

**AERIAL SURVEY OF  
QUIRIMBAS NATIONAL PARK AND ADJOINING  
AREAS**

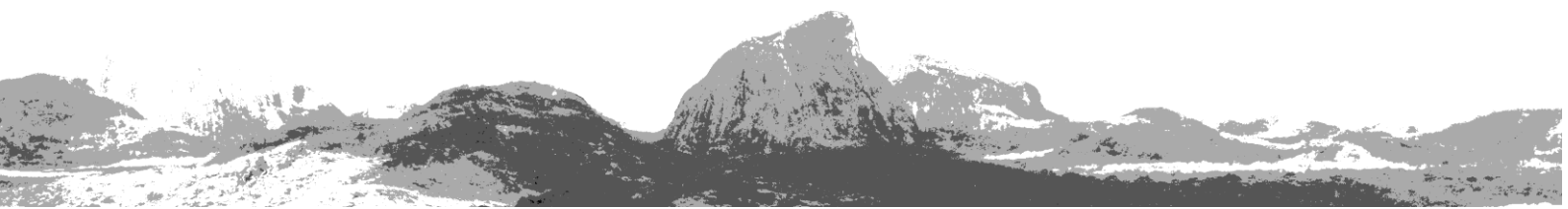
*Mozambique, November 2013*

**Prepared for  
WWF Mozambique**



**By**

**G C Craig  
DG Ecological Consulting cc**





The 2013 aerial survey and census of Quirimbas National Park and adjoining areas was commissioned and organized by the World Wide Fund for Nature (WWF) Mozambique Country Office. The survey was jointly funded by the Swedish International Development Cooperation Agency (SIDA), through WWF-Sweden (CEAI Sustaining Life Project Nr. MZ001113) and the Agence Française de Développement (AFD) (Support for Quirimbas National Park, Project Nr. CMZ1075).

- Copyright: 2013 WWF Mozambique Country Office, Maputo.  
Reproduction of this publication for educational or other non-commercial purposes is authorized without prior written permission of the copyright holder provided the source is fully acknowledged. Reproduction of this publication for resale or other commercial purposes is prohibited without prior written permission of the copyright holder.
- Citation: Craig, G.C. 2013 *Aerial Survey of Quirimbas National Park and Adjoining Areas, 2013*. WWF Mozambique Country Office.
- Disclaimer: Opinions expressed in this report do not necessarily reflect those of WWF. Technical queries should be addressed to the author.



**Survey area in Mozambique**

**AERIAL SURVEY OF  
QUIRIMBAS NATIONAL PARK AND  
ADJOINING AREAS**

*Mozambique, November 2013*

## SUMMARY

An aerial survey of Quirimbas National Park and a corridor joining the park to Niassa Wildlife Reserve took place between 5<sup>th</sup> and 10<sup>th</sup> of November 2013. Estimates of species seen for the entire survey area were as follows:

SPECIES	Estimated Number	95% Confidence Range
<b>Elephants in Family groups</b>	<b>854</b>	<b>350 - 1359</b>
<b>Elephants in Bull groups</b>	<b>0</b>	
<b>Elephant Carcasses</b>	<b>811</b>	<b>609 - 1014</b>
<b>Baboon</b>	<b>1795</b>	<b>1095 - 2495</b>
<b>Buffalo</b>	<b>119</b>	<b>12 - 341</b>
<b>Bushbuck</b>	<b>432</b>	<b>256 - 609</b>
<b>Bushpig</b>	<b>57</b>	<b>6 - 134</b>
<b>Duiker</b>	<b>4624</b>	<b>3905 - 5344</b>
<b>Grysbok</b>	<b>364</b>	<b>243 - 485</b>
<b>Kudu</b>	<b>278</b>	<b>94 - 463</b>
<b>Monkey</b>	<b>373</b>	<b>101 - 644</b>
<b>Sable</b>	<b>137</b>	<b>29 - 340</b>
<b>Warthog</b>	<b>598</b>	<b>293 - 903</b>
<b>Cattle</b>	<b>2762</b>	<b>402 - 6847</b>
<b>Sheep/goats</b>	<b>1678</b>	<b>480 - 2875</b>

Population estimates were generally low and comparable with the 2011 survey results, although the precisions of the estimates are too low to demonstrate the presence or absence of trends.

The estimate of elephant carcasses, however, was very high: 49% of the elephants seen were dead. Based on these results, it is estimated that between 480 and 900 elephants died in the area between 2011 and 2013, or 240-450 *per annum*. The elephant deaths are probably due to illegal hunting and the losses are likely to be unsustainable.

Logging has increased in the survey area, including the park, since 2011 and there is evidence of continuing illegal activity.

Cultivation and settlement are widespread in the park. However, 58% of the park is relatively free of permanent human influence and is shown contain a wide diversity of natural habitats.

## TABLE OF CONTENTS

1 INTRODUCTION .....	1
2 RESULTS AND DISCUSSION .....	3
2.1 Observations of Wildlife.....	4
2.2 Observations of Livestock .....	26
2.3 Observations of Human Activities.....	27
2.4 Other Observations .....	37
2.5 Observations of Vegetation.....	39
3 GENERAL DISCUSSION AND CONCLUSIONS.....	42
4 ACKNOWLEDGEMENTS .....	44
5 REFERENCES .....	45
APPENDIX I: METHODS .....	46
APPENDIX II: RESULTS.....	49
SUPPORTING DATA.....	49
RESULTS BY STRATUM.....	53

## LIST OF ILLUSTRATIONS

Figure 1: Stratum Boundaries .....	1
Figure 2: Density distribution of Wildlife .....	3
Figure 3: Density distribution of elephants.....	4
Figure 4: Elephant sightings .....	5
Figure 5: Elephant carcass sightings.....	9
Figure 6: Density Distribution of elephant carcasses .....	9
Figure 7: Buffalo sighting.....	10
Figure 8: Bushbuck sightings.....	11
Figure 9: Bushpig sightings .....	12
Figure 10: Duiker sightings .....	13
Figure 11: Grysbok sightings.....	14
Figure 12: Eland sighting.....	15
Figure 13: Ground hornbill sightings.....	16
Figure 14: Sightings of Hyrax and Klipspringer.....	17
Figure 15: Kudu sightings.....	18
Figure 16: Baboon sightings .....	19
Figure 17: Monkey sightings .....	20
Figure 18: Turtle sightings.....	21
Figure 19: Sable sightings.....	22
Figure 21: Warthog sightings.....	23
Figure 22: Zebra sighting .....	24
Figure 23: Sightings of carcasses of other (unknown) species .....	25
Figure 24: Sightings of Livestock.....	26
Figure 25: Sightings of fishing attributes.....	28
Figure 26: Sightings of illegal hunting .....	29
Figure 27: Sightings of wood utilisation.....	31
Figure 28: Sightings of cultivation .....	32
Figure 29: Sightings of habitation.....	34
Figure 30: All records of cultivation and habitation .....	34
Figure 31: Unoccupied areas of Quirimbas National Park .....	35
Figure 32: Sightings of mineral extraction .....	36
Figure 33: Distribution of fires .....	37
Figure 34: All water sightings.....	38
Figure 35: Classification of vegetation from aerial observations in 2013 .....	39
Figure 36: Sightings of palm trees .....	40
Figure 37: Sightings of <i>Acacia xanthophloea</i> .....	40
Figure 38: Sightings of Baobabs ( <i>Adansonia digitata</i> ).....	41
Figure 39: Locations with smothering vines.....	41
Figure 40: Transects.....	46
Figure 41: Record of tracks flown .....	49

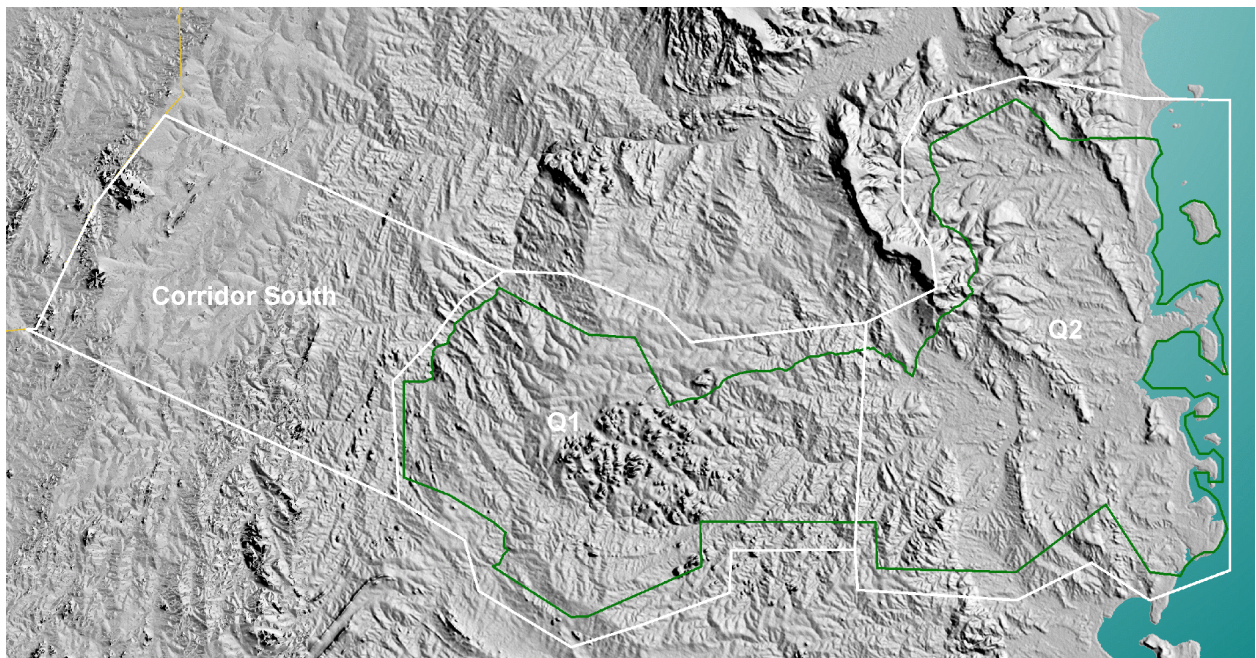


# AERIAL SURVEY OF QUIRIMBAS NATIONAL PARK AND ADJOINING AREAS November 2013

## 1 INTRODUCTION

Quirimbas National Park is in Cabo Delgado province in Northern Mozambique (Frontispiece). It is managed by the Mozambique government, in cooperation with Worldwide Fund for Nature (WWF). A previous survey of the Park and some other areas of interest in the province took place in October 2011 (Craig, 2012). This suggested a high level of elephant poaching was taking place in the area, numbers of other wildlife species were low, and indicated levels of human activity, legal and illegal, which posed threats to conservation of the park. As a follow up, it was decided to repeat the survey in 2013. This report describes the results of that 2013 survey.

The survey was done under the auspices of WWF to cover Quirimbas National park, a buffer area around the park, and a corridor linking Niassa Reserve with Quirimbas NP (an overall area of 14 000 km<sup>2</sup>). The objectives of the survey were to: establish status, trends and distribution of wildlife populations, human activities and other attributes. An emphasis was placed on elephant populations and the number of elephant carcasses as an index of losses due to poaching. Flying took place between 5<sup>th</sup> and 10<sup>th</sup> of November 2013.



**Figure 1: Stratum Boundaries**

Fig. 1 shows the boundaries of the three strata (white lines) that the survey area was divided into. Strata Q1 and Q2 cover the land area of Quirimbas National Park (green line) and a buffer around it. Q2 extends over the ocean as an aid to planning (because of the uncertain

shoreline); the marine part of the park was not part of the survey. Corridor south adjoins block L8 of Niassa game reserve at its eastern end. It is the southern part of the corridor stratum from the 2011 survey – the northern end of that stratum, and an isolated stratum around Palma in the northeast of the province, were excluded from this survey to save time and resources, as they had contained few elephants in 2013.

Methods followed the previous system employed for Niassa Reserve (Gibson, 1998), and were the same as used for this area in 2011 (Craig, 2012b). Stratified systematic transect sampling (Norton Griffiths, 1978) was carried out in a light aircraft (a Cessna 206) flying at a nominal height of 300 feet above the ground. The nominal sampling intensity was 10%. Analysis was according to Jolly (1969). Additional details are provided in Appendix I.

The intention of the report is to present and interpret the results of the survey so that they may inform management decisions. Therefore the results (wildlife populations by species, livestock, human activities and other attributes and vegetation) are described first (section 2), with discussion under each attribute where necessary. A general discussion (section 3) follows. Although prominence is given to results, no necessary detail is omitted: methods are described in Appendix I; supporting data indicating standards achieved and detailed results by stratum are given in Appendix II. Raw data is provided as an annex.

## 2 RESULTS AND DISCUSSION

For each wildlife species in this section, a sighting map is provided along with a table of estimates for each stratum. In the table the “range” refers to the range within which there is a 95% probability that the true number falls (i.e. it is the 95% confidence interval). Strictly, for most species this is actually the range within which 95% of independent *estimates* made by the same method would fall. The true value is likely to be higher on average because of undercounting bias.

“No. seen” is the number of animals seen within sampling strips and “No. out” is the number seen outside of the sampling strips. Where animals were seen only outside of the sampling strips no estimate can be made by this method although the record shows that the species occurs.

Wildlife species in section 2.1 are arranged in alphabetical order of their common names with the exception of: elephant, which is placed first; baboon, which is put next to monkey; and grysbok, which is placed next to duiker. Under elephants, elephant carcasses are tabulated and carcass ratios are given in the table.

Livestock estimates are placed in section 2.2, other human impacts in 2.3, Fire and water in 2.4 and vegetation observations in 2.5.

Fig. 2 shows the density distribution of all wildlife in large stock units (1 unit = 450kg)

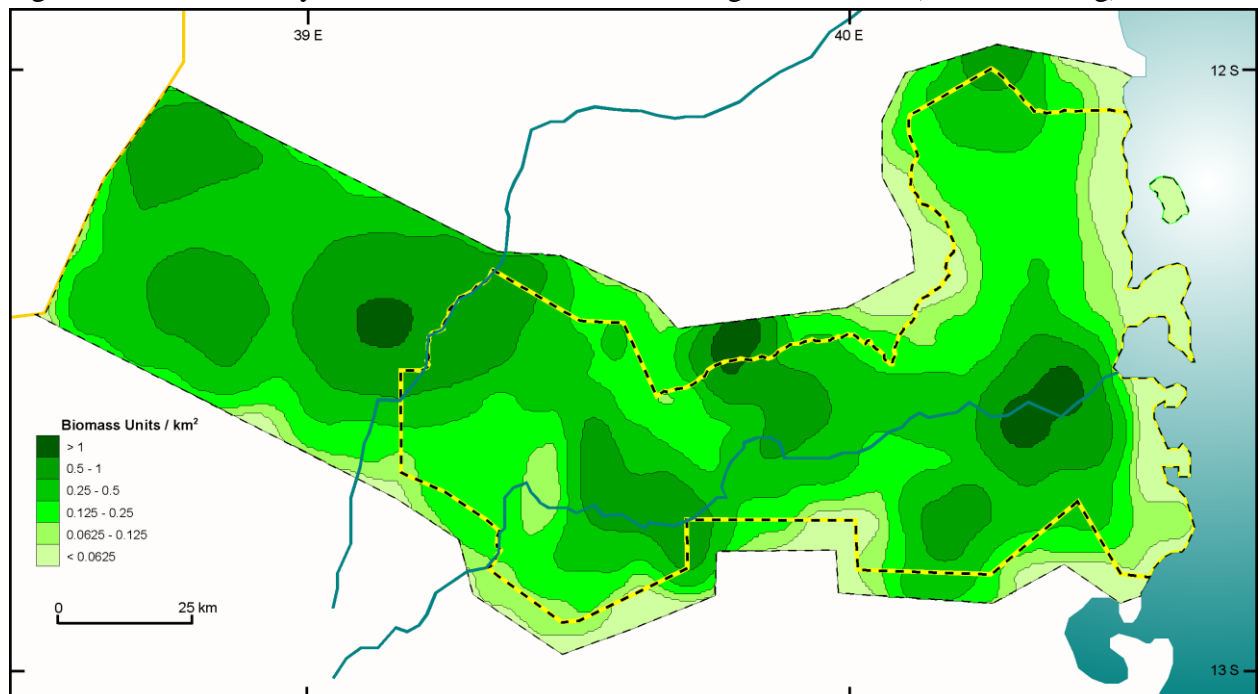


Figure 2: Density distribution of Wildlife

The map is not a precise guide to wildlife distribution, because it is based on so little data, but shows the general features. Wildlife is generally at low densities which do not approach those

reached in Niassa reserve (Craig 1012a). Although most species are underestimated because of their poor visibility some allowance has been made for this, i.e. correction factors have been applied to compensate for this (but only in Fig.2 – not in the tabulated estimates). Densities only reach a level of one locally: one might speculate that a higher number could be carried. Wildlife concentrations are mostly away from human influence. The largest area of medium concentration is in the west of the park and in the corridor.

Results for individual species follow.

## 2.1 OBSERVATIONS OF WILDLIFE

### *Elephant*

Fig. 3 provides a very crude illustration of elephant distribution of elephant distribution, as there are very few sightings. Elephants are mainly found away from human activity. Only family groups were seen.

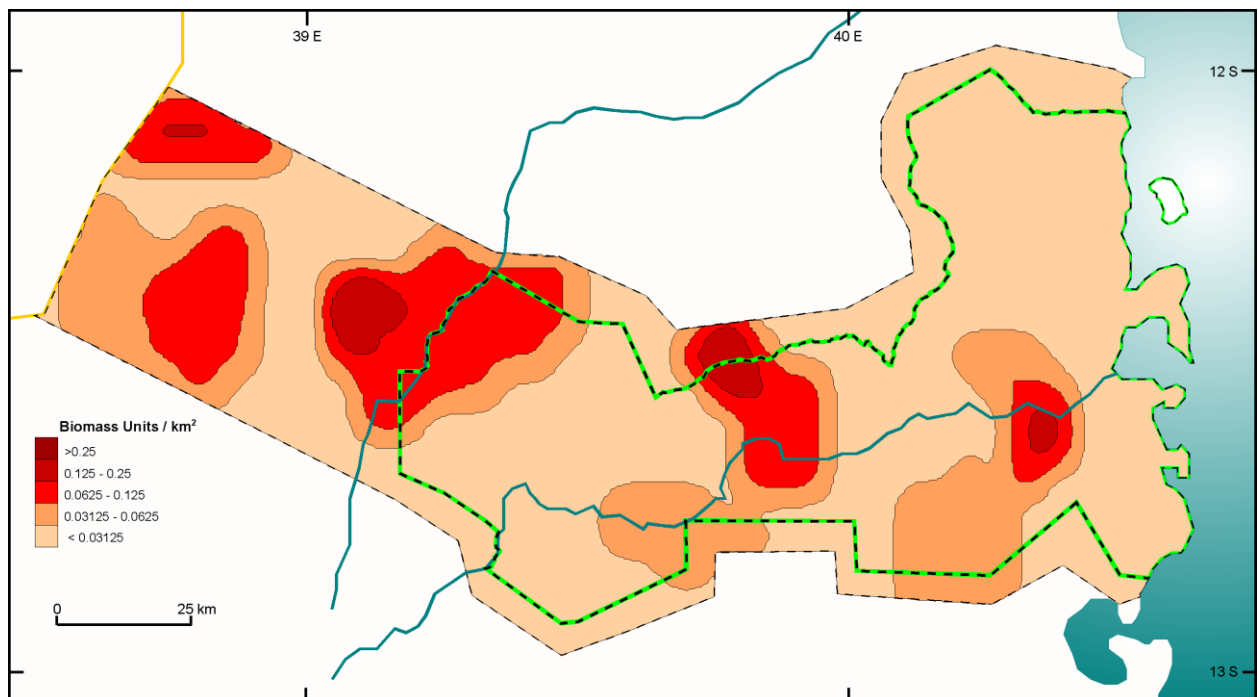
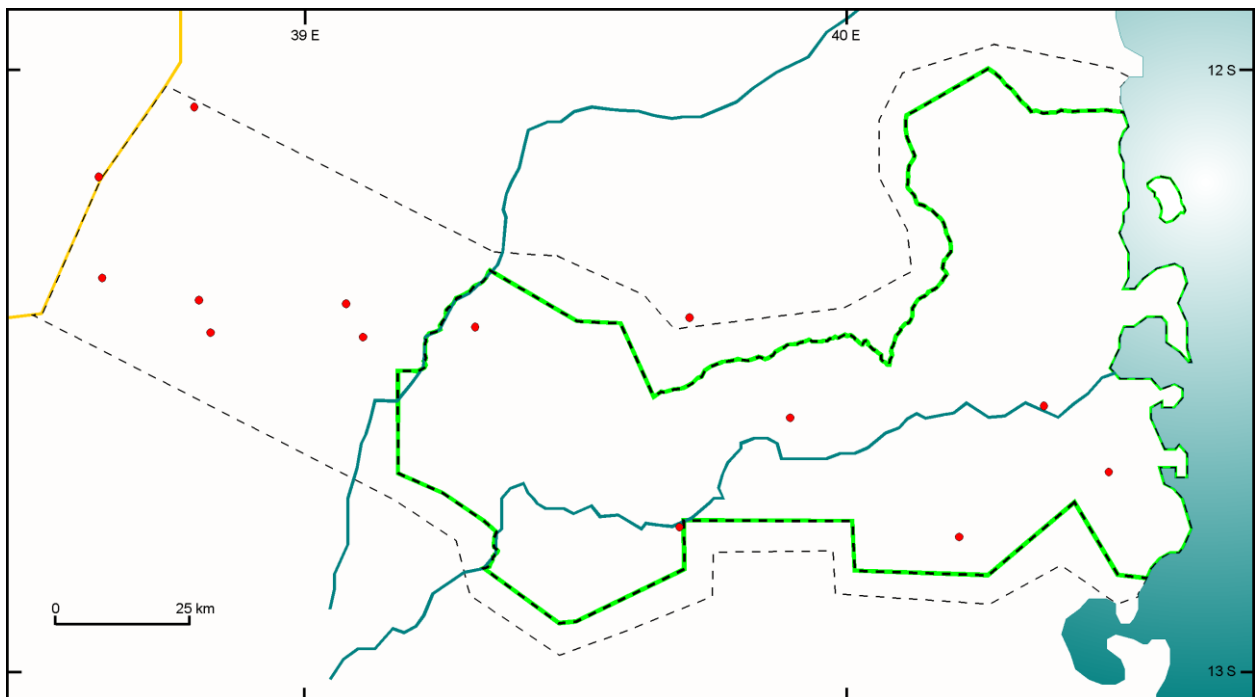


Figure 3: Density distribution of elephants

*ElephantFamily*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	227	34 - 495	23	11	0.0472
Q2	333	34 - 721	34	0	0.059
Quirimbas	560	100 - 1020	57	11	0.0537
Corridor S	294	63 - 525	32	10	0.0834
<b>Overall</b>	<b>854</b>	<b>350 - 1359</b>	<b>89</b>	<b>21</b>	<b>0.061</b>



**Figure 4: Elephant sightings**

The estimated population of elephants is almost the same as that for 2013 (787) for the same area, and is not significantly different. However, the precision of both estimates is low so the data do not rule out a decline.

There may have been a decline in the number of bulls but again, the precision of the 2011 estimates is insufficient to confirm this, as an estimate of zero in 2013 could have occurred by chance alone, even if the bull population had not declined.

*Elephant carcasses**Elephant Carcass 1 (Fresh)*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q2	10	1 - 29	1	0	0.0017
Quirimbas	10	1 - 29	1	0	0.001
Corridor S	0	1 - 0	0	1	0
<b>Overall</b>	<b>10</b>	<b>2 - 28</b>	<b>1</b>	<b>1</b>	<b>0.0007</b>

*Elephant Carcass 2*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	10	1 - 29	1	0	0.0021
Q2	29	5 - 61	3	2	0.0052
Quirimbas	39	6 - 75	4	2	0.0038
Corridor S	37	4 - 79	4	0	0.0104
<b>Overall</b>	<b>76</b>	<b>23 - 129</b>	<b>8</b>	<b>2</b>	<b>0.0054</b>

*Recent Elephant carcasses (Carcass 1 + Carcass 2)*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	10	1 - 29	1	0	0.0021
Q2	39	6 - 76	4	2	0.007
Quirimbas	49	9 - 90	5	2	0.0047
Corridor S	37	5 - 79	4	1	0.0104
<b>Overall</b>	<b>86</b>	<b>30 - 142</b>	<b>9</b>	<b>3</b>	<b>0.0062</b>

Recent carcasses are those which still have skin covering the bone and are assumed to be less than one year old. Fresh carcasses still have flesh under the skin (Appendix I).

*Elephant Carcass 3*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	69	7 - 134	7	0	0.0144
Q2	98	31 - 165	10	1	0.0174
Quirimbas	167	76 - 258	17	1	0.016
Corridor S	46	6 - 90	5	1	0.013
<b>Overall</b>	<b>213</b>	<b>114 - 312</b>	<b>22</b>	<b>2</b>	<b>0.0152</b>

*Elephant Carcass 4*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	148	50 - 246	15	1	0.0308
Q2	245	127 - 363	25	2	0.0435
Quirimbas	393	244 - 542	40	3	0.0376
Corridor S	120	35 - 204	13	4	0.0339
<b>Overall</b>	<b>513</b>	<b>345 - 680</b>	<b>53</b>	<b>7</b>	<b>0.0367</b>

*Old Elephant carcasses (Carcass 3 + Carcass 4)*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	217	100 - 335	22	1	0.0452
Q2	343	207 - 478	35	3	0.0608
Quirimbas	560	385 - 735	57	4	0.0537
Corridor S	165	70 - 261	18	5	0.0469
<b>Overall</b>	<b>726</b>	<b>531 - 920</b>	<b>75</b>	<b>9</b>	<b>0.0518</b>

Stage 3 carcasses still have the skeleton articulated. Criteria (Appendix I) are due to Douglas-Hamilton (1996).

*All Elephant carcasses*

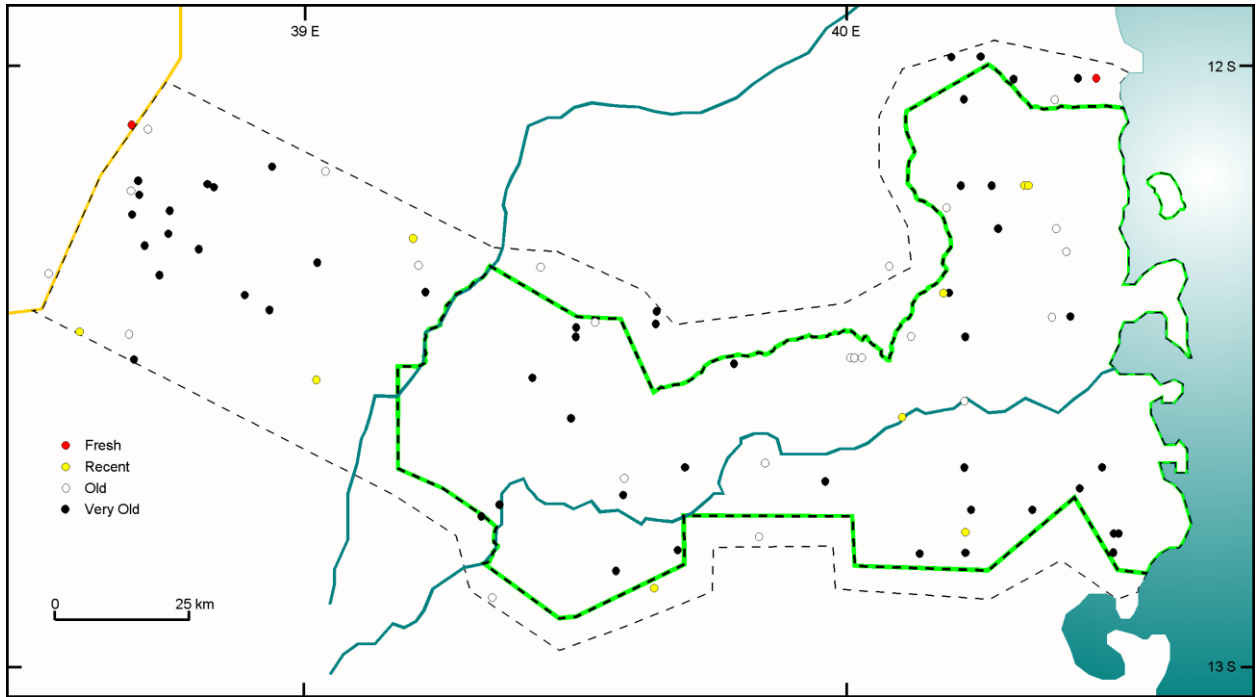
Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>	CRatio%
Q1	227	108 - 346	23	1	0.0472	50
Q2	382	242 - 522	39	5	0.0677	53.4
Quirimbas	609	430 - 789	62	6	0.0583	52.1
Corridor S	202	98 - 307	22	6	0.0573	40.7
<b>Overall</b>	<b>811</b>	<b>609 - 1014</b>	<b>84</b>	<b>12</b>	<b>0.0579</b>	<b>48.7</b>

The approximate 95% confidence range for the carcass ratio (see Appendix I for definition) is 34.8 – 68.2%. This is a significant increase over the ratio of approximately 15% recorded in 2011 (Craig, 2012b). This alone serves as an indication of unusual mortality: natural mortality would yield a ratio of less than 5%. It is less clear what the ratio means in terms of annual mortality. Carcasses are visible for 5 years or more (Douglas-Hamilton, 1996) so a ratio of, say, 15% accumulated over several years as a result of 3% annual mortality would not represent an unsustainable loss. On the other hand, if most of the 15% results from deaths over the previous one or two years then the losses are not sustainable. A comparison between two surveys, as follows, gives a more useful measure of mortality.

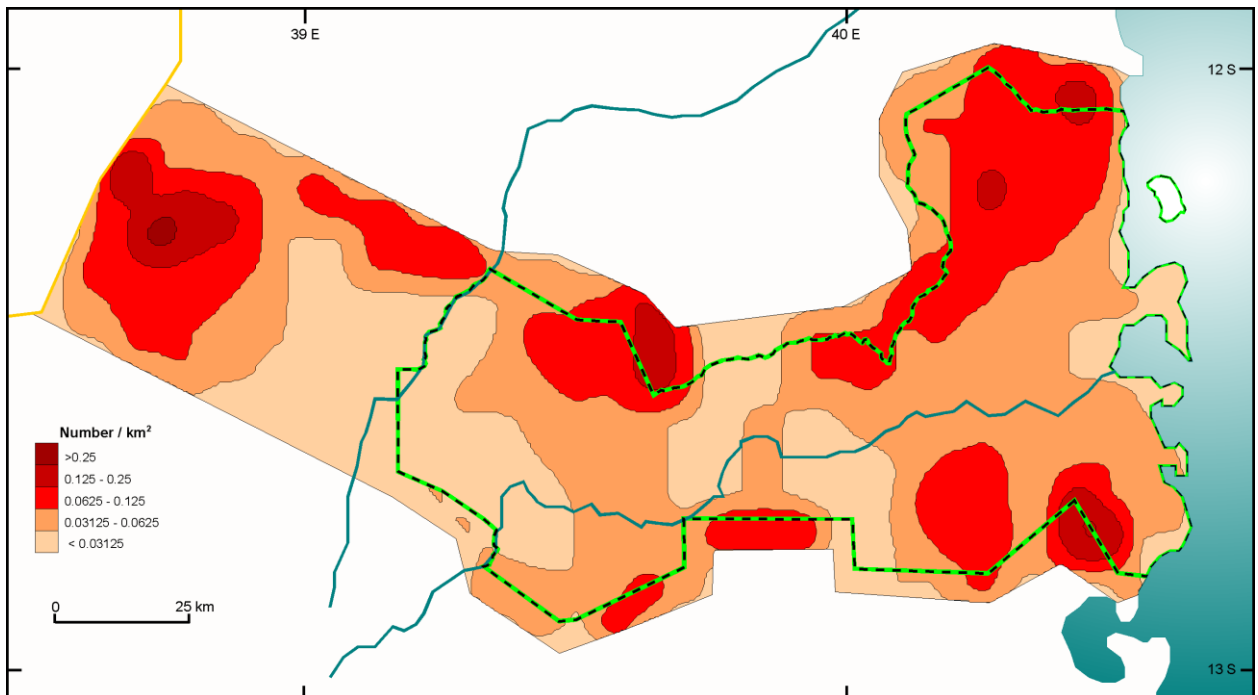
The estimate of carcasses represents an increase of 692 over the 2011 estimate for the same area. Taking the precision into account, this implies that 480 – 904 (95% confidence range of the difference) elephants died in the area in the two years between surveys. This may still be an underestimate of deaths because some carcasses present in 2011 may no longer be visible and carcasses, especially recent ones, may be underestimated.

It is of interest that if one accepts the given ages of the various carcass classes (Douglas-Hamilton, 1996) there are more old (>1yr) carcasses than expected if mortality was similar over the two years between surveys. This is a common finding and was noted by Craig (2012a) with reference to the 2011 Niassa survey. Very much greater mortality in 2012 than 2013 can probably be discounted as a cause. That leaves two possibilities: recent carcasses deteriorate faster towards stage 3 than claimed because scavengers (or people) remove the hide relatively soon after the elephant's death; or recent carcasses are underestimated because when the hide still covers the bones they are less visible. It would be useful to determine which of these interpretations is correct.





**Figure 5: Elephant carcass sightings**

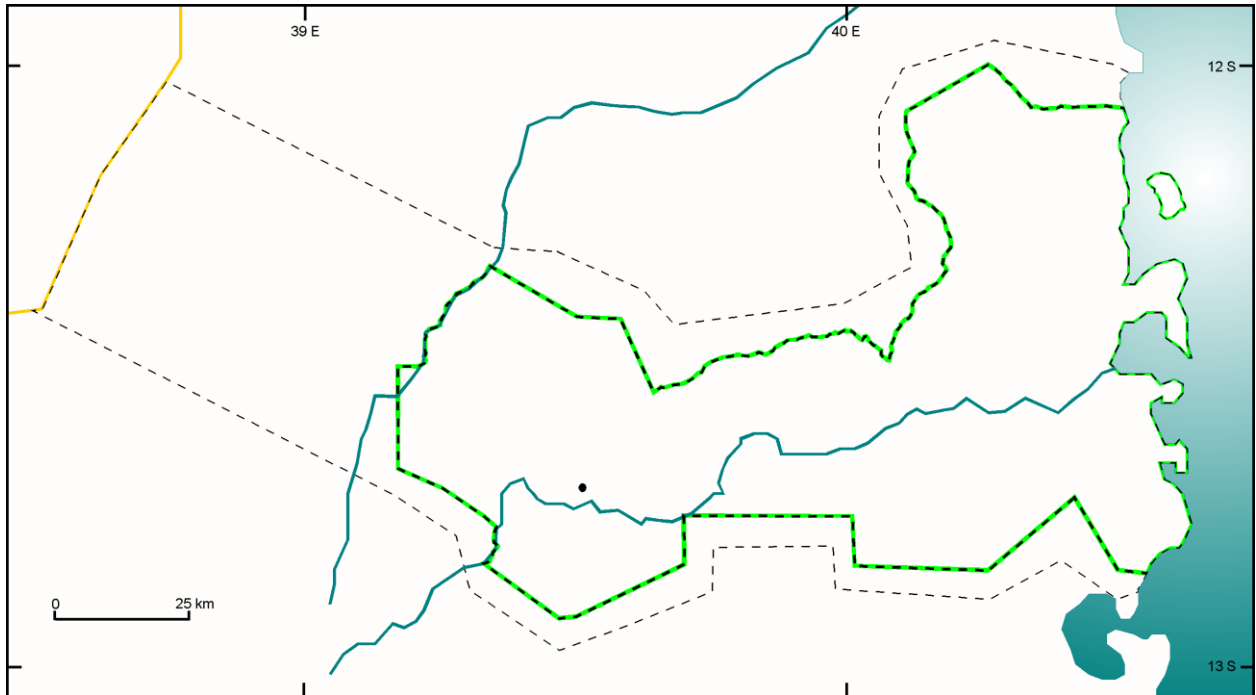


**Figure 6: Density Distribution of elephant carcasses**

Fig. 5 shows the location of individual carcasses. Fig. 6 generalises the distribution to highlight the areas of highest carcass concentration.

*Buffalo*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	119	12 - 349	12	0	0.0246
Quirimbas	119	12 - 342	12	0	0.0113
<b>Overall</b>	<b>119</b>	<b>12 - 341</b>	<b>12</b>	<b>0</b>	<b>0.0085</b>



**Figure 7: Buffalo sighting**

Only one sighting was made; no buffalo were seen in 2011. The tendency of buffalo to be grouped, and the population to consist of few groups, causes the estimates to be very imprecise, especially when the population is small.

*Bushbuck*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	79	8 - 156	8	0	0.0164
Q2	215	98 - 333	22	0	0.0383
Quirimbas	295	157 - 432	30	0	0.0282
Corridor S	138	16 - 259	15	0	0.0391
<b>Overall</b>	<b>432</b>	<b>256 - 609</b>	<b>45</b>	<b>0</b>	<b>0.0309</b>

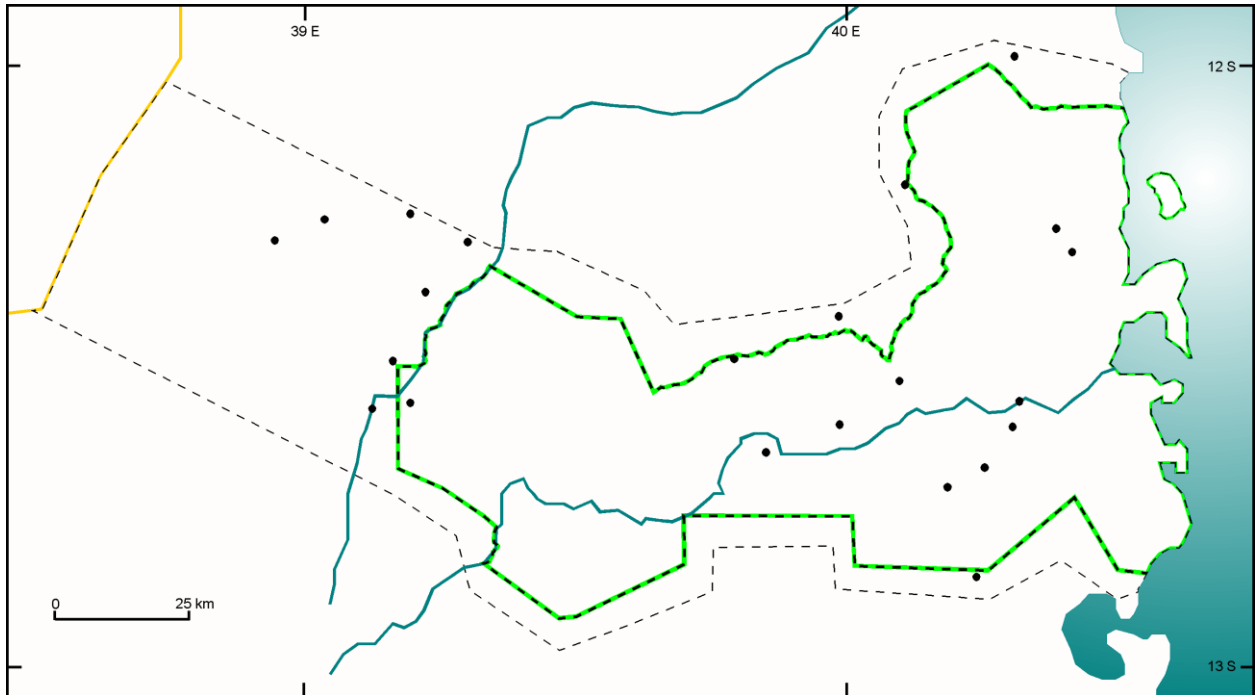
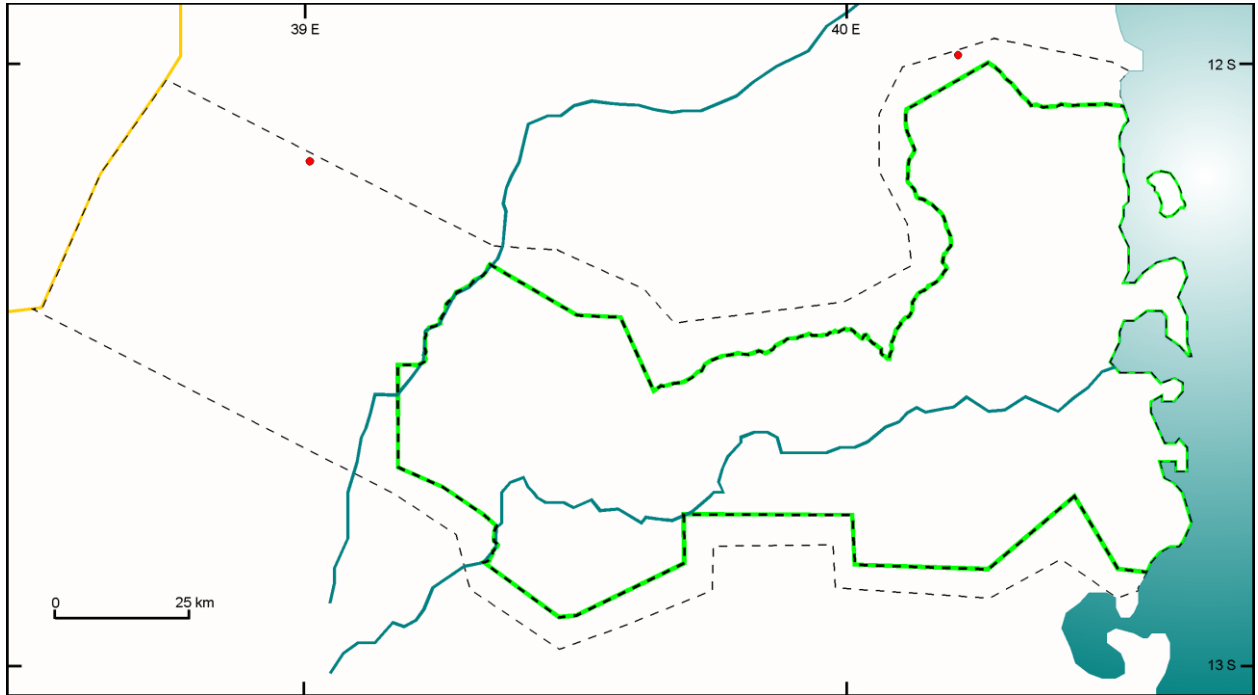


Figure 8: Bushbuck sightings

*Bushpig*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>2</sup>
Q2	29	3 - 88	3	0	0.0052
Quirimbas	29	3 - 87	3	0	0.0028
Corridor S	28	3 - 84	3	0	0.0078
<b>Overall</b>	<b>57</b>	<b>6 - 134</b>	<b>6</b>	<b>0</b>	<b>0.004</b>

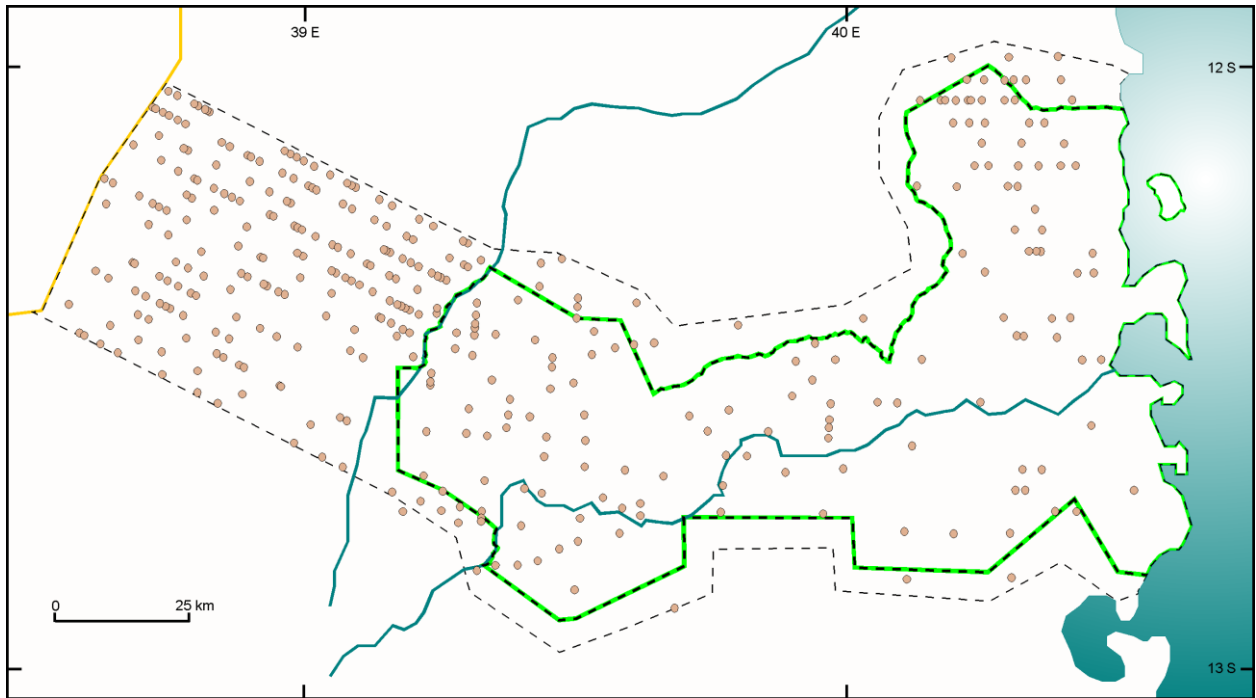


**Figure 9: Bushpig sightings**

Bush-pig are mainly nocturnal and are seldom seen. The two sightings were made on the first transects of two of the survey days.

*Duiker*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>2</sup>
Q1	1294	948 - 1640	131	3	0.2689
Q2	940	645 - 1235	96	1	0.1668
Quirimbas	2234	1792 - 2677	227	4	0.2139
Corridor S	2390	1770 - 3011	260	0	0.6773
<b>Overall</b>	<b>4624</b>	<b>3905 - 5344</b>	<b>487</b>	<b>4</b>	<b>0.3302</b>



**Figure 10: Duiker sightings**

Duiker is the commonest species. Nevertheless the population is probably greatly underestimated.

*Grysbok*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	119	49 - 188	12	0	0.0246
Q2	108	36 - 180	11	0	0.0191
Quirimbas	226	129 - 324	23	0	0.0216
Corridor S	138	59 - 217	15	0	0.0391
<b>Overall</b>	<b>364</b>	<b>243 - 485</b>	<b>38</b>	<b>0</b>	<b>0.026</b>

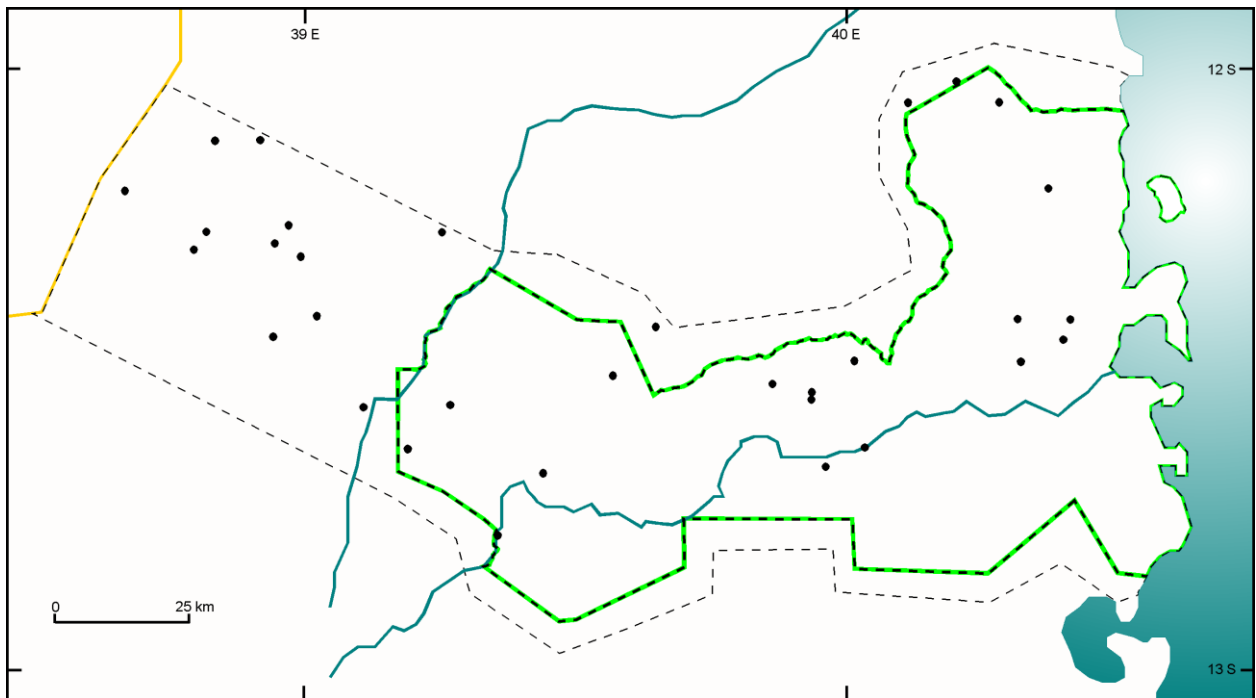
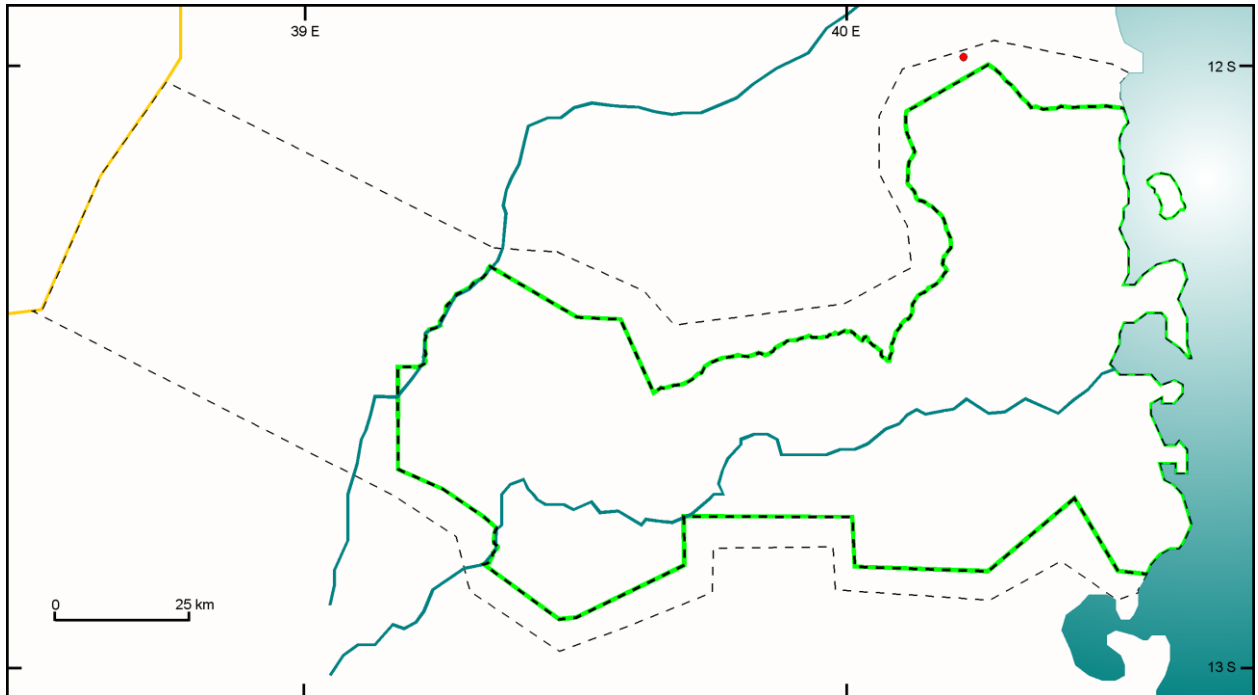


Figure 11: Grysbok sightings

*Eland*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>2</sup>
Q2	0	8 -	0	8	0
Quirimbas	0	8 -	0	8	0
<b>Overall</b>	<b>0</b>	<b>8 -</b>	<b>0</b>	<b>8</b>	<b>0</b>

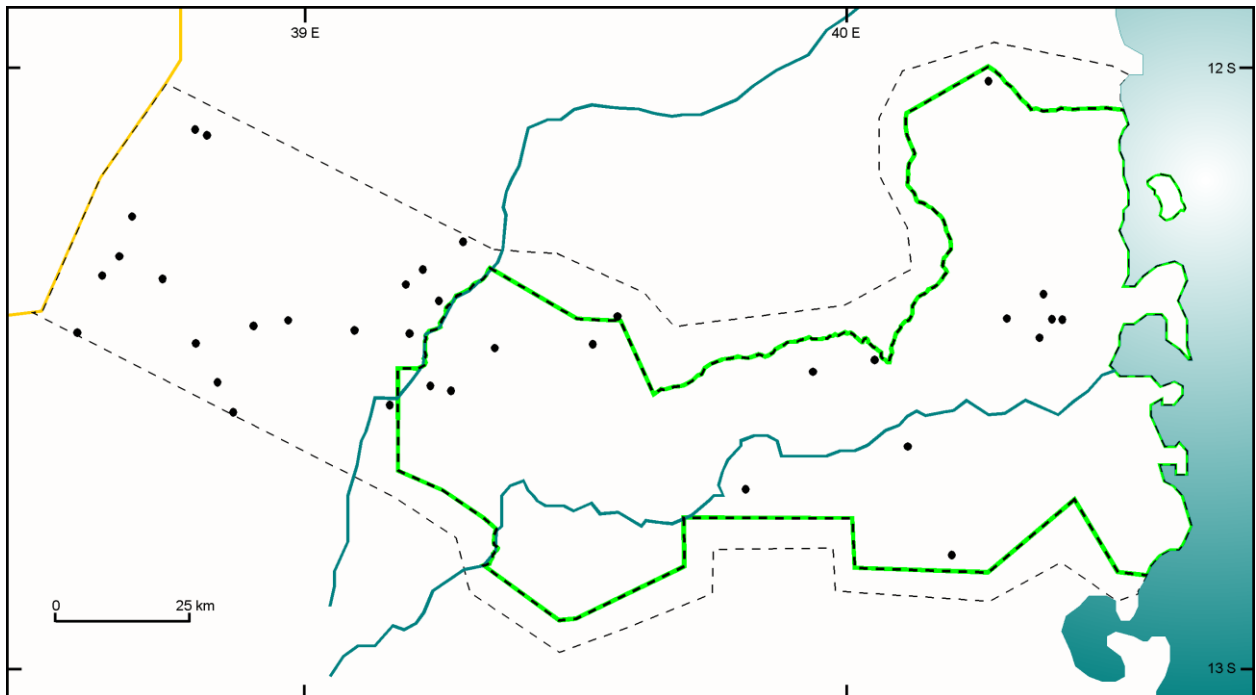


**Figure 12: Eland sighting**

One group was seen outside the sample strips and on the margins of the area.

*Ground Hornbill*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	247	70 - 424	25	0	0.0513
Q2	186	26 - 346	19	1	0.0331
Quirimbas	433	201 - 665	44	1	0.0415
Corridor S	368	217 - 519	40	3	0.1042
<b>Overall</b>	<b>801</b>	<b>531 - 1070</b>	<b>84</b>	<b>4</b>	<b>0.0572</b>



**Figure 13: Ground hornbill sightings**

Ground hornbills may provide an index of woodland habitat quality.

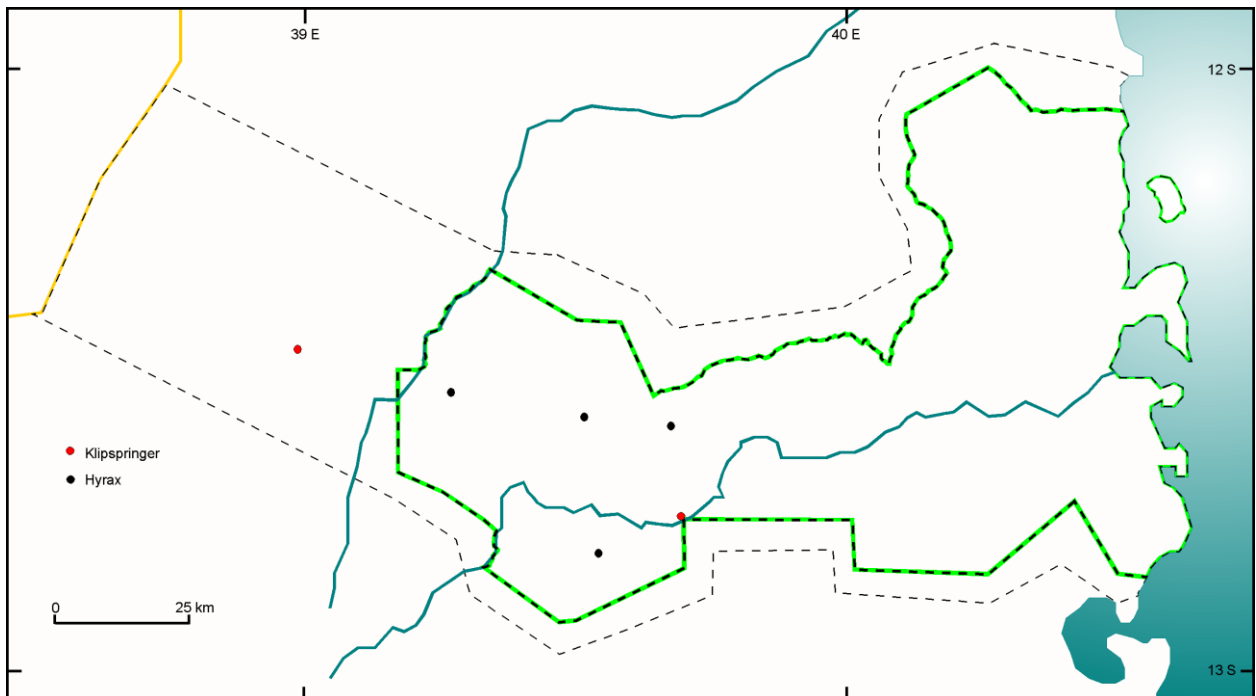


*Hyrax*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	277	28 - 597	28	0	0.0575
Quirimbas	277	28 - 587	28	0	0.0265
<b>Overall</b>	<b>277</b>	<b>28 - 586</b>	<b>28</b>	<b>0</b>	<b>0.0198</b>

*Klipspringer*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	30	3 - 88	3	0	0.0062
Quirimbas	30	3 - 86	3	0	0.0028
Corridor S	18	2 - 56	2	0	0.0052
<b>Overall</b>	<b>48</b>	<b>5 - 114</b>	<b>5</b>	<b>0</b>	<b>0.0034</b>

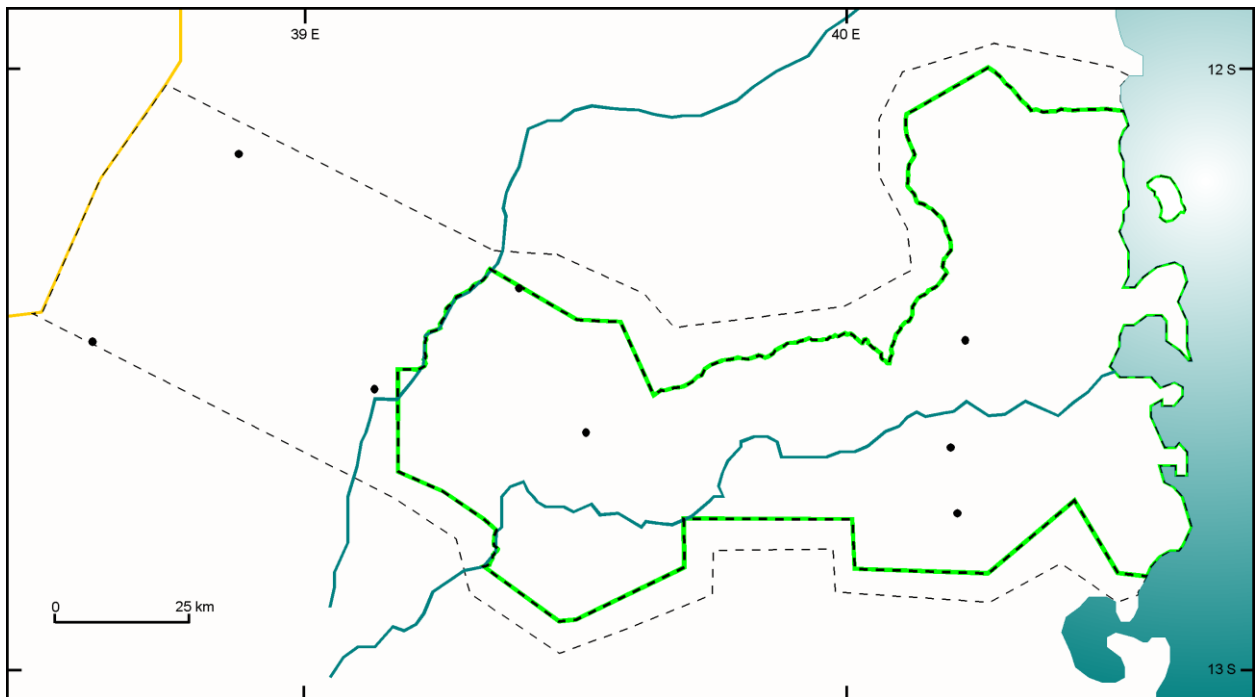


**Figure 14: Sightings of Hyrax and Klipspringer**

Klipspringer and hyrax are probably common on inselbergs, though difficult to see. Sightings were made when the aircraft was low over the slope.

*Kudu*

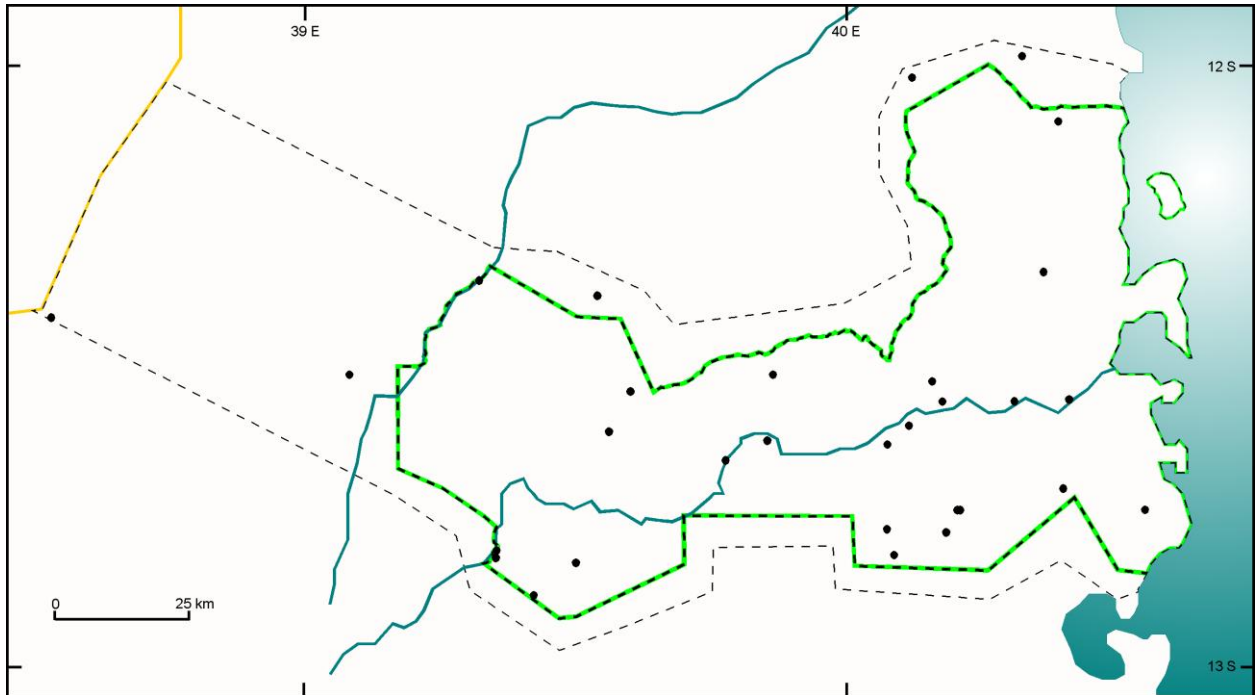
Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	99	10 - 230	10	0	0.0205
Q2	78	8 - 163	8	0	0.0139
Quirimbas	177	26 - 329	18	0	0.0169
Corridor S	101	12 - 217	11	1	0.0287
<b>Overall</b>	<b>278</b>	<b>94 - 463</b>	<b>29</b>	<b>1</b>	<b>0.0199</b>



**Figure 15: Kudu sightings**

*Baboon*

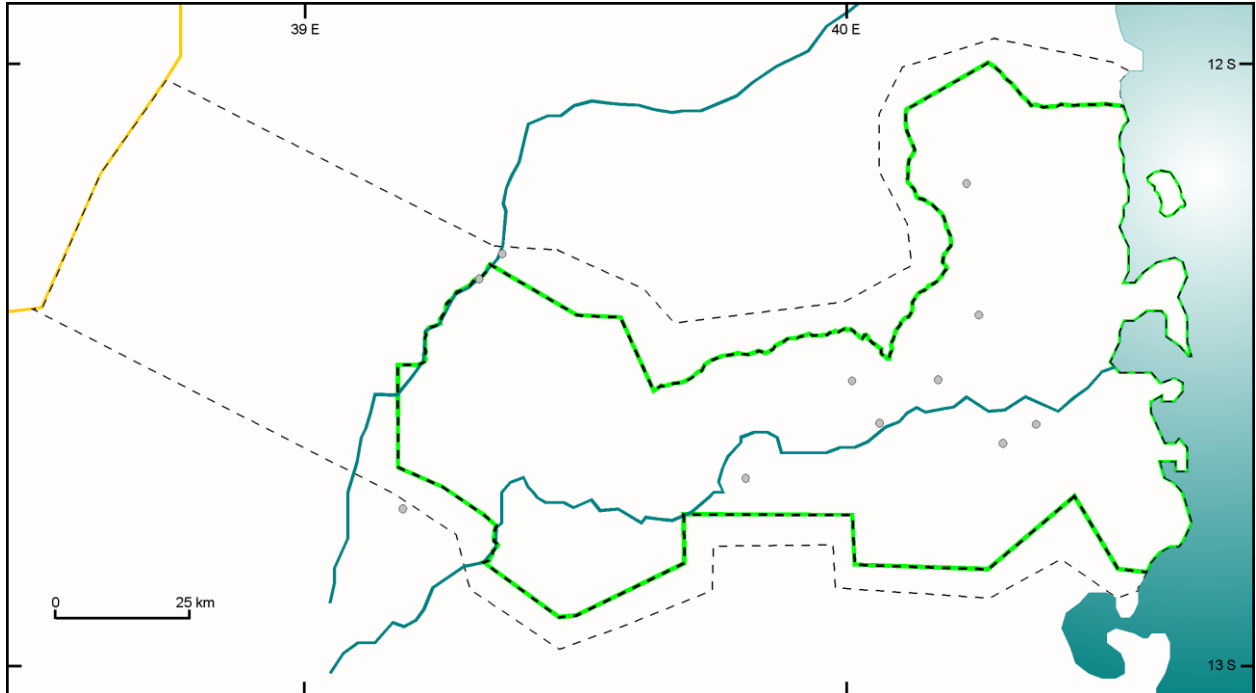
Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	662	234 - 1090	67	0	0.1375
Q2	1087	511 - 1663	111	0	0.1929
Quirimbas NP	1749	1049 - 2449	178	0	0.1674
Corridor S	46	5 - 122	5	0	0.013
<b>Overall</b>	<b>1795</b>	<b>1095 - 2495</b>	<b>183</b>	<b>0</b>	<b>0.1281</b>



**Figure 16: Baboon sightings**

*Monkey*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	59	7 - 129	6	1	0.0123
Q2	313	44 - 583	32	0	0.0556
Quirimbas	373	100 - 646	38	1	0.0356
<b>Overall</b>	<b>373</b>	<b>101 - 644</b>	<b>38</b>	<b>1</b>	<b>0.0267</b>

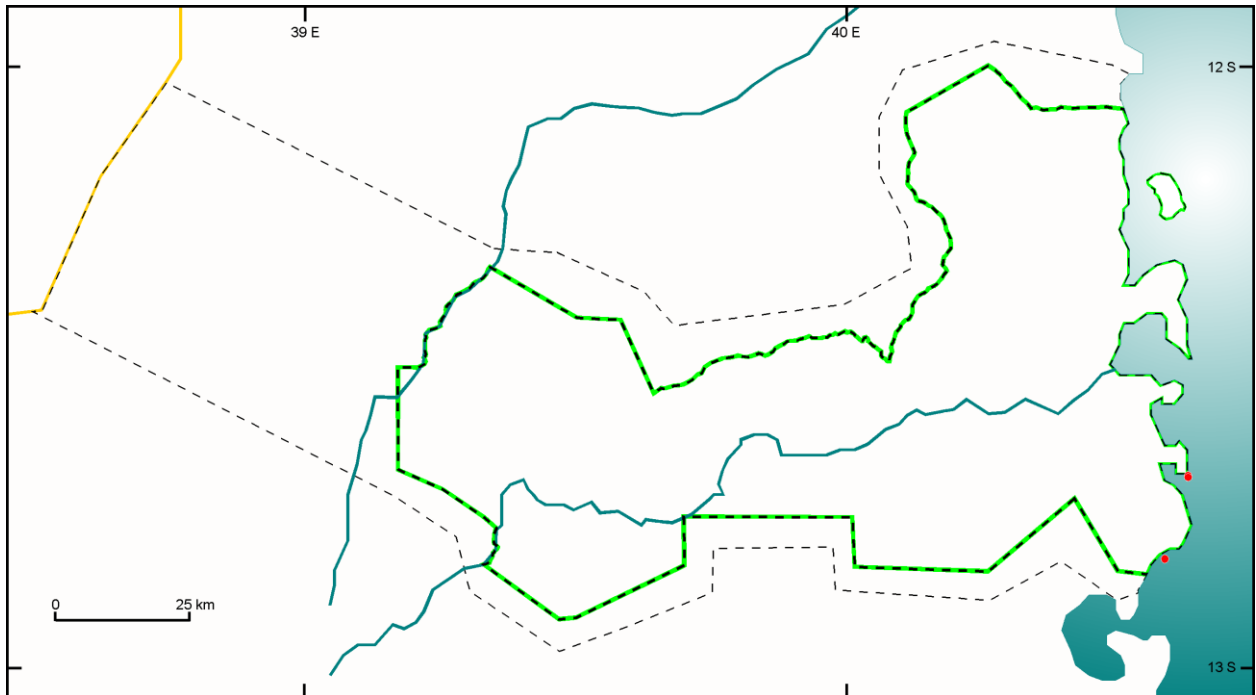


**Figure 17: Monkey sightings**

Both vervet and blue monkeys are probably present, but were not distinguished.

*Turtle*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q2	0	37	0	37	0
Quirimbas	0	37	0	37	0
<b>Overall</b>	<b>0</b>	<b>37</b>	<b>0</b>	<b>37</b>	<b>0</b>

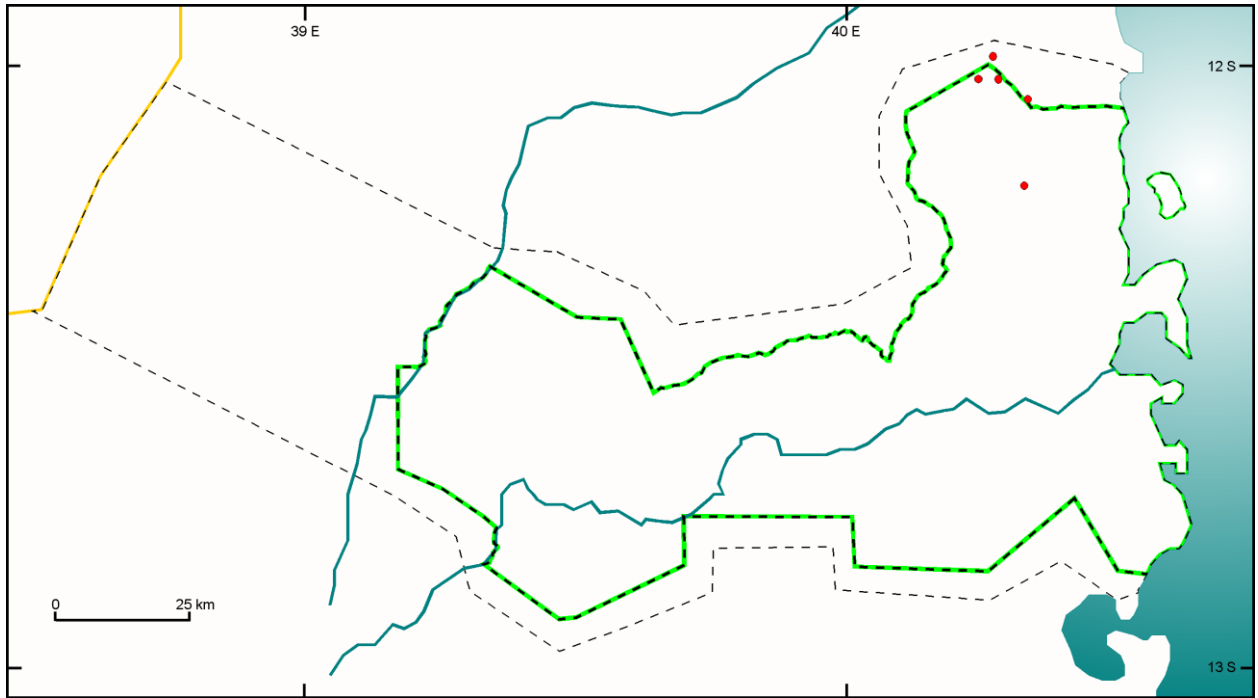


**Figure 18: Turtle sightings**

Transects were not flown over the sea: the sightings were made after the end of transects. One sighting contained 36 turtles. It must have been a lucky chance to find so many in a concentration on the surface and close inshore. Species was probably the green turtle but identification was not possible.

*Sable*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q2	137	29 - 345	14	15	0.0244
Quirimbas	137	29 - 341	14	15	0.0131
<b>Overall</b>	<b>137</b>	<b>29 - 340</b>	<b>14</b>	<b>15</b>	<b>0.0098</b>

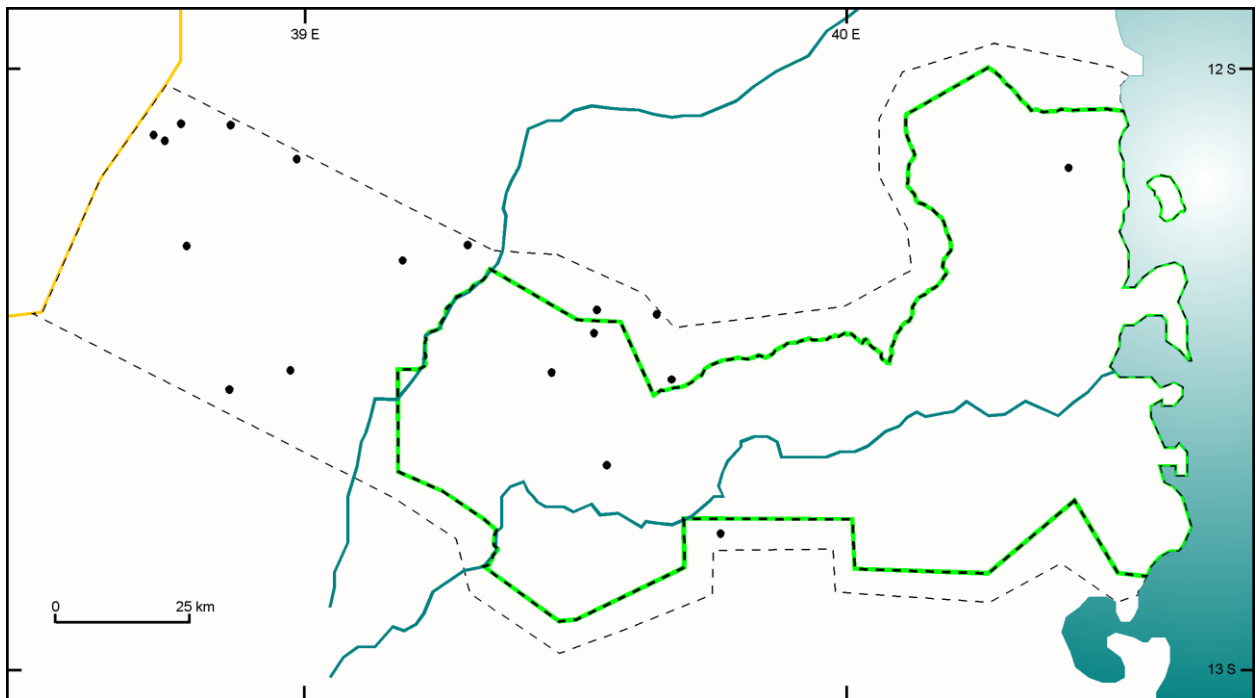


**Figure 19: Sable sightings**

Sable were found close to the park boundary in the north of Q2. They were in, or close to, tree savanna in this area.

*Warthog*

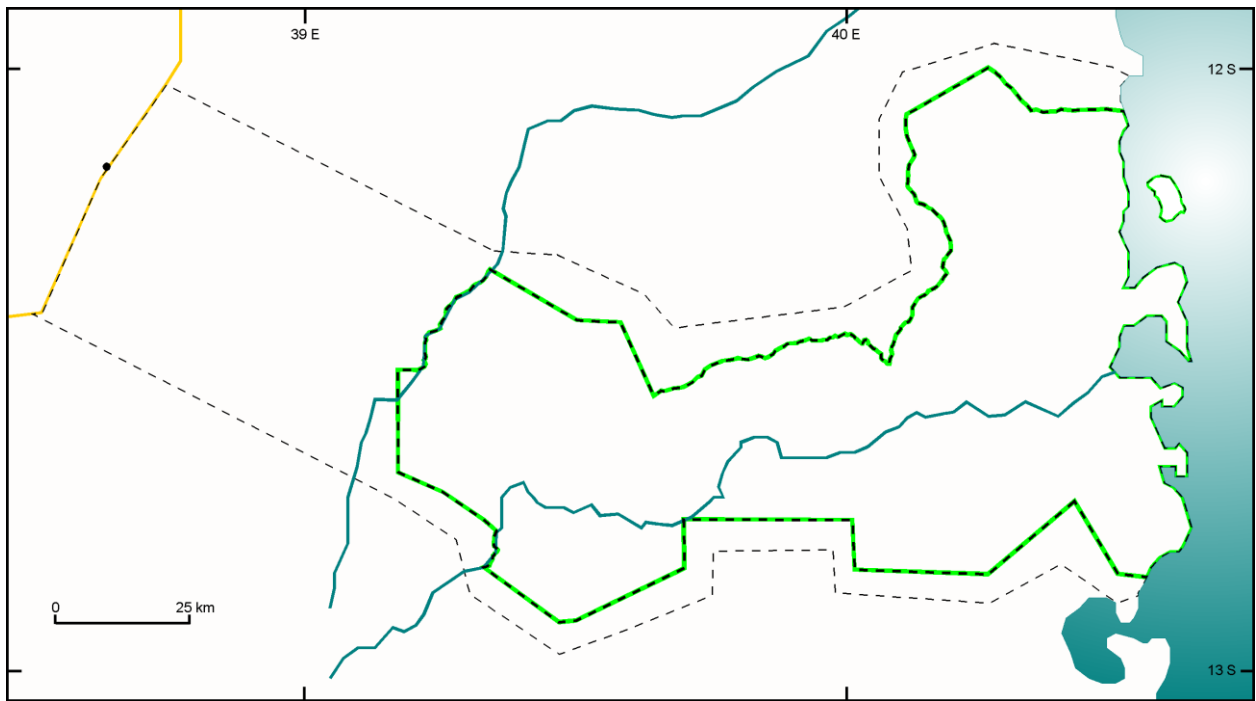
Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	227	60 - 395	23	0	0.0472
Q2	49	5 - 144	5	0	0.0087
Quirimbas	276	89 - 463	28	0	0.0264
Corridor S	322	59 - 585	35	0	0.0912
<b>Overall</b>	<b>598</b>	<b>293 - 903</b>	<b>63</b>	<b>0</b>	<b>0.0427</b>



**Figure 20: Warthog sightings**

*Zebra*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Corridor S	0	4	0	4	0
<b>Overall</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>4</b>	<b>0</b>



**Figure 21: Zebra sighting**

The one group that was seen was between transects just inside block L8 of Niassa Game Reserve.

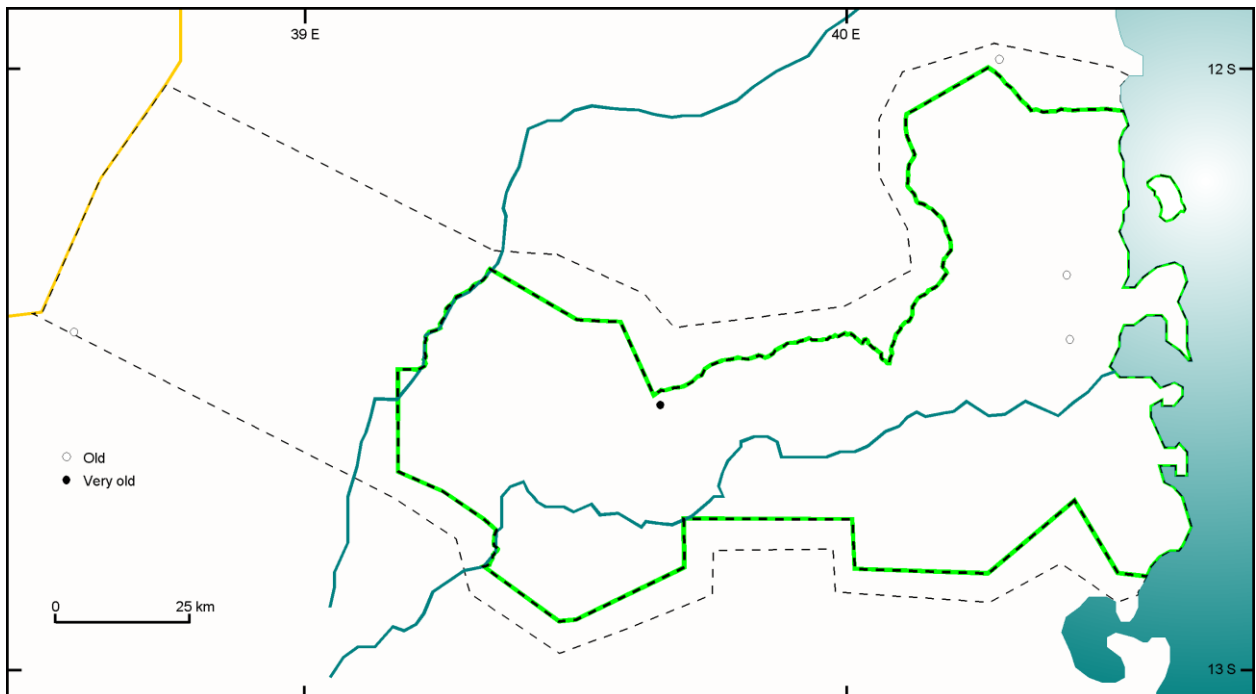


*Other Carcasses**Carcass 3*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q2	29	3 - 62	3	0	0.0052
Quirimbas	29	3 - 61	3	0	0.0028
Corridor S	9	1 - 28	1	0	0.0026
<b>Overall</b>	<b>39</b>	<b>4 - 75</b>	<b>4</b>	<b>0</b>	<b>0.0028</b>

*Carcass 4*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	10	1 - 29	1	0	0.0021
Quirimbas	10	1 - 29	1	0	0.001
<b>Overall</b>	<b>10</b>	<b>1 - 29</b>	<b>1</b>	<b>0</b>	<b>0.0007</b>



**Figure 22: Sightings of carcasses of other (unknown) species**

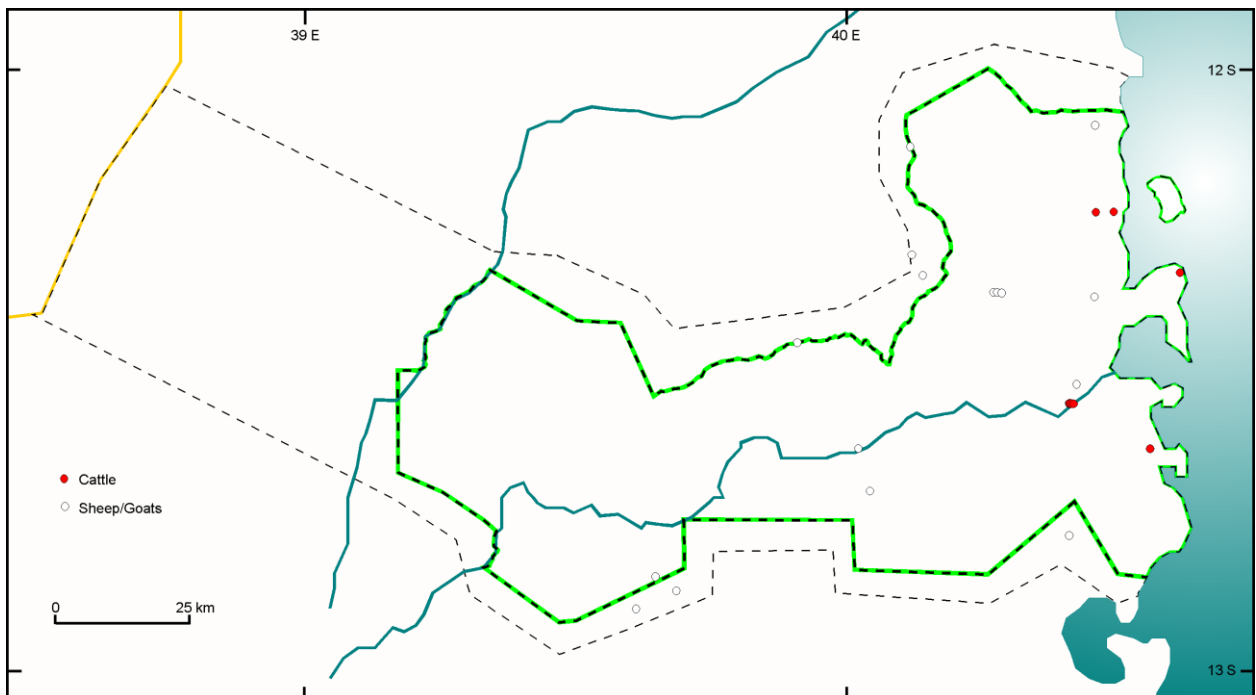
## 2.2 OBSERVATIONS OF LIVESTOCK

### *Cattle*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q2	2762	402 - 6954	282	120	0.49
Quirimbas	2762	402 - 6868	282	120	0.2644
<b>Overall</b>	<b>2762</b>	<b>402 - 6847</b>	<b>282</b>	<b>120</b>	<b>0.1973</b>

### *Sheep/goats*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	346	35 - 799	35	0	0.0719
Q2	1332	188 - 2476	136	0	0.2364
Quirimbas	1678	474 - 2881	171	0	0.1605
<b>Overall</b>	<b>1678</b>	<b>480 - 2875</b>	<b>171</b>	<b>0</b>	<b>0.1198</b>



**Figure 23: Sightings of Livestock**

Estimates of cattle and goats were greater than in 2011, though not significantly. Though localised, the populations in the park are greater than for any wildlife species.

## 2.3 OBSERVATIONS OF HUMAN ACTIVITIES

### *Fishing*

#### *Fishing camp*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q2	69	25 - 112	7	0	0.0122
Quirimbas	69	26 - 111	7	0	0.0065
<b>Overall</b>	<b>69</b>	<b>26 - 111</b>	<b>7</b>	<b>0</b>	<b>0.0049</b>

#### *Boat*

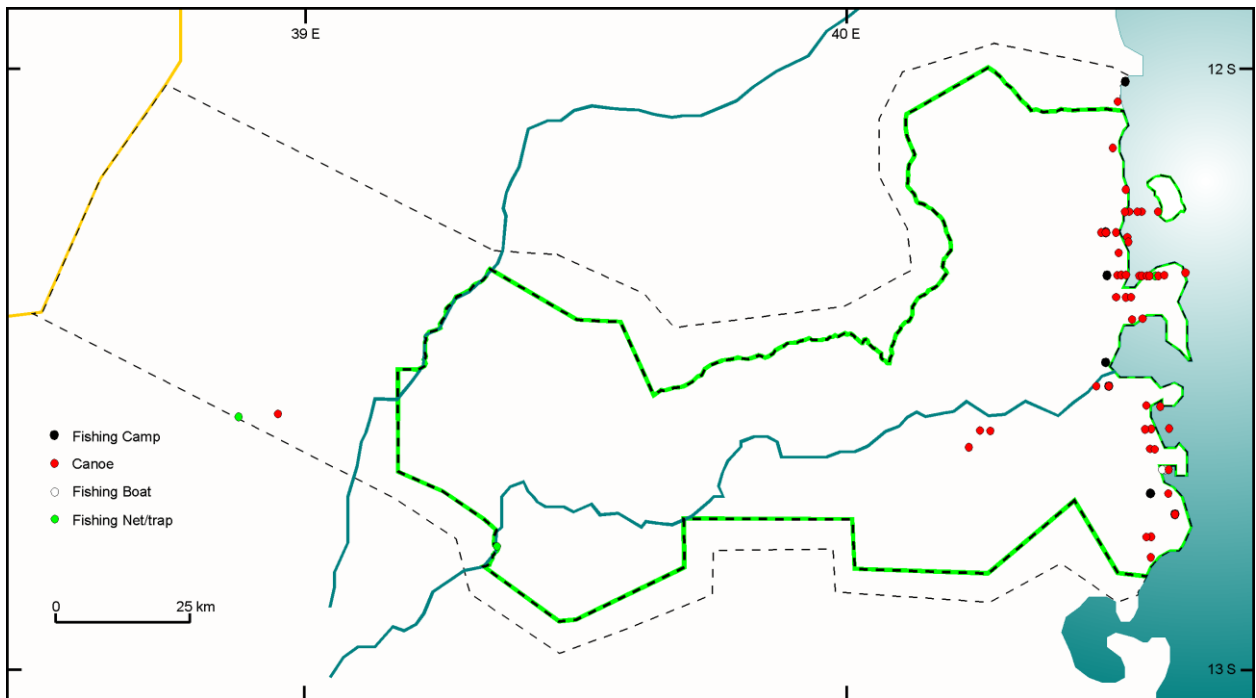
Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q2	20	9 - 46	2	7	0.0035
Quirimbas	20	9 - 45	2	7	0.0018
<b>Overall</b>	<b>20</b>	<b>9 - 45</b>	<b>2</b>	<b>7</b>	<b>0.0014</b>

#### *Fishtrap/net*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	10	1 - 29	1	0	0.0021
Q2	196	20 - 456	20	0	0.0348
Quirimbas	206	21 - 461	21	0	0.0197
Corridor S	28	3 - 84	3	0	0.0078
<b>Overall</b>	<b>233</b>	<b>24 - 492</b>	<b>24</b>	<b>0</b>	<b>0.0167</b>

#### *Canoe*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q2	2439	1171 - 3707	249	47	0.4327
Quirimbas	2439	1197 - 3681	249	47	0.2334
Corridor S	9	1 - 28	1	0	0.0026
<b>Overall</b>	<b>2448</b>	<b>1212 - 3684</b>	<b>250</b>	<b>47</b>	<b>0.1749</b>



**Figure 24: Sightings of fishing attributes**

Fishing was taking place mainly along the coast. The number of canoes appeared to have increased since 2011. As counting canoes was not a priority, and they could move outside the counted area onto the sea, the apparent increase may not be real.

## Illegal Hunting

### Snare line

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	168	72 - 264	17	0	0.0349
Q2	10	1 - 29	1	0	0.0017
Quirimbas	178	83 - 272	18	0	0.0171
Corridor S	634	519 - 750	69	0	0.1797
<b>Overall</b>	<b>812</b>	<b>670 - 954</b>	<b>87</b>	<b>0</b>	<b>0.058</b>

### Poachers' camp

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	10	1 - 29	1	0	0.0021
Quirimbas	10	1 - 29	1	0	0.001
<b>Overall</b>	<b>10</b>	<b>1 - 29</b>	<b>1</b>	<b>0</b>	<b>0.0007</b>

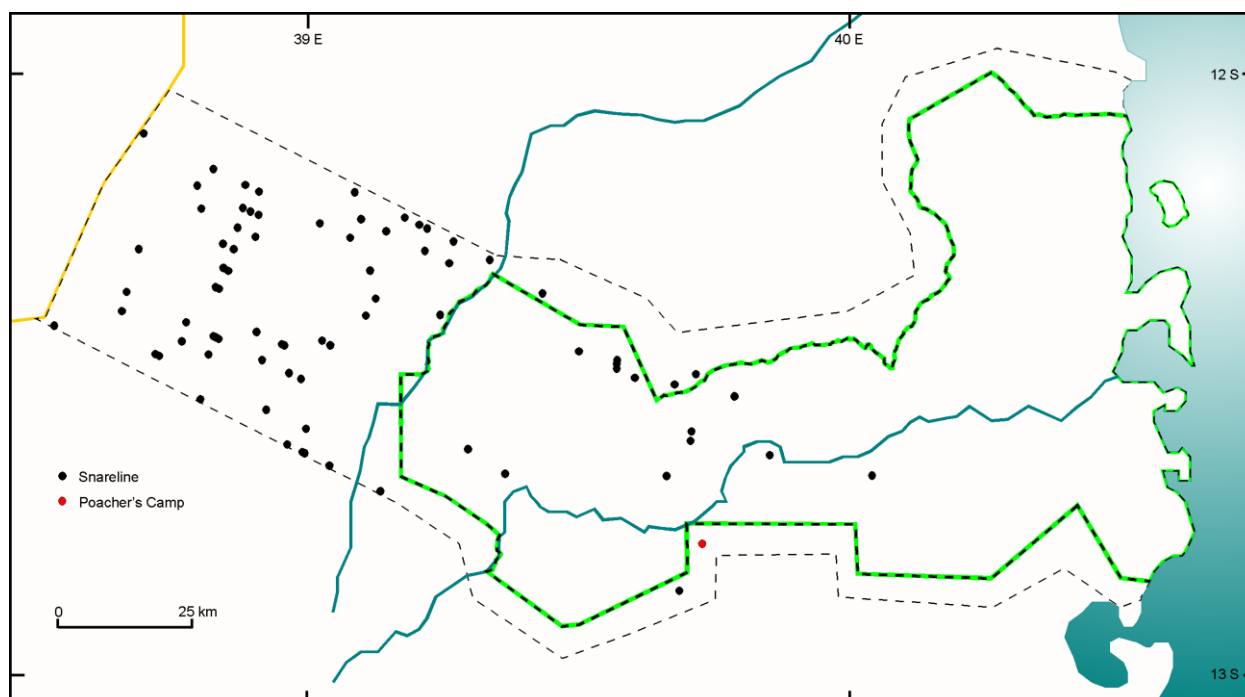


Figure 25: Sightings of illegal hunting

The number of brush lines for snares seen increased, but not significantly. The one poachers camp seen was in use.

*Wood utilisation**Logging*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	1975	1593 - 2358	200	2	0.4106
Q2	1293	956 - 1630	132	0	0.2294
Quirimbas	3268	2772 - 3765	332	2	0.3128
Corridor S	2363	1722 - 3003	257	0	0.6695
<b>Overall</b>	<b>5631</b>	<b>4863 - 6399</b>	<b>589</b>	<b>2</b>	<b>0.4021</b>

*Timber yard*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q2	10	1 - 29	1	0	0.0017
Quirimbas	10	1 - 28	1	0	0.001
Corridor S	28	3 - 58	3	0	0.0078
<b>Overall</b>	<b>37</b>	<b>4 - 71</b>	<b>4</b>	<b>0</b>	<b>0.0027</b>

*Timber truck*

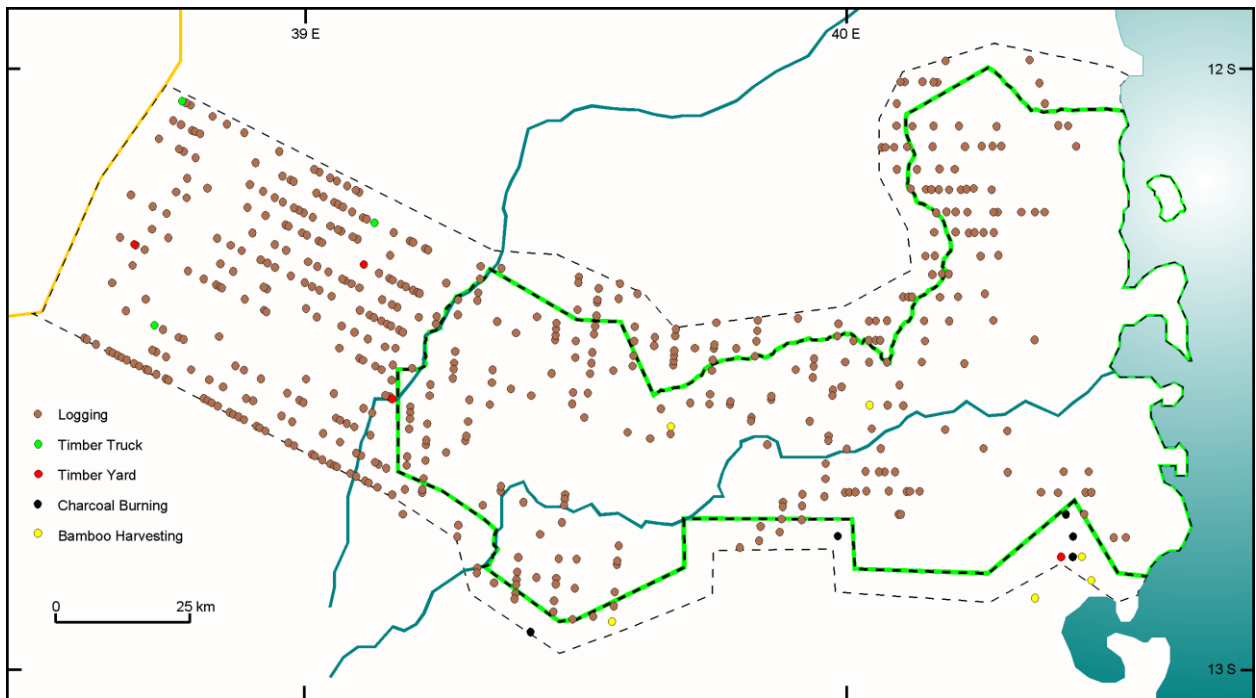
Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Corridor S	46	5 - 90	5	0	0.013
<b>Overall</b>	<b>46</b>	<b>5 - 87</b>	<b>5</b>	<b>0</b>	<b>0.0033</b>

*Bamboo cutting*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	20	2 - 46	2	0	0.0041
Q2	29	4 - 62	3	1	0.0052
Quirimbas	49	8 - 90	5	1	0.0047
<b>Overall</b>	<b>49</b>	<b>9 - 90</b>	<b>5</b>	<b>1</b>	<b>0.0035</b>

*Charcoal burning*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	10	1 - 29	1	0	0.0021
Q2	39	4 - 83	4	0	0.007
Quirimbas	49	5 - 96	5	0	0.0047
<b>Overall</b>	<b>49</b>	<b>5 - 96</b>	<b>5</b>	<b>0</b>	<b>0.0035</b>

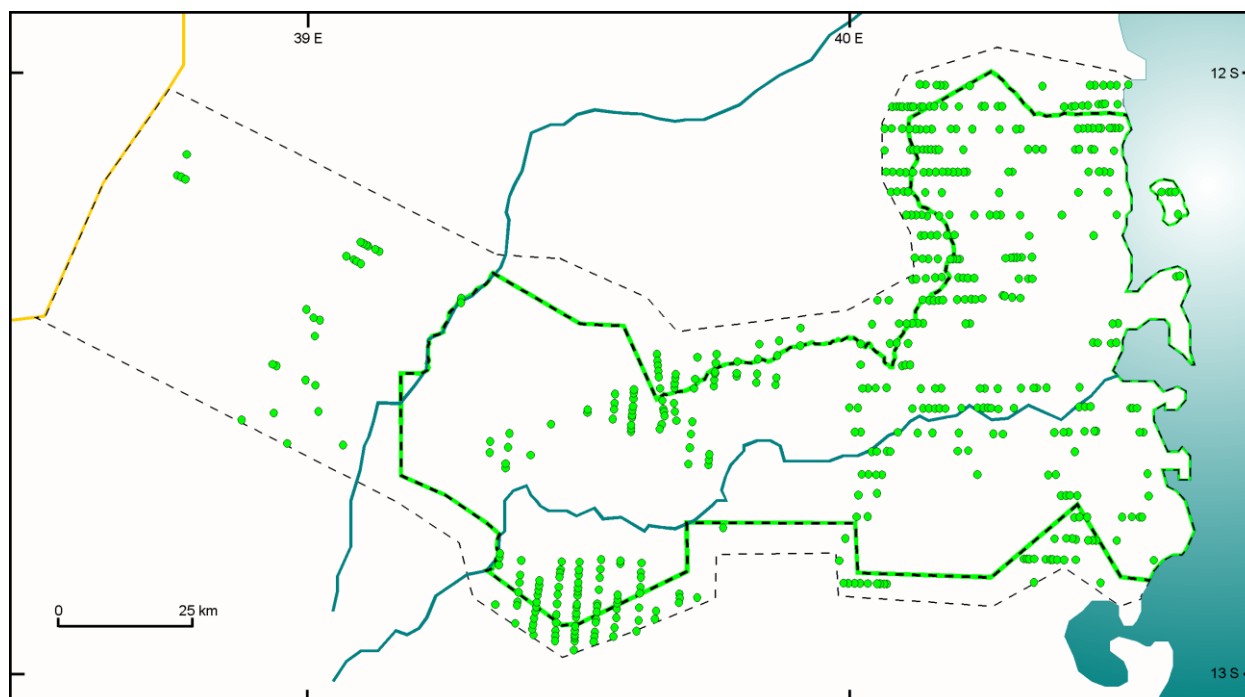


**Figure 26: Sightings of wood utilisation**

Logging increased significantly between surveys. Evidence of commercial logging (trucks and storage yards) was not seen inside the park, as it had been in 2011. The observers reported some logging with axes (i.e. without chainsaws) within the park. Tree felling for land clearance is excluded from these observations. Charcoal burning was outside of the park.

*Cultivation*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km- 2
Q1			232	1	
Q2			430	4	
Quirimbas			662	5	
Corridor S			35	3	
<b>Overall</b>			<b>697</b>	<b>8</b>	



**Figure 27: Sightings of cultivation**

The pattern of cleared fields is similar to that for 2011.



*Habitation**Village*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	593	319 - 866	60	3	0.1232
Q2	1009	712 - 1306	103	14	0.179
Quirimbas	1602	1208 - 1995	163	17	0.1533
Corridor S	64	12 - 130	7	5	0.0182
<b>Overall</b>	<b>1666</b>	<b>1269 - 2062</b>	<b>170</b>	<b>22</b>	<b>0.119</b>

*Big Village*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1			6	3	
Q2			11	6	
Quirimbas			17	9	
Corridor S			2	2	
<b>Overall</b>			<b>19</b>	<b>11</b>	

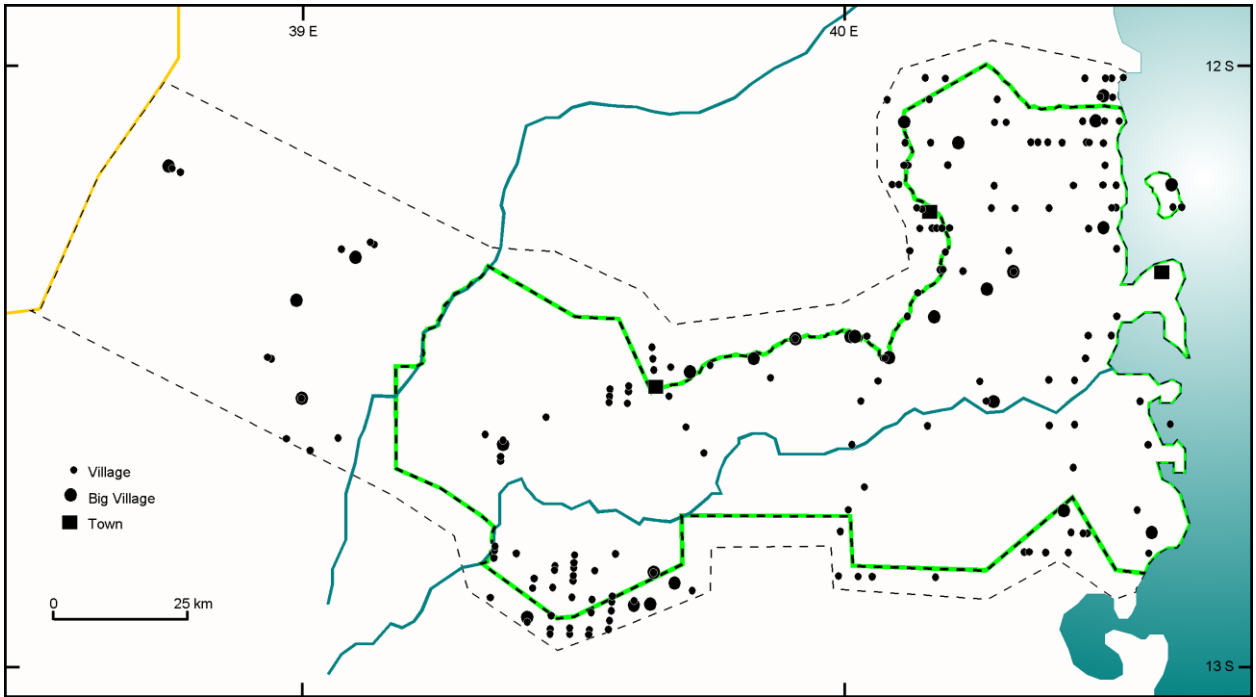
*Town*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1			2		
Q2			2		
Quirimbas			4		
<b>Overall</b>			<b>4</b>		

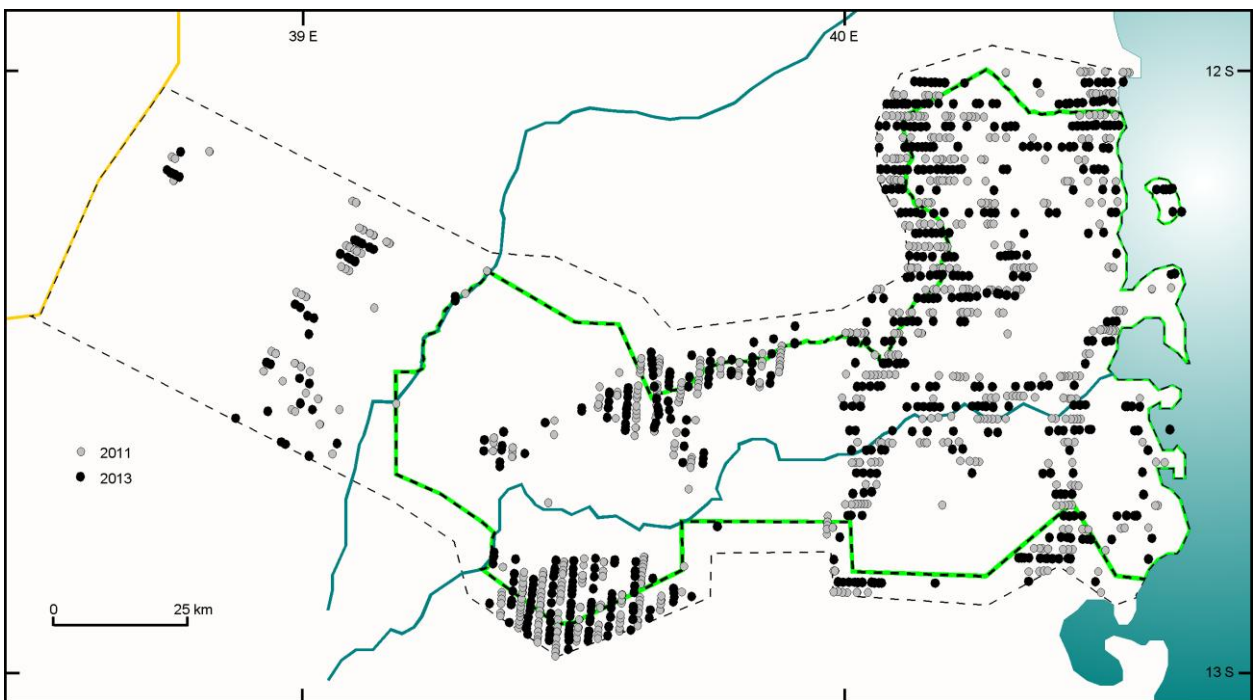
*Lodge/camp*

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1			1		
Q2			2		
Quirimbas			3		
<b>Overall</b>			<b>3</b>		

The label “town” is applied here to denote very large settlements. This implies nothing about official status, which is not known.

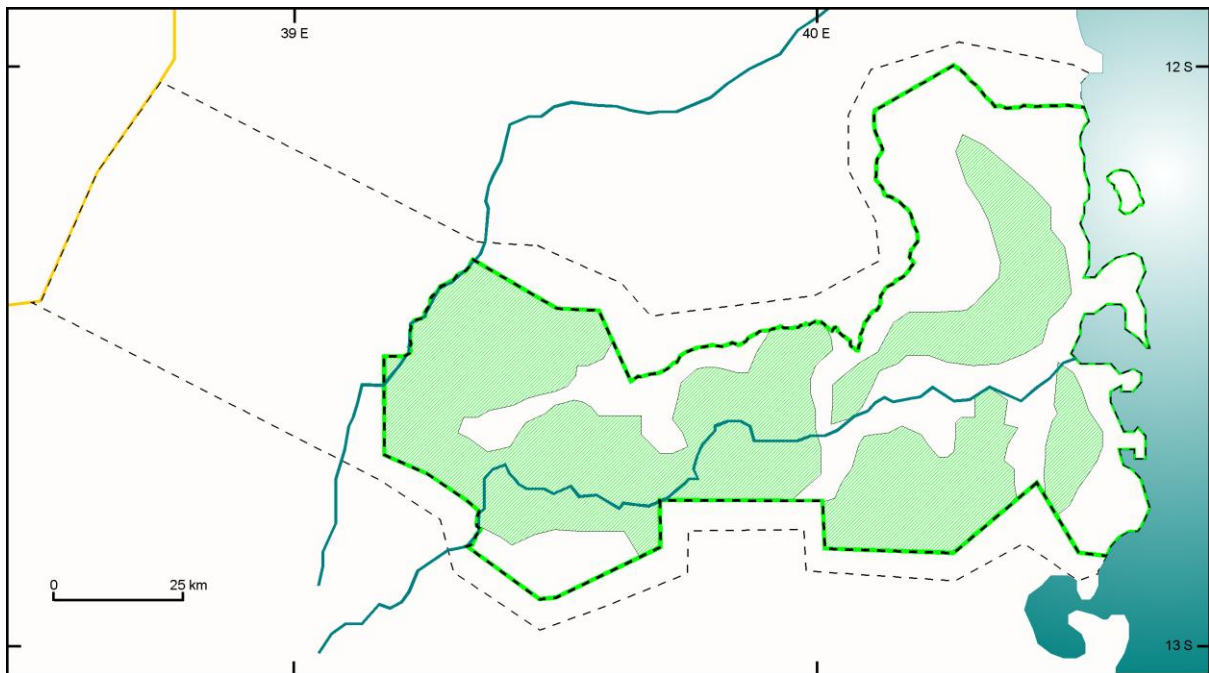


**Figure 28: Sightings of habitation**



**Figure 29: All records of cultivation and habitation**

All records of fields and settlements made in 2011 and 2013 are mapped in Fig. 29. Expansion, if any, is not obvious. The combined data give a clear picture of what areas are free of development.



**Figure 30: Unoccupied areas of Quirimbas National Park**

Based on Fig. 29, areas which are presently free of development can be delineated. These are illustrated in Fig 30. The total unoccupied area is 4600 km<sup>2</sup>, which is approximately 58% of the land area of the park.

## Extraction of Minerals

### Prospecting

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Corridor S	18	2 - 44	2	0	0.0052
<b>Overall</b>	<b>18</b>	<b>2 - 42</b>	<b>2</b>	<b>0</b>	<b>0.0013</b>

### Mining

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1	79	22 - 136	8	1	0.0164
Quirimbas	79	24 - 134	8	1	0.0076
<b>Overall</b>	<b>79</b>	<b>24 - 134</b>	<b>8</b>	<b>1</b>	<b>0.0057</b>

### Salt extraction

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q2		4 -	4	0	
Quirimbas		4 -	4	0	
<b>Overall</b>		<b>4 -</b>	<b>4</b>	<b>0</b>	

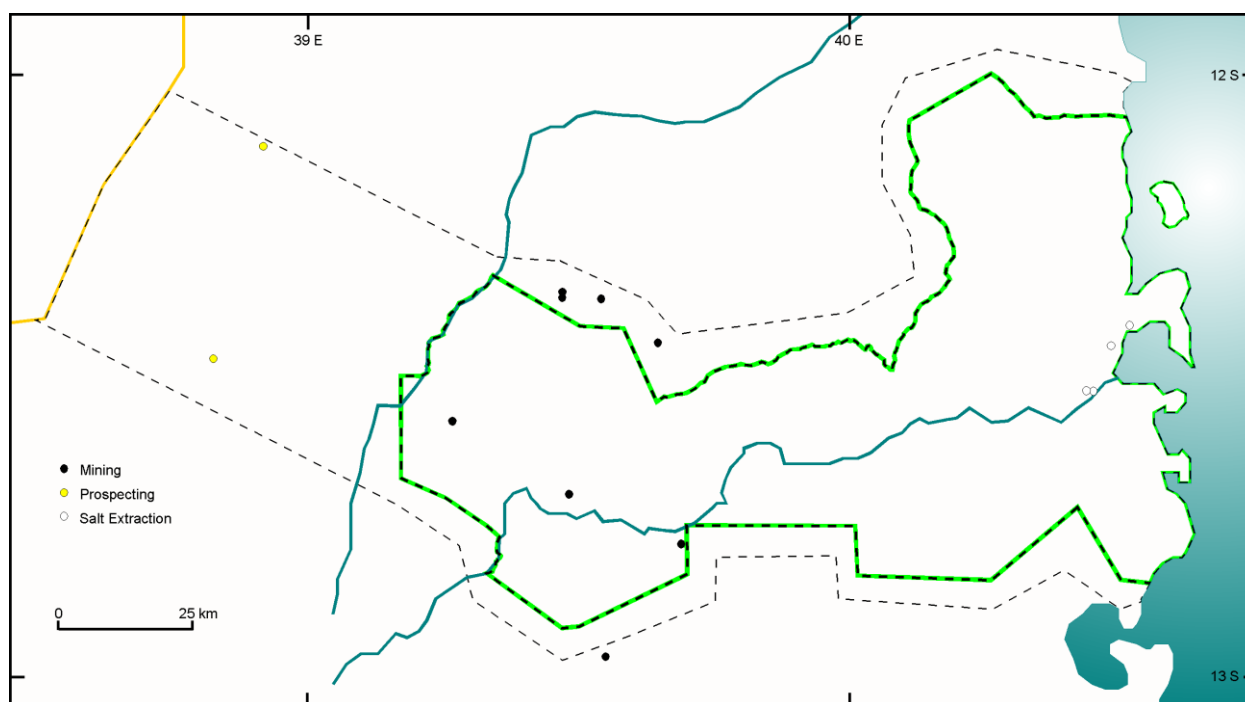


Figure 31: Sightings of mineral extraction

## 2.4 OTHER OBSERVATIONS

### Fire

Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>-2</sup>
Q1		4	0	4	
Q2		4	2	2	
Quirimbas		8	2	6	
<b>Overall</b>		<b>8</b>	<b>2</b>	<b>6</b>	

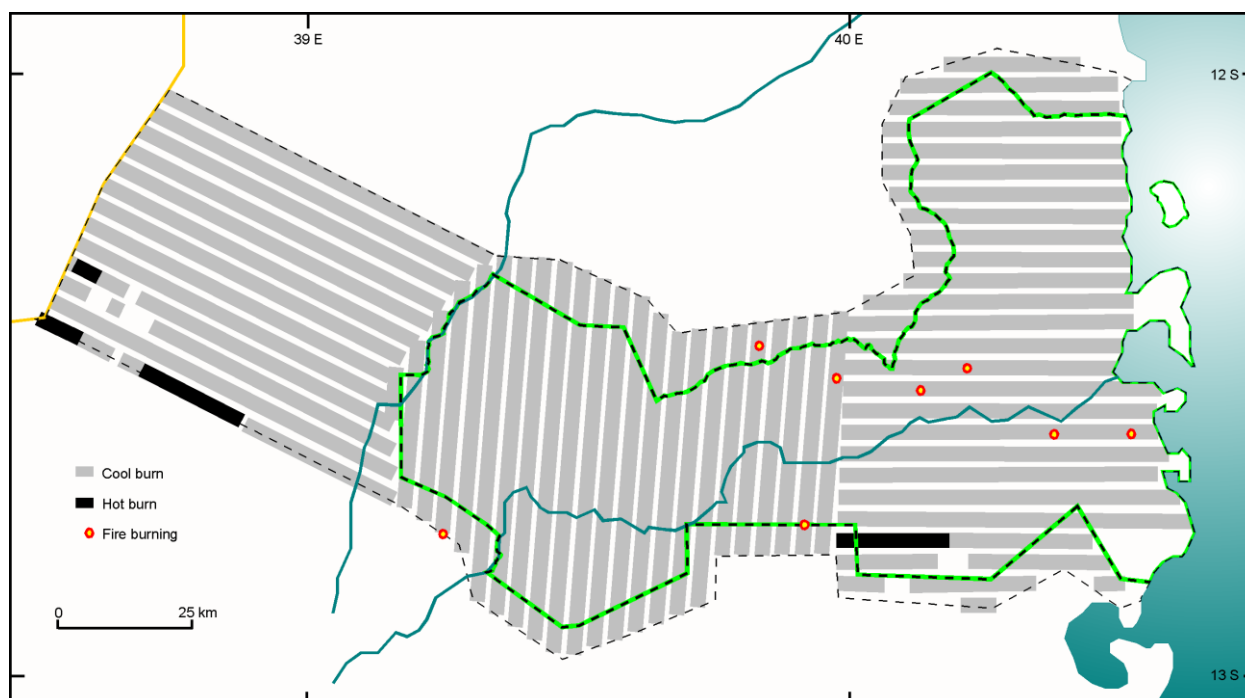
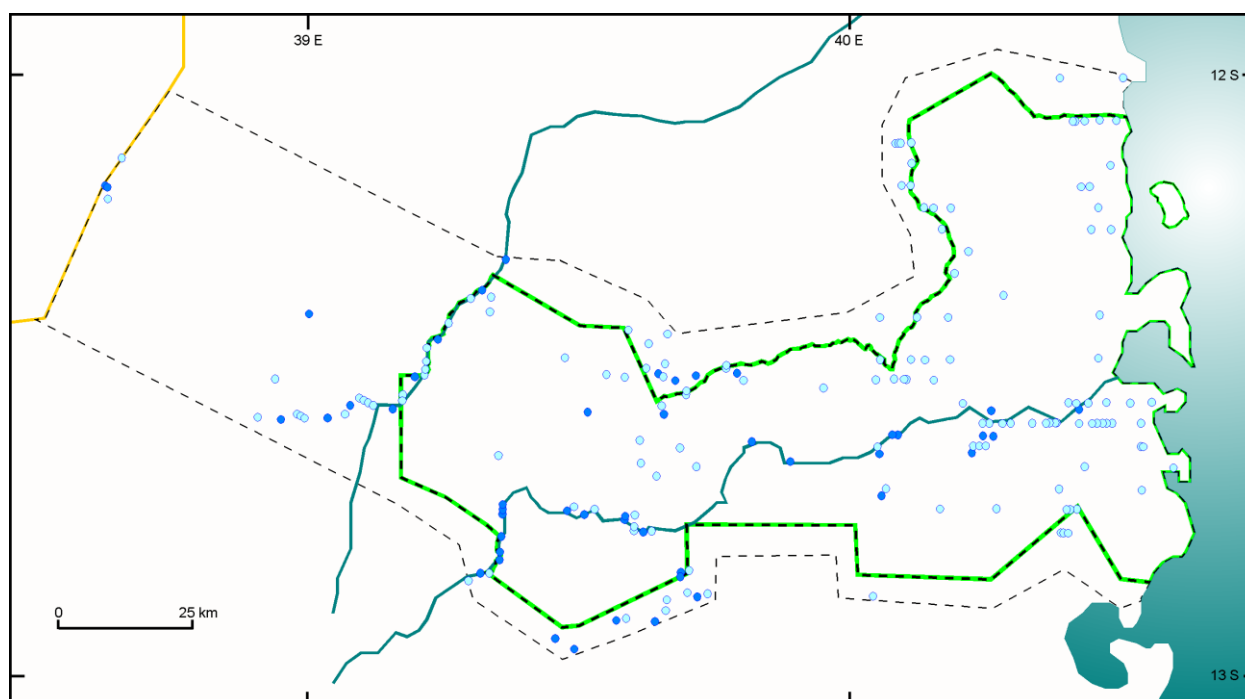


Figure 32: Distribution of fires

As the survey took place very late, most of the area had been burned much earlier. That it had probably burned early and cool made it difficult to determine whether it had burned. Unless an unburned patch was definitely identified, the area was assumed to have burned. Early burns are incomplete, but the patchiness was too fine scale to record. Hot burns are complete and leave ash tree-skeletons. Only a few such areas were recorded. Fires seen burning were probably in patches left over from the earlier cool burns.

*Water*

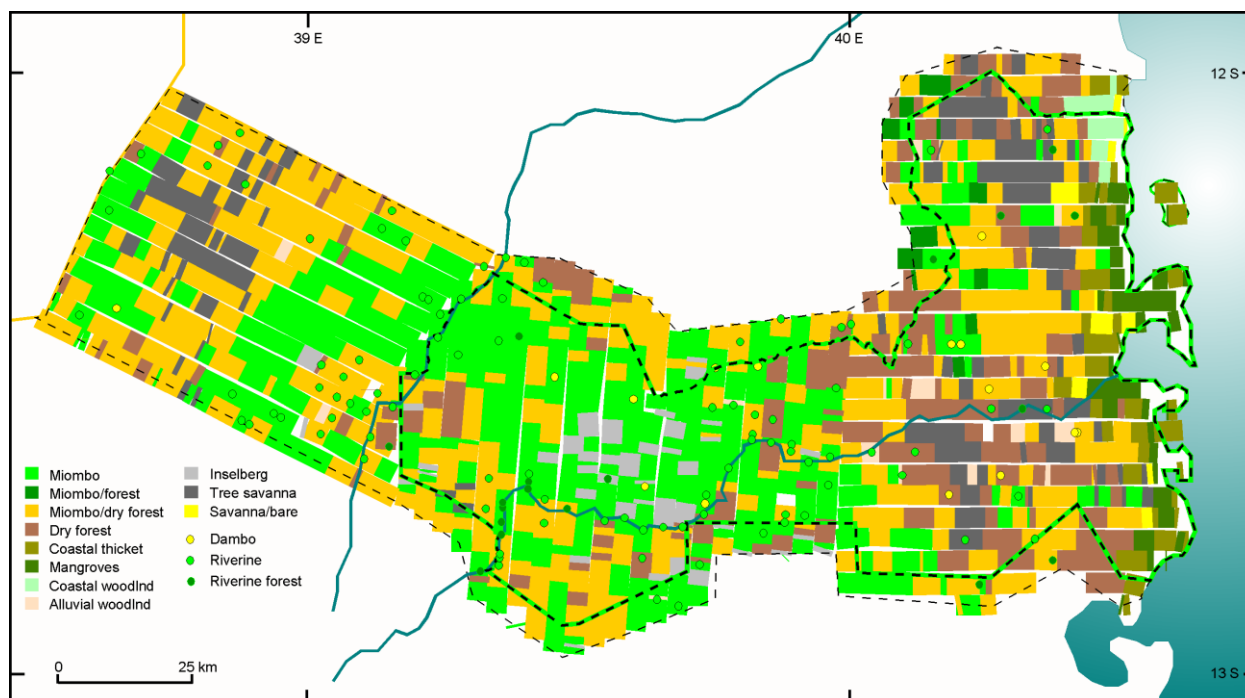
Strata	Pop. Est	95%Range	No. seen	No. out	No. km <sup>2</sup>
Q1	385	215 - 556	39	0	0.0801
Q2	98	10 - 203	10	0	0.0174
Quirimbas	483	289 - 678	49	0	0.0463
Corridor S	83	12 - 153	9	0	0.0234
<b>Overall</b>	<b>566</b>	<b>362 - 770</b>	<b>58</b>	<b>0</b>	<b>0.0404</b>



**Figure 33: All water sightings**

Water recorded in 2011 is included in Fig 33 (light blue). In 2013 water was left unrecorded in the north of stratum Q2. Water near the coast, which might be brackish, was not recorded in 2013. Most natural water points are along rivers.

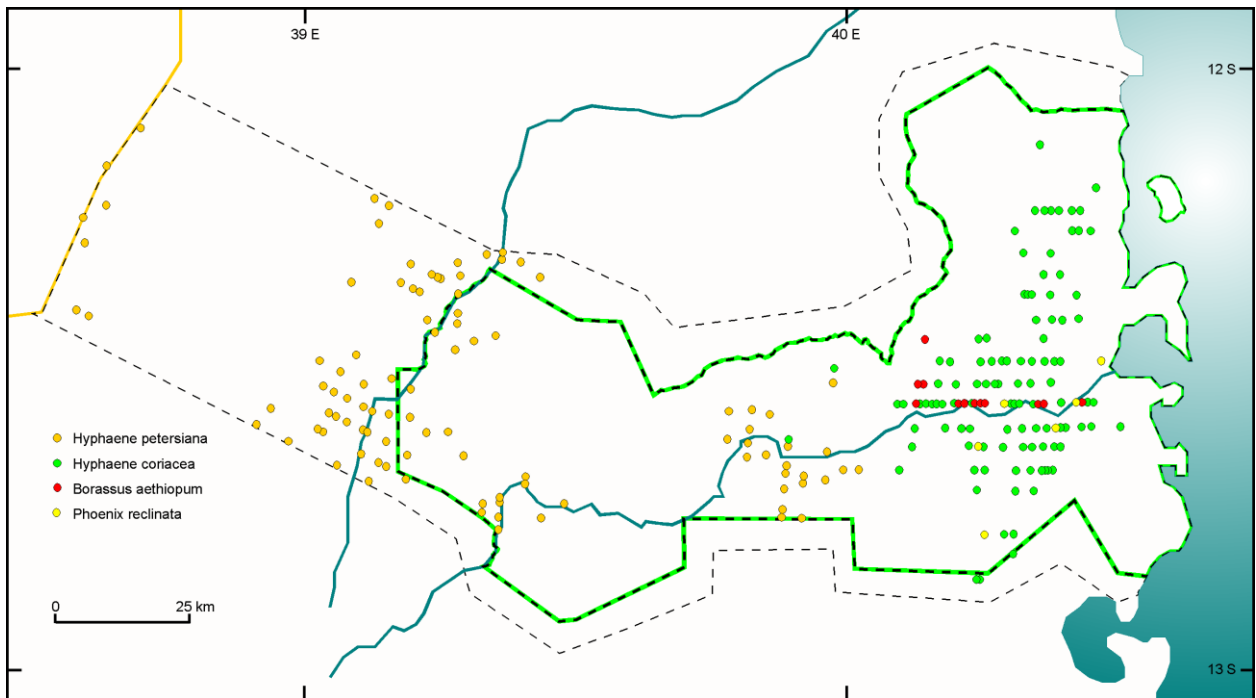
## 2.5 OBSERVATIONS OF VEGETATION



**Figure 34: Classification of vegetation from aerial observations in 2013**

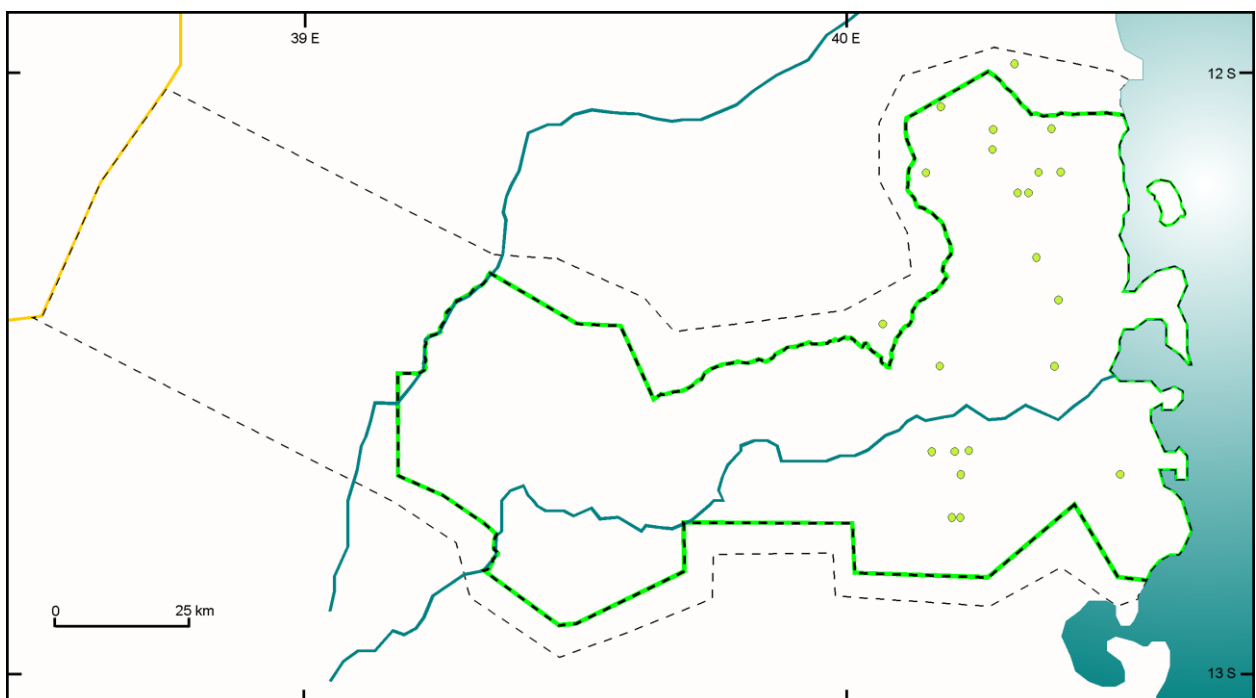
While ground surveys are necessary for a rigorous description of vegetation, they cannot provide the systematic coverage that an aerial reconnaissance gives the opportunity for. Types are recorded subjectively by structure and presence/absence of key species. In 2013 tree savannas and inselbergs were more comprehensively mapped compared to 2011 and low coastal thicket was separated from inland dry forest with a more extensive tree canopy. Dry forest – miombo/dry forest – miombo is a continuum with arbitrary and subjective borders between types. The more advanced canopy flush changed the perception of where the divisions between these types should be relative to 2011. The map emphasises a different aspect of biodiversity to the wildlife results and augments the existing map of GRNB (2010).

It is not possible to record many different species of plant on the survey, because only a few are prominent enough to identify and it is not possible to maintain search images for a large number. The following maps show a few species which give additional insights into the vegetation diversity. Sightings are not quantitative: each sighting contains one to many trees.



**Figure 35: Sightings of palm trees**

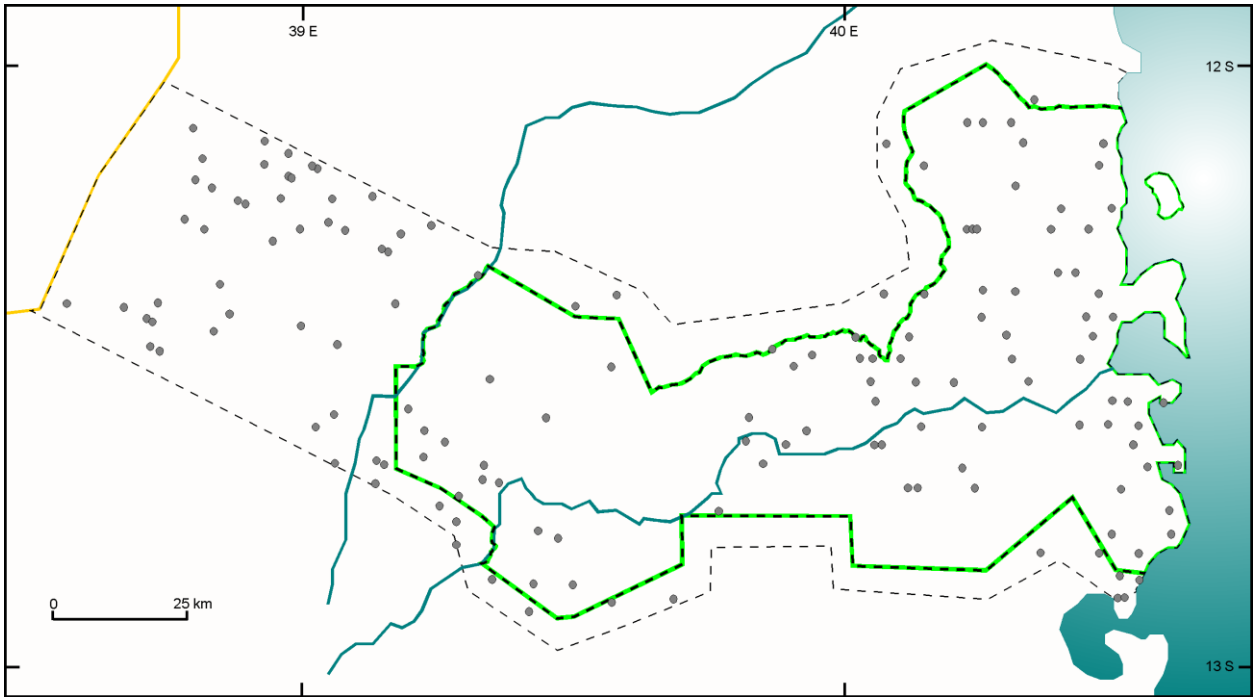
Palms are readily identifiable. *Hyphaene* and *Borassus* have palmate fronds, but *Borassus* has a more robust, lighter grey trunk. *H. coriacea* is dichotomously branched while *H. petersiana* is unbranched. *Phoenix* has pinnate fronds and is multi-stemmed from the base.



**Figure 36: Sightings of *Acacia xanthophloea***

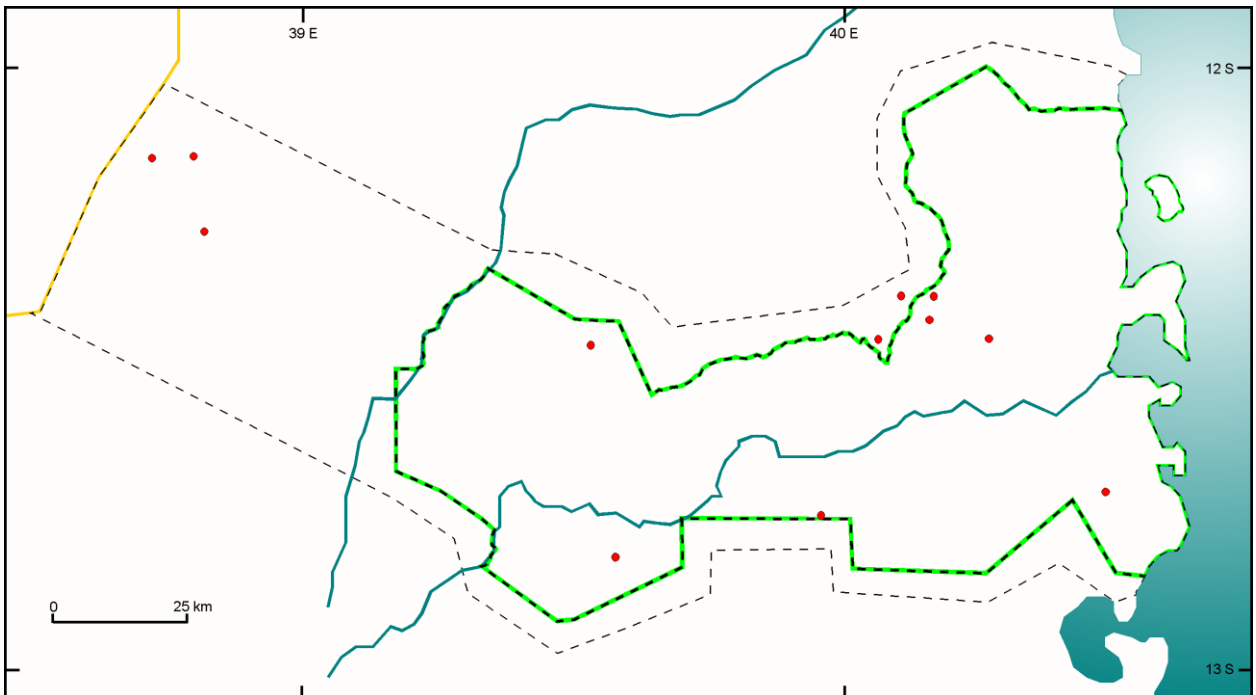
The identity of this species is not certain, as *A. seyal* occurs in the area and bears some similarities. *Acacias* are not common in the area. This one appears to be restricted to (and sometimes dominant on) tree savanna on black soil, but only at low altitude.





**Figure 37: Sightings of Baobabs (*Adansonia digitata*)**

*Adansonia digitata* occurs throughout the survey area up to the coast, but is rare in miombo woodland proper.



**Figure 38: Locations with smothering vines**

At some locations the natural vegetation, including tree canopies, is smothered by vines. This may be unusual growth of lianas consequent on removal of trees, but could be due to an invading alien vine.

### 3 GENERAL DISCUSSION AND CONCLUSIONS

#### *Elephants*

The key finding of this survey is that between 480 and 904 elephant carcasses have accumulated between 2011 and 2013, which represent losses to the population over the period. Actual losses could be higher, if some carcasses in the sample are missed by the observers. Losses are not reflected in the population estimates of live elephants, which actually increased over the period. However, precision of the live elephant estimates is very low, yielding an estimate of possible change over the two years ranging from a decline of 628 elephants to an increase of 762 (95% confidence limits of the difference). Precision of the carcass estimates is very much better because carcasses are mainly seen singly, in contrast to live elephants, whose sightings are concentrated into herds. In the surveyed area population changes can also occur as a result of immigration and emigration, as the boundaries are open to movement. Carcass counts are therefore the most powerful way to detect unusual mortality.

While carcass ratio provides an indication of unusual mortality from a single survey (the near 50% found on this survey is such an indication), comparison of successive surveys is necessary to give a measure of mortality. The present result provides evidence of an average annual loss of between 240 and 450 elephants *per annum* between surveys from the survey area. The losses are probably due to illegal hunting, as no other cause of such a large die-off is likely; the contribution of natural mortality is not likely to exceed 10 carcasses *per annum*, even on a population of 1000 animals.

#### *General Trends*

Trends based on two surveys are problematic for this area, as most populations are small, and the estimates have poor precision. Where a species is likely to be undercounted, which applies to most, the bias is likely to vary between surveys due to changes in visibility, giving spurious differences. With a long series of surveys precision improves and bias variations, which are random, tend to even out. A comparison of two surveys gives a much less reliable indication of trends.

Differences between the 2011 and 2013 surveys (for Quirimbas National Park and buffer, whose strata are comparable) are shown in the following table. The probabilities of the Student's *t* values are given as *p* and the significant values are highlighted by asterisks.

Elephant carcasses show a highly significant change, as discussed previously. The only other species to show significant change are duiker and grysbok; this is most likely to be due to changing visibility bias. Other species show no significant change. However, change in any species is not ruled out; there may be changes, but insufficient information to detect them.

There is a significant increase in the number of canoes, and in the amount of logging. Snare lines have increased, but this is inconclusive as the difference is not significant. Interestingly, the number of timber storage yards has decreased significantly in the park and buffer.

*Comparison of 2013 with 2011 results for Quirimbas NP (Q1+Q2)*

	2011	2013	Difference	$p$	
Baboon	1397	1749	352	0.501	
Buffalo	0	119	119	0.289	
Bushbuck	153	295	142	0.087	
Bushpig	48	29	-19	0.721	
Duiker	938	2234	1296	1.24E-05	***
Eland	19	0	-19	0.134	
ElephantBull	124	0	-124	0.184	
ElephantFamily	393	560	167	0.581	
Elephant carcass	86	609	523	9.71E-07	***
GroundHornbill	568	433	-135	0.389	
Grysbok	0	226	226	2.33E-05	***
Hyrax	0	277	277	0.079	
Klipspringer	0	30	30	0.292	
Kudu	182	177	-5	0.965	
Monkey	305	373	68	0.742	
Sable	162	137	-25	0.878	
Warthog	555	276	-279	0.09	
Cattle	791	2762	1971	0.36	
Sheep/goats	1062	1678	616	0.373	
Fishing camp	76	69	-7	0.843	
Fishtrap/net	76	206	130	0.323	
Canoe	619	2439	1820	0.008	**
Snareline	125	178	53	0.442	
Logging	2196	3268	1072	0.003	**
Timber yard	356	10	-346	3.07E-05	***
Bamboo cutting	105	49	-56	0.289	

***General***

Some shortcomings of the results have been referred to throughout and are worth restating.

The precision of wildlife estimates is low as a result of the small numbers of sightings. This precludes detection of trends in the short term. To improve precision on such small populations would require a large increase in sampling intensity. It should be asked whether the increased cost of this could be justified by the relative importance of any of the populations. Some improvement could be made by excluding parts of the area where there are high human impacts, now that these have been mapped, and concentrating on other areas.

The methods employed can be expected to give accurate (i.e. unbiased, if not precise) estimates of elephants. All other species are likely to be undercounted and comparison of the current results with those of ground-counts (Araman and Mahommed, 2006) tends to bear this out. Undercounting not only underestimates populations, but introduces additional

variation between surveys because of varying sighting conditions. Sighting conditions should be optimised to minimise this bias. This can be done by carrying out surveys at a time of year when visibility is at a maximum (the 2013 survey took place at a time when many of the trees were already in leaf). Survey flights should take place as early and late in the day as possible to avoid the hotter parts of the day when animals seek shade. This is difficult when operating from an airport with fixed opening hours.

The survey area's boundaries are open to movement of wildlife, especially from the north and west. Several of the sighting maps suggest there may be significant numbers of wildlife in places beyond the limits of the surveyed area. This will make it difficult to detect or account for changes in some wildlife populations (not least, elephants), as changes can occur through immigration/emigration. Ideally surveys should be extended into unsurveyed areas of wildlife habitat in the province.

#### **4 ACKNOWLEDGEMENTS**

The survey was supported by the WWF Coastal East Africa initiative by grants from SIDA and AFD (see front page).

Pilots and wives of Missionary Aviation Fellowship provided invaluable back-up for the survey crew.

Staff of Quirimbas National Park at Pemba and of the Pemba office of WWF provided invaluable logistic assistance.

Maps with topography were developed using NASA Shuttle Radar Topography data.

## 5 REFERENCES

Literature cited in main text and Appendix I is included here.

Araman, A and JD Mahommed. 2006 *Ground Count of Mammals of interest in the Quirimbas National Park, 2006*. Ministry of Tourism, Mozambique.

Craig G.C. 2012a. *Aerial Survey of Wildlife in the Niassa Reserve, October 2011*, Sociedade para a Gestão e Desenvolvimento da Reserva do Niassa, Maputo.

Craig G.C. 2012b. *Aerial Survey of Quirimbas National Park and Adjacent Areas, October 2011*. WWF. Annex I of *Aerial Survey of Wildlife in the Niassa Reserve, October 2011*, Sociedade para a Gestão e Desenvolvimento da Reserva do Niassa, Maputo.

Douglas-Hamilton I. 1996. Counting elephants from the air - total counts. In: *Studying Elephants*. Ed. K. Kangwana. *AWF Technical Handbook series, African Wildlife Foundation Nairobi, Kenya*.

Gibson D. St.C. 1998. *Aerial survey of Wildlife in and around Niassa Game Reserve, Moçambique, October 1998*. Sociedade para a Gestão e Desenvolvimento da Reserva do Niassa

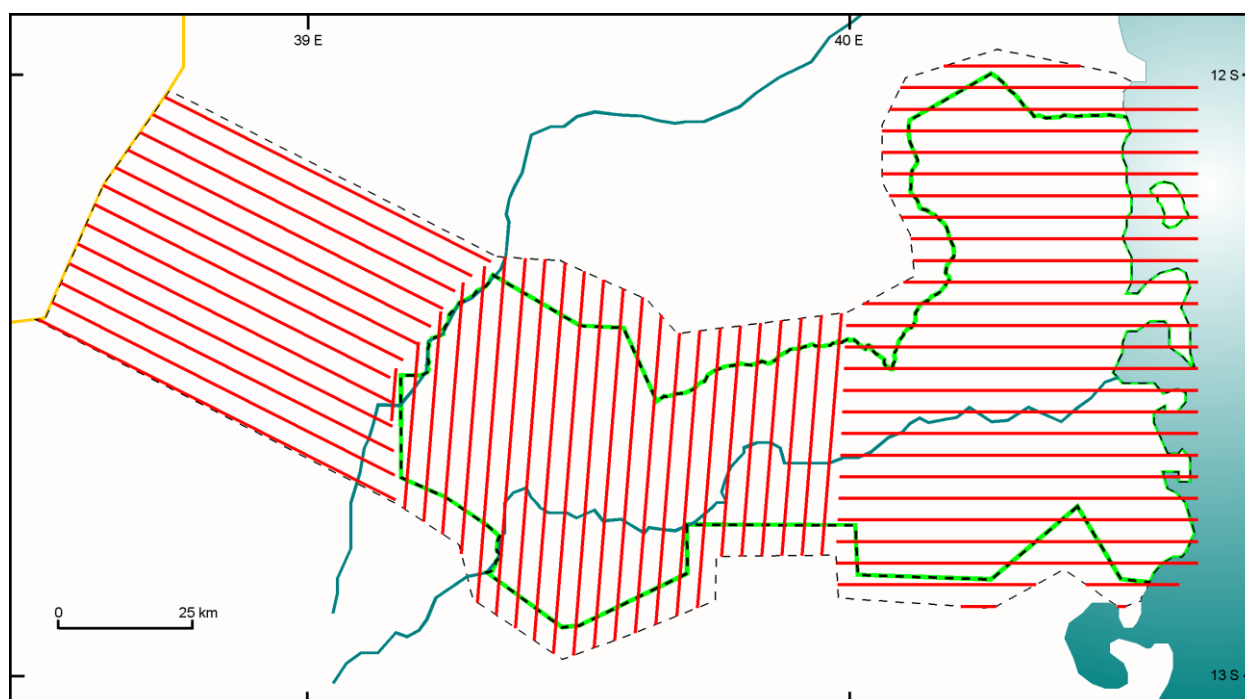
GRNB (2010) *Biodiversity Baseline of the Quirimbas National Park, Mozambique*. GRNB, Maputo.

Jolly G.M.1969. Sampling methods for aerial censuses of wildlife populations. *E. Afr. Agricultural & Forestry Journal - special issue: 46 -49*.

Norton Griffiths M. 1978. *Counting Animals*. Handbook No. 1, African Wildlife Foundation, Nairobi, Kenya.

## APPENDIX I: METHODS

Methods were the same as in Niassa Surveys, and as described in the previous survey report for this area (Craig, 2012). Stratification was according to the requirements of WWF, although Quirimbas National Park was divided into two strata in order to permit the transects to be orientated along presumed ecological gradients. Transect (sampling unit) selection is shown in Fig. 39. Transects in Q2 were extended over the ocean in order to ensure that all land was included. Counting and flying were stopped at the coast (see Fig. 40). Transect spacing was 4 km throughout. For this survey, transect positions were not selected by even spacing from a randomly selected starting point. Instead, the transects are offset by 2 km from the set used in 2011. This provides two interleaved sets of results which, together, show a more complete distribution of the permanent human impacts, habitation and cultivation (Fig.29).



**Figure 39: Transects**

The systematic aerial reconnaissance method was used (Norton Griffiths 1978). Transects were flown at 300 ft above ground (using a radar altimeter) at a groundspeed of 90 knots (nominal values). Left and right observers in the back seats of a Cessna 206 made observations in strips marked by rods attached to the lift struts. Strips were calibrated at a nominal 200m per side at 300ft. Height was recorded at regular intervals from the radar altimeter to enable correction of the strip widths to give an area for each transect. The density calculated from numbers seen and transect areas enabled an estimate of numbers for the stratum. Precision was calculated for the estimates using Jolly's method for unequal sized sampling units (Jolly, 1969). Formulae used for the calculations are also given in Gibson (1998) and are repeated at the end of this section. Sampling intensity for stratum Q2 could be calculated using the full area with the full transect lengths or the land area with the flown

transect lengths. As the land area is not known exactly (due to uncertain mapping and the existence of tidal flats), the former approach was used.

The front seat passenger recorded observations made by the observers, marked positions on the GPS, made height readings, and fire and vegetation observations. Vegetation and fire were recorded by marking positions of changes on the ground to delimit transect segments of similar type.

Vegetation and fire maps were made by plotting the transect segments of the various attributes as lines expanded to fill the space between transects.

### ***Elephant sightings, carcass classification and ratios***

Elephants were recorded as being in family groups or bull groups, defined as follows:

Family groups - herds in which females and young are present. Any bulls in the group are counted as part of the group.

Bull groups - single bulls or herds which contain no females or juveniles.

Carcasses were classified into four categories according to their estimated time since death (Douglas-Hamilton, 1996). These are:

Carcass 1 - Fresh (<1 month): skin covered, with flesh present giving the body a rounded appearance; vultures often present; ground still moist from body fluids.

Carcass 2 - Recent (<1 year): rot patch still visible; hide still attached to carcass; bones not scattered

Carcass 3 - Old (>1 year): skin absent; bones not scattered; vegetation regrown in rot patch.

Carcass 4 - Very old (up to 10 years): bones bleached and scattered.

Carcasses of other species were also classified, as far as possible, according to the same criteria.

Carcass *ratio* is defined as the: number of carcasses / (carcasses + live elephants) and is expressed here as a percentage. While the term ratio evokes an impression of a simple ratio between carcasses and elephants, the above definition has become accepted.

### ***Crew***

Survey crew comprised D. Holmes (Pilot), C. Craig (coordinator and front-seat observer), N. Chitemamuswe (left hand observer) and D. Chipesi (right hand observer).

**Data Analysis**

Jolly's (1969) method for blocks of unequal size was used to calculate estimates of density and variance for each species in each stratum as follows:

$$R = (\sum y) / \sum z$$

$$\hat{Y} = Z \cdot R$$

$$\sigma^2_{\hat{Y}} = (N \cdot (N - n) / n) \cdot (s^2_y - 2 \cdot R \cdot \text{cov}_{zy} + R^2 \cdot s^2_z)$$

where:

$R$  = density of animals

$\hat{Y}$  = total number of animals estimated in stratum

$Z$  = total area of stratum

$y$  = number of animals counted in a transect

$\sum y$  = total animals counted in all transects in stratum

$z$  = area of a transect

$\sum z$  = total area of transects in stratum

$n$  = number of transects

$N$  = number of transects possible in stratum, where  $N = n \cdot Z / \sum z$

$s^2_y$  = variance of number seen per transect

$s^2_z$  = variance of transect areas

$\text{cov}_{zy}$  = covariance between number seen per transect and transect area

$\sigma^2_{\hat{Y}}$  = variance of estimated number in stratum (i.e. variance of  $\hat{Y}$ )

Overall estimates and variances were obtained from the sums of the stratum estimates and their variances.



## APPENDIX II: RESULTS

### SUPPORTING DATA

#### *Aerial coverage achieved*

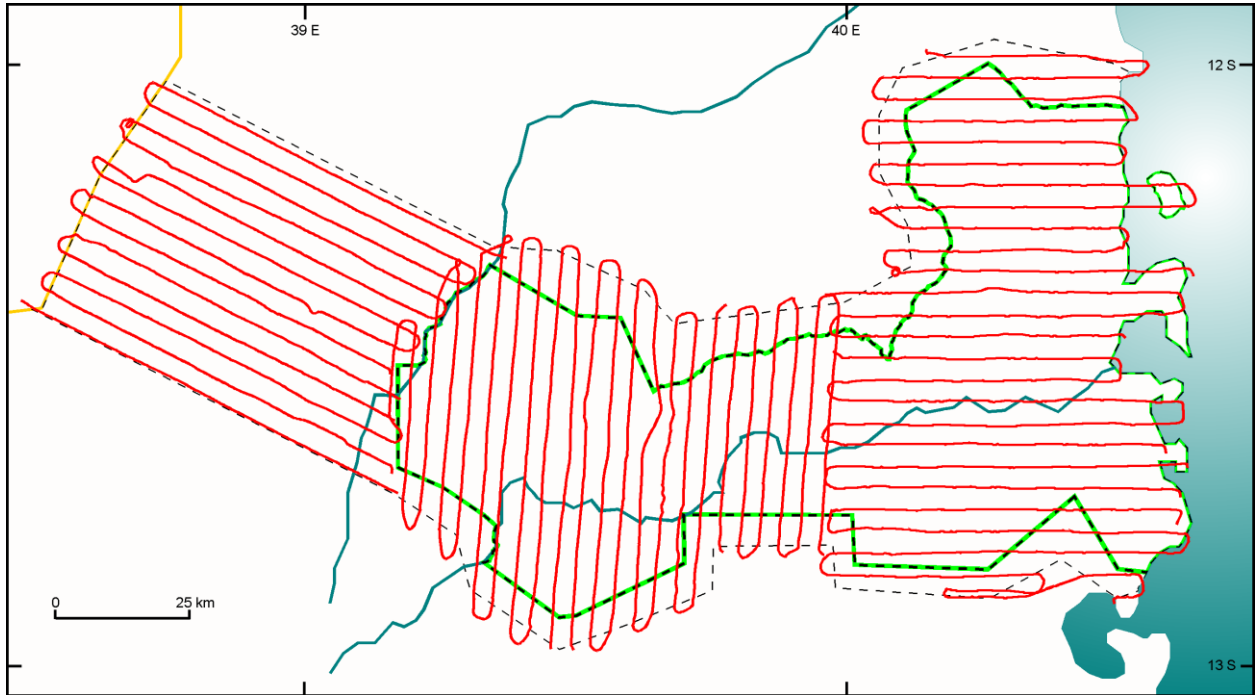


Figure 40: Record of tracks flown

#### *Maintenance of height*

Mean height above ground was 302.4 feet. 95% of recorded heights were within 51ft of this.

#### *Sampling and searching rates*

Stratum	Area	Sample Area	Sampling intensity	Sampling units	Speed (Knots)	Search rate (km <sup>2</sup> /min)
Q1	4811	487.10	10.10	23	98.4	1.22
Q2	5637	581	10.3	28	92.3	1.17
CorrS	3529	383.9	10.9	13	93.6	1.2
Overall	13977	1452.00	10.4	64	94.4	1.2

The desired speed was 90 knots and the desired search-rate was 1 km<sup>2</sup> per minute.

*Calibration results*

	H	L		R		Width		Corrected		Tot W
		in	out	in	out	L	R	L	R	
1	250	7	24	8	25	180	180	216	216	432
2	280	8	27	7	23	200	170	214.29	182.14	396.43
3	250	14	31	2	19	180	180	216	216	432
4	280	12	31	4	23	200	200	214.29	214.29	428.57
5	280	12	30	3	21	190	190	203.57	203.57	407.14
6	270	7	26	9	28	200	200	222.22	222.22	444.44
7	320	13	31	6	25	190	200	178.13	187.5	365.63
8	290	6	27	5	22	220	180	227.59	186.21	413.79
9	280	10	28	5	22	190	180	203.57	192.86	396.43
10	320	7	26	11	29	200	190	187.5	178.13	365.63
11	290	9	27	4	20	190	170	196.55	175.86	372.41
12	320	11	30	7	27	200	210	187.5	196.88	384.38
13	270	6	26	10	27	210	180	233.33	200	433.33
14	250	8	26	4	20	190	170	228	204	432
15	280	8	27	10	26	200	170	214.29	182.14	396.43
16	310	13	32	5	20	200	160	193.55	154.84	348.39
17	280	7	26	7	26	200	200	214.29	214.29	428.57
18	280	11	29	5	22	190	180	203.57	192.86	396.43
19	260	7	25	5	23	190	190	219.23	219.23	438.46
20	260	12	31	2	19	200	180	230.77	207.69	438.46
21	270	10	28	5	20	190	160	211.11	177.78	388.89
									Mn	406.66
									Var	813.35
									SE	6.22
									PRP%	3.06

The desired total strip-width was 400m. A precision (PRP) of better than 4% (95% confidence interval as a percentage of the mean) is aimed at. Left observer was N. Chitemamuswe and right was D. Chipesi.

*Comparison of observers*

Number of observations (groups seen):

Species	Left		Right		Chi <sup>2</sup>	p
	Observed	Expected	Observed	Expected		
<b>Baboon</b>	25	16.03	6	14.97	10.4	0.0013 **
<b>Buffalo</b>	0	0.52	1	0.48	1.07	0.3008
<b>Bushbuck</b>	9	12.41	15	11.59	1.94	0.1638
<b>Bushpig</b>	2	1.03	0	0.97	1.87	0.1717
<b>Duiker</b>	208	196.99	173	184.01	1.27	0.2589
<b>Recent EleCarcass</b>	5	4.14	3	3.86	0.37	0.5411
<b>Old EleCarcass</b>	38	36.19	32	33.81	0.19	0.6654
<b>ElephantFamily</b>	8	6.2	4	5.8	1.08	0.2996
<b>GroundHornbill</b>	21	18.61	15	17.39	0.63	0.4260
<b>Grysbok</b>	22	16.54	10	15.46	3.72	0.0536
<b>Hyrax</b>	3	2.07	1	1.93	0.87	0.3511
<b>Klipspringer</b>	2	1.03	0	0.97	1.87	0.1717
<b>Kudu</b>	5	4.14	3	3.86	0.37	0.5411
<b>Monkey</b>	0	5.17	10	4.83	10.71	0.0011 **
<b>Nyala</b>	1	0.52	0	0.48	0.93	0.3338
<b>Sable</b>	2	1.55	1	1.45	0.27	0.6040
<b>Warthog</b>	8	9.31	10	8.69	0.38	0.5377
<b>Cattle</b>	4	4.14	4	3.86	0.01	0.9232
<b>Sheep/goats</b>	12	9.31	6	8.69	1.61	0.2039
<b>Total</b>	<b>375</b>	<b>345.89</b>	<b>294</b>	<b>323.11</b>	<b>5.07</b>	<b>0.0243 *</b>

The left observer saw significantly more groups of animals overall but there were only significant differences for baboon (left observer saw more) and monkeys (right observer saw more). These species are both difficult to see. There was no evidence of bias for elephants or elephant carcasses. It is unusual for observers to be perfectly matched in what they see and lack of significance does not rule out selective bias.

The following wildlife species were observed:

Name in text	Full name	Species
Baboon	Yellow baboon	<i>Papio cynocephalus</i>
Bushbuck**	Bushbuck	<i>Tragelaphus scriptus</i>
Bushpig	Bushpig	<i>Potamochoerus porcus</i>
Duiker	Grey duiker	<i>Sylvicapra grimmia</i>
Eland	Cape eland	<i>Taurotragus oryx</i>
Elephant	African elephant (savanna form)	<i>Loxodonta africana africana</i>
Ground Hornbill	Ground Hornbill	<i>Bucorvus leadbeateri</i>
Hyrax	Rock dassie*	<i>Procavia capensis</i>
Hyrax	Yellow-spotted rock dassie*	<i>Heterohyrax brucei</i>
Klipspringer	Klipspringer	<i>Oreotragus oreotragus</i>
Kudu	Greater kudu	<i>Tragelaphus strepsiceros</i>
Monkey	Blue monkey*	<i>Cercopithecus mitis</i>
Monkey	Vervet monkey*	<i>Cercopithecus aethiops</i>
Sable	Sable antelope	<i>Hippotragus niger</i>
Warthog	Warthog	<i>Phacochoerus aethopicus</i>
Zebra	Grant's zebra	<i>Equus burchelli boehmi</i>
Turtle***	Green turtle	<i>Chelonia mydas</i>

\*Allied species not distinguished

\*\* A sighting of Nyala (*Tragelaphus angasii*) was made. This was probably a bushbuck

\*\*\*species not identified

## RESULTS BY STRATUM

The following tables give the results for each stratum based on the numbers seen in the sample. Results for all species and attributes counted are given. Only number seen is given where none were seen in the sample, or where there is doubt that the attribute can be fairly sampled. Column 6, labelled PRP (Percent Relative Precision) is the 95% confidence limit expressed as a percentage of the estimate. Densities are based on land area.

**Overall Survey Area (Corridor S + Q1 + Q2) AREA: 14878 km<sup>2</sup> (Land Area = 14006 km<sup>2</sup>)**

SPECIES/ATTRIBUTE	Pop. est.	No. seen	No. Out	Variance	PRP%	95%Range	Density /km <sup>2</sup>
Baboon	1795	183	0	122602.5	39	1095 - 2495	0.1281
Buffalo	119	12	0	12333.2	187.4	12 - 341	0.0085
Bushbuck	432	45	0	7757	40.7	256 - 609	0.0309
Bushpig	57	6	0	1487.3	135.4	6 - 134	0.004
Duiker	4624	487	4	129591	15.6	3905 - 5344	0.3302
Eland	0	0	8	0	0	8	0
ElephantFamily	854	89	21	63597.8	59	350 - 1359	0.061
All Elephants	854	89	21	63597.8	59	350 - 1359	0.061
EleCarcass 1	10	1	1	86.7	190	2 - 28	0.0007
EleCarcass 2	76	8	2	702.6	69.7	23 - 129	0.0054
Recent E carcasses	86	9	3	789.2	65.5	30 - 142	0.0062
EleCarcass 3	213	22	2	2459.1	46.5	114 - 312	0.0152
EleCarcass 4	513	53	7	7013.9	32.7	345 - 680	0.0367
Old E carcasses	726	75	9	9472.9	26.8	531 - 920	0.0518
All E carcasses	811	84	12	10262.2	25	609 - 1014	0.0579
GroundHornbill	801	84	4	18150.1	33.6	531 - 1070	0.0572
Grysbok	364	38	0	3669.7	33.3	243 - 485	0.026
Hyrax	277	28	0	23887.8	111.8	28 - 586	0.0198
Klipspringer	48	5	0	1096.4	137.9	5 - 114	0.0034
Kudu	278	29	1	8514.2	66.3	94 - 463	0.0199
Monkey	373	38	1	18441.2	72.9	101 - 644	0.0267
Turtle	0	0	37	0	0	37	0
Sable	137	14	15	10294.4	147.9	29 - 340	0.0098
Warthog	598	63	0	23229.7	51	293 - 903	0.0427
Zebra	0	0	4	0	0	4	0
Cattle	2762	282	120	4173089	147.9	402 - 6847	0.1973
Sheep/goats	1678	171	0	358628	71.4	480 - 2875	0.1198
OtherCarcass 3	39	4	0	323.6	93.2	4 - 75	0.0028
OtherCarcass 4	10	1	0	87.1	188.9	1 - 29	0.0007
Water	566	58	0	10397.6	36	362 - 770	0.0404
Fire	20	2	6	339.3	188	8 - 56	0.0014

SPECIES/ATTRIBUTE	Pop. est.	No. seen	No. Out	Variance	PRP%	95%Range	Density /km <sup>2</sup>
Fishing camp	69	7	0	450.7	61.9	26 - 111	0.0049
Boat	20	2	7	161.5	129.7	9 - 45	0.0014
Fishtrap/net	233	24	0	16766.7	111	24 - 492	0.0167
Canoe	2448	250	47	381914	50.5	1212 - 3684	0.1749
Snareline	812	87	0	5019	17.4	670 - 954	0.058
Poachers' camp	10	1	0	88.1	190	1 - 29	0.0007
Logging	5631	589	2	147425	13.6	4863 - 6399	0.4021
Timber yard	37	4	0	276.3	88.9	4 - 71	0.0027
Timber truck	46	5	0	414.8	88.6	5 - 87	0.0033
Bamboo cutting	49	5	1	412.4	82.6	9 - 90	0.0035
Charcoal burning	49	5	0	550.8	95.7	5 - 96	0.0035
Cultivation		697	8			5742	
Village	1666	170	22	39317.7	23.8	1269 - 2062	0.119
Big Village		19	11			110	
Town		4	0			4	
Lodge/camp		2	0			2	
Prospecting	18	2	0	137.4	127.5	2 - 42	0.0013
Mining	79	8	1	758.9	69.7	24 - 134	0.0057
Salt works		4	0			4 -	

Quirimbas NP and Buffer Zone (Q1 + Q2) AREA: 11349 km<sup>2</sup> (Land Area = 10477)

SPECIES/ATTRIBUTE	Pop. est.	No. seen	No. Out	Variance	PRP%	95%Range	Density /km <sup>2</sup>
Baboon	1749	178	0	121374.6	40	1049 - 2449	0.1674
Buffalo	119	12	0	12333.2	188.3	12 - 342	0.0113
Bushbuck	295	30	0	4648.8	46.5	157 - 432	0.0282
Bushpig	29	3	0	809.3	194.5	3 - 87	0.0028
Duiker	2234	227	4	48520.1	19.8	1792 - 2677	0.2139
Eland	0	0	8	0	0	8 - 0	0
ElephantFamily	560	57	11	52366.9	82.1	100 - 1020	0.0537
All Elephants	560	57	11	52366.9	82.1	100 - 1020	0.0537
EleCarcass 1	10	1	0	86.7	191	1 - 29	0.001
EleCarcass 2	39	4	2	319.1	91.4	6 - 75	0.0038
Recent E carcasses	49	5	2	405.7	82.5	9 - 90	0.0047
EleCarcass 3	167	17	1	2042.6	54.4	76 - 258	0.016
EleCarcass 4	393	40	3	5520.2	38	244 - 542	0.0376
Old E carcasses	560	57	4	7562.8	31.2	385 - 735	0.0537
All E carcasses	609	62	6	7968.6	29.4	430 - 789	0.0583
GroundHornbill	433	44	1	13353.1	53.6	201 - 665	0.0415
Grysbok	226	23	0	2346.6	43	129 - 324	0.0216
Hyrax	277	28	0	23887.8	112.3	28 - 587	0.0265
Klipspringer	30	3	0	794.2	191.1	3 - 86	0.0028
Kudu	177	18	0	5673.8	85.5	26 - 329	0.0169
Monkey	373	38	1	18441.2	73.2	100 - 646	0.0356
Turtle	0	0	37	0	0	37	0
Sable	137	14	15	10294.4	148.7	29 - 341	0.0131
Warthog	276	28	0	8669.1	67.8	89 - 463	0.0264
Cattle	2762	282	120	4173089	148.6	402 - 6868	0.2644
Sheep/goats	1678	171	0	358628	71.7	474 - 2881	0.1605
OtherCarcass 3	29	3	0	249.6	108	3 - 61	0.0028
OtherCarcass 4	10	1	0	87.1	189.9	1 - 29	0.001
Water	483	49	0	9357	40.2	289 - 678	0.0463
Fire	20	2	6	339.3	188.9	8 - 57	0.0018
Fishing camp	69	7	0	450.7	62.2	26 - 111	0.0065
Boat	20	2	7	161.5	130.4	9 - 45	0.0018
Fishtrap/net	206	21	0	16101.3	123.9	21 - 461	0.0197
Canoe	2439	249	47	381839.2	50.9	1197 - 3681	0.2334
Snareline	178	18	0	2222.6	53.3	83 - 272	0.0171
Poachers' camp	10	1	0	88.1	191	1 - 29	0.001
Logging	3268	332	2	61087.2	15.2	2772 - 3765	0.3128
Timber yard	10	1	0	85	189.1	1 - 28	0.001
Bamboo cutting	49	5	1	412.4	83.1	8 - 90	0.0047
Charcoal burning	49	5	0	550.8	96.1	5 - 96	0.0047
Cultivation		662	5			5440	

SPECIES/ATTRIBUTE	Pop. est.	No. seen	No. Out	Variance	PRP%	95%Range	Density /km <sup>2</sup>
Village	1602	163	17	38405.5	24.6	1208 - 1995	0.1533
Big Village		17	9			95	
Town		4	0			4	
Lodge/camp		2	0			2	
Mining	79	8	1	758.9	70.1	24 - 134	0.0076
Salt works		4	0			4 -	



Stratum: Q1

Area: 4811 km<sup>2</sup>      Sampling intensity:                      10.1 %

SPECIES/ATTRIBUTE	Pop. est.	No. seen	No. Out	Variance	PRP%	95%Range	Density /km <sup>2</sup>
Baboon	662	67	0	42587.51	64.7	234 - 1090	0.1375
Buffalo	119	12	0	12333.2	194.3	12 - 349	0.0246
Bushbuck	79	8	0	1390.274	97.9	8 - 156	0.0164
Duiker	1294	131	3	27841.24	26.7	948 - 1640	0.2689
ElephantFamily	227	23	11	16630.32	117.7	34 - 495	0.0472
All Elephants	227	23	11	16630.32	117.7	34 - 495	0.0472
EleCarcass 2	10	1	0	87.96271	196.9	1 - 29	0.0021
Recent E carcasses	10	1	0	87.96271	196.9	1 - 29	0.0021
EleCarcass 3	69	7	0	978.2597	93.8	7 - 134	0.0144
EleCarcass 4	148	15	1	2228.763	66.1	50 - 246	0.0308
Old E carcasses	217	22	1	3207.023	54.1	100 - 335	0.0452
All E carcasses	227	23	1	3294.985	52.4	108 - 346	0.0472
GroundHornbill	247	25	0	7269.354	71.6	70 - 424	0.0513
Grysbok	119	12	0	1114.414	58.4	49 - 188	0.0246
Hyrax	277	28	0	23887.75	115.9	28 - 597	0.0575
Klipspringer	30	3	0	794.1641	197.2	3 - 88	0.0062
Kudu	99	10	0	3979.941	132.5	10 - 230	0.0205
Monkey	59	6	1	1136.063	118	7 - 129	0.0123
Warthog	227	23	0	6513.727	73.7	60 - 395	0.0472
Sheep/goats	346	35	0	47763.38	131.1	35 - 799	0.0719
OtherCarcass 4	10	1	0	87.07069	195.9	1 - 29	0.0021
Water	385	39	0	6756.804	44.3	215 - 556	0.0801
Fire	0	0	4	0	0	4	0
Fishtrap/net	10	1	0	85.60657	194.3	1 - 29	0.0021
Snareline	168	17	0	2137.385	57.1	72 - 264	0.0349
Poachers' camp	10	1	0	88.07703	197.1	1 - 29	0.0021
Logging	1975	200	2	34035	19.4	1593 - 2358	0.4106
Bamboo cutting	20	2	0	164.9704	134.9	2 - 46	0.0041
Charcoal burning	10	1	0	85.41111	194.1	1 - 29	0.0021
Cultivation		232	1			1515	
Village	593	60	3	17400.3	46.2	319 - 866	0.1232
Big Village		6	3			9	
Town		2	0			2	
Lodge/camp		1	0			1	
Mining	79	8	1	758.9009	72.3	22 - 136	0.0164

## Stratum Q2

Area: 6538 km<sup>2</sup> (Land Area = 5665 km<sup>2</sup>)

Sampling intensity: 10.2 %

SPECIES/ATTRIBUTE	Pop. est.	No. seen	No. Out	Variance	PRP%	95%Range	Density /km <sup>2</sup>
Baboon	1087	111	0	78787.1	53	511 - 1663	0.1929
Bushbuck	215	22	0	3258.491	54.4	98 - 333	0.0383
Bushpig	29	3	0	809.2747	198.6	3 - 88	0.0052
Duiker	940	96	1	20678.84	31.4	645 - 1235	0.1668
Eland	0	0	8	0	0	8 - 0	0
ElephantFamily	333	34	0	35736.54	116.5	34 - 721	0.059
All Elephants	333	34	0	35736.54	116.5	34 - 721	0.059
EleCarcass 1	10	1	0	86.66196	195	1 - 29	0.0017
EleCarcass 2	29	3	2	231.1236	106.1	5 - 61	0.0052
Recent E carcasses	39	4	2	317.7855	93.4	6 - 76	0.007
EleCarcass 3	98	10	1	1064.374	68.3	31 - 165	0.0174
EleCarcass 4	245	25	2	3291.429	48.1	127 - 363	0.0435
Old E carcasses	343	35	3	4355.803	39.5	207 - 478	0.0608
All E carcasses	382	39	5	4673.588	36.7	242 - 522	0.0677
GroundHornbill	186	19	1	6083.786	86	26 - 346	0.0331
Grysbok	108	11	0	1232.173	66.8	36 - 180	0.0191
Kudu	78	8	0	1693.887	107.8	8 - 163	0.0139
Monkey	313	32	0	17305.17	86.1	44 - 583	0.0556
Turtle	0	0	37	0	0	37	0
Sable	137	14	15	10294.36	151.8	29 - 345	0.0244
Warthog	49	5	0	2155.327	194.5	5 - 144	0.0087
Cattle	2762	282	120	4173089	151.7	402 - 6954	0.49
Sheep/goats	1332	136	0	310864.6	85.9	188 - 2476	0.2364
OtherCarcass 3	29	3	0	249.633	110.3	3 - 62	0.0052
Water	98	10	0	2600.223	106.8	10 - 203	0.0174
Fire	20	2	2	339.2648	192.9	4 - 57	0.0035
Fishing camp	69	7	0	450.7131	63.5	25 - 112	0.0122
Boat	20	2	7	161.4789	133.1	9 - 46	0.0035
Fishtrap/net	196	20	0	16015.69	132.5	20 - 456	0.0348
Canoe	2439	249	47	381839.2	52	1171 - 3707	0.4327
Snareline	10	1	0	85.18059	193.3	1 - 29	0.0017
Logging	1293	132	0	27052.24	26.1	956 - 1630	0.2294
Timber yard	10	1	0	84.99149	193.1	1 - 29	0.0017
Bamboo cutting	29	3	1	247.4669	109.8	4 - 62	0.0052
Charcoal burning	39	4	0	465.3496	113	4 - 83	0.007
Cultivation		430	4				
Village	1009	103	14	21005.21	29.5	712 - 1306	0.179
Big Village		11	6			53	
Town		2	0			2	

SPECIES/ATTRIBUTE	Pop. est.	No. seen	No. Out	Variance	PRP%	95%Range	Density /km <sup>2</sup>
Lodge/camp		2	0			2	
Salt works		4	0			4 -	

## Stratum Corridor South

Area: 3529 km<sup>2</sup>

Sampling intensity: 10.9 %

SPECIES/ATTRIBUTE	Pop. est.	No. seen	No. Out	Variance	PRP%	95%Range	Density /km <sup>2</sup>
Baboon	46	5	0	1227.914	166.1	5 - 122	0.013
Bushbuck	138	15	0	3108.186	88.1	16 - 259	0.0391
Bushpig	28	3	0	678.0352	205.7	3 - 84	0.0078
Duiker	2390	260	0	81070.87	26	1770 - 3011	0.6773
ElephantFamily	294	32	10	11230.93	78.5	63 - 525	0.0834
All Elephants	294	32	10	11230.93	78.5	63 - 525	0.0834
EleCarcass 1	0	0	1	0	0	1 - 0	0
EleCarcass 2	37	4	0	383.5009	116	4 - 79	0.0104
Recent E carcasses	37	4	1	383.5009	116	5 - 79	0.0104
EleCarcass 3	46	5	1	416.4237	96.7	6 - 90	0.013
EleCarcass 4	120	13	4	1493.678	70.5	35 - 204	0.0339
Old E carcasses	165	18	5	1910.102	57.5	70 - 261	0.0469
All E carcasses	202	22	6	2293.603	51.6	98 - 307	0.0573
GroundHornbill	368	40	3	4797	41	217 - 519	0.1042
Grysbok	138	15	0	1323.118	57.5	59 - 217	0.0391
Klipspringer	18	2	0	302.1958	206	2 - 56	0.0052
Kudu	101	11	1	2840.327	114.8	12 - 217	0.0287
Warthog	322	35	0	14560.69	81.7	59 - 585	0.0912
Zebra	0	0	4	0	0	4	0
OtherCarcass 3	9	1	0	73.93702	203.8	1 - 28	0.0026
Water	83	9	0	1040.61	85	12 - 153	0.0234
Fishtrap/net	28	3	0	665.4332	203.8	3 - 84	0.0078
Canoe	9	1	0	74.73616	204.9	1 - 28	0.0026
Snareline	634	69	0	2796.413	18.2	519 - 750	0.1797
Logging	2363	257	0	86337.73	27.1	1722 - 3003	0.6695
Timber yard	28	3	0	191.3119	109.3	3 - 58	0.0078
Timber truck	46	5	0	414.7556	96.5	5 - 90	0.013
Cultivation		35	3			72	
Village	64	7	5	912.2183	102.3	12 - 130	0.0182
Big Village		2	2			4	
Prospecting	18	2	0	137.4103	138.9	2 - 44	0.0052