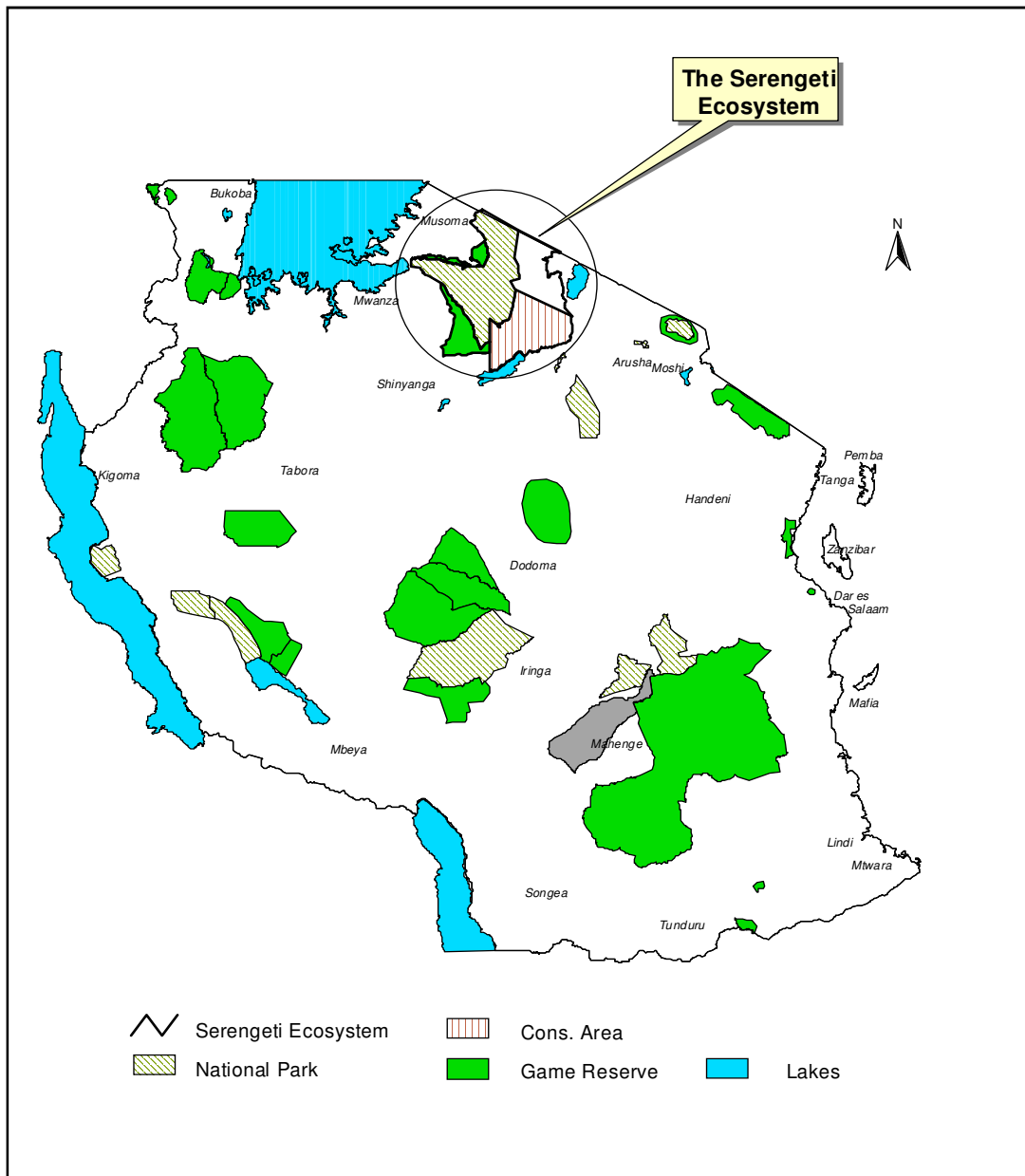
The SRF survey was conducted by employing the methodology of Norton Griffiths (1978), using a light aircrafts with four crews (Appendix I). Similar surveys carried out in the Serengeti Ecosystem in the past years are listed in Table 1.

The study area (26,827 km<sup>2</sup>) 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).

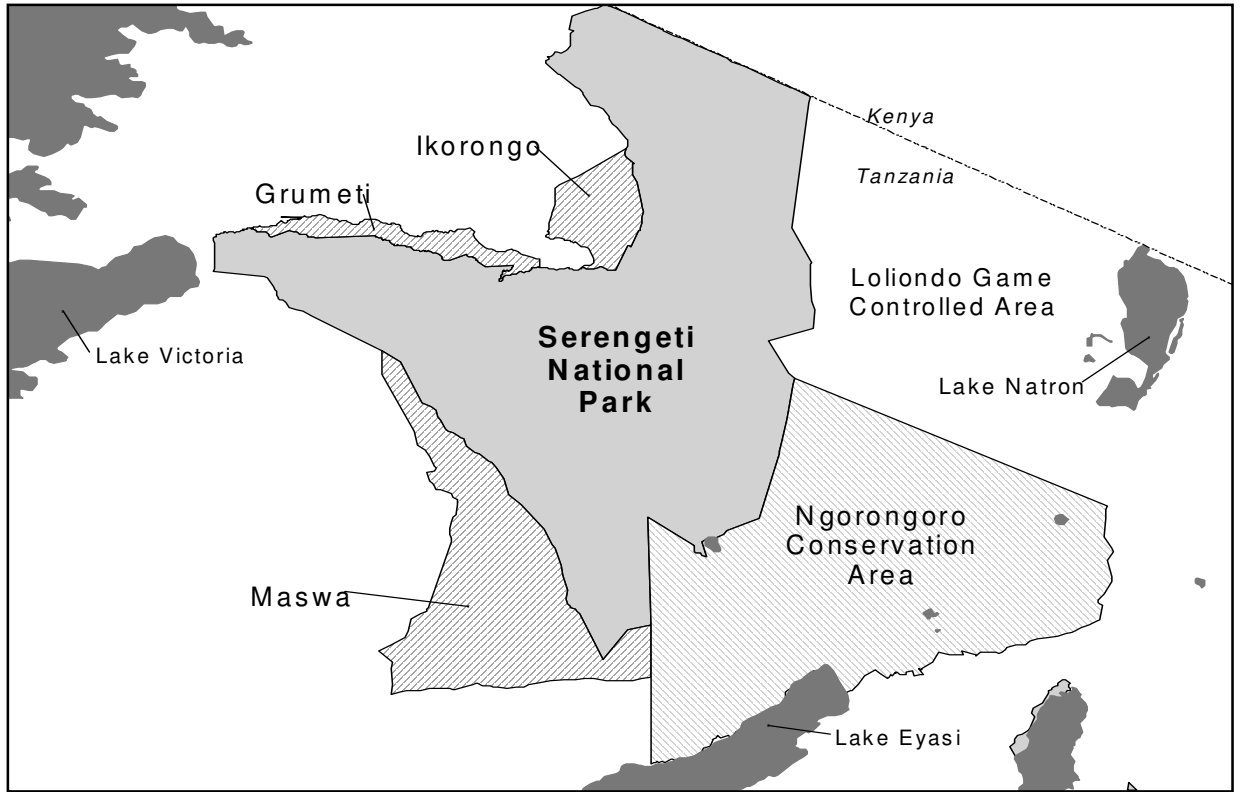
Pilots recorded the beginning and end points of each transect by using Geographical Positioning System and flight lines were drawn on maps in ArcView, with coordinates written out for pilots to follow mark as completed. Each transect was divided into sub-units defined by thirty-second flying time, which 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 (Aerial Point Surveys).

## Laboratory Work

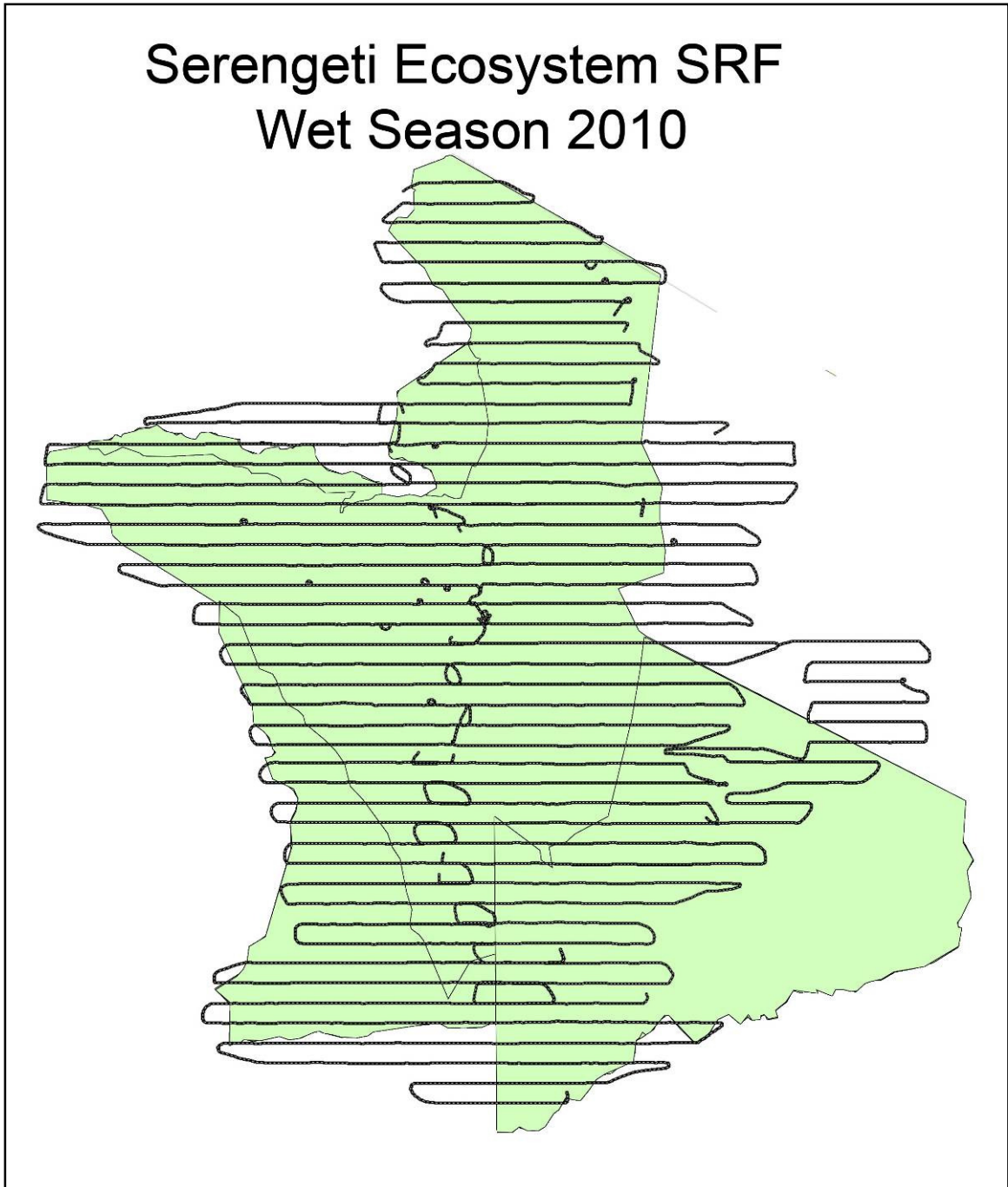
Census data were entered in computers and analyzed using software (SISTA) developed at CIMU specifically for SRF surveys. Population estimates were calculated using Jolly's Method of 2 unequal sized units (Jolly 1969). The *d-test* (Cochran 1963, Norton Griffiths 1978) was used to detect population changes.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



**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

Aircraft	5H-ZGF
Number of Transects	89
Total Sub Units	3271
Area in km <sup>2</sup>	26,827
Average altitude (ft)	328
Median altitude (ft)	340
Most used altitude (ft)	350
Max altitude (ft)	500
Min altitude (ft)	150
Strip width (Left)(m)	131
Strip width (Right) (m)	99
Combined strip width (m)	230

## 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 ( $207,166 \pm 37,638$ ), Thomson gazelle ( $165,973 \pm 34,218$ ), Grants gazelle ( $119,707 \pm 26,450$ ), impala ( $74,837 \pm 9,106$ ), and buffalo (32,001). Other species recorded in the area were wildebeest ( $41,759 \pm 10,823$ ), topi ( $38,497 \pm 12,856$ ), eland ( $36,297 \pm 6,169$ ), hartebeest ( $15,908 \pm 2,434$ ) and giraffe ( $12,078 \pm 1,645$ ) warthog ( $11,273 \pm 1,822$ ), elephant (3680), baboon ( $5,897 \pm 1,707$ ), ostrich ( $5,419 \pm 1,135$ ), waterbuck ( $2,567 \pm 1,083$ ), reedbuck ( $1,545 \pm 1,342$ ), and hippopotamus ( $1,306 \pm 1,068$ ). 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**

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

Serengeti NP	12,930 km <sup>2</sup>			
	Counted	Observations	Estimates	S.E
Bushbuck	1	1	22	21
Baboon	212	13	4656	1508
Bat-eared Fox	14	3	308	175
Cheetah	3	2	66	47
Crocodile	1	1	22	22
Duiker	10	1	220	215
Elephant Carcass	4	4	88	42
Eland	371	36	8148	2594
Grants Gazelle	1625	94	35688	8612
Greater Kudu	5	1	110	107
Giraffe	268	56	5886	1221
Hippo	52	2	1142	1054
Hyaena	6	5	132	68
Impala	1996	128	43837	6219
Jackal (all species)	1	1	22	22
Kongoni/Hartebeest	517	81	11354	1932
Lion	29	10	637	225
Ostrich	113	28	2481	661
Reedbuck	68	6	1493	1353
Roan Antelope	1	1	22	21
Thomson Gazelle	1564	52	34349	10675
Topi	1617	137	35512	12435
Waterbuck	79	11	1735	1030
Warthog	413	111	9070	1524
Wildebeest	608	40	13353	7526
Zebra	3285	156	72144	23125

<b>Ngorongoro Conservation Area</b>	<b>4,238 km<sup>2</sup></b>			
<b>Common name</b>	<b>Counted</b>	<b>Observations</b>	<b>Estimates</b>	<b>S.E</b>
Eland	691	60	14969	3288
Grants Gazelle	2875	126	62280	17043
Giraffe	70	16	1516	545
Hyaena	12	2	260	236
Impala	139	12	3011	1259
Jackal (all species)	4	1	86	85
Kongoni/Hartebeest	40	7	867	423
Lion	8	1	173	171
Ostrich	75	18	1625	591
Thomson Gazelle	4275	143	92607	20408
Warthog	3	1	65	65
Wildebeest	754	16	16334	7195
Zebra	3944	238	85437	17366
<b>Maswa Game Reserve</b>				
	<b>345 km<sup>2</sup></b>			
<b>Common name</b>	<b>Counted</b>	<b>Observations</b>	<b>Estimates</b>	<b>S.E</b>
Baboon	37	2	798	579
Eland	147	4	3170	2331
Grants Gazelle	16	3	345	322
Giraffe	71	15	1531	602
Hippo	8	1	172	170
Impala	462	28	9962	3518
Kongoni/Hartebeest	26	4	561	373
Lion	2	1	43	39
Ostrich	18	4	388	269
Roan Antelope	12	1	259	261
Thomson Gazelle	6	1	129	132
Topi	12	1	259	259
Waterbuck	4	2	86	56
Warthog	35	9	755	308
Zebra	128	11	2760	1105

Common name	Counted	Observations	Estimates	S.E
Baboon	10	1	222	207
Grants Gazelle	23	2	510	546
Giraffe	1	1	22	24
Impala	21	2	466	259
Kongoni/Hartebeest	11	1	244	225
Topi	58	7	1287	862
Waterbuck	14	5	311	142
Warthog	17	4	377	158
Zebra	50	3	1110	1136
<b>Loliondo Game Controlled Area</b>				
<b>2,534 km<sup>2</sup></b>				
Common name	Counted	Observations	Estimates	S.E
Eland	424	26	9181	3591
Grants Gazelle	962	46	20829	7650
Giraffe	103	19	2230	720
Impala	295	15	6387	2851
Jackal (all species)	2	1	43	42
Kongoni/Hartebeest	102	17	2209	713
Lion	4	1	87	84
Ostrich	11	4	238	134
Thomson Gazelle	1782	77	38584	15396
Topi	51	5	1104	664
Wildebeest	557	27	12060	4506
Zebra	1966	99	42568	9851

<b>Outside Protected Area</b>	<b>3,485 km<sup>2</sup></b>			
<b>Common name</b>	<b>Counted</b>	<b>Observations</b>	<b>Estimates</b>	<b>S.E</b>
Eland	35	1	745	707
Giraffe	36	7	766	429
Impala	526	25	11200	2982
Kongoni/Hartebeest	35	4	745	458
Ostrich	9	3	192	109
Reedbuck	3	1	64	62
Topi	25	6	532	280
Waterbuck	7	3	149	120
Warthog	33	8	703	372
Zebra	47	6	1001	530
<b>Grumeti GR</b>				
	<b>304 km<sup>2</sup></b>			
<b>Common name</b>	<b>Counted</b>	<b>Observations</b>	<b>Estimates</b>	<b>S.E</b>
Baboon	12	3	1485	1283
Giraffe	6	1	266	193
Ostrich	23	1	133	97
Topi	6	5	510	129
Waterbuck	14	2	133	60
Warthog	17	1	310	404
Zebra	100	4	377	332

**Table 5:** Wildlife population estimate trends in the Serengeti ecosystem, 1996-2010

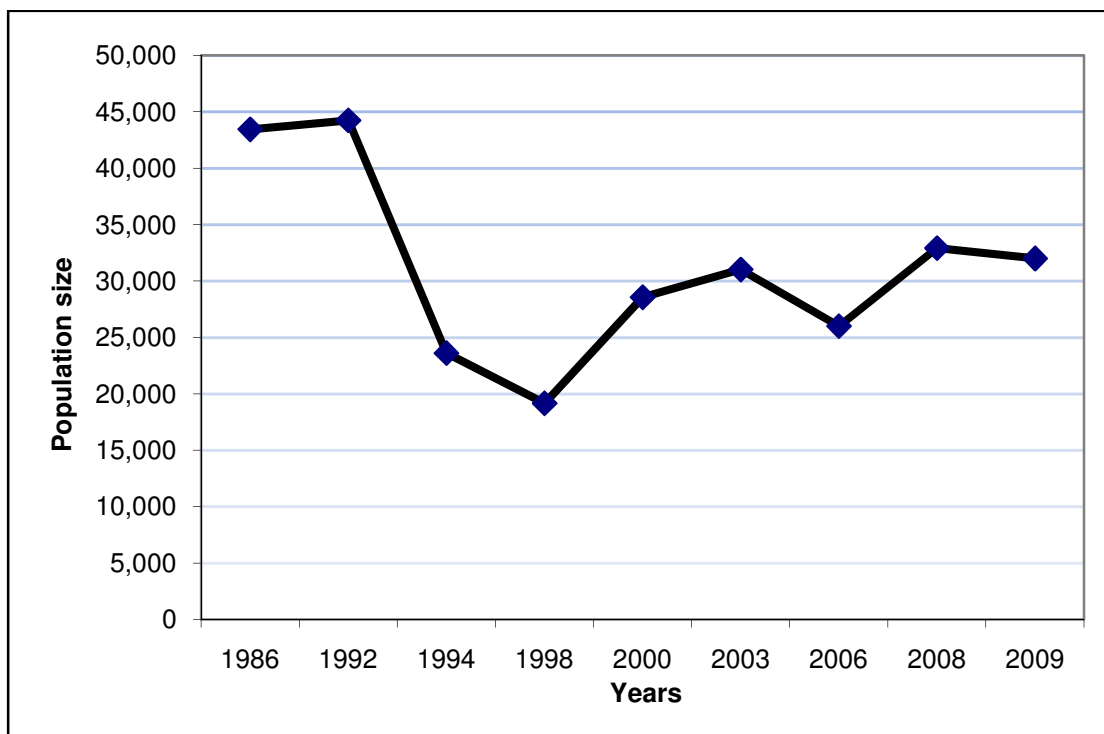
<b>Wet season</b>	<b>1996</b>		<b>2001</b>		<b>2003</b>		<b>2006</b>				<b>2010</b>	<i>d-test</i>
Area km <sup>2</sup>	27,992		26,691		31,589		27,113		26,827			<b>2006/10</b>
Species	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE		
<b>Species with Increasing populations</b>												
G. gazelle	126,419	19,183	47,182	7,412	55,109	8,139	35,537	5,564	119,707	26,450		<b>3.11</b>
Giraffe	6,166	485	14,228	1,866	10,552	1,678	5,246	871	12,078	1,645		<b>3.67</b>
Hartebeest	11,122	1,039	15,405	2,647	16,184	1,802	7,204	1,440	15,908	2,434		<b>3.08</b>
Eland	11,736	2,964	20,015	4,552	15,912	1,169	17,957	3,898	36,297	6,169		<b>2.51</b>
Warthog	4,943	567	2,637	647	3,769	577	3,370	619	11,273	1,823		<b>4.10</b>
<b>Species with stable populations</b>												
Hyena	984	176	264	158	1,105	345	279	127	392	246		<b>0.41</b>
Hippo	963	463	1,251	694	3,542	2,046	1,974	1,525	1,306	1,068		<b>-0.36</b>
Impala	70,651	8,634	92,628	12,669	91,490	18,288	72,159	12,887	74,837	9,106		<b>0.17</b>
Reedbuck	324	119	365	199	348	45	279	167	1,545	1,342		<b>0.94</b>
T. gazelle	229,887	41,018	119,759	18,335	175,548	29,062	241,308	50,088	165,973	34,218		<b>-1.24</b>
Topi	49,959	5,153	46,333	3,469	39,333	5,213	35,044	10,456	38,497	12,856		<b>0.21</b>
Waterbuck	1,559	429	3,532	2,144	1,196	443	1,085	428	2,567	1,083		<b>1.27</b>
Lion	690	209	956	296	999	205	510	193	936	290		<b>1.22</b>

Wildebeest#	135,282	33,631	6,668	697	57,425	7,835	34,271	11,894	41,759	10,823	<b>0.47</b>
Zebra	150,834	16,537	166,303	33,368	185,434	31,986	161,049	24,748	207,166	37,638	<b>1.02</b>
Ostrich	8,485	1,414	2,855	332	5,132	420	6,019	1,125	5,419	1,135	<b>-0.38</b>
Baboon	10,334	5,384	6,374	291	6,298	383	6,184	2,523	5,897	1,707	<b>-0.09</b>

## Species with declining populations

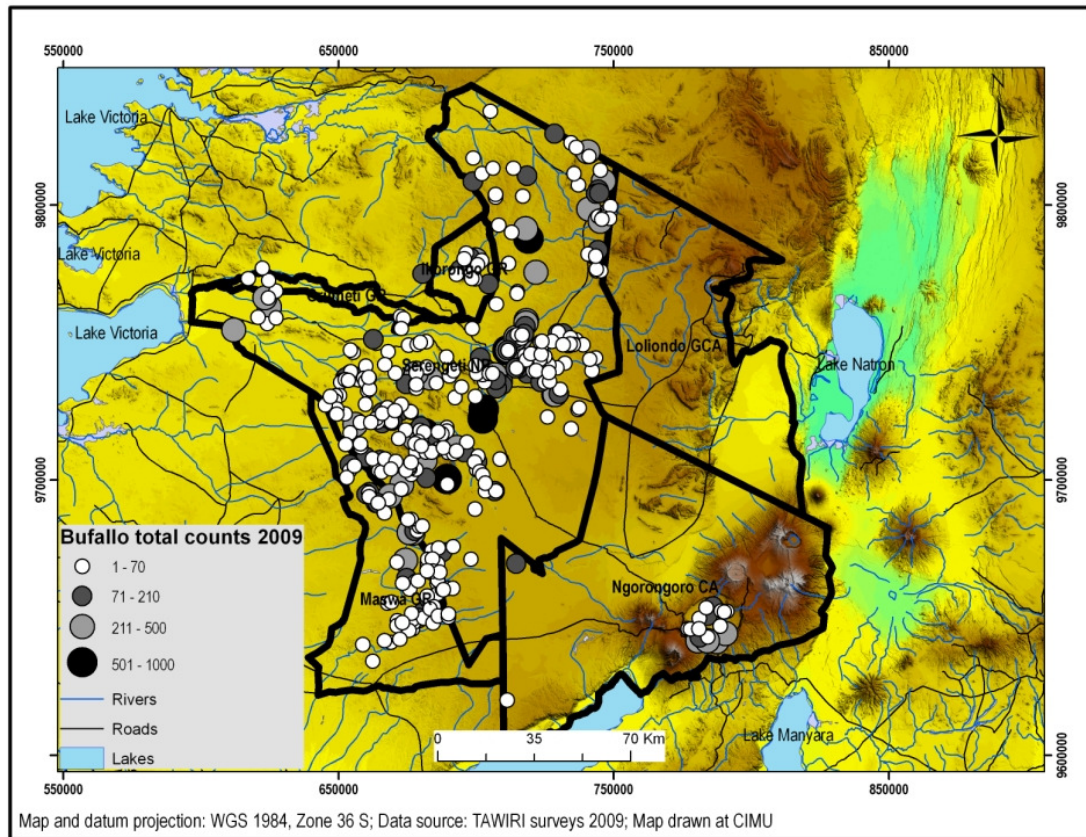
### Buffalo (*Syncerus caffer*)

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).



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



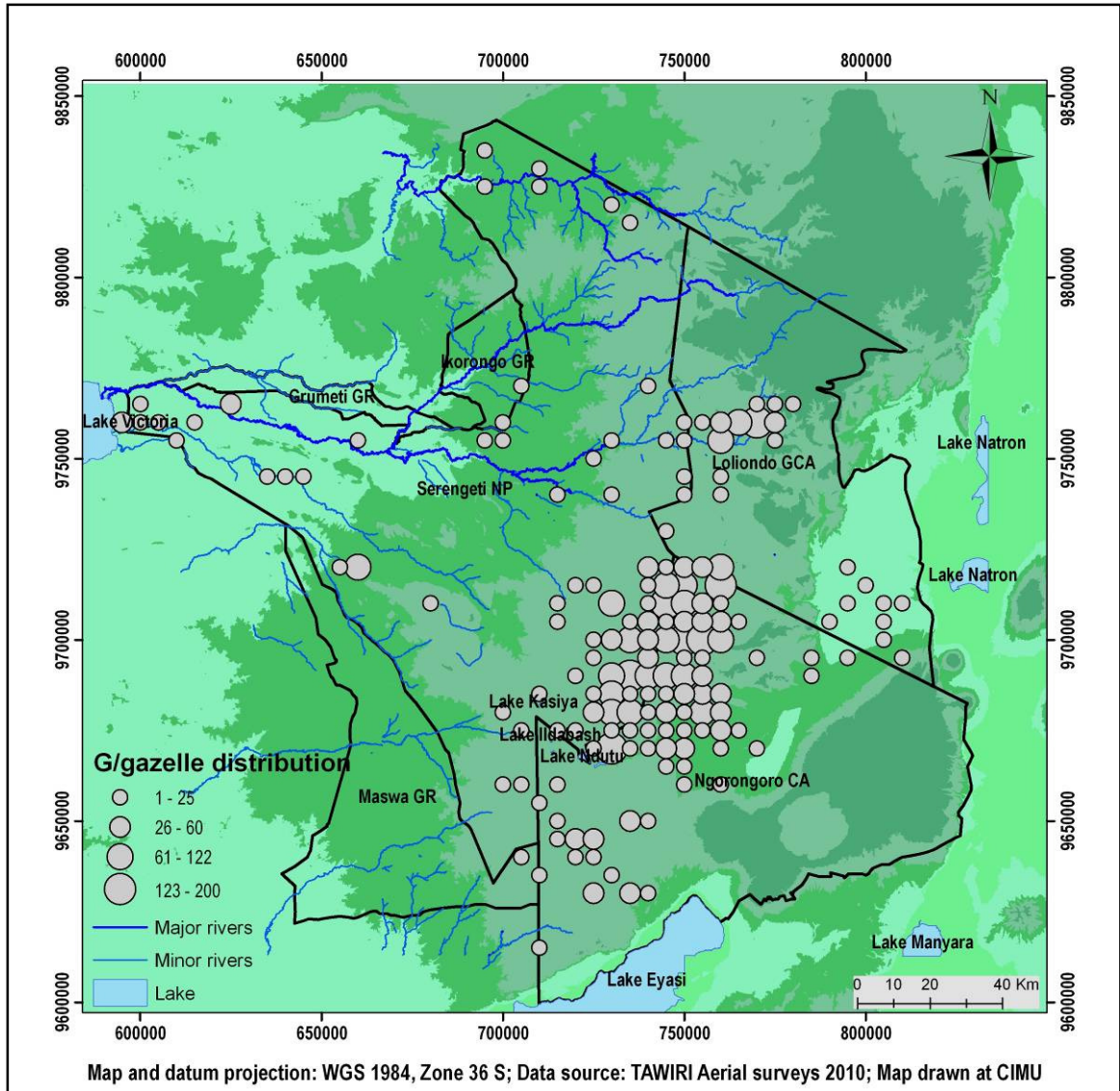


**Figure 5:** Density and distribution of buffalo in the Serengeti ecosystem, February 2010

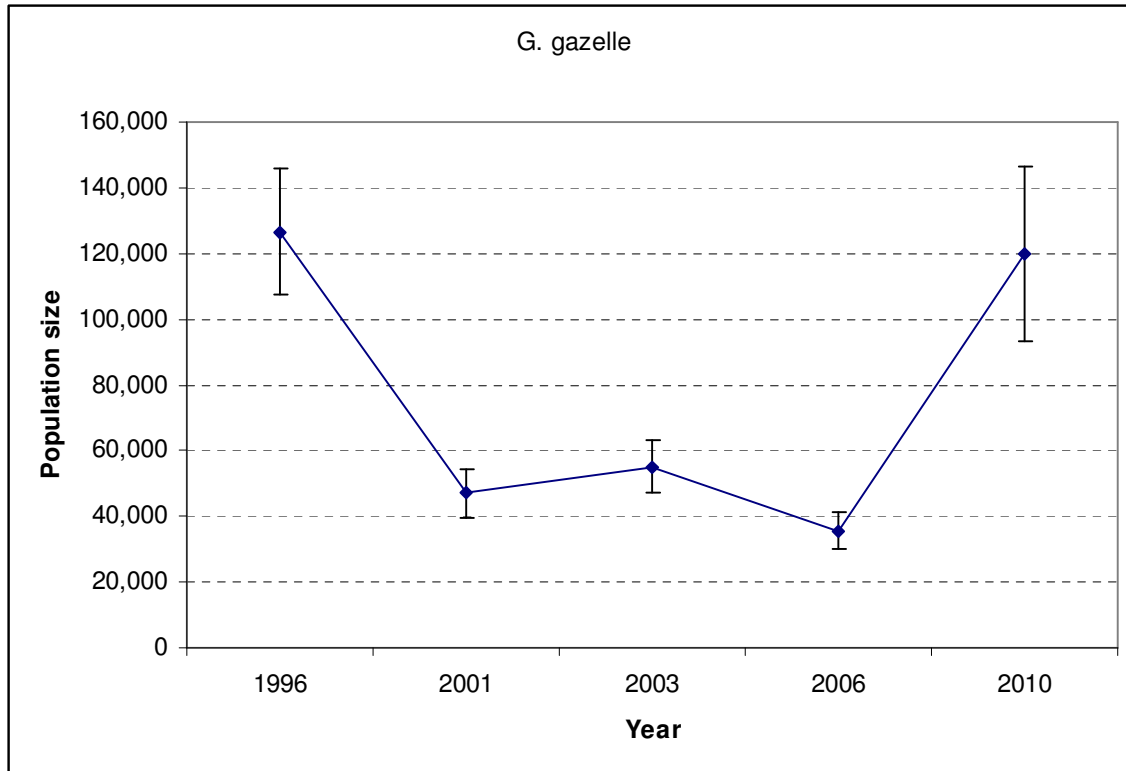
## Species with increasing populations

### Grants Gazelle

Grants gazelle was another species that appeared to be most abundant in the area. Analysis showed that there were  $119,707 \pm 26,450$  SE individuals in the area and also suggest a significant increase (Table 5) ( $d\text{-test} = 3.11$ ) when compared to  $35,537 \pm 5,564$  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).



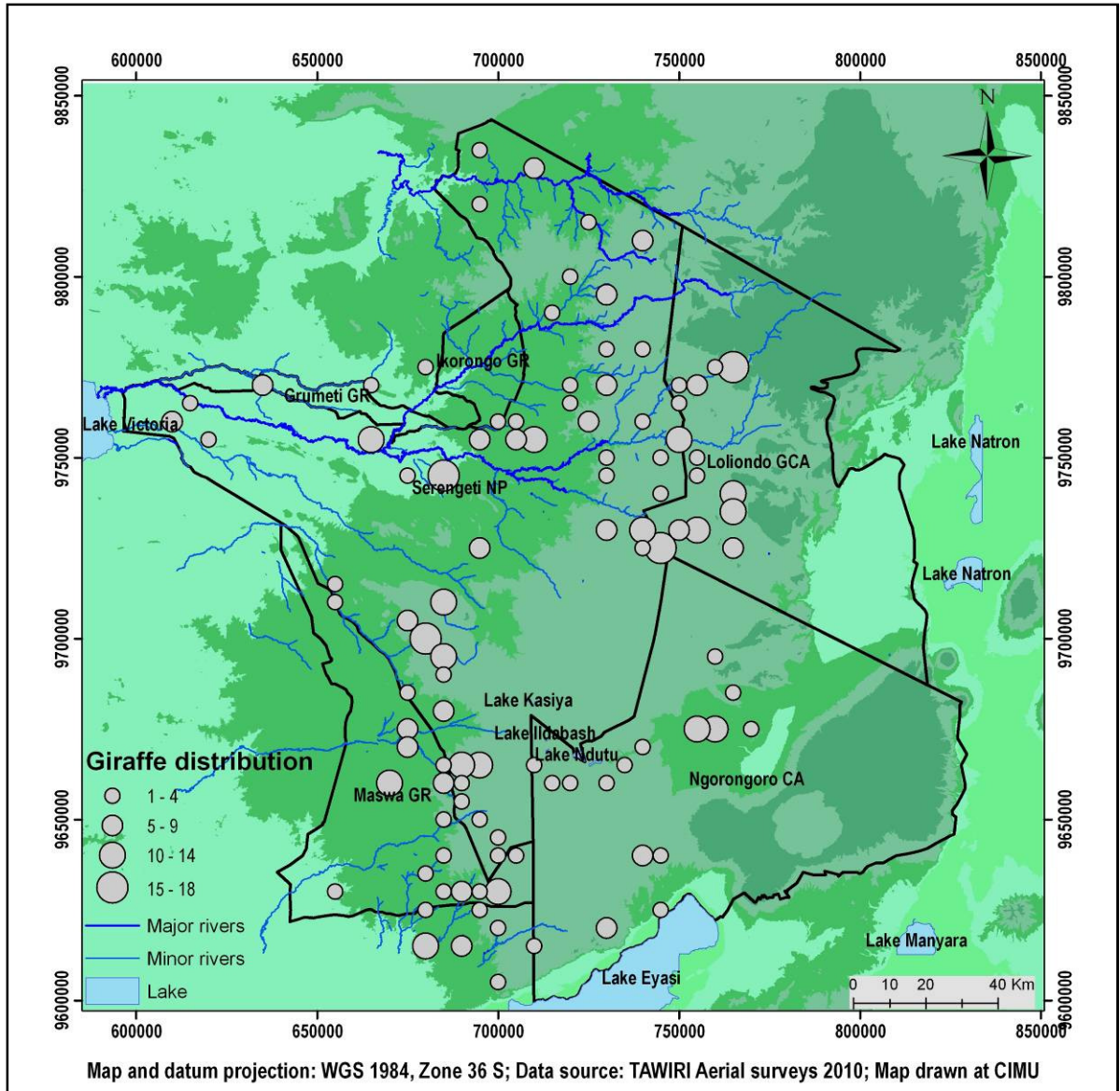
**Figure 6:** Density and distribution of grant gazelle in the Serengeti ecosystem, February 2010



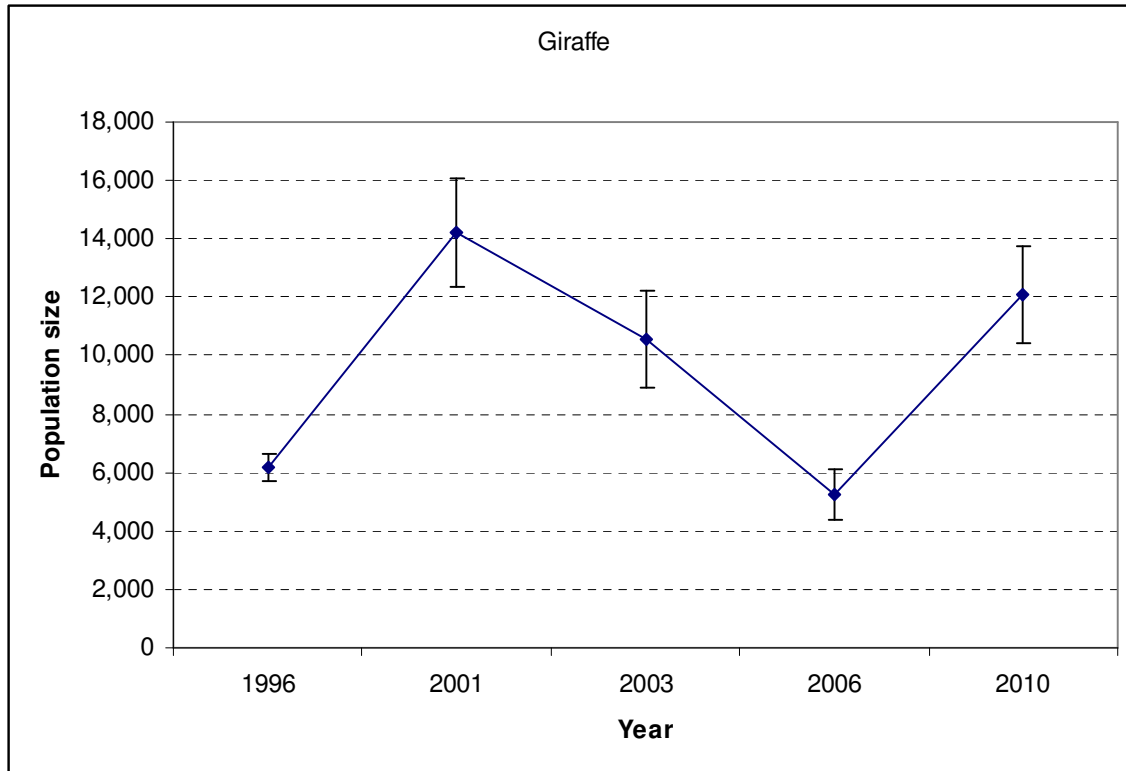
**Figure 7:** Grants gazelle population estimate trends in the Serengeti Ecosystem, 1996 – 2010

### **Giraffe (*Giraffa camelopardalis*)**

Other most abundant species recorded in the ecosystem was Giraffe. The species population increased significantly (almost double) from  $5,246 \pm 871$  SE in the year 2006 to  $12,078 \pm 1,645$  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



**Figure 9:** Giraffe population estimate trends in the Serengeti Ecosystem, 1996 - 2010

### Hartebeest

Hartebeest (Kongoni) were also abundant in the area estimated at  $15,908 \pm 2,434$  SE. This was significantly higher ( $d = 3.08$ ) when compared to  $7,204 \pm 1,440$  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.

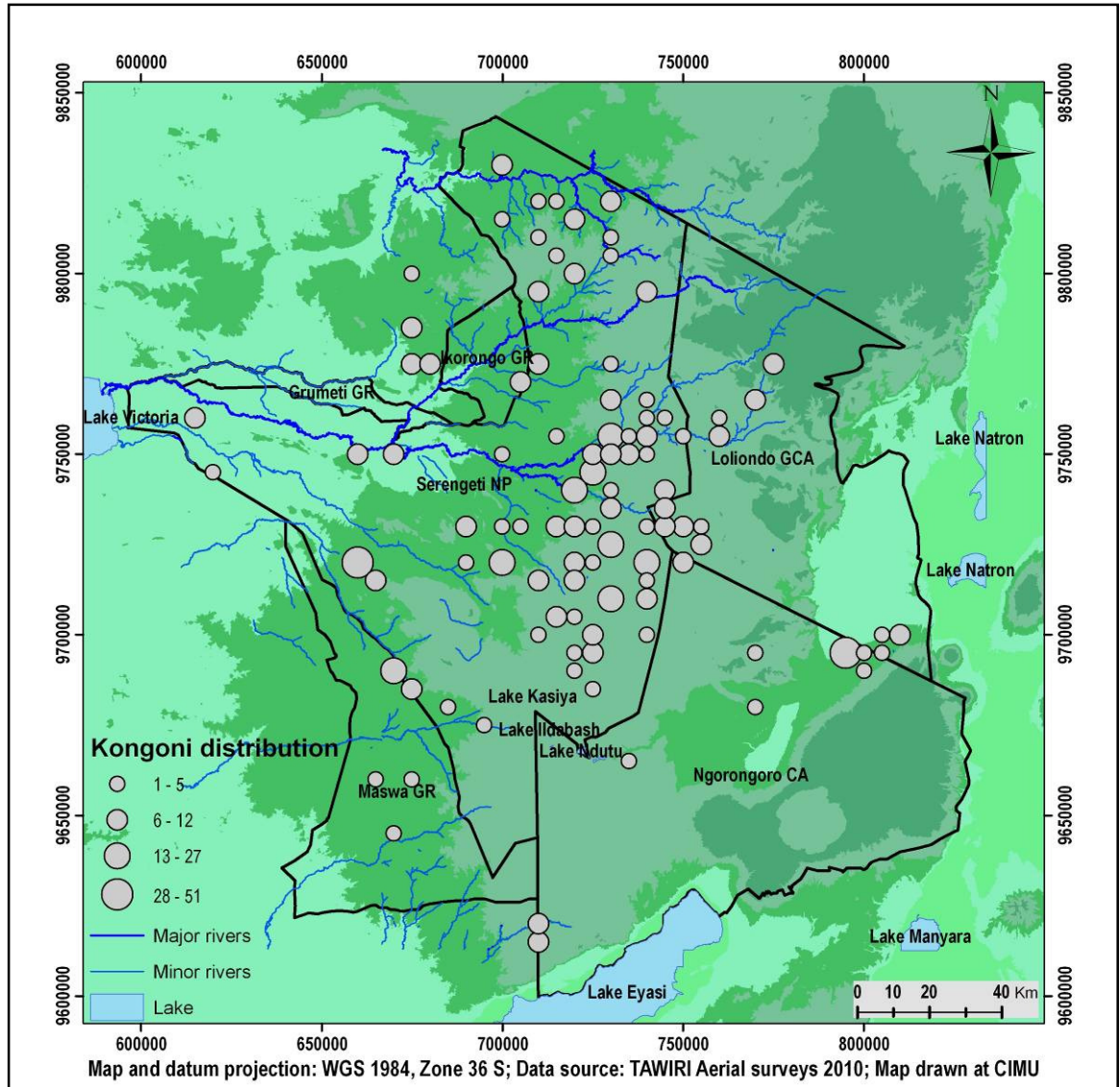
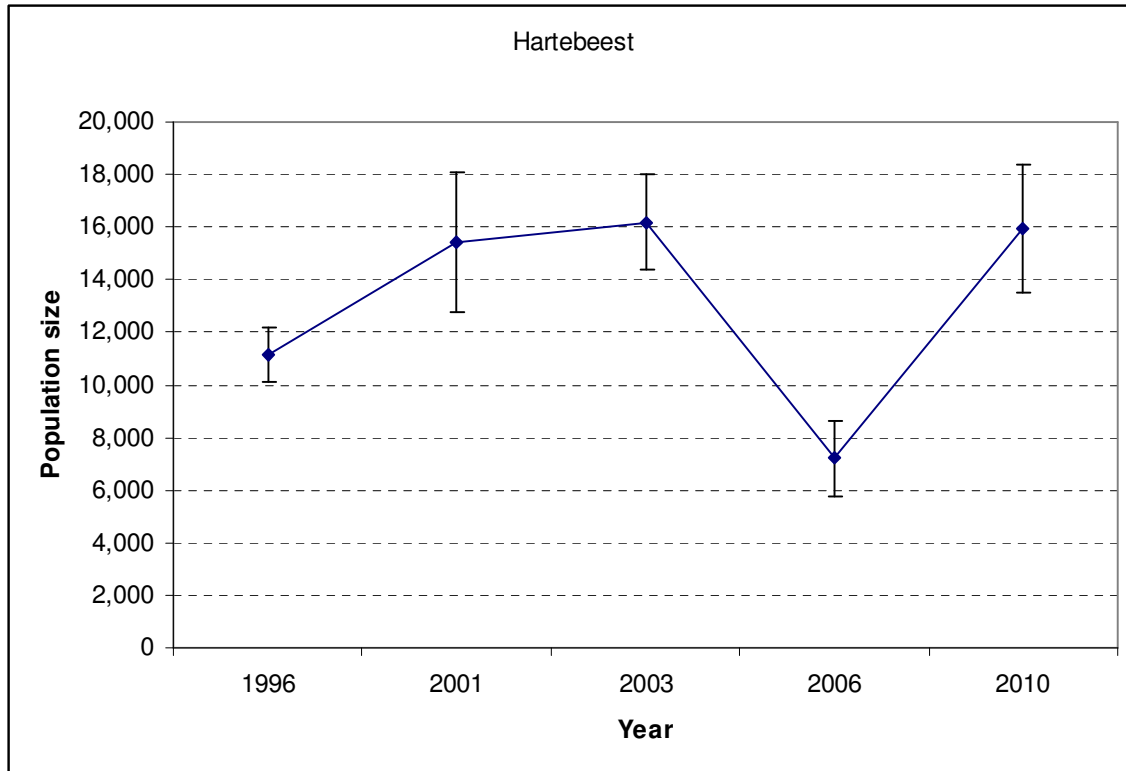


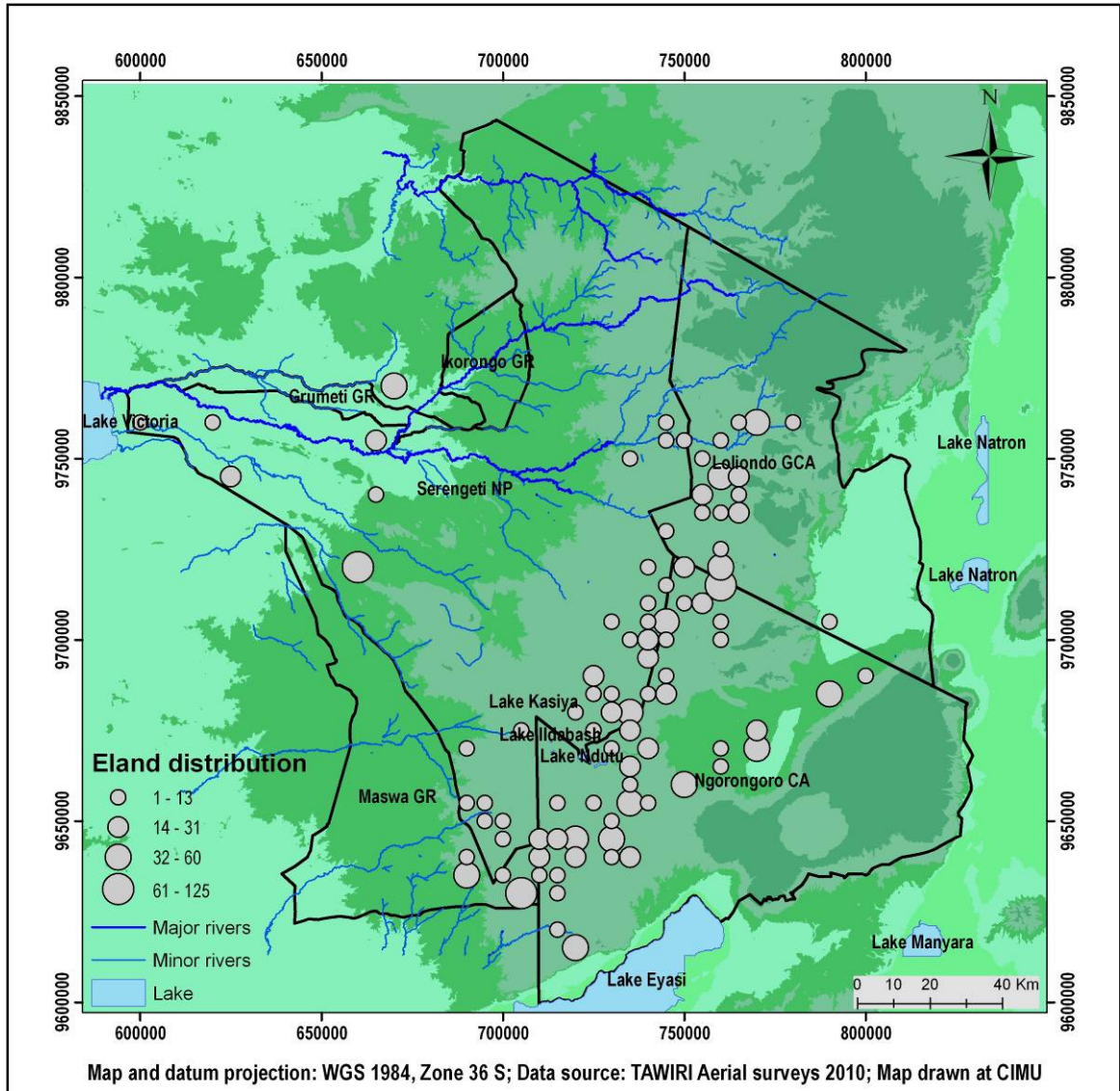
Figure 10: Density and distribution of hartebeest in the Serengeti ecosystem, February 2010



**Figure 11:** Hartebeest population estimate trends in the Serengeti Ecosystem, 1996 to 2010

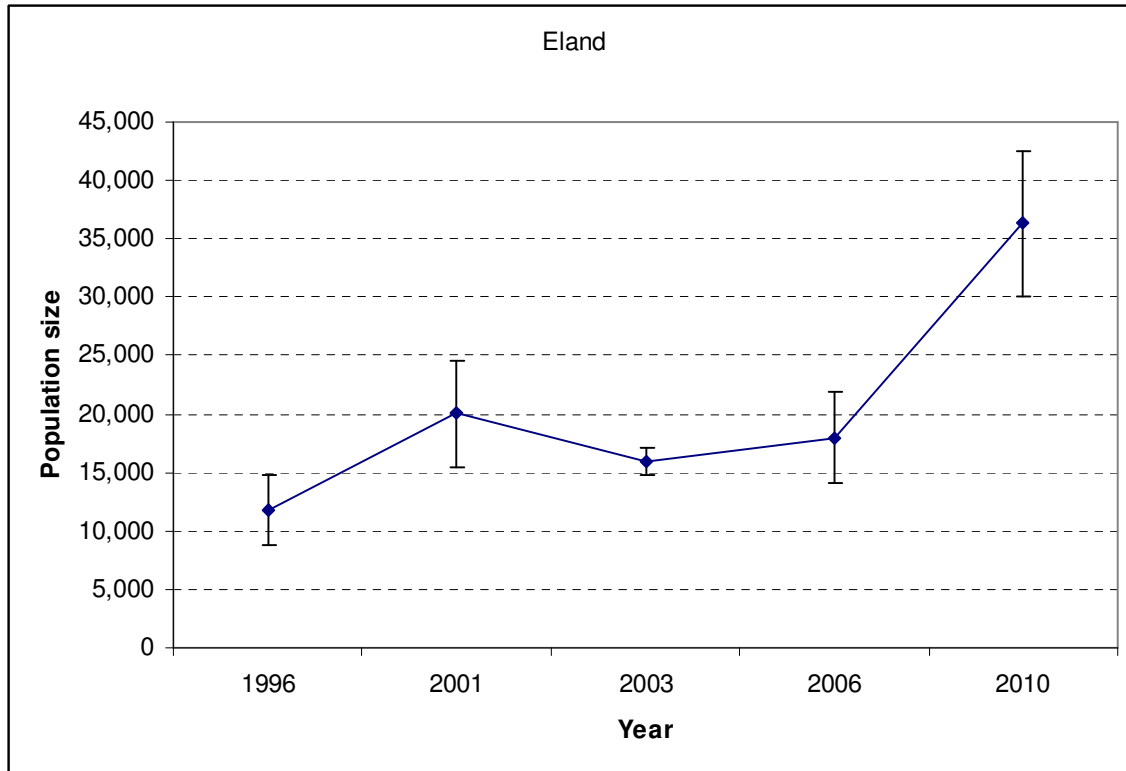
### **Eland (*Taurotragus derbianus*)**

Eland were also found to be among the abundant species in the area estimated at  $36,297 \pm 6,169$  SE individuals. The species indicated a significant increase ( $d = 2.51$ ) as compared to  $17,957 \pm 3,898$  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 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

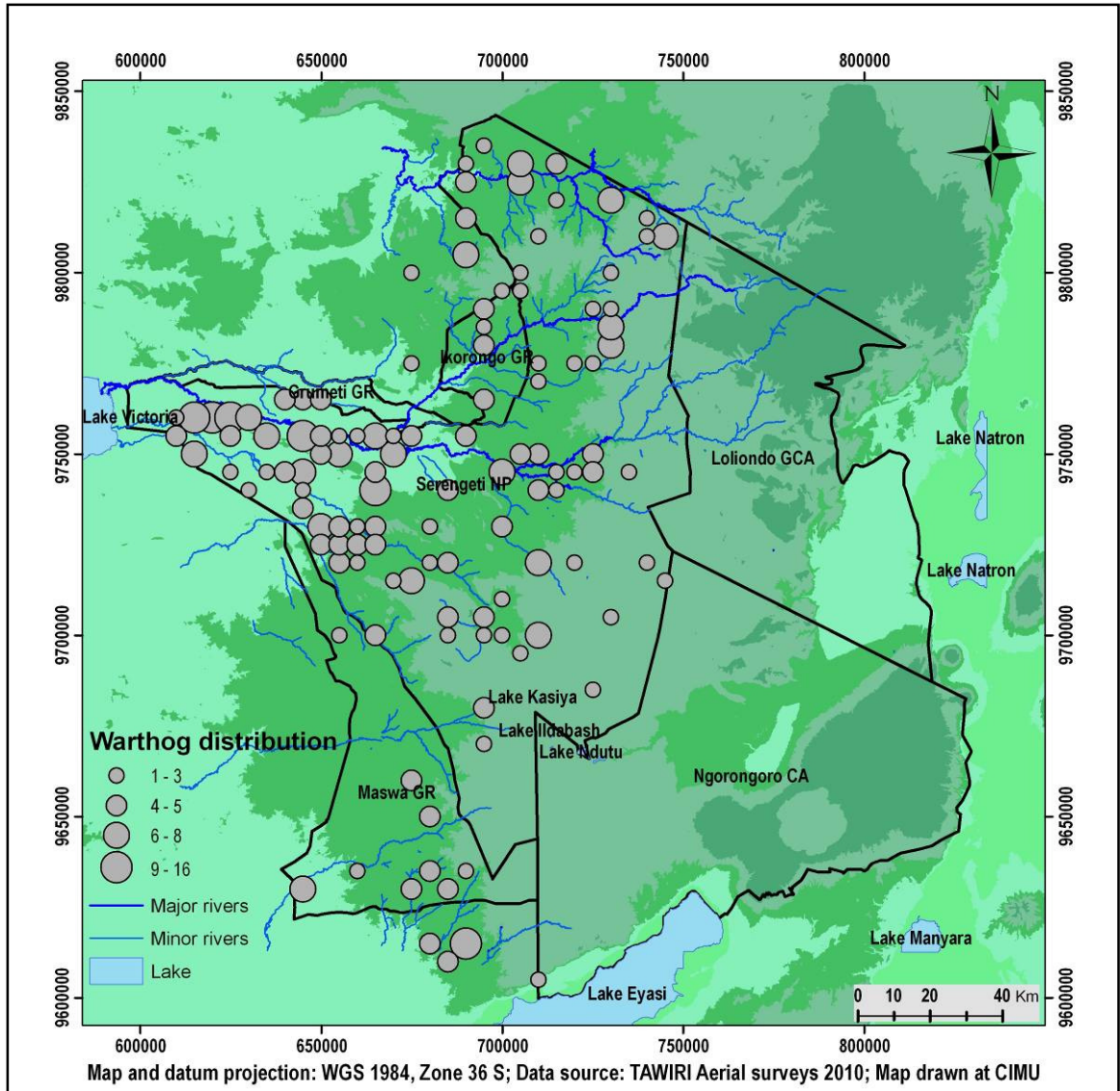




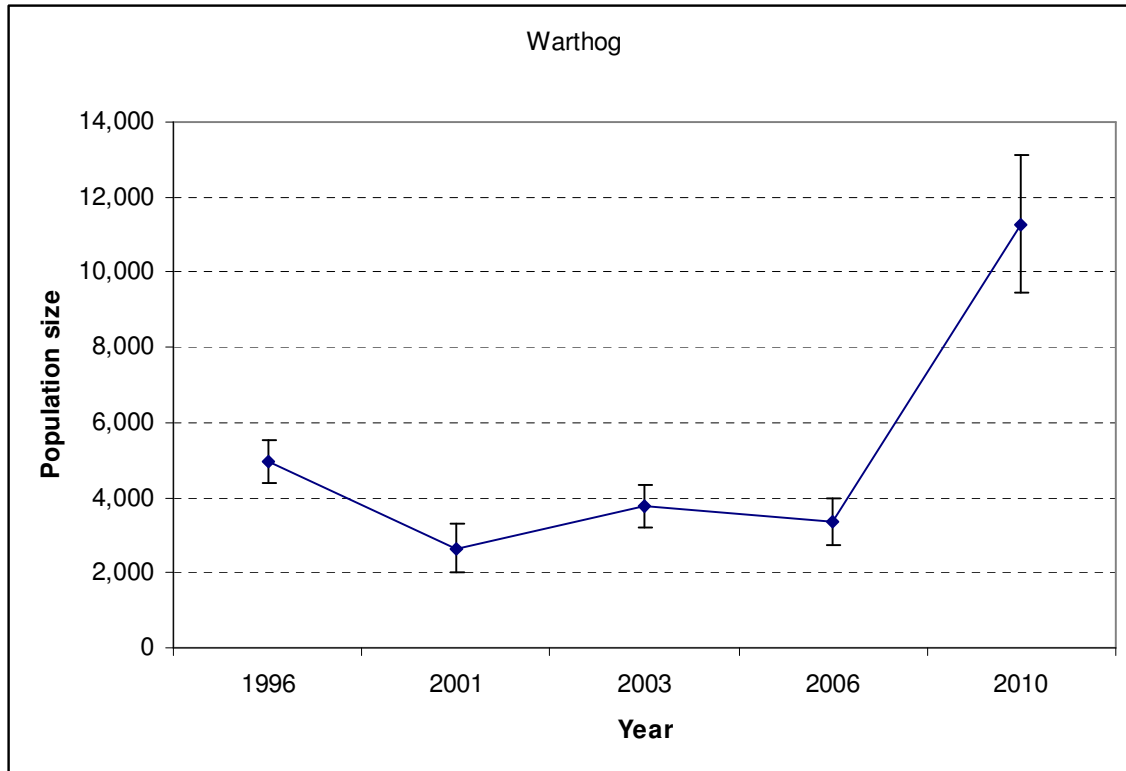
**Figure 13:** Eland population estimate trends in the Serengeti Ecosystem, years 1996 to 2010

#### **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



**Figure 15:** Warthog population estimate trends in the Serengeti Ecosystem, years 1996 - 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).

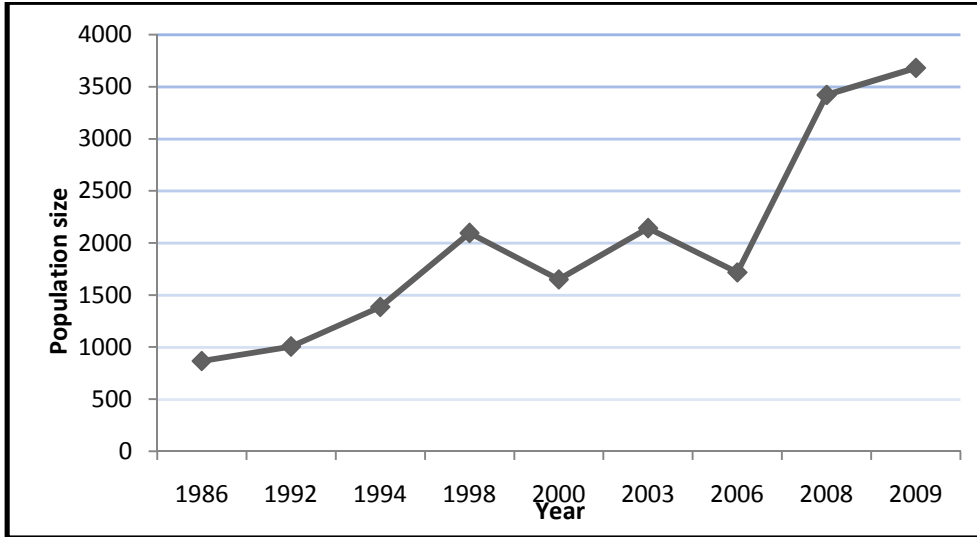


Figure 16: Elephant population trends in the Serengeti Ecosystem, years 1986 – 2009

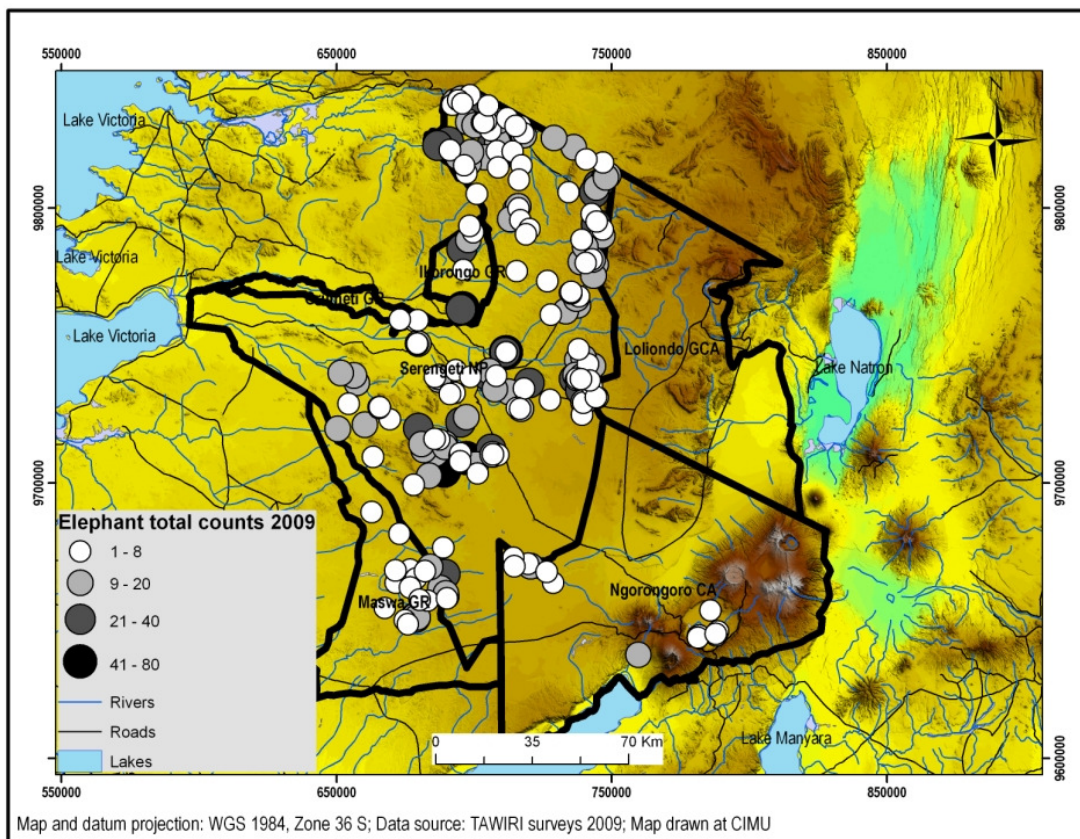
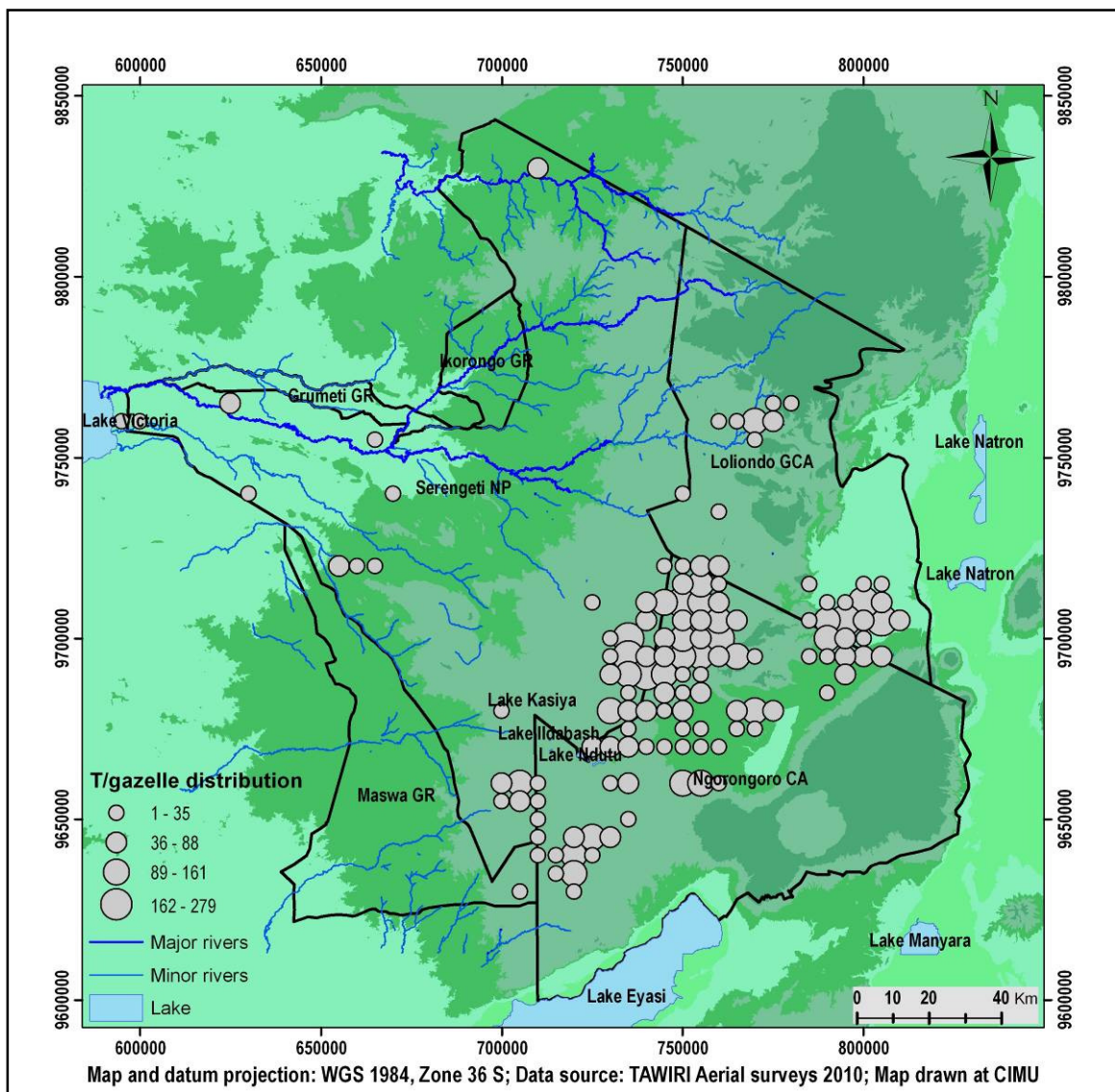


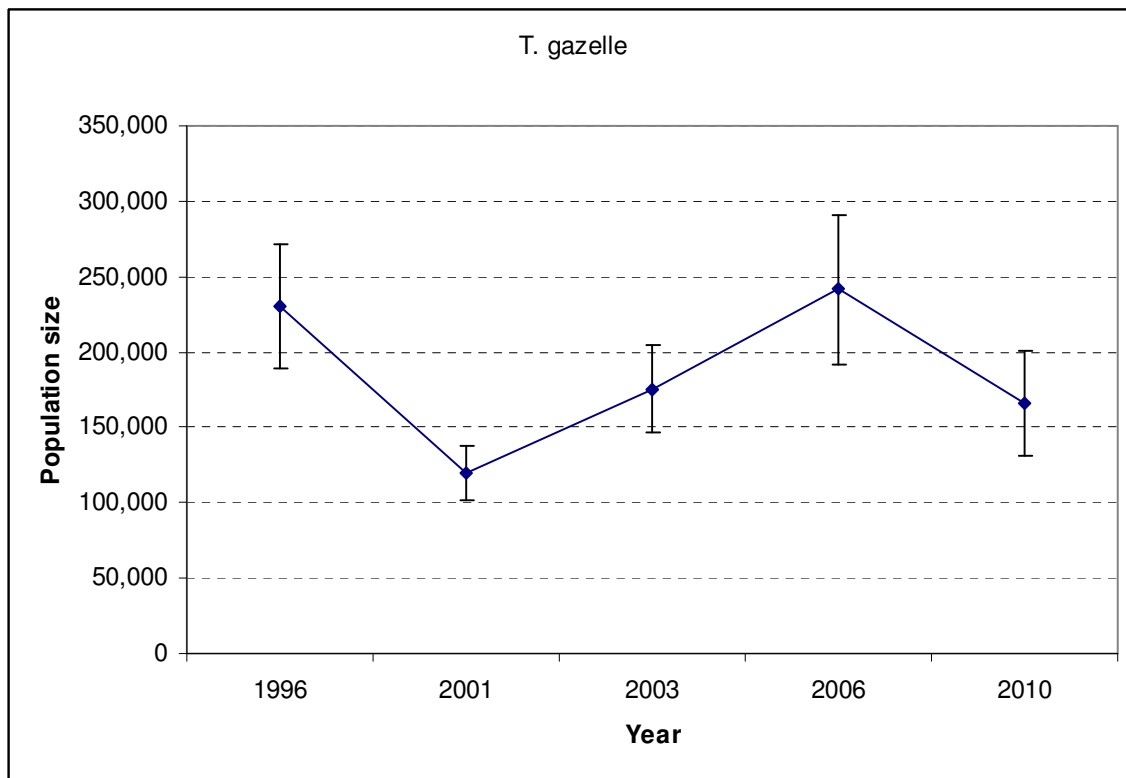
Figure 17: Density and distribution of elephant in the Serengeti ecosystem, February 2010

### 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  $214,308 \pm 50,088$  SE in the year 2006 to  $165,975 \pm 34,218$  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).



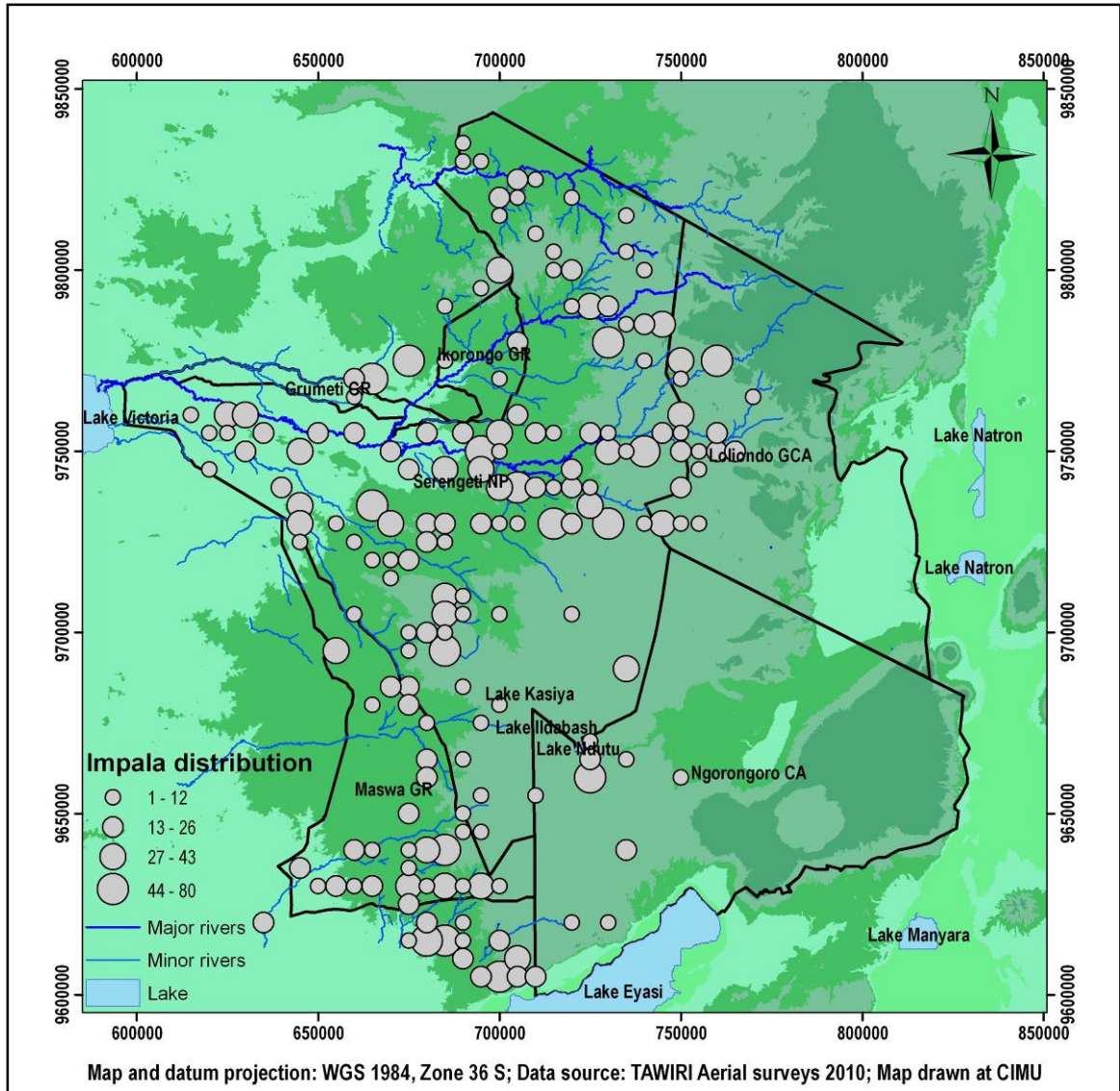
**Figure 18:** Density and distribution of Thomson's gazelle in the Serengeti ecosystem, February 2010



**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  $74,837 \pm 9,106$  SE individuals. The estimates indicates no significant different from the year 2006 estimates that stood at  $72,159 \pm 12,887$  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

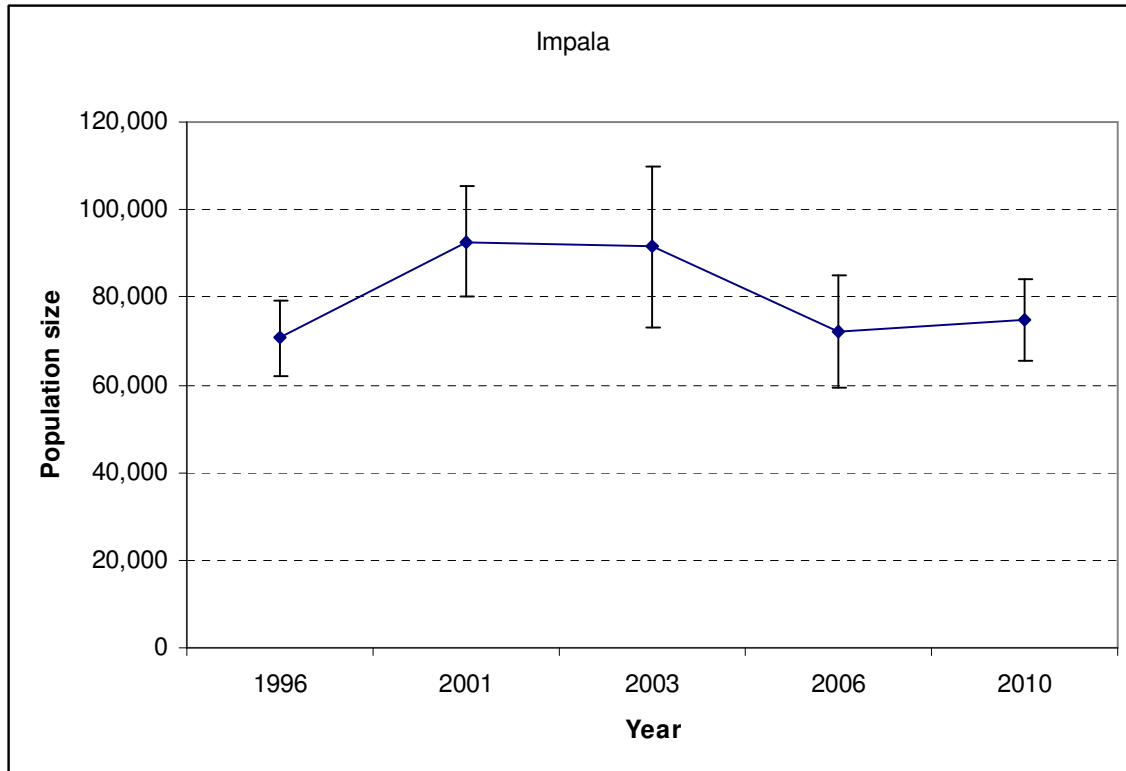


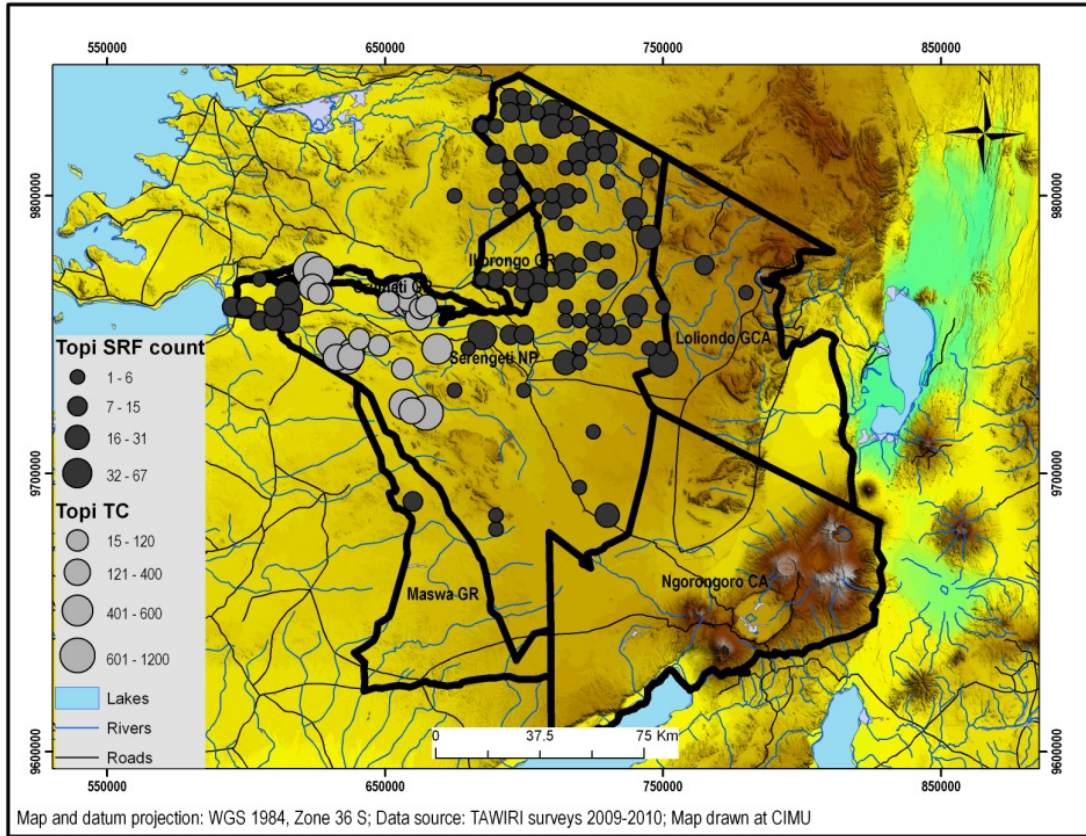
Figure 21: Impala population estimate trends in the Serengeti Ecosystem, years 1996 - 2010

### Topi (*Damaliscus lunatus*)

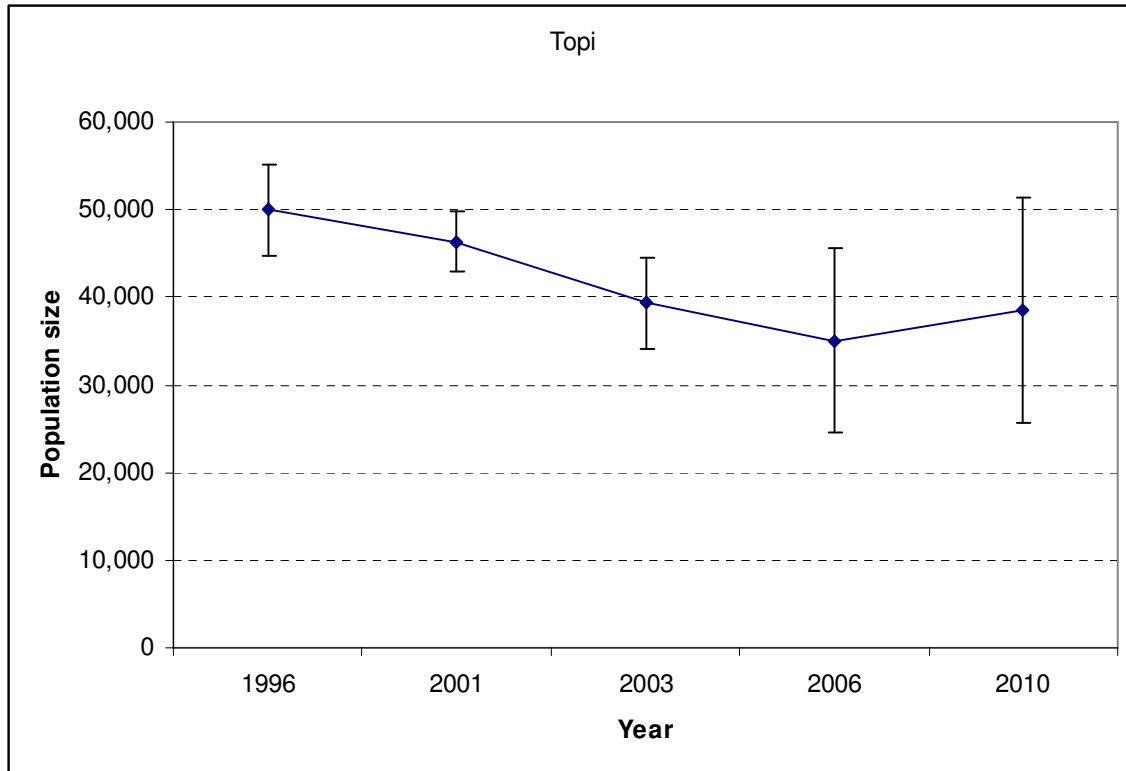
Population estimate of topi was  $38,497 \pm 12,856$  individuals excluding large groups of topi found in the plain of the Western Serengeti namely Nyasirori and Msabi. The estimate is slightly higher than that of the year 2006 survey that estimated  $35,044 \pm (10,085 \text{ SE})$  individuals (Table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





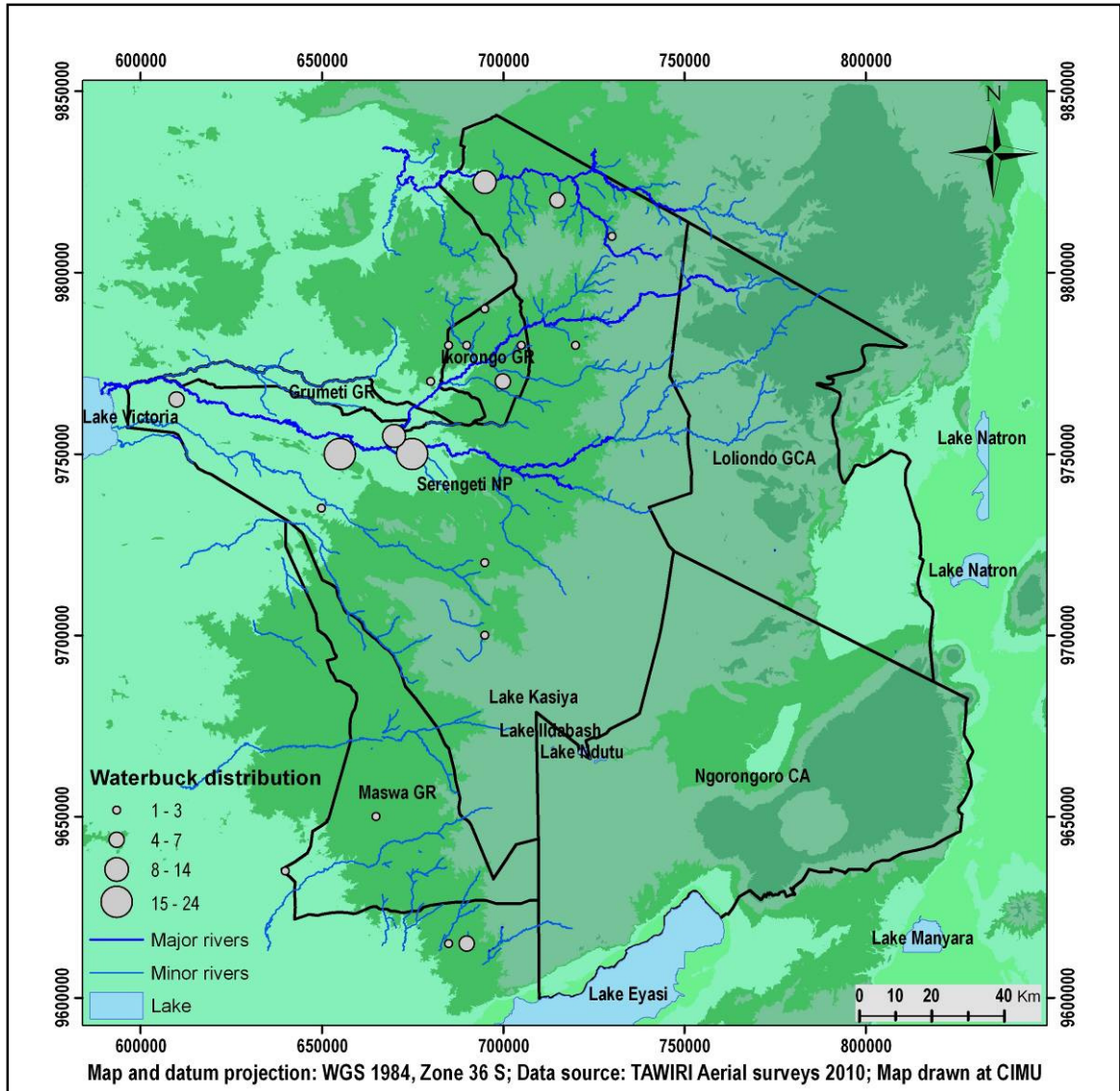
**Figure 22:** Density and distribution of topi in the Serengeti ecosystem, February 2010



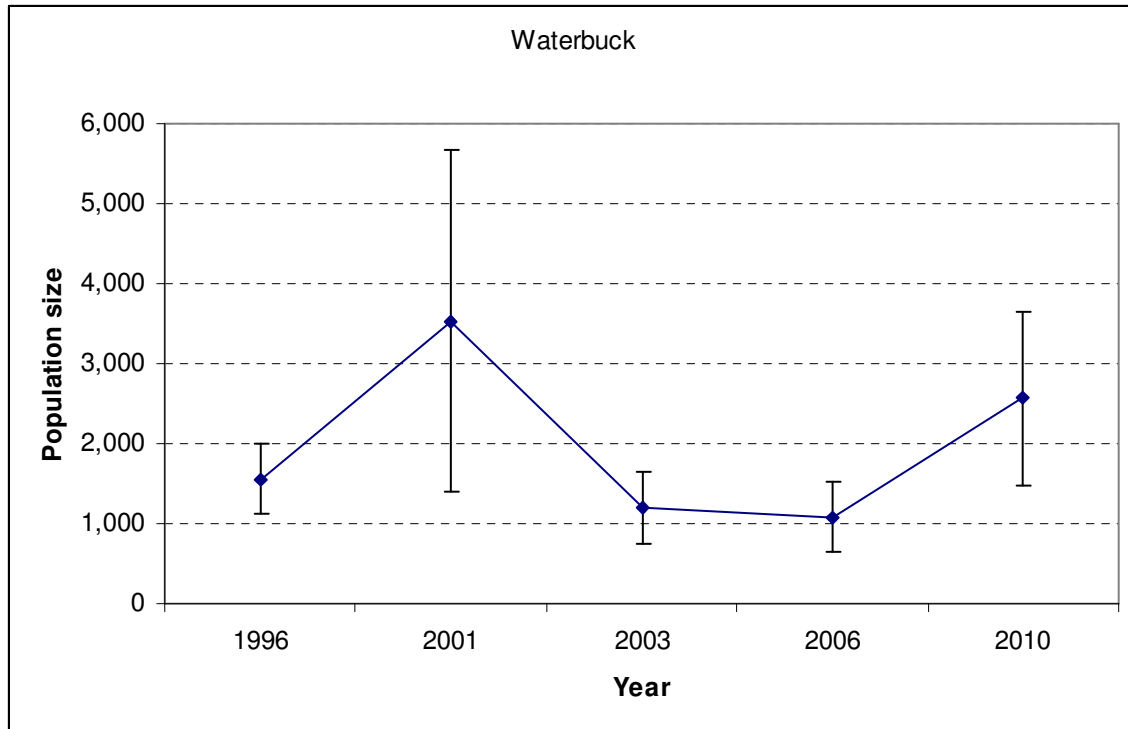
**Figure 23:** Topi population estimate trends in the Serengeti Ecosystem, years 1996 - 2010

#### **Waterbuck (*Kobus ellipsyprimnus*)**

The survey results estimated  $2,567 \pm 1,083$  SE waterbuck, and that is slightly higher than  $1,085 \pm 428$  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  $5,419 \pm 1,135$  SE individuals which is slightly less when compared to  $6,019 \pm 1,125$  SE estimated in the year 2006. However, this is not significant different (Table 5) ( $d\text{-test} = 0.38$ ), 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).

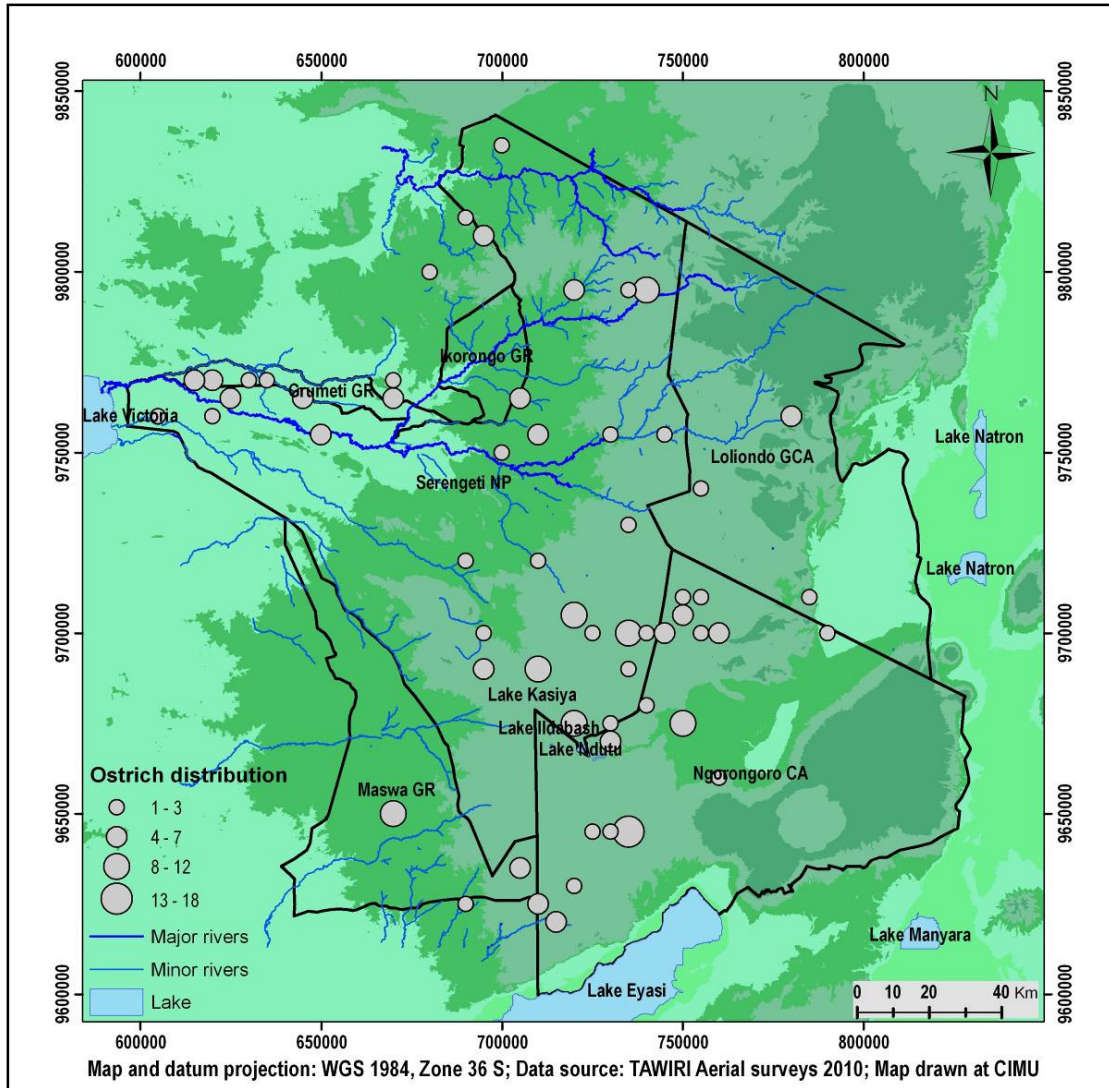
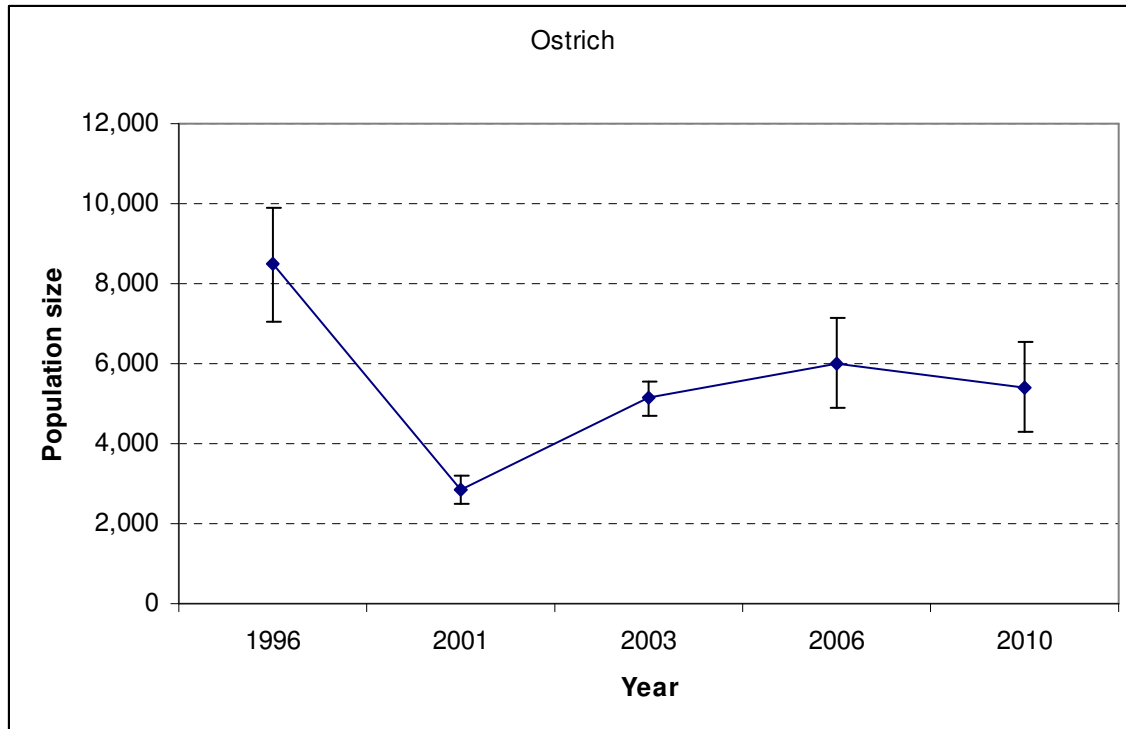


Figure 26: Density and distribution of ostrich in the Serengeti ecosystem, February 2010



**Figure 27:** Ostrich population estimate trends in the Serengeti Ecosystem, years 1996 – 2010

Other species recorded in the area that indicated stable population included Reedbuck (*Redunca redunca*)  $1,545 \pm 1,342$  SE, Hippopotamus (*Hippopotamus amphibius*)  $1,306 \pm 1054$  SE, Hyena (*Crocuta crocuta*)  $392 \pm 246$  SE, Wildebeest (*Connochaetes taurinus*)  $4141,759 \pm (10,823)$  SE, Zebra (*Equus burchelli*),  $207,166 \pm 37,638$  SE, and Baboon (*Papio cynocephalus*) that has  $5,897 \pm 1,707$  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

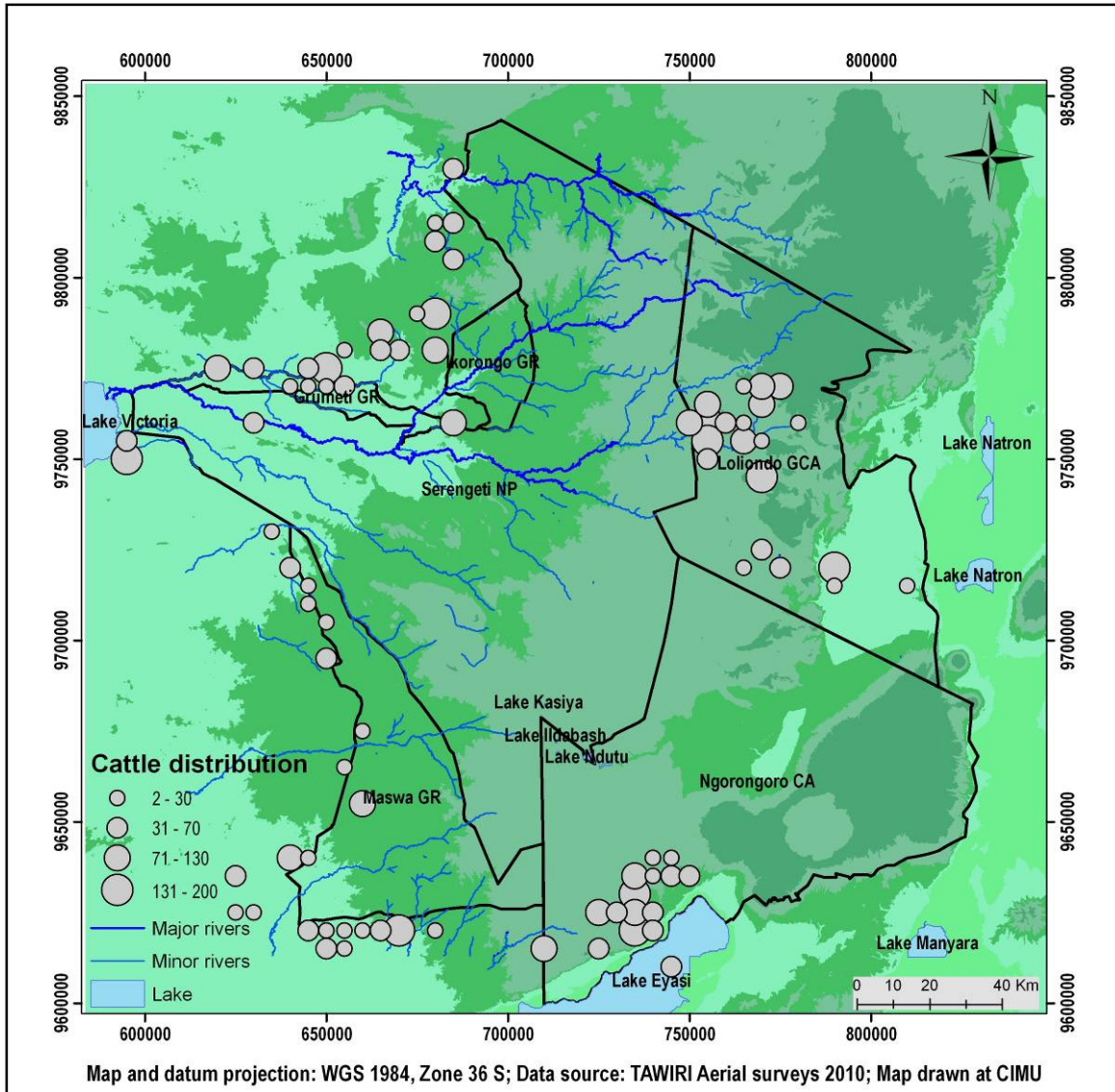
We recorded 11 types of human activities which included occupied bomas ( $4,134 \pm 1,839$  SE) and ( $1,154 \pm 296$  SE) abandoned bomas. Huts/houses with iron sheet roof were  $1,741 \pm 850$  SE, thatch roof ( $5,006 \pm 1,552$  SE), cattle ( $113,070 \pm 20,190$  SE), sheep and goats (sheeps) ( $87,612 \pm 19,509$  SE) and donkeys ( $349 \pm 260$ ). 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

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

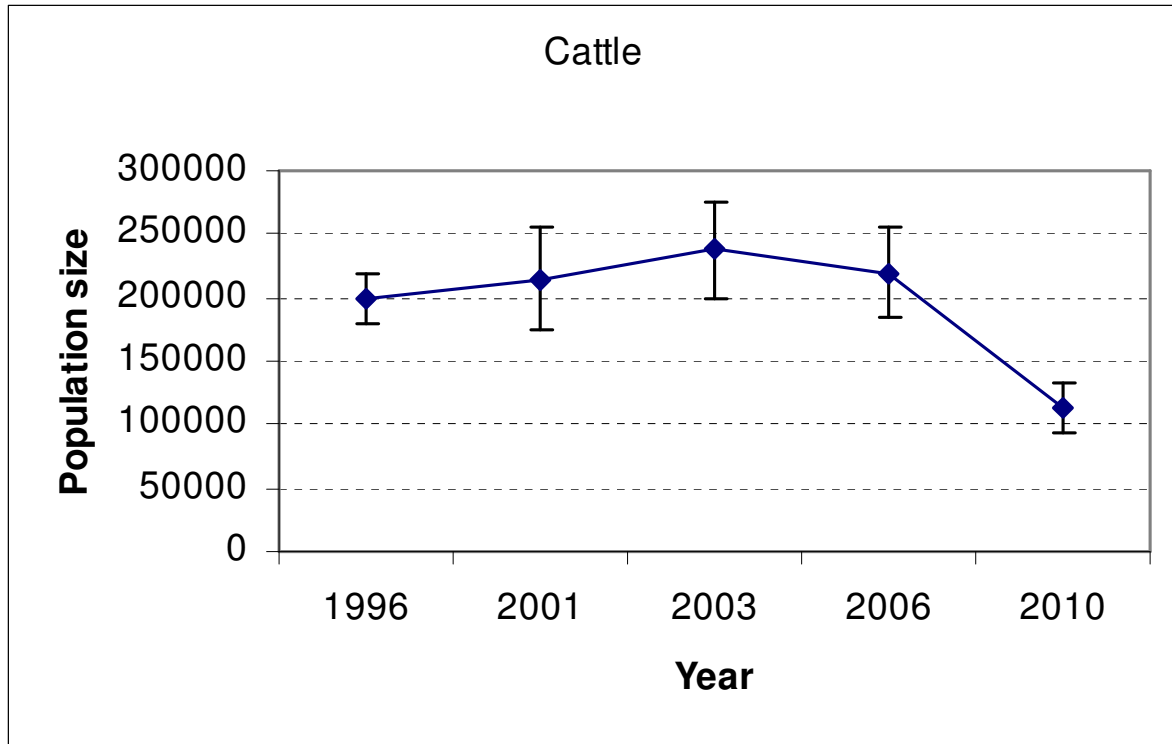
## Cattle

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 ( $d\text{-test} = 2.60$ ) (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 ( $d\text{-test} = 1.14$ ) (Table 7), there appear to be a steady decline since the year 2003 census (Figure 31).

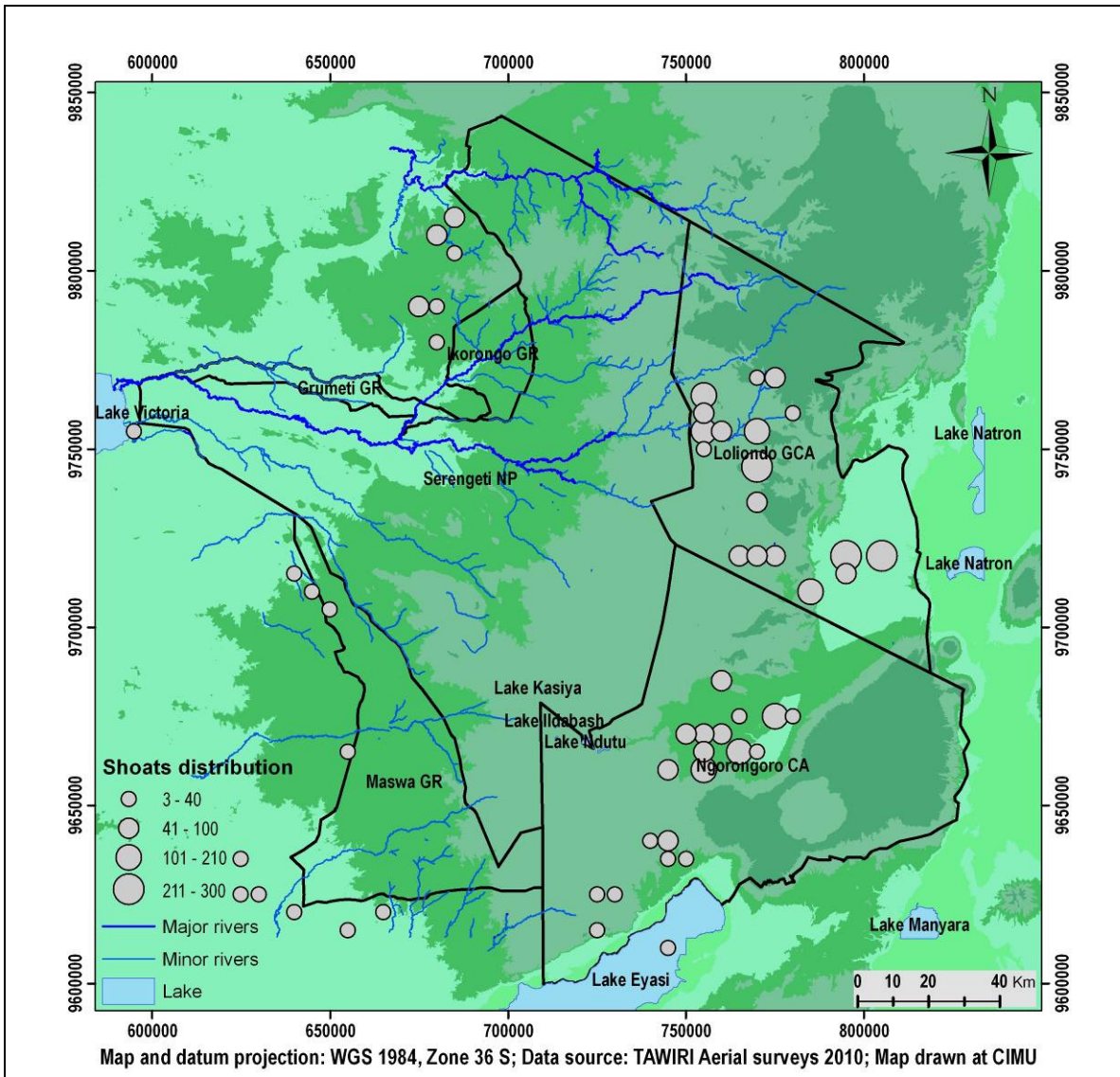
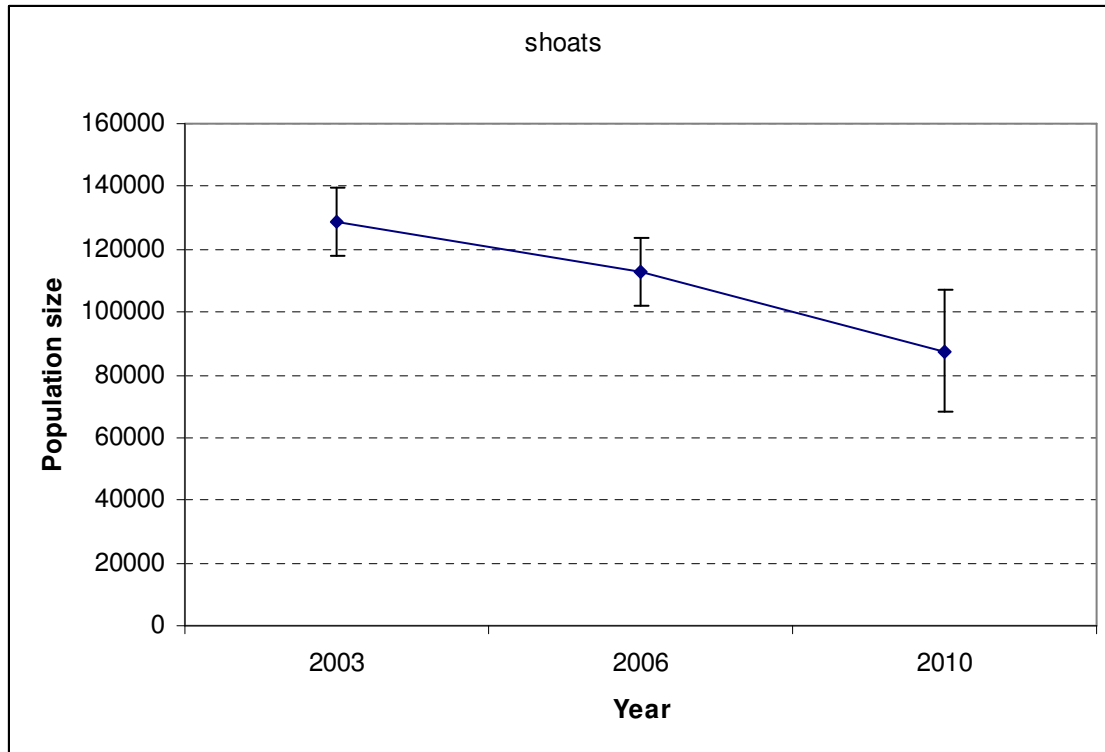


Figure 30: Density and distribution of shoats in the Serengeti ecosystem, February 2010



**Figure 31:** Shoats population estimate trends in the Serengeti Ecosystem, years 2003 - 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 ( $d\text{-test} = 1.26$ ) when compared to year 2006 census results (Table 7), although it appears to fluctuate over time (Figure 33).

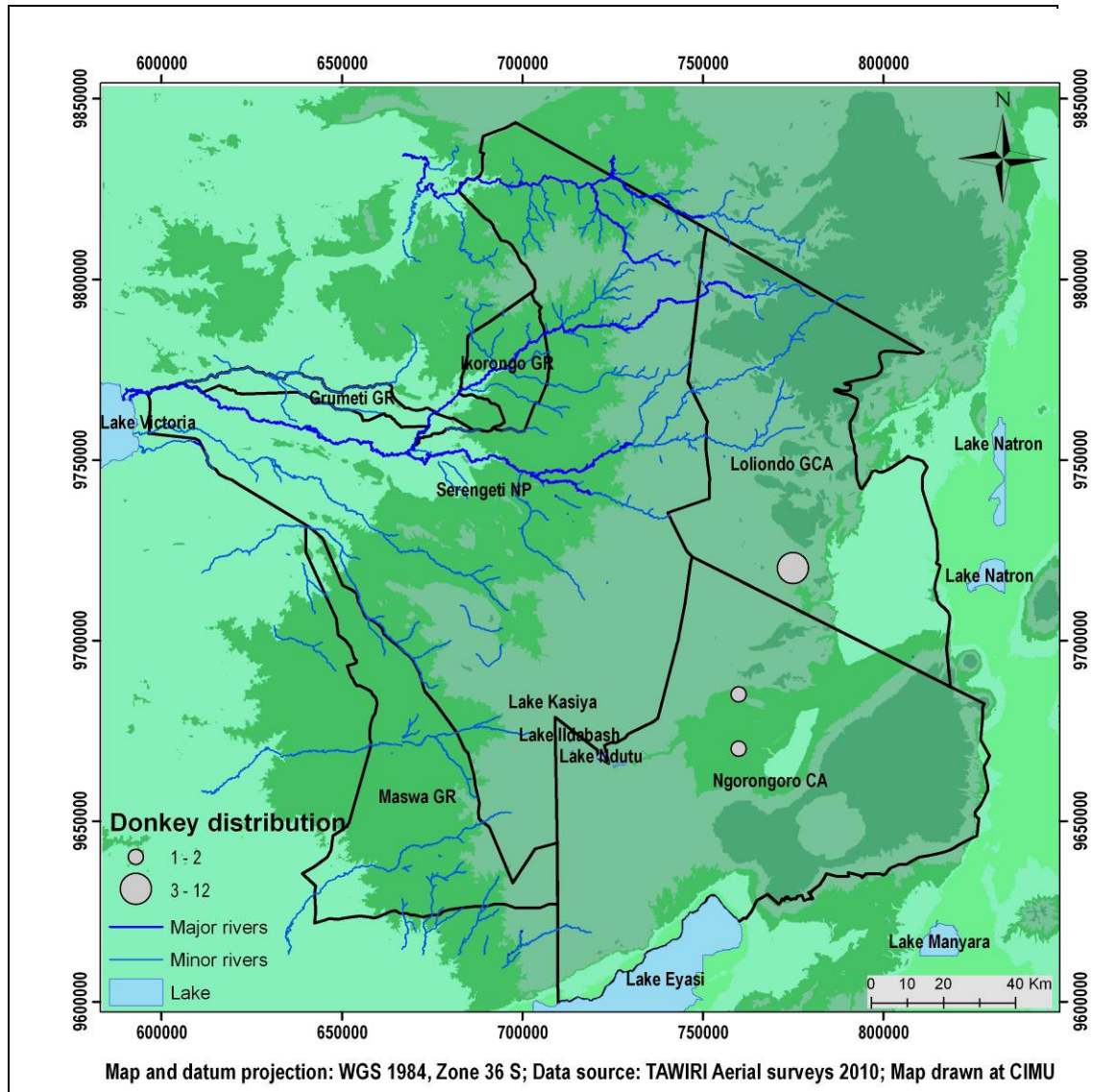
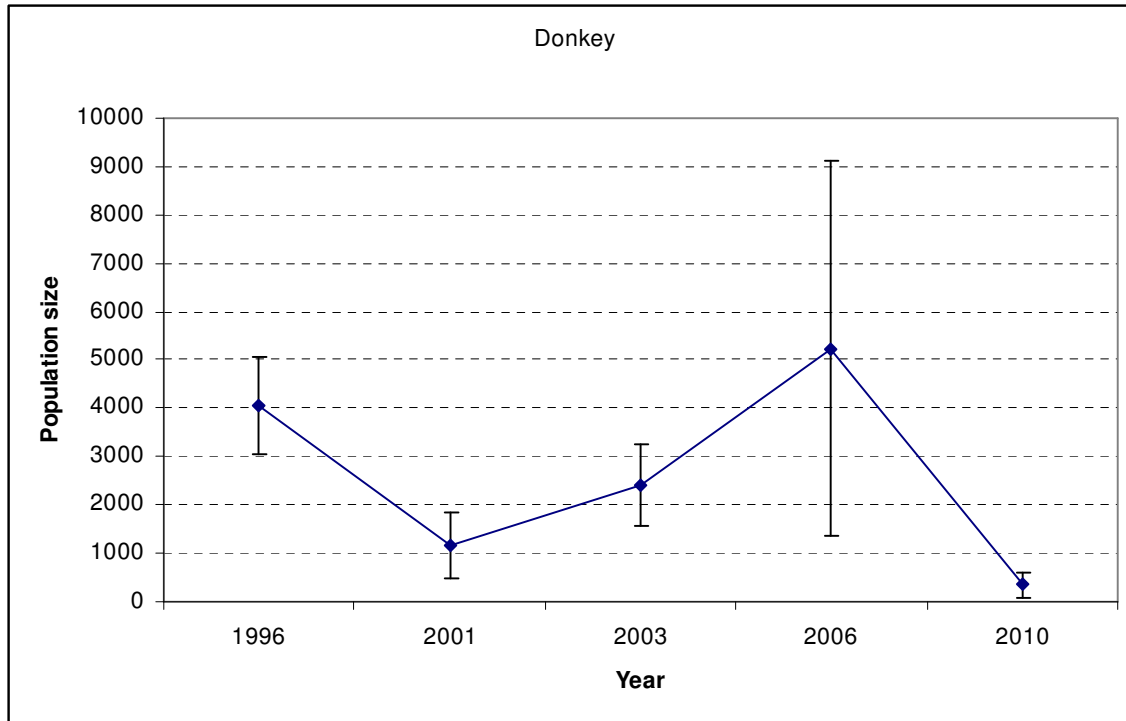


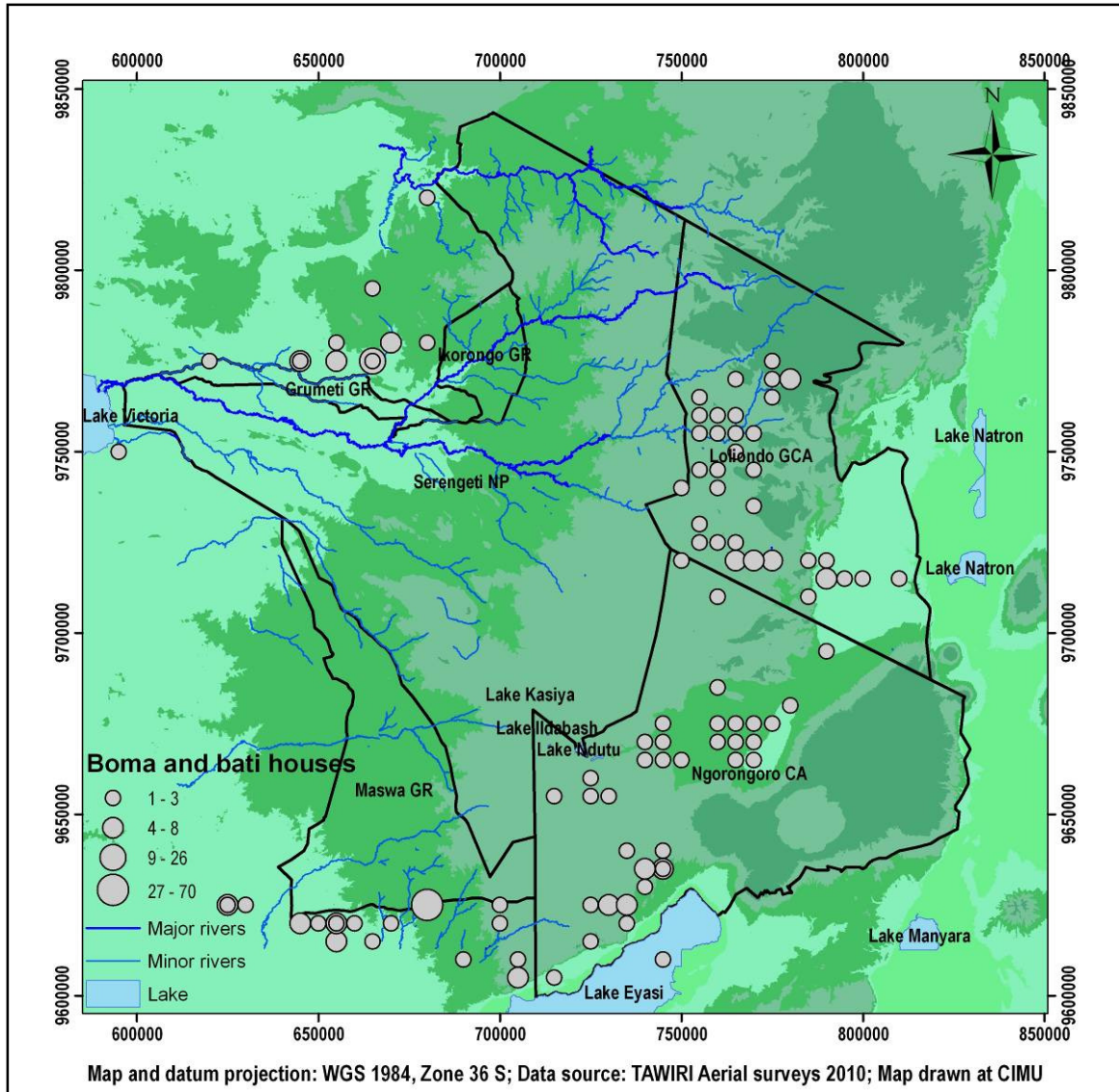
Figure 32: Density and distribution of donkey in the Serengeti ecosystem, February 2010



**Figure 33:** Donkey population estimate trends in the Serengeti Ecosystem, years 1996 - 2010

## Human Settlements

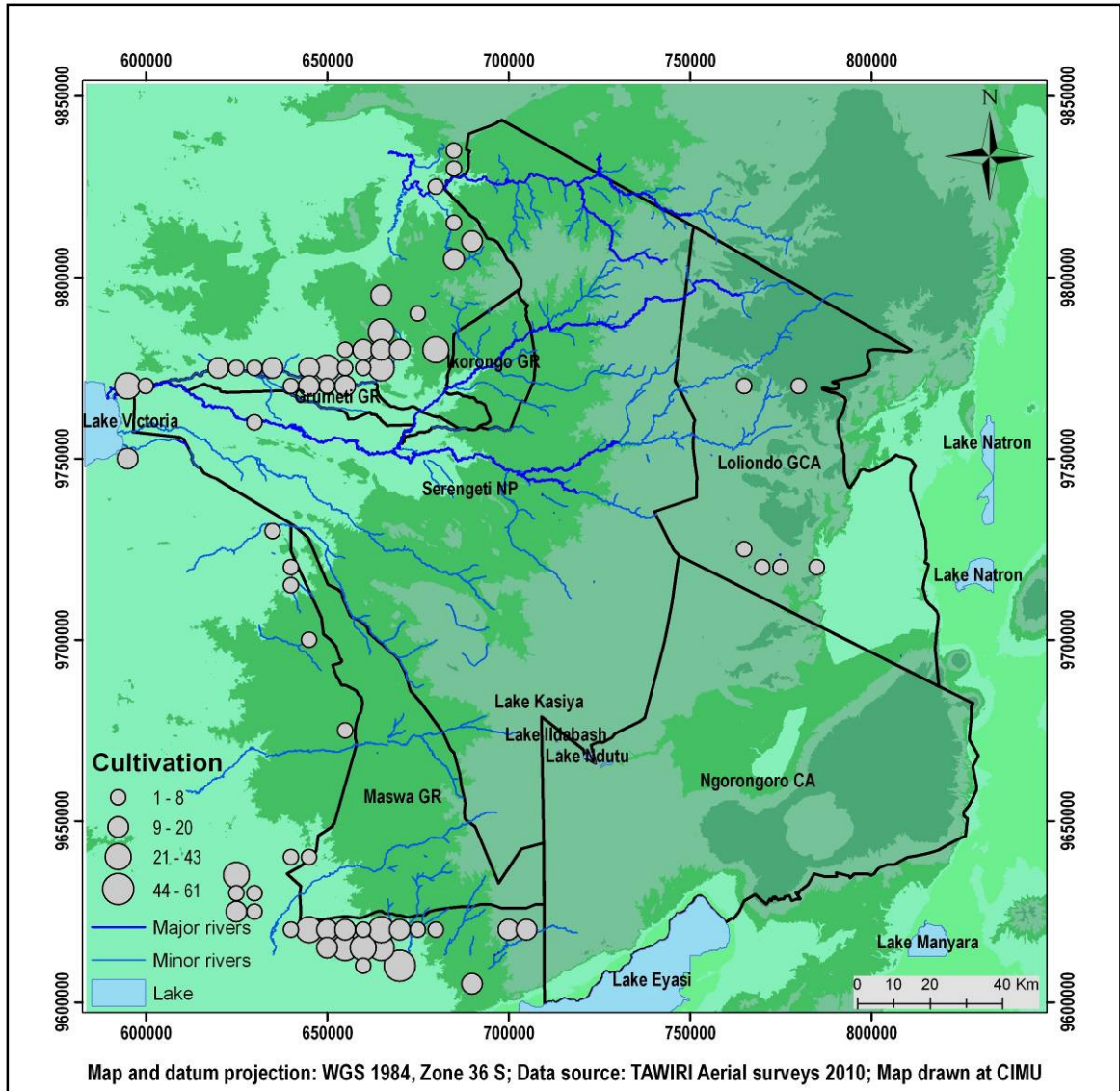
Settlements (bomas and thatch/iron sheet roofs) were restricted to areas outside the National Park, and Game Reserves with high concentrations in the periphery of Maswa Game Reserve and Grumeti Game Reserve and were found more scattered throughout western NCA and LGCA (Figure 34).



**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 ( $d\text{-test} = 5.09$ ) (Table 7) (Figure 36).



**Figure 35:** Density and distribution of cultivation in the Serengeti ecosystem, February 2010

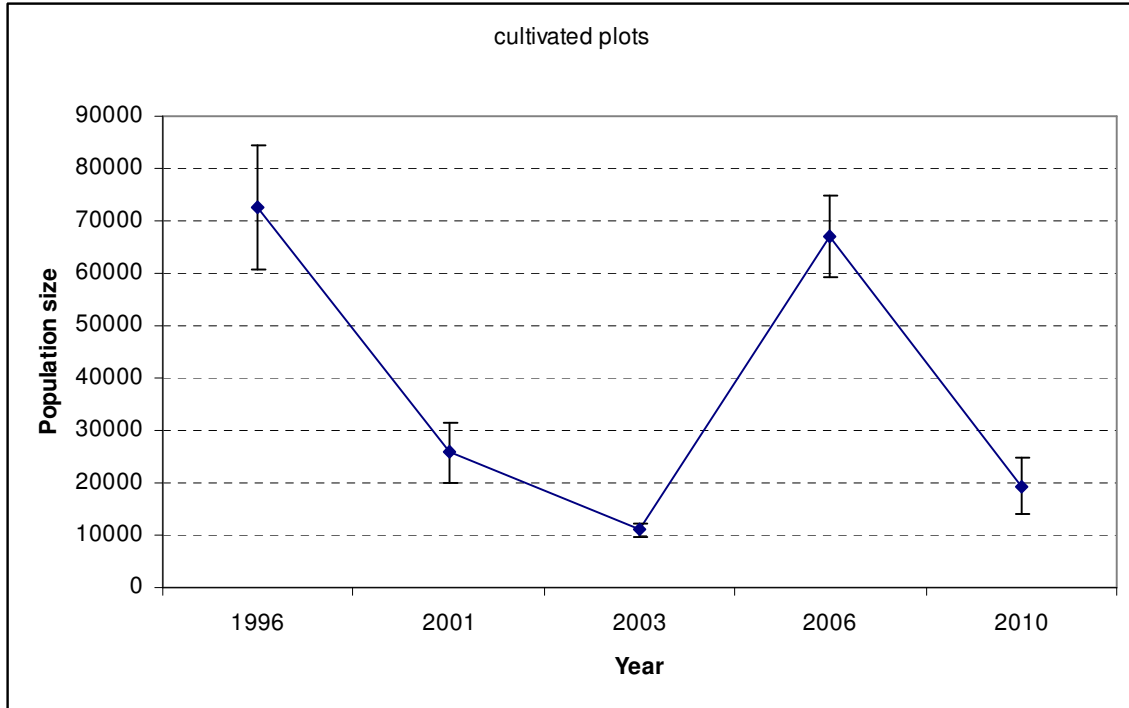


Figure 36: Cultivation plots population estimate trends in the Serengeti Ecosystem, years 1996 - 2010



**Table 7:** Human activities population estimate trends in the Serengeti ecosystem, 1996-2010

Year	1996	1996	2001	2001	2003	2003	2006	2006	2010	2010	2006/10
Human Activity	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	d-test
<b>Declined human activities</b>											
Boma Abandoned	1562	219	1094	223	363	59	2615	231	1154	296	<b>3.89</b>
Cattle	199393	19962	215121	40874	237591	38984	219783	35712	113070	20190	<b>2.60</b>
Agriculture / Cultivation	72465	11850	25769	5673	11082	1277	67058	7727	19366	5310	<b>5.09</b>
<b>Stable Human activities</b>											
Hut with Mabati roof	2179	907	3151	1136	2740	386	3783	976	1741	850	<b>1.58</b>
Masai Boma - Occupied	3531	334	547	175	2195	222	7518	1019	4134	1839	<b>1.61</b>
Donkey	4056	1000	1161	695	2422	845	5231	3869	349	260	<b>1.26</b>
Sheep and Goats	106				128780	10993	112927	10741	87612	19509	<b>1.14</b>
Hut with Thatched Roof	13121	1764	12785	3483	19939	439	4162	378	5006	1552	<b>0.53</b>
Village	1139	157	182	70	45	25	510	45	478	505	<b>0.06</b>

## 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.

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**APPENDIX I: PARTICIPANTS**

<b>Aircraft</b>	<b>Initials</b>	<b>Name</b>	<b>Role</b>
5H-ZGF	FDB	Felix Dieter Borner	Pilot
5H-ZGF	HKK	Hamza Khalid Kija	FSO
5H-ZGF	NJK	Nelson Joseph Ole Kuwai	RSO
5H-ZGF	SKB	Samwel Kanyawana Bakari	RSO
5H-ZGF	HTM	Honori Thomas Maliti	Coordinator

<b>Data entry:</b>	Hadia Hajji - TAWIRI
<b>Data verification and analysis:</b>	Honori T. Maliti & Hamza K. Kija - TAWIRI
<b>Report writing:</b>	Edeus T. Massawe, Honori T. Maliti & Samwel K. Bakari and Hamza Kija - TAWIRI

## APPENDIX II: Species list

### Mammals:

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

### Birds:

Marabou Stork	<i>Leptoptilos crumeniferus</i>
Ostrich	<i>Struthio camelus</i>