Aerial Census Report for Maputo Special Reserve, Futi Corridor & the Sanctuary Area
December 2019

AERIAL CENSUS REPORT FOR MAPUTO SPECIAL RESERVE
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1.   INTRODUCTION

The aerial census was undertaken towards the end of July 2019, and the overall aim was to determine the current status of some of the most abundant large herbivore species in Maputo Special Reserve. The status of the re-introduced and supplemented species remains a priority, particularly the further supplementation of game over the last 8 years, and so it was important to undertake an aerial census in 2019 as the previous aerial census was undertaken in 2016. The other main objective was to continue gathering long-term data regarding the species' population trends. The census also provides information on the spatial distribution of the game populations, which in turn provides information on the habitat use of the species.

The count was initially planned for the beginning of August, but in order to tie in counts in the area the count was undertaken from 22 to 24 July. Despite some rain having been received throughout the winter months, the rainy season had not yet begun. However, due to these winter rains as well as the temperate winter experienced in 2019, some leaf flush had already started which made observation of some species, such as nyala, difficult. However, as the count was undertaken earlier than the 2016 count, the sightings of most species were higher.

This transect aerial census builds on those of the previous years, and will contribute to the understanding of long-term herbivore population trends. The methods used were the same as previous censuses. However, a Long Ranger was used in 2019 as opposed to a Hughes 500 helicopter which had been used for the preceding years. Two methods were used, namely (i) total area aerial count and (ii) transect distance sampling count.

The aerial census was undertaken by Tristan Parsons (pilot), Cathariné Hanekom (co-ordinator & recorder) with Leonard Muller, Natercio Ngovene, Rodolfo Cumbane, Brian Neubert and Philip Jordaan as observers.

2.   METHODS

Aerial Census

a)   *Total Aerial Count*

1.   A helicopter containing a minimum of four people (pilot & recorder in front, and two observer in back) was flown on pre-determined, parallel east-west orientated transects over the reserve, and with a north-south orientation over the Futi Corridor and Sanctuary areas. These transects are situated 1km apart and arranged systematically to cover the whole census area (Appendix 1).

2. The helicopter was flown at 90m (300ft) above the ground and at an air speed of approximately 30-40 knots. Transects were flown in the morning and afternoon for periods of up to a maximum of 3hrs at a time. This resulted in three survey sessions per day. The hottest part of the day was avoided as far as possible, as animals tend to rest under shade in the heat of the day and consequently are more difficult to spot.

3. Devices were fitted to both sides of the helicopter which, when flying at a height of 90m, demarcated a distance of 500m on each side of the helicopter. All individuals of all herbivore species were recorded in the 1km wide belt.

4. Where large groups of species, such as elephant, hippo and wildebeest, were spotted, the helicopter deviated from the transect line, a total count was undertaken, the locality captured and then returned to continue the count from the point of departure.

5. All data were captured on a notebook computer using Cartalinx v1.2 (Clark Labs, Clark University, 1999) which, when connected to a GPS unit, allowed the simultaneous collection of flight path information, animal numbers (as way points) and the number of the transect being traversed.

6. Where the number of sightings and their distribution allowed, mapping of the distribution of species was done by importing the Cartalinx data into ArcGIS.

b) *Distance Sampling*

1. Data were collected for the distance sampling analyses at the same time as for the total count.

2. In order to enable Distance Sampling to be applied to the census results, counting bars were fitted to both sides of the helicopter which, when flying at a height of 90m, demarcated a distance of 500m on each side of the helicopter. The 500m was further divided into five sectors: 0-30m, 31-90m, 91-180m, 181-300m and 301-500m. This division differs from previous years and is based on the vegetation and thus associated visibility of game. Whenever an individual or group of individuals were observed they were recorded as occurring in one of the distance sectors.

3. Animal observations recorded during the aerial census were edited and then exported directly to Distance 6 from the Microsoft Access database constructed whilst entering the data using Cartalinx. Where the number of observations allowed, density along each transect and from this population size, was estimated using the statistical routines in distance 6 (Thomas *et.al.* 2001).

4. A statistically robust estimate can only be derived for species with approximately 60 sightings. Although species with observations as low as 30 can also be analysed with Distance, these estimates should not be considered reliable but rather considered as best estimates of population sizes for those species which have been under-sampled.

3. RESULTS

Aerial Counts

The complete aerial survey of the entire reserve (79 594ha), the Futi Corridor (3 120ha) and the Sanctuary area (8 000ha), took two and a half days (17hrs) to complete (Table 1). This was done in three (one to three) sessions per day, so as to allow for re-fuelling and avoidance of the hot midday periods.

The counting days were mild with good visibility on the first and third days, while the second day heavy smoke was experienced due to the massive wild fire which had been started towards the north of the reserve and of which the smoke was blowing southwards. Game

visibility remains fair to poor in the sand forest covered areas, as is expected, but more nyala were counted in the 2019 count that preceding years.

Table 1. Aerial survey flight sessions, 2019.

Day	Session	Start	End	Hrs
1	1	09:00	10:00	1
	2	10:52	12:57	2.05
	3	14:47	16:48	2.01
2	4	07:20	09:30	2.1
	5	10:20	11:30	1.1
	6	13:45	16:15	2.7
3	7	06:46	09:05	2.59
	8	09:40	11:03	1.63
	9	11:27	13:00	1.73
				16.91 (17)

a)   *Total Aerial Count and Distance Analysis*

With respect to distance sampling, grey duiker, red duiker, elephant, hippo, impala, nyala, reedbuck, warthog, waterbuck wildebeest and zebra had sightings of more than 20 observations. Red duiker, reedbuck, wildebeest and zebra had more than 60 observations, with hippo having almost 50 and waterbuck over 50 sightings. However, all species with almost and over 30 sightings were also analysed using Distance (Table 2). Elephant were also analysed using Distance, as an attempt to estimate the total elephant population in MSR, in the absence of monitoring, despite only having 32 observations. The 2016 and 2019 counts produced almost identical numbers of observations and minimum counts, however, the 2019 Distance analysis had a higher confidence interval.

Table 2. Large herbivore population estimates from Distance sampling, 2019.

Species	Distance sampling estimates for 2016	
	Estimate	95% CV
Duiker, Grey	322*	173 – 602 / 31.4%
Duiker, Red	543	380 – 777 / 17.7%
Elephant	193	146 – 255 / 13.2%
Hippo	196	152 – 251 / 12%
Impala	252	176 – 361 / 16.2%
Nyala	333	241 – 460 / 16.1%
Reedbuck, Common	2241	1755 – 2861 / 12.1%
Warthog	148	112 – 195 / 13.2%
Waterbuck	227	148 – 348 / 20.8%
Wildebeest, Blue	273	185 – 403 / 19%
Zebra	378	303 – 472 / 10.9%

*Unreliable estimate

The number of groups and the total number of animals counted in Maputo Special Reserve, the Futi corridor and the Sanctuary Area for 2019 and past information is summarised in

Table 6. The distribution of sightings for the larger, abundant and more significant species is presented in Figures 2 – 15.

Best Estimate of Numbers

Acceptable estimates for 10 species (Table 3) was achieved. For all other species the counts were higher from that of the past few years, and although a more consistent trend can be observed from 2006 to 2016, the significant increase in counts is largely due to a more appropriate counting technique (Table 4).

Table 3. The final large herbivore population estimates for 2019.
Estimation method: 1 – Known group; 2 – Total Area Count; 3 – Distance Sample; 4 – Introduction Based Growth Estimate; 5 – Field Ranger Encounter Rates; 6 – informed Guess; 7 – Drone count; * - Unknown.

Species	Total Count	Distance Sample	Final Estimate
Buffalo	45	-	199[4]
Bushbuck	13	-	
Bushpig	44		50[6]
Crocodile	72	-	150*
Duiker, Grey	33	173 – 602 / 31.4%	322[3]
Duiker, Red	90	380 – 777 / 17.7%	543[3]
Eland	0	-	20[4]
Elephant	269	146 – 255 / 13.2%	400[2,5]
Giraffe	48		48[2]
Hippo	211	176 – 361 / 16.2%	196[3]
Impala	254		906[4]
Jackal, Side-striped	1		*
Kudu	40		160[4]
Nyala	82	281 – 634 / 20.3%	333[3]
Reedbuck, Common	2125	1887 – 3611 / 16.3%	2241[2]
Serval	-		*
Steenbok	3		*
Suni	1		*
Warthog	82	112 – 195 / 13.2%	148[2]
Waterbuck	287	148 – 348 / 20.8%	1250[4]
Wildebeest, Blue	807	185 – 403 / 19%	807[4]
Zebra	828	303 – 472 / 10.9%	1124[4]

Sightings of the introduced species were significantly higher than in 2016, despite additional supplementations of the populations. Some species have seen significant increases during the 2016 aerial census, which can be ascribed to the earlier timing of the count as well as the continued northwards dispersal of some of the re-introduced species. The increase of some species, such as impala, blue wildebeest and zebra, since introduction was also noticeable. There is some concern that there may have been some double counting of wildebeest, but this will be cleared up in the next count. A summary of the re-introductions to date is detailed in table 5.

Reedbuck remain the most abundant species in the reserve, with a total of 2125 individuals having been counted in 2019, which is a significant increase from the 2016 count of 873 (Figure 2). Blue Wildebeest and Zebra have increased significantly from 351 to 797, and from 446 to 828 respectively, and have begun to move slightly further afield from their introduction areas (Figures 3&4). Kudu have again shown a slight increase in sightings, while giraffe sightings increased significantly from 28 individuals in 2016 to 48 individuals in 2019.

Since the 2006 aerial census the hippo population has shown a consistent increase. However, the hippo count decreased slightly from 219 counted in 29 groups in 2016 to 211 counted in 42 groups in 2019 spread between the different water bodies (Figure 5). This decrease can presumably be ascribed to the low water levels due to the continued drought, and the supposition that many hippo have moved out of the park to alternative water bodies. This can be borne out in the fact that the hippo count in Ndumo Game Reserve, which is linked to Maputo Special Reserve via the Usuthu/Rio Maputo river, has seen a dramatic decrease in hippo numbers in their 2019 count. The anthropogenic influences on these transboundary aquatic species need to be more thoroughly investigated in the future to provide greater insight into the population drivers.

The total count of red duiker has increased from 53 in 2016 to 90 in 2019 (Figure 6), while the grey duiker has also increased from the total count of 22 in 2016 to 33 in 2019. The earlier timing of the count as well as the greater visibility provided by the Long Ranger helicopter.

The total count for bushpig has shown a marked increase after a consistent decrease from the counts over the past few years, increasing from 6 counted in 2016 to 44 in 2019. This is a direct result from a more accurate count facilitated by a more appropriate helicopter. Bushbuck have remained mostly unchanged over the past number of years up to 2016, but showed a significant increase from 19 in 2016 to 45 in 2019.

Sightings for species such as steenbok and suni remain low, with only 2 sightings of steenbok being made in 2019, the same as in 2016. However, it is the first time sinc e2008 that a suni was counted from the air, albeit only one individual. This can again be ascribed to the Long Ranger and the better visibility from this type of helicopter as compared to a Hughes which has been used for the preceding years. The sightings of other more forest dwelling species, such as kudu and nyala also increased in the 2019 count, from 33 to 40 and 41 to 82 respectively. In total 45 female buffalo were counted in the 2019 count.

The total counts for impala have continued to show a dramatic increase over the years, with the 2019 count again increasing from 162 in 2016 to 254 in 2019.

From these counts it is evident that the re-introduced populations are steadily increasing and flourishing (Table 5). It is well-known that re-introduced species often take some time to show marked increases in number and to start showing natural dispersal patterns within the landscape (Table 8). However, the Long Ranger helicopter used for the 2019 count also afforded greater visibility of species across the spectrum, and thus more accurate counts of all species, and particularly the re-introduced species, could be obtained.

The total number of elephants counted in the 2019 survey was 269, which is slightly lower than the 2016 survey of 286. No herds were counted outside the reserve. (Figure 7). In order to obtain better estimates of the population, it has been suggested that collars be deployed based on geographical location, and in 2019 this was done. These will provide

valuable information regarding movement and landscape use, as well as population estimates within an unknown population. The majority of elephant sightings continue to be made between mid-morning and the afternoon, during the hotter times of the day (Table 6), and so mid-day elephant specific counts would provide more accurate elephant counts.

Table 6. Elephant sightings per survey session.

Session	No of Groups	Number Counted
Day 1 – 1 (09:00 - 10:00)	2	4
Day 1 – 2 (10:52 – 12:57)	2	17
Day 1 – 3 (14:47 – 16:48)	1	1
Day 2 – 1 (07:20 – 09:30)	1	1
Day 2 – 2 (10:20 – 11:30)	4	39
Day 2 – 3 (13:45 – 16:15)	7	45
Day 3 – 1 (06:46 – 09:05)	4	25
Day 3 – 2 (09:40 – 11:03)	9	135
Day 3 – 3 (11:27 – 13:00)	0	0

4.   HUMAN ACTIVITY

Many homesteads still remain occupied within Maputo Special Reserve, and signs of human impact are evident in the form of agricultural plots, gillnets in the pans and the continued maintenance of fish and crab kraals in the tidal areas of Maputo Bay.

A total of 4 gill nets were recorded in the 2019 count compared to 6 in the 2016 count, which is a negligible reduction.

The numbers of cattle in Maputo Special Reserve have decreased significantly from 611 counted in 2016 to 169 in 2019, while goat numbers have also decreased significantly from 278 in 2016 to 44 in 2019 (Table 7). However, as part of the long-term goals for the protected area, the number of cattle and goats need to be substantially reduced and the homestead relocation programme accelerated.

Table 7. Current human activity impacts recorded during the survey.

Species / Activity	2008	2009	2010	2011	2012	2013	2014	2015	2016	2019
Cattle	50	119	277	149			585	513	611	169
Domestic dogs									3	
Goats		387	623	466			259	397	278	44
Gill nets				1			6	1	6	4
Boats										29

The high cattle numbers and human agricultural activity in the protected area continues to result in the uncontrolled burning of vast tracts of grasslands for grazing for domestic stock. This uncontrolled burning also damages the sand forest patches found within this mosaic, the impact of which may be irreversible in the long term. The areas burnt in 2019 were some of the most extensive in the past few years, and with the continued drought in southern Africa, this may have serious consequences in the medium to long term. The thick smoke affected the second day's count due to poor visibility conditions.

5.   CONCLUSIONS

Overall, the aerial census conditions were good during the 2019 count. However, the smoke pollution from the uncontrolled fire on the second day proved problematic for sightings until mid-morning. The total area counts produced generally good population estimates, with most species' counts having increased significantly from previous counts.

Current elephant estimates are similar to most previous estimates, but these results need to be treated cautiously. It is perhaps time that more specific elephant counts and monitoring be applied to the elephant population. Given man power limitations, additional GPS logger or satellite collars are suggested as useful tools with which to locate the herds and some free roaming bulls. These data are will give valuable insight into which areas are used by the elephants, as well as how their movement patterns may change once the area is completely fenced. In this way areas of possible future conflict or fence-breaking may be predicted or detected early so as to avoid damage to infrastructure and possible human wildlife conflict.

As expected, the species found to be the most abundant are hippo, impala, reedbuck, elephant, grey duiker, red duiker, waterbuck, blue wildebeest and zebra, while giraffe populations are increasing steadily. The supplementation of waterbuck was confirmed with the count, with 287 individuals being counted in 2019.

From the distribution patterns of the game populations, it is suggested that any future re-introductions be focused further north within the protected area. Most re-introduced populations remain concentrated in the south of the reserve, although they are now beginning to disperse further north and eastwards from their initial release locations.

Of significance is the sharp decrease in cattle and goat numbers present in the reserve. Although this is a positive situation, these numbers are unsustainable in the long term given the objectives for the reserve and the re-introduction of a number of species, and must be managed to a point of complete elimination from the reserve.

6.   RECOMMENDATIONS

From the results obtained, it was felt that the 2019 aerial census effort was a great success, and some recommendations can be made and should be incorporated into the following census programme:

1)   When possible the game population census for Maputo Special Reserve, the Futi corridor and Sanctuary area should continue to be undertaken using the methods described here and reported upon. Of particular note is the use of a Long Ranger helicopter, which has resulted in higher sightings as well as more accurate counts.
2)   The next census should be conducted between the end of July and the end of August, prior to the rainy season and thus prior to the vegetation flushing. The same equipment and software should be used. The use of a larger helicopter, such as a Long-Ranger, has proven more reliable and should be retained.
3)   Ensure that the census is completed at a flight speed of 30kts, and that flying is not done during the hotter midday periods and are completed prior to nightfall.
4)   In the case of the centre of the reserve, as far as possible these areas should be covered towards the middle to afternoon of the day. This will increase the probability of locating the elephant in the reed bed areas or near the water bodies.

5) Graphical analyses of the trends of the more important species should continue to be undertaken.
6) Additional counts to be undertaken to supplement counts for smaller species, such as suni, or these may be conducted in the form of research projects to compile base line surveys.

7. REFERENCES

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igure 1. The census flight path based on the defined transects, covering the MSR, Futi Corridor and Sanctuary areas.

Figure 2. The distribution of reedbuck in Maputo Special Reserve, 2019.
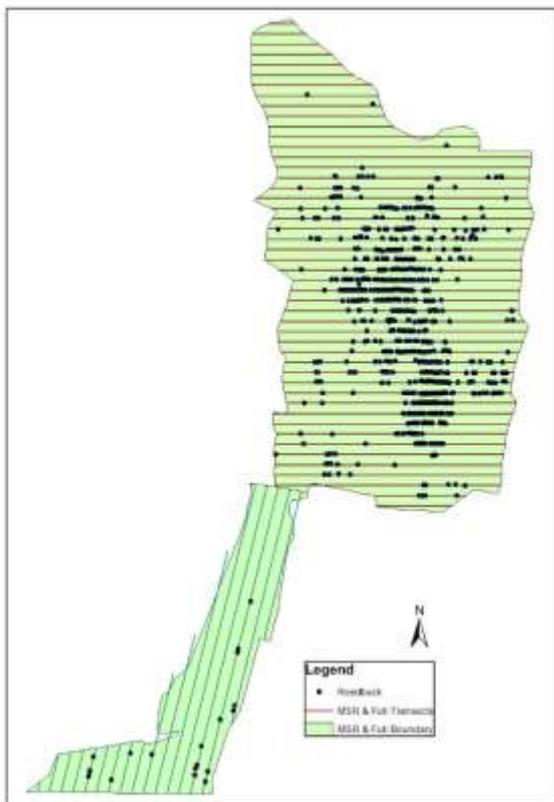
Figure 3. The distribution of blue wildebeest Maputo Special Reserve, 2019.
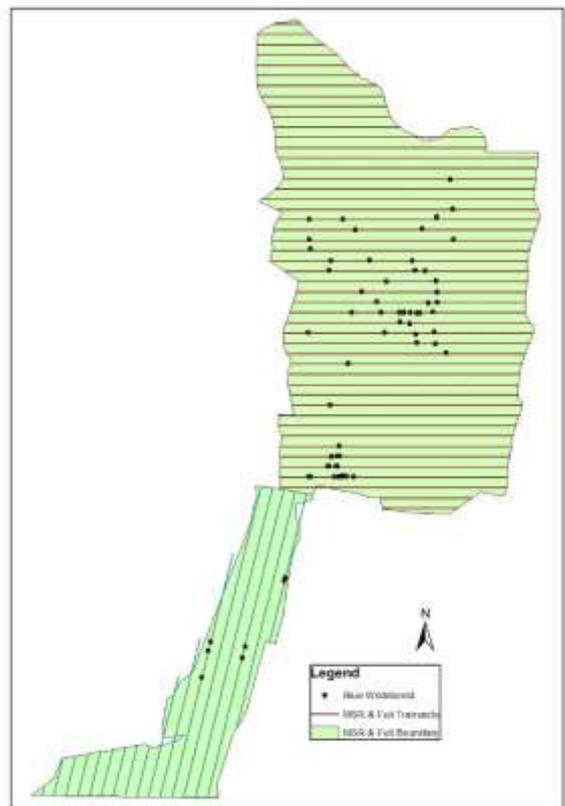
Figure 4. The distribution of Zebra in Maputo Reserve, 2019.
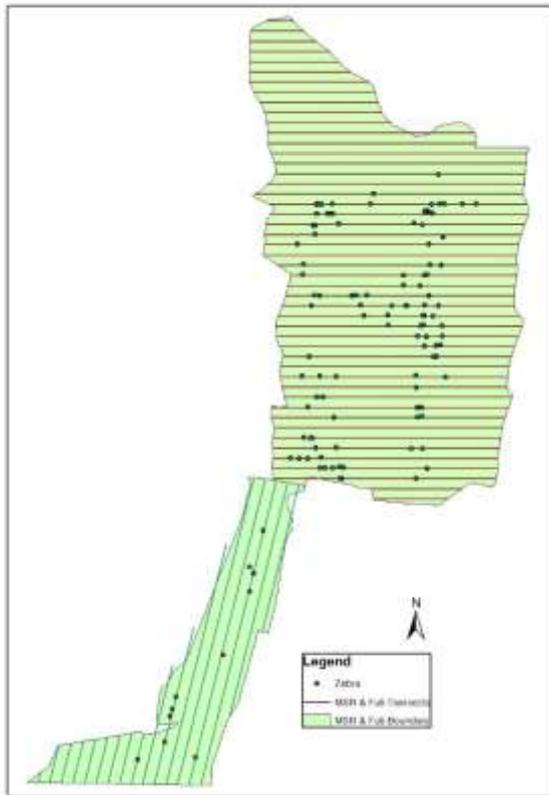
Figure 5. The distribution of Hippo in Maputo Special Reserve, 2019.
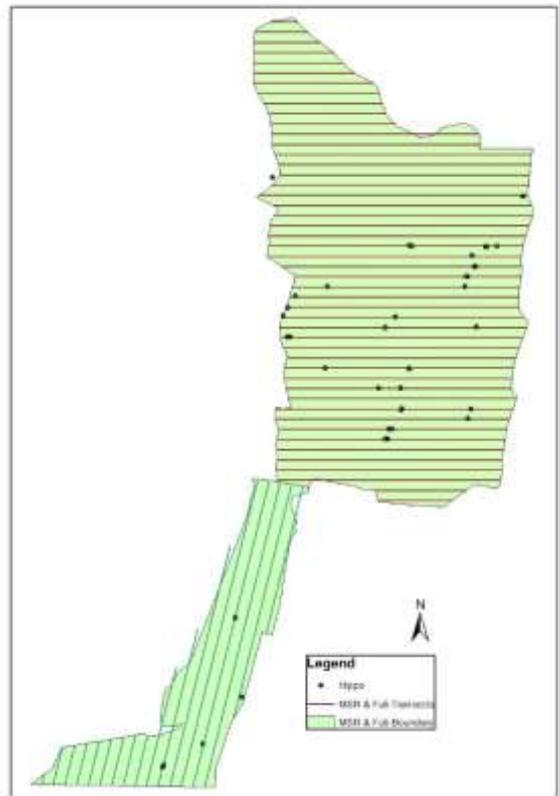
Figure 6. The distribution of Red Duiker in Maputo Special Reserve, 2019.

Figure 7. The distribution of Elephant in Maputo Reserve, 2019.
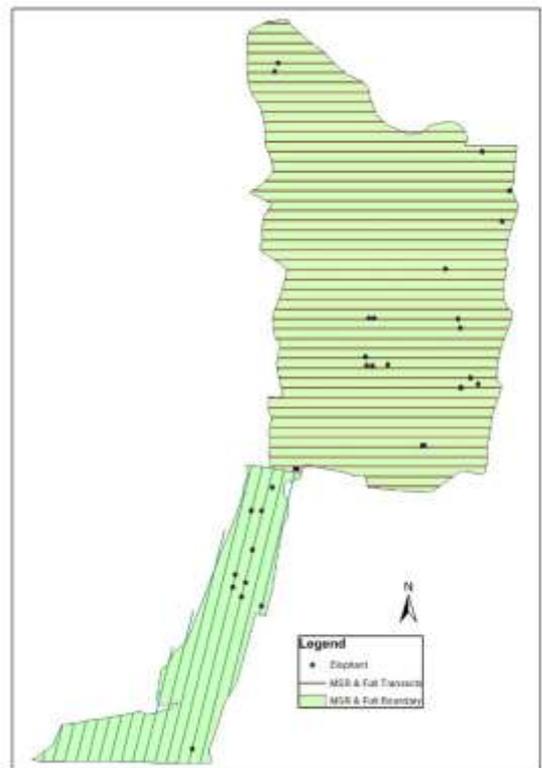
Figure 8. The distribution of Grey Duiker in Maputo Special Reserve, 2019.

Figure 9. The distribution of Buffalo in Maputo Reserve, 2019.
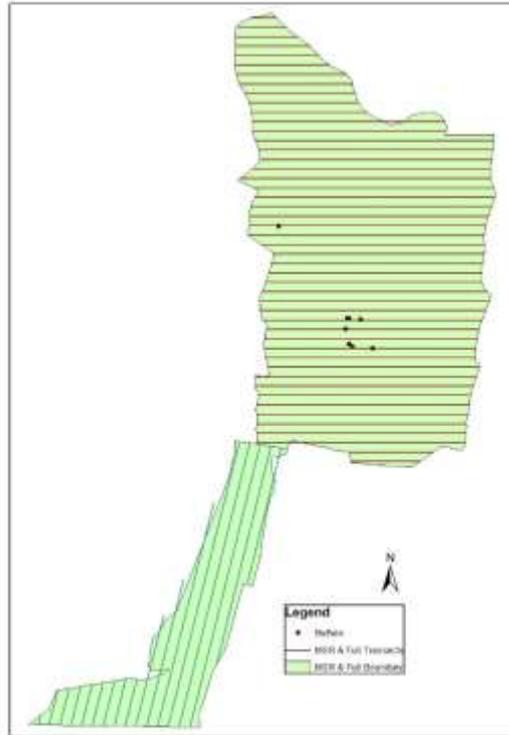
Figure 10. The distribution of Crocodile in Maputo Maputo Special Reserve, 2019.

Figure 11. The distribution of Giraffe in Reserve, 2019.
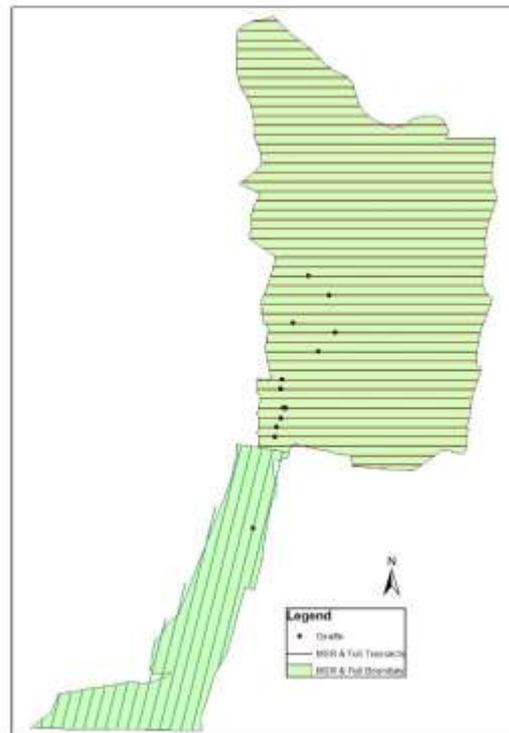
Figure 12. The distribution of Impala in Maputo Special Reserve, 2019.
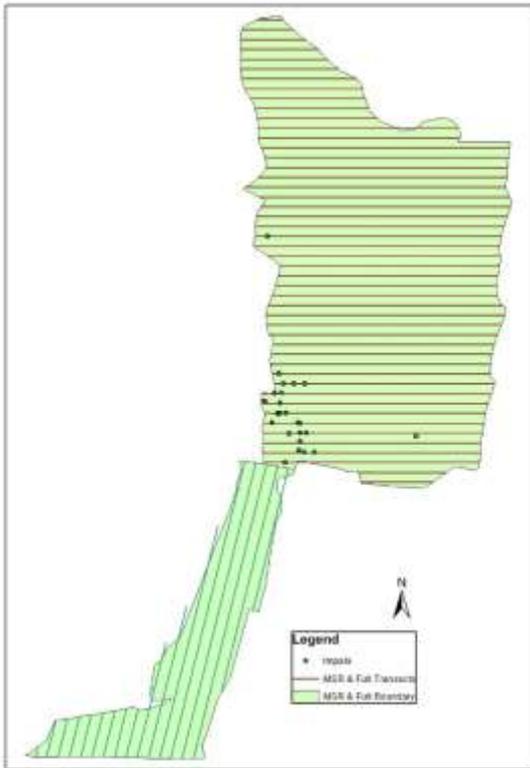
Figure 13. The distribution of Nyala in Maputo Reserve, 2019.

Figure 14. The distribution of Warthog in Maputo Special Reserve, 2019.

Figure 15. The distribution of Waterbuck in Maputo Reserve, 2019

Table 4. Total count estimates for large herbivores in MSR, up to and including 2019.

Species	1972 Tello	1995 Hatton	2005 Aerial Census Helicopter	2006 Aerial Census Helicopter	2008 Aerial Census Helicopter	2011 Aerial Census Helicopter	2012 Aerial Census Helicopter	2013 Aerial Census Bathawk	2014 Aerial Census Helicopter	2015 Aerial Census Helicopter No. Groups	2015 No. Counted	2016 Aerial Census Helicopter No. Groups	2016 No. Counted	2019 Aerial Census Helicopter No. Groups	2019 No. Counted
Buffalo														8	45
Bushbuck			18	30	33	8	27	30	23	21	23	17	19	8	45
Bushpig			8	102	78	9	33	39	27	7	24	3	6	13	44
Crocodile		1		24	42	23	41	19		13	29	20	26	23	72
Duiker, Grey		12	12	40	37	21	22	12	42	21	29	21	22	31	33
Duiker, Red		14	37	113	122	28	50	33	50	86	96	51	53	83	90
Elephant	350	150	9	329	368	228	264	288	239 (In-147, Out-92)	25	172	34	286 (Plus 14 outside)	32	269
Giraffe							1	9	35	2	21	3	28	14	48
Hippo	272	5	4	179	140	196	168	185	181	42	268	29	219	42	211
Impala							52	33	51	3	40	5	162	27	254
Jackal, Side-striped				4	3				2			1	1	1	1
Kudu				6	2	3	15	3	26	6	31	10	33	11	40
Nyala		1	2	47	8	18	80	87	8	41	89	25	41	34	82
Reedbuck, Common		22		797	824	309	598	355	499	378	819	386	873	896	2125
Rhino, White	40														
Serval											1				
Steenbok		1		3	13	3	8	10	5			2	2	1	2
Suni		5	10	7	3									1	1
Warthog								2	19	8	16	8	17	29	82
Waterbuck				4	3				7	3	10	1	2	53	287
Wildebeest, Blue								62	126	16	276	25	351	70	797
Zebra						24	177	115	270	37	303	37	446	118	828

Table 5. Summary of game re-introduced to MSR – 2010-2019.

SPECIES	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Buffalo	0	0	0	0	0	0	0	31	42	126	**199**
Eland	0	0	0	0	0	0	0	0	0	20	**20**
Giraffe	0	0	8	12	0	0	0	12	0	6	**38**
Impala	22	0	74	75	0	0	199	494	20	22	**906**
Kudu	0	0	84	26	0	0	0	50	0	0	**160**
Nyala	20	0	74	72	0	0	0	236	49	0	**451**
Oribi	0	0	0	0	0	0	0	0	0	46	**46**
Warthog	9	0	33	48	0	0	50	99	0	0	**239**
Waterbuck	0	0	0	0	0	0	204	799	0	247	**1250**
Wildebeest	0	0	0	73	0	127	60	200	0	29	**489**
Zebra	3	24	159	88	0	97	60	401	95	197	**1124**
Totals	**54**	**24**	**432**	**394**	**0**	**224**	**573**	**2322**	**206**	**693**	**4922**