Monitoring the recovery of wildlife in the Parque Nacional da Gorongosa through aerial surveys

2000 - 2012

A preliminary analysis

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July 2012

Summary

- A total of 7 aerial wildlife surveys have been undertaken from 2000 to 2012 in the Gorongosa National Park. These have been sampling surveys covering 9 to 22% of the Park.

- The data of these 6 helicopter and 1 fixed-wing (2004) survey have not yet been fully analysed. The data were combined in a single data base of 15 083 individual species occurrence records. These data were also incorporated in a Geographic Information System.

- The results clearly indicate that there has been since 2000 a significant increase in wildlife numbers for most species. The vast majority of the wildlife is found in the central and southern part of the fertile Rift Valley. However, densities are much lower in the infertile miombo in the east and west as well as in the Rift Valley closer to human habitation. Where higher levels of protection from illegal hunting are maintained, such as in the Sanctuario, higher densities of wildlife are now recorded even though the recovery started from similar low levels as in other parts of the Park.

- The current sampling design has significant shortcomings that make the estimate of overall population numbers problematic, especially for species with relatively low numbers and a clumped distribution (e.g. buffalo and elephant). This makes it difficult to evaluate the current populations against historical wildlife numbers.

- The current design is not considered good enough for the quality of data required for ecological research and for the auditing of management performance.

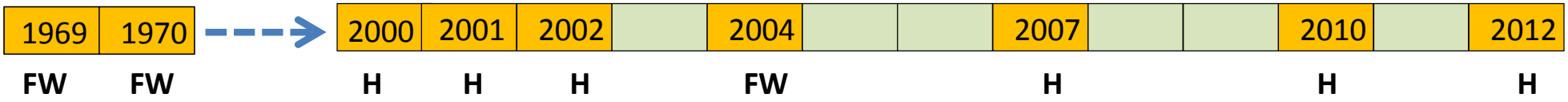
- A different design that switches to a 'block count' rather than a 'sample line' design is recommended. The focus of the survey would be on the central and southern part of the Rift Valley. The preferred scenario is for an annual survey of a larger area of 1800 km^2 (45% of the Park) at least for the next 3 to 5 years, to set a baseline, after which one could revert to a biennial survey. This will require a higher investment in flying hours from the current 30 hours to 66 hours.

- Despite several shortcomings, aerial surveys, in particular helicopter counts, provide the most practical tool to determine wildlife numbers and trends in medium- to large-sized African grassland and woodland systems. The proposed change from a 'sample count' approach to a 'block count' strategy should result in a much better determination of actual numbers and dynamics of wildlife in the core area of the Gorongosa National Park.

Aims of this document:

- Report on available aerial survey data (year 2000 onwards, including the results of the May 2012 survey)
- Describe the consolidation of the data into a single database
- Present preliminary results in terms of numbers recorded and trends
- Illustrate some of the potential uses of the data set (including spatio-temporal distribution patterns)
- Evaluate strengths and weaknesses of the available data, particularly where they are used to estimate overall population numbers
- Make recommendations on future survey design, timing and frequency

Sequence of aerial wildlife surveys in Parque Nacional da Gorongosa



FW = Fixed wing

H = Helicopter

Flight specification:

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 and 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 (east and west stratum) or 3 km (central stratum) apart

Helicopter surveys - specific equipment and technique:

- 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 (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;
- 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 stored. 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;
- All observers wear yellow goggles that reduce shadows and enhance contrast for better visibility and detection of the animals;
- Sessions lasting about two to three hours were flown. A short break was taken after 1 to 1.5 hours to relieve observer fatigue. Two to three sessions were generally flown in a single day.

2012 survey team
Pilot: Mike Pingo – Sunrise Aviation
Data recorder/navigator: Marc Stalmans / Alan Short
Observers: Tongai Castigo, Luis Oliveira, Alan Short, Marc Stalmans

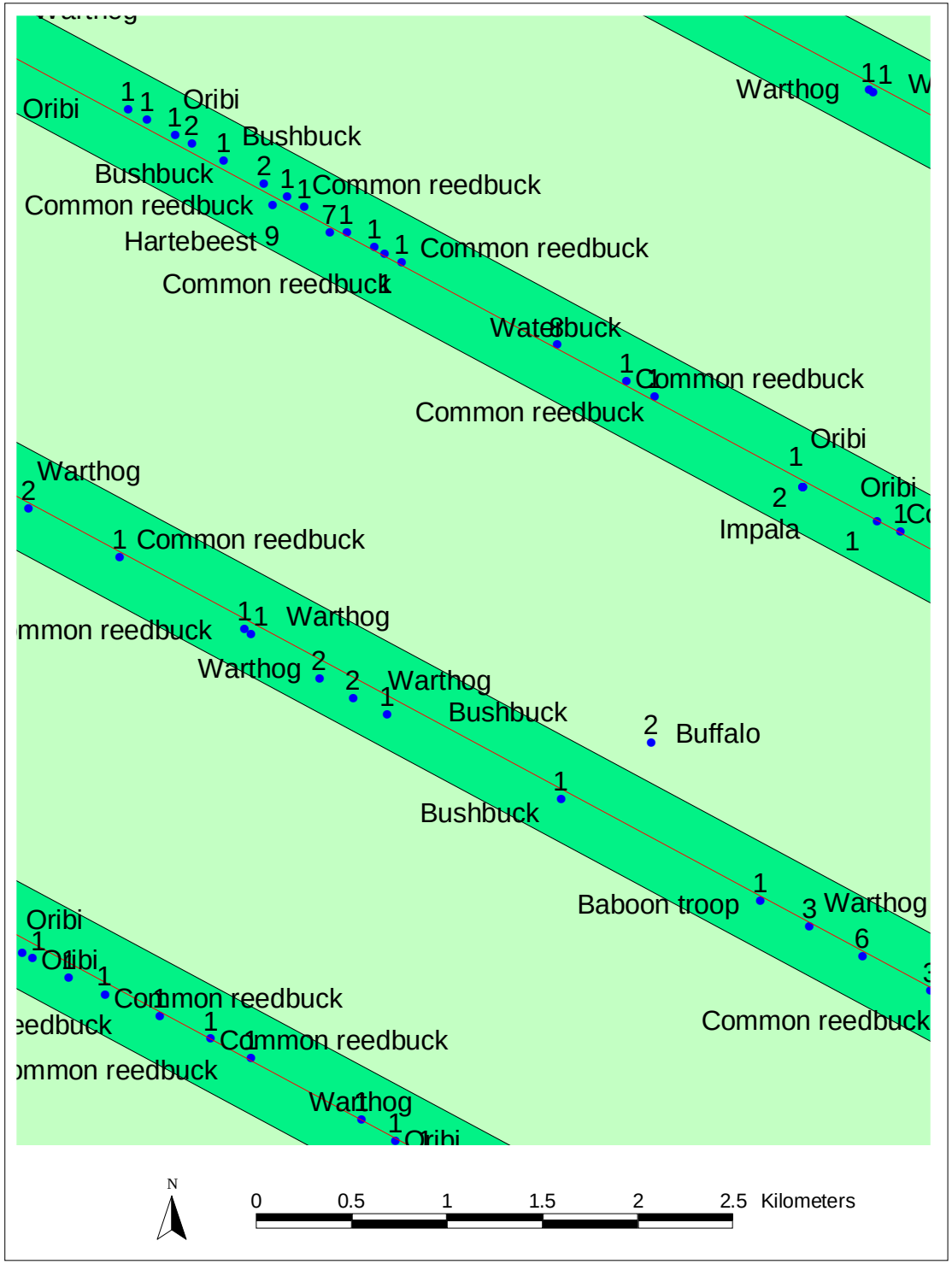
Visual presentation of raw count data

2012 sample lines (25% coverage)

Dark green = sample strip of 250 m on each side of the flight line (in red). All animals seen within this strip are recorded on the on-board computer.

GPS records of wildlife are represented as blue dots

Buffalo observation outside the sample strip represents an additional record not used for population estimates



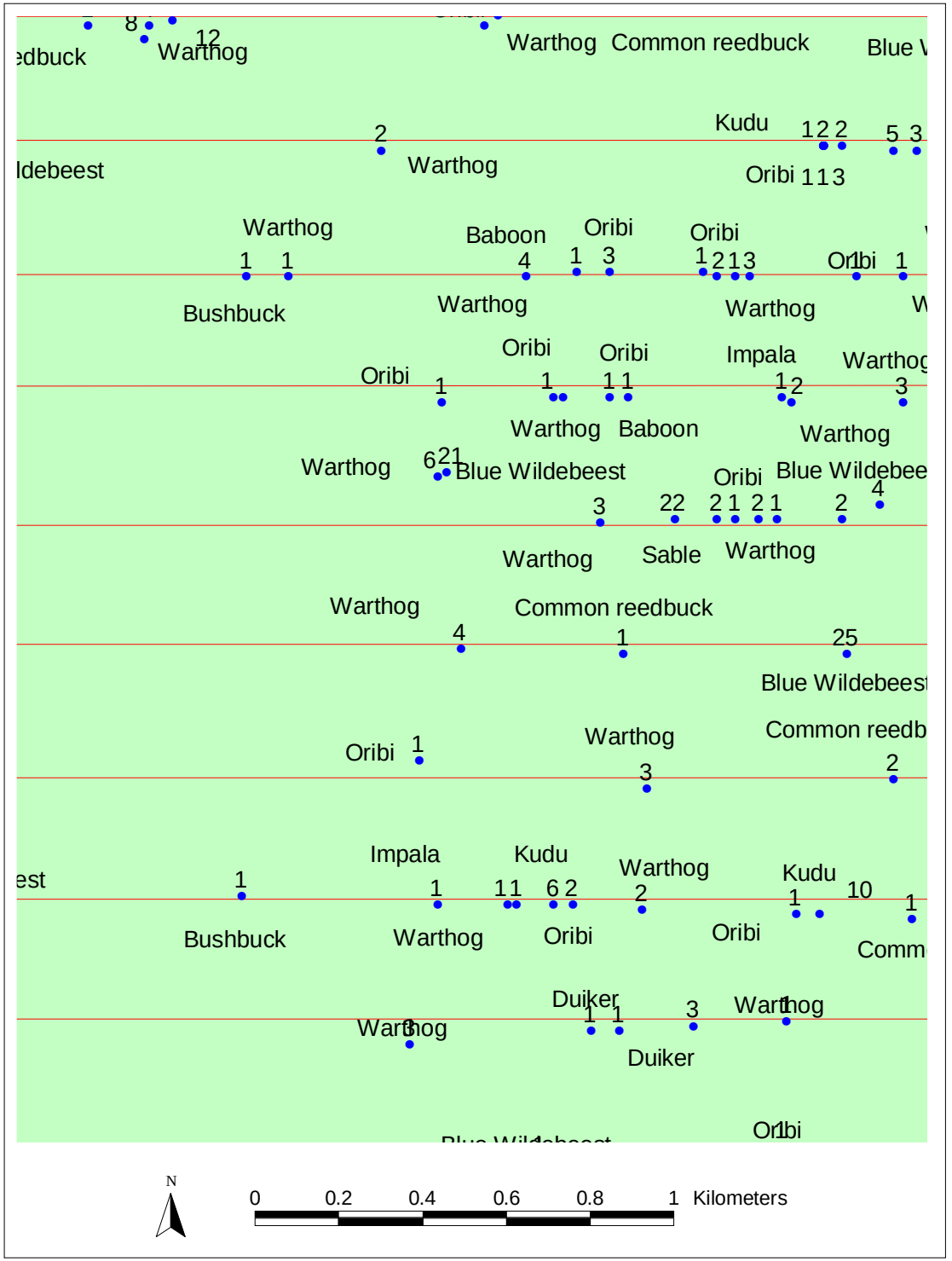
Visual presentation of raw count data

2012 Sanctuario – 100% cover

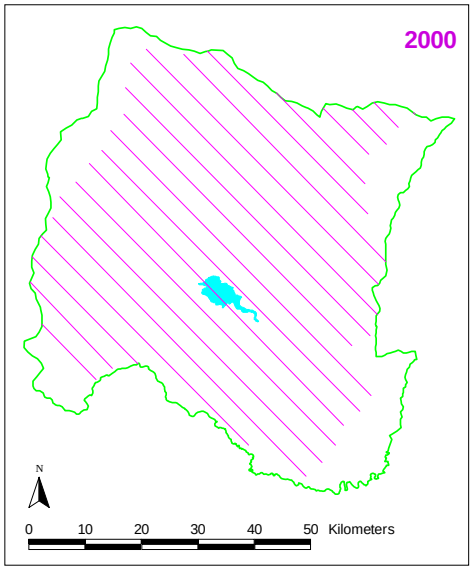
Flight line in red

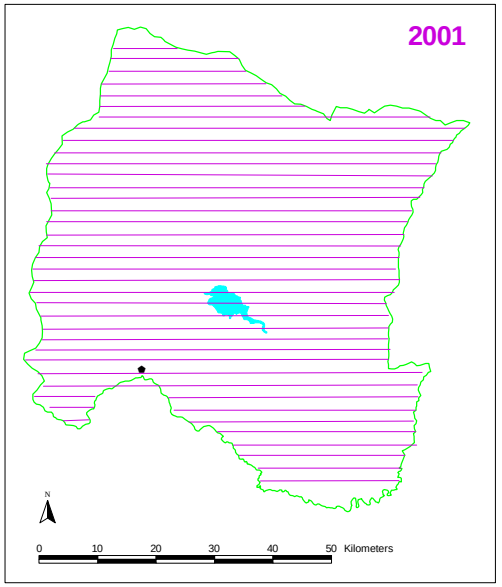
GPS records of wildlife as blue dots

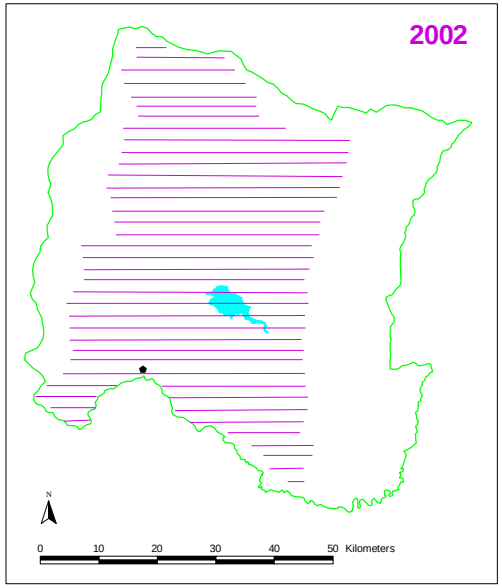
Full coverage resulting from adjacent individual strips of 300 m wide

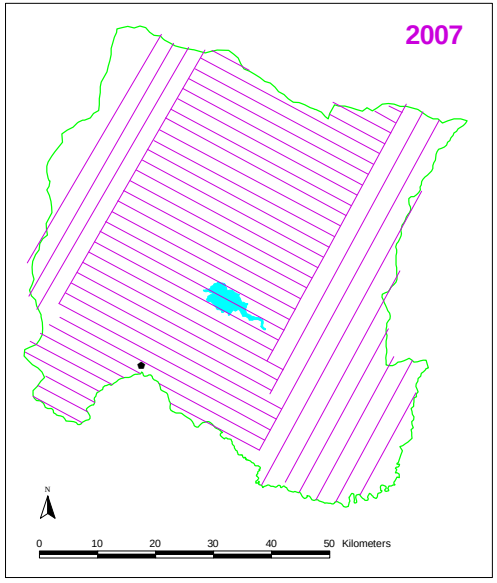


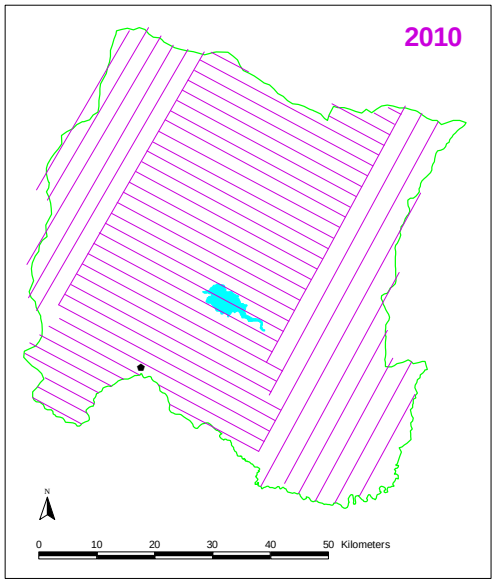
FLIGHTLINES

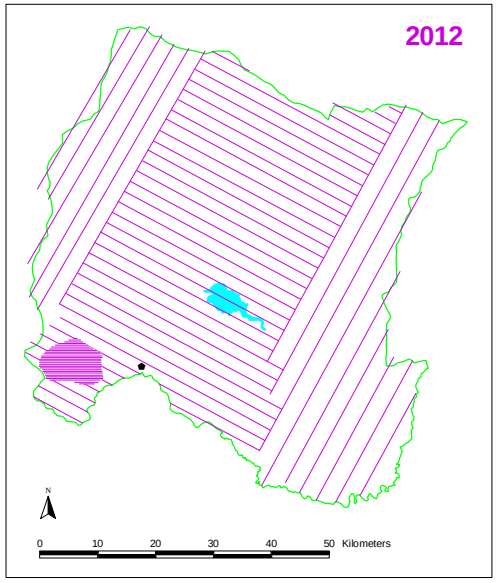






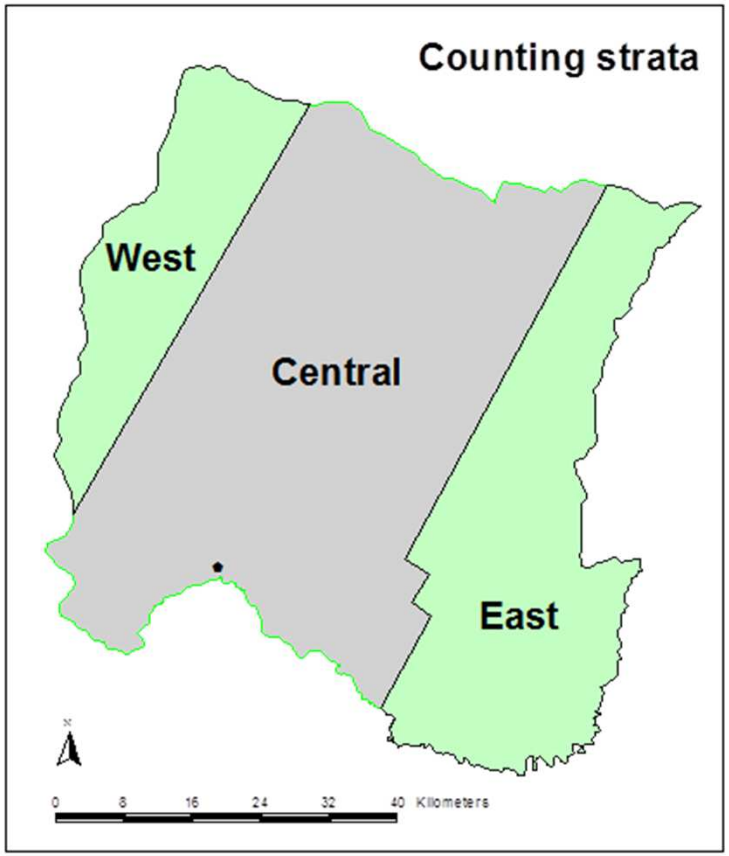






Survey coverage

Transect lengths (km)					
		Stratum			
Year	West	Central	East	**Total**	Width of strip (m)
2000	97	543	187	**827**	500
2001	119	1 079	341	**1 538**	500
2002	87	910	60	**1 056**	500
2004	162	691	317	**1 170**	300
2007	194	1 072	370	**1 635**	500
2010	283	1 072	370	**1 724**	500
2012	283	1 042	370	**1 695**	500
2012 Sanctuario		212		**212**	300
2012 total	283	1 254	370	**1 907**	



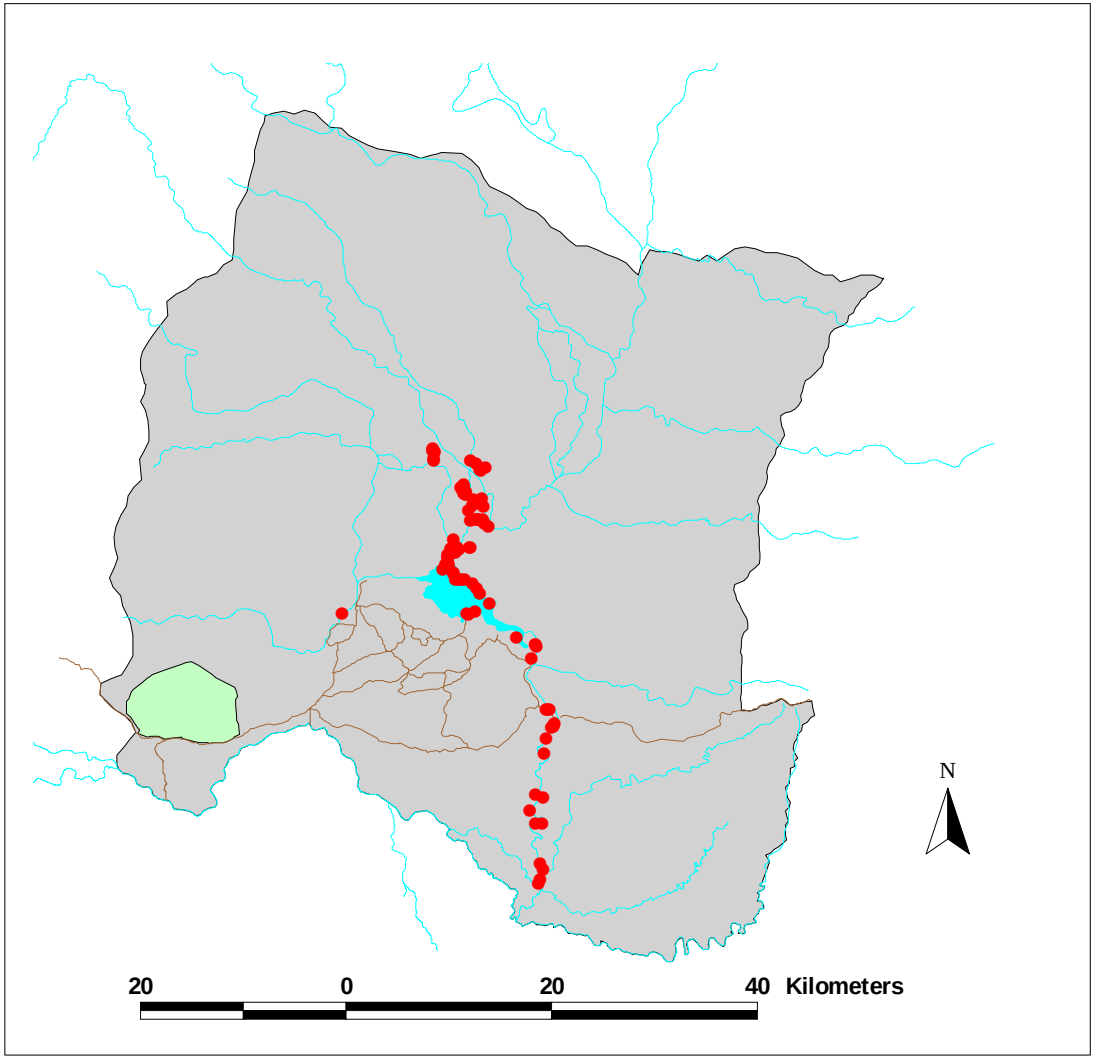
	Area surveyed (ha)				Percentage of stratum/Park			
Year	West	Central	East	**Total**	West	Central	East	**Total**
2000	4 850	27 150	9 350	41 350	8.7	11.9	8.4	10.5
2001	5 925	53 950	17 025	76 900	10.6	23.6	15.3	19.4
2002	4 325	45 500	2 975	52 800	7.7	19.9	2.7	13.4
2004	4 860	20 730	9 495	35 085	8.7	9.1	8.5	8.9
2007	9 675	53 575	18 500	81 750	17.3	23.5	16.6	20.7
2010	14 125	53 575	18 500	86 200	25.3	23.5	16.6	21.8
2012	14 125	52 100	18 500	84 725	25.3	22.8	16.6	21.4
2012 Sanctuario		6 360		6 360				
2012 total	14 125	58 460	18 500	91 085	25.3	25.6	16.6	23.0

Stratum size	**ha**
West	55 843
Central	228 349
East	111 290
	395 482

Dedicated hippo count

Flight from the park boundary in the west along the Vundudzi River to Lake Urema and then south to the confluence of the Urema River with the Pungue River

- 2004
- 2007 (only Lake Urema and Urema River)
- 2010
- 2012



All hippo records from dedicated counts 2007 - 2012

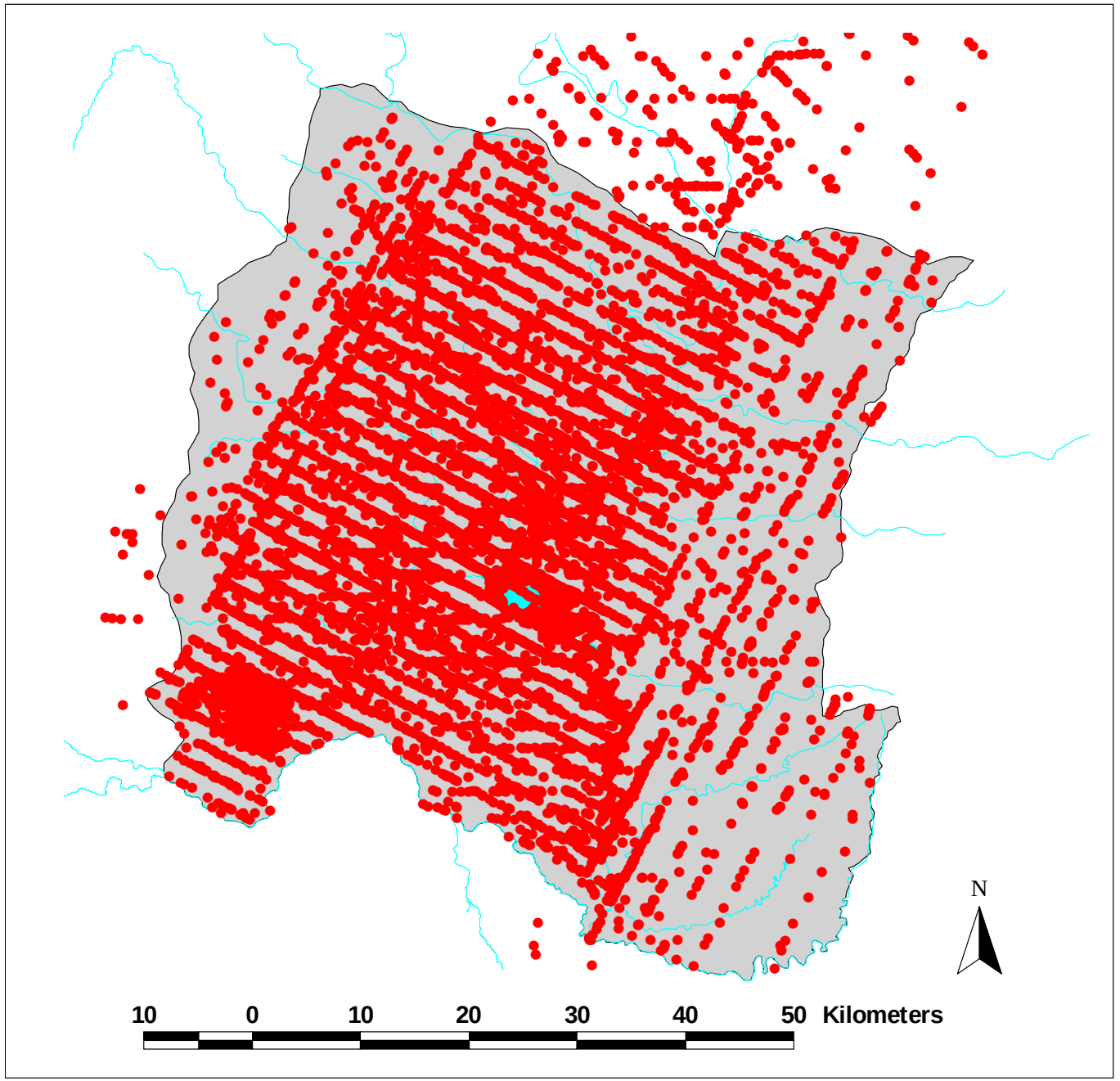
Consolidation of raw data

- All available data are in txt format
- Imported in Excel
- Cleaned and re-labeled for consistency of species spelling
- Each data point has the following information:
    - Unique ID number
    - Species
    - Number of animals
    - Year
    - Day
    - Time
    - Latitude / Longitude
    - Transect line
    - Stratum (west, central or east as defined above)

- Resulting data base has **15 083 individual species occurrence records**

ID	Count	ID_count	Latitude	Longitude	Count day	Session	Date	Time	Transect line	Species	Number	Sanctuary	Stratum
13412	2012	2894	-18.85110	34.67540	5	8	5/7/2012	10:41:40 AM	7	Bushbuck	1	0	West
13413	2012	2895	-18.99500	34.59780	5	9	5/7/2012	12:36:44 PM	7	Hartebeest	7	0	West
13414	2012	2896	-19.01950	34.58420	5	9	5/7/2012	12:38:29 PM	7	Nyala	2	0	West
13415	2012	2897	-19.02510	34.58110	5	9	5/7/2012	12:38:52 PM	7	Hartebeest	2	0	West
13416	2012	2898	-19.02260	34.58300	5	9	5/7/2012	12:39:19 PM	7	Hartebeest	2	0	West
13417	2012	2899	-19.02800	34.57910	5	9	5/7/2012	12:39:49 PM	7	Warthog	4	0	West
13418	2012	2900	-19.02920	34.57870	5	9	5/7/2012	12:39:54 PM	7	Waterbuck	8	0	West
13419	2012	2901	-19.02960	34.57850	5	9	5/7/2012	12:39:56 PM	7	Warthog	5	0	West
13420	2012	2902	-19.03030	34.57820	5	9	5/7/2012	12:39:58 PM	7	Waterbuck	2	0	West
13421	2012	2903	-19.03330	34.57680	5	9	5/7/2012	12:40:12 PM	7	Impala	3	0	West

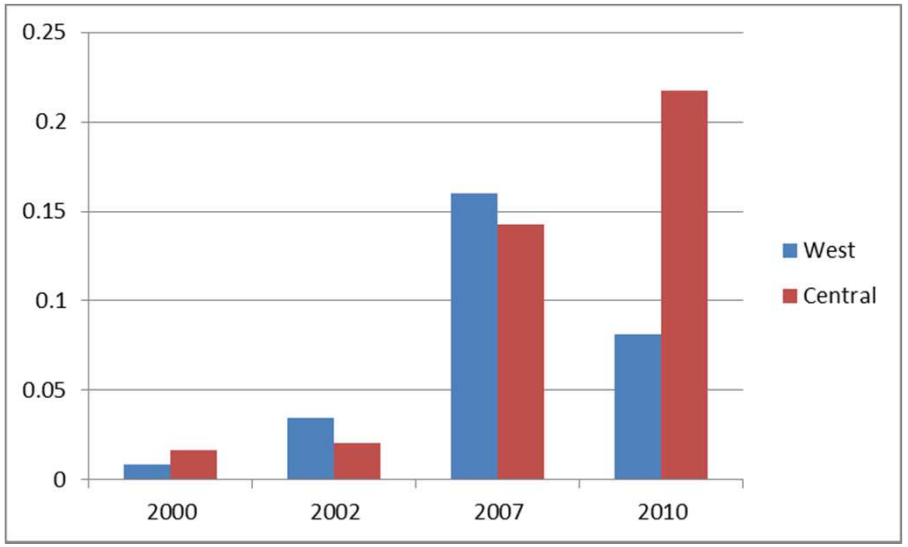
All 15 083 GPS points (within count strips and outside) for all 7 surveys



Are the lower number of wildlife observed in the west and east an artifact caused by lower visibility in those woodlands compared to the more open floodplain of the central stratum?

- Visibility in the east and west stratum (miombo woodlands) is indeed lower;
- However, animals are still spotted by helicopter. The two largest herds of buffalo observed in 2012 the Sanctuario were under dense tree cover in the miombo woodlands (western stratum).
- Ground observations confirm the pattern of lower animal densities close to the boundaries.
- The low densities of wildlife on the boundary are illustrated by the case study of kudu. There is a drop in the graph in the number of kudu observed per km transect line from 2007 to 2010 in the western stratum whereas the central stratum shows increasing densities. This is an artificial result, because of the addition in 2010 of two extra transect lines further west of the previous transect lines. These two extra lines close to the boundary and its settlements carry even less animals.

Number of kudu per km of transect flown



Count results (animals observed within the sampling strips and Sanctuario)

	2000	2001	2002	2004	2007	2010	2012
Baboon Troop			20		95	65	72
Blue Wildebeest					23	119	377
Buffalo		15	26		18	363	328
Bushbuck	166	97	197	75	515	542	309
Bushpig	28	27	15	1	99	66	46
Civet							1
Common reedbuck	191	235	392	186	2259	2824	2119
Crocodile		390	216	12	1358	421	391
Crowned crane				2	79	15	12
Duiker grey	10	12	3	13	69	85	23
Duiker red					46	31	10
Eland		20				43	3
Elephant	163		79		168	165	144
Ground Hornbill			26	31	56	61	80
Hartebeest	33	6	9	7	166	195	252
Hippo	48	43	9	62	219	220	227
Impala	53	16	61	54	275	391	584
Jackal				1			
Kudu	22	39	22	63	196	259	245
Lion		6		2	5		
Marabou stork					1		
Mongoose					6		
Monkey Troops						6	
Nyala	52	148	71	19	165	401	49
Oribi	79	82	306	60	628	1174	272
Porcupine						2	1
Sable	39	101	12	111	132	225	272
Saddlebill stork				2	13	32	
Steenbuck					3	33	
Vervet monkey					3		
Warthog	190	316	801	279	1747	2467	2511
Waterbuck	399	418	1071	627	2295	5643	4848
Wattled Crane		2					
Zebra	6	5	6		2	17	5

Note that these are only the numbers of animals that were directly counted.

As only a portion of the Park was assessed, the total population number could be substantially higher

General drop in rate of increase or even numbers which results from the use of a fixed-wing (which is a less effective platform for aerial surveys)

Count results (= animals present within the sample strips as well as some additional observations outside the transects)

(Additional records of elephant, buffalo, wildebeest and zebra)

	2000	2001	2002	2004	2007	2010	2012
Baboon Troop			20		105	68	72
Blue Wildebeest		2			28	119	409
Buffalo		15	26	1	18	364	384
Bushbuck	178	142	197	85	557	572	309
Bushpig	47	42	15	1	106	68	46
Civet							1
Common reedbuck	203	328	392	228	2347	2869	2119
Crocodile		390	216	12	1382	427	391
Crowned crane				2	79	15	12
Duiker grey	11	17	3	13	75	89	23
Duiker red					54	33	10
Eland		20				43	14
Elephant	163		79		187	165	240
Ground Hornbill			26	34	74	79	89
Hartebeest	45	11	9	7	183	205	252
Hippo	50	44	9	63	242	226	227
Impala	53	38	61	54	280	408	584
Jackal				1			
Kudu	29	39	22	63	213	288	245
Lion		6		2	5	4	4
Marabou stork					1		
Mongoose					6		
Monkey Troops						6	
Nyala	67	162	71	19	186	423	49
Oribi	96	101	306	60	663	1213	272
Porcupine						3	1
Sable	51	102	12	111	166	286	279
Saddlebill Stork				2	13	36	
Steenbuck					3	33	
Vervet monkey					3		
Warthog	222	489	801	279	1857	2550	2511
Waterbuck	503	457	1071	627	2392	5660	4848
Wattled Crane		2					
Zebra	13	5	6		2	19	10

Note that these are only the numbers of animals that were directly counted.

As only a portion of the Park was assessed, the total population number could be substantially higher

Estimating numbers from sample counts : methodological problems associated with current design

These have been sample counts only. Total animal population needs to be estimated taking into account the proportion of the area sampled. However, this is not as straightforward as extrapolating from the percentage sampled up 100% coverage of the Park.

There are some significant shortcomings with the nature of the sampling design as well as the data collected when used for the calculation of estimates of the total population, including:

- Insufficient individual 'groups of animals'. For some of the key species (e.g. buffalo) only a very few 'groups' are observed in a single survey. As an example only 2 groups were observed within the transect lines of 2012 (excluding the Sanctuario). The groups were respectively 131 and 4 buffalo strong. In some years only a single observation or no observation was made for certain species. This affects the statistical outcome in a major way
- The number of 'groups' of individual species is not consistently defined. As an example 7 groups of buffalo were recorded in 2010. However, closer examination of the data reveals that there are 3 sets of 2 observations taken within a few seconds, probably representing the same 'group' whereby a first count is supplemented by a second number as the whole group becomes visible. In effect there were only 4 separate sightings
- Although there is stratification (East, West and Central), there is no adjustment in the sampling effort within each stratum in function of the different animal densities between strata (see Norton-Griffiths 1978) (Note: on the basis of the difference in relative densities of animals between the 3 strata, the sampling effort for the Central stratum should be much higher)
- The East and West strata are covered by long lines that run parallel to the topographical contours. The recommendation from a theoretical perspective (see Strindberg *et al.* 2007) is that these lines should be short and should run perpendicular to the contours and to the decreasing trend of animal density from the Rift Valley floor to the Escarpment edges.

> The following comments on the Gorongosa data by Petri Viljoen who is very experienced with aerial surveys is very relevant: "My first comment is that Distance Sampling is not an ideal way to obtain population estimates during aerial surveys of general African game under most circumstances. Some swear by it but there are not many examples where the methodology has delivered truly good results during a general aerial survey. Norman-Owen Smith, who has tried to work with the Kruger's Distance Sampling data collected since the late 1990s, will tell you that those population estimates are of very little value. I could elaborate on the reasons for this if anyone is interested. Distance Sampling, however, is no doubt a really good technique for many other types of surveys. It is a question of using the right tool for a specific job." (25 March 2012).

Number of 'groups' of individual species

Count	Blue Wildebeest	Buffalo	Eland	Elephant	Hartebeest	Zebra
2000				5	4	4
2001		1	1		2	1
2002		1		6	1	1
2004					2	
2007	5	1		33	43	1
2010	4	7	4	22	47	5
2012	2	2	1	11	39	1

Current report does not consider 'population estimates' but uses 'indices' to evaluate trends.

However, total population number remains important in terms of evaluating the relative degree of attainment of the restoration goals (compared to e.g. historical animal numbers or compared to intrinsic carrying capacity of the habitat).

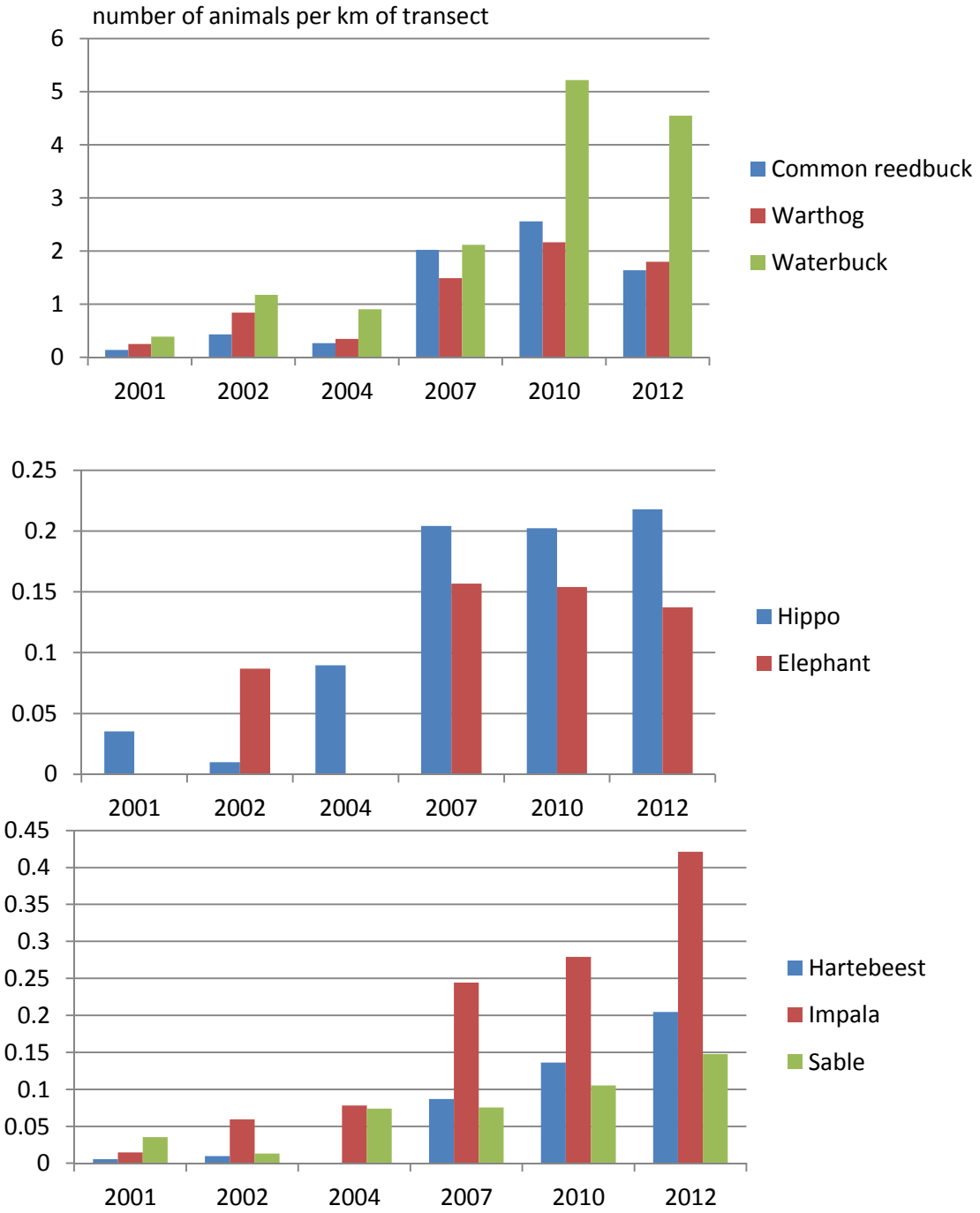
Indices

Number of animals observed in the sample transects of the Central stratum (per km of flying, Sanctuario excluded)

Generally upward trend

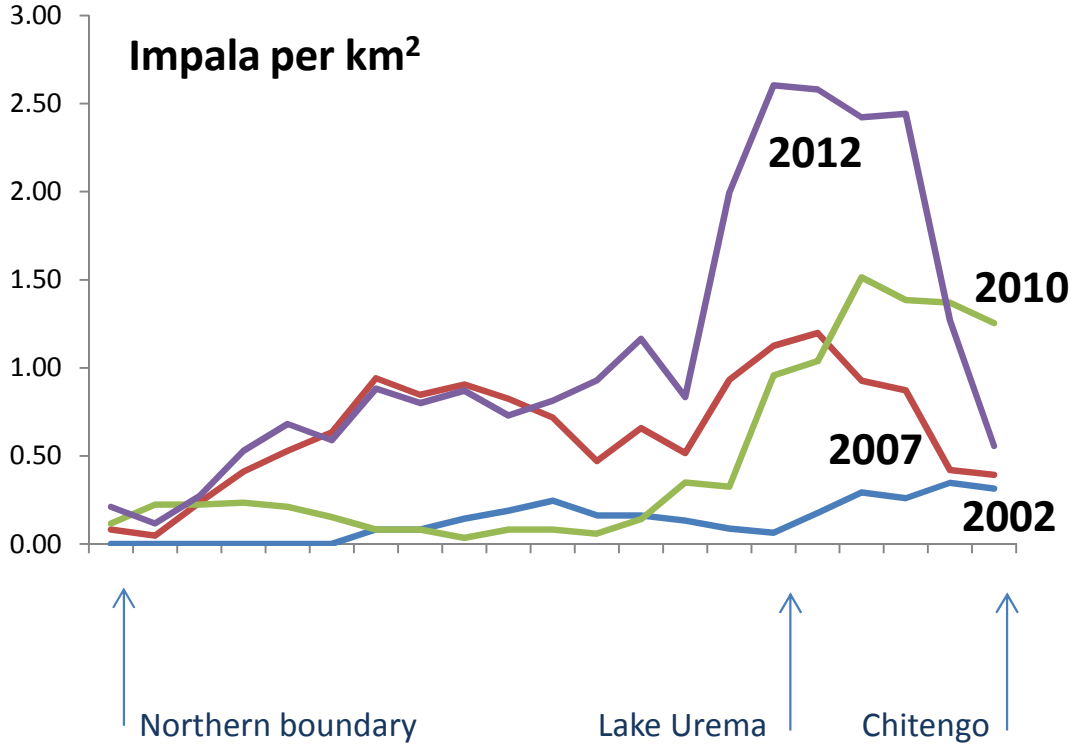
Lower reedbuck and warthog numbers in 2012 are likely the result of the 'early' count with long grass that reduces visibility

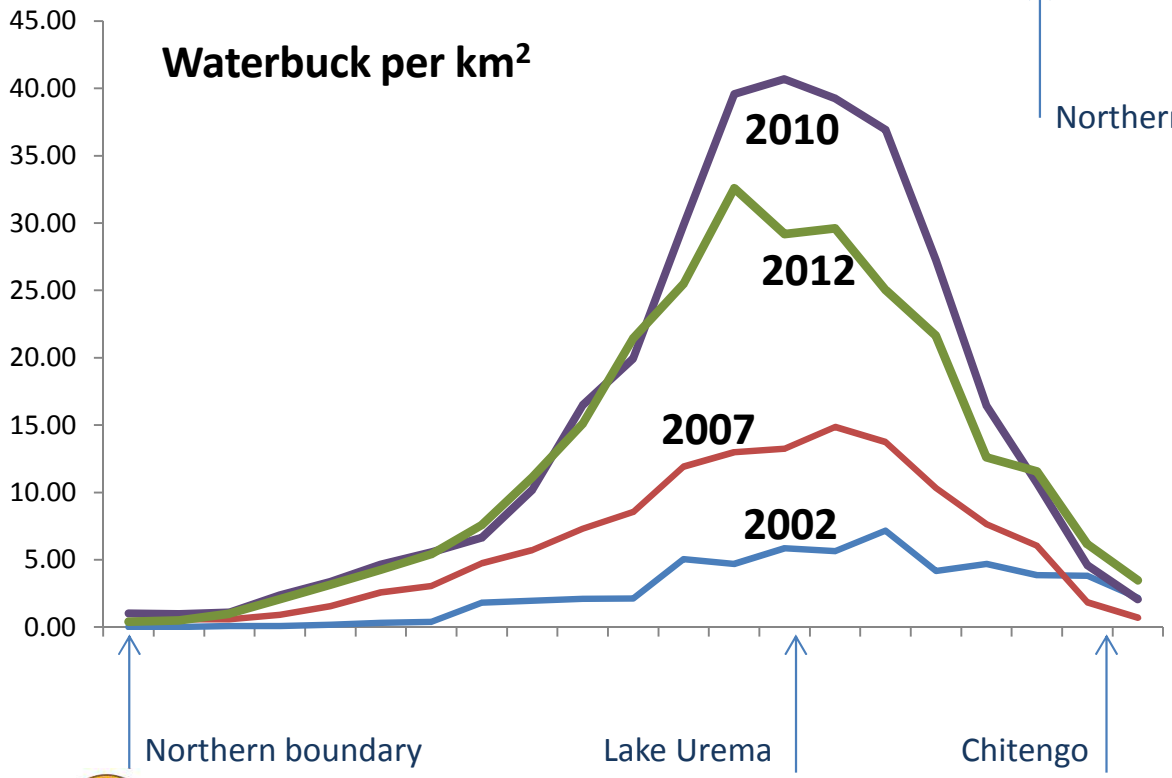
Differences in elephant numbers reflect the problem of the wide spacing of the transect lines and the clumped (herd) distribution of elephant. Not seeing one large herd because it was feeding in between transect strips can result in major overall differences because of the small number of groups (no 'evening' out as would happen in larger populations)



Density of animals across the Central stratum

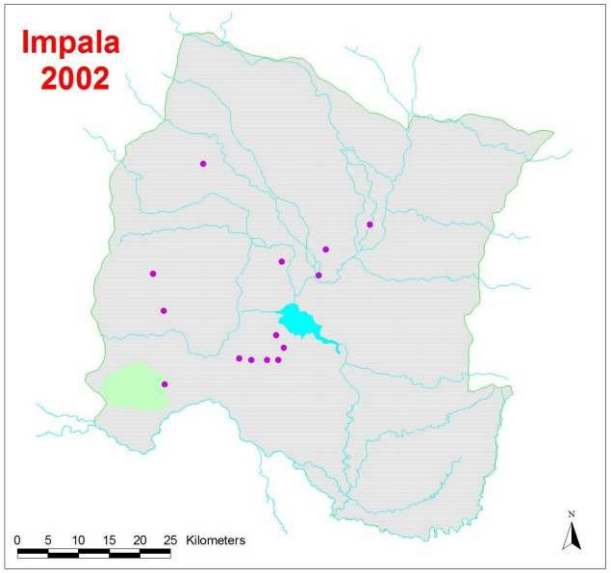
Calculation: number of animals observed in a strip along the transect lines from the northern boundary down to Chitengo. Running average of density across 5 transect lines.

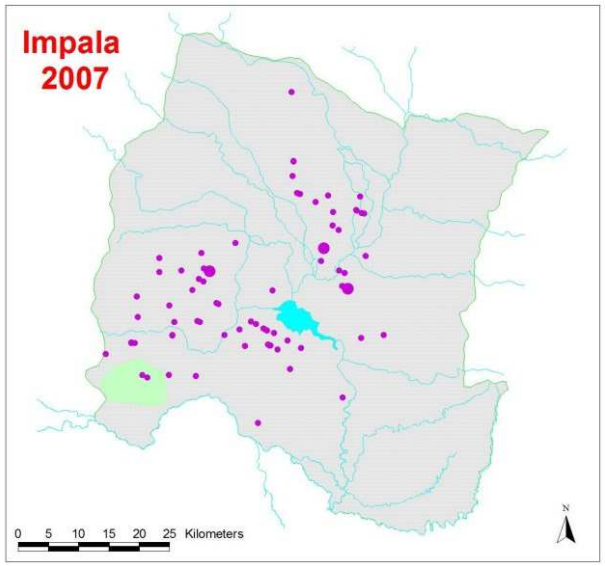


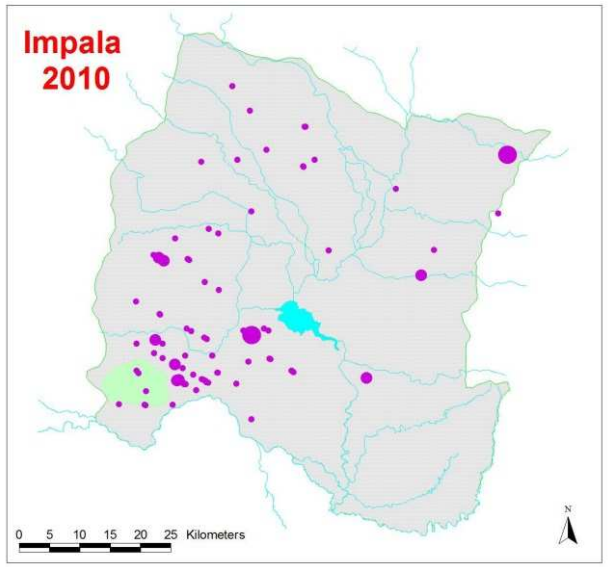


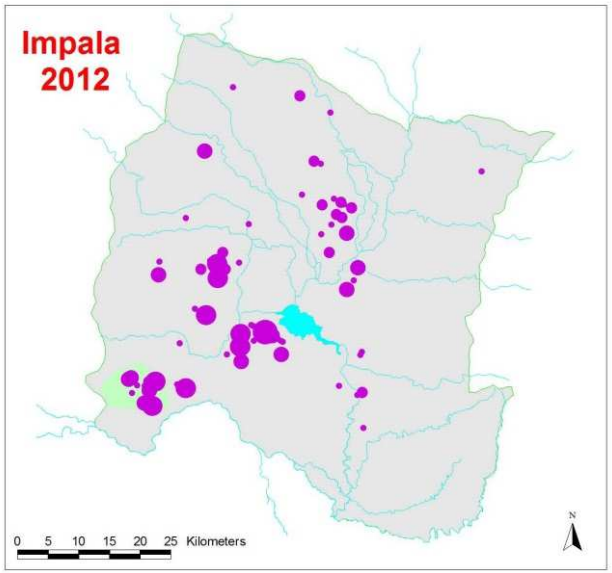
This would seem to indicate that recovery is best around the Lake Urema area. This is despite the northern part of the Park also offering very good habitat (indicating greater human pressure and levels of illegal hunting?). The tapering off towards Chitengo reflects the transition from floodplain habitat into woodlands.

Visualisation of expanding occurrence across the Park and increasing herd size

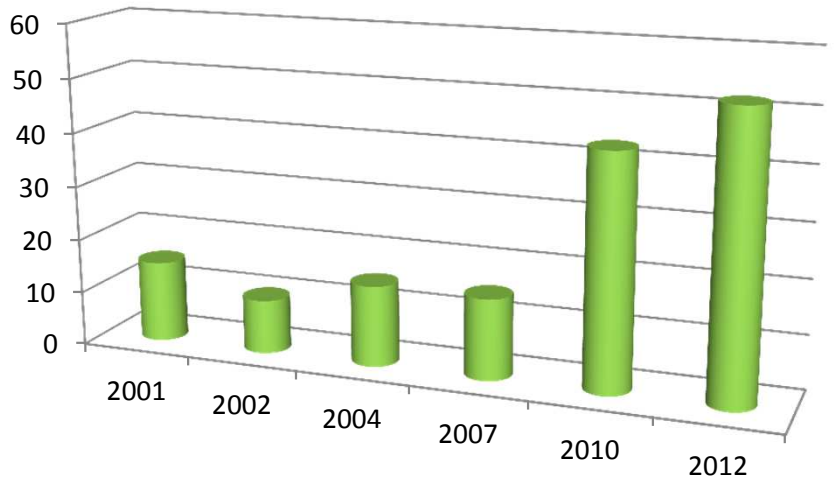




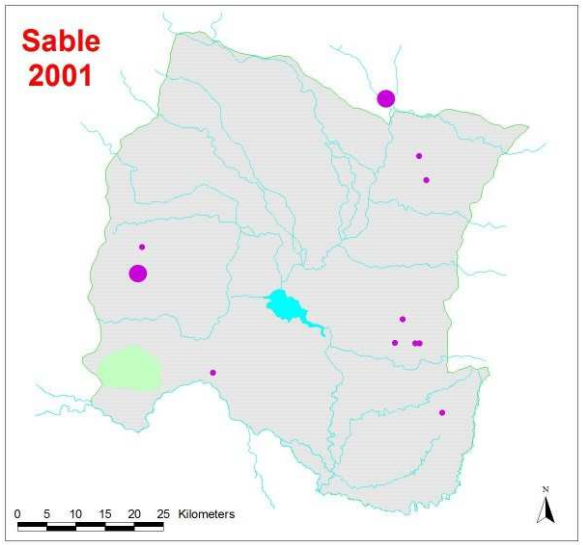


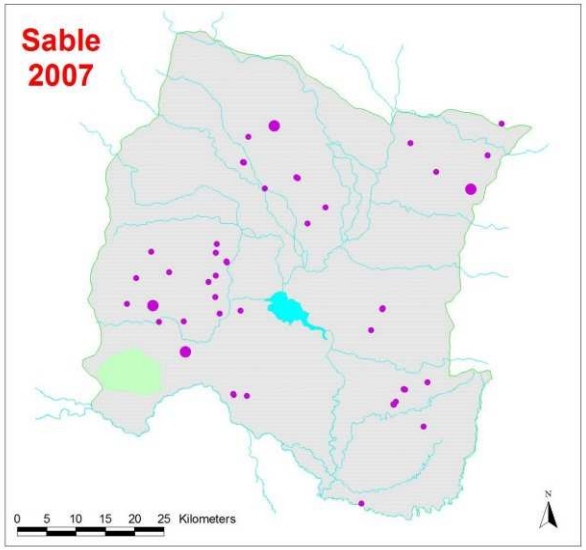


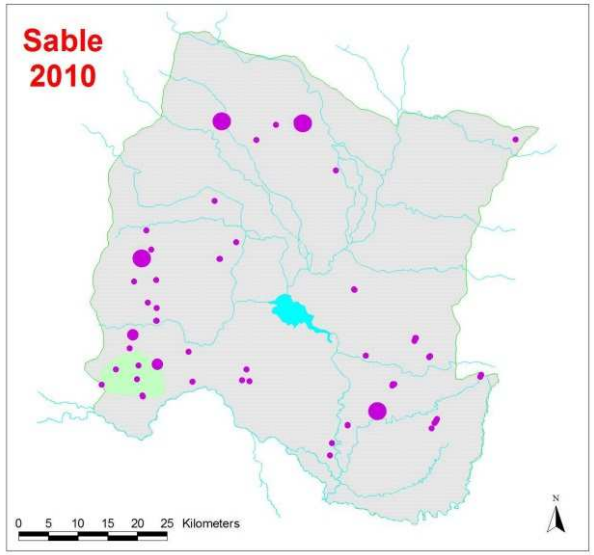
Max group size

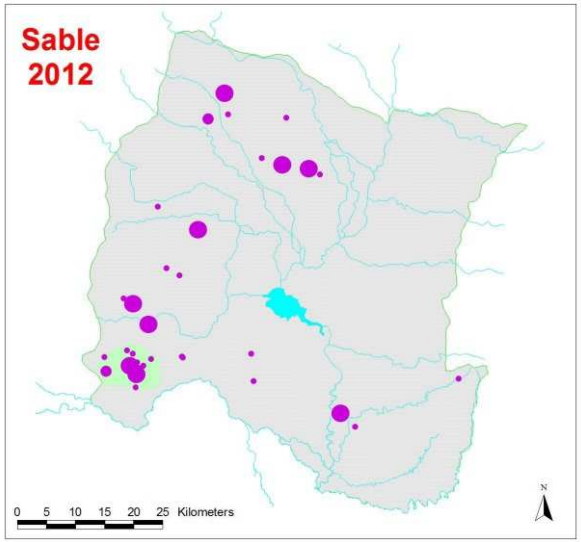


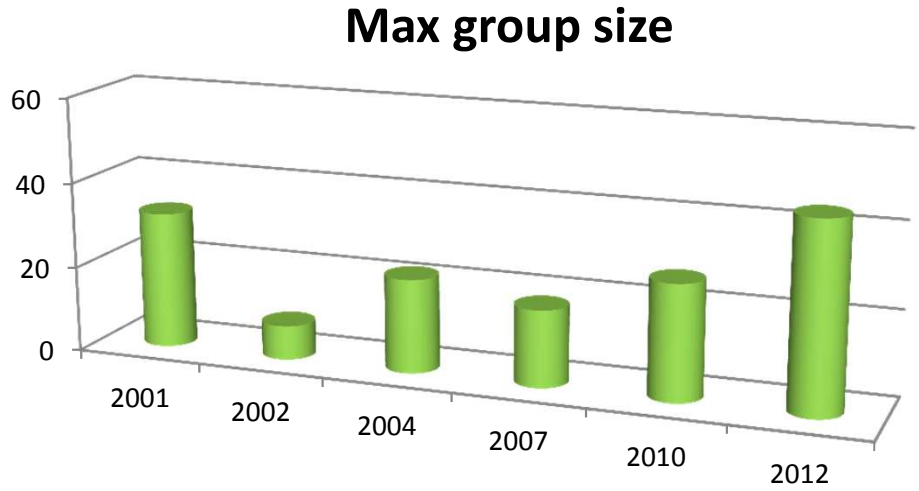
Visualisation of expanding occurrence across the Park and increasing herd size



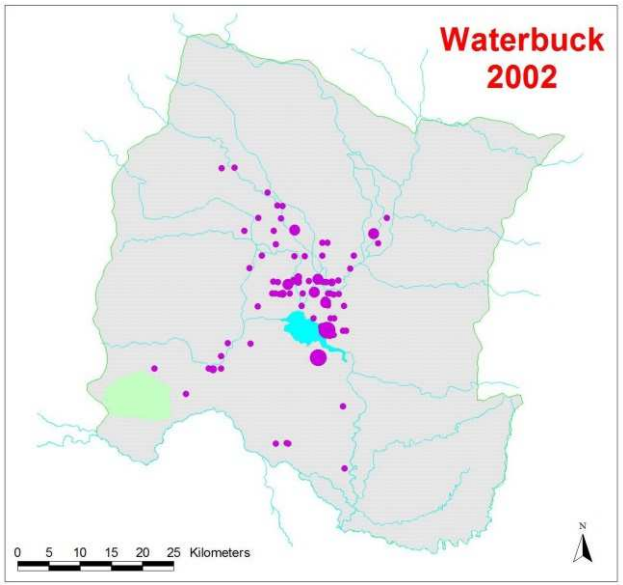


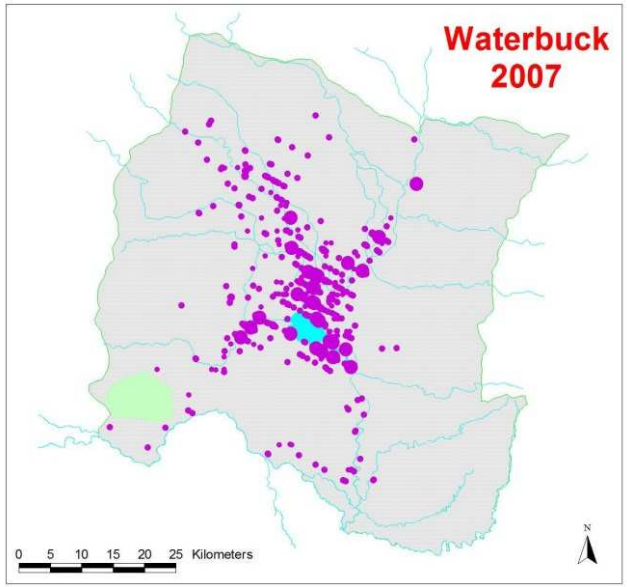


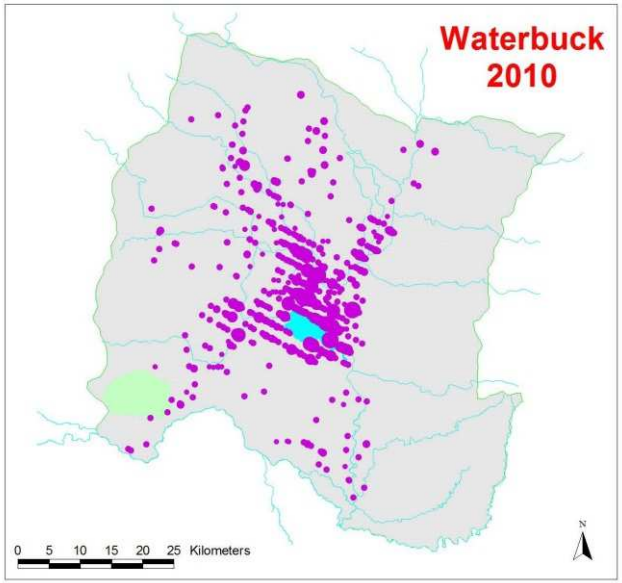


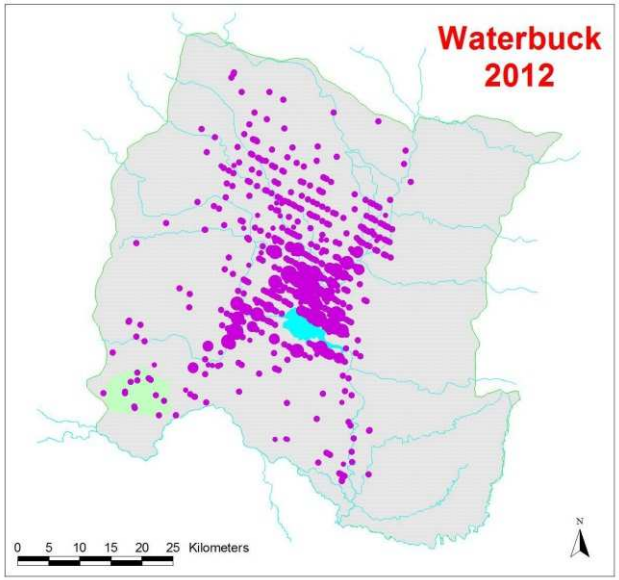


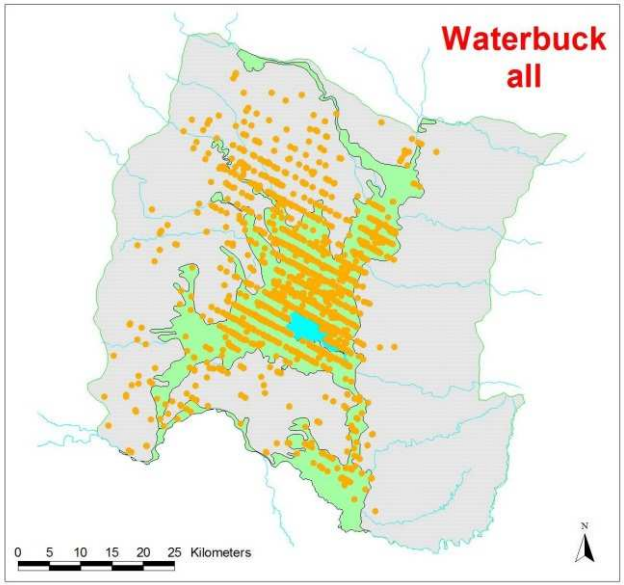
Visualisation of expanding occurrence across the Park





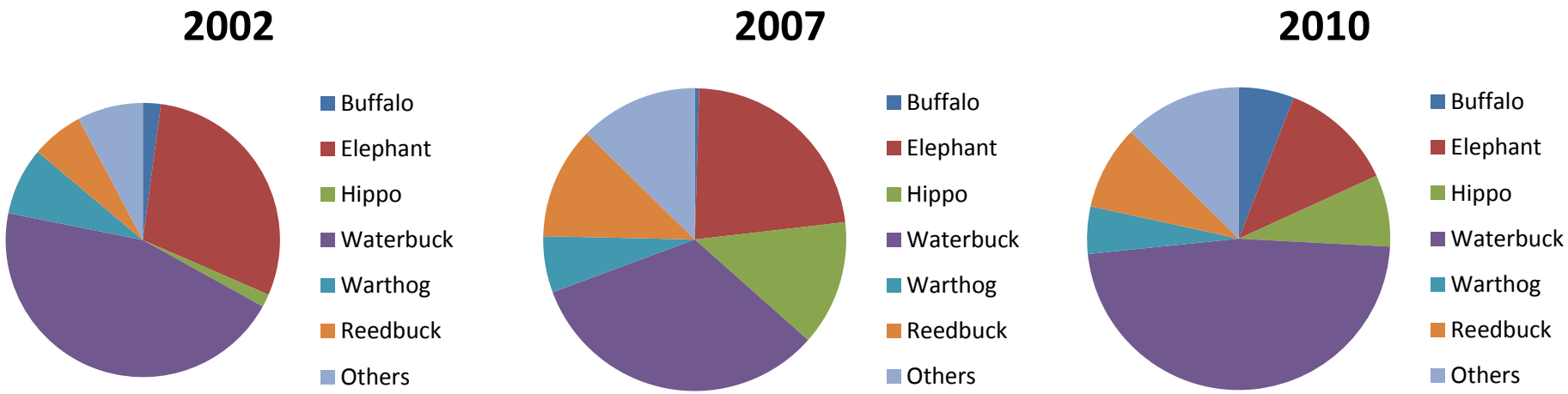






Strong association with the Rift Valley Riverine & Floodplain Landscape

Change in relative biomass of individual species



The above partly exposes the shortcomings of the sampling approach, with species that occur in a few large groups, such as elephant, being 'missed' in the areas between the sampling lines and influencing the proportions from year to year.

The most crucial observation is that the animal biomass is dominated by waterbuck.

Sanctuario

Fully fenced (2006-2007)

- Size 6 200 ha (62 km^2)
- Buffalo and blue wildebeest have been introduced since 2007
- A number of other species that occurred in the area were accidentally fenced in
- The Sanctuario enjoys a higher patrolling rate and protection effort than other parts of the Park.

Densities per km^2 in the Central stratum and in the Sanctuario (a similar point of departure has been assumed for both areas in 2007)

	2007 baseline	2010	2012
Number of **reedbuck** per km^2			
Central	4.0	5.1	3.3
Sanctuario	4.0		5.9
Number of **impala** per km^2			
Central	0.5	0.6	0.8
Sanctuario	0.5		1.8
Number of **warthog** per km^2			
Central	3.0	4.3	3.6
Sanctuario	3.0		7.8

Results for the first full aerial survey of the Sanctuario

Blue wildebeest	372
Buffalo	193
Sable	68
Common reedbuck	364
Impala	112
Waterbuck	38
Lichtenstein hartebeest	9
Kudu	140
Warthog	482
Oribi	116
Nyala	8
Bushbuck	58
Grey duiker	11
Red duiker	4

- Blue wildebeest are doing well. Using a simple population model on a spreadsheet, starting with the introductions and the releases as known, a healthy growth rate of 20% seems to have been experienced;
- Buffalo numbers are much lower than expectations from the staff. However, using a crude spreadsheet model, lower numbers are achieved than those expected by staff. The buffalo would seem to have grown at 10 to 12%. There is uncertainty as to the number of animals that have escaped following an accidental breaching of the fence by a falling tree.
- Although it is not known what animals were originally fenced in, the impression at that time was that wildlife densities were low and poaching levels high. It is therefore very gratifying to see such healthy numbers of many different species.
- Assuming a same 'baseline' density of animals per km^2, the densities in the Sanctuario have increased to higher levels than those in the Central Stratum as a whole (see table).
- **This all strongly suggests that the strategy of using a Sanctuario to boost animal numbers has been appropriate and that the management and protection efforts by the staff are being effective.**

Sanctuary – Blue wildebeest population model

WILDEBEEST

	2007	2008	2009	2010	2011	2012
Introductions	180					
Releases				52		
Total at end of year after increase	216	259	311	311	373	448

Annual growth rate used: 20%

Modelled population: 373 animals

Counted number: 372

This is the number expected at the end of 2011, going into 2012. the 2012 number is for 31 December 2012 after the births for the new season

Time and cost issues

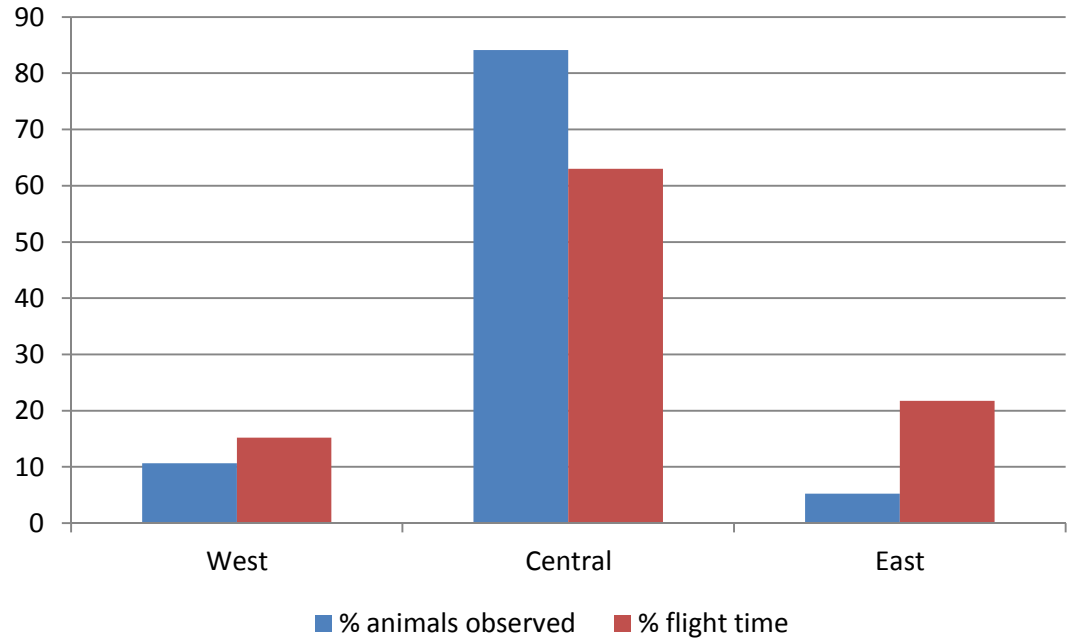
- Overall time expenditure at present is approximately 30 hours of helicopter flying per count (28 hours in 2012). The area that was is covered is 83 500 ha (835 km^2) (approximately 1 700 km of transect lines with a strip width of 500 m). The 'search rate' is therefore 2 700 to 2 900 ha per flying hour

- The Sanctuario count with its narrower search strips and specific assessment of buffalo and wildebeest took 4 hours for 6 200 ha (search rate of 1 500 ha per hour)

- Surveying of the Western and Eastern strata is not cost-effective (low animal numbers and proportionally over-expenditure in flying time)

Relative proportion of all animals counted in the different strata in the last 3 surveys (2007-2012) in relation to the distance flown for each stratum:

15% of all animals counted at the cost of 37% of the flying time



Discussion

- Generally, an upward trend is detected for all species

- In particular, the increased protection effort in the Sanctuario shows that animal populations can quickly grow in the highly fertile and productive floodplain habitats of Gorongosa

- The current sampling design, with its 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 to obtain any reliable population estimates *

- As a Monitoring & Evaluation tool, the current survey approach is not robust enough. It does not allow for the quantification of goal attainment of the restoration process

- Much of the current survey is spent on surveying areas of very low animal density. Although this serves a 'surveillance' purpose, it is not cost-effective, especially considering that re-allocating this flying time to the Central stratum will significantly increase the state of knowledge of this area.

* Some practical examples illustrate this problem:

  - Only 5 blue wildebeest were observed during the 2012 count in all the sample transects (excluding the Sanctuario). However, a herd of 32 blue wildebeest were observed close to Chitengo on one of the ferry flights.
  - A known herd of 31 buffalo in the Xivulo area was not observed (this constitutes 23% of the number seen in the transects). Only 2 groups were observed in the transects, including a herd of 131. The 25% coverage of the Central stratum means that there was only a one in 4 chance to effectively encounter this herd. Its eventual absence from the count could be interpreted as a major dip in buffalo numbers.

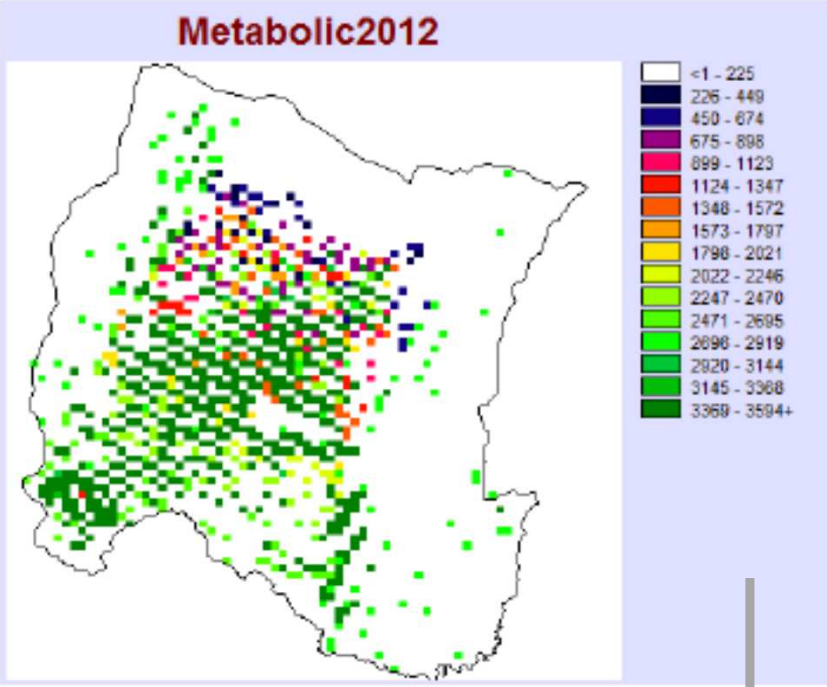
Recommendations going forward

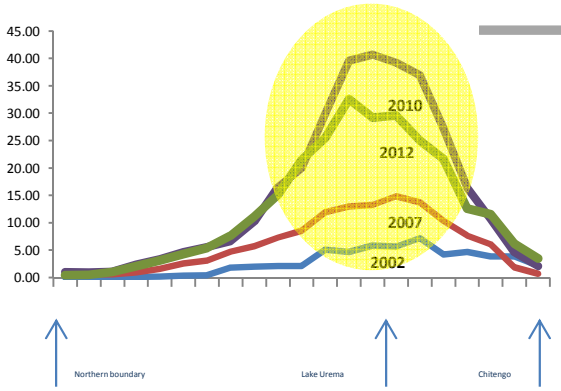
- Change in conceptual approach: from a sample count to a total count
- As it would be too expensive to cover the full Park, the survey area must be chosen to be most cost-effective
- This will also mean a decoupling of the surveillance role of the helicopter survey on the boundaries from the assessment of wildlife numbers
- The high increase rates of certain species means that large movements in numbers are possible between the surveys that have been spanning 2 to 3 years. Ideally, an annual survey should be undertaken. Alternatively surveys should be held at least every second year.
- With regard to timing it is recommended to conduct the survey at the height of the dry season (October-November) when the grass is lower, there are less leaves on the trees and the animals are more concentrated towards the Lake.*
- Re-analysing of the available data, probably using Jolly's method for unequal-sized sampling units in order to calculate population estimates with confidence intervals (will require expert input)

* The 2012 survey was purposefully conducted 'early' in the season in order to distinguish spatial distribution patterns of wildlife in relation to the extent of standing water in the landscape. However, it is clear from the lower numbers of smaller ungulates (oribi e.g.) or from species occurring in thick woodlands (nyala e.g.) that the ideal timing for a survey is towards the end of the dry season (October – November)

Defining a new survey area

Individual animals: metabolic mass (body mass^$^{0.75}$, Mentis and Duke 1976) was used to express the number of animals per unit area (stocking density). Stocking density was calculated per km^2

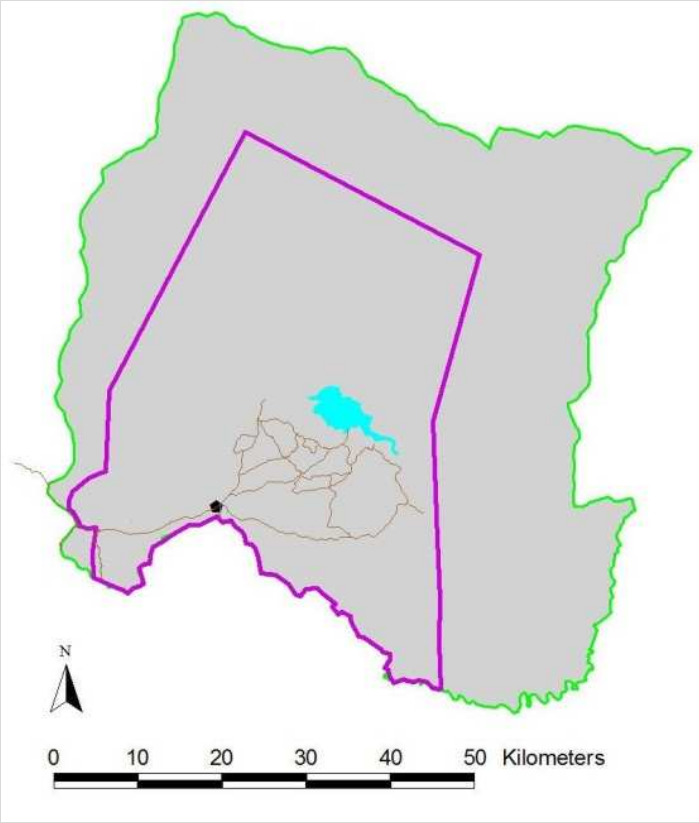




- Surveying current peak densities
- Assessing those areas with the highest intrinsic potential for wildlife
- Ignoring areas with very low densities and/or capacity

Recommended survey scenario

1 800 km^2 = 66 flying hours



Full coverage of this block

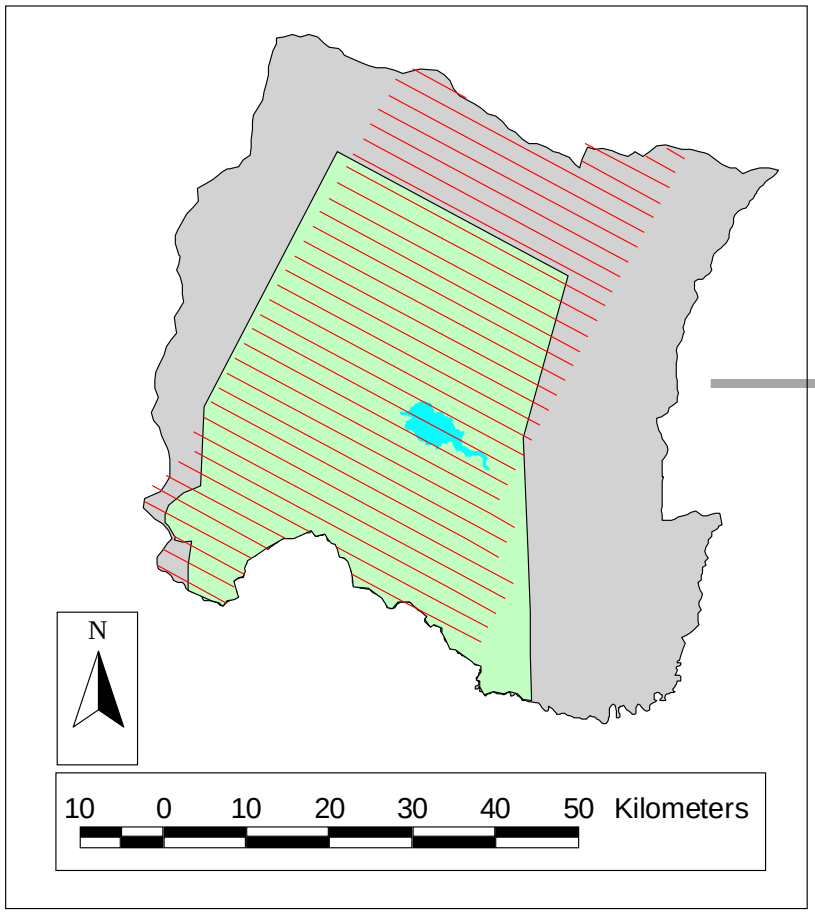
Lines spaced 500 m apart

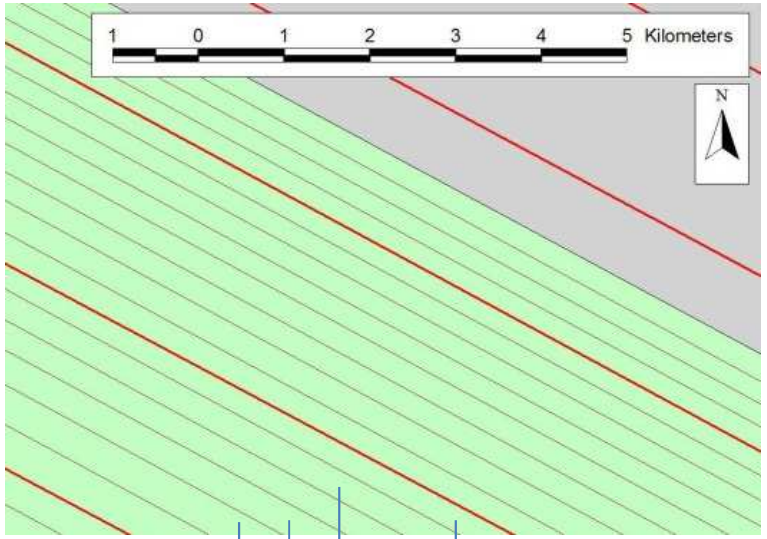
45% coverage of the whole Park

Correspondence ‘new’ and ‘old’ flight lines

Same orientation of current and newly proposed flight lines

The ‘new’ lines total 782.5 km in length. This is 75.3% of the current flight lines in the central stratum. This will therefore still allow a comparison of new data with the old sampling data, especially as the 25% not included consist of low density areas.





Current flight lines (spaced 2 km apart)

New flight lines
(spaced 500 m apart)

Concluding remarks

- Despite several shortcomings, aerial surveys, in particular helicopter counts, provide the most practical tool to determine wildlife numbers and trends in medium- to large-sized African grassland and woodland systems

- The proposed change from a ‘sample count’ approach to a ‘block count’ strategy should result in a much better determination of actual numbers and dynamics of wildlife in the core area of the Gorongosa National Park

- A higher investment in flying hours will be essential (from current 30 hours to 66 hours). Several survey scenario’s are possible, including:

    - Annual survey of larger area (66 hours of flying annually). This is the preferred scenario, even if only for 3 to 5 years, to set a baseline, after which one could revert to a biennial survey
    - Biennial surveys (every second year) of larger area (average of 33 hours annually).

- The new design will provide a better M&E tool to assess the effectiveness of the restoration of the Park.

Acknowledgements

- The survey teams from 2000 onwards. In particular, helicopter pilot Mike Pingo must be mentioned for his involvement since 2000 and his technical input on the software programme used for the surveys.

- Dr Rob Pringle, board member of the Gorongosa Restoration Projects, for comments on the first draft.

- Dr Mike Peel of the Agricultural Research Council for telephonic discussions on sampling strategy and comparison with the 2010 survey which he conducted.

- The junior and senior staff of the Parque Nacional da Gorongosa for logistical arrangements and support.

- The funders of the Park for continued financial support since 2000.

5 May 2012 – herd of 131 buffalo

END