



## **Parque Nacional de Banhine, Moçambique**

**Wildlife survey**

**November 2009**

### **Technical report commissioned by *ACTF - MITUR***

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## **EXECUTIVE SUMMARY**

### **Background**

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

### **Methodology**

Balancing the requirements for objectivity, repeatability and affordability, a partial survey (sample count) was applied using a helicopter. The survey was expanded to cover more of the open grasslands. This was a recommendation that came out of the analysis of the 2007 data. The expanded coverage included all of the survey blocks that were also used in the 2004 and 2007 surveys. A total of 119,200 ha (or 1,192km<sup>2</sup>) representing 19% of Banhine was covered by the survey blocks.

A Global Positioning System with pre-determined survey blocks and flight lines was used to accurately cover 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**

Nevertheless, the overall sampling intensity of 19% compares well with sample counts in for example the Kruger National Park that is based on 22% coverage. Within this overall coverage of 19%, the Wetland and Grassland landscapes are very well sampled (99 and 85% respectively) whereas only 8.4% of the Sandveld and 6.9% of the Mopane Landscapes was sampled.

### **Animal numbers**

The same species of larger animals as in 2007 were observed. 'New' species observed included buffalo (a very healthy looking herd of 16 that included 3 calves – Fig. 1) and elephant (a young bull – Fig. 1).

Viable populations of bushpig, common reedbuck, grey duiker, impala, kudu, oribi, ostrich and steenbuck exist (Table 1). Ostrich in particular appear to be thriving. In addition to the 361 ostriches observed, a total of 18 nests and 123 chicks were counted. Banhine probably holds the best population of this species in the GLTP and possibly in the sub-region. 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 2009 aerial survey of Banhine.

Species	Survey block							Total
	10	11	3	4	5	6	8	
Buffalo	16							16
Bushpig	115							115
Common reedbuck	209	15						224
Duiker	464	27	49	19	11	18	36	624
Elephant	1							1
Impala	572	15						587
Kudu	140		30	37	72	104		383
Nyala				48		5		53
Oribi	397	5						402
Ostrich	357		2			2		361
Steenbuck	290	5	12	8	13	13	16	357
Warthog	32			3		7		42
Ground Hornbill	19			2	3			24
Kori bustard	6							6
Saddlebill Stork	8	2						10
Wattled crane		2						2
Baboon Troops	1				2	1		4
Vervet monkey troop						1		1
African wild cat	2	2			1	1		6
Blackbacked jackal	6	1			1			8
Caracal							1	1
Civet	1							1
Grter grey mongoose	3							3
Porcupine	3				7	1		11
Cattle	624	70						694
Goat	527	17						544

The total number of animals that were observed during 2009 is higher even when compared to the blocks that were counted in 2004 and 2007 (Table 2).

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

Species	Total number			
	2004	2007	2009 (same blocks as covered during 2004 & 2007)	2009 expanded coverage of Wetland / Grassland
Buffalo	1	0	16	16
Bushpig	50	28	70	115
Common reedbuck	67	83	189	224
Duiker	75	171	190	491
Elephant	0	0	1	1
Impala	108	81	263	587
Kudu	35	32	86	140
Nyala	0	0	0	0
Oribi	39	192	212	402
Ostrich	71	130	134	357
Steenbuck	21	130	111	295
Warthog	0	8	4	32

Given that the extent of the central grasslands and wetland area that was surveyed was nearly 6 times more than in 2007, one would (under a scenario of even distribution) expect a similar ratio between the total number of animals recorded in 2009 and the number recorded in the 2004/2007 areas only. A ratio below 6 would indicate a higher concentration in the previously used survey blocks. A ratio above 6 would indicate a greater density outside the previously used survey blocks.

For the 6-fold increase in area, only a 2 to 3-fold proportional increase in animal numbers was observed. The animals are thus concentrated around the Wetland landscape now that it has dried up and is providing good grazing. This would explain the relatively low numbers of oribi recorded in 2004. Large areas of the survey block were flooded at that stage and conditions were not good for this species. They probably moved outwards towards the fringes of the Grassland landscape.

An estimated 120,000 ha in the north-east therefore make up the 'core' of the Park that holds the vast majority of the animals. These animals move inwards to and outwards from the Wetland landscape in response of 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.

If this conceptual model holds, than it means that the 2009 survey probably 'captured' the majority of the numbers of species such as oribi and common reedbuck occurring in the Park. Although ostrich occur at low densities in the woodlands, the majority of their numbers has also been recorded. The same applies to impala.

Kudu and nyala are an exception to this. Their strongholds are the dry sandveld and mopane woodlands to the west and the south. All indications are that the kudu numbers are increasing at a good rate of 17 to 21% annually.

### **Other species**

As in 2004 and 2007, an interesting, diverse suite of small carnivores such as caracal, African wild cat, civet, mongooses and black-backed jackal were observed. As in the previous surveys, a number of porcupine that were active during the day were observed. Ground hornbills, Saddle bill storks and Wattled cranes were recorded.

### **Livestock**

The number of cattle (694) and goats (544) that were recorded rose sharply. Whereas this does not as yet present a big problem in terms of negative impact on the grazing resource, the consequences of this trend are significant.

The increasing livestock numbers will undoubtedly lead to an increased expectation by the local communities as to their rights of access to the natural resources. How will the livestock number further increase and how will this impact on the recovery of the Park, particularly where it concerns large grazing species such as wildebeest, zebra and buffalo ?

### **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 (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 3 wildlife counts (2004, 2007 and now in 2009) 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. It therefore becomes critical that a 'Sanctuario' should not permanently fence off a significant part of the 'core'. Rather, the 'Sanctuario' should be of a very temporary nature. A large 'boma' system whereby the re-introduced animals are allowed to settle for a few weeks at most should be sufficient. It is very unlikely that the re-introduced animals would leave the 'core' because its large size and plentiful resources.

### **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 to in future cover the same area of nearly 100,00 ha that represents the dynamic core of the Park. 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 2009 survey of Banhine (top – buffalo, middle – impala, bottom – elephant).

## **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 transfrontier 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 real number if possible) of animals occurring within PAs represents valuable 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 monitor 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 and 2007 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) and 2007 surveys (Stalmans 2007).

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 (approximately 6,000 km<sup>2</sup>), 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 requires a spatially-explicit assessment whereby a follow-up survey can be undertaken on the same area(s). Given the low expected 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<sup>2</sup>) 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.

As a result, a proposal was made by the service provider and accepted by MITUR to increase the coverage from 7.8 to 15% of the Park. During the actual survey it was realised that a larger area could be covered within the available budget. This resulted in an extra 24,196 ha (or 3.8% of the Park) being flown while remaining within the original budget (Fig. 2).

The expanded coverage includes all of the 2004/2007 blocks (Fig. 3). This now covers the vast majority of the Wetland and Grassland Landscape (Fig. 4).

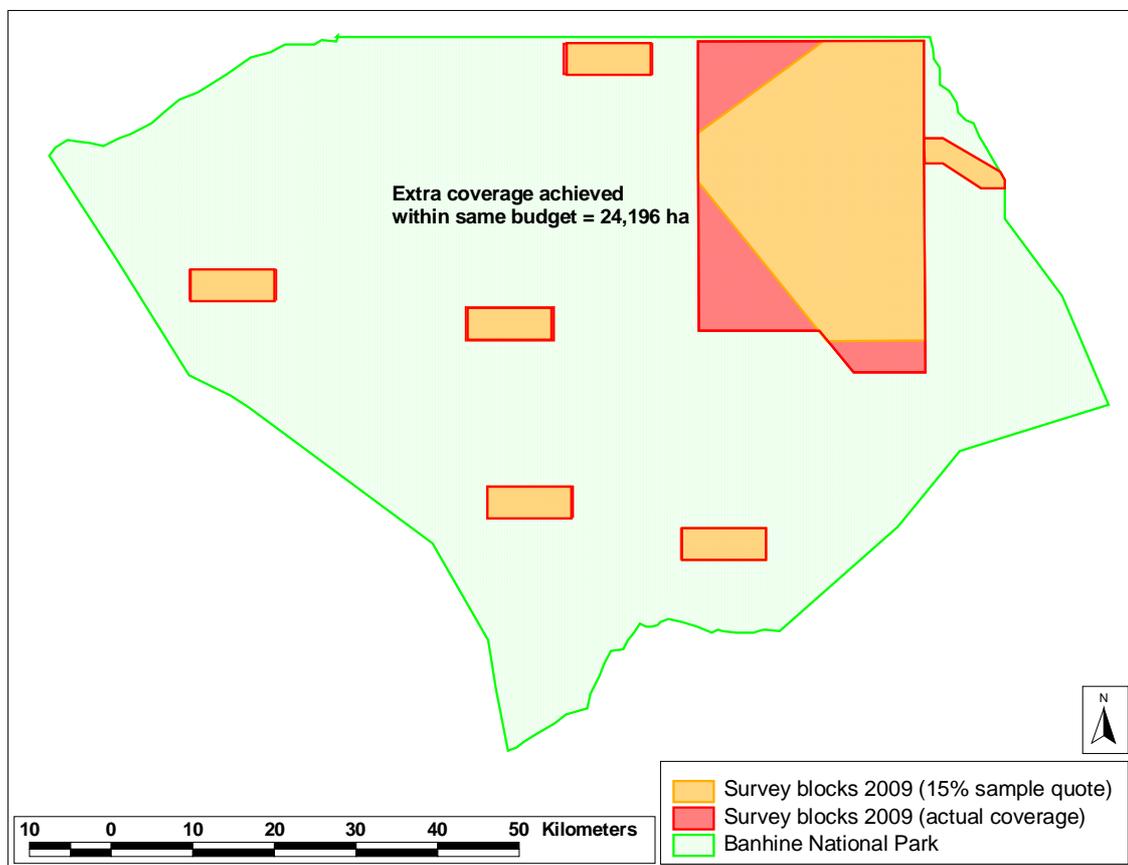


Fig. 2: Actual survey coverage achieved in 2009 within the same budget as compared to the quoted survey coverage.

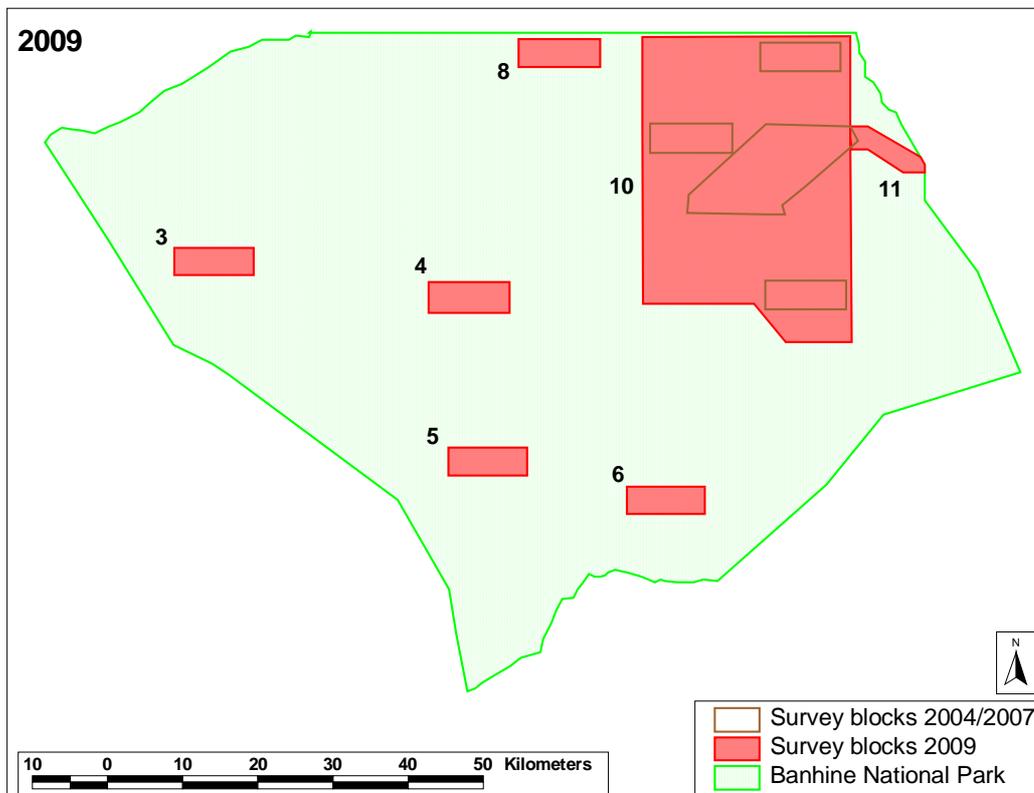
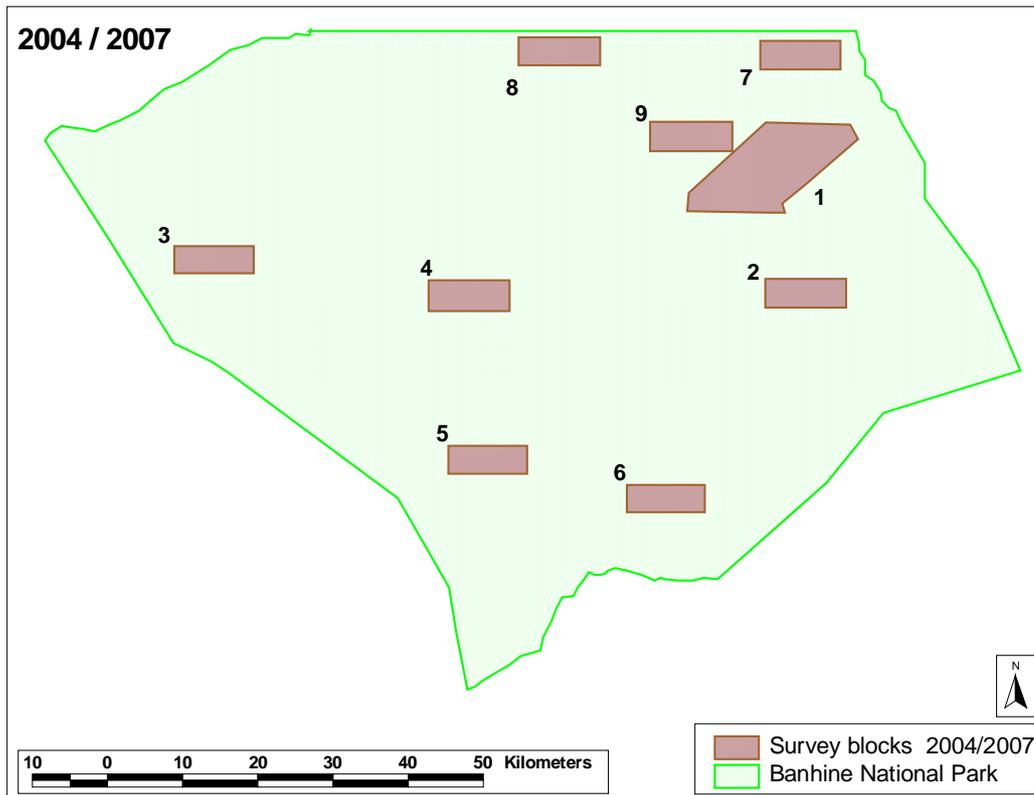


Fig. 3. Survey blocks for the sample count of the Parque Nacional de Banhine for the period 2004 – 2009. Note the expanded coverage in 2009 compared to 2004/2007.

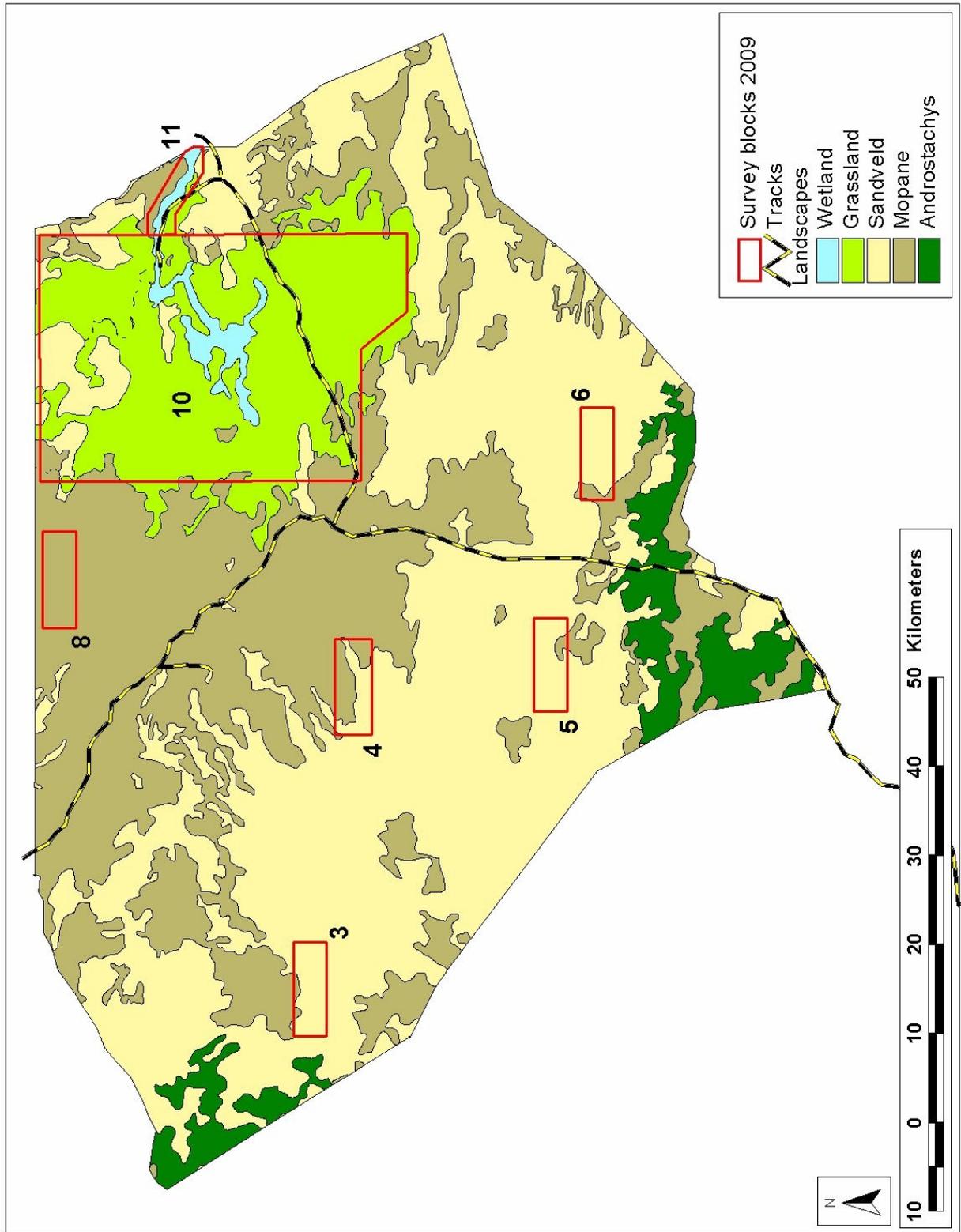


Fig. 4. Landscape make-up of the survey blocks for the sample count of the Parque Nacional de Banhine during 2009.

## 2.2. Survey technique

The specific equipment and technique are as follows (Fig. 5):

- 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.

The survey was flown by pilot Mr Mike Pingo (Sunrise Aviation) with navigator/observer Dr Marc Stalmans (International Conservation Services). Dr Mike Peel permanently occupied the one observer seat. These three persons have now completed all of the counting for the 2004, 2007 and 2009 surveys. The second observer seat was rotated amongst Mr John Peel (also present in 2004 and 2007), Mr Andre Jacobs (also present in 2007), Mr Lukas Manaka and Mr Hendrik de Beer of the Animal Production Institute of the Agricultural Research Council. Mr Roger Mortlock from Sunrise Aviation acted as observer for a few of the sessions.

The warden of Banhine, Snr Domingo Conjo, as well as Snr Pedro Perreira (MITUR) accompanied the survey crew during 4 different sessions.

The survey was undertaken between 26 October and 1 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 refuelling.

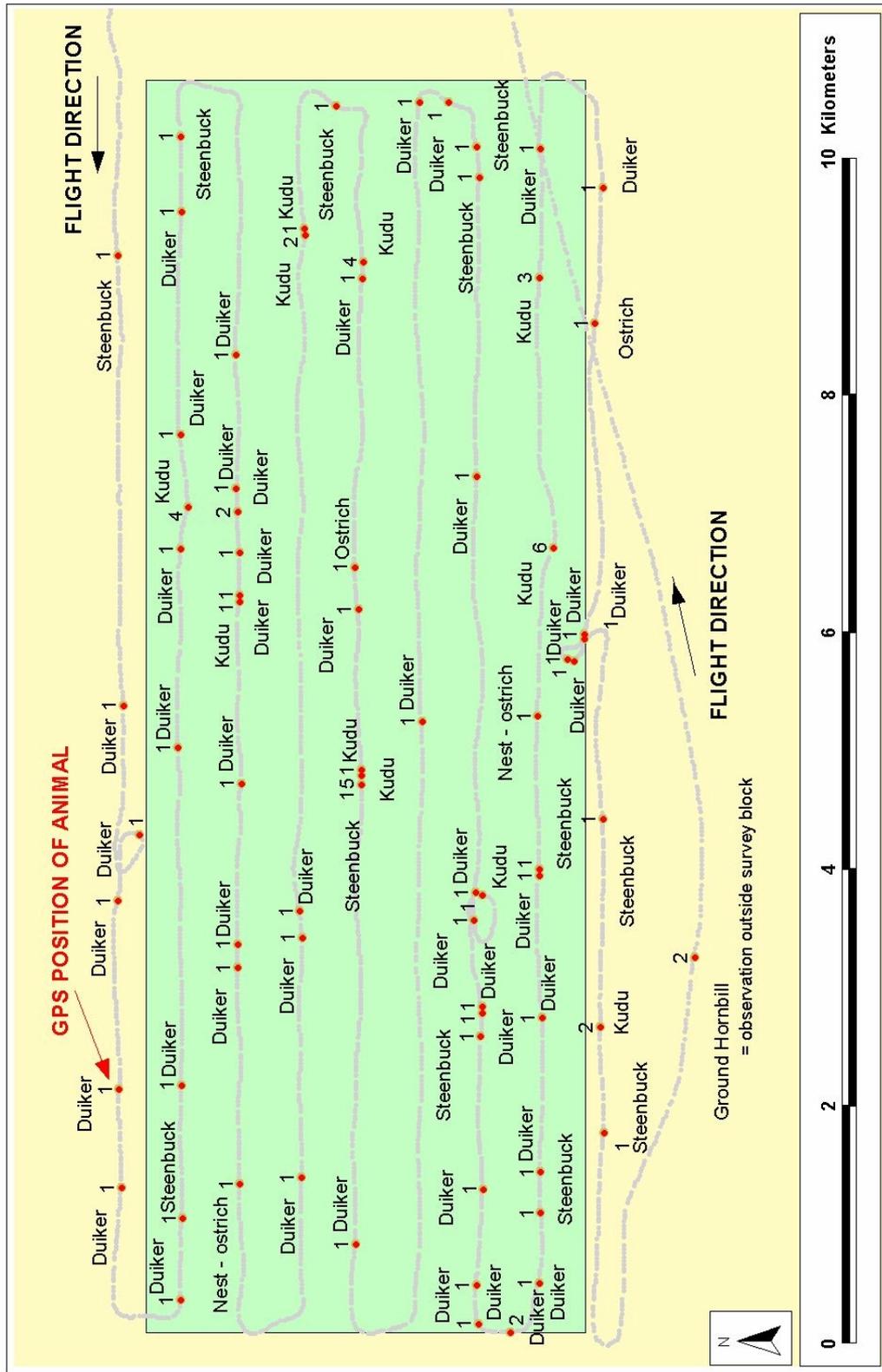


Fig. 5: Count block with flight lines and GPS position and number of animals observed (illustrated for count block 3 – flight 30 October 2009).

Table 3: Weather conditions during 2007 survey of Banhine.

Date	Block	Cloud cover (1 to 8 scale)	Session	Visibility	Temp. °C
26-Oct	11	2/8	1	good-moderate	35.0
27-Oct	10	6-7/8	2	mod-poor-mod	24.5
27-Oct	10	6/8	3	mod-good	27.5
27-Oct	10	3/8	4	good-exc-good	32.0
28-Oct	10	6-7/8	5	poor-mod	23.0
28-Oct	10	4/8	6	mod-good-good	28.0
28-Oct	10	3/8	7	good-excellent	32.0
28-Oct	8	1-2/8	8	good-excellent	33.0
29-Oct	10	1/8	9	good-excellent	26.0
29-Oct	10	3/8	10	mod-good-excellent	30.0
29-Oct	10	3-4/8	11	good	33.0
30-Oct	3	8/8	12	poor	19.0
30-Oct	5/6	8/8	13	poor-moderate	21.5
30-Oct	4	8/8	14	poor	20.0
31-Oct	10	7/8	15	poor-mod-good	21.0
31-Oct	10	5/8	16	mod-good-good	26.0
31-Oct	10	6-8/8	17	mod-good-moderate	29.0

### 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 and 2007 counts. It is thus possible to analyse differences between the 3 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, commonsense 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 total area covered by the blocks was 119,200 ha (or 1,192 km<sup>2</sup>) which represents 19% of the Park (Fig. 4). The blocks each have a different make-up in terms of landscape composition (Table 4).

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
6	Sandveld	Mopane
8	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 much better covered than the mopane and sandveld landscapes (Table 5). It is important to understand that the 'habitat' that was covered by water in 2004 has changed much in appearance and suitability for different species of animals as the wetland dried up in 2007. And to a lesser extent in 2009. This is illustrated visually in Fig. 6.

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. This means that the different surveys, although using some of the same counting blocks, do not necessarily cover the same habitat. This confuses and complicates comparisons between the different surveys.

Table 5: Coverage of the dominant landscapes of Banhine by the 2009 survey.

Landscape	Proportion of Park	Area covered by survey blocks (ha)	Proportion of landscape covered by survey
Wetland	1.10%	6,548	99.39%
Grassland	13.60%	72,354	84.95%
Sandveld	46.70%	24,542	8.39%
Mopane	33.90%	14,574	6.87%

### 3.2. Species observed

With regard to the large mammals, the same suite of species was observed during 2009 as in 2004 and 2007 (Table 6). In addition, a very healthy looking herd of 16 buffalo including 3 calves (Fig. 1) were observed as well as a single elephant.

As in 2004 and 2007, an interesting variety of small carnivores were observed including blackbacked jackal, caracal (first observation during the aerial surveys), civet and African wildcat.

Amongst the large bird species, wattled crane, saddle bill stork and kori bustard were observed.

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

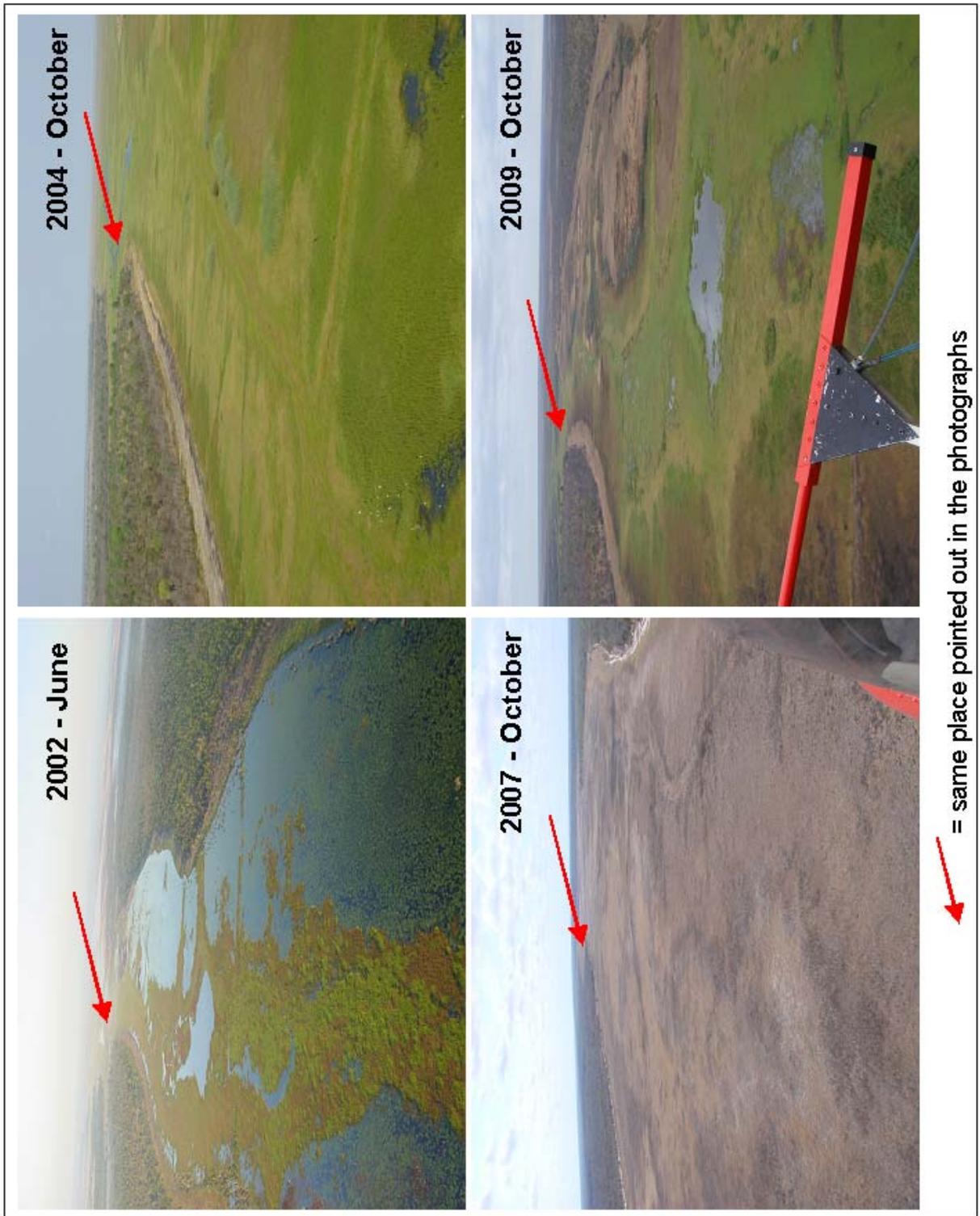


Fig. 6: Change in appearance of the 'wetland' habitat from 2002 to 2009.



### 3.3. Numbers observed

A total of 3,165 ostriches and large mammals were recorded in the blocks and ferry lines (Table 7). This represents the absolute minimum number of animals that must be present in Banhine. The actual number is higher as only a proportion of the Park was surveyed. The ostrich count excludes chicks. A total of 123 chicks and young birds were counted.

Table 7: Wildlife and livestock numbers observed during the 2009 aerial survey of Banhine.

Species	Survey block							Total
	10	11	3	4	5	6	8	
Buffalo	16							16
Bushpig	115							115
Common reedbuck	209	15						224
Duiker	464	27	49	19	11	18	36	624
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Ground Hornbill	19			2	3			24
Kori bustard	6							6
Saddlebill Stork	8	2						10
Wattled crane		2						2
Baboon Troops	1				2	1		4
Vervet monkey troop						1		1
African wild cat	2	2			1	1		6
Blackbacked jackal	6	1			1			8
Caracal							1	1
Civet	1							1
Grter grey mongoose	3							3
Porcupine	3				7	1		11
Cattle	624	70						694
Goat	527	17						544

### 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 2009 aerial survey (Table 8). The ratios all indicate healthy and productive populations.

It is of interest to note that these ratios 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 8: Sex ratio of selected species as recorded during the 2009 survey of Banhine.

Species	Female	Male	F/M ratio
Kudu	74.2%	25.8%	2.9
Nyala	74.2%	25.8%	2.9
Impala	77.9%	22.1%	3.5
Ostrich	52.9%	47.1%	1.1

Note: 'females' may include young animals which can not yet be differentiated

## **4. Discussion of numbers and distribution**

### **4.1. Landscape and area preferences**

Wildlife species are unevenly distributed across Banhine (Fig. 7 to Fig. 14). The general pattern that has emerged from the three 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 very tightly in and around the edges of the Wetland Landscape (Fig. 12). Even within the grassland block, the large population of impala occurs in a 'clumped' manner mostly close to the remaining natural water (Fig. 9). 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.

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 6). As in 2004 and 2007, nyala were observed in Block 4. For the first time, nyala were also found in a second block (Block 6).

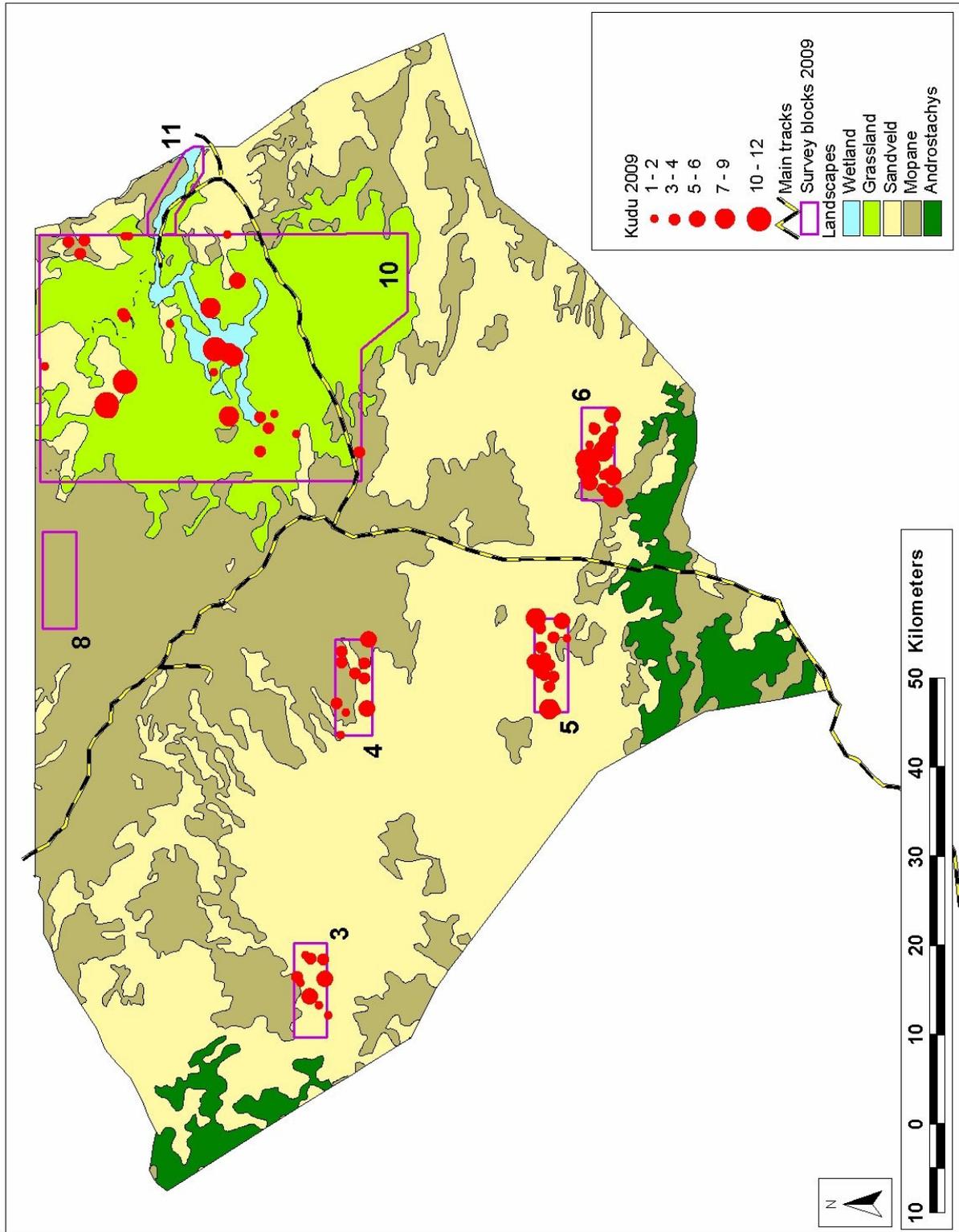


Fig. 7: Distribution of kudu during the 2009 survey of Banhine.

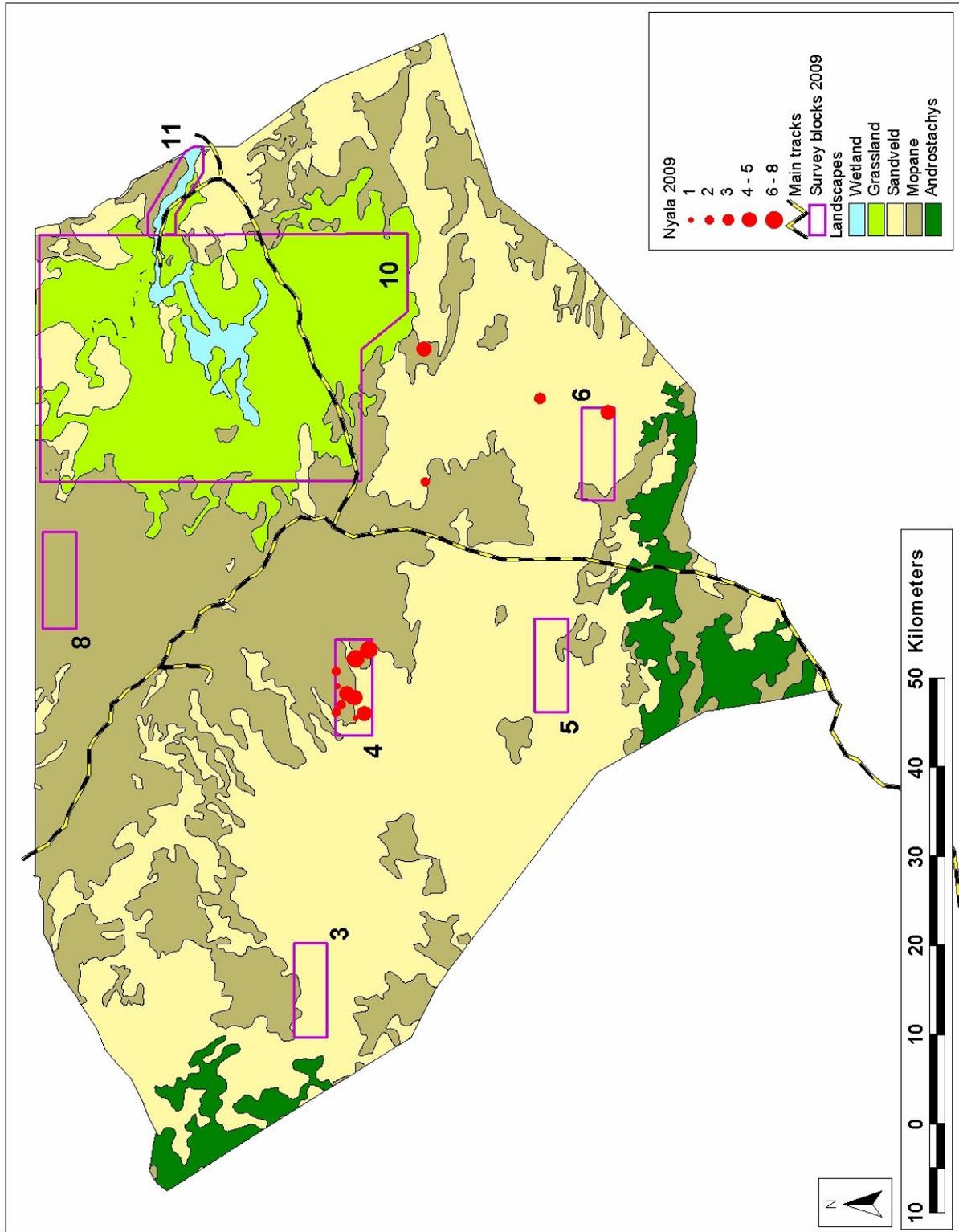


Fig. 8: Distribution of nyala during the 2009 survey of Banhine. The position of nyala that were observed outside of the survey blocks has been displayed on the map.

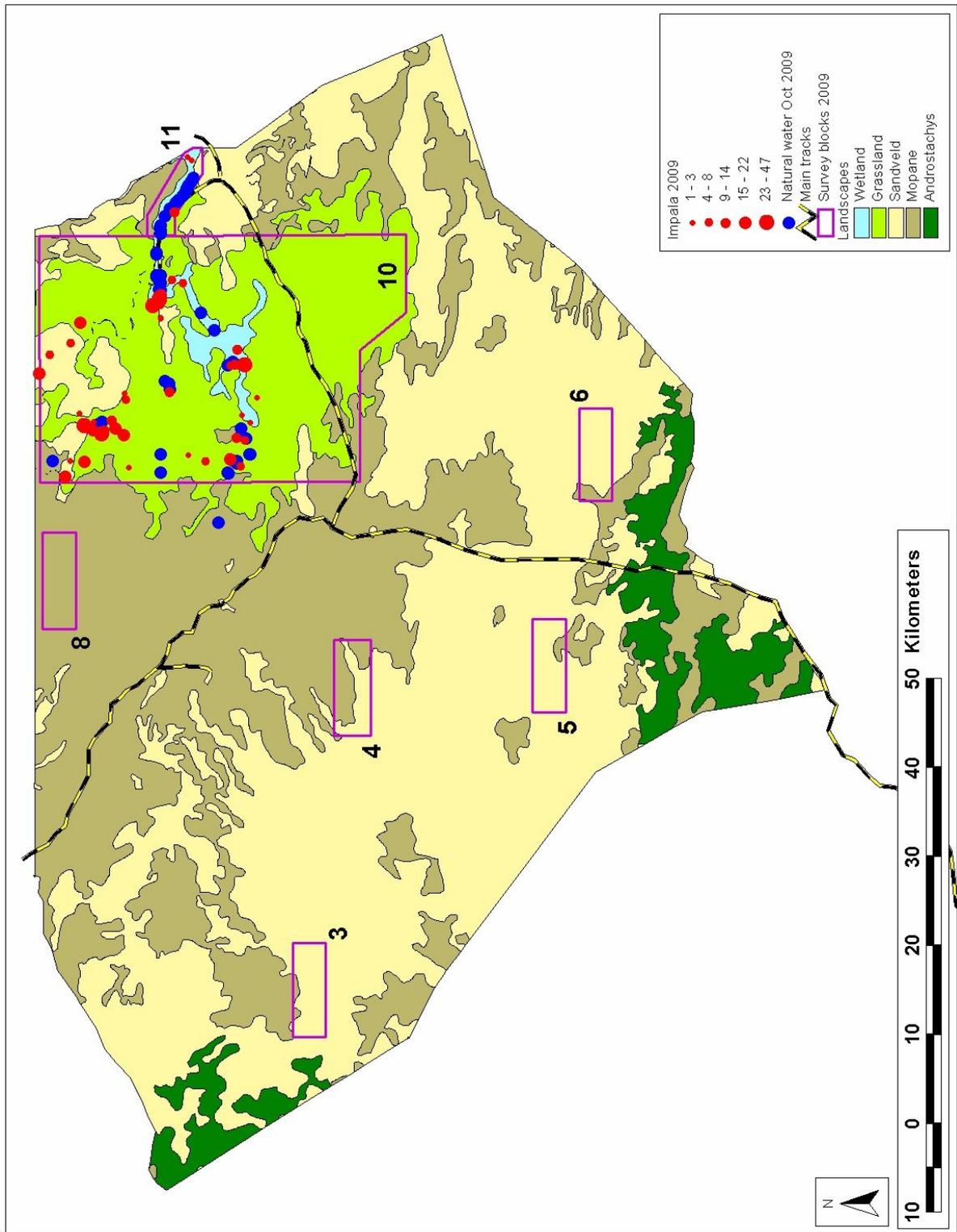


Fig. 9: Distribution of impala during the 2009 survey of Banhine. The impala on the extreme northern border have access to surface water that is found just outside the Park.

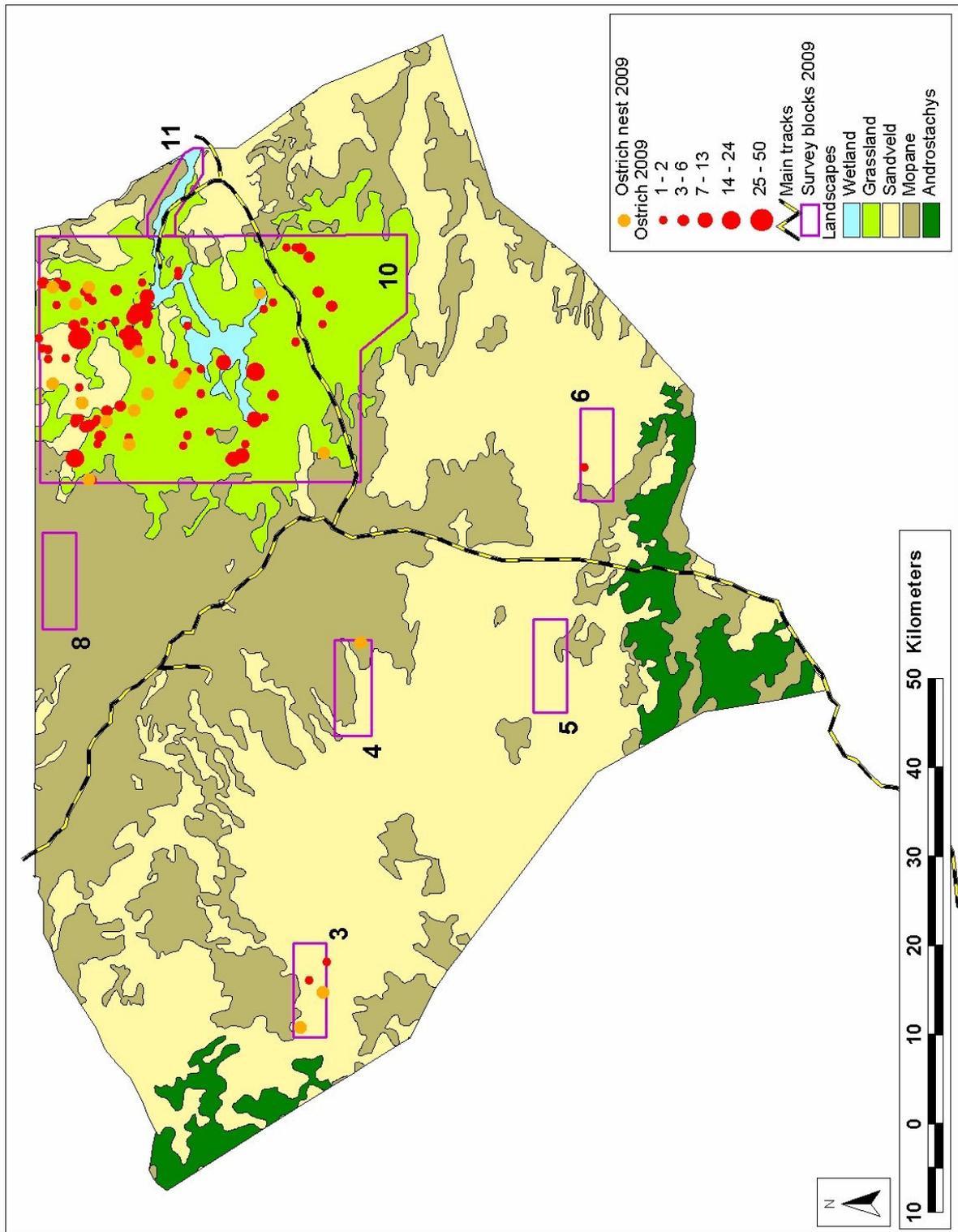


Fig. 10: Distribution of ostrich during the 2004 and 2007 surveys of Banhine. Note the occurrence of nests.

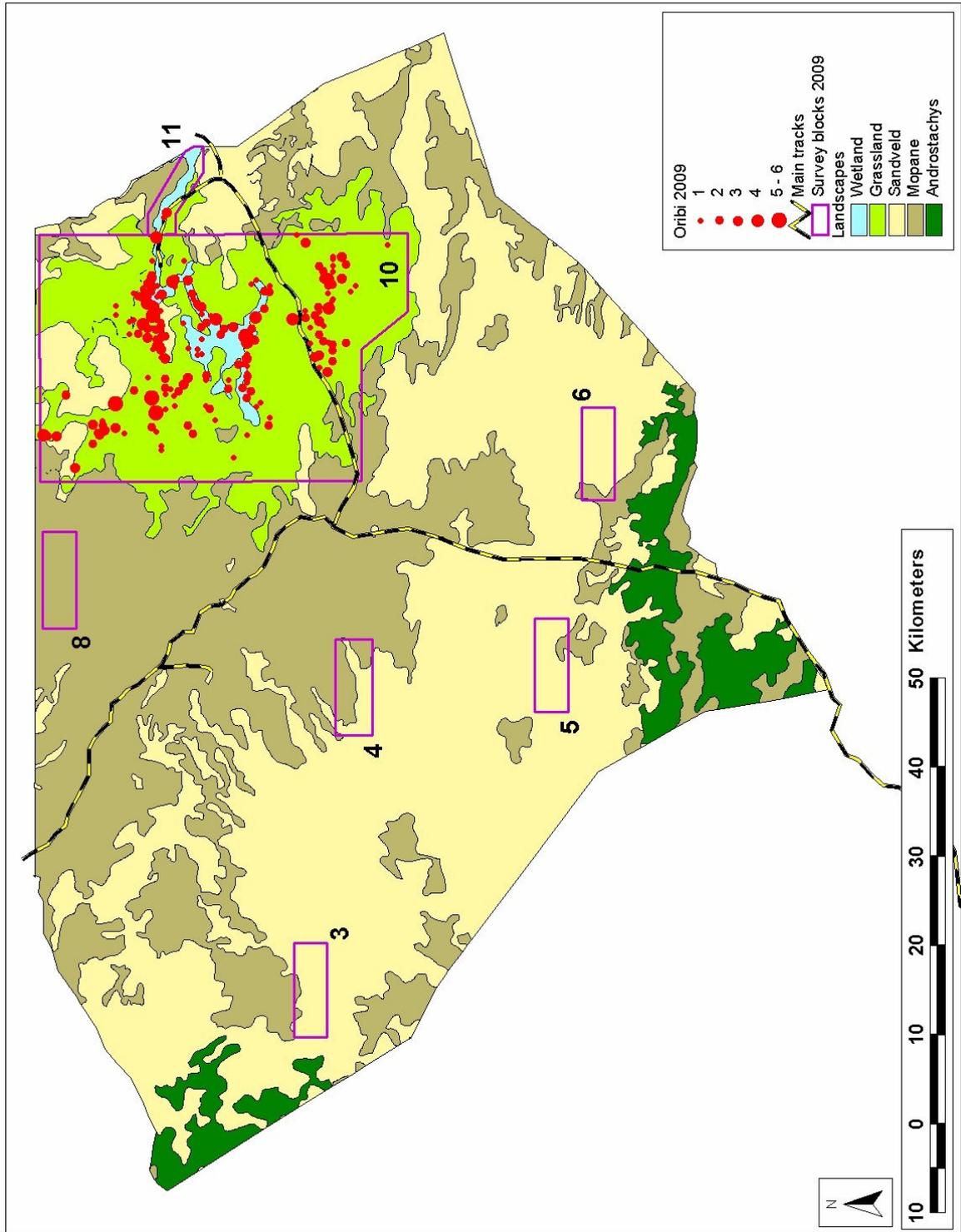


Fig. 11: Distribution of oribi during the 2009 survey of Banhine.

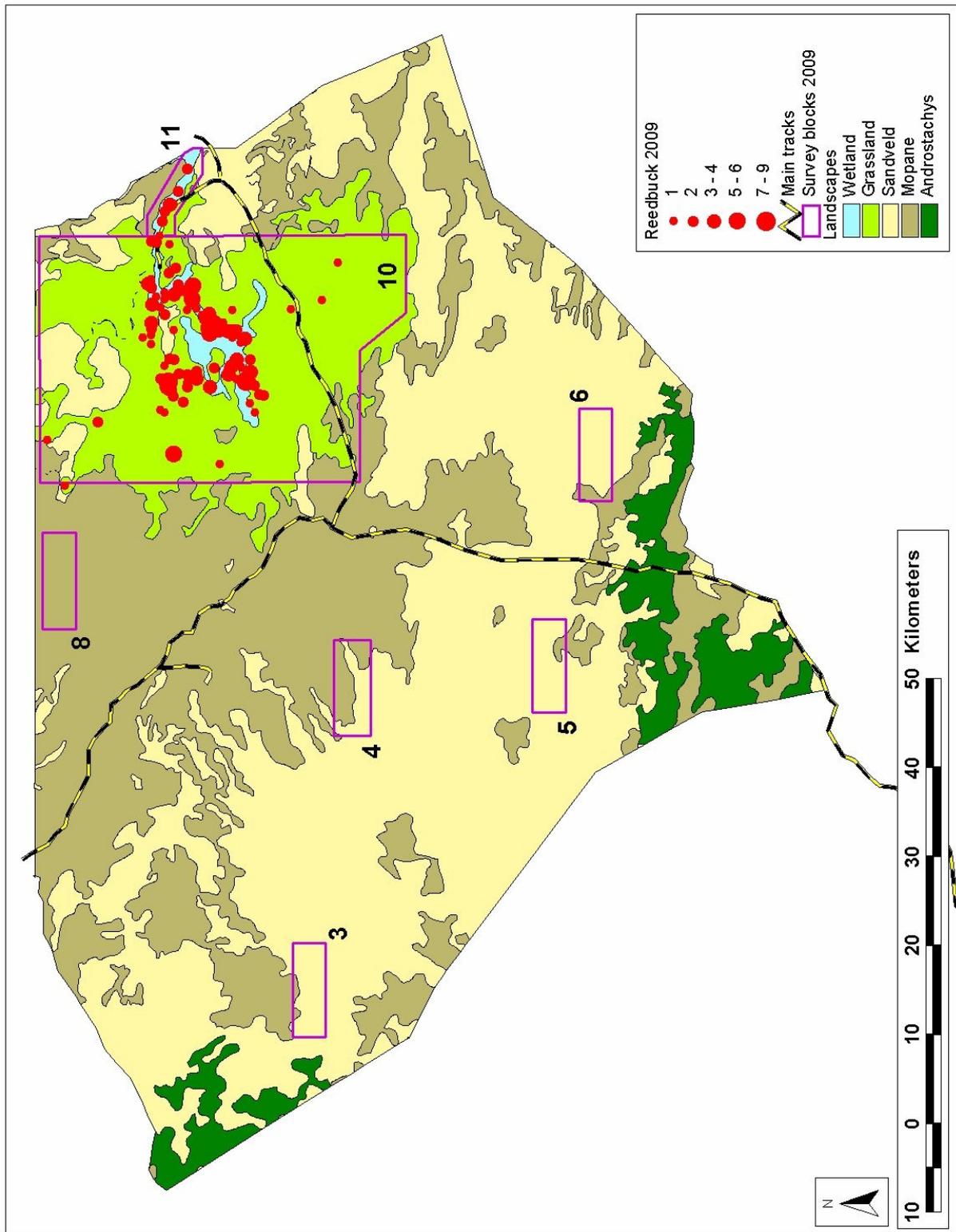


Fig. 12: Distribution of common reedbuck during the 2009 survey of Banhine.

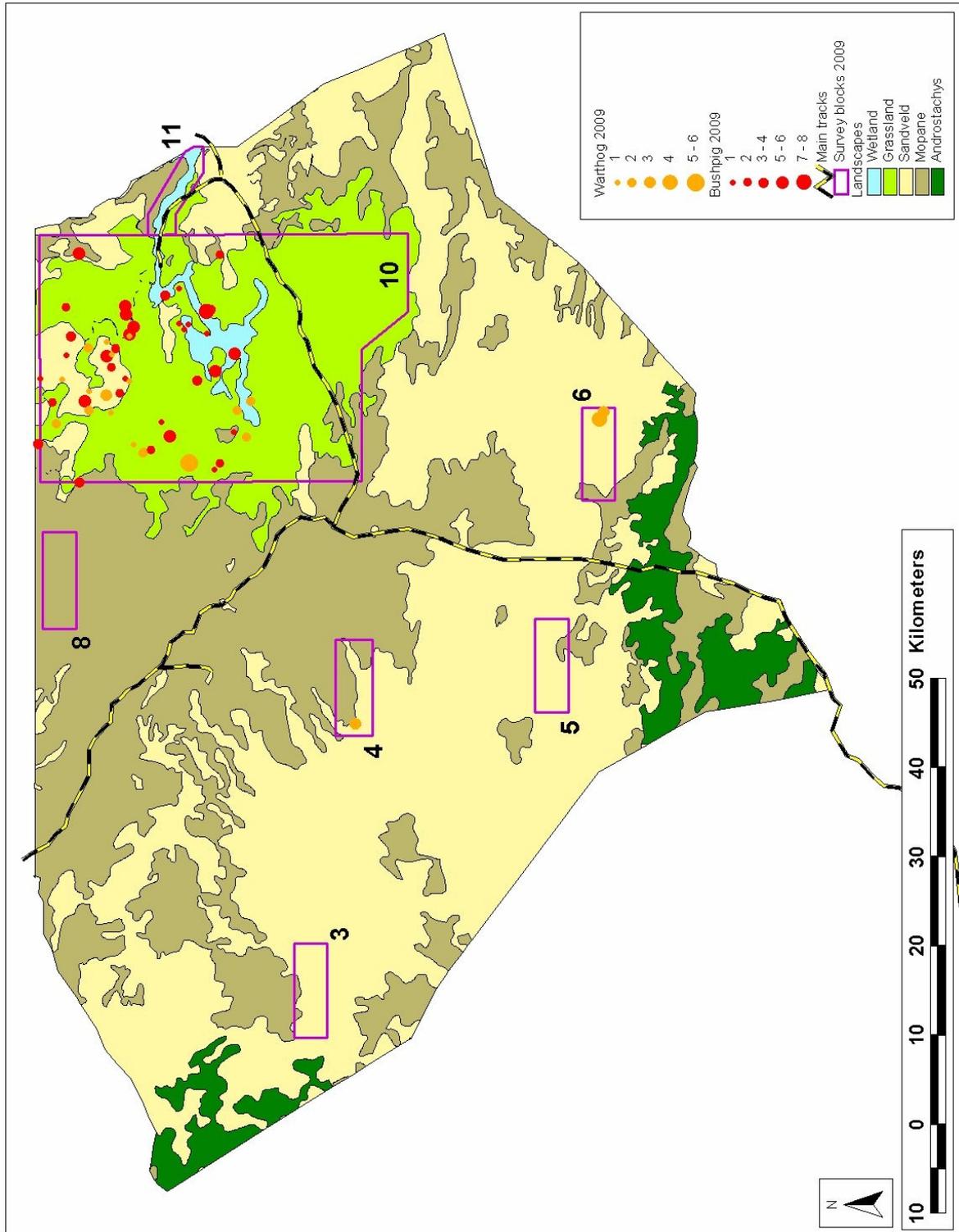


Fig. 13: Distribution of bushpig and warthog during the 2009 survey of Banhine.

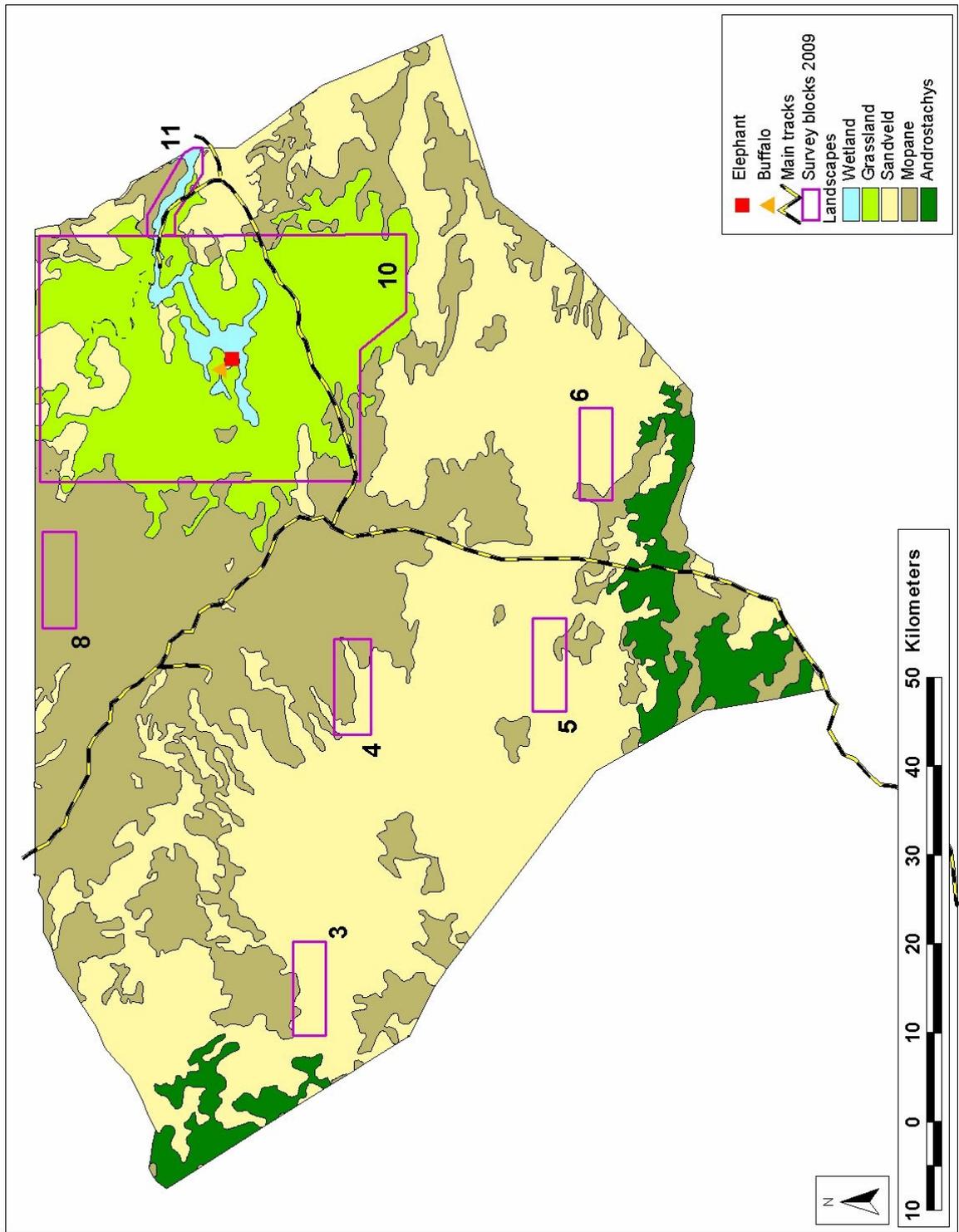


Fig. 14: Distribution of elephant and buffalo during the 2009 survey of Banhine.

## 4.2. Comparison between the different aerial counts since 2004

Any comparison between the 2004, 2007 and 2009 counts must take into account the change in sampling design. Whereas only 7.8% of the Park was previously surveyed, this percentage has now increased to 19%.

Even though the sampling percentage for the Wetland and Grassland was previously high (79 and 25% respectively), the survey blocks are open and animals can easily move.

Conditions in the Park vary considerably from year to year (see Fig. 6 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).

The following explanation as given in the 2007 report for the big differences in the animal numbers from 2004 (wet) to 2007 (very dry):

‘The biomass of animals per km<sup>2</sup> has increased considerably for the wetland block. This increase seems to have been fed by dispersal from the grasslands. It could be that under these very dry conditions the grassland landscape constitutes the poorest landscape at this time of the year. The woodlands (sandveld and mopane) probably already offer some new growth on the trees and shrubs even if the grass has not yet started growing. The wetland area that was previously inaccessible probably offers some of the best remaining grass.’

The following cautionary note was however made:

‘The problem with the relatively low coverage of the Park is that this explanation can not be proven as there is insufficient coverage of areas where numbers would be lower than those recorded in the previous survey.’

During the current survey, virtually the whole of the north-eastern grasslands were covered. If this area was used fairly uniformly by the animals, one could expect that any large sample could simply be scaled up to arrive at an extrapolated figure for the whole area.

The 2009 records that correspond with the area covered in 2004/2007 were extracted from the database (Table 9). Given that the extent of the central grasslands and wetland area that was surveyed was nearly 6 times more than in 2007, one would (under a scenario of even distribution) expect a similar ratio between the total number of animals recorded in blocks 10/11 and the number recorded in the 2004/2007 areas only.

This was not the case. For the 6-fold increase in area, only a 2 to 3-fold proportional increase in animal numbers was observed (Table 10). The animals are thus concentrated around the Wetland landscape now that it has dried up and is providing good grazing. This would explain the relatively low numbers of oribi recorded in 2004. Large areas of the survey block were flooded and conditions were not good for this species. They probably moved outwards towards the fringes of the Grassland landscape where we did not count in 2004.

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

Species	Total number			
	2004	2007	2009 (same blocks as covered during 2004 & 2007)	2009 expanded coverage of Wetland / Grassland
Buffalo	1	0	16	16
Bushpig	50	28	70	115
Common reedbuck	67	83	189	224
Duiker	75	171	190	491
Elephant	0	0	1	1
Impala	108	81	263	587
Kudu	35	32	86	140
Nyala	0	0	0	0
Oribi	39	192	212	402
Ostrich	71	130	134	357
Steenbuck	21	130	111	295
Warthog	0	8	4	32

Table 10: Ratio between the number of animals recorded in 2009 in the expanded coverage and in the previous survey blocks (used in the 2004/2007 surveys). The ratio should be 6 if the animals are evenly distributed. A ratio below 6 would indicate that the animals were concentrating in the previously used survey blocks. A ratio above 6 would indicate a greater density outside of the previously used survey blocks.

Species	Ratio of animal numbers in expanded coverage as compared to old survey blocks
Bushpig	1.6
Common reedbuck	1.2
Duiker	2.6
Impala	2.2
Kudu	1.6
Oribi	1.9
Ostrich	2.7
Steenbuck	2.7
Warthog	8.0

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 (see conceptual model in Fig. 15). 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 survey 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. The observed and modelled numbers for the woodland survey blocks 3, 4, 5, 6 and 8 indicate an annual rate of increment of 21% (Table 11). This is within the biological norms for the species and similar to the natural increments of these species found in Lowveld areas in South Africa (Peel unpublished data). Such increases will continue and may even overshoot the point of 'equilibrium' with the available natural resources whence there will be a correction to a range around some central domain of attraction (mean). The rate of increment was calculated at 17% for Block 6 which is the block with the highest density of kudus (Table 12).

Table 11: Observed and modelled numbers of kudu in woodland blocks 3, 4, 5, 6 and 8 assuming a 21% annual rate of increase.

Year	Number counted	Number modelled
<b>2004</b>	94	
2005		114
2006		138
<b>2007</b>	173	167
2008		201
<b>2009</b>	243	244

Table 12: Observed and modelled numbers of kudu in Block 6 assuming a 17% annual rate of increase.

Year	Number counted	Number modelled
<b>2004</b>	47	
2005		55
2006		64
<b>2007</b>	75	75
2008		88
<b>2009</b>	104	103

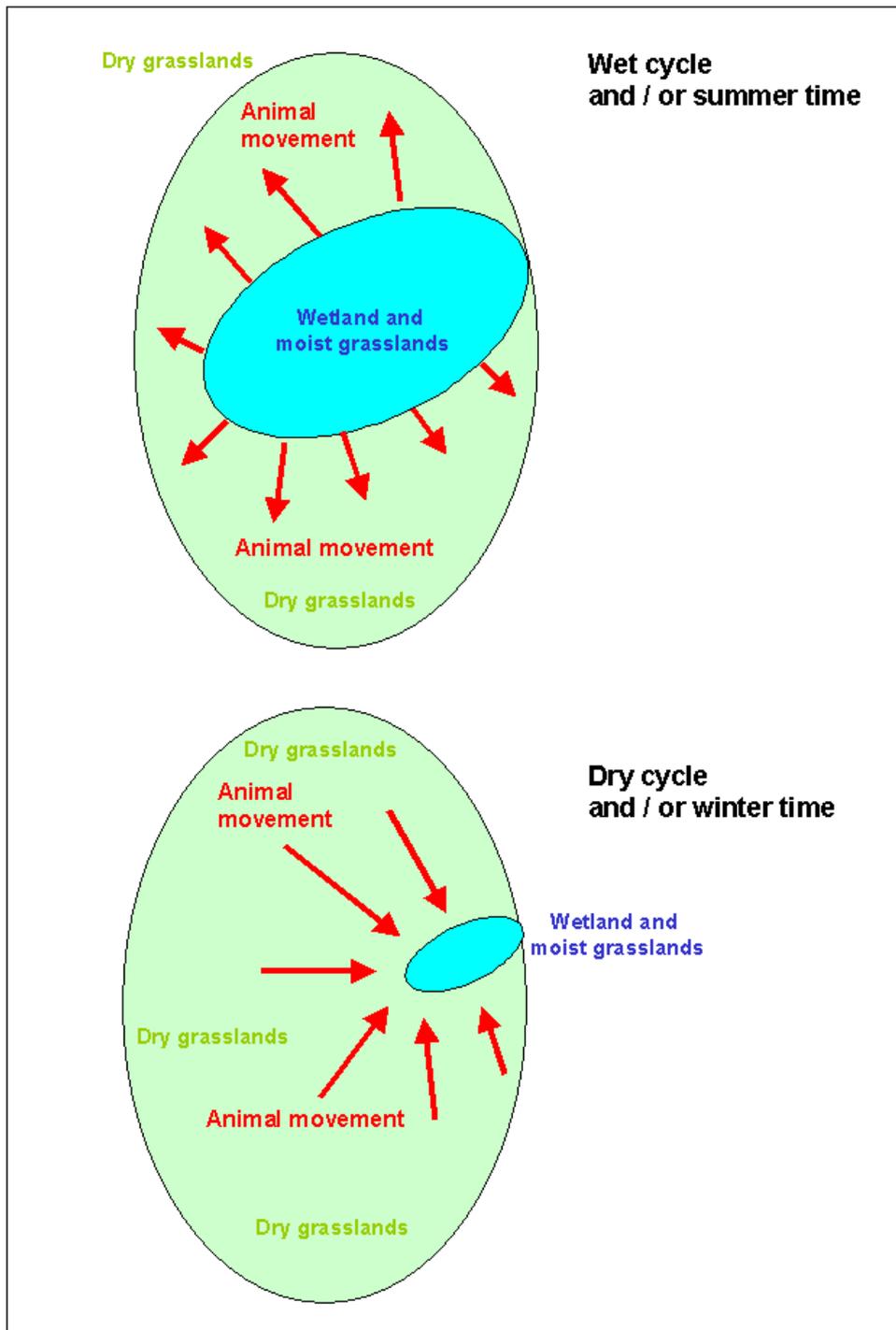


Fig. 15: Conceptual model of the functioning of the 'core' area of the Banhine National Park.

### **4.3. Livestock numbers**

A total of 694 cattle and 544 goats were recorded. They were mostly found close to the remaining natural pans as well as close to settlements and water wells (Fig. 16).

The number of cattle and goats appears to be rising sharply. Whereas this does not as yet present a big problem in terms of negative impact on the grazing resource, the consequences of this trend are significant.

The increasing livestock numbers will undoubtedly lead to an increased expectation by the local communities as to their rights of access to the natural resources. How will the livestock number further increase and how will this impact on the recovery of the Park, particularly where it concerns large grazing species such as wildebeest, zebra and buffalo?

The livestock often use the same general paths to get to and from the water. This has resulted in some very obvious degradation corridors that stretch for kilometres through the landscape (Fig. 17.).

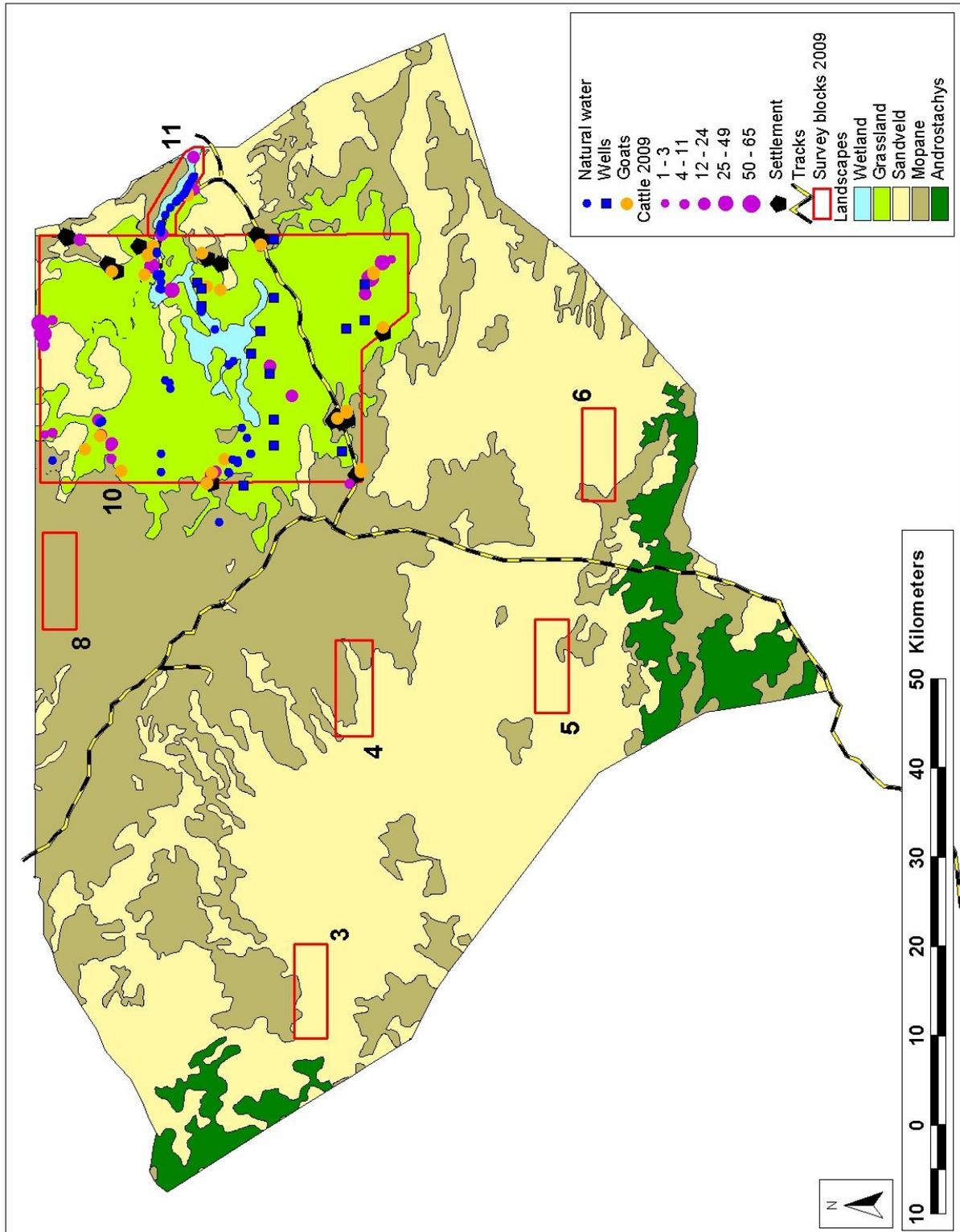


Fig. 16: Distribution of livestock and settlements in relation to natural and artificial water in Banhine (2009). Note cattle on the extreme northern boundary are close to standing water that is found just outside the Park.

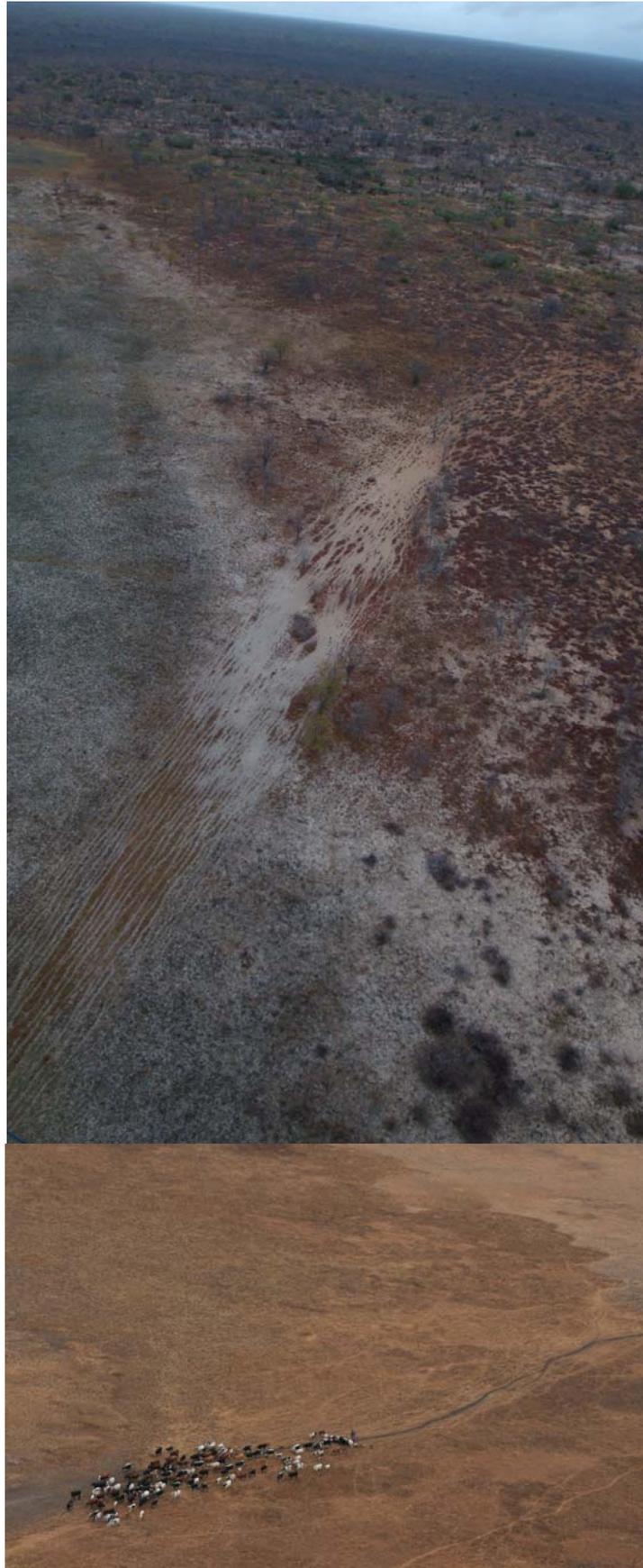


Fig. 17: Degradation 'corridor' as a result of livestock movement to and from water.

#### 4.4. Current animal numbers in the context of carrying capacity

How do the densities that were recorded compare to what the habitat could support? This is an important question to ask as its answer is very relevant to the efforts to restore the Park.

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 420 kg km<sup>-2</sup>.

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<sup>-2</sup> is calculated. The 'core' area of Banhine is stocked at only 20% of its theoretical value.

Given the fact that the habitats are generally in a very good condition, it is only the past and current illegal hunting that can be considered to be responsible for this state of affairs.

## **5. Restoration of the Park**

Although a number of species appear to be doing well and although some immigration from the Limpopo or Gonarezhou Park is likely (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 3 wildlife counts (2004, 2007 and now in 2009) 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 therefore becomes critical that a 'Sanctuario' should not permanently fence off a significant part of the 'core'. Rather, the 'Sanctuario' should be of a very temporary nature. A large 'boma' system whereby the re-introduced animals are allowed to settle for a few weeks at most should be sufficient. It is very unlikely that the re-introduced animals would leave the 'core' because its large size and plentiful resources.

## **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. All efforts should be made to in future cover the same area of nearly 100,00 ha that represents the dynamic core of the Park. A bi-annual count therefore 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).

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**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 Portuguese names of wildlife observed during the wildlife surveys of the Parque Nacional de Banhine during 2004, 2007 and 2009.

species listed alphabetically with English names first

<b>Common name (English)</b>	<b>Common name (Portugese)</b>	<b>Species (scientific name)</b>
African civet	Civeta-africana	Civettictis civetta
African Wild Cat	Gato bravo africana	Felis lybica
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 Portuguese names first

<b>Common name (Portugese)</b>	<b>Common name (English)</b>	<b>Species (scientific name)</b>
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
Ratel / Melivora	Honey badger	Mellivora capensis