Parque Nacional de Banhine, Moçambique

Wildlife survey

November 2012

Technical report commissioned by *ACTF - MITUR*

Projecto Áreas de Conservação Transfronteira e
Desenvolvimento do Turismo (ACTFDT)
Ministério do Turismo
REPÚBLICA DE MOÇAMBIQUE
Enquiries: Dr Bartolomeu Soto

Service provider

International Conservation Services
Agricultural Research Council – Animal Production Institute
Sunrise Aviation

Dr M Stalmans International Conservation Services PO Box 10180 GEORGE 6530 South Africa stalmans@ics-consulting.co.za	Dr M Peel Agricultural Research Council PO Box 7063 NELSPRUIT 1200 South Africa Mikep@arc.agric.za

Contract number: UC-ACTF/018/12 - Grant number: TF 056038MOZ

Contents	Page

EXECUTIVE SUMMARY

Background

A wildlife survey was undertaken during October-November 2012 of the Parque Nacional de Banhine as a follow-up to the surveys previously undertaken during 2004, 2007 and 2012. The same experienced team that undertook the 2004, 2007 and 2009 surveys was also responsible for the 2012 survey.

Methodology

Balancing the requirements for objectivity, repeatability and affordability, a partial survey (sample count) was applied using a helicopter. The survey design from previous years was slightly changed to take into account recent changes to the boundaries of Banhine. Two 4,000 ha new blocks were created, one on the far north-west and one of the far east of the Park. A total of 127,200 ha (or 1,272km^2) was covered by the survey blocks. This represents 15.8% of the 'new' Park. Part of the central survey block (22,000 ha out of 103,000 ha) now falls outside of the new park boundaries. However, the previous block was counted in its totality as this represent an open ecological system with the animals freely moving across the boundary. The survey covered 19% of the 'old' Park.

A Global Positioning System with pre-determined survey blocks and flight lines was used to accurately cover the important habitats and landscapes. The position of wildlife that was observed was captured and integrated into the Geographic Information System for Banhine. This allowed for the analysis of distribution patterns in relation to the different landscapes. Changes over time can also be evaluated using the GPS data collected since 2004.

During 2007, the replicability of the technique was tested. Two blocks were counted three times. The statistical analysis was limited to a few species only because of the very low number of sightings and low densities that tended to confuse the issue. Furthermore, the sample blocks are 'open' to the larger system and movement in and out of the blocks was possible. Nevertheless, the results indicate that CV factors of less than 0.2 (20%) can be attained with CV's as low as 4.5% for nyala and 15.4 for kudu. This would indicate that that the technique is robust at the block scale. If the animals are present, they are likely to be picked up by the observer team and counted correctly. However, the replicates do not inform one as to whether the overall sampling percentage was sufficient.

Coverage

The overall sampling intensity of 15% (new Park) to 19% (old Park) compares well with sample counts that were previously undertaken in the Kruger National Park 22% coverage. Within this overall coverage, the Wetland and Grassland landscapes are very well sampled (95 and 85% respectively) whereas less than 10% of the Sandveld and Mopane Landscapes were sampled.

Animal numbers

The same species of larger animals as in 2009 were observed. Viable populations of bushpig, common reedbuck, grey duiker, impala, kudu, nyala, oribi, ostrich, steenbuck and warthog exist (Table 1).

Ostrich in particular are thriving. A total of 519 ostriches were counted. Banhine holds the best population of this species in the GLTP and likely in the whole sub-region. Five bull elephants were observed as well as a healthy population of 57 buffalo. Other large species such as the zebra, wildebeest etc. that were still found in the Park in the early 1970's have since been exterminated and remain absent to date.

Table 1: Wildlife and livestock numbers observed during the 2012 survey of Banhine.

	Survey block								In ferry lines	Total
Species	**10**	**11**	**3**	**4**	**5**	**8**	**12**	**13**		
Buffalo									57	**57**
Bushpig	15				1				2	**18**
Common reedbuck	103	12				2				**117**
Duiker	370	7	62	43	29	38	29	39	87	**704**
Elephant	5									**5**
Impala	647								11	**658**
Kudu	217		16	42	75	1		10	70	**431**
Nyala				7					12	**19**
Oribi	381	12							6	**399**
Ostrich	506					1			12	**519**
Steenbuck	219	3	10	21	18	29	17	21	35	**373**
Warthog	23		3						7	**33**
Ground Hornbill	10	4		2			7	2	8	**33**
Kori bustard										**11**
Saddlebill Stork	6								2	**8**
Wattled crane										**2**
Baboon Troops					1		1		2	**4**
Vervet monkey trp							1			**1**
African wild cat	2									**2**
Bat-eared fox	5						1			**6**
Blackbacked jackal	19		2	1			1		1	**24**
Caracal						1				**1**
Gr grey mongoose	3									**3**
Porcupine		1				3			3	**7**
Cattle	268							92	216	**576**
Donkey	5								2	**7**
Goat	369							111	182	**662**

The total number of animals that were observed during 2012 is comparable with the results from 2009 (Table 2). The very dry conditions in this current year seem to have affected bushpig and common reedbuck negatively. Oribi numbers have remained static . If anything, kudu, impala and ostrich are benefiting from the dry conditions. These observations are in line with the characteristics of these different species.

Table 2: Comparison between 2004, 2007, 2009 and 2012 survey results for the Wetland and Grassland landscapes.

Species	Total number			
	2004	2007	2009 expanded coverage of Wetland / Grassland	2012 - approx. same coverage as 2009
Buffalo	1	0	16	0*
Bushpig	50	28	115	15
Common reedbuck	67	83	224	115
Duiker	75	171	491	377
Elephant	0	0	1	5
Impala	108	81	587	647
Kudu	35	32	140	217
Nyala	0	0	0	0
Oribi	39	192	402	393
Ostrich	71	130	357	506
Steenbuck	21	130	295	222
Warthog	0	8	32	23

*57 buffalo observed outside of the wetland/grassland block

An estimated 120,000 ha in the north-east of the Park make up the ‘core’ that holds the vast majority of the animals. These animals move inwards to and outwards from the Wetland landscape in response to its drying up or flooding. The varying mosaic of burnt, sprouting and unburned patches is obviously key in determining local grazing conditions but that mosaic is underpinned by the cycle of flooding and drying-out. It appears that there has been an increase in the area burned in comparison with that observed during previous counts (Peel *pers. obs*.).

With the changes in boundaries of the Park, an area of 22,000 ha has been excised from this ‘core’. However, this is an open system with the animals moving freely across the boundary. The excised area holds some of the most important wetland habitat and water sources for the wildlife. There is a clear threat to the wildlife population and the Park as a whole if this excised area becomes a ‘sink’ when animals venture into this are under a greater danger of being hunted.

Kudu and nyala are an exception to this. Their strongholds are the dry sandveld and mopane woodlands to the west and the south.

Other species

As in the previous surveys of 2004, 2007 and 2009, an interesting, diverse suite of small carnivores such as caracal, African wild cat and black-backed jackal were observed. It is of interest that Bat-eared foxes were observed for the very first time. This is a species that is very typical of arid areas and the current dry conditions would definitely benefit this species. As in the previous surveys, a number of porcupine that were active during the day were observed. Ground hornbills, Kori bustards, Wattled cranes and Saddle bill storks were also recorded. A diversity of vultures, varying from the dominant Lappet-Faced Vultures through White-Headed to the smaller Hooded Vulture were observed. Many raptors were observed notably in excess of 15 Short-Tailed Eagles (Bateleur), six Black-breasted Snake Eagles, two African Hawk Eagles and a host of other raptors.

Livestock

The number of cattle (576) and goats (662) that were recorded is similar to the numbers from 2009.

Restoring previously extant species in the Park

Although a number of species appear to be doing well and although some immigration from the Limpopo or Gonarezhou Park is likely (as seen in the increasing numbers of elephant and buffalo), the restoration of wildebeest, zebra and giraffe will require an active introduction.

Way forward with the aerial surveys

The recommendation made after the 2007 survey to expand the coverage to a larger portion of the grasslands was obviously the right one. All efforts should be made in future to cover the same area of 100,000 ha to 120,000 ha that represents the dynamic core of the Park. Therefore, the portion of the grasslands and wetland that falls outside of the new boundaries must still be surveyed. A bi-annual count would seem to be appropriate. As recommended in 2007, some form of ecological monitoring at ground level should be instituted in order to supplement the aerial survey (sex- and age structure, relative densities in different habitats and seasonal change thereof).

Fig. 1: Selected species observed during 2012 survey of Banhine
(top – Bat-eared Fox, middle – ostrich with chicks, bottom – elephant bulls).

1. Background

The Government of Mozambique has received a Credit from the IDA, a Grant from Global Environment Facility and PHRD Grant from the Government of Japan, towards the costs of the Trans-frontier Conservation Areas and Tourism Development Project, which will be implemented during the period 2006-2012.

Focusing on the targeted area, the Project intends to improve the management effectiveness of protected areas (PAs) within the Limpopo TFCA, through improvement of the management capacity of the relevant management bodies in the Limpopo National Park, the Banhine National Park (BNP) and the Zinave National Park (ZNP). These three protected areas represent, with the Kruger National Park in South Africa and the Gonarezhou National Park in Zimbabwe, one of the major trans-frontier conservation units (the Great Limpopo TFCA) in the whole continent, which offers a unique opportunity to achieve both valuable conservation goals and benefits to local populations.

It is generally accepted that the estimation (or absolute number if possible) of animals occurring within PAs represents critical information to improve their management and conservation. Counting large and medium size animals becomes very efficient using aerial survey techniques. In this context, the Government of Mozambique, throughout the Ministry of Tourism (MITUR), has commissioned a survey to obtain reliable information on the abundance of large and medium size animals in the Parque Nacional de Banhine in order to improve the conservation and management of their populations.

The objective of the study was therefore to conduct an assessment of the wildlife resource of Banhine for the purpose of comparing the current situation to the results obtained from the 2004, 2007 and 2009 surveys.

2. Methodology

2.1. General approach

The study had to take into account the technical criteria formulated by MITUR (see Appendix A) and had to repeat the methodology used in the 2004 (Stalmans 2004), 2007 (Stalmans 2007) and 2009 surveys (Stalmans & Peel 2009).

Furthermore, the survey had to fit the criteria of objectivity, repeatability and affordability. A pre-determined quantitative method is required in terms of objectivity. Given the large size of the Park (previously approximately 6,000 km^2) but now with redesigned boundaries and expanded to approximately 8,000 km^2, the lack of an extensive road network and the generally flat topography without vantage points, some form of aerial survey represented the only realistic approach. The criteria for repeatability require a spatially-explicit assessment whereby a follow-up survey can be undertaken on the same area(s). Given the relatively low densities of wildlife and the fact that some of the most important species are small-bodied (e.g. oribi) a helicopter was preferred to a fixed-wing aircraft. The high cost of flying required the adoption of a sampling approach rather than a full count.

A landscape map is available for Banhine (Stalmans 2003 and Stalmans & Wishart 2005). A total of 9 count blocks were originally defined in 2004 to cover the different landscapes and geographical parts of Banhine within the available budget for flying hours. The largest block covered the wetland area whilst the other 8 blocks were each 4,000 ha (40 km^2) in extent. The same survey blocks were used in 2007. Following the analysis of the 2007 data it was recommended that a larger area of the grasslands should be surveyed. This was applied in 2009.

Following the recent changes in the boundaries the Park, the previous block design was adapted (Fig. 2). The landscape make-up of the blocks is depicted in Fig. 3. The available landscape map does unfortunately not extend beyond the previous boundaries of the Park. From direct observations, the dominant habitats of the new survey blocks 12 and 13 consist of mopane and sandveld.

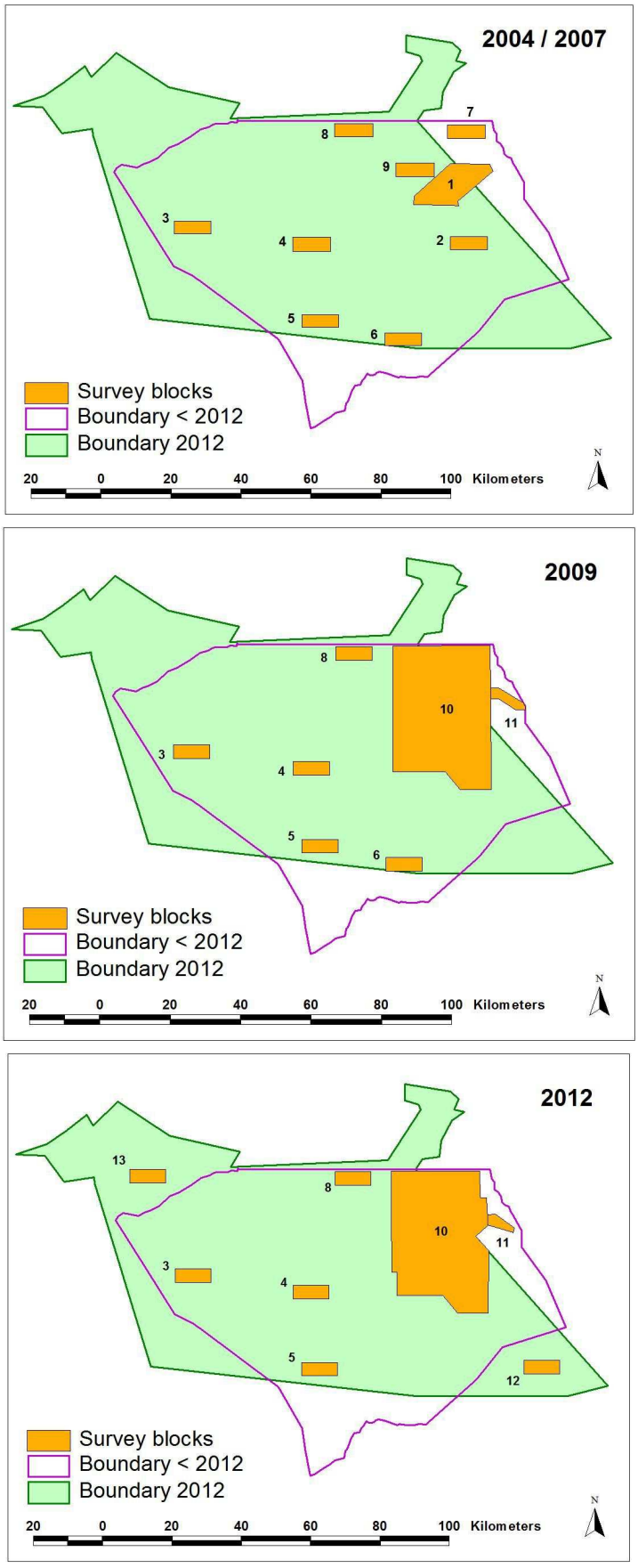


Fig. 2: Survey blocks used in 2004/2007 (top), 2009 (middle) and 2012 (bottom).

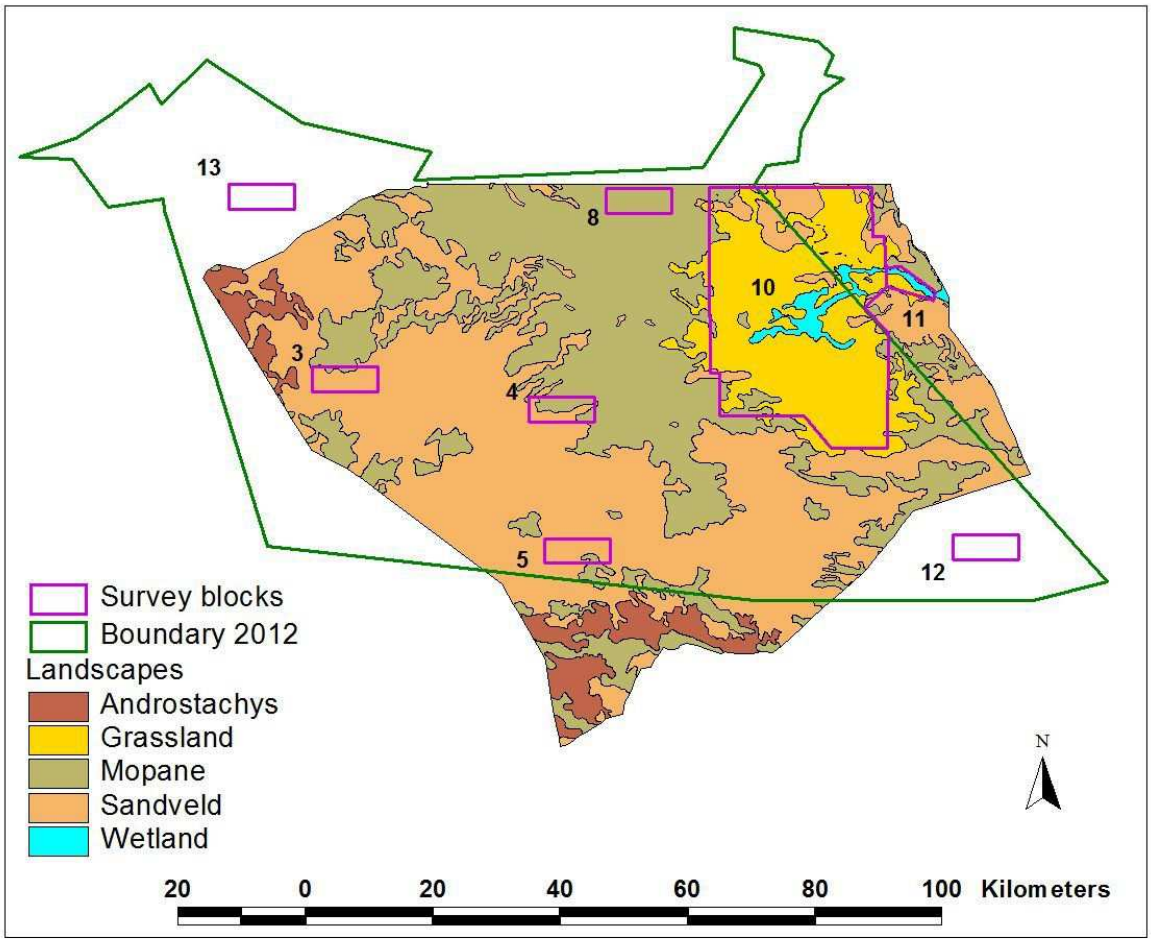


Fig. 3. Landscape make-up of the survey blocks for the sample count of the Parque Nacional de Banhine during 2012.

2.2. Survey technique

The specific equipment and technique are as follows (Fig. 4):

- 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, number, sex (where possible) and age (where young are easily determined) 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 on screen of the animals already spotted assists in preventing double counting or under counting;
- An east-west grid was flown;
- All observers wore yellow goggles that reduce shadows and enhance contrast for better visibility and detection of the animals (see Table 3 for weather conditions during the 2009 survey);
- Sessions lasting about two hours were flown. A short break was taken after 1 hour to relieve observer fatigue. Three sessions were generally flown in a single day. A total of 17 sessions were flown over 6 counting days.

The survey was flown by pilot Mr Mike Pingo (Sunrise Aviation) with navigator/observer Dr Mike Peel (Agricultural Research Council). The observers consisted of Mr John Peel, Mr Lukas Manaka, Mr Andre Jacobs and Snr Domingo Conjo (Warden of Banhine).

The survey was undertaken between 30 October and 4 November 2007. A total of 40 hours of helicopter flying were spent on the count.

The research camp near Pio Cabral was used as the logistics basis. Park staff assisted with re-fuelling.

Dr Marc Stalmans (International Conservation Services) was responsible for data anlysis and report writing. He was assisted by Dr Mike Peel.

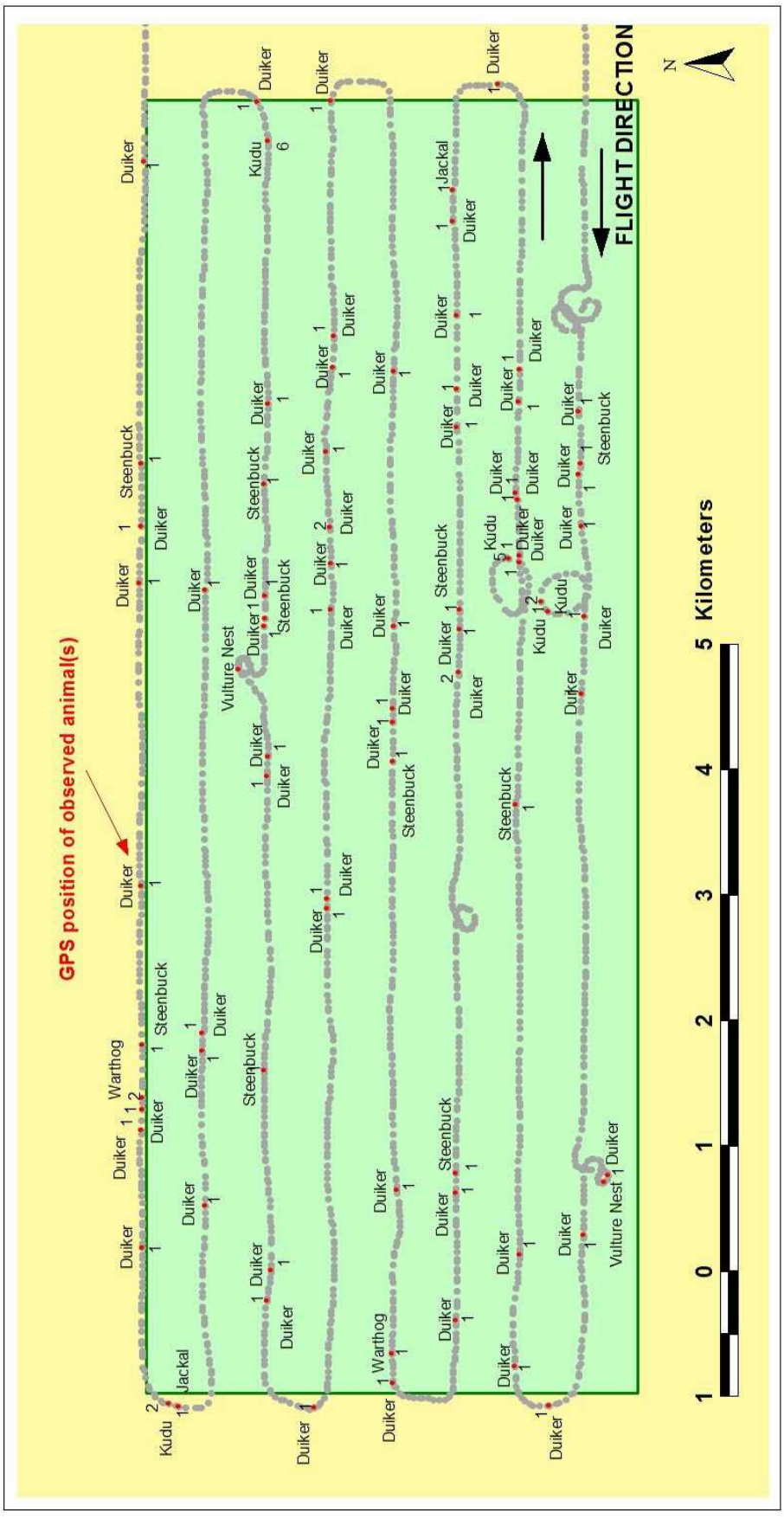


Fig. 4: Survey block with flight lines and GPS position and number of animals observed (illustrated for survey block 3 – flight 4 November 2012).

Table 3: Weather conditions during 2012 survey of Banhine.

Date	Block	Cloud cover (1 to 8 scale)	Session	Visibility	Temp. ºC
30/10	10	0 - 2	1	Excellent - Good	23 - 26
30/10	10	2	2	Good	29 - 31
30/10	10	0	3	Good	34 - 33
31/10*	10/11	8	5	Poor	20
31/10	10	8**	6	Moderate	22 - 26
31/10	10	2 - 6	7	Moderate	27 - 28
01/11	10	7 - 6	7	Moderate	19 - 23
01/11	10	6 - 5	8	Moderate	24 -26
01/11	10	5 - 3	9	Moderate	26 - 27
02/11	10	0	10	Excellent	17 - 20
02/11	ferry		11		
02/11	12	3	12	Good	24 - 25
03/11	5	0	13	Excellent	19 - 22
03/11	4	0	14	Excellent	24 - 25
04/11	13	0	15	Excellent	20 - 23
04/11	3	0	16	Excellent	30 - 33
04/11	8	0	17	Excellent	35 -34

*Session aborted due to bad weather; ** High cloud

2.3. Data analysis

The GPS positions of the flight lines and wildlife that was observed were integrated into the GIS information for Banhine. An ArcGis shapefile is thus available and the individual observations are also consolidated in an ACCESS database. This database and the GIS already held the results from the 2004, 2007 and 2009 counts. It is thus possible to analyse differences between the 4 surveys in general and for each individual block in particular.

No sophisticated statistical analysis was undertaken. This is mainly because many of the assumptions required for such analysis were violated. This relates in particular to the requirement for the wildlife to be uniformly and independently distributed throughout the survey region in relation to randomly placed sample lines (Buckland *et al*. 2001). This is definitely not the case for Banhine.

Furthermore, the efficiency of statistical analysis may be poor if wildlife density is highly variable due to the diversity of habitat types such as found in Banhine. In order to improve the efficiency of the technique it is necessary that areas with marked variation in densities should either be sampled with appropriate variation in technique or at least be subjected to data analysis that considers those variations. The areas must however remain large enough to provide the minimum number of observations that are required by the much-used program DISTANCE to conduct analysis. Some 60 to 80 observations per species are required. Low wildlife densities on Banhine precluded attaining this number of observations for most species.

Only duiker and steenbuck have a very high number of sightings. These are species for which there is relatively little concern to have very accurate numbers given their wide distribution and self-regulatory densities.

A conservative, common sense approach was taken to infer possible numbers and distribution patterns of wildlife throughout Banhine. The raw data however remain available for more sophisticated analysis and comparison with the results of surveys that may be undertaken in the future.

3. Results

3.1. Area covered

The survey design from previous years was slightly changed to take into account recent changes to the boundaries of Banhine. Two 4,000 ha new blocks were created, one on the far north-west and one of the far east of the Park. A total of 127,200 ha (or 1,272km^2) was covered by the survey blocks. This represents 15.8% of the 'new' Park. A 22,000 ha part of the central survey block falls outside the new park boundaries. However, the previous block was counted in its totality as this represent an open ecological system with the animals freely moving across the boundary. The survey covered 19% of the 'old' Park.

Table 4: Landscapes of the 7 count blocks for Banhine.

Count blocks	Dominant landscape	Other landscapes
10	Grassland	Wetland / Sandveld / Mopane
11	Wetland	Grassland / Mopane
3	Sandveld	Mopane
4	Mopane	Sandveld
5	Sandveld	Mopane
8	Mopane	
12	Sandveld	Mopane
13	Sandveld	Mopane

Note: Block 10 incorporates blocks 1, 2, 7 and 9 from 2004 and 2007.

Due to their importance in the functioning of this ecosystem, the wetland and grassland landscapes are proportionally more comprehensively covered than the mopane and sandveld landscapes. The Wetland and Grassland landscapes are sampled at 95 and 85% respectively whereas less than 10% of the Sandveld and Mopane Landscapes were sampled.

The year 2012 appears to have been a very dry one. There was hardly any standing water left in the landscape. These changes have important implications. The original landscape map (Stalmans 2003) was drawn up based on the 2002-2003 conditions. The 'wetland' landscape was still very obvious during the 2004 survey. However, in 2007, the 'wetland' landscape essentially changed to a 'grassland' landscape. During 2009, although conditions were slightly wetter, the same applied with the grassland

being more prominent. During 2012, the wetland landscape again appears mostly as a grassland landscape (Fig. 5). This means that the different surveys, although using mostly the same counting blocks, do not necessarily cover the same habitat. This may confuse and complicate comparisons between the different surveys.

3.2. Species observed

With regard to the large mammals, the same suite of species was observed during 2012 as in 2004, 2007 and 2009 (Table 5). Five elephant were observed as well as a healthy population of 57 buffalo. The latter were seen outside of the survey blocks.

As in in the previous surveys of 2004, 2007 and 2009, an interesting, diverse suite of small carnivores such as caracal, African wild cat and black-backed jackal were observed. It is of interest that Bat-eared foxes were observed for the very first time. This is a species that is of arid areas. The current dry conditions would definitely benefit this species. As in the previous surveys, a number of porcupine that were active during the day were observed.

Amongst the large bird species, Ground hornbills, Kori bustards, Wattled cranes and Saddle bill storks were also recorded. A diversity of vultures, varying from the dominant Lappet-Faced Vultures through White-Headed to the smaller Hooded Vulture were observed. Many raptors were observed notably in excess of 15 Short-Tailed Eagles (Bateleur), six Black-breasted Snake Eagles, two African Hawk Eagles and a host of other raptors.

English, Portugese and scientific names for the different wildlife species are given in Appendix B.

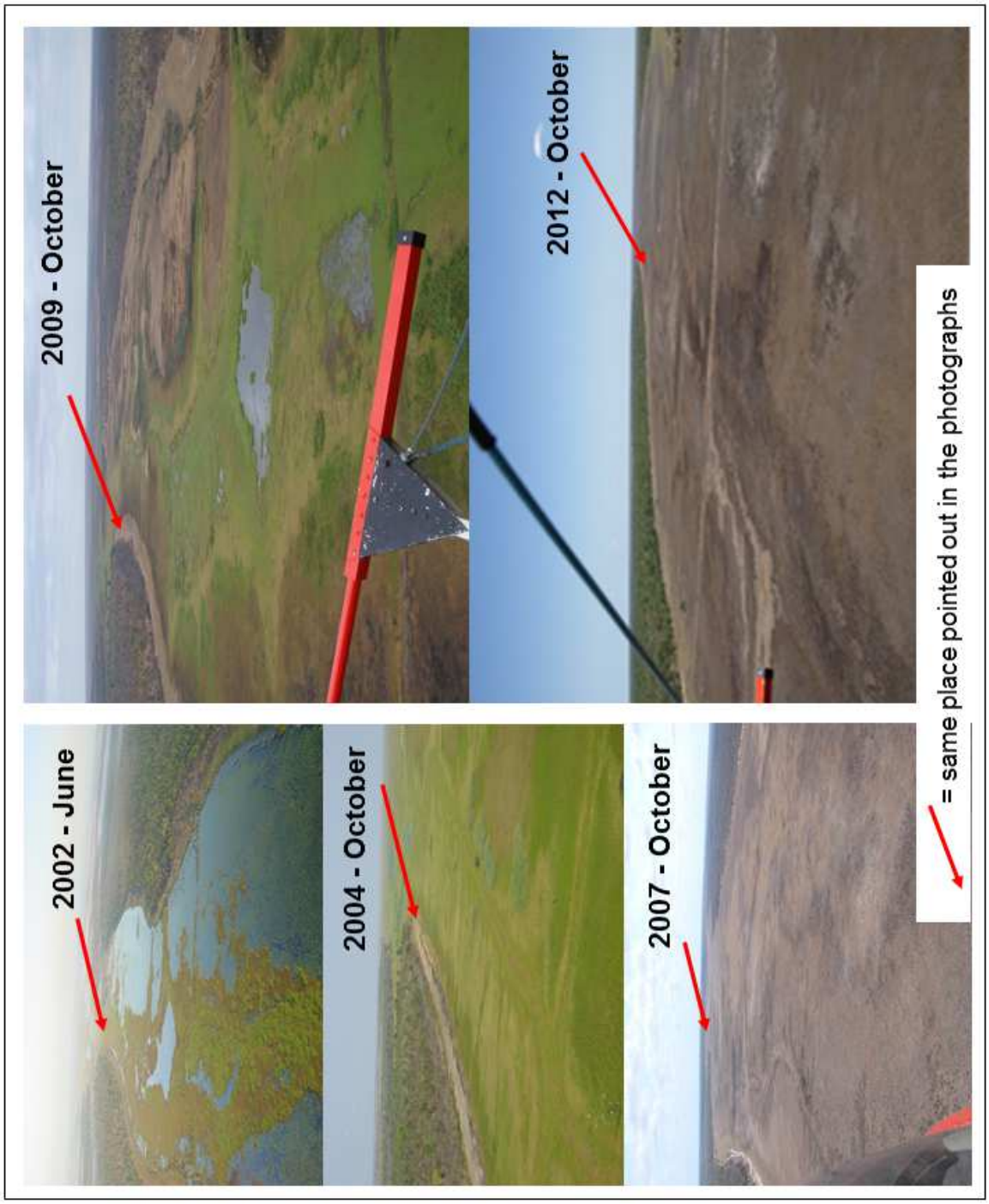
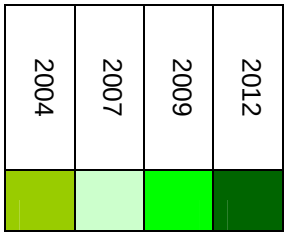


Fig. 5: Change in appearance of the ‘wetland’ habitat from 2002 to 2012.

Table 5: Animal species encountered during the 2004, 2007, 2009 and 2012 surveys.



	Survey blocks																													
	10				3				4				5				8				11				12				13			
Species	**including 1,2,7,9**				**3**	**3**	**3**	**3**	**4**	**4**	**4**	**4**	**5**	**5**	**5**	**5**	**8**	**8**	**8**	**8**	**11**	**11**	**11**	**11**	**12**	**12**	**12**	**12**	**13**	**13**	**13**	**13**
Buffalo																														
Bushpig																														
Common reedbuck																														
Duiker																														
Elephant																														
Impala																														
Kudu																														
Nyala																														
Oribi																														
Ostrich																														
Steenbuck																														
Warthog																														
Baboon troop																														
Vervet monkey troop																														
Ground Hornbill																														
Kori bustard																														
Saddlebill stork																														
Secretary bird																														
Wattled crane																														
African wild cat																														
Bateared fox																														
Blackbacked jackal																														
Caracal																														
Civet																														
Honey badger																														
Large grey mongoose																														
Large-spotted genet																														
Porcupine																														
Serval																														
Spotted hyena																														
Cattle																														
Donkey																														
Goat																														

3.3. Numbers observed

A total of 3,328 ostriches and large mammals were recorded in the blocks and ferry lines (Table 6). This represents the absolute minimum number of wild animals that must be present in Banhine. The actual number is higher as only a proportion of the Park was surveyed.

Table 6: Wildlife and livestock numbers observed during the 2012 aerial survey of Banhine.

	Survey block								In ferry lines	
Species	**10**	**11**	**3**	**4**	**5**	**8**	**12**	**13**		**Total**
Buffalo									57	**57**
Bushpig	15				1				2	**18**
Common reedbuck	103	12				2				**117**
Duiker	370	7	62	43	29	38	29	39	87	**704**
Elephant	5									**5**
Impala	647								11	**658**
Kudu	217		16	42	75	1		10	70	**431**
Nyala				7					12	**19**
Oribi	381	12							6	**399**
Ostrich	506					1			12	**519**
Steenbuck	219	3	10	21	18	29	17	21	35	**373**
Warthog	23		3						7	**33**
Ground Hornbill	10	4		2			7	2	8	**33**
Kori bustard										**11**
Saddlebill Stork	6								2	**8**
Wattled crane										**2**
Baboon Troops					1		1		2	**4**
Vervet monkey trp							1			**1**
African wild cat	2									**2**
Bat-eared fox	5						1			**6**
Blackbacked jackal	19		2	1			1		1	**24**
Caracal						1				**1**
Civet										
Gr grey mongoose	3									**3**
Porcupine		1				3			3	**7**
Cattle	268							92	216	**576**
Donkey	5								2	**7**
Goat	369							111	182	**662**

3.4. Population structure

While aerial helicopter surveys are very good at determining total numbers they are not the ideal platform for determining population structure (sex and age) which is better done using ground based methods.

Only a few species were thus sexed during the 2012 aerial survey (Table 7). The ratios all indicate healthy and productive populations.

It is of interest to note that these ratio's are similar to those recorded in 2007 (female proportion for kudu 77%, nyala 64.9% and impala 79.3%). This confirms that these populations seem stable and skewed towards being productive. It also indicates that the survey method that is being used yields consistent results.

Table 7: Sex ratio of selected species as recorded during the 2012 survey of Banhine.

Species	Female	Male	F/M ratio
Kudu	77.6%	22.4%	3.5
Nyala	61.1%	38.9%	1.6
Impala	72.6%	27.4%	2.6
Ostrich	64.7%	35.3%	1.8

Note: 'females' may include young animals which are not easily differentiated

The upward trend in species such as impala and kudu is also illustrated by the steadily growing size of the herds (Fig. 6 and 7).

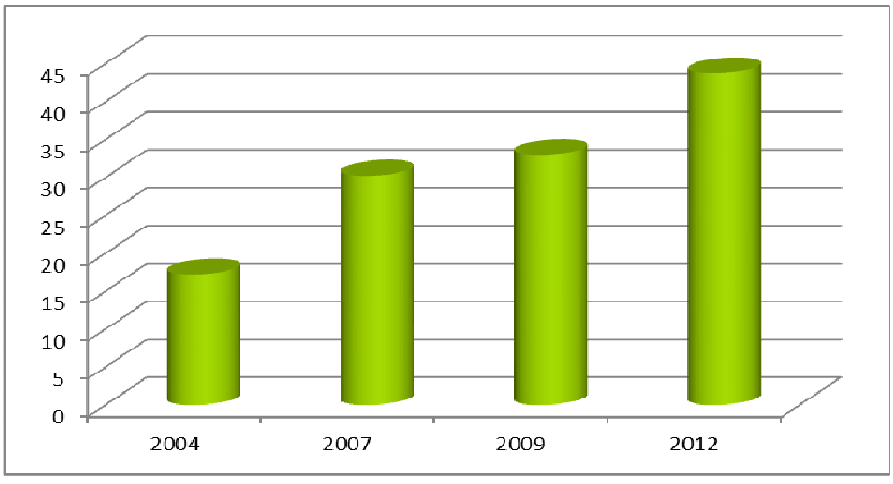


Fig. 6: Average size of the 4 largest herds of impala observed during the 4 surveys since 2004.

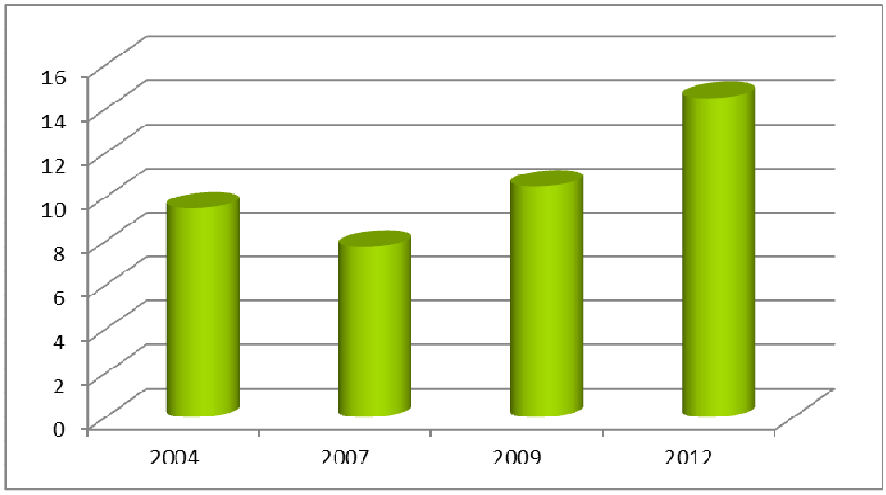


Fig. 7: Average size of the 4 largest herds of kudu observed during the 4 surveys since 2004.

4. Discussion of numbers and distribution

4.1. Landscape and area preferences

Wildlife species are unevenly distributed across Banhine (Fig. 8 to Fig. 15). The general pattern that has emerged from the four surveys since 2004 is that most species occur preferentially and often exclusively in the north-eastern Wetland and Grassland Landscapes.

This applies in particular to oribi, common reedbuck and impala. The reedbuck are concentrated in and around the edges of the Wetland Landscape (Fig. 13). The marked drop in reedbuck numbers is also reflected in their smaller group size. A maximum group size of only 4 was recorded whereas in 2009 groups of 7 to 9 animals were observed.

Even within the grassland block, the large population of impala occurs in a ‘clumped’ manner mostly close to the remaining natural water (Fig. 10). The highest densities of ostriches are found on the grassland but they are also widespread at low densities in the woodlands to the south and west. The largest group of ostriches that was observed numbered 79.

Steenbuck and duiker are found throughout the Park but largely in the Sandveld landscape. Warthog occur at low densities in the different landscapes

The highest densities of kudus are found in the Sandveld landscape, particularly in the south (Block 5). As in 2004, 2007 and 2009, nyala were observed in Block 4.

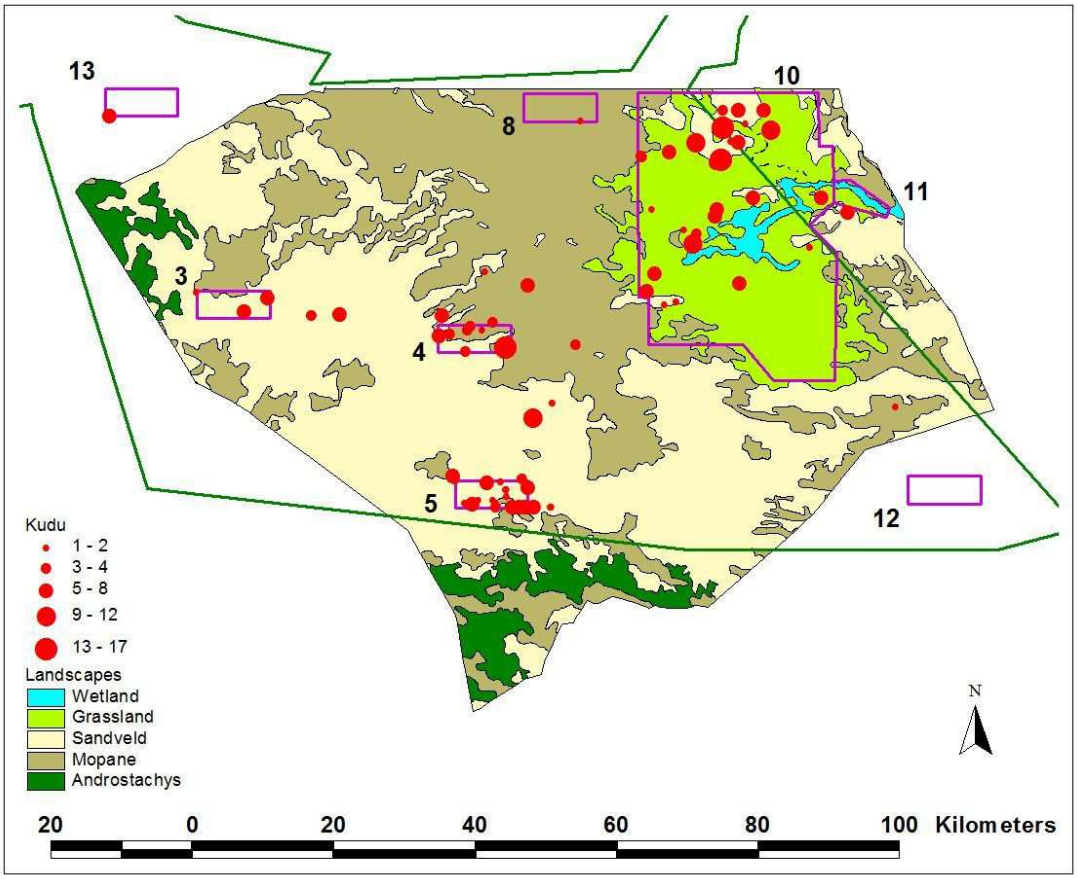


Fig. 8: Kudu – Banhine 2012 aerial survey.

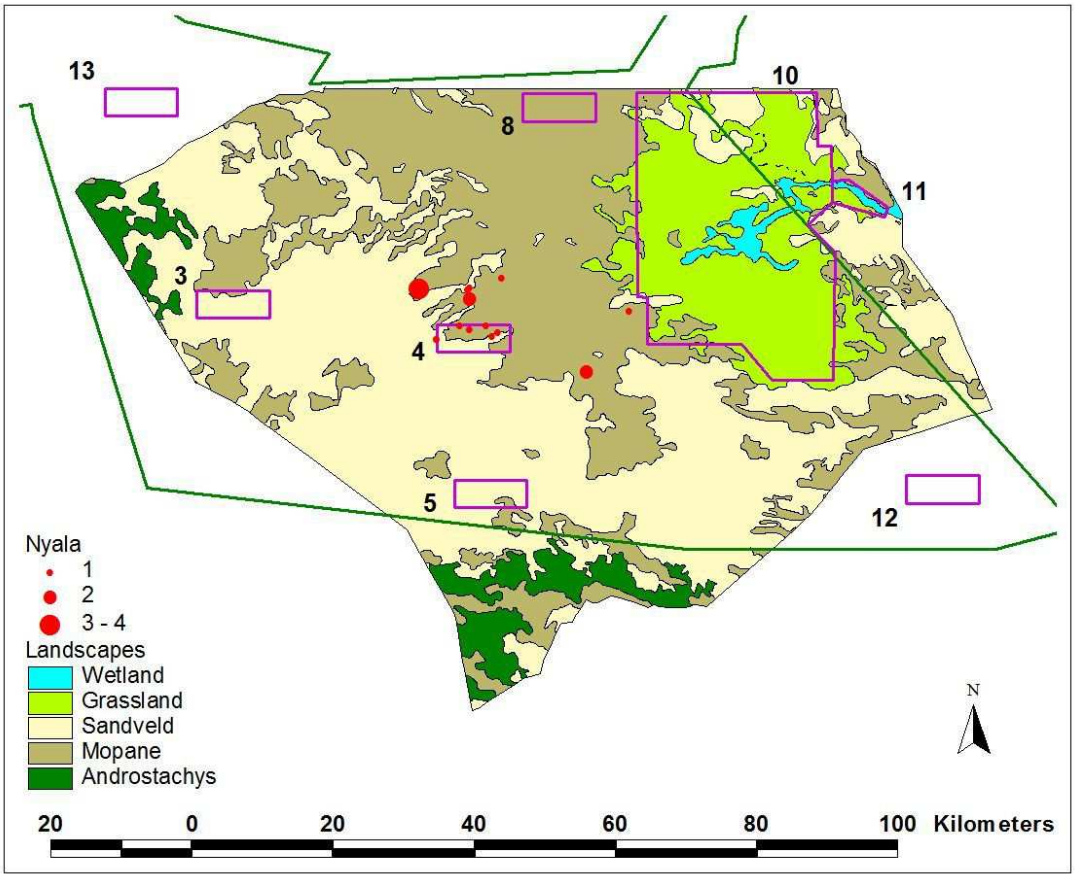


Fig. 9: Nyala – Banhine 2012 aerial survey.

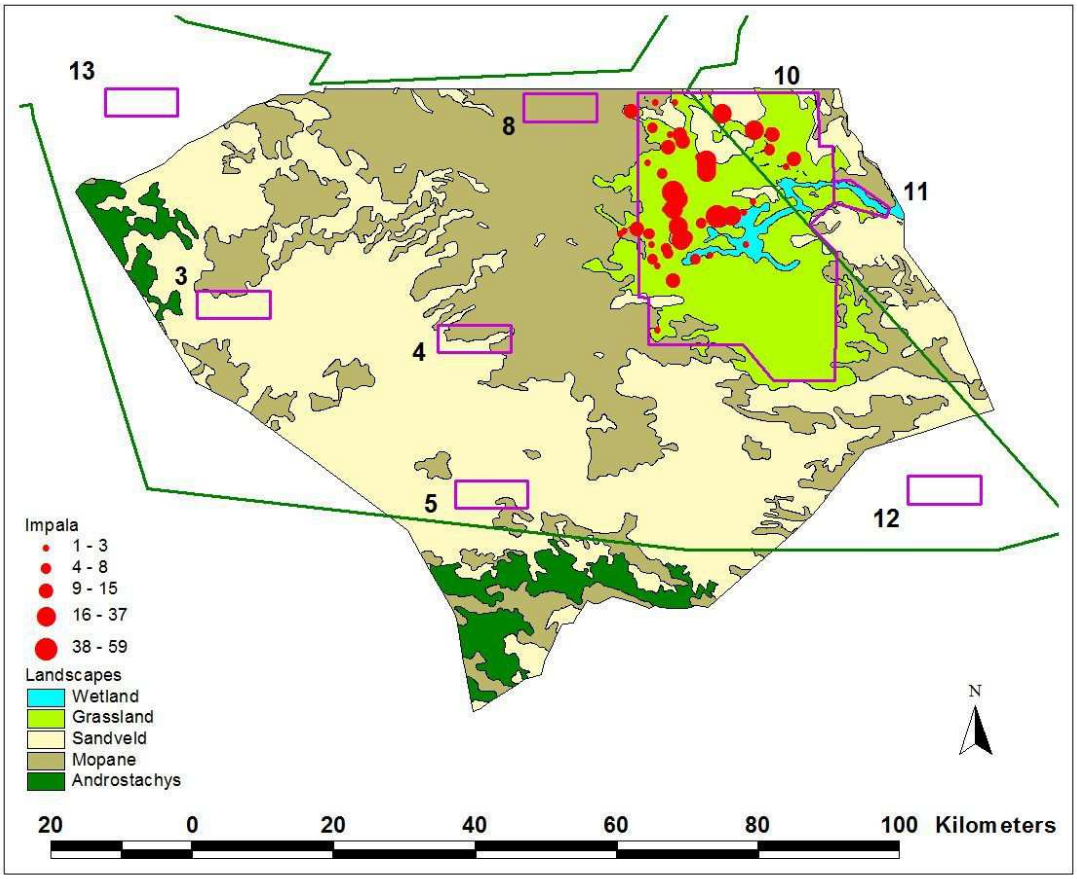


Fig. 10: Impala – Banhine 2012 aerial survey.

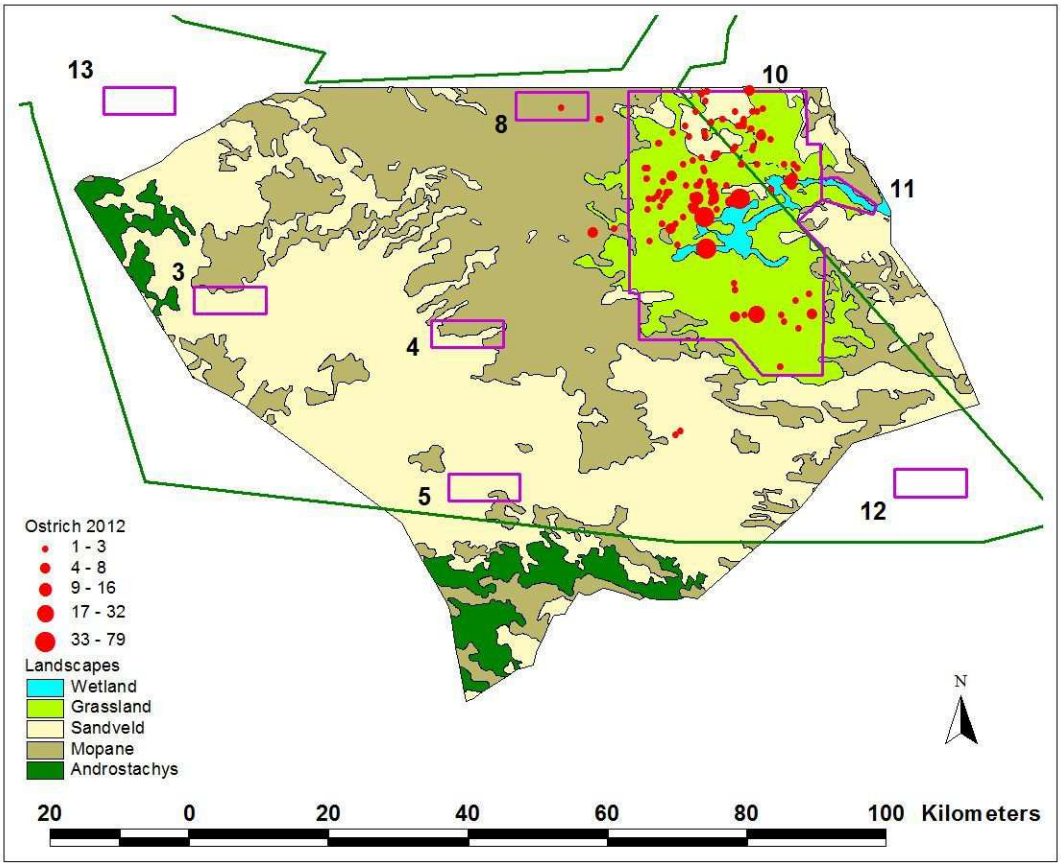


Fig. 11: Ostrich – Banhine 2012 aerial survey.

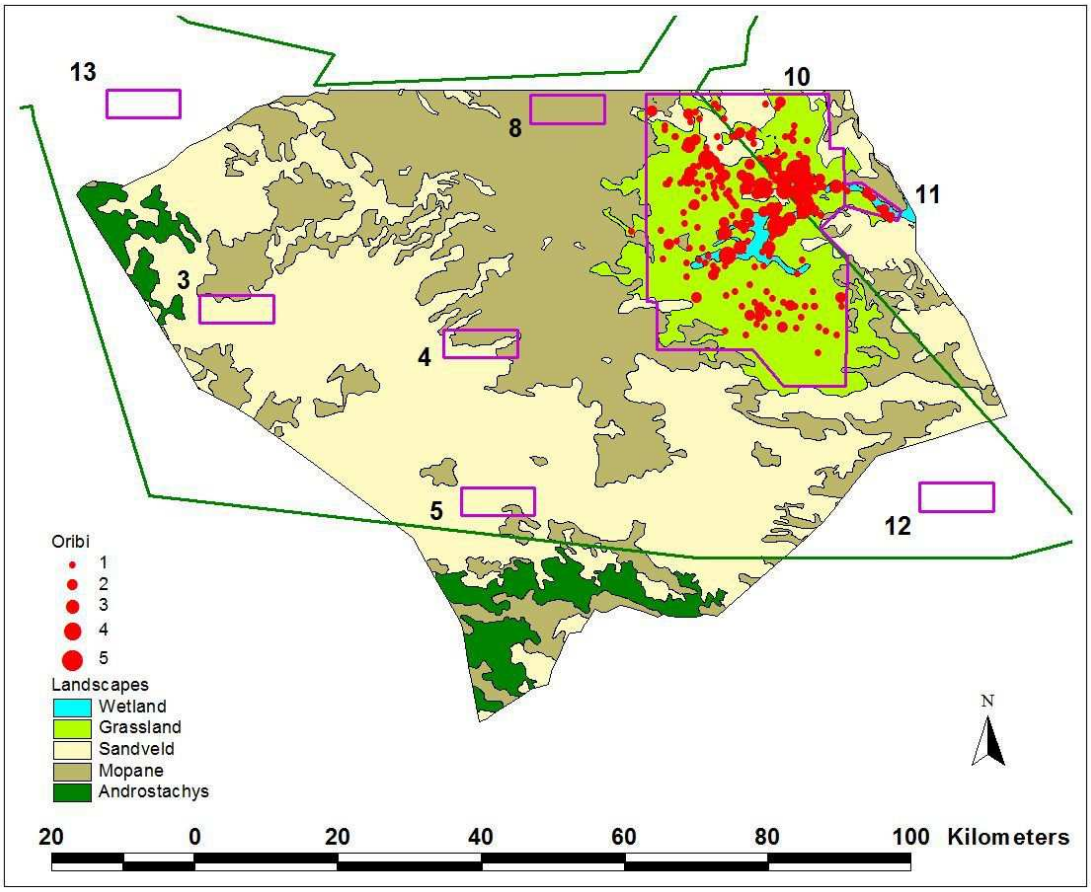


Fig. 12: Oribi – Banhine 2012 aerial survey.

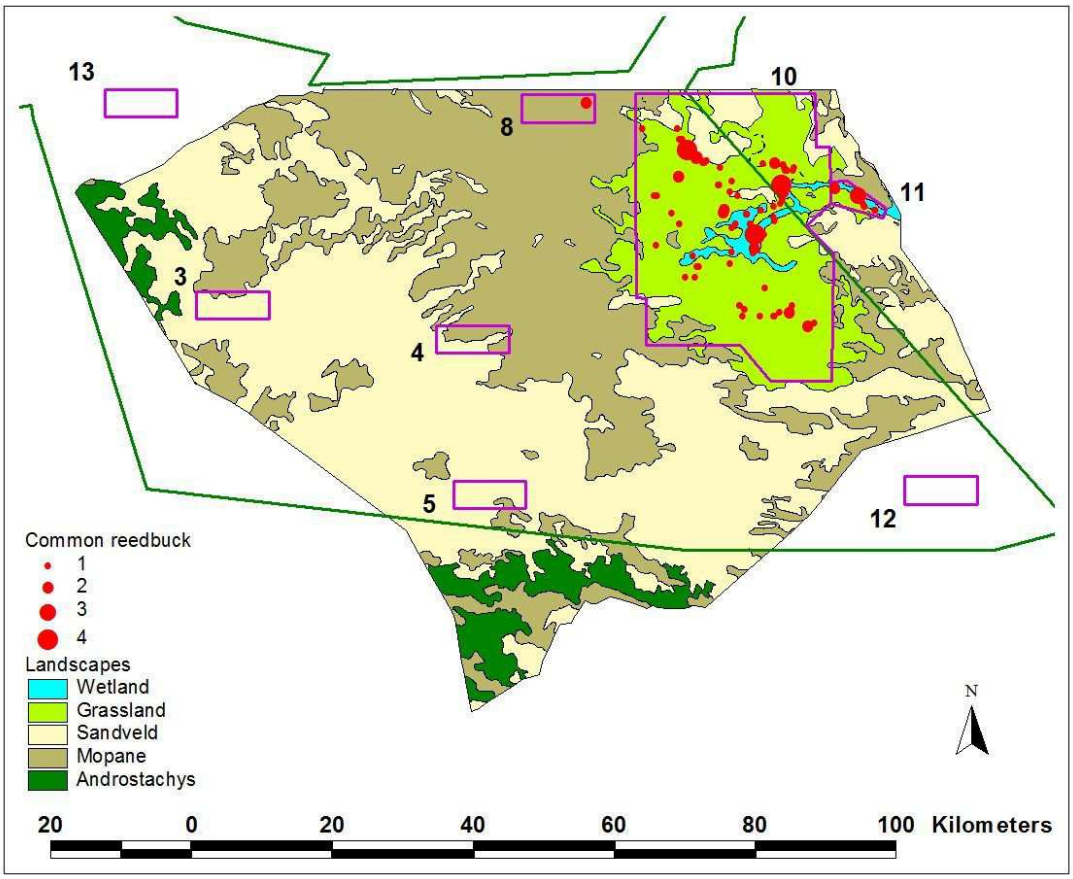


Fig. 13: Common reedbuck – Banhine 2012 aerial survey

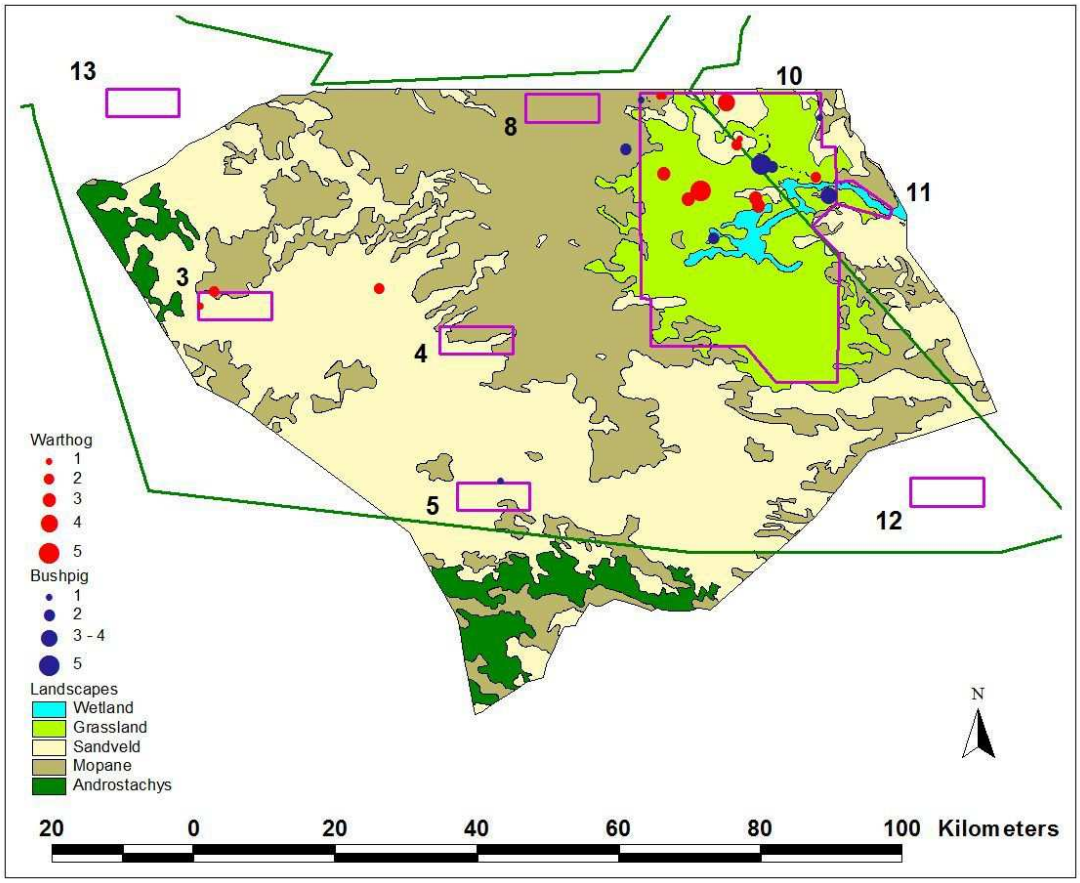


Fig. 14: Bushpig and Warthog – Banhine 2012 aerial survey.

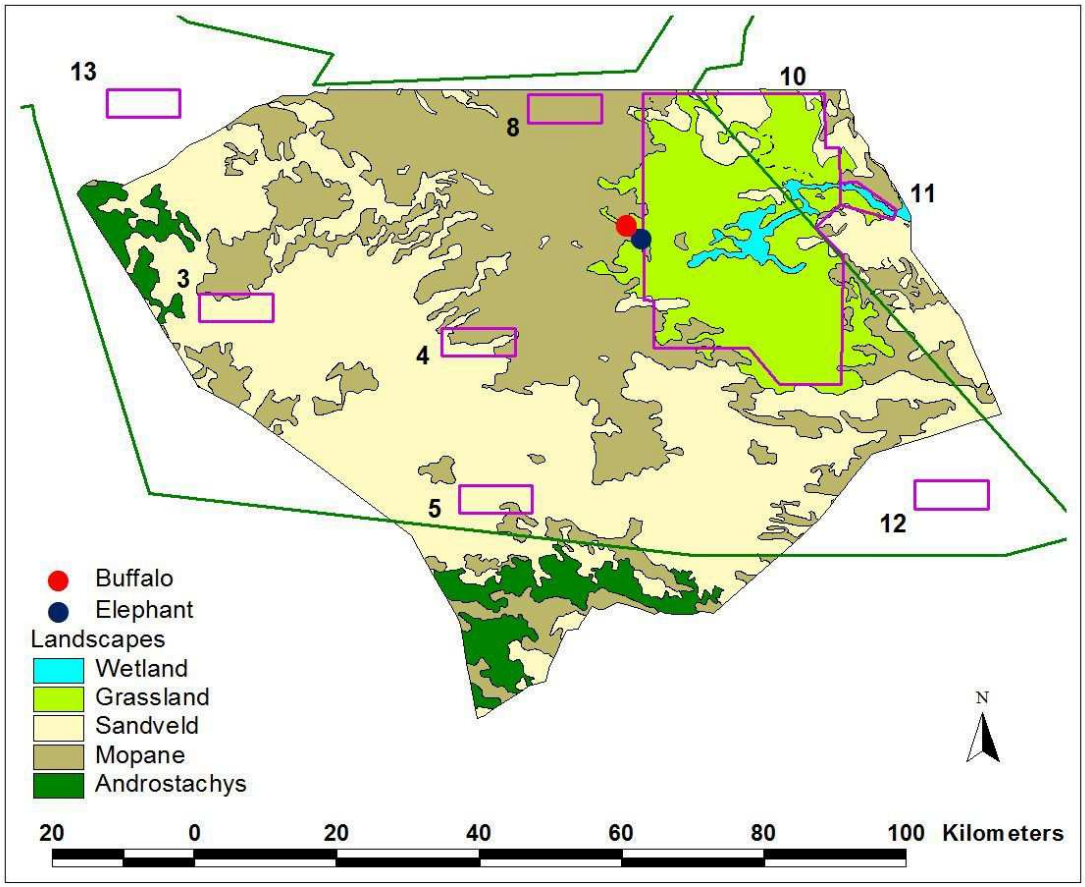


Fig. 15: Elephant and Buffalo – Banhine 2012 aerial survey.

4.2. Comparison between the different aerial counts since 2004

Any comparison between the 2004, 2007, 2009 and 2012 counts must take into account the change in sampling design. Whereas only 7.8% of the Park was surveyed in 2004, this percentage has now increased to 15%.

Even though the sampling percentage for the Wetland and Grassland is very high (95 and 85% respectively), the survey blocks are open and animals can easily move in and out.

Conditions in the Park vary considerably from year to year (see Fig. 5 for a visual appraisal). The Park was wet in 2004 (with large expanses of water), very dry in 2007 (with very little surface water and good grazing limited to the formerly inundated areas) and somewhere in-between in 2009 with limited but widespread surface water and relatively abundant grazing (except where large fires were experienced). This year, 2012, is extremely dry.

The greatest diversity and greatest densities of wildlife is consistently found in the Grassland and Wetland landscapes (Table 9).

Table 9: Survey results for 2012 in relation to the areas covered during 2004, 2007 and 2009 in the Wetland and Grassland landscapes.

Species	Total number			
	2004	2007	2009 expanded coverage of Wetland / Grassland	2012 with approx. same coverage as 2009 overall but same for Wetland / Grassland
Buffalo	1	0	16	0
Bushpig	50	28	115	15
Common reedbuck	67	83	224	115
Duiker	75	171	491	377
Elephant	0	0	1	5
Impala	108	81	587	647
Kudu	35	32	140	217
Nyala	0	0	0	0
Oribi	39	192	402	393
Ostrich	71	130	357	506
Steenbuck	21	130	295	222
Warthog	0	8	32	23

An estimated 120,000 ha in the north-east of the Park therefore make up the 'core' that holds the vast majority of the animals. These animals move inwards to and outwards from the Wetland landscape in response to its drying up or flooding. The varying mosaic of burnt, sprouting and unburned patches is obviously key in determining local grazing conditions but that mosaic is underpinned by the cycle of flooding and drying-out. This spatial movement occurs at two different temporal scales. On a longer scale of several years to a decade, the cycle is one of response to the flooding of the wetland due to cyclonic action and water entering from outside of the Banhine system followed by its gradual drying out (period 2000 to 2007). On an annual time scale there is localised movement in response to summer rainfall followed by drying out during the winter.

If this conceptual model holds, then it means that the 2009 and 2012 surveys probably 'captured' the vast majority of the numbers of species such as oribi and common reedbuck. Although ostrich and impala occur at low densities in the woodlands, the majority of their numbers has also been recorded in the current exercise.

Kudu and nyala prove to be an exception to this 'rule'. Their strongholds are the dry sandveld and mopane woodlands to the west and the south. It would appear that their numbers and movement patterns are largely independent of the dynamics of the 'core' area. All indications are that the kudu numbers are increasing at a satisfactory rate.

4.3. Livestock numbers

The number of cattle (576) and goats (662) that were recorded is similar to the numbers from 2009 when a total of 694 cattle and 544 goats were recorded. They were mostly found close to the water wells close to settlements and water wells (Fig. 16).

It would appear that the land that was recently added to the Park in the north-west has many people and livestock (see Fig. 16).

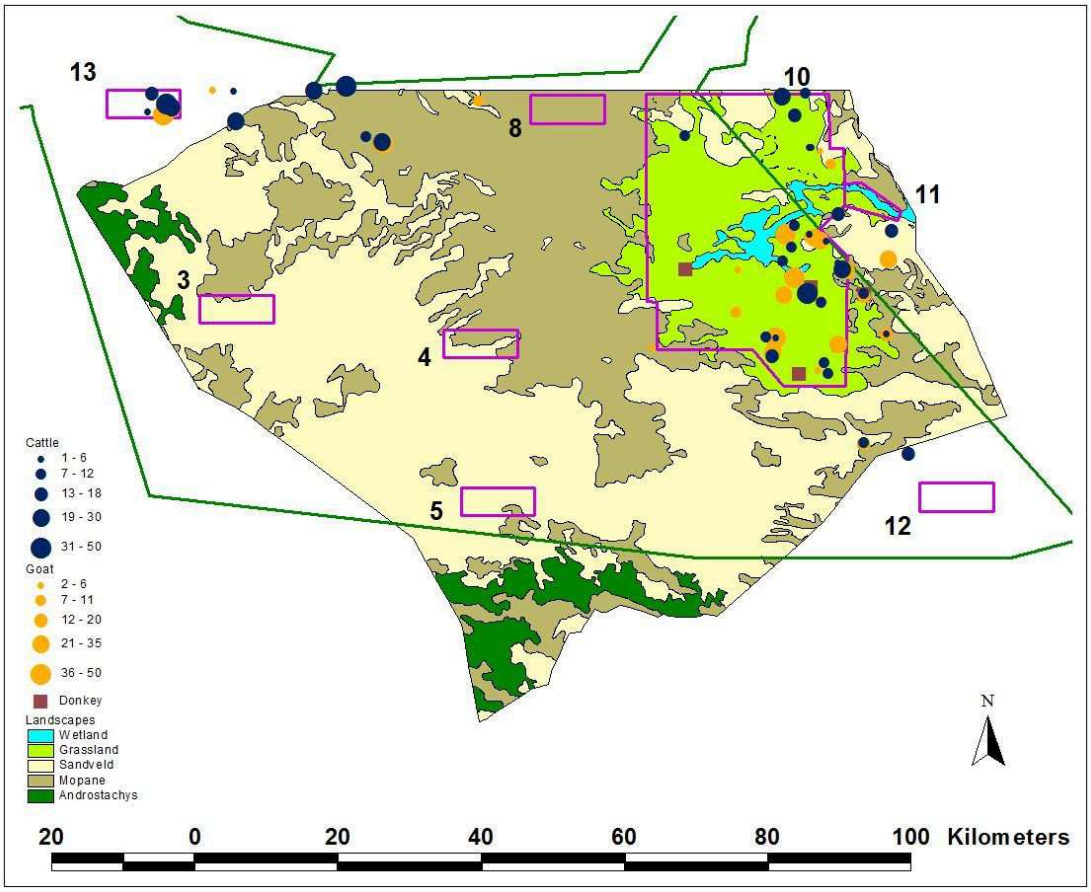


Fig. 16: Distribution of livestock in Banhine (2012).

4.4. Current animal numbers in the context of carrying capacity

The following was already presented in the 2009 report (Stalmans & Peel 2009):

> No formal assessment of carrying capacity for the Park was made as this fell outside the Terms of Reference for this survey. However, there are general equations available that relate rainfall to carrying capacity (Coe et al. 1976) and rainfall in combination with soil fertility to carrying capacity (Fritz & Duncan 1994; Peel *et al.* 2005). Furthermore, the results for a carrying capacity of the Sanctuario in the Limpopo National Park (Stalmans & Peel 2003) can be used to a certain extent.

The combined animal biomass (wildlife and livestock) on the 100,000 ha of the 'core' that was surveyed amounts to an average stocking of less than 300 kg km^{-2}.

Using the landscape make-up of the 'core' and considering the equations mentioned earlier, a weighted average carrying capacity figure in excess of 2,000kg km^{-2} is calculated. The 'core' area of Banhine is stocked at only 15% of its theoretical potential.

5. Restoration of the Park

Although a number of species appear to be doing well and although some immigration from the Limpopo or Gonarezhou National Park is likely (as was observed for buffalo and elephant), the restoration of wildebeest, zebra and giraffe will require an active introduction.

The better ecological understanding that has been attained through the 4 wildlife counts (2004, 2007, 2009 and now in 2012) can assist in formulating the right re-introduction strategy. Two aspects are critical. Firstly, there are important spatial and temporal movements of wildlife in the 'core' part of the Park. Secondly, it appears that the animals need to be able to move into and out of the wetland area in response to changes in water and grazing availability. Thirdly, it would also be important not to compromise the sensitive species such as oribi and reedbuck by the introduction of these stronger competitors.

It is probably not necessary to use a 'Sanctuario' approach for Banhine. The re-introduced animals will tend to remain within the prime wetland and grassland habitats, A large 'boma' system whereby the re-introduced animals are allowed to settle for a week or so should be sufficient. It is very unlikely that the re-introduced animals would leave the 'core' because of its large size and plentiful resources.

It is evident from the distribution maps (Fig. 8 to 14) that much wildlife is found in that part of the core that now falls outside the Park boundaries. The full and long-term restoration of Banhine National park will require this section to be protected from illegal hunting and incompatible forms of land use.

6. Way forward with the aerial surveys

The recommendation made after the 2007 survey to expand the coverage to a larger portion of the grasslands was obviously the right one. The results from the 2009 and 2012 surveys appear consistent and seem to capture the most essential part of the Park.

All efforts should be made to continue covering the same area of approximately 100,000 to 120,000 ha that represents the dynamic core of the Park. A bi-annual count seems appropriate.

As recommended in 2007, some form of ecological monitoring at ground level should be instituted in order to supplement the aerial survey (sex- and age structure, relative densities in different habitats and seasonal change thereof). The monitoring would ideally also include fixed vegetation plots to follow the effects of the wet and dry periods on the quality and quantity of feed resources available for the wildlife.

7. References

Buckland, S.T., Anderson, D.R., Burnham, K.P. & Laake, J.L. 1993. Distance sampling – Estimating abundance of biological populations. Chapman & Hall, London.

Coe M.J., Cumming D.H. & Phillipson J. 1976. Biomass and production of large African herbivores in relation to rainfall and primary production. Oecologia 22: 341-354.

Dunham K.M. 2004. Aerial survey of large herbivores in Gorongosa National Park, Mozambique. Unpublished report to the Gregory C. Carr Foundation, Cambridge MA, USA.

Fritz H. & Duncan P. 1994. On the carrying capacity for large ungulates of African savanna ecosystems. *Proc. R. Soc. Lond.* 256: 77-82.

Peel M.J.S., Kruger J.M. & Zacharias P.J.K 2005. Environmental and management determinants of vegetation state on protected areas in the eastern Lowveld of South Africa. *African Journal of Ecology* 43: 352-361.

Smither R.H.N. & Lobão Tello J.L.P. 1976. Check List and Atlas of the Mammals of Mocambique. Museum Memoir No. 8. Trustees of the National Museums and Monuments of Rhodesia, Bulawayo, Zimbabwe.

Stalmans M. 2003. Plant communities and landscapes of the Parque Nacional de Banhine, Moçambique. Unpublished report *Development Alternatives Inc.*

Stalmans M. 2004. Parque Nacional de Banhine – wildlife census. Unpublished report to the African Wildlife Foundation and USAID.

Stalmans M. 2007. Parque Nacional de Banhine – wildlife survey. Unpublished report to ACTF – MITUR by International Conservation Services, Agricultural Reasearch Council and Sunrise Aviation.

Stalmans M. & Peel M. 2009. Parque Nacional de Banhine – wildlife survey. Unpublished report to ACTF – MITUR by International Conservation Services, Agricultural Reasearch Council and Sunrise Aviation.

Stalmans M. & Wishart M. 2005. Plant communities, wetlands and landscapes of the Parque Nacional de Banhine, Moçambique. Koedoe 48(2):43-58.

Stalmans M. & Peel M. 2003. Assessment of habitat suitability and carrying capacity for herbivores - the 'Sanctuary', Limpopo National Park. Unpublished report to the PIU, Parque Nacional do Limpopo.

Whyte I. & Kruger J. 2005. Ecological aerial surveys (1977-1997) and aerial line transects (1998-2005) in the Kruger National Park. Unpublished report to the South African National Parks Board.

Appendix A: Technical specifications for the study (as defined by MITUR).

1. Aerial sample count of the large and medium size animals in BNP using blocks or transect sample units;

2. Aerial sample count of the large and medium size animals in ZNP using blocks or transect sample units;

3. Use of the same sampling methods and techniques previously adopted for the aerial survey of BNP in 2004, in order to compare data obtained;

4. Semi-random stratify sampling strategy in order to cover all major habitats types existing in BNP and ZNP;

5. Sampling strategy in order to reach a confidence of CV = 0.2 (20%) with p = 0.05. Whereas these confidence limits are not to be reached, propose alternative values providing necessary justifications;

6. GIS database of all animal's sightings;

7. Relevant information, whenever possible, on the animals spotted (i.e. sex, group composition, activity);

8. Quotation should include all costs (e.g. fuel and aircraft/helicopter rental).

Appendix B: Scientific, English and Portugese names of wildlife observed during the wildlife surveys of the Parque Nacional de Banhine during 2004, 2007, 2009 and 2012.

species listed alphabetically with English names first

Common name (English)	Common name (Portugese)	Species (scientific name)
African civet	Civeta-africana	Civettictis civetta
African Wild Cat	Gato bravo africana	Felis lybica
Bateared fox	Raposa orelhuda	Otocyon megalotis
Blackbacked jackal	Chacal de Sela/Chacal de costas pretas	Canis mesomelas
Buffalo	Búfalo	Syncerus cafer
Bushpig	Porco bravo	Potamochoerus porcus
Caracal	Caracal	Felis caracal
Chacma baboon	Macaco-cão cinzento	Papio ursinus
Elephant	Elefante	Loxodonta africana
Grey duiker	Cabrito tinvento	Sylvicapra grimmia
Honey badger	Ratel / Melivora	Mellivora capensis
Impala	Impala	Aepyceros melampus
Kudu	Cudo	Tragelaphus strepsiceros
Large grey mongoose	Manguço gigante cinzento	Herpestes ichneumon
Large spotted genet	Geneta / Simba de mahas grandes	Geneta tigrina
Nyala	Inhala	Tragelaphus angasi
Oribi	Oribi	Ourebia ourebi
Ostrich	Avestruz	Struthio camelus
Porcupine	Porco espinho	Hystrix africaeaustralis
Reedbuck	Chango	Redunca arundinum
Serval	Gato serval	Felis serval
Spotted hyena	Hiena malhada	Crocuta crocuta
Vervet monkey	Macaco de cara preta / Macaco azul	Cercopithecus aethiops
Warthog	Facocero	Phacochoerus africanus

species listed alphabetically with Portugese names first

Common name (Portugese)	Common name (English)	Species (scientific name)
Avestruz	Ostrich	Struthio camelus
Búfalo	Buffalo	Syncerus cafer
Cabrito tinvento	Grey duiker	Sylvicapra grimmia
Caracal	Caracal	Felis caracal
Chacal de Sela/Chacal de costas pretas	Blackbacked jackal	Canis mesomelas
Chango	Reedbuck	Redunca arundinum
Civeta-africana	African civet	Civettictis civetta
Cudo	Kudu	Tragelaphus strepsiceros
Elefante	Elephant	Loxodonta africana
Facocero	Warthog	Phacochoerus africanus
Gato bravo africana	African Wild Cat	Felis lybica
Gato serval	Serval	Felis serval
Geneta / Simba de mahas grandes	Largespotted genet	Geneta tigrina
Hiena malhada	Spotted hyena	Crocuta crocuta
Impala	Impala	Aepyceros melampus
Inhala	Nyala	Tragelaphus angasi
Macaco de cara preta /Macaco azul	Vervet monkey	Cercopithecus aethiops
Macaco-cão cinzento	Chacma baboon	Papio ursinus
Oribi	Oribi	Ourebia ourebi
Porco bravo	Bushpig	Potamochoerus porcus
Porco espinho	Porcupine	Hystrix africaeaustralis
Raposa orelhuda	Bateared fox	Otocyon megalotis
Ratel / Melivora	Honey badger	Mellivora capensis