Aerial wildlife count of the Parque Nacional da Gorongosa, Mozambique, October 2014

Approach, results and discussion

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December 2014

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Summary

- An aerial wildlife count of the southern and central parts of the Parque Nacional da Gorongosa was conducted between 25 October and 4 November 2014.

- Previously, sample counts were conducted along lines spaced 2 to 3 km apart, resulting in a 10.5 to 21.8% coverage of the park. This sample methodology has shortcomings, particularly related to the recovery from a low base with only small numbers found of individual groups/herds of species such as elephant and buffalo. The survey method was changed to a full coverage of the central core of the park.

- 183,200 hectares, representing 49.7% of the park, was fully covered by means of a helicopter. The focus was on the Rift Valley in the southern and central sector of the park. Systematic, parallel strips that were 500 m wide were assessed. All large mammals observed were counted. All data, including geographical positions, were directly entered into a custom-made census programme.

- A total of 71,086 herbivores of 19 species and 1,582 crocodiles were counted. These are actual counts, not estimates. This represents the absolute minimum number of large animals that occur in the park.

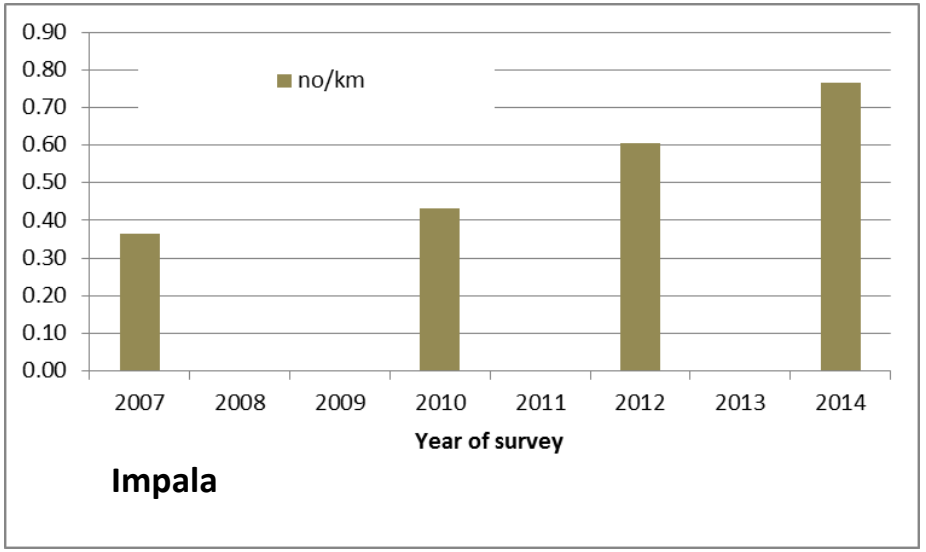
- More animals still occur outside the block that was counted, but no estimates can be made. However, the count block represents the area with the best habitat and the highest known densities of wildlife and is therefore likely to hold the bulk of most species.

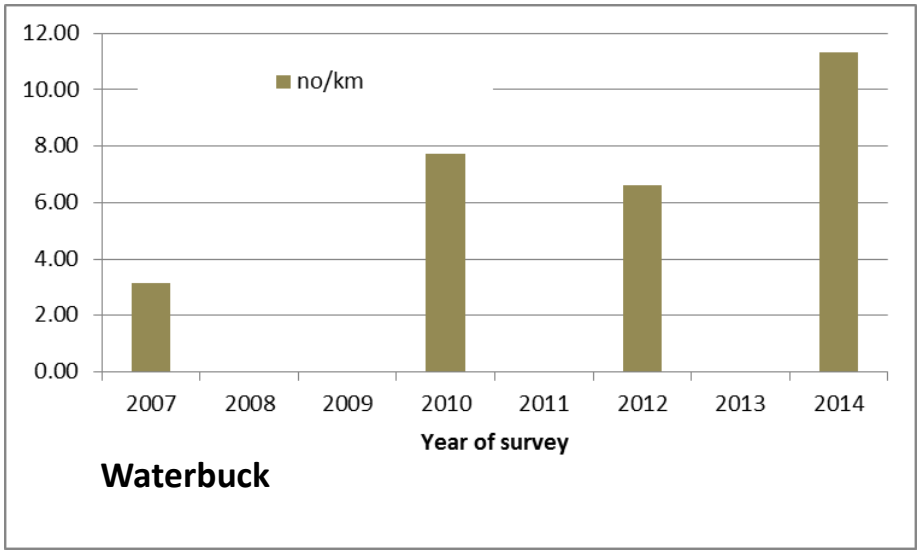
Species	Total number counted
Duiker red	27
Zebra	33*
Duiker grey	65
Eland	96
Bushpig	181
Blue wildebeest	361
Hippo	436
Elephant	535
Hartebeest	613
Buffalo	670
Sable	786
Nyala	964
Kudu	1,223
Crocodile	1,582
Bushbuck	2,294
Impala	2,735
Oribi	4,490
Warthog	9,158
Common reedbuck	11,912
Waterbuck	34,507
	72,668

* 15 held in the Sanctuary.

Summary - continued

- Due to the aforementioned problems with the previously used sampling method, it was not possible to directly compare the results from 2014 with those from previous counts. However, density estimates that take into account the length of the counting lines flown and the habitats covered can be used for comparative purposes. This approach is most useful for those species that are widespread and not clumped in a few herds.
- There has been a marked increase in density since 2007 for species such as waterbuck, impala and kudu. The waterbuck have recovered to what is likely the single largest population in any protected area in Africa.
- Elephant numbers exceed 500 which is more than the estimates based on the current population study whereby individual animals and herds are being identified. This probably reflects the large presence of elephant in the southern part of the park that has been mostly inaccessible to the elephant researchers due to the limited road network.
- The results of the count indicate that all large herbivore species, with the exception of the *crawshayi* subspecies of zebra, now occur in numbers that are sufficient for their continued recovery and viability.





Summary - continued

- Blue wildebeest was the only species whose numbers fell below expectations. The expected numbers were based on the known number of animals reintroduced and past count results. Wildebeest have been targeted by poachers for their tails. There is also some predation by lion. This will require focused monitoring.
- A number of observations of illegal activities were made during the count. Two poachers were caught red-handed with two freshly killed Lichtenstein's hartebeest. They were arrested. One elephant carcass that was several months old, as well as a recently snared sable antelope and zebra were recorded. Signs of commercial timber cutting as well as of felling of trees for the purpose of opening new fields were documented. Despite the very encouraging growth in wildlife numbers it is clear that illegal activities remain a serious threat to the park.
- Certain inputs can now be made by having confidence, for the first time, in the total numbers obtained:
    - Contribution of overall elephant numbers into the Mozambican national census which itself will feed into the African census currently being undertaken;
    - Available prey biomass for the modelling of larger predator habitat suitability;
    - Defining new research projects that focus on the high proportion of biomass occupied by waterbuck, likely future trends, future management requirements etc.
- The 2014 count has re-affirmed the importance of these regular surveys. The aerial wildlife count using a helicopter is one of the most important and critical tools to evaluate the status of the recovery and the effectiveness of park management. It will be important to continue with regular counts.
- In the years to come, the coverage of the aerial count will probably need to be expanded in order to account for the spread of the animals beyond the current counting block.

1. Methodology

1.1. Previous and current survey

Two aerial surveys were conducted by means of a fixed wing aircraft prior to the civil war. Since the recovery efforts started following the end of the war, a total of six helicopter surveys and one fixed wing survey were undertaken.

The 2014 count is the 8th post-war survey.

The flight specifications for the fixed wing and helicopter surveys are as follows:

Fixed wing (2004)

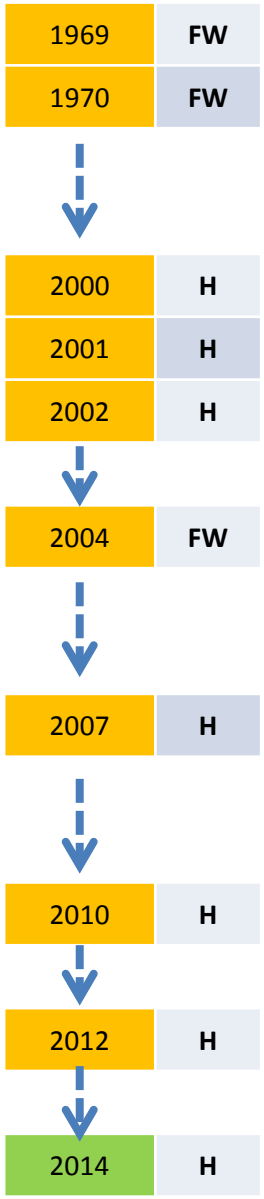
- Cessna 206
- Speed 160 km / hour
- Altitude 300 feet
- Strip width 300 m
- Count lines 3 km apart

Helicopter (2000, 2001, 2002, 2007, 2010, 2012)

- Bell JetRanger with all 4 doors off for better visibility
- Speed 96 km / hour
- Altitude 160 feet
- Strip width 500 m
- Count lines 2 km (east and west stratum) or 3 km (central stratum) apart

Helicopter (2014)

- As above, but full cover (no gap between the flight lines).

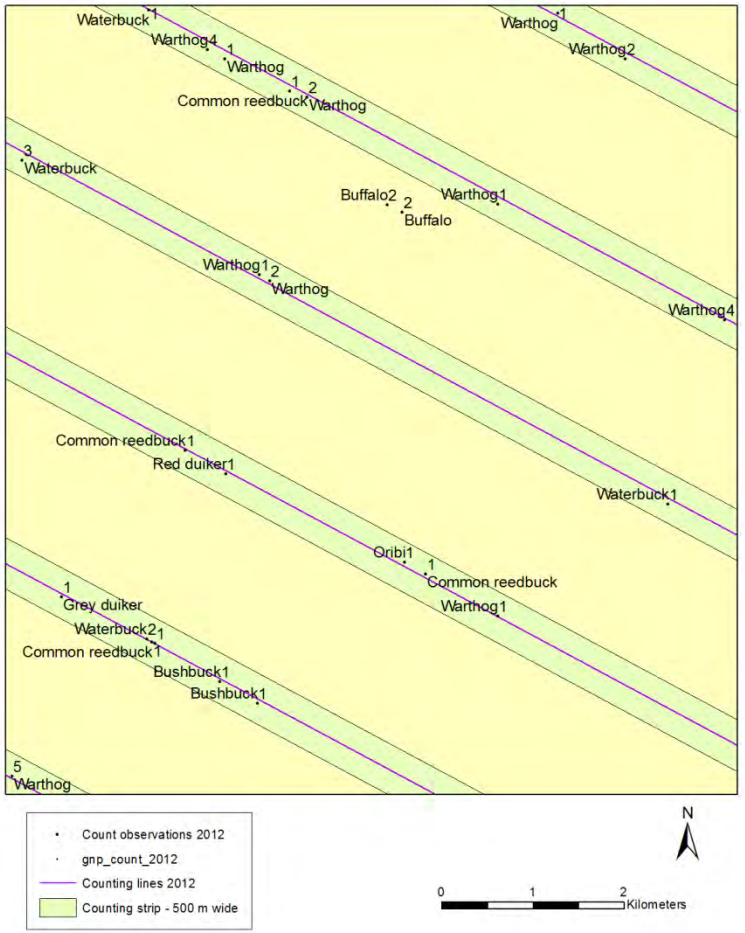


FW = fixed wing, H = helicopter

1.2. Perceived problems with the previous sampling approach

Despite achieving a respectable 20%+ coverage of the park, the previous sampling approach has several shortcomings:

- The widely spaced lines, the very heterogeneous habitat with the resulting clumped nature of the distribution of the animals and the low number of herds of certain key species (such as buffalo) make it very difficult from a statistical perspective to obtain any reliable population estimates;
- In practice , it has been 'hit-and-miss' on the individual herds, which would result in either an underestimate or overestimate of the number of animals present across the park;
- Ideally, the transect method relies on a distance measure from the centre line to the individual animal or herd. In reality, with the large herds of waterbuck and reedbuck, the full strip may be occupied by a continuous group of animals. These large herds of waterbuck will even straddle several strips and a cut-off as to the exact number of animals occurring within a particular strip becomes nearly impossible to determine especially if the animals start moving due to the disturbance by the helicopter;
- Two of the major assumptions for the distance method that are difficult to satisfy are that all animals on the line are seen and that the animal when sighted has not moved in response to the aircraft (or whatever mode) approach
- Surveying of the Western and Eastern strata has not been cost-effective with only 15% of all animals counted occurring in those strips at the cost of 37% of the flying time;
- The lack of any firm minimum known number of animals creates uncertainty in terms of current population viability. This has a bearing on the re-introduction programme.



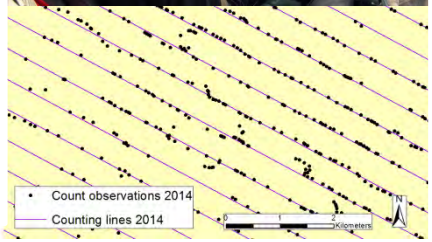
Light green = sample strip of 250 m on each side of the flight line (in purple). All animals seen within this strip are recorded on the on-board computer. GPS records of wildlife are represented as black dots. Buffalo observation outside the sample strip represent additional records not used for population estimates

1.3. Survey procedure for 2014

A switch was made from the 'sample line' design to a 'block count'. The 'block count' results in a full (100%) coverage of the area. The focus was on central and southern parts of the park that hold the best habitat and the known highest densities of wildlife.

The specific technique used was as follows:

- 4-seat Bell Jet Ranger helicopter with the pilot in the right front seat, data capture / observer in the left front seat and two observers in the back;
- For the sake of maximum visibility, all doors of the helicopter are removed during the actual count;
- Parallel strips of 500 m width are flown. This means that observers look for wildlife in a strip of 250 m wide on each side of the helicopter. Marker bars indicate the strip width to avoid looking too far from the helicopter;
- The helicopter is maintained at a constant height of 50 to 55 m (160 feet) above the ground. Airspeed is maintained at around 96 km/h (60 knots). When a large herd is observed (e.g. impala) the pilot circles around to enable an accurate count;
- All animals are individually counted. The presence of baboon troops was recorded but the number of individual baboons is not enumerated;
- Photographs of some large buffalo and sable herds and of some large waterbuck concentrations were successfully used to accurately determine the number of animals;
- A flight dedicated to assess crocodiles and hippo in the river and Lake system was done from the middle Vundudzi River downstream to the confluence of the Urema-Pungue;
- A GPS-based system (Global Positioning System) is used for accurate navigation. A grid is generated on a notebook computer that is linked to the helicopter's GPS. Every 2 seconds a flight co-ordinate is downloaded onto the hard disc. When a sighting is made the position together with the species code and number is logged. The flight path and the observations are visible on screen. This enables the pilot to keep the helicopter on the pre-determined line and avoids the risk of areas not being covered or being covered twice. The latter also frees the pilot to assist with observation and counting. The position of the animals that have already been spotted is displayed on screen which assists in preventing double counting or under counting;
- The observers in the back wear yellow goggles that reduce shadows and enhance contrast for better visibility and detection of the animals;
- Sessions lasting about two to three hours are flown. A short break is taken after 1 to 1.5 hours to relieve observer fatigue. Two to three sessions are generally flown in a single day.



1.4. Data handling

Following their on-board capture, the data were consolidated into an Excel spreadsheet and exported to an Access database. The 2014 data were amalgamated with the data from previous data to facilitate analysis and general comparisons.

Each data point has the following information:

- Unique ID number
- Species
- Number of animals
- Year of count
- Day
- Time
- Latitude / Longitude
- Transect line.

The relational Access data base allows linking these individual observations with other species characteristics such as the average weight for each species that can be used for the calculation of stocking rates. The count data were also converted to shapefiles for use in ArcGis.

ID	Count	ID_count	Latitude	Longitude	Count day	Session	Date	Time	TransectLine2014	Species	Number
32215	2014	17132	-18.62730	34.46490	11	26	11/4/2014	07:44:18 AM	3	Oribi	3
32216	2014	17133	-18.62930	34.46810	11	26	11/4/2014	07:44:31 AM	3	Waterbuck	16
32217	2014	17134	-18.63010	34.46920	11	26	11/4/2014	07:44:36 AM	3	Impala	2
32218	2014	17135	-18.63040	34.46970	11	26	11/4/2014	07:44:38 AM	3	Impala	8
32219	2014	17136	-18.63050	34.46990	11	26	11/4/2014	07:44:39 AM	3	Warthog	2
32220	2014	17137	-18.63160	34.47190	11	26	11/4/2014	07:44:48 AM	3	Oribi	1
32221	2014	17138	-18.63200	34.47300	11	26	11/4/2014	07:44:51 AM	3	Waterbuck	5
32222	2014	17139	-18.63470	34.47810	11	26	11/4/2014	07:45:12 AM	3	Waterbuck	15
32223	2014	17140	-18.63570	34.47980	11	26	11/4/2014	07:45:19 AM	3	Oribi	1
32224	2014	17141	-18.63640	34.48120	11	26	11/4/2014	07:45:25 AM	3	Waterbuck	7
32225	2014	17142	-18.63670	34.48170	11	26	11/4/2014	07:45:26 AM	3	Kudu	4

2. Results

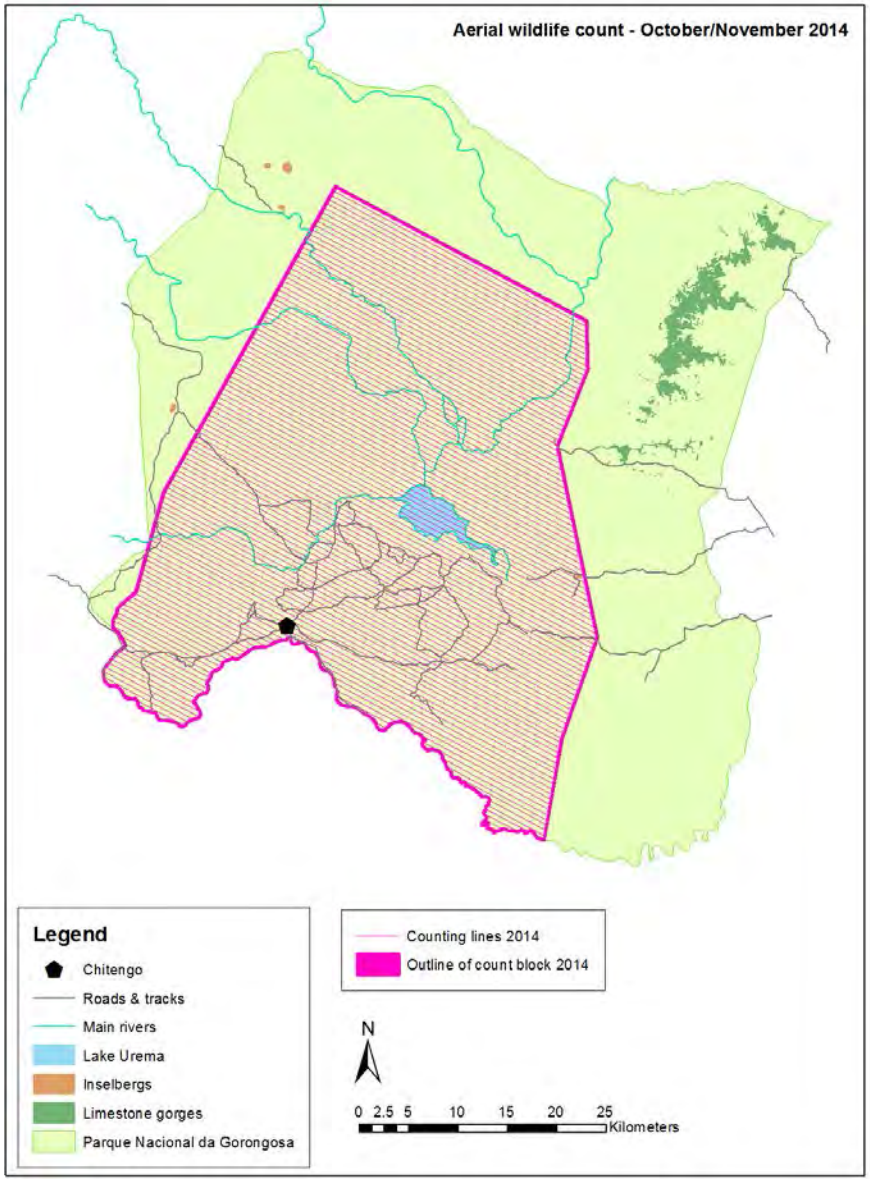
2.1. Survey statistics

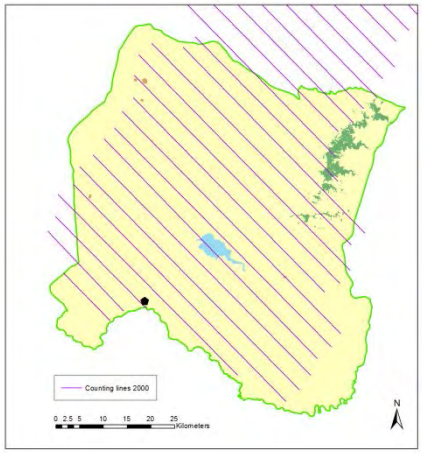
A total of 183,200 hectares, representing 49.7% of the park, was fully covered. Although a block design was applied, there is a large overlap with the previous counting lines, in particular those used for the Central stratum in 2007, 2010 and 2012 (see comparison maps).

The total flying time for the survey was 72 hours and 50 minutes. The average area covered per flying hour was 2,515 hectares. This would vary from day to day depending on distance from the base (longer or shorter ferry time) , density of the animals and nature of the vegetation structure.

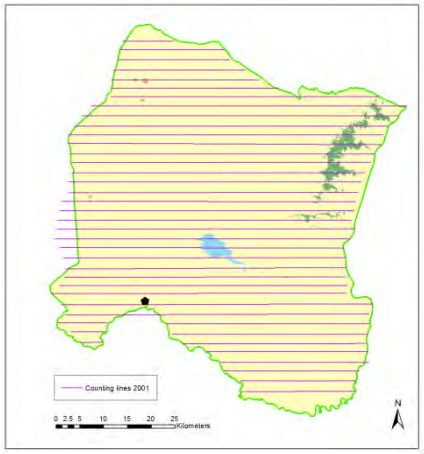
This was pilot Mike Pingo's seventh helicopter wildlife count of Gorongosa. Observer Dr Mike Peel from the Agricultural Research Council is very experienced with wildlife counts in South Africa. This was his second survey of Gorongosa. This was also the second count of Gorongosa for data recorder Dr Marc Stalmans. The remaining observer seat was rotated between a number of staff from the Department of Conservation and Scientific Services (Dr Tara Massad, Dr Rui Branco, Tongai Castigo (third survey of Gorongosa) and Marcelino Denja).

Flying and counting conditions varied with some very hot days being experienced (see table). The counting sessions were adapted in order to avoid the hottest time of the day when animals would tend to remain under the shade which made their detection more difficult.



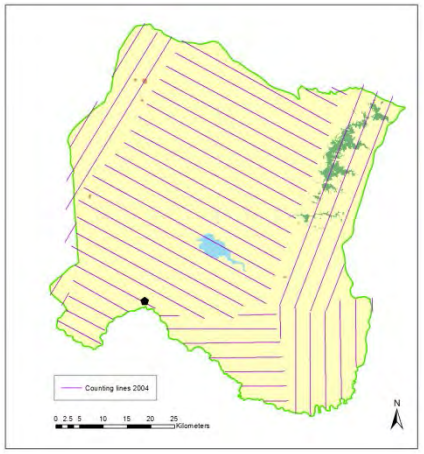


Year: 2000
% of park covered: 10.5%

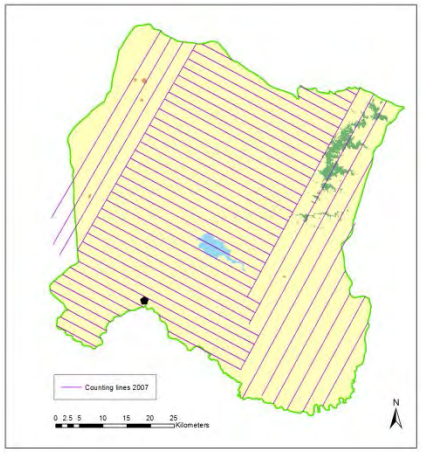


Year: 2001
% of park covered: 19.4%

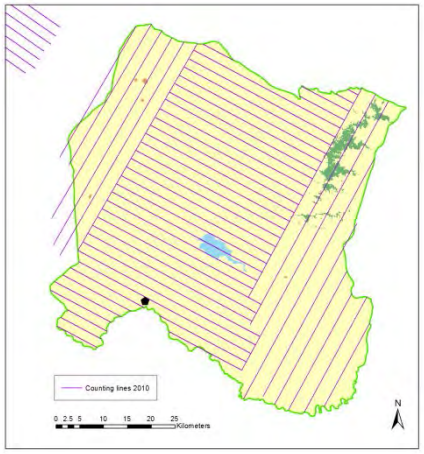
Year: 2002
% of park covered: 13.4%



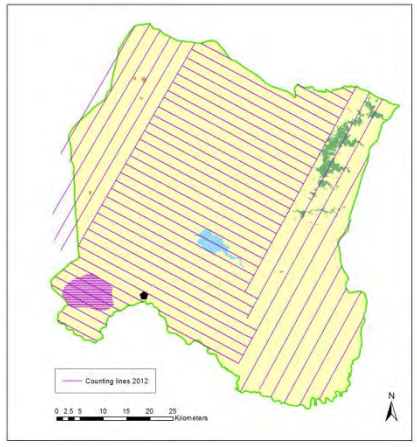
Year: 2004
% of park covered: 8.9%



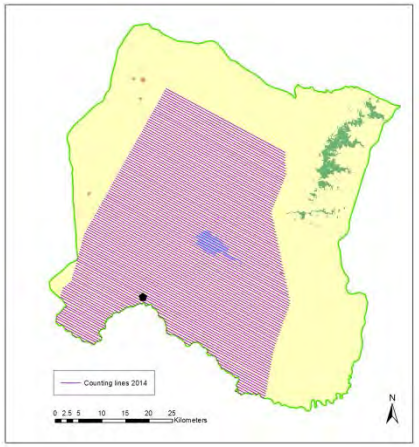
Year: 2007
% of park covered: 20.7%



Year: 2010
% of park covered: 21.8%



Year: 2012
% of park covered: 23.0%



Year: 2014
% of park covered: 49.7%

Counting team and conditions

Date	Session	Cloud cover (1 to 8 scale)	Visibility	Temp. ºC	Team
24/10	1	0	Good (G)– early on long shadows	19-24	Marc Stalmans (MS); Mike Pingo (MP) Mike Peel (MP); Tongai Castigo (TC) part Tara Massad (TM)
24/10	2	0	G-Excellent (E)	29-32	MS; MP,MP; TM
24/10	3	0	G-Moderate (M)-Poor (P) (smoke)	36-33	MS; MP, MP; TM
25/10	1	5-7	M-P-M	21-27	MS; MP, MP; TM
25/10	2	6-3	M-G	27-33	MS; MP, MP; TC
26/10	1	8 (high)	P-P-M	22-25	MS; MP,MP; TC/TM (part session each)
26/10	2	4-2	M-M-G	27-30	MS; M, MP; TC
26/10	3	0	G-G-M – later long shadows	29-27	MS; MP, MP; TC
27/10	1	8	P – short session	22-20	MS; MP, MP; TC
27/10	2	8	P	20-26	MS; MP, MP; TC/TM (part session each)
27/10	3	2-0	G	23-27	MS; MP, MP; TC
28/10	1	6	M – high cloud	22-26	MS; MP, MP; TM
28/10	2	2	G	24-26	MS; MP,MP; TM
28/10	3	0	G	26-24	MS; MP, MP; TM
29/10	1	6-3	M-G-G	22-25	MS; MP, MP; TM
29/10	2	3	M-G-M-G-G	28-30	MS; MP, MP; TC/TM (part session each)
29/10	3	0	G-E	29-30	MS; MP, MP; TC
30/10	1	0	E	23-28	MS; MP, MP; Rui Branco (RB)
30/10	2	0	G	34-32	MS; MP, MP; TM
31/10	1	0	E	23-30	MS; MP, MP; TC
31/10	2	0	E-G	38-34	MS; MP, MP; TM
02/11	1	8 (high)	P-M-P	25-28	MS; MP, MP; TM
02/11	2	2	M-G-G	31-34	MS; MP, MP; TM
03/11	1	8-6	M-M-G	25-30	MS; MP, MP; TM
03/11	2	2	G-M-P	35-30	MS; MP,MP; TM
04/11	1	3	P-M-M-G-G	25-27	MS; MP, MP; TM
04/11	River	0	E	34-30	MS; MP, MP; TM

2.2. Numbers recorded

A total of 71,086 herbivores of 19 species and 1,582 crocodiles were counted. These are actual counts, not estimates. This represents the absolute minimum number of large animals that occur in the park given that only 50% of the Park was counted.

These records were amalgamated in the database together with the data from the previous counts. At present, the database holds 32,843 individual observations from 8 wildlife counts.

It is of interest to notice that the 2014 count generated more observations (17,760) than all the observations of the previous 7 surveys combined (15,083). More animals were also counted in 2014 (72,668) than in all, other surveys combined (50,439). Only 16,271 animals were counted in 2010 which is the highest number for any count prior to 2014.

More animals still occur outside the block that was counted in 2014, but no estimates can be made. However, the count block represents the area with the best habitat and the highest known densities of wildlife and is therefore likely to hold the bulk of most species.

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Duiker red	27
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Duiker grey	65
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Oribi	4,490
Warthog	9,158
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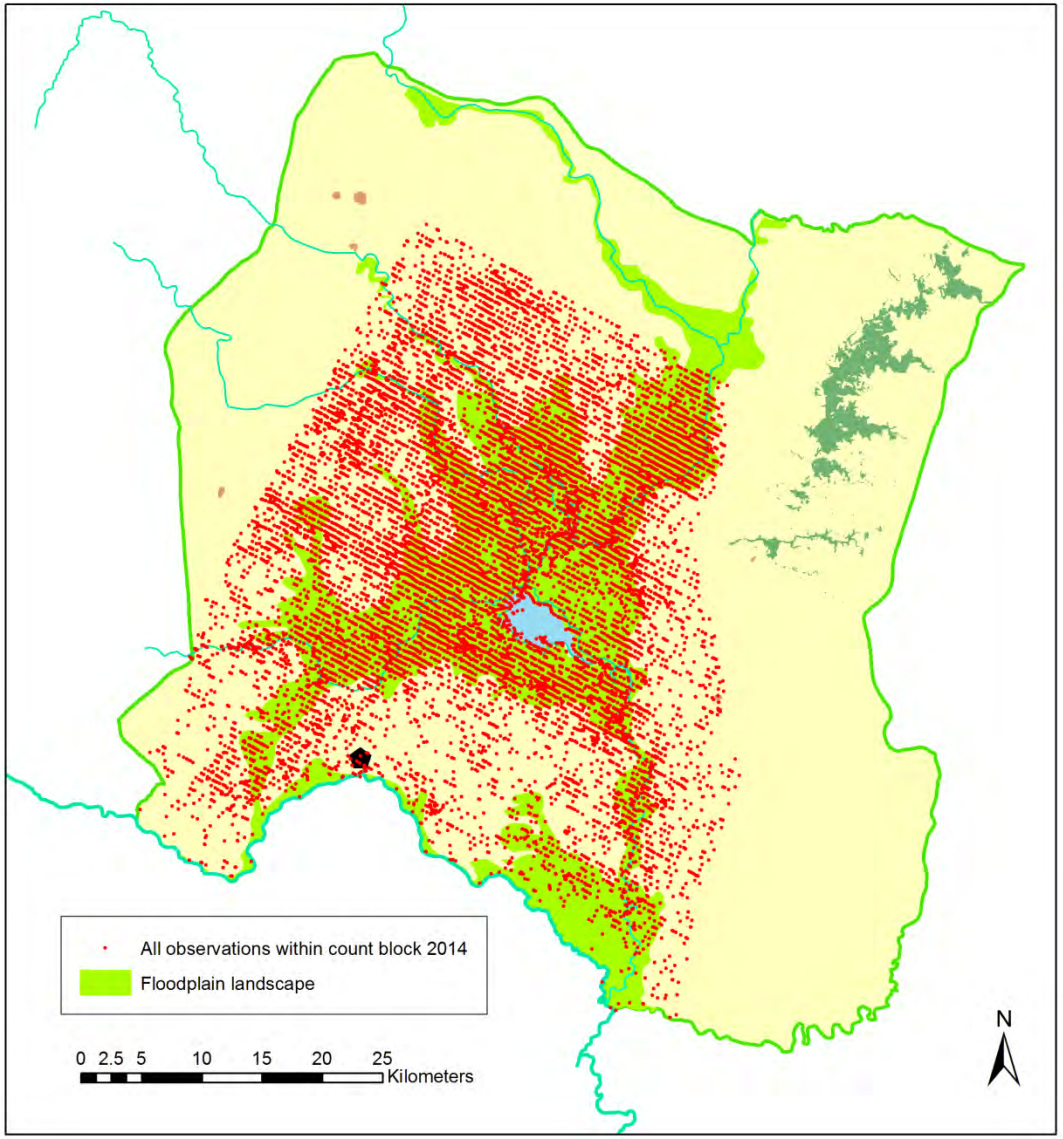
2.3. Spatial distribution patterns

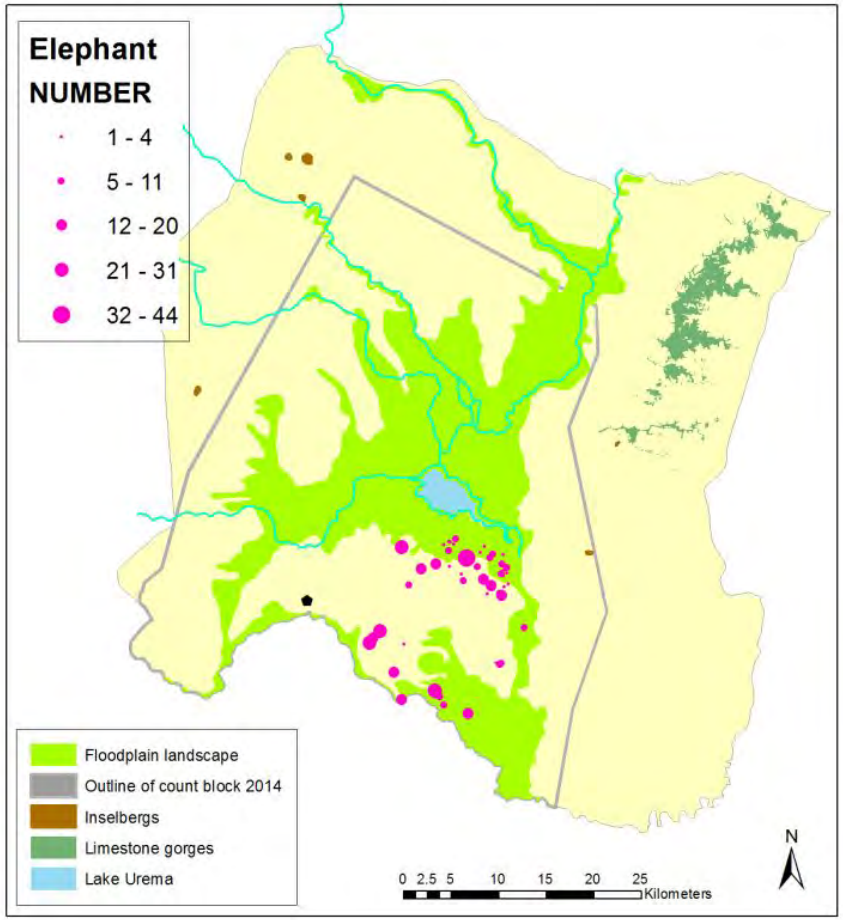
The distribution of the different species across the count block indicates a general preference for the floodplain area[1]. However, a larger than expected concentration of wildlife appears to be found in the west, south of the Vundudzi River. This seems to coincide with the flushing of burnt grasslands and woodlands together with the presence of surface water in some pans and in the rivers. The positive legacy of the recently opened Sanctuary is also clearly seen from the concentration of sightings in the eastern low-lying and floodplain section of the Sanctuary.

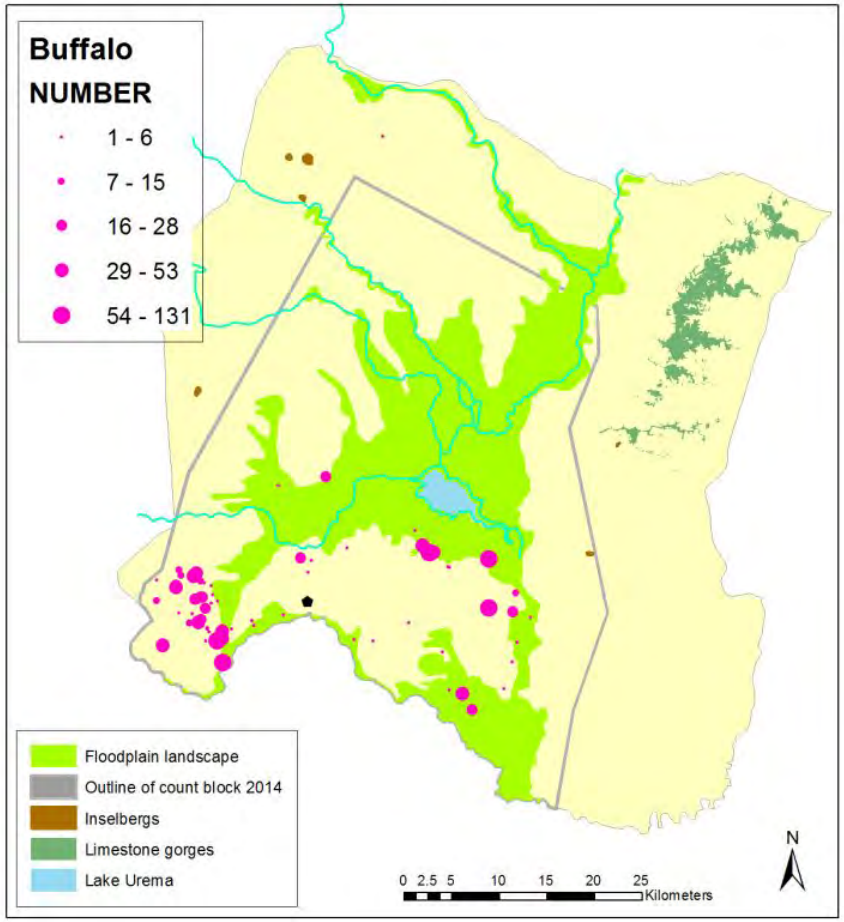
[1] Floodplain landscape as defined by Stalmans & Beilfuss (2008)



Individual species

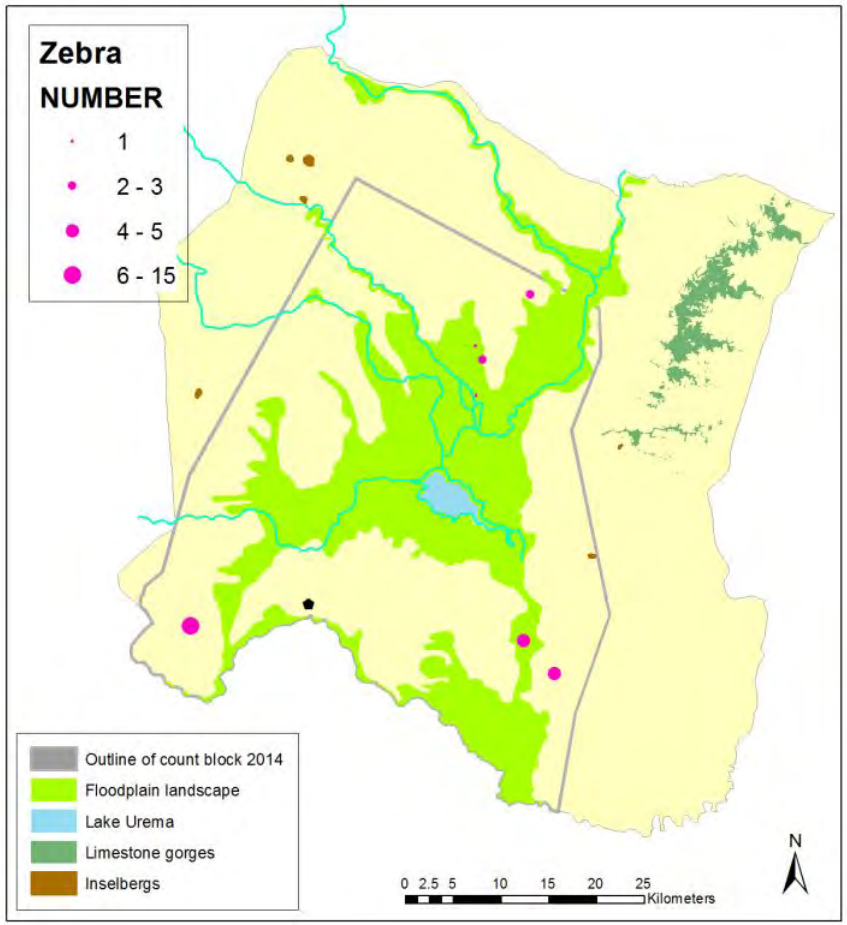
Mainly woodland and edge of floodplain species. There has already been a clear movement from the buffalo outside of the recently opened Sanctuary.

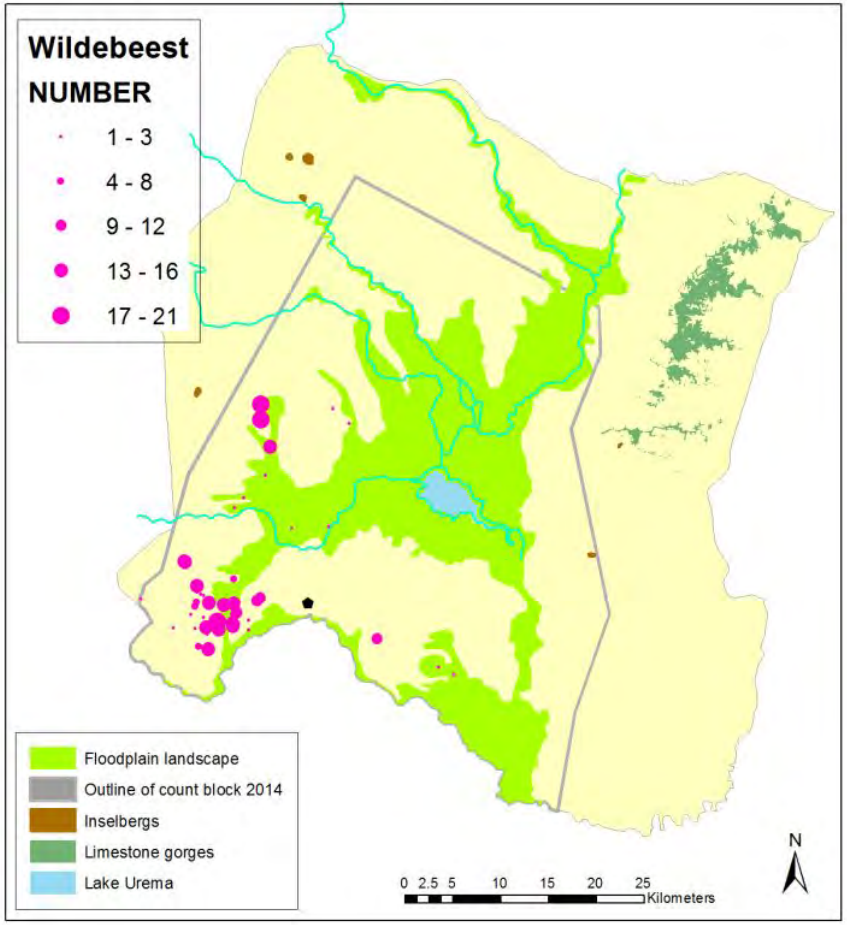




Individual species

Mainly woodland and edge of floodplain species. Wildebeest have remained fairly sedentary following the opening of the Sanctuary fence.



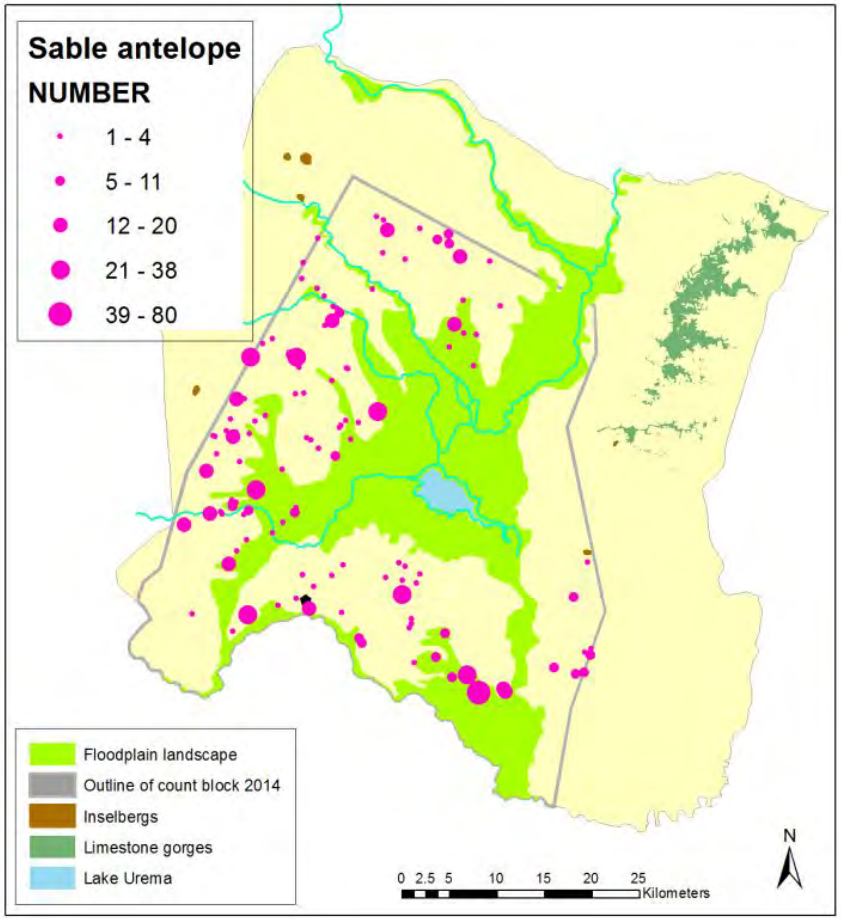


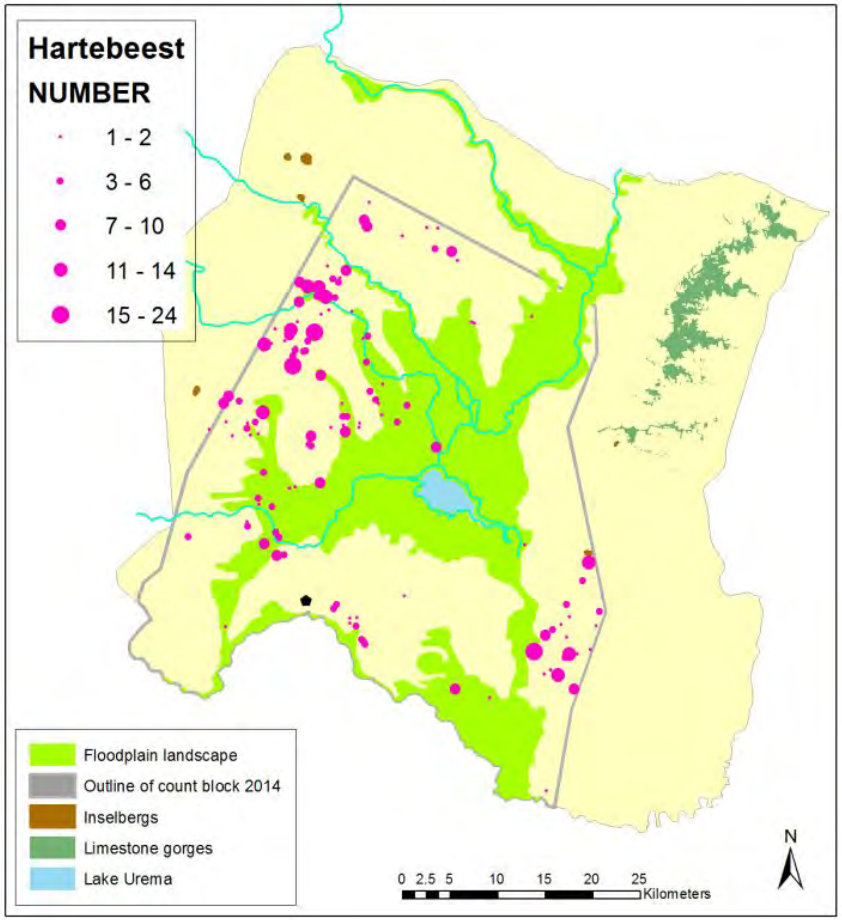
Eland herd of 81 animals (26 October 2014)

Sable herd of 80 animals (26 October 2014)

Individual species

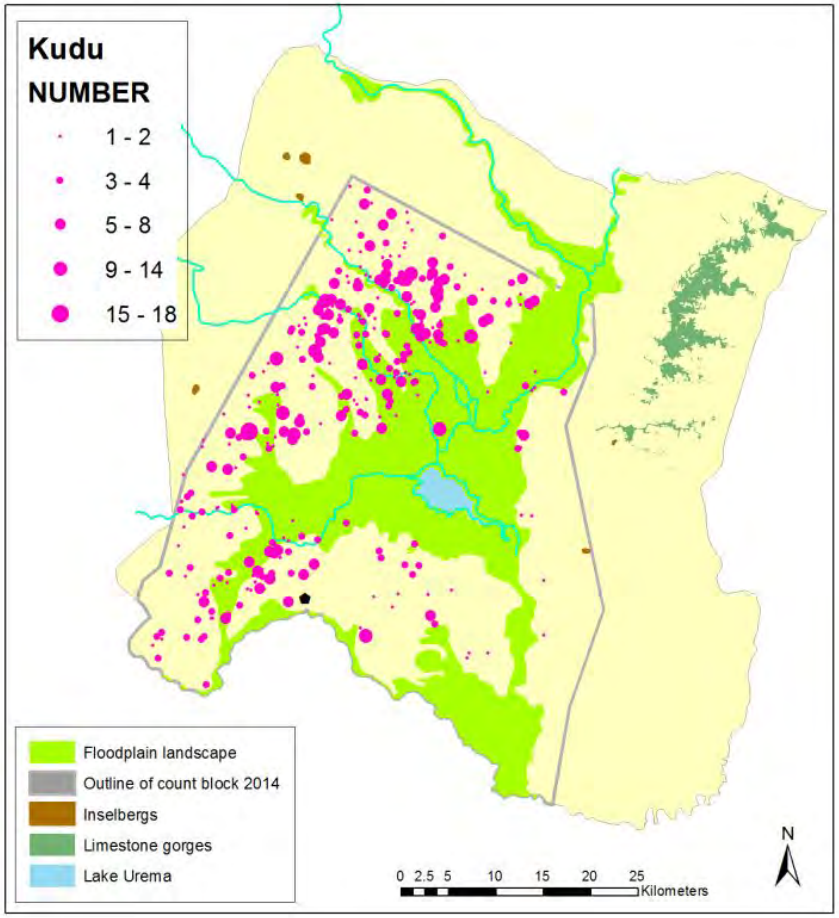
Mainly woodland and edge of floodplain species

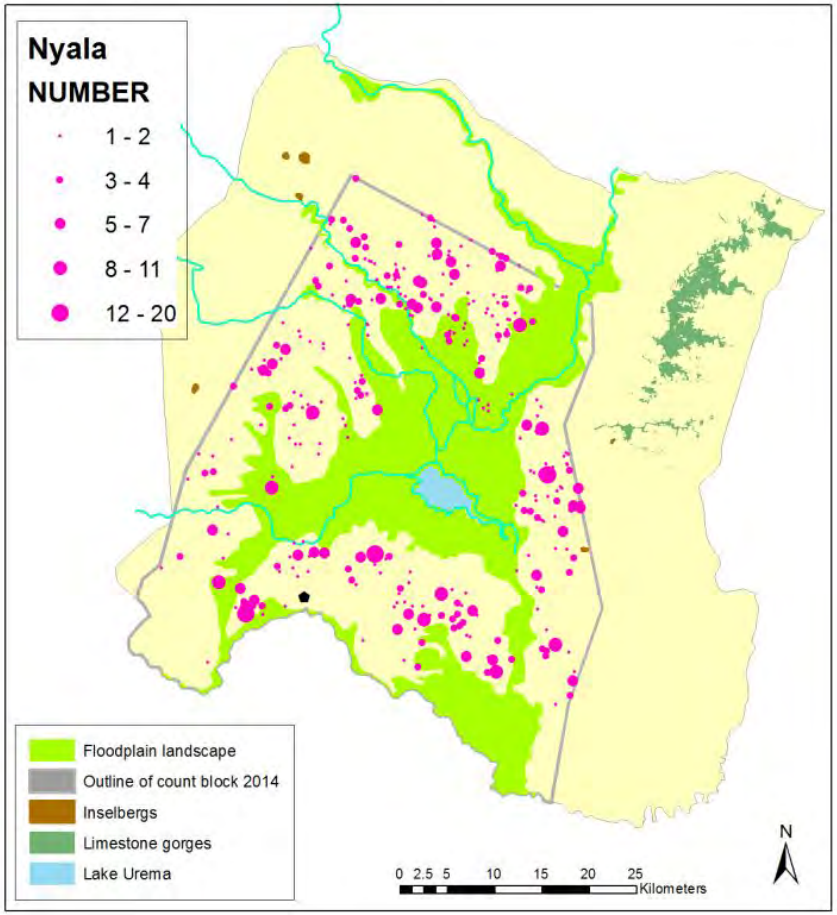




Individual species

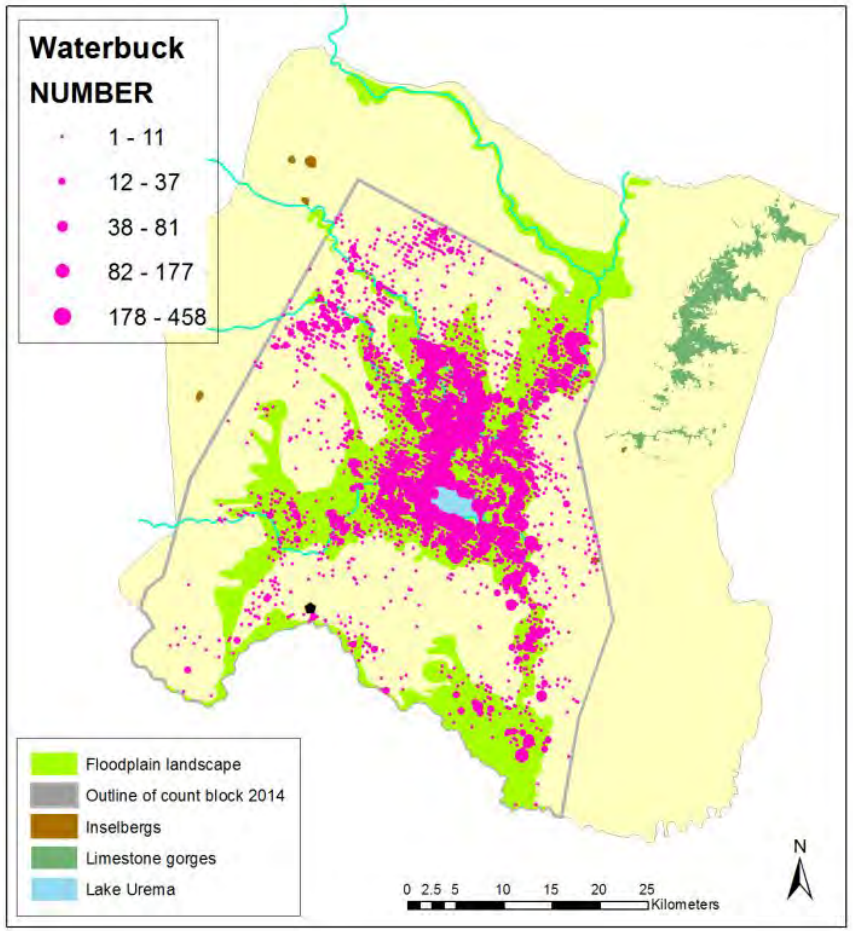
Mainly woodland and edge of floodplain species. Few kudu were observed east of Lake Urema whereas nyala are widespread in the eastern part.

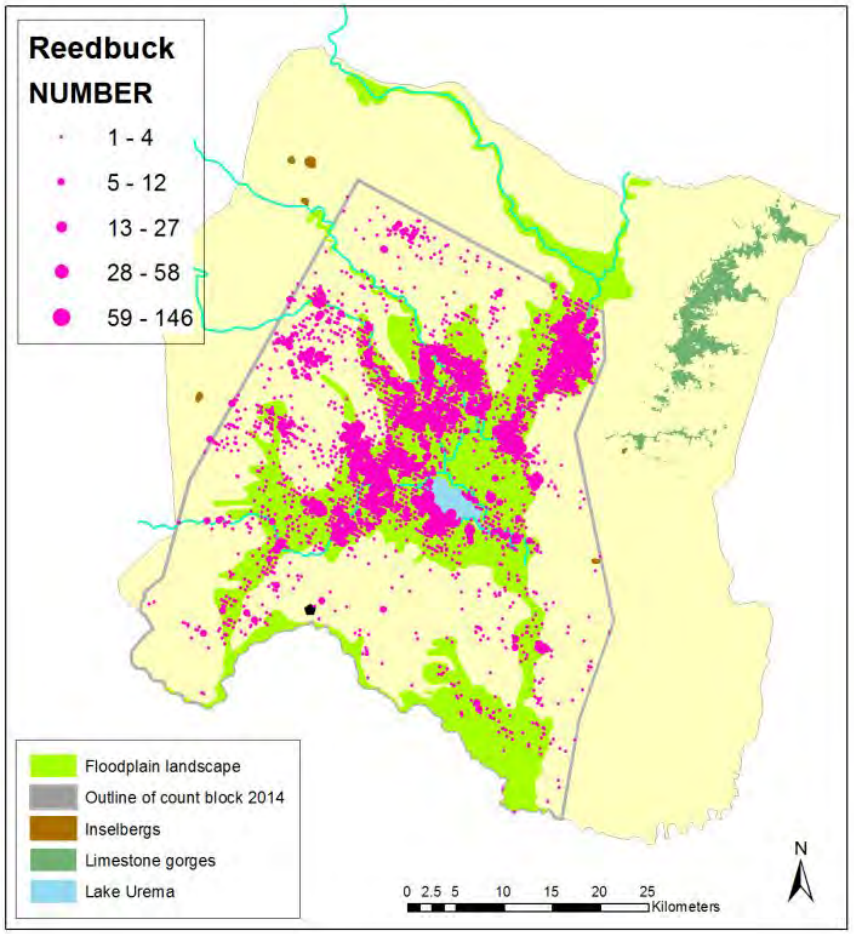




Individual species

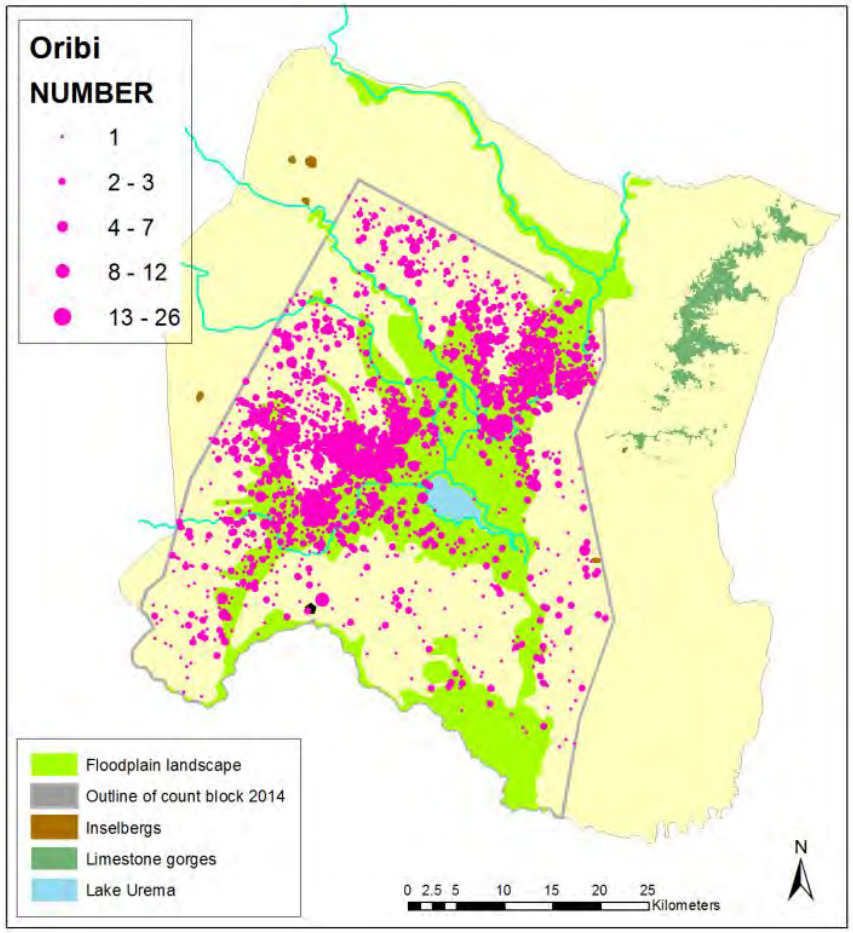
Mostly floodplain species

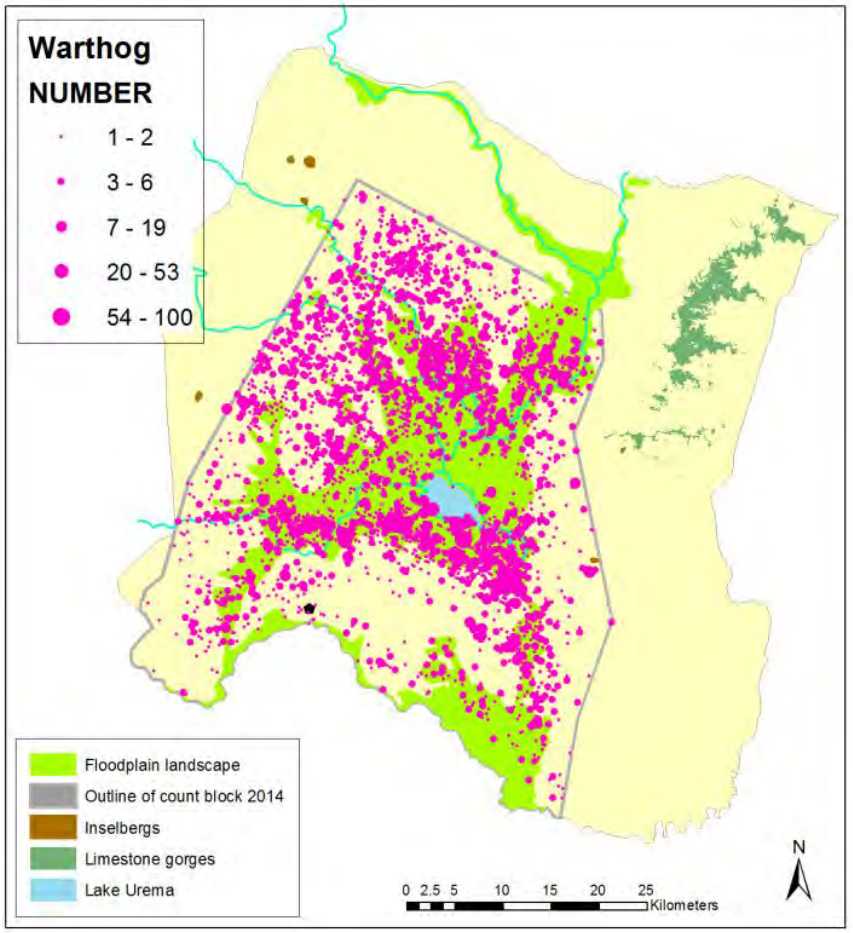




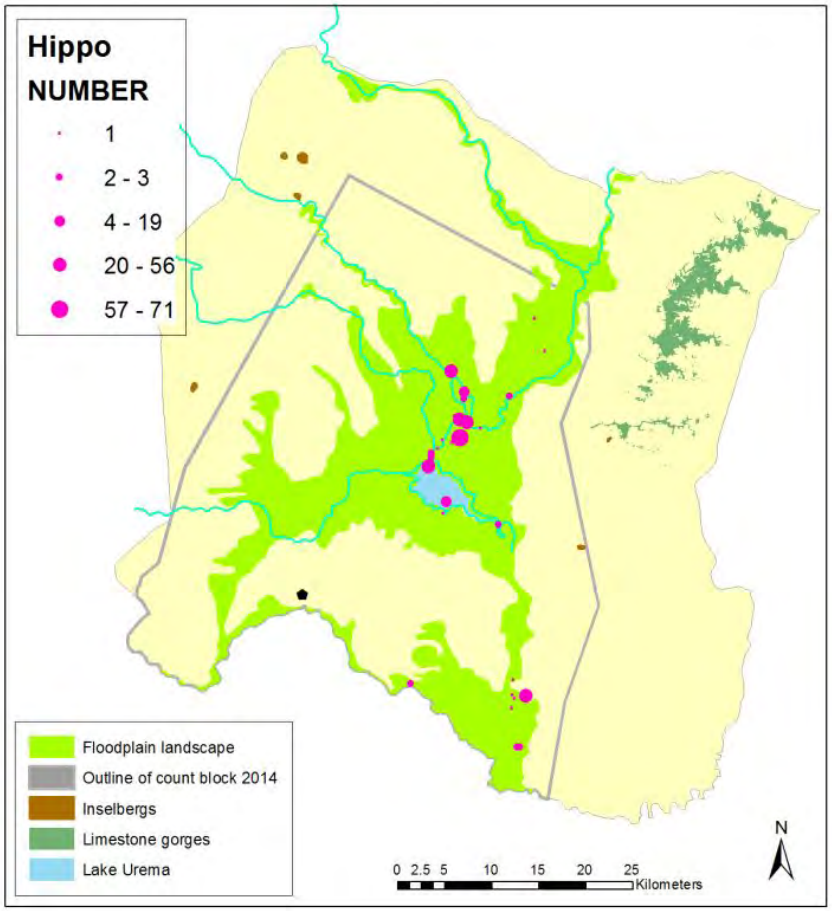
Individual species

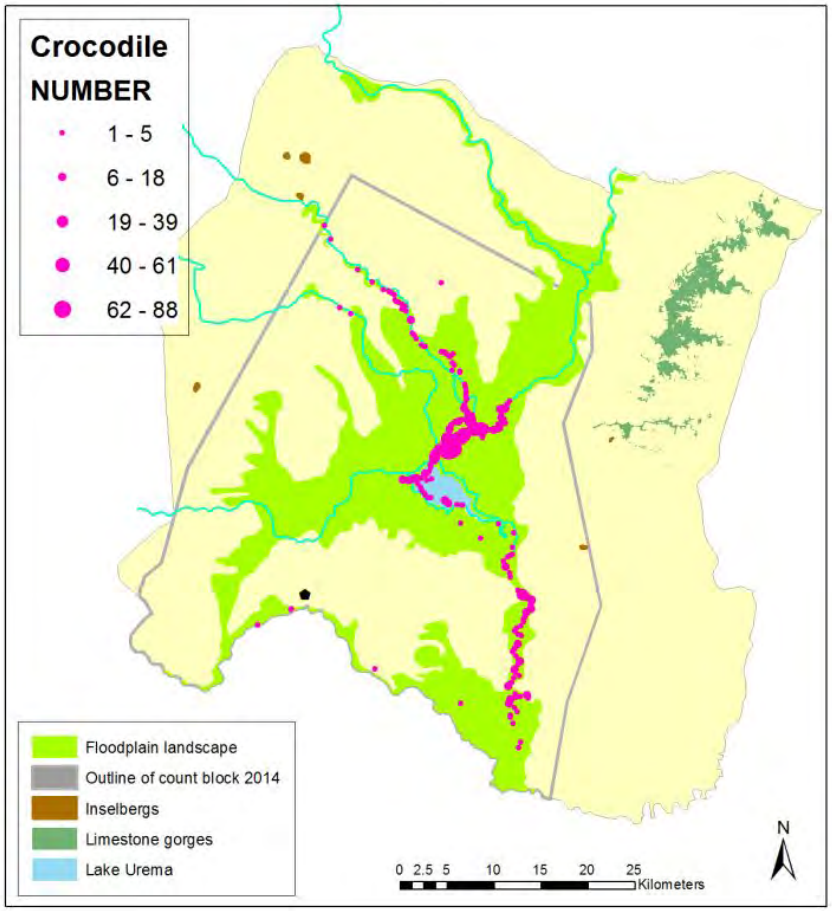
Mostly widespread species





Hippo and crocodiles

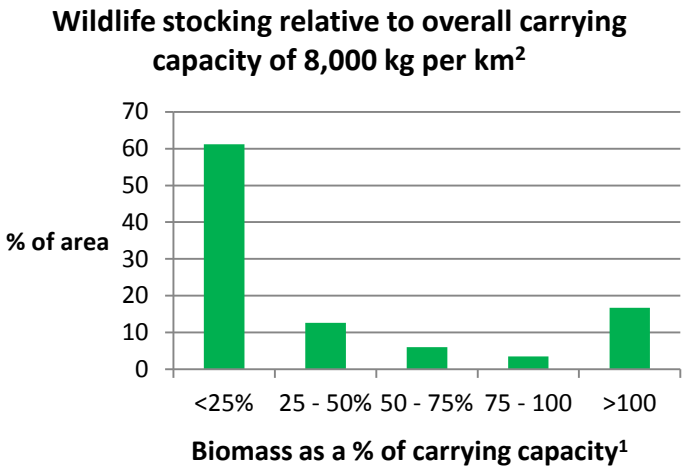


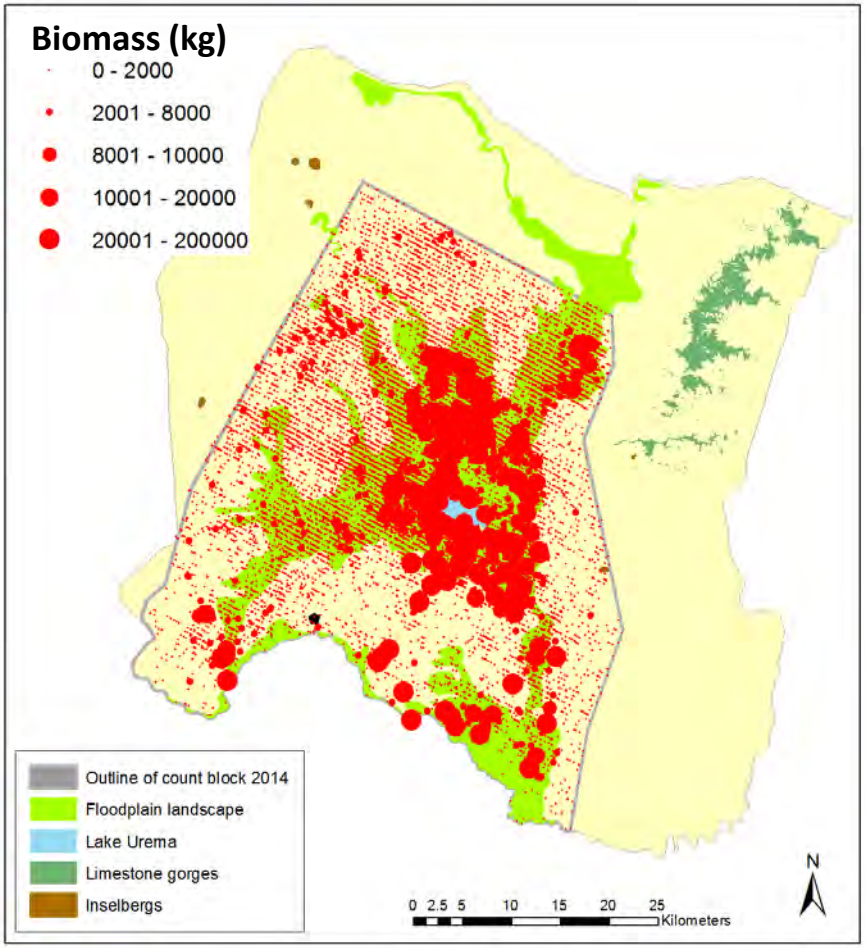


2.4. Wildlife biomass

The distribution of animal weight is plotted across the landscape. The highest animal biomass is found around Lake Urema.

The resulting map has been translated in terms of the percentage of the landscape stocked at different proportions of a conservative carrying capacity of 8,000 kg per km^2.





[1] Refer to Stalmans (2006) for a discussion on carrying capacity.

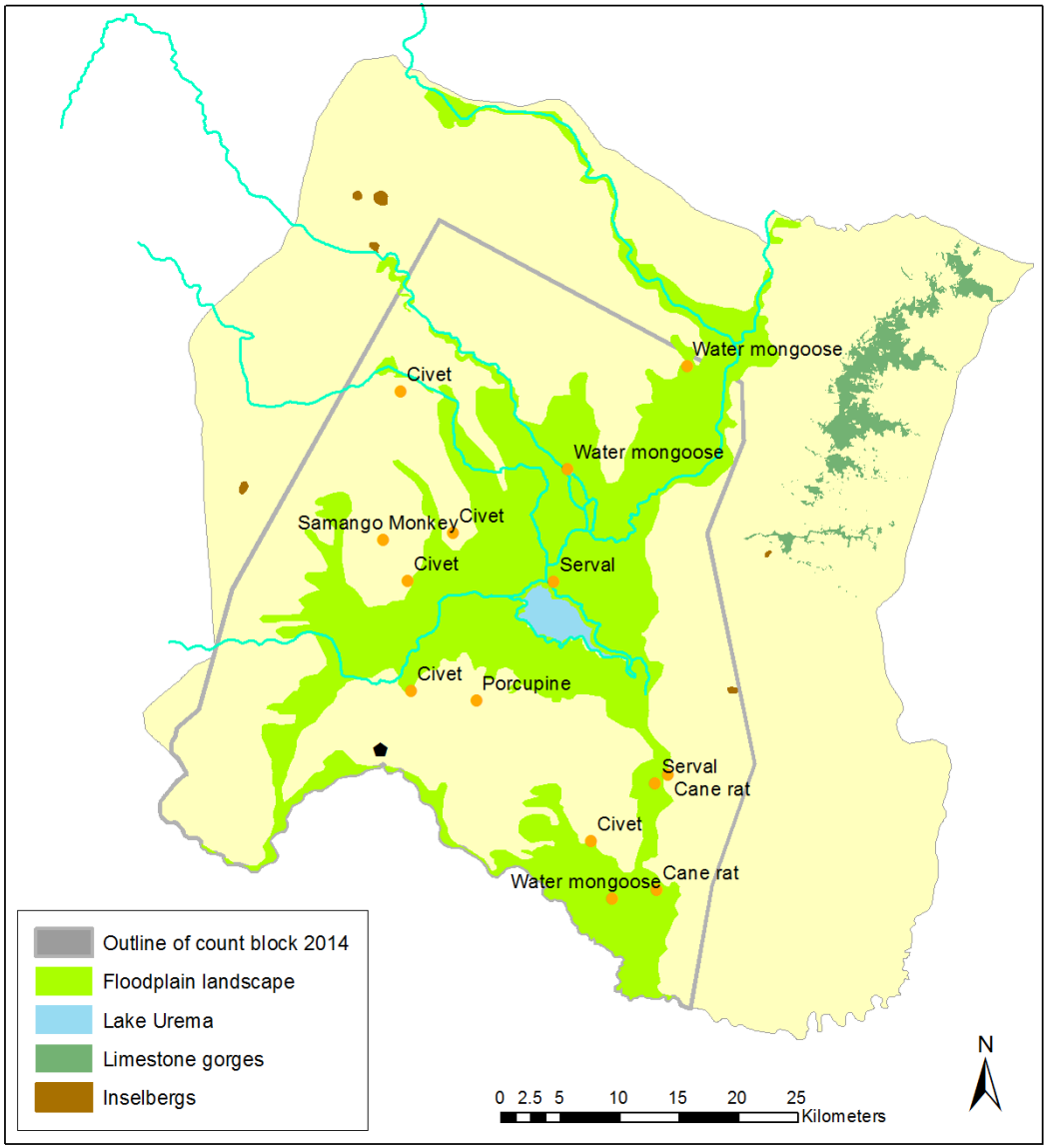
2.5. Additional species records

In addition to the larger herbivores, all sightings of carnivores and other smaller mammals were recorded. This information is incorporated in the biodiversity database for the park.

Furthermore, the presence of crowned cranes, saddle-bill storks and ground hornbills were also recorded. These large birds are generally under some pressure in southern Africa.

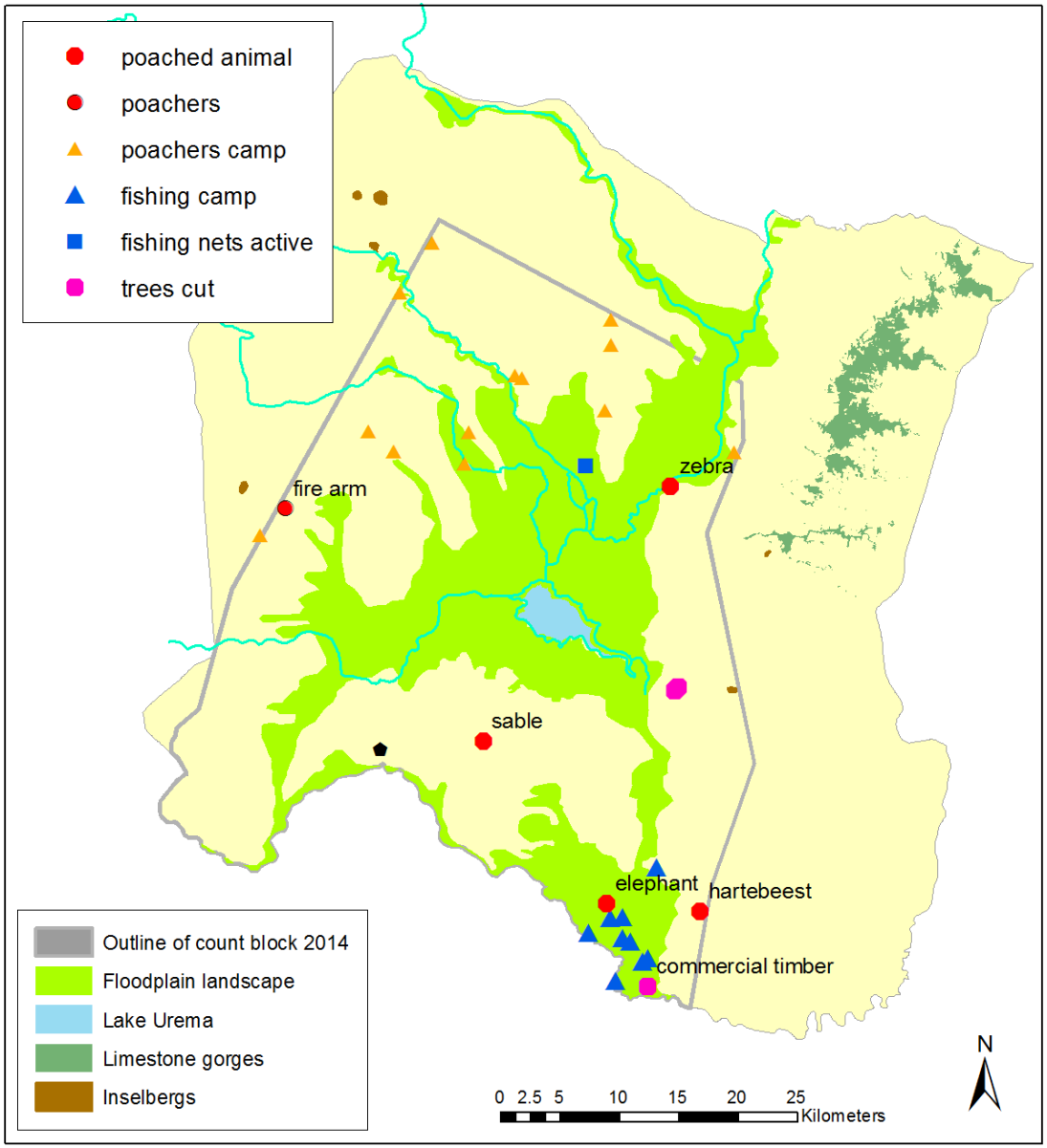
A total of 153 ground hornbills were recorded. Due to their great mobility and the fact that the count was done over an extended period it is quite likely that several individuals and flocks were recorded at least twice. The data have been shared with the Mabula Ground Hornbill Project for further interpretation.

Although not a good tool to census lions, the helicopter count did yield records of lions not yet know to the Lion Project researchers.



2.6. Illegal activities

During the count, signs of illegal activities were recorded. Two poachers were caught red-handed with two freshly killed Lichtenstein's hartebeest. They were arrested. One elephant carcass that was several months old, as well as a recently snared sable antelope and zebra were recorded. Signs of commercial timber cutting as well as of felling of trees for the purpose of opening new fields were documented. Despite the very encouraging growth in wildlife numbers it is clear that illegal activities remain a serious threat to the park.



Zebra foal in snare

Snared Lichtenstein's hartebeest

Snared sable with back leg removed

Trap line where 2 hartebeest were snared

3. Discussion

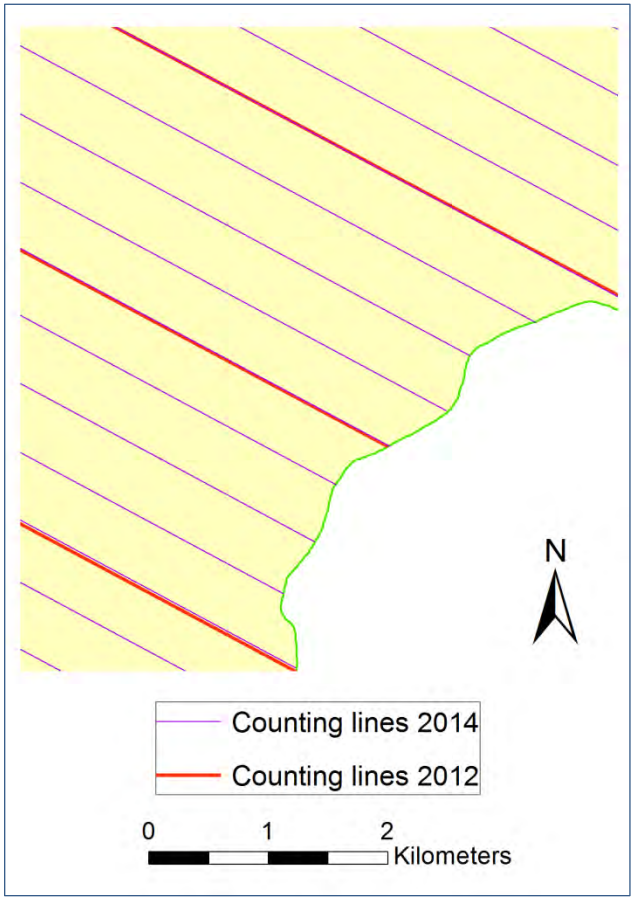
3.1. A reflection on the previously used sampling approach

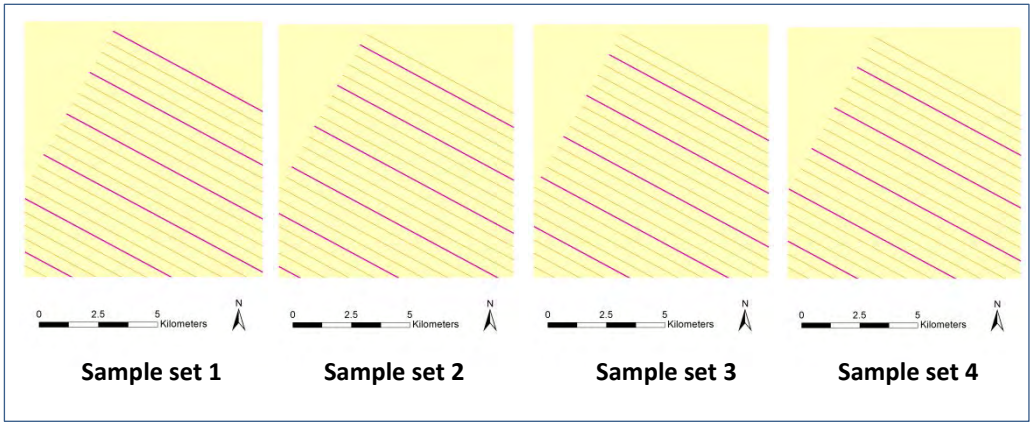
The change from a sampling approach to a block approach complicates the interpretation of change over time. However, as the count lines for the block used the same base line as the previous sample count lines, it becomes possible to assess in more detail the difference between the two approaches.

The previous counting lines for 2007, 2010 and 2012 in the Rift Valley are matched by 2014 counting lines. Additionally, in 2014, there were 3 parallel new counting lines at 500 m intervals that fill the 2 km gap between the original count lines.

The 2014 data set was used to explore the difference between the full block count and a 25% data sampling approach. Four sets of a 25% sample block count based on the previously used approach in which count lines were 2 km apart were generated by selecting respectively the original lines and then moving 1, 2 and 3 lines down.

The number of animals encountered for each set of sample lines was compared to the total number encountered in the block (all sample lines).





The discrepancies between the total count in the block and the results obtained through sub-sampling generally increase for those species that occur in smaller numbers. This is especially so for those species that group into distinct herds

These differences mean that care should be taken with any extrapolations and conclusions drawn from widely-spaced sample counts.

Species	Total counted in block	Total in sample set 1 (adjusted for sample size)	Total in sample set 2 (adjusted for sample size)	Total in sample set 3 (adjusted for sample size)	Total in sample set 4 (adjusted for sample size)	% difference of sample set 1 with total	% difference of sample set 2 with total	% difference of sample set 3 with total	% difference of sample set 4 with total	Minimum % difference	Maximum % difference
Waterbuck	33 323	32 242	32 558	37 305	32 482	3.2	2.3	-12.0	2.5	2.3	12.0
Common reedbuck	11 435	11 087	12 062	11 907	12 424	3.0	-5.5	-4.1	-8.7	3.0	8.7
Warthog	8595	8940	8101	9065	8540	-4.0	5.7	-5.5	0.6	0.6	5.5
Oribi	4315	4882	3928	4301	4373	-13.1	9.0	0.3	-1.3	0.3	13.1
Impala	2 573	2 381	2 077	2 921	2 590	7.5	19.3	-13.5	-0.7	0.7	19.3
Bushbuck	2 185	2 220	2 389	2 319	2 074	-1.6	-9.3	-6.1	5.1	1.6	9.3
Kudu	1 066	1 013	835	1 428	1 280	5.0	21.7	-34.0	-20.1	5.0	34.0
Nyala	859	1 251	772	761	788	-45.6	10.2	11.4	8.3	8.3	45.6
Sable	672	640	937	254	341	4.8	-39.5	62.2	49.3	4.8	62.2
Hartebeest	575	597	910	417	286	-3.8	-58.3	27.5	50.2	3.8	58.3
Elephant	324	345	96	372	286	-6.6	70.4	-14.7	11.6	6.6	70.4
Buffalo	228	14	197	561	3	94.0	13.4	-145.9	98.5	13.4	145.9
Blue wildebeest	78	3	11	149	108	95.7	86.5	-90.8	-38.2	38.2	95.7

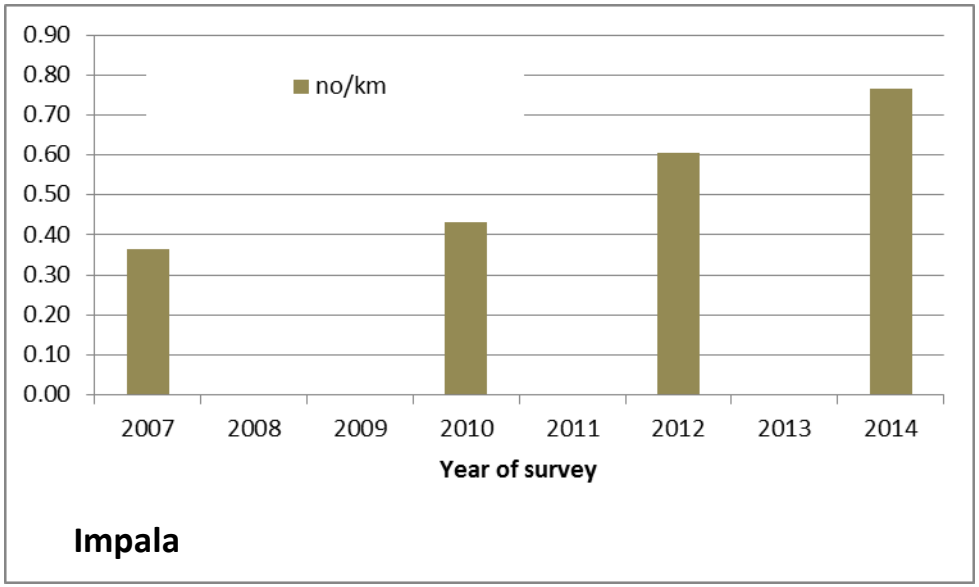
Note: Sample sets 1 to 4 as illustrated on page 27. The selected set of lines covers 3,156 km in length for the block and approximately 788 km for each 25% sample set.

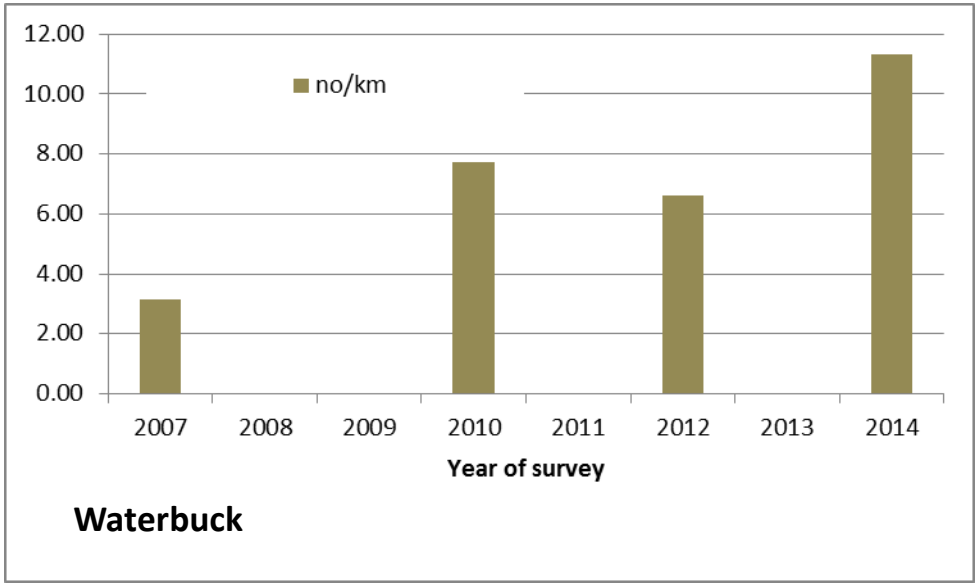
3.2. Historical trends

Notwithstanding the problems with the previously used sampling approach, the figures were used to assess the general trend over time of the populations of different species. The results are expressed as an index of animals per km of counting line. The 2007, 2010 and 2012 data were 'clipped' in order to fall within the same block as the 2014 data. For 2014, only those records that fell within the previous sample count strips were selected to calculate the indices. This approach maximises the comparability in terms of the habitat that was assessed.

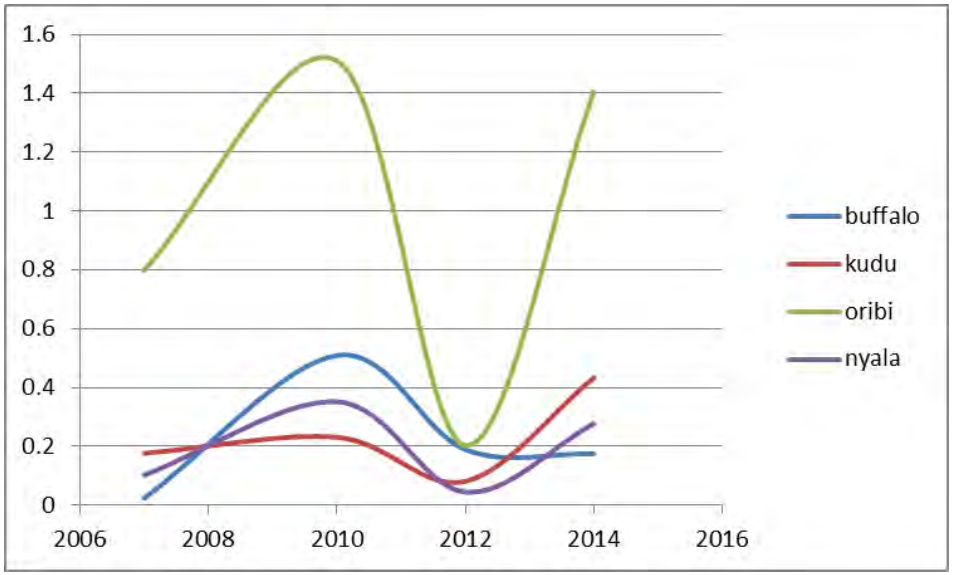
Some of the smaller species were obviously undercounted in 2012 as the survey took place early in the season when the grass was still very long. This applies especially to bushbuck, oribi, warthog and reedbuck. However, the inconsistencies between successive surveys which have lower densities could also be attributed to the variation caused by the sampling approach as discussed in section 3.1.

There is a general upward trend from 2007 in the density of animals per km flown as shown in the individual graphs for impala and waterbuck. Regardless of the wide variation observed for some of the other species, the general trend remains upward .

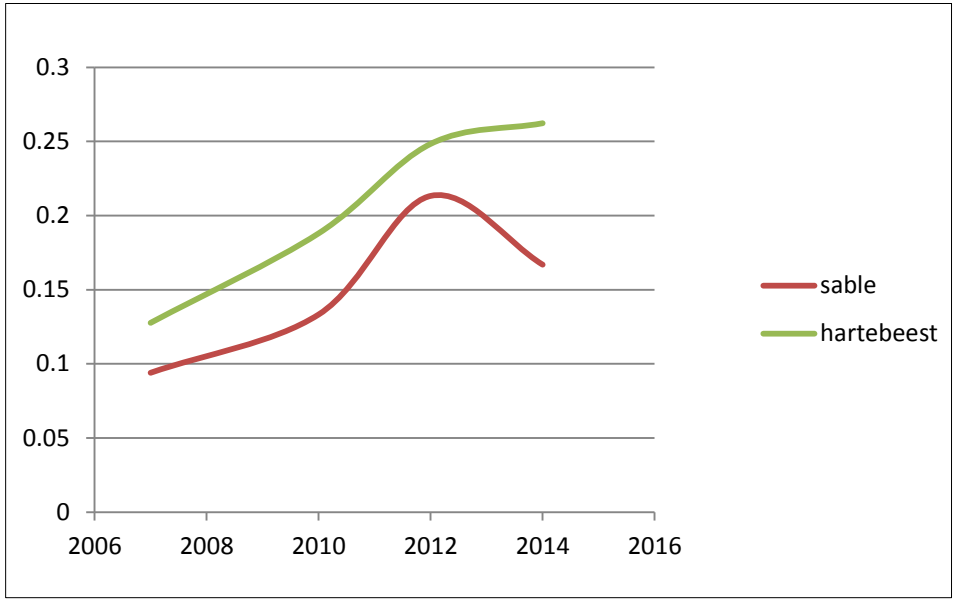




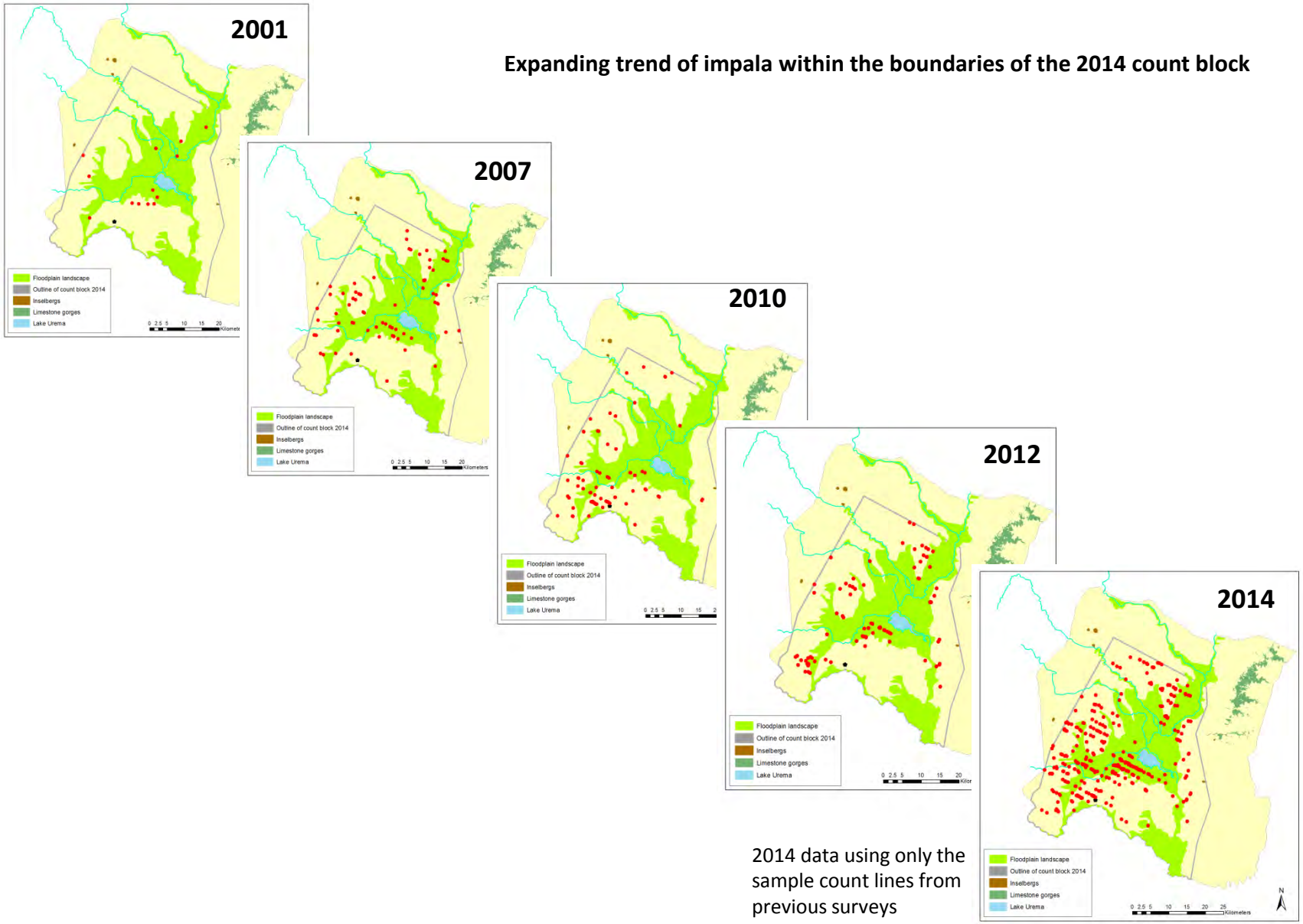
Number of animals per km of counting line



Number of animals per km of counting line

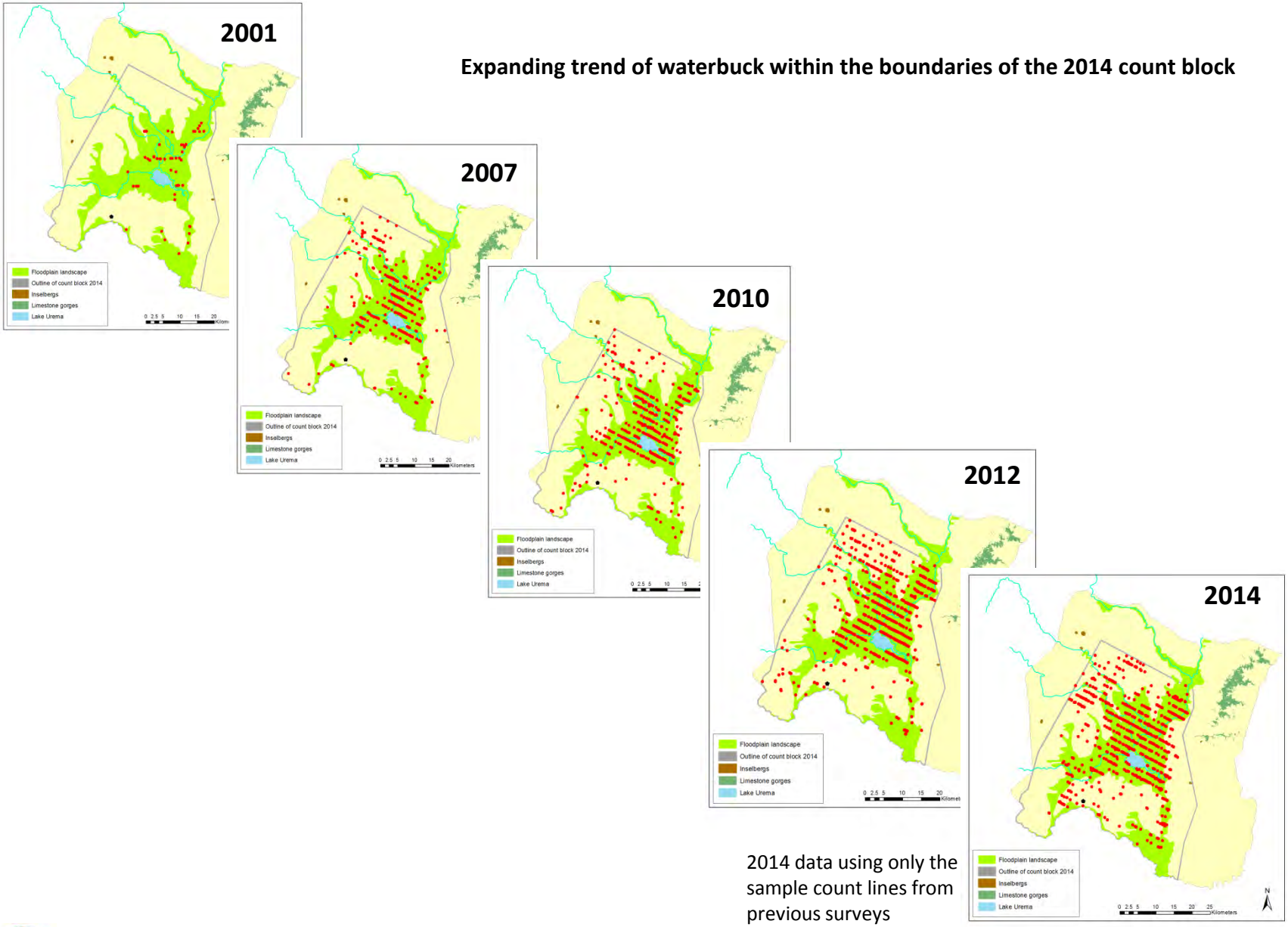


Expanding trend of impala within the boundaries of the 2014 count block



2014 data using only the sample count lines from previous surveys

Expanding trend of waterbuck within the boundaries of the 2014 count block



2014 data using only the sample count lines from previous surveys

How far have wildlife numbers recovered ?

Species	1972 estimate (Tinley 1977)	2000 estimate	Loss 1972 - 2000	2014 Numbers	Current recovery as % of historical levels
Buffalo	14 000	<100	>99%	>650	<5%
Elephant	2 500	<200	>92%	>500	>20%
Hippo	3 500	<100	>97%	>430	>15%
Waterbuck	3 500	<300	>91%	>34,000	>100%
Zebra	3 500	<20	>99%	<40	<2%
Blue wildebeest	6 500	<20	>99%	>350	<7%
Sable antelope	700	<100	>86%	>750	>100%
Lichtenstein hartebeest	800	<100	>88%	>600	>75%
Lion	200	?	?	> 50	> 25%

Note 1: Some historical numbers were likely much greater as the fixed wing counts would tend to underestimate the true numbers. Even sable numbers may have been underestimated as they often occur in closed woodlands.
Note 2: Little reliable historical information is available on species such as nyala, impala and kudu.

3.3. Stocking rates

The distribution of animal weight across the landscape clearly shows a larger animal biomass in the floodplain areas (graph on page 23) .

The overall stocking rate is 5,500 kg per km^2 as compared to a conservative upper limit stocking rate of 8,000 kg per km ^{2}.

Only 17% of the area is stocked at a level higher than the putative upper limit of 8000 kg per km^2.

Most of these high weight concentrations occur within the floodplain area that generally has a potential carrying capacity in excess of 10,000 kg per km^2.

Information source	Carrying capacity	
	kg km^{-2}	ha / AU
Stalmans field estimate - *Piliostigma-Borassus*	**3,971**	**11.3**
Coe et. al. (1976) lower limit	4,017	11.2
Stalmans field estimate - *Dichrostachys cinerea* shrubland	**4,500**	**10.0**
Fritz & Duncan (1994) low fertility	4,916	9.2
Stalmans field estimate - mopane woodland	**5,000**	**9.0**
East 1984 – Serengeti – rainfall 803mm - high fertility	5,144	8.7
Tinley (1977)	5,531	8.1
Stalmans field estimate - *Acacia-Combretum-Milletia* Open Woodland	5,625	8.0
Coe et. al. (1976) average	6,089	7.4
Myre & Antão (1972) - *Urochloa* savanna grassland (average)	6,428	7.0
Stalmans field estimate - *Acacia - Combretum* woodland	**7,290**	**6.2**
Stalmans field estimate - *Acacia* with saline grassland	**7,500**	**6.0**
Fritz & Duncan (1994) medium fertility	7,677	5.9
Stalmans field estimate - *Setaria* grassland	**7,941**	**5.7**
Coe et. al. (1976) upper limit	8,160	5.5
Stalmans field estimate - Palmveld	**8,504**	**5.3**
East 1984 - Luangwa Valley – rainfall 832 mm - medium fertility	8,555	5.3
Fritz & Duncan (1994) high fertility	8,920	5.0
Stalmans field estimate - *Acacia xanthophloea* woodlands	**11,124**	**4.0**
Myre & Antão (1972) - flooded alluvial grasslands (average)	12,857	3.5
Timberlake (1994) - Chobela 686 mm *Acacia* on clay loam	14,950	3.0
Timberlake & Reddy (1986) - Chokwe grassy bottomland on heavy soil 656mm	19,565	2.3
Stalmans field estimate - *Cynodon-Digitaria* short grassland	**21,429**	**2.1**

Estimate of carrying capacity for the Rift Valley based on predictive models (assuming an annual rainfall of 840 mm) as well as recorded stocking rates from other studies. Estimates are ranked from lowest (top) to highest (bottom) (Stalmans M. & Beilfuss R. 2008.) AU = Animal Unit, a standardised unit that is used to translate domestic livestock and wild herbivores to a common denominator (in this case an average cow of 450 kg live weight). Ha/AU: the number of hectares required to support a single Animal Unit .

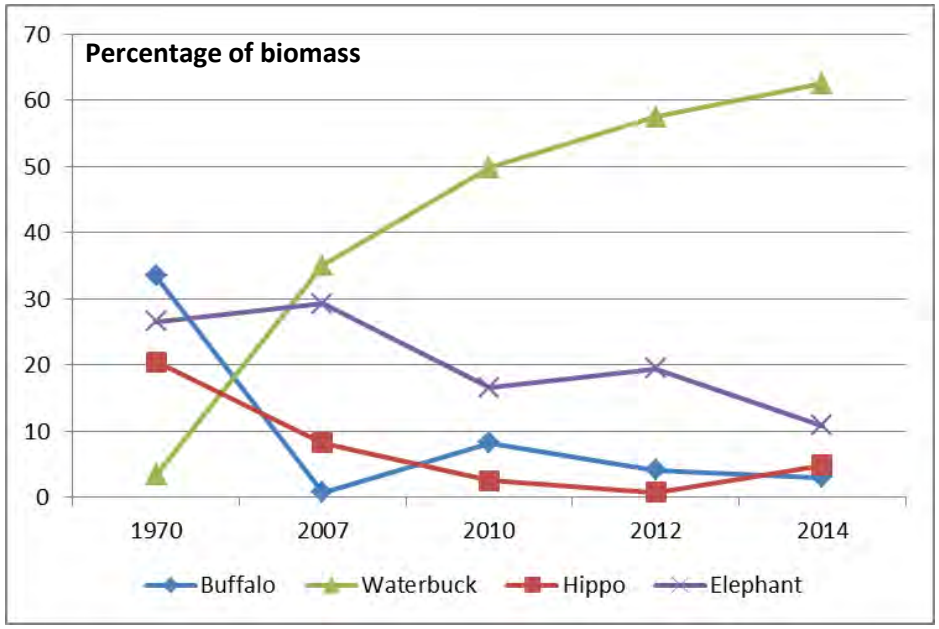
3.4. Biomass proportions

Information on the historical animal numbers is based on fixed-wing counts. These did not enable a good count of smaller species such as reedbuck, warthog, oribi and impala.

The relative make-up of the total biomass by different species is presented in the following table and graph.

Historically, buffalo totalled approximately 6.3 million kg. Currently, waterbuck total 6.2. million kg. The buffalo were spread over a larger area than that covered by the count block of 2014. There is a very interesting comparison study to be made here between the much more strongly herding buffalo and the herding but less strongly so waterbuck and the impact on rangelands in the long term.

In the past, much more of the biomass was made up of megaherbivores such as elephant, hippo and buffalo. These represented almost 70% of the total biomass. At present, these megaherbivores make up less than 20% of the total biomass and waterbuck dominate the system with a 62% contribution to overall biomass. The relative contribution of waterbuck has been increasing continuously since 2007.



Percentage of biomass

	Year of survey				
Species	**1970**	**2007**	**2010**	**2012**	**2014**
Buffalo	33.4	0.7	8.2	4.1	3.0
Hippo	20.4	8.2	2.5	0.7	4.8
Waterbuck	3.3	35.0	49.8	57.5	62.5
Reedbuck common	1.5	9.7	7.3	6.0	6.0
Warthog	1.2	6.1	5.1	5.5	4.1
Elephant	26.5	29.2	16.5	19.4	10.8
Other	13.7	11.1	10.6	6.6	8.8

3.5. Implications for decision making, planning, research and future counts

- The results of the count indicate that all large herbivore species, with the exception of the *crawshayi* subspecies of zebra, now occur in numbers that are sufficient for their continued recovery and viability;
- The 2014 count has re-affirmed the importance of these regular surveys. Certain lessons were learned from the difficulties encountered (see text box);
- Certain inputs can now be made by having confidence, for the first time, in the total numbers obtained:
    - Available prey biomass for the modelling of larger predator habitat suitability;
    - Contribution of overall elephant numbers into the Mozambican national census which itself will feed into the African census currently being undertaken;
    - Defining new research projects that focus on the high proportion of biomass occupied by waterbuck, likely future trends, future management requirements etc.
- The aerial wildlife count using a helicopter is one of the most important and critical tools to evaluate the status of the recovery and the effectiveness of park management. It will be important to continue with regular counts;
- In the years to come, the coverage of the aerial count will probably need to be expanded in order to account for the spread of the animals beyond the current counting block.

- Timing - by the end of the count there was considerable flushing of new leaves on the trees. This reduces visibility and the likelihood of detecting kudu, nyala etc. Although leaf flush will vary depending on rainfall received and temperature, it is important that the survey does not take place too late in the year. The time window 1 October till 30 October is probably ideal in most years;
- As temperatures are often very high in October, the best approach would be to have only two counting sessions each day – one of 3 hours in the early morning (before 10:00 am) and one of 2 to 2.5 hours in the late afternoon (after 15:30). This reduces the area that is counted in a single day and will require a longer counting period. The drawback of this approach is that there will be more risk of movement of herds from one counting block to another thereby leading to an undercount or over count. This could be problematic for mobile species such as elephant;
- The counting methodology should be adapted to deal with the large number of waterbuck on the open floodplains. It has become extremely difficult to handle the large concentrations of waterbuck. It is proposed to test flying transects with the Bathawk ultralight aircraft. A geo-referenced video setup or aerial photographs should enable the accurate counting of waterbuck. The helicopter would then be used for the survey without attempting to enumerate waterbuck in these open areas. This could cut down on the helicopter flying time. However, the current state of the technology does not yet allow accurate counting of most animals in the woodlands using a Bathawk or a drone.

4. Conclusion

In conclusion, the 2014 aerial wildlife count was highly successful.

It confirmed for the first time, through a full-count approach, approach (albeit covering only 50% of the park) that very substantial populations of most of the major species occur.

Arguably Africa's single largest population of waterbuck occurs in Gorongosa National Park.

The count confirms that wildlife populations are recovering rapidly in the park. However, the numerous signs of poaching and other illegal activities also indicate that there is continuous pressure on the park. Law enforcement efforts needs to be sustained and even increased in many parts of the park.

The recovering wildlife occurs in proportions that are very different from those documented in historical times. The system has switched from being dominated by buffalo to a system dominated by waterbuck. There are interesting research opportunities that need to be taken up in order to help with developing a better understanding of the system dynamics that will assist with management and decision-making.

The aerial wildlife count using a helicopter is one of the most important and critical tools to evaluate the status of the recovery and the effectiveness of park management. It will be important to continue with regular counts. The aerial wildlife count is a vital M&E tool for the GRP.

Serval on the floodplain of Gorongosa

5. References

Stalmans M. 2006. Vegetation and carrying capacity of the 'Santuario', Parque Nacional da Gorongosa, Moçambique. Unpublished report by International Conservation Services to the Carr Foundation and the Ministry of Tourism.

Stalmans M. & Beilfuss R. 2008. Landscapes of the Gorongosa National Park. Unpublished report to the Gorongosa Restoration Project.

Tinley. K.L. 1977. Framework of the Gorongosa Ecosystem. Ph.d. thesis. University of Pretoria.

6. Acknowledgements

The helicopter survey would not have been possible without the input and assistance of many people. The following are acknowledged:

- The GRP and its partners for the funding of the survey;
- Park and government authorities for the necessary clearances;
- Helicopter pilot Mike Pingo for his highly professional and experienced flying of the survey including advice on the best conditions and approaches;
- Dr Mike Peel of the Agricultural Research Council for his inputs based on many years of similar wildlife counts in southern Africa and his contribution in terms of general ecological observations;
- All of the different observers for their professional approach to the counting job;
- Diogo Duarte and Lorraine Chittock for photographs;
- Mike Marchington and his team for the logistical support offered at Chitengo in particular with the refuelling.

Large concentration of hippo and crocodiles upstream of Lake Urema 9

24 October 2014 – herd of buffalo on the Pungue River

END