

Aerial Census Report for Maputo Special Reserve, Futi Corridor & the Sanctuary Area
January 2022



AERIAL CENSUS REPORT FOR MAPUTO SPECIAL RESERVE JANUARY 2022

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1. INTRODUCTION

The aerial census was undertaken towards the middle of September 2021, 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 since the large-scale supplementation of game in 2017 and subsequent years. The previous aerial census was undertaken in 2019, and due to limited financial resources due to the Covid-19 pandemic in 2020, it was important to undertake an aerial census in 2021 to avoid too great a gap between aerial counts such as occurred between 2016 and 2019. 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 14-16 September, but due to permit delays due to Covid-19 shutdowns of the required offices, the count was undertaken from 18 to 20 September. Despite some rain having been received throughout the winter months, the rainy season had not yet begun. Some leaf flush had already started but this did not significantly hamper observations of traditionally difficult to count species, such as nyala. The sightings of most species were higher in the 2021 count, but interestingly those species not supplemented showed figures very similar to the 2016 count, including nyala which had not been significantly supplemented since 2017.

This transect aerial census data 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. A Long Ranger was again used as in the 2019 count. 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 (one session) and Brian Neubert as observers.

The census was made possible through funding from the National Administration for Conservation Areas (ANAC) and the Peace Parks Foundation.

2. METHODS

Aerial Census

a) *Total Aerial Count*

1. A helicopter containing a minimum of four people (pilot & recorder in front, and two observers 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 an average of 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, wildebeest and zebra, 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 laptop 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 is the same as used in 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 7.3 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 (Thomas *et.al.* 2001).
4. A statistically robust estimate can only be derived for species with approximately 60 sightings and more. 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. This is also borne out by the confidence intervals of these estimates.
5. Those species which naturally congregate and have restricted distribution, such as hippo and crocodile, the count provided a minimum estimate for the population.

3. RESULTS

Aerial Counts

The complete aerial survey of the main body of the reserve (79 594ha), the Futi Corridor (3 120ha) and the Sanctuary area (8 000ha), took two and a half days (19hrs) to complete (Table 1). This was done in three sessions on day one and three, and in four sessions on day two. This allowed for re-fuelling and avoidance of the hottest 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, 2021.

Day	Start	End	Hrs	Total Hrs
1	08:20	11:05	2,45	7,02
	12:12	14:49	2,37	
	15:32	17:12	1,40	
2	06:47	07:43	0,56	7,37
	08:42	11:40	2,58	
	13:00	15:37	2,37	
	16:04	17:10	1,06	
3	07:04	07:26	0,22	4,01
	07:30	09:09	1,39	
	09:50	11:50	2,00	
				18,40 (19)

a) Total Aerial Count and Distance Analysis

With respect to distance sampling, bushbuck, grey duiker, red duiker, elephant, hippo, impala, kudu, nyala, reedbuck, waterbuck, warthog, wildebeest and zebra had sightings of more than 20 observations. Bushbuck, grey duiker, red duiker, impala, nyala, reedbuck, waterbuck, warthog, wildebeest and zebra had more than 60 observations, with hippo having 50 observations. 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 29 observations. The number of observations for the 2021 count were all significantly higher than those of previous years, as is also evidenced in the increased-minimum counts. Interestingly the 2021 Distance analysis showed higher confidence intervals for the plains game than the 2019 count, but lower confidence intervals for the forest and thicket dwelling species. However, the minimum counts for all species are high and in line with expected growth rates and the known introductions.

Table 2. Large herbivore population estimates from Distance sampling, 2021.

Species	Distance sampling estimates for 2016	
	Estimate	95% CV
Duiker, Grey	438	285 – 673 / 21.8%
Duiker, Red	870	600 – 1263 / 18.9%
Elephant	898*	554 – 1457 / 24.3%
Hippo	1277*	742 – 2198 / 27.7%
Impala	3787	2409 – 5953 / 22.8%
Nyala	1495*	906 – 2470 / 25.8%
Reedbuck, Common	8592	6710 – 11003 / 12.5%
Waterbuck	3364	2638 – 4290 / 12.3%
Warthog	923	676 – 1260 / 15.5%
Wildebeest, Blue	4365	3166 – 6018 / 16.2%
Zebra	3433	2598 – 4538 / 14.0%

*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 2021 and past data is summarised in Table 4. The distribution of sightings for the larger, more abundant and more significant species is presented in Figures 2 – 15.-

Best Estimate of Numbers

Acceptable estimates for 8 species (Table 3) was achieved. For most other species the counts were higher from that of previous 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 which reflects the high levels of game introductions since 2017 (Table 4).

Sightings of the introduced species were significantly higher than in 2016 and also higher than in 2019, which is to be expected given the high numbers of additional population supplementations. Some species have seen significant increases during the 2021 aerial census, which can be ascribed to the timing of the count as well as the continued northwards dispersal of some of the re-introduced species into the open grassland species, as is expected of plains game. The increase of some species, such as impala, blue wildebeest and zebra, since introduction was also noticeable, and interestingly they were found in larger groups. The introductions have clearly been successful for most of these species, given that their minimum counts were consistently higher than their predicted growth rate increases. 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 2933 individuals having been counted in 2021, which is a significant increase from the 2019 count of 2125 (Figure 2). Blue Wildebeest and Zebra have increased significantly from 797 to 1518, and from 828 to 1240 respectively, and have begun considerably further afield from their introduction areas (Figures 3&4). Kudu sightings continue to increase, and have shown a marked increase in both sightings and minimum count from 2019 to 2021, with the minimum count increasing from 40 to 108. Giraffe sightings increased significantly from 28 individuals in 2016 to 48 individuals in 2019, and again to 67 in 2021.

Table 3. The final large herbivore population estimates for 2021.

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	243	-	243 ²
Bushbuck	101	717 (434 – 1184) / 25.7%	101 ²
Bushpig	45	-	45 ²
Crocodile	148	-	148 ²
Duiker, Grey	68	438 (285 – 673) / 21.8%	438 ³
Duiker, Red	114	870 (600 – 1263) / 18.9%	870 ³
Eland	11	-	11 ¹
Elephant	180	898 (554 – 1457) / 24.3%	400 ^{2,5}
Giraffe	67	-	67 ²
Hippo	263	1277 (742 – 2198) / 27.7%	263 ²
Impala	822	3787 (2409 – 5953) 22.8%	822 ⁴
Jackal, Side-striped	9		*
Kudu	108		196 ⁴
Nyala	163	1495 (906 – 2470) / 25.8%	622 ⁴
Oribi	0		53 ⁴
Porcupine	1		*
Reedbuck, Common	2933	8592 (6710 – 11003) / 12.5%	2933 ²
Serval	1		*
Steenbok	21		*
Suni	0		*
Warthog	302	923 (676 – 1260) / 15.5%	1043 ⁴
Waterbuck	1224	3364 (2638 – 4290) / 12.3%	1224 ²
Wildebeest, Blue	1518	4365 (3166 – 6018) / 16.2%	1518 ²
Zebra	1240	3433 (2598 – 4538) / 14%	1240 ²

Since the 2006 aerial census the hippo population continues to show a consistent increase, and increased from 211 counted in 42 groups in 2019 to 263 counted in 50 groups in 2021 spread between the different water bodies (Figure 5). All the water bodies in the park were in good condition with high water levels, clearly anchoring the population in the park.

The total count of red duiker has increased slightly from 90 in 2019 to 114 in 2021 (Figure 6), while grey duiker increased markedly from the total count of 33 in 2019 to 68 in 2021 (Figure 8). The timing of the count as well as the greater visibility provided by the Long Ranger helicopter is clearly important for these smaller bodied species.

The total count for bushpig remained largely unchanged from 44 counted in 2019 to 45 counted in 2021. The sightings of bushbuck have increased dramatically from 13 counted in 13 groups in 2019 to 101 counted in 88 groups. The visibility provided by a Long Ranger is invaluable for these more cryptic species.

Sightings for species such as steenbok and suni remain low, with no suni having been counted in 2021. However, 21 steenbok were counted in 2019, the highest count over all the years. The use of the Long Ranger helicopter since 2016 has provided increased sightings in nyala from 41 in 2016, 82 in 2019 and 163 in 2021. Despite this being less than 50% of introduced individuals, this continued increase in sightings justifies the type of helicopter used, as forest dwelling species are extremely difficult to count from the air. In total 234 buffalo were counted in the 2021 count, which positively reflects their success post-introduction, with the predicted growth from the introduced individuals being 234.

The predicted growth based population for impala is 888, and the total count for impala in 2021 produced a figure of 822, which is indicative of the accuracy of the 2021 count. Many groups in excess of 15 individuals together were counted, while the largest group consisted of 85 individuals.

From these counts it is evident that the re-introduced populations are steadily increasing and flourishing, and the introduction can be considered a success (Table 4). 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. However, the continued use of a Long Ranger helicopter for the 2021 count is proving invaluable as it affords greater visibility of species across the spectrum, and thus more accurate counts of all species, particularly the re-introduced species, could be obtained. The counts for more cryptic and forest dwelling species are also more accurate than those achieved in previous years.

The total number of elephants counted in the 2021 survey was 180, a substantially lower count than the 269 counted in 2019. This was unexpected and given the good counting conditions and good visibility with the helicopter used, there does not seem to be an obvious reason for this decline. No herds were counted outside the reserve, and this situation may have been alleviated by the capture of 38 elephants from outside the Futi Corridor (Figure 7). Interestingly though, 69 elephants were counted in the Futi Corridor and 109 in the main body of the reserve. In order to obtain better estimates of the population, it has been suggested that collars be deployed based on geographical location, and in 2019 some were deployed. 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. The fixed-wing aeroplane as well as the drone on site could be used to undertake these mid-day counts, which would enable a number of repetitive counts to be done at a reduced cost.

Table 6. Elephant sightings per survey session.

Session	No of Groups	Number Counted
Day 1 – 1 (08:20 - 11:05)	0	0
Day 1 – 2 (12:12 – 14:49)	4	27
Day 1 – 3 (15:32 – 17:12)	1	1
Day 2 – 1 (06:47 – 07:43)	1	9
Day 2 – 2 (08:42 – 11:40)	4	37
Day 2 – 3 (13:00 – 15:37)	7	26
Day 2 – 3 (16:04 – 17:10)	1	9
Day 3 – 1 (07:04 – 07:26)	0	0
Day 3 – 2 (07:30 – 09:09)	3	52
Day 3 – 3 (09:50 – 11:50)	5	17

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 29 gill nets were recorded in the 2021 count compared to only 4 in the 2019 count, which is a significant increase. The Covid-19 restrictions on movements and employment may have been a contributing factor to this increase, but is difficult to measure.

The numbers of cattle in Maputo Special Reserve show a slight increase from 169 counted in 2019 to 180 in 2021, while goat numbers continue to decrease from 44 counted in 2019 to 30 counted in 2021 (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 as the burning regime implemented by the communities favours their livestock and the wildlife. The number of homesteads were not counted, but rather the number of structures, and these number 206.

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

Species / Activity	2008	2009	2010	2011	2012	2013	2014	2015	2016	2019	2021
Cattle	50	119	277	149			585	513	611	169	180
Domestic dogs									3		3
Domestic cat											1
Goats		387	623	466			259	397	278	44	30
Gill nets				1			6	1	6	4	29
Boats										29	18

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 2021 were again quite extensive but fortunately largely restricted to the north of the park.

5. CONCLUSIONS

Overall, the aerial census conditions were very good during the 2021 count, as is evident in the minimum count figures as well as the confidence intervals for the Distance Sampling results. Most species' counts continue to increase significantly from previous counts, again supporting the efficacy of the methods used.

Current elephant estimates are similar to the 2015 estimates which is surprising and cannot be ascribed to counting conditions or visibility. More specific elephant counts and monitoring need to be applied to the elephant population in order to obtain more reliable and consistent population estimates. Given manpower limitations, additional LoRa or satellite collars are suggested as useful tools with which to locate the herds and some free roaming bulls. These data will also give valuable insight into which areas are used by the elephants, as well as how their movement patterns may change seasonally. 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. The number of elephants crossing from Mozambique into South Africa, including Tembe Elephant Park, have dramatically increased in 2021, and so the collaring of free-roaming elephants is also necessary to try and understand the drivers behind these movements, thereby hopefully also reducing elephant-human conflict.

Other than elephant, all species occurring in Maputo Special Reserve showed significant increases, with those species which have been supplemented were seen in abundance. The 2021 count was also very successful in counting a number of traditionally more difficult species, such as bushbuck and nyala, as well as crocodiles. Those species found to be the most abundant are buffalo, hippo, impala, common reedbuck, warthog, waterbuck, blue wildebeest and zebra, while giraffe, kudu and steenbok populations are increasing steadily. The supplementation of eland was not wholly successful, with a number of mortalities post-introduction. Of the 20 eland introduced in 2019 only 11 remain, and these were counted in the 2021 count. It is suggested that species which are very region specific, such as eland, be sourced from the most appropriate areas to ensure they are better suited to the conditions of MSR and the coastal plain environmental conditions.

From the distribution patterns of the game populations, it is evident that the introduced species have started moving further north than seen in previous years. The efforts made to release these animals further north in the reserve have assisted with this dispersal. The number of sightings in the Futi Corridor continue to increase, which is a combination of targeted introductions as well as natural dispersal of game.

Of significance is the sharp decrease in cattle and goat numbers present in the reserve since 2016. 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 game species, and must be managed to a point of complete elimination from the reserve. Their biggest impact is in the form of ill-timed burning by the inhabitants to produce green grazing areas for their livestock. These burning regimes will eventually impact on available grazing for wildlife, as well as the negative impacts on sand forest as many of these fires burn large tracts of this traditionally dry forest.

6. RECOMMENDATIONS

From the results obtained, it was felt that the 2021 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 consistently 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 and even into the beginning of September, 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. The consistency of the counters used in 2021 also support these more reliable results, and so efforts should be made to keep the counters consistent. The Long-Ranger is able to accommodate additional spotters which will enable skills

transfer and training of additional counters, but the main counters should remain consistent on the individual days.

- 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 and can be done more affordably.

7. REFERENCES

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Figure 1. The census flight path based on the defined transects, covering the MSR, Futi Corridor and Sanctuary areas, depicting all species recorded in the 2021 census.

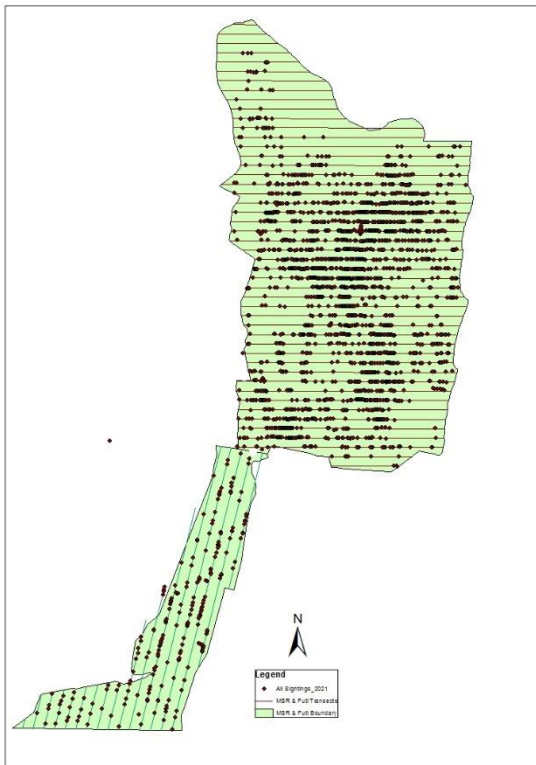


Figure 2. The distribution of Reedbuck in Maputo Special Reserve, 2021.

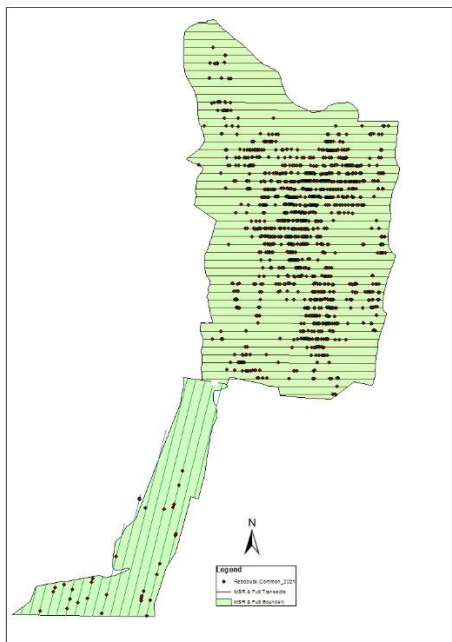


Figure 3. The distribution of Blue Wildebeest in Maputo Special Reserve, 2021.

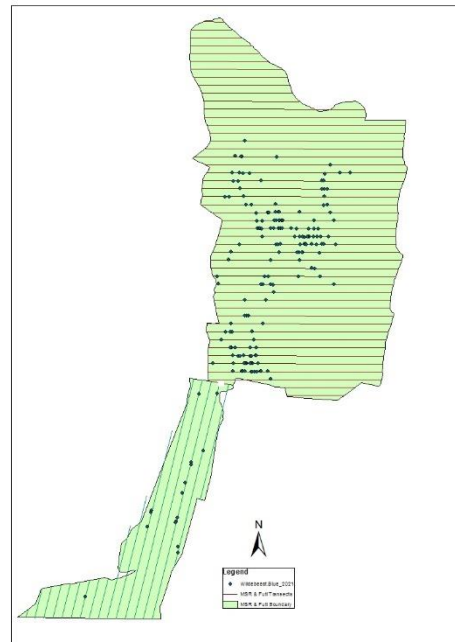


Figure 4. The distribution of Zebra in Maputo Special Reserve, 2021.

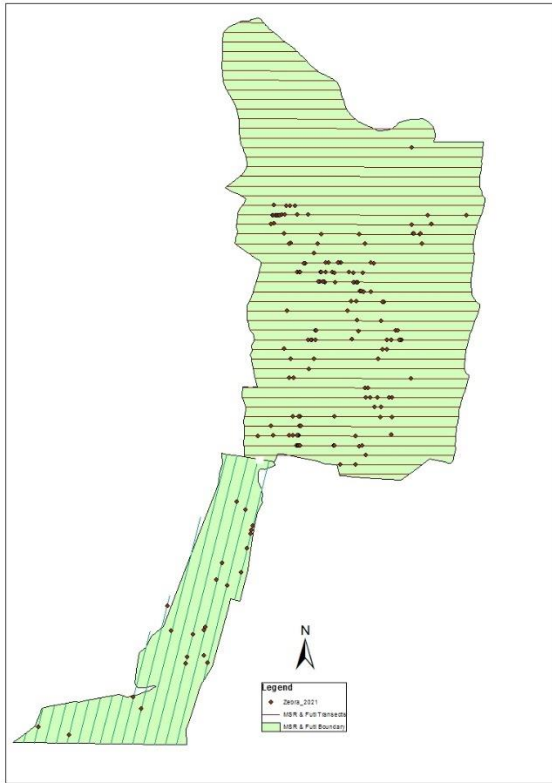


Figure 5. The distribution of Hippo in Maputo Special Reserve, 2021.

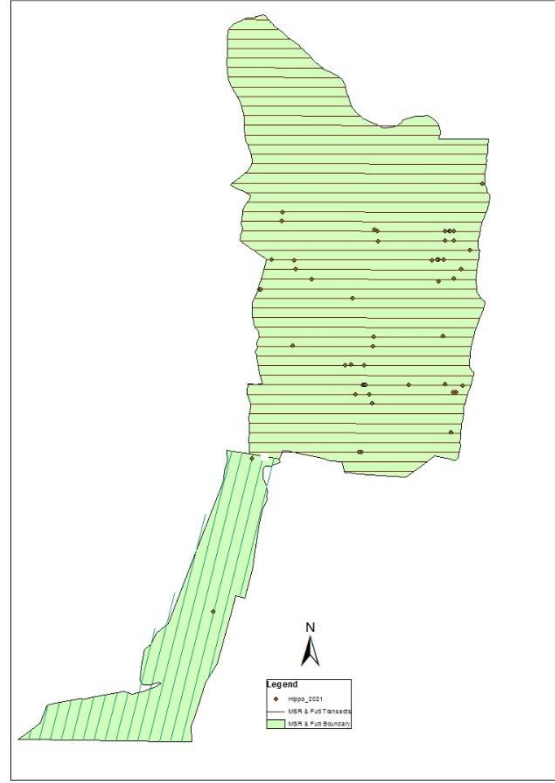


Figure 6. The distribution of Red Duiker in Maputo Special Reserve, 2021.



Figure 7. The distribution of Elephant in Maputo Special Reserve, 2021.



Figure 8. The distribution of Grey Duiker in Maputo Special Reserve, 2021.



Figure 9. The distribution of Buffalo in Maputo Special Reserve, 2021.



Figure 10. The distribution of Crocodile in Maputo Special Reserve, 2021.



Figure 11. The distribution of Giraffe in Maputo Special Reserve, 2021.



Figure 12. The distribution of Impala in Maputo Special Reserve, 2021.



Figure 13. The distribution of Nyala in Maputo Special Reserve, 2021.

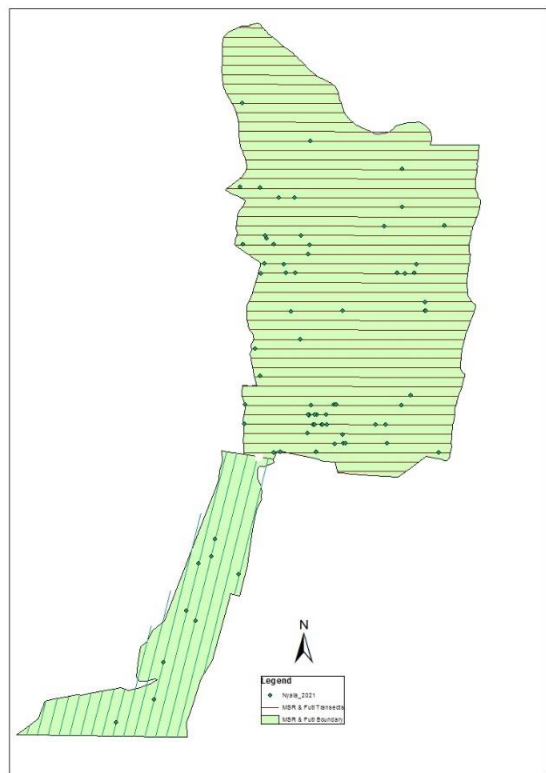


Figure 14. The distribution of Warthog in Maputo Special Reserve, 2021.

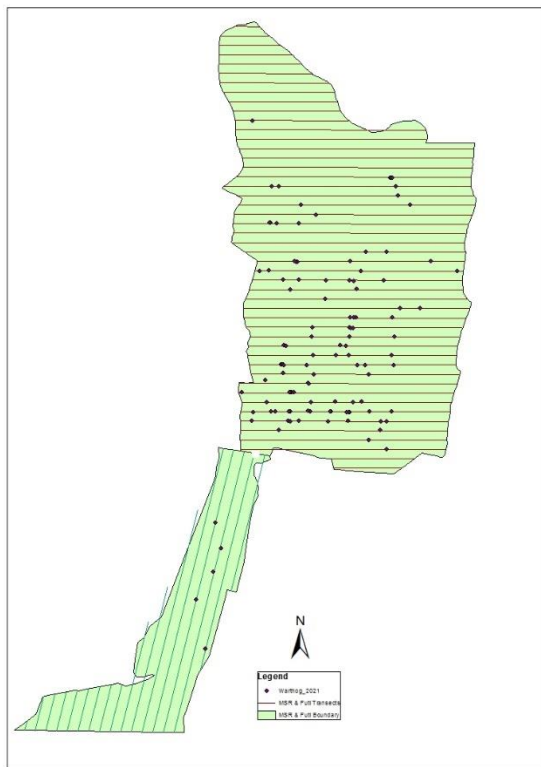


Figure 15. The distribution of Waterbuck in Maputo Reserve, 2021.

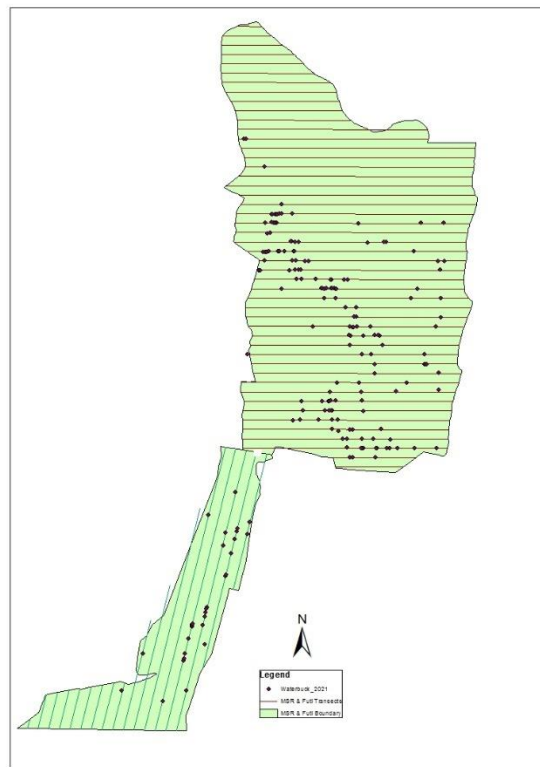


Table 4. Total count estimates for large herbivores in MSR, up to and including 2021.

Species	1972	1995	2005	2006	2008	2011	2012	2013	2014	2015		2016		2019		2021		
	Tello	Hatton	Aerial Census Helicopter	Aerial Census Helicopter	Aerial Census Helicopter	Aerial Census Helicopter	Aerial Census Helicopter	Aerial Census Bathawk	Aerial Census Helicopter	Aerial Census Helicopter	No. Groups	No. Counted	No. Groups	No. Counted	No. Groups	No. Counted	No. Groups	No. Counted
Buffalo															8	45	10	243
Bushbuck			18	30	33	8	27	30	23	21	23	17	19	13	13	88	101	
Bushpig			8	102	78	9	33	39	27	7	24	3	6	13	44	12	45	
Crocodile		1		24	42	23	41	19		13	29	20	26	23	72	42	148	
Duiker, Grey		12	12	40	37	21	22	12	42	21	29	21	22	31	33	62	68	
Duiker, Red		14	37	113	122	28	50	33	50	86	96	51	53	83	90	110	114	
Eland																4	11	
Elephant	350	150	9	329	368	228	264	288	239 (In-147, Out-92)	25	172	34	286 (Plus 14 outside)	32	269	29	180	
Giraffe							1	9	35	2	21	3	28	14	48	10	67	
Hippo	272	5	4	179	140	196	168	185	181	42	268	29	219	42	211	50	263	
Impala							52	33	51	3	40	5	162	27	254	66	822	
Jackal, Side-striped				4	3				2			1	1	1	1	8	9	
Kudu				6	2	3	15	3	26	6	31	10	33	11	40	23	108	
Nyala		1	2	47	8	18	80	87	8	41	89	25	41	34	82	73	163	
Oribi																	0	
Reedbuck, Common		22		797	824	309	598	355	499	378	819	386	873	896	2125	1371	2933	
Rhino, White	40																	
Serval											1					1	1	
Steenbok		1		3	13	3	8	10	5			2	2	1	2	20	21	
Suni		5	10	7	3									1	1		0	
Warthog								2	19	8	16	8	17	29	82	115	302	
Waterbuck				4	3				7	3	10	1	2	53	287	188	1224	
Wildebeest, Blue								62	126	16	276	25	351	70	797	178	1518	
Zebra						24	177	115	270	37	303	37	446	118	828	165	1240	

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

SPECIES	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2121	
Buffalo								31	42	129		7	209
Cheetah												4	4
Eland										20			20
Giraffe			8	12				12		6			38
Impala	22		74	75				494	20	22			707
Kudu			84	26				50					160
Nyala	20		74	72				236	49				451
Oribi										46			46
Warthog	9		33	48				99		0			189
Waterbuck								799		247			1046
Wildebeest				73		127		200		29			429
Zebra	3	24	159	88		97		401	95	197			1064
TOTAL	54	24	432	394	0	224	0	2322	206	696	0	11	4363