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AERIAL SURVEY OF WILDLIFE IN THE NIASSA RESERVE AND ADJACENT AREAS
Mozambique, October 2009

Prepared for
Sociedade para a Gestão e Desenvolvimento da Reserva do Niassa
Moçambique

By

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Survey Area in Mozambique

AERIAL SURVEY OF WILDLIFE
IN THE NIASSA RESERVE
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The 2009 survey of Niassa Reserve was the sixth of a series commissioned and organized by the Sociedade para a Gestão e Desenvolvimento da Reserva do Niassa, Maputo.

Citation: Craig, G.C. 2009 *Aerial Survey of Wildlife in the Niassa Reserve and adjacent areas, October 2009* Sociedade para a Gestão e Desenvolvimento da Reserva do Niassa, Maputo.

SUMMARY

The 2009 aerial survey of wildlife in the Niassa Reserve and adjacent blocks took place between 28 September and 19 October 2009. In Niassa Reserve a total area of 42300 km^2 was sampled at an average intensity of 9.3%. An additional 6700 km^2 was surveyed to the south of the reserve at the same sampling intensity.

The estimates of numbers of wildlife species in Niassa Reserve (with their 95% confidence ranges) are given in the table below.

SPECIES	ESTIMATED NUMBER	95% RANGE	
Elephants	20118	17417	- 22819
Elephant family groups	17682	15031	- 20333
Elephant bull groups	2436	1918	- 2954
Baboon	4649	3535	- 5764
Buffalo	6833	4095	- 9571
Bushbuck	366	221	- 510
Bush pig	711	343	- 1079
Duiker	22082	20457	- 23706
Eland	5856	3754	- 7959
Grysbok	85	30	- 141
Hartebeest	5011	3764	- 6257
Hippo	1325	701	- 1949
Impala	2175	1470	- 2881
Klipspringer	183	58	- 309
Kudu	2928	2195	- 3661
Reedbuck	2041	1574	- 2509
Sable	14686	12830	- 16541
Warthog	10089	8763	- 11415
Waterbuck	2952	2177	- 3727
Wildebeest	1124	384	- 1863
Zebra	6229	5033	- 7425
Ground Hornbill	4350	3620	- 5079

In combination with those of previous surveys, the results show a significant overall increase in wildlife and significant increases in the majority of individual species since 1998. The elephant estimate has increased although being stable over the previous 3 surveys. No species shows a decline.

Indices of illegal activities have increased, including snaring, logging and illegal hunting of elephants.

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1   INTRODUCTION

The 2009 aerial survey of wildlife in the Niassa Reserve and adjacent areas in northern Mozambique was undertaken from 28 September to 19 October. This was the sixth survey of the area promoted and organised by the Sociedade para a Gestão e Desenvolvimento da Reserva do Niassa (SGDRN) and the data from these surveys provide information not only about the size but also of trends of the populations of the more numerous species. Previous surveys were carried out in 1998, 2000, 2002, 2004 and 2006 (Gibson 1998; Gibson 2000; Craig & Gibson 2002; Craig & Gibson 2004 Craig 2006) .

The Reserve is adjacent to Tanzania along the Rovuma River (Frontispiece and Fig. 1). It now incorporates the adjacent hunting blocks and is divided into 17 management units (Fig 2) of a total area of 42 300 km^2.

The survey was based out of Mbatamela and also operated from airstrips at Catembe, Kambako, Sable and Valadim (Fig. 1).

Figure 1: Survey areas showing survey bases

The 2004 and 2006 surveys also covered Chipanje-Chetu community-based natural resource management project area, on the western boundary of Niassa. This was also planned for 2009 but the resources were diverted towards surveying adjacent blocks of equivalent area along the southern boundary of Niassa including parts of 3 adjacent hunting concessions (Fig. 2). The results serve to provide a picture of wildlife distribution adjacent to the reserve that was no previously available. The additional area is 6 750 km^2. The total area surveyed was 49 100 km^2.
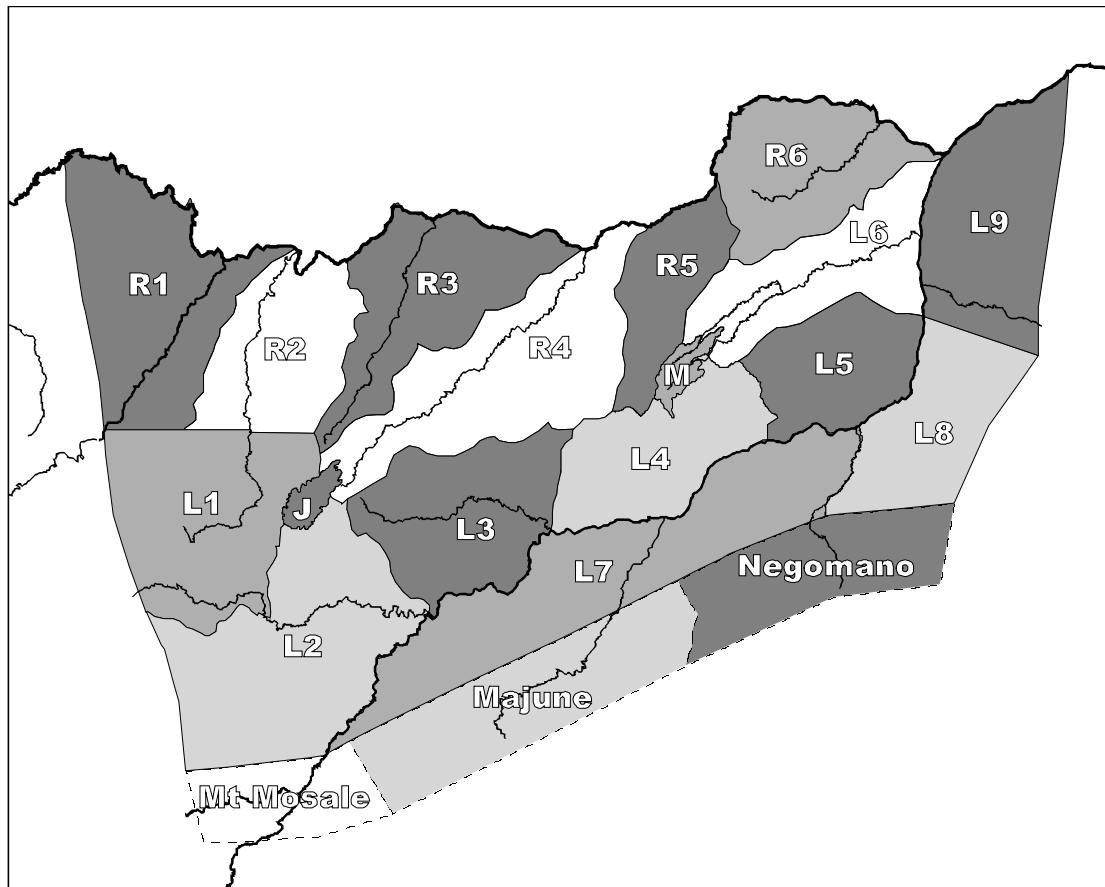
Figure 2: Management units

The survey was planned based on strata corresponding to the previous management units (see Appendix I) as the updated boundaries (Fig. 2) were not available at the planning stage. However, results are presented according to the new management units. As the updated outer boundaries are slightly different to the ones previously in use to design surveys, there ar small differences between the overall results of the survey (Appendix II) and those reported for the management blocks. The area surveyed as Niassa reserve was 42 400 km^2 as opposed to 42 000 for the actual reserve. Fig. 3 compares the surveyed and reporting areas.
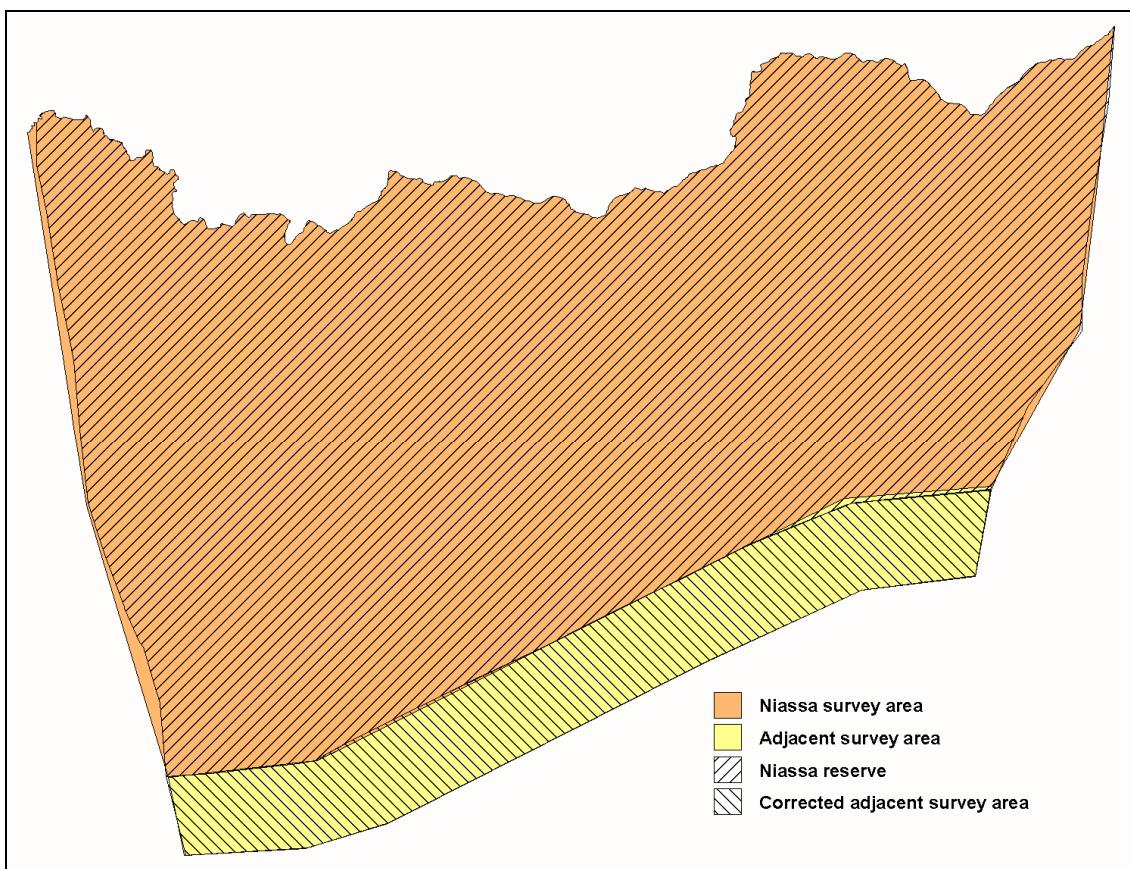
Figure 3: Comparison of surveyed area and updated boundaries

As in previous surveys (1998, 2000, 2002, 2004 and 2006), the method of stratified systematic transect sampling was used (Norton Griffiths, 1978) in a light aircraft (a Cessna 206) flying at a nominal height of 300 feet above the ground. As in the 2000, 2002, 2004 and 2006 surveys, the nominal sampling intensity was 10%.

This report follows a similar format to that used for the previous five surveys of the area. Section 2, Results, comprises maps showing the sightings and tables of estimates for each species. The estimated numbers and densities of animals are given for each of the management units within the survey area, as well as the overall totals.

Section 3 provides a summary of other information recorded during the survey which may be directly relevant to the management of the area. Section 4, trends describes trends in the animal populations over the 6 surveys, while Section 5 is a brief discussion of the usefulness of the survey.

Descriptions of methods are provided in Appendix I. Appendix II gives details of survey implementation, i.e. times, sampling intensities, calibration, etc. It also contains the original computer-generated tables of results for each of the sampling strata. That is, the conventionally analysed results according to the designed strata, as opposed to the further processed information in Section 2.

2   RESULTS FOR WILDLIFE

A full list of species seen during the survey is provided in Appendix II.

For each wildlife species in this section a sighting map is provided along with a table of estimates for each management unit. 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 this section are arranged in alphabetical order of their common names with the exception of :Elephant and buffalo, which are placed first and second respectively; monkeys, which are put next to baboons; crocodiles, which are placed with hippos; grysbok and klipspringer, which are placed after duiker; and carnivores, which are put together after Zebra. At the end other carcasses seen are reported for the first time in this series of surveys.

Under elephants, elephant carcasses are tabulated and carcass ratios are given in a separate table.

The density distribution of wildlife in the area in October 2009 (Fig. 4) is similar to that observed in previous years. Fig. 5 shows the distribution of biomass in large stock units (1LU = 450 kg). Biomass is less evenly spread because it is determined mainly by elephants. General wildlife density is mainly determined by individuals of the most abundant species, particularly duiker, which are more evenly distributed.
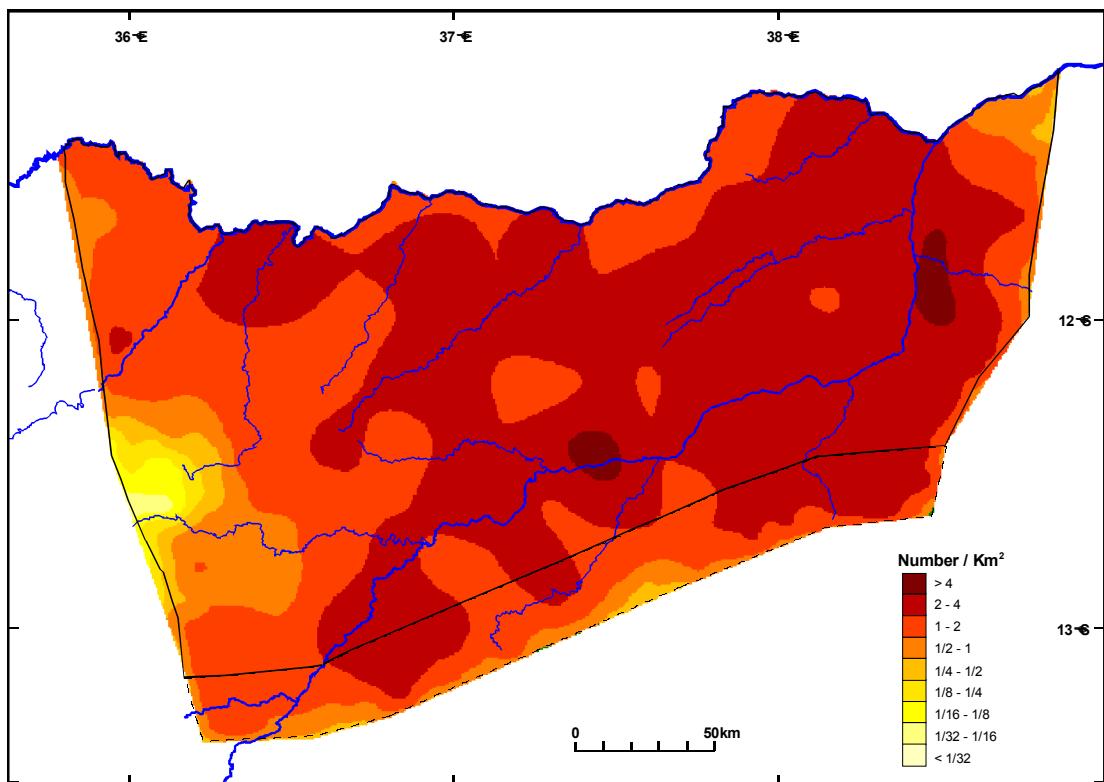
Figure 4: Density distribution of wildlife
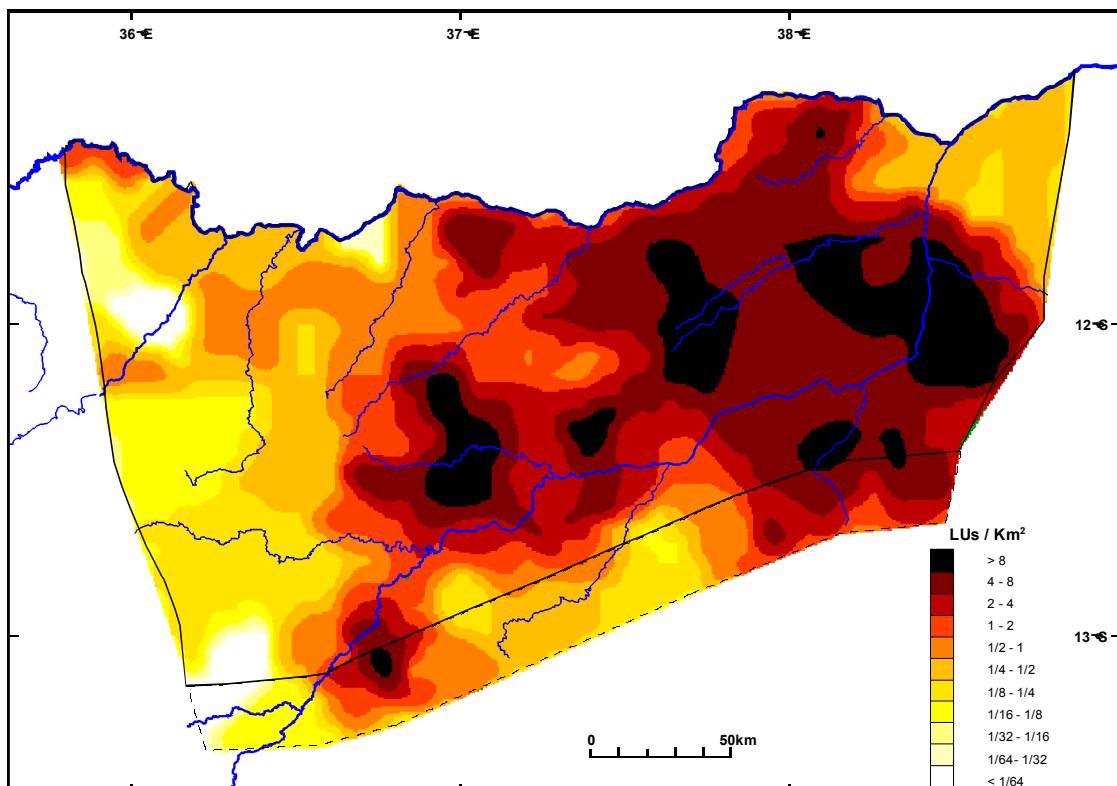
Figure 5: Biomass in large stock units
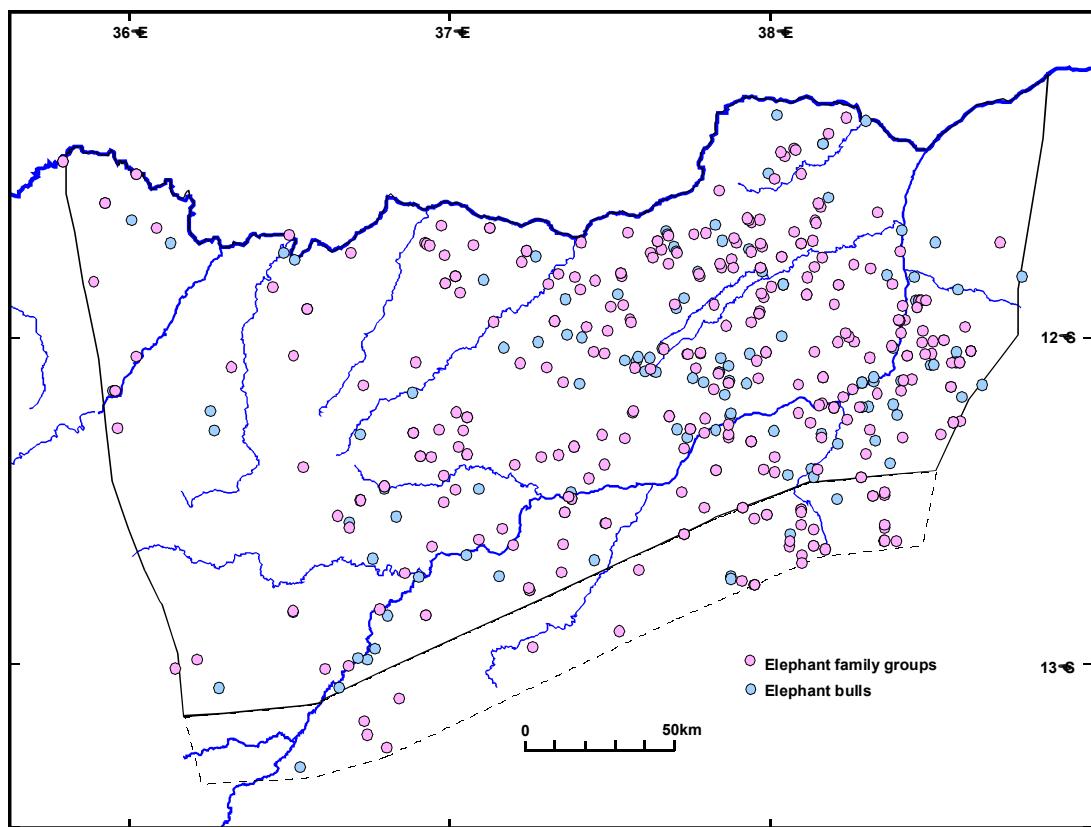
Figure 6: Elephant sightings

Table 1: Elephant estimates

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	282	56	-	536	27	29	0.0817
R2	455	77	-	833	44	2	0.2021
R3	963	370	-	1556	90	33	0.3606
R4	1373	685	-	2060	125	45	0.3698
R5	1004	381	-	1628	94	39	0.6833
R6	1086	427	-	1744	101	46	0.4669
Jao	83	8	-	250	8	0	0.3987
Mecula	192	22	-	398	22	0	0.8331
L1	76	7	-	178	7	0	0.0229
L2	652	192	-	1112	61	2	0.1559
L3	2004	1067	-	2941	183	20	0.7591
L4	1986	1041	-	2931	185	38	0.8980
L5	1775	881	-	2669	165	56	0.9711
L6	2246	1255	-	3237	208	22	0.9762
L7	2206	1293	-	3118	205	37	0.4961
L8	3225	1952	-	4498	296	28	1.5177
L9	509	136	-	881	48	3	0.1748
Totals	**20118**	**17417**	**-**	**22819**	**1869**	**400**	**0.4759**
Adjacent blocks:							
Negomano	1980	715	-	3245	185	58	0.8769
Majune	514	94	-	933	48	17	0.1706
Mt Mosale	43	4	-	121	4	0	0.0302
Totals	**2537**	**1248**	**-**	**3826**	**237**	**75**	**0.3788**
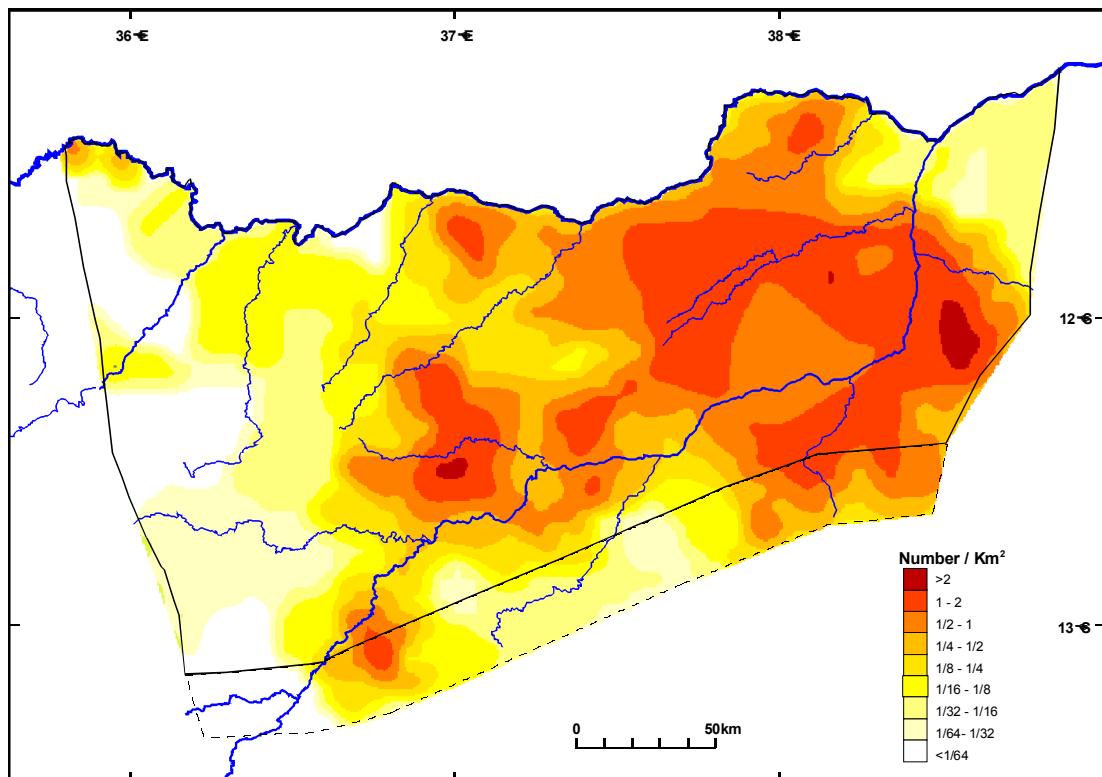
Figure 7: Density distribution of elephants

Table 2: Estimates of elephants in family groups

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	199	48	-	434	19	29	0.0574
R2	401	41	-	772	39	2	0.1782
R3	899	311	-	1487	84	33	0.3366
R4	1122	457	-	1786	102	44	0.3022
R5	855	247	-	1462	80	36	0.5813
R6	989	339	-	1638	92	39	0.4252
Jao	83	8	-	250	8		0.3987
Mecula	72	9	-	225	9		0.3118
L1	32	3	-	112	3		0.0098
L2	598	144	-	1052	56		0.1430
L3	1928	996	-	2861	176	20	0.7305
L4	1793	862	-	2725	167	31	0.8107
L5	1625	742	-	2508	151	52	0.8888
L6	2052	1073	-	3031	190	17	0.8917
L7	1809	925	-	2693	168	35	0.4069
L8	2855	1603	-	4107	262	18	1.3435
L9	371	38	-	721	35	3	0.1274
Totals	**17682**	**15031**	**-**	**20333**	**1641**	**359**	**0.4182**
Adjacent blocks:							
Negomano	1873	613	-	3133	175	54	0.8295
Majune	514	94	-	933	48	17	0.1706
Mt Mosale	22	2	-	86	2		0.0151
Totals	**2408**	**1124**	**-**	**3692**	**225**	**71**	**0.3595**

Table 3: Elephant bulls

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	84	8	-	177	8		0.0242
R2	54	5	-	128	5		0.0238
R3	64	6	-	144	6		0.0240
R4	251	77	-	426	23	1	0.0677
R5	150	17	-	289	14	3	0.1020
R6	97	16	-	203	9	7	0.0417
Jao							
Mecula	120	13	-	258	13		0.5214
L1	43	4	-	108	4		0.0131
L2	54	7	-	125	5	2	0.0129
L3	75	7	-	163	7		0.0286
L4	193	35	-	351	18	7	0.0874
L5	150	18	-	288	14	4	0.0823
L6	194	41	-	348	18	5	0.0845
L7	397	171	-	623	37	2	0.0893
L8	370	137	-	604	34	10	0.1742
L9	138	13	-	265	13		0.0473
Totals	**2436**	**1918**	**-**	**2954**	**228**	**41**	**0.0576**
Adjacent blocks:							
Negomano	107	14	-	219	10	4	0.0475
Majune							
Mt Mosale	22	2	-	65	2		0.0151
Totals	**129**	**16**	**-**	**244**	**12**	**4**	**0.0192**
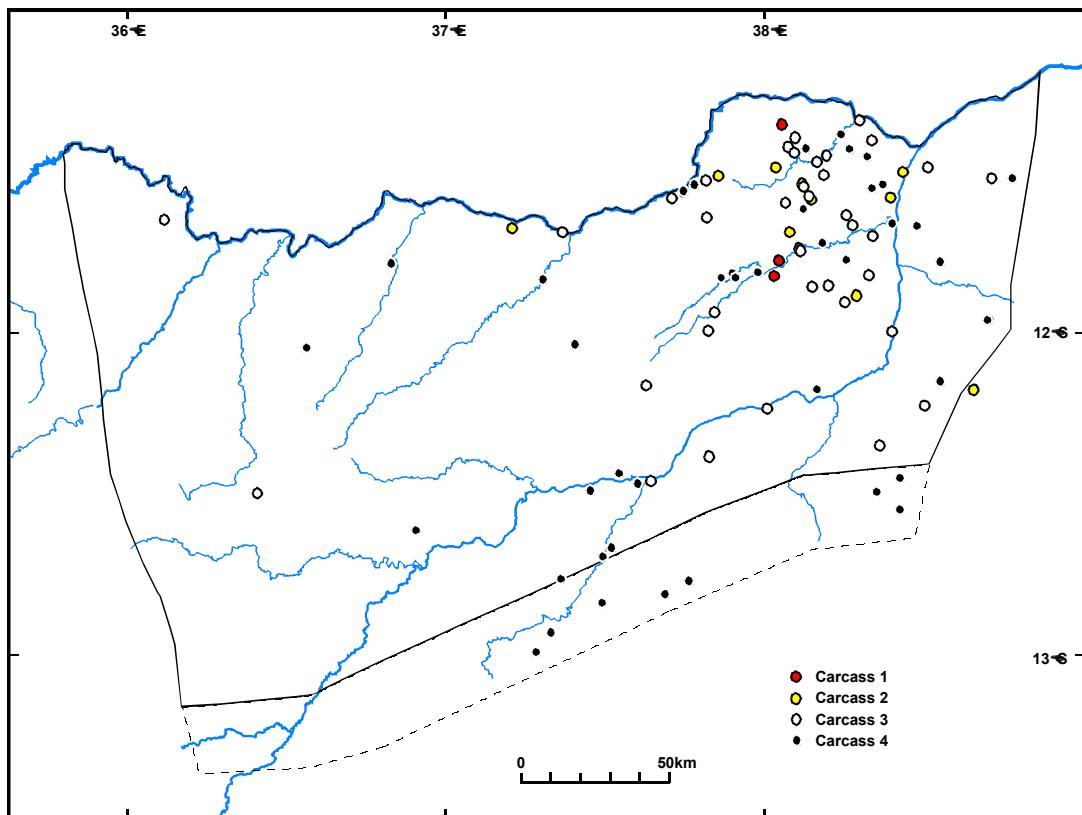
Figure 8: Elephant carcasses

Table 4: Elephant carcass stage 1

Niassa blocks:	Estimate	Range		No seen	No out	Density
R6	11	1 - 35		1		0.0046
L6	33	3 - 78		3		0.0141
Totals	**43**	**4 - 92**		**4**		**0.0010**

Table 5: Elephant carcass stage 2

Niassa blocks:	Estimate	Range		No seen	No out	Density
R3	11	1 - 30		1		0.0040
R6	43	4 - 90		4		0.0186
L5	11	1 - 32		1		0.0059
L6	33	3 - 71		3		0.0141
Totals	**97**	**34 - 160**		**9**		**0.0023**

Table 6: Elephant carcass stage 3

Niassa blocks:	Estimate	Range		No seen	No out	Density
R1	11	1 - 30		1		0.0031
R3	11	1 - 30		1		0.0040
R5	21	2 - 53		2		0.0145
R6	130	42 - 218		12		0.0558
L1	10	1 - 30		1		0.0031
L4	11	1 - 31		1		0.0049
L5	43	4 - 89		4		0.0235
L6	87	19 - 154		8		0.0376
L7	32	3 - 69		3		0.0073
L8	22	2 - 53		2		0.0103
L9	23	2 - 53		2		0.0077
Totals	**400**	**267 - 532**		**37**		**0.0095**

Table 7: Elephant carcass stage 4

Niassa blocks:	Estimate	Range		No seen	No out	Density
R2	11	1 - 32		1		0.0048
R3	11	1 - 32		1		0.004
R4	22	2 - 54		2		0.0059
R5	22	3 - 55		2	1	0.0146
R6	54	5 - 111		5		0.0233
L3	11	1 - 32		1		0.0041
L4	11	1 - 33		1		0.0049
L5	11	1 - 33		1		0.0059
L6	98	19 - 176		9	1	0.0424
L7	54	5 - 107		5		0.0121
L8	11	1 - 33		1		0.0051
L9	43	5 - 92		4	1	0.0148
Totals	**356**	**224 - 489**		**33**	**3**	**0.0084**
Adjacent blocks:						
Negomano	54	5 - 121		5		0.0237
Majune	43	4 - 82		4		0.0142
Totals	**96**	**20 - 172**		**9**		**0.0144**

Table 8: All elephant carcasses

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	11	1	-	30	1	0	0.0031
R2	11	1	-	32	1	0	0.0048
R3	32	3	-	67	3	0	0.012
R4	22	2	-	54	2	0	0.0059
R5	43	5	-	89	4	1	0.0292
R6	238	120	-	355	22	0	0.1022
Jao							
Mecula							
L1	10	1	-	30	1	0	0.0031
L2							
L3	11	1	-	32	1	0	0.0041
L4	21	2	-	52	2	0	0.0097
L5	64	9	-	120	6	0	0.0353
L6	249	130	-	368	23	1	0.1083
L7	86	8	-	151	8	0	0.0193
L8	33	3	-	71	3	0	0.0154
L9	66	7	-	123	6	1	0.0225
Totals	**897**	**693**	**-**	**1100**	**83**	**3**	**0.0212**
Adjacent blocks:							
Negomano	54	4	-	121	5	0	0.0237
Majune	43	4	-	82	4	0	0.0142
Mt Mosale							
Totals	**96**	**20**	**-**	**172**	**9**	**0**	**0.0144**

Table 9: Carcass ratios

Niassa blocks:	Live elephants	Elephant carcasses	Total	Ratio %	Range		
R1	27	1	28	3.57	0	-	10.77
R2	44	1	45	2.22	0	-	6.65
R3	90	3	93	3.23	0	-	6.86
R4	125	2	127	1.57	0	-	3.76
R5	94	4	98	4.08	0.11	-	8.05
R6	101	22	123	17.89	11.05	-	24.73
Jao	8	0	8	0			
Mecula	22	0	22	0			
L1	7	1	8	12.5	0	-	40.15
L2	61	0	61	0			
L3	183	1	184	0.54	0	-	1.61
L4	185	2	187	1.07	0	-	2.55
L5	165	6	171	3.51	0.73	-	6.29
L6	208	23	231	9.96	6.08	-	13.84
L7	205	8	213	3.76	1.19	-	6.32
L8	296	3	299	1	0	-	2.14
L9	48	6	54	11.11	2.53	-	19.69
Totals	1869	83	1952	4.25	3.36	-	5.15
Adjacent blocks:							
Negomano	185	5	190	2.63	0.34	-	4.92
Majune	48	4	52	7.69	0.27	-	15.11
Mt Mosale	4	0	4	0			
Totals	237	9	246	3.66	1.3	-	6.02

Table 10: Buffalo

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	21	2	-	57	2		0.0061
R2	21	2	-	58	2		0.0095
R3	118	11	-	278	11		0.0441
R4	915	525	-	1875	83	442	0.2465
R5	32	3	-	86	3		0.0218
R6	97	9	-	239	9		0.0419
Jao							
Mecula							
L1	32	3	-	85	3		0.0098
L2	96	9	-	228	9		0.0230
L3	242	22	-	544	22		0.0917
L4	838	160	-	1774	78	82	0.3786
L5	204	19	-	477	19		0.1117
L6	2135	220	-	4197	197	23	0.9277
L7	1044	377	-	2116	97	280	0.2348
L8	719	76	-	1549	66	10	0.3384
L9	318	32	-	708	30	2	0.1092
Totals	**6833**	**4095**	**-**	**9571**	**631**	**839**	**0.1616**
Adjacent blocks:							
Negomano							
Majune	11	1	-	31	1		0.0035
Mt Mosale	108	50	-	326	10	40	0.0755
Totals	**119**	**51**	**-**	**324**	**11**	**40**	**0.0177**
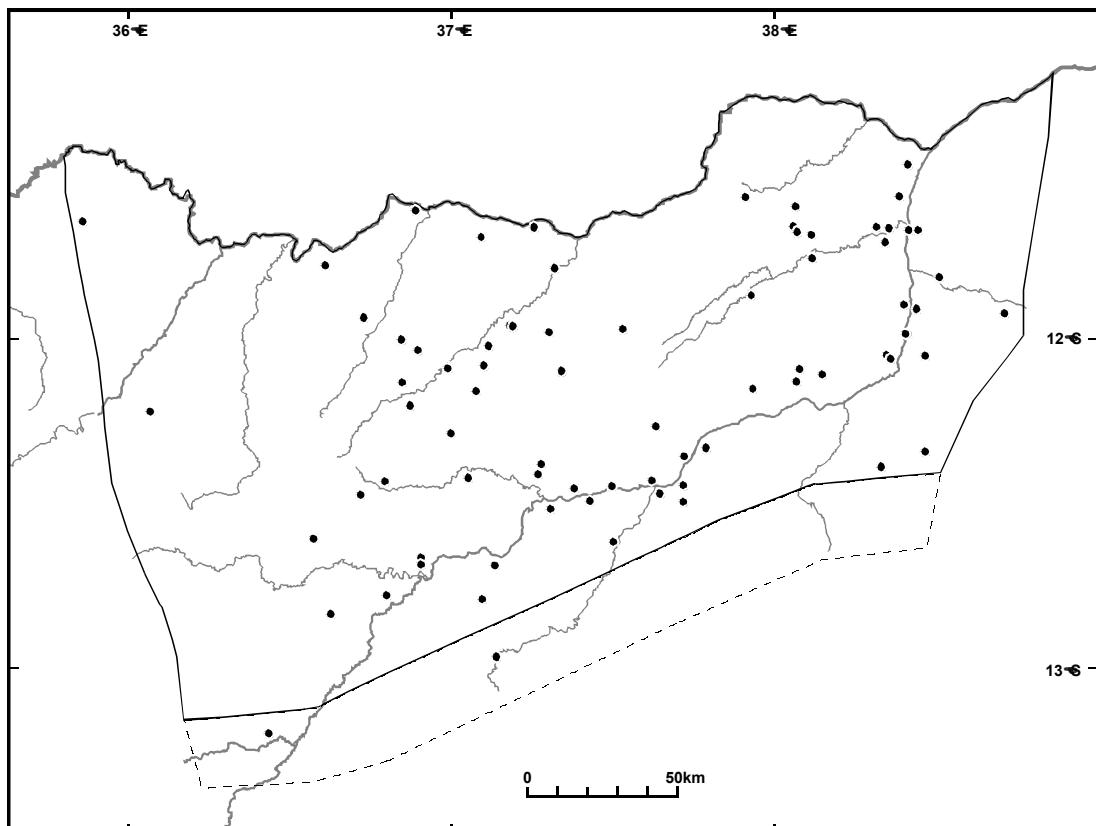
Figure 9: Buffalo sightings

Table 11: Baboon

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	418	80	-	755	42	5	0.1208
R2	330	31	-	630	31		0.1468
R3	289	27	-	558	27		0.1083
R4	87	8	-	213	8		0.0235
R5							
R6	443	77	-	809	41		0.1906
Jao							
Mecula							
L1	289	27	-	561	27		0.0874
L2	576	167	-	985	54	2	0.1378
L3	172	16	-	366	16		0.0653
L4							
L5							
L6							
L7	1065	467	-	1663	99	5	0.2396
L8	610	157	-	1063	56		0.2872
L9	369	51	-	687	33		0.1267
Totals	**4649**	**3535**	**-**	**5764**	**434**	**12**	**0.1100**
Adjacent blocks:							
Negomano	460	100	-	820	43		0.2038
Majune	673	217	-	1129	63	5	0.2235
Mt Mosale	216	20	-	420	20		0.1511
Totals	**1349**	**753**	**-**	**1945**	**126**	**5**	**0.2014**
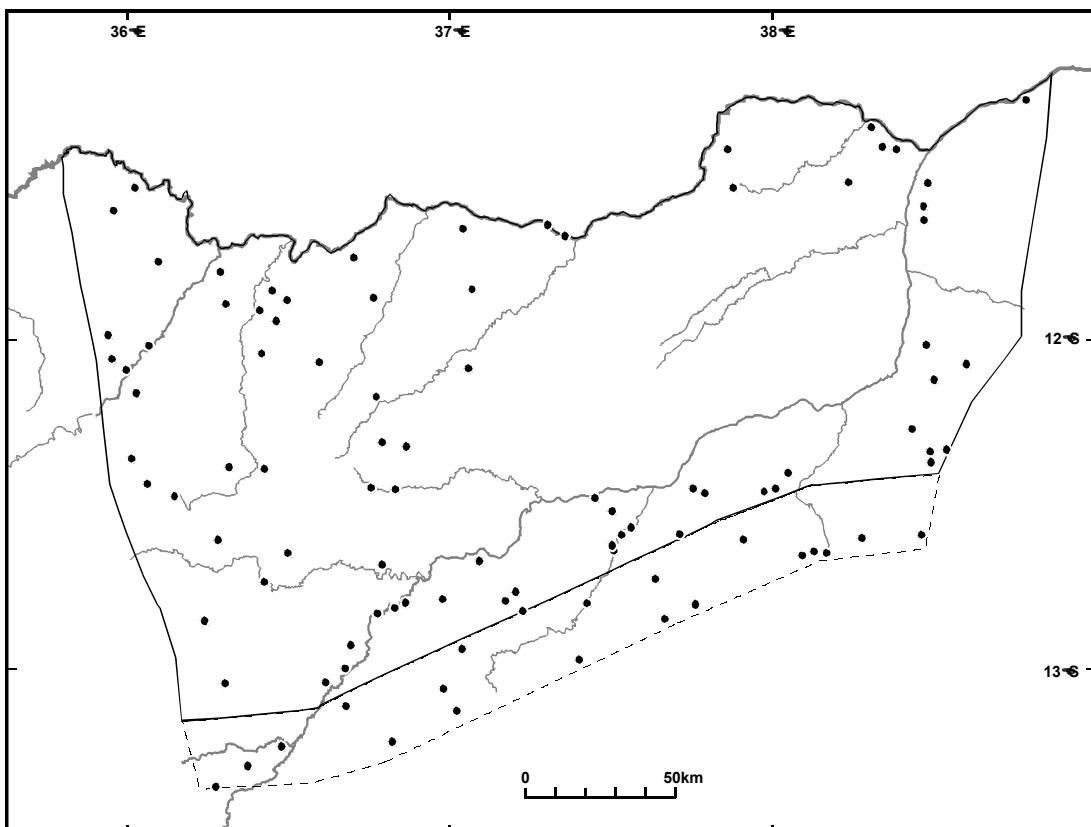
Figure 10: Baboon sightings

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Table 12: Vervet Monkey

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	106	10	-	267	10		0.0306
R2							
R3	75	7	-	204	7		0.0280
R4							
R5	64	6	-	188	6		0.0436
R6	108	10	-	278	10		0.0463
Jao							
Mecula							
L1							
L2	372	35	-	739	35		0.0891
L3	43	4	-	132	4		0.0163
L4	0						
L5	43	4	-	138	4		0.0237
L6							
L7							
L8							
L9	45	4	-	139	4		0.0155
Totals	**856**	**381**	-	**1332**	**80**		**0.0203**
Adjacent blocks:							
Negomano	107	10	-	256	10		0.0474
Majune							
Mt Mosale							
Totals	**107**	**10**	-	**250**	**10**		**0.016**
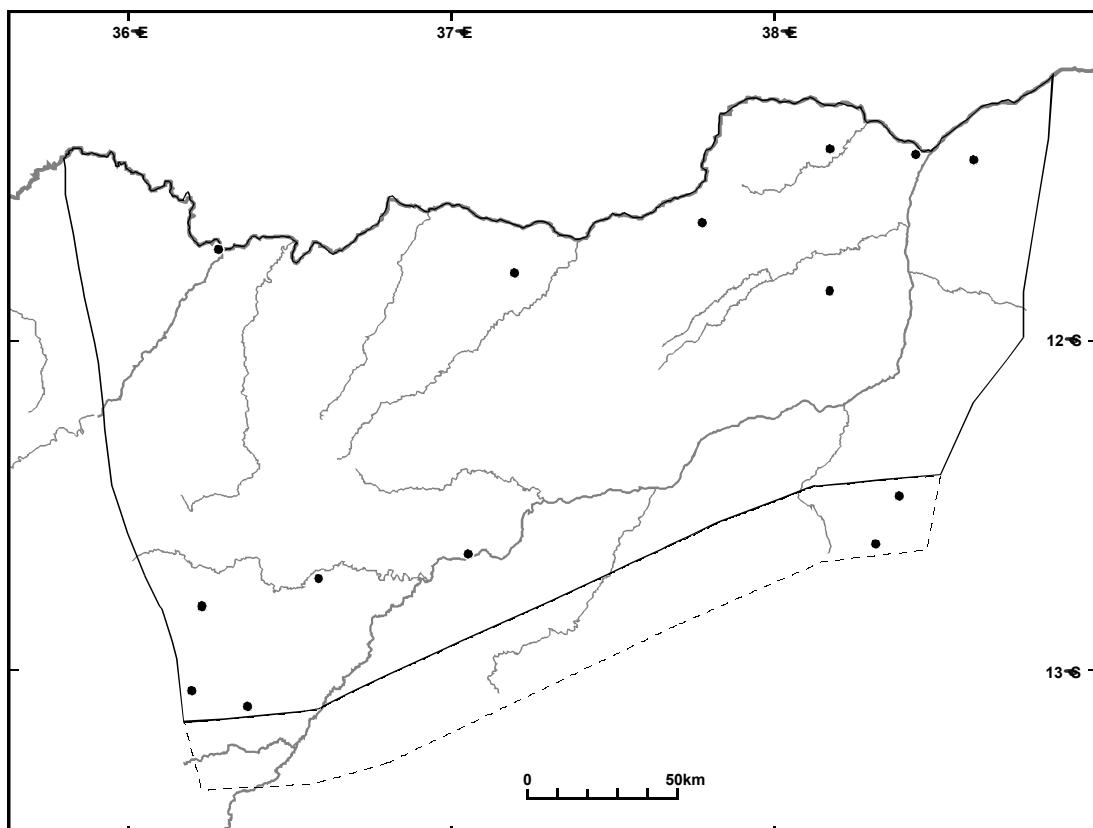
Figure 11: Monkey sightings

Table 13: Bushbuck

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	21	2	-	53	2		0.0061
R2	10	1	-	29	1		0.0043
R3	11	1	-	30	1		0.0040
R4	44	4	-	98	4		0.0119
R5	21	2	-	56	2		0.0145
R6	75	7	-	158	7		0.0323
Jao							
Mecula							
L1							
L2	22	2	-	54	2		0.0052
L3	54	5	-	117	5		0.0206
L4							
L5	11	1	-	31	1		0.0059
L6	32	3	-	76	3		0.0141
L7	21	2	-	53	2		0.0048
L8	11	1	-	32	1		0.0051
L9	32	3	-	75	3		0.0109
Totals	**366**	**221**	**-**	**510**	**34**		**0.0086**
Adjacent blocks:							
Negomano	64	6	-	156	6		0.0284
Majune	21	2	-	50	2		0.0071
Mt Mosale	22	2	-	51	2		0.0151
Totals	**107**	**10**	**-**	**204**	**10**		**0.0160**
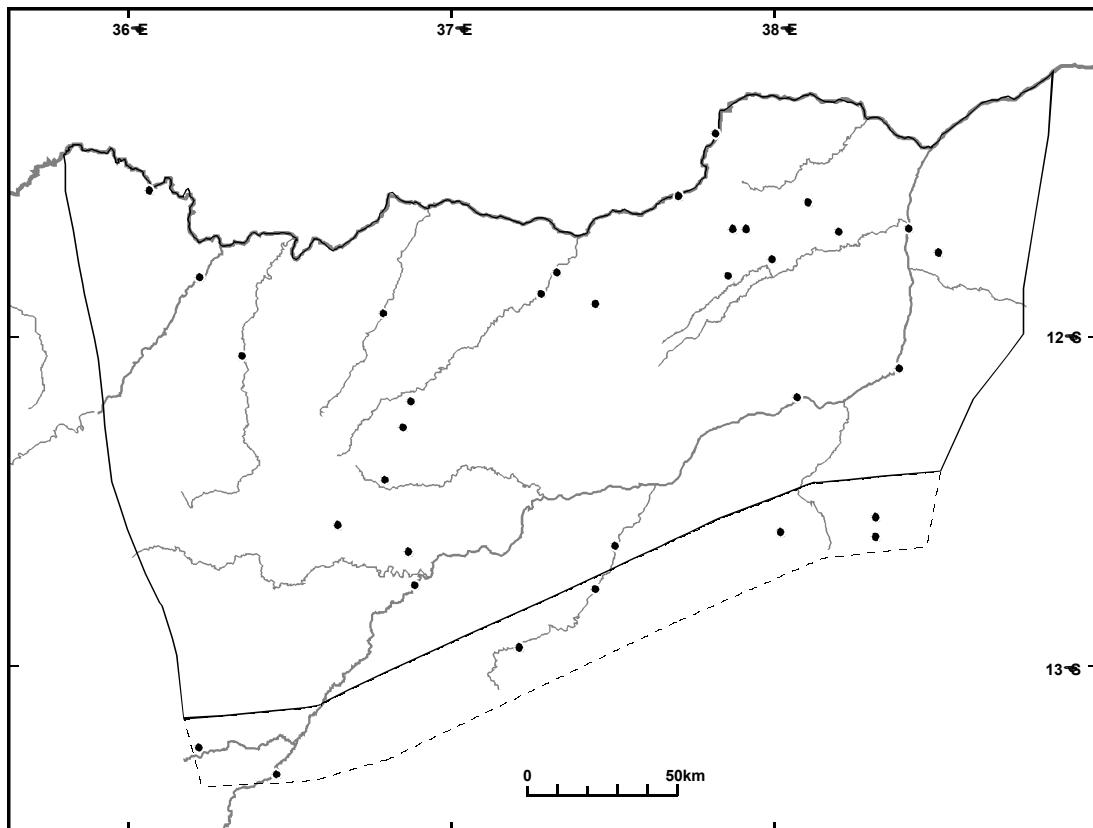
Figure 12: Bushbuck sightings

Table 14: Bushpig

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	199	19	-	435	19		0.0574
R2	68	7	-	179	7		0.0304
R3							
R4							
R5							
R6	65	6	-	172	6		0.0277
Jao			-				
Mecula	56	7	-	167	7		0.2425
L1	22	2	-	68	2		0.0065
L2	106	10	-	254	10		0.0255
L3	79	7	-	198	7		0.0298
L4	21	2	-	69	2		0.0097
L5							
L6							
L7							
L8							
L9	95	9	-	235	9		0.0328
Totals	**711**	**343**	**-**	**1079**	**69**		**0.0168**
Adjacent blocks:							
Negomano							
Majune	171	16	-	383	16		0.0567
Mt Mosale	76	7	-	180	7		0.0529
Totals	**246**	**23**		**476**	**23**		**0.0368**
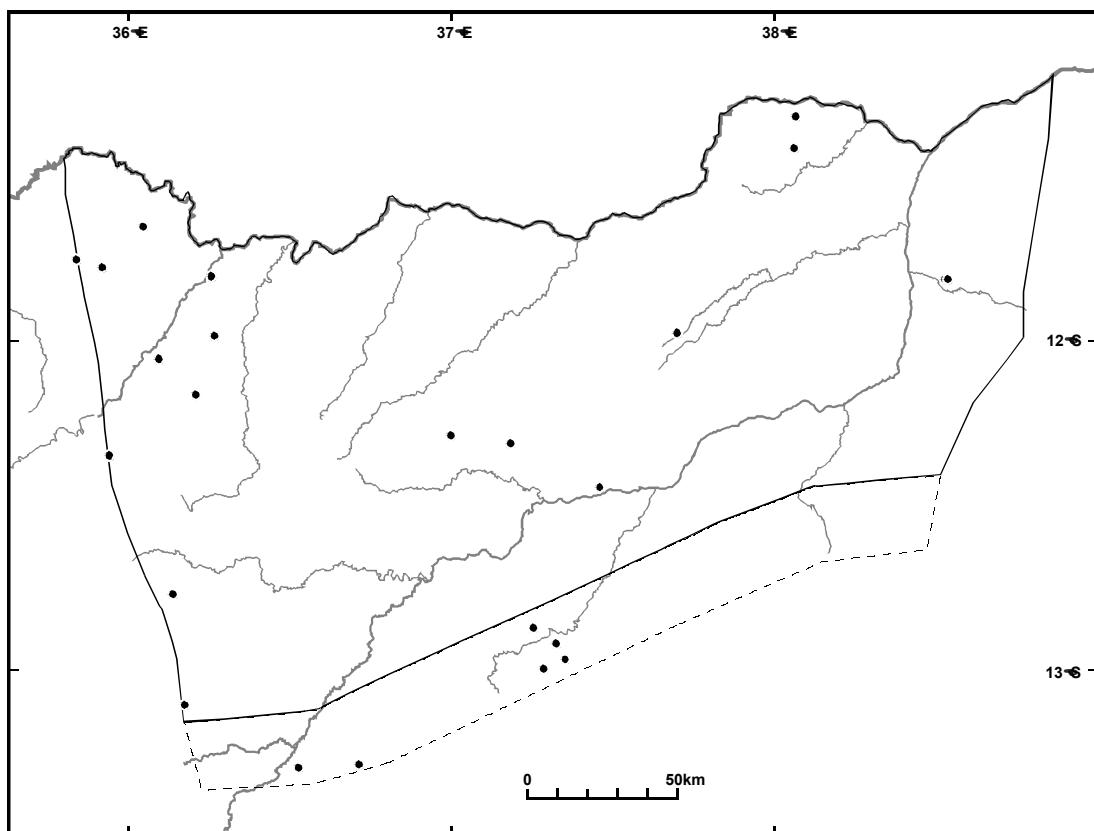
Figure 13: Bushpig sightings

Table 15: Duiker

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	1627	1178	-	2076	159	6	0.4706
R2	1181	823	-	1538	111	2	0.5246
R3	2442	1821	-	3062	228	1	0.9141
R4	2772	2092	-	3452	254		0.7468
R5	1037	703	-	1371	97	1	0.7052
R6	1499	1060	-	1937	139	3	0.6446
Jao	31	8	-	54	3		0.1495
Mecula							
L1	708	474	-	942	67		0.2141
L2	1335	956	-	1714	125		0.3194
L3	1016	708	-	1325	93		0.3850
L4	762	507	-	1018	71		0.3447
L5	709	466	-	952	66		0.3879
L6	1275	901	-	1648	118		0.5539
L7	2538	1907	-	3169	236	2	0.5708
L8	719	472	-	966	66		0.3384
L9	2431	1801	-	3060	224		0.8352
Totals	**22082**	**20457**	**-**	**23706**	**2057**	**15**	**0.5223**
Adjacent blocks:							
Negomano	1916	1398	-	2434	179	1	0.8484
Majune	2295	1703	-	2886	215	5	0.7621
Mt Mosale	658	431	-	886	61		0.4607
Totals	**4869**	**4076**	**-**	**5662**	**455**	**6**	**0.7269**
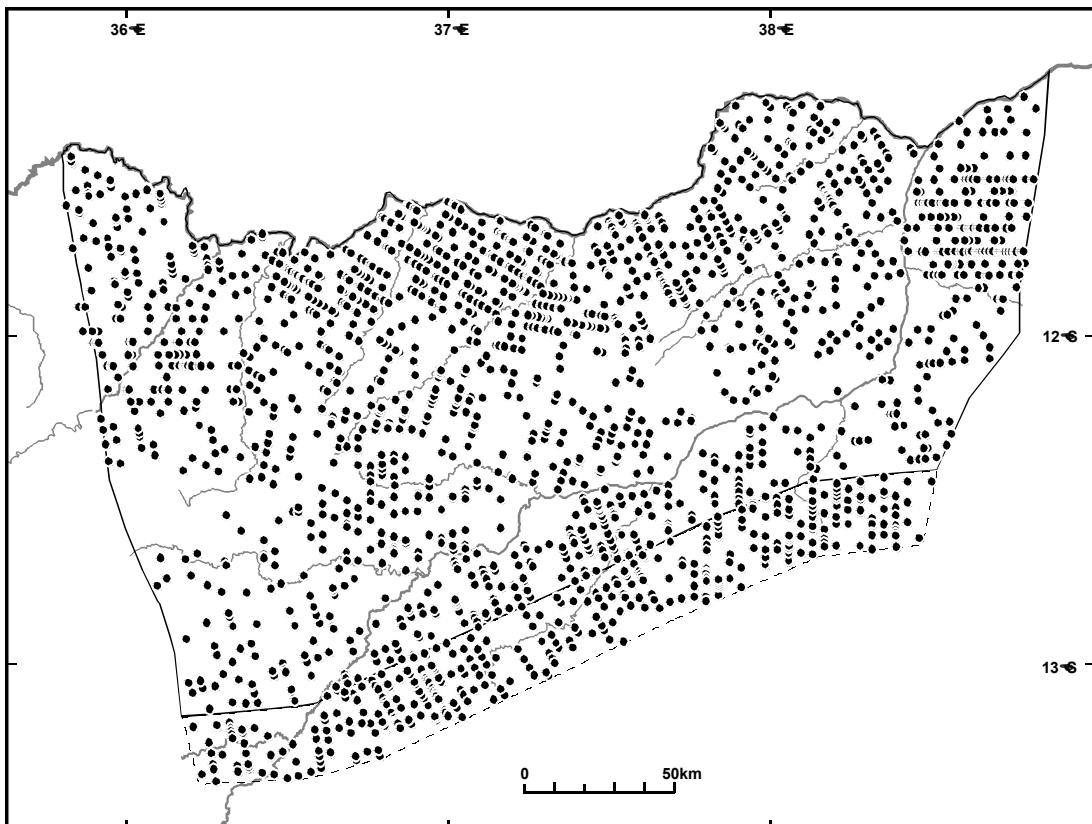
Figure 14: Duiker sightings

Table 16: Klipspringer

Niassa blocks:	Estimate	Range			No seen	No out	Density
R4	44	4	-	108	4		0.0118
L2	43	4	-	105	4		0.0102
L6	22	2	-	65	2		0.0094
L7	43	4	-	106	4		0.0097
L8	32	3	-	89	3		0.0151
Totals	**183**	**58**	**-**	**309**	**17**		**0.0043**
Adjacent blocks:							
Negomano	32	3	-	87	3		0.0142
Totals	**32**	**3**	**-**	**85**	**3**		**0.0048**

Table 17: Grysbok

Niassa blocks:	Estimate	Range			No seen	No out	Density
R2	11	1	-	30	1		0.0047
R5	11	1	-	31	1		0.0073
L2	21	2	-	51	2		0.0051
L6	11	1	-	30	1		0.0046
L7	22	2	-	51	2		0.0048
L9	11	1	-	30	1		0.0036
Totals	**85**	**30**	**-**	**141**	**8**		**0.002**
Adjacent blocks:							
Negomano	32	3	-	78	3		0.0142
Majune	11	1	-	31	1		0.0035
Mt Mosale	11	1	-	33	1		0.0076
Totals	**54**	**5**	**-**	**107**	**5**		**0.008**
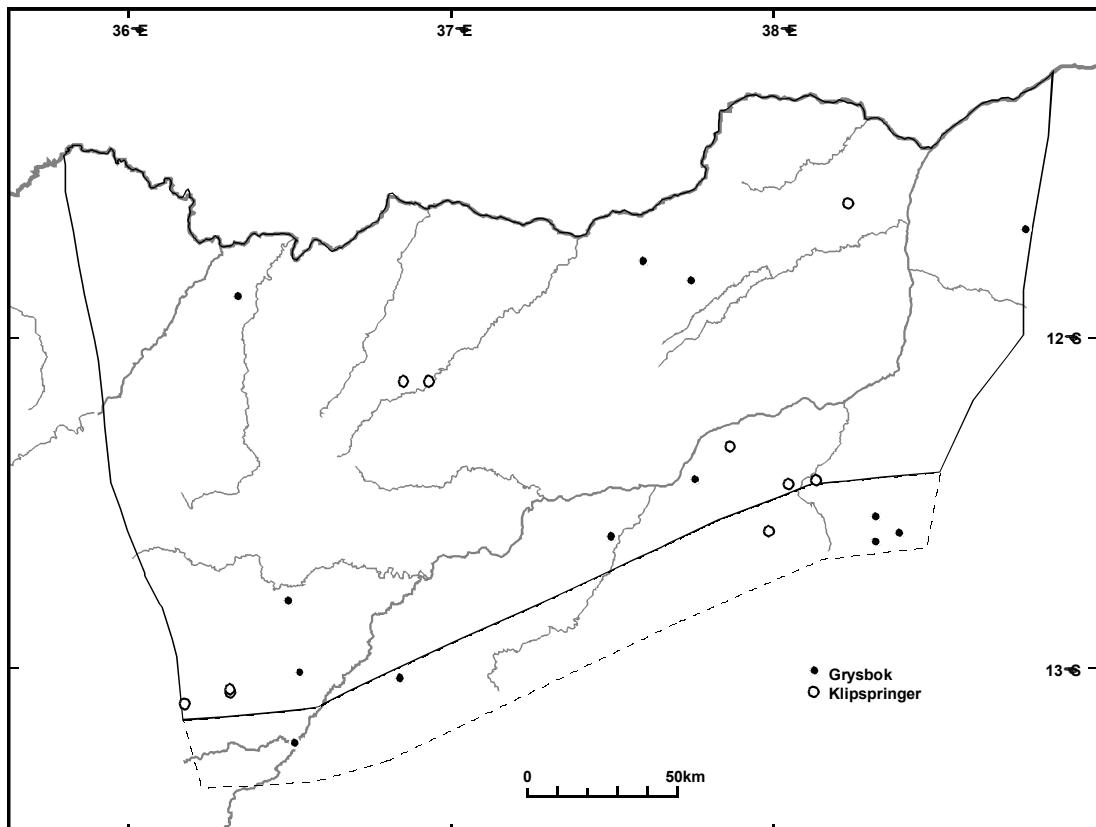
Figure 15: Other small antelopes

Table 18: Eland

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	261	27	-	621	25	2	0.0756
R2	257	29	-	622	24	5	0.1141
R3	568	54	-	1279	53	1	0.2126
R4	982	104	-	2120	88	16	0.2646
R5	256	24	-	634	24		0.1743
R6	379	51	-	899	35	16	0.1629
Jao							
Mecula							
L1	293	28	-	696	28		0.0885
L2	334	31	-	775	31		0.0799
L3	55	6	-	146	5	1	0.0208
L4	215	20	-	531	20		0.0971
L5	290	37	-	704	27	10	0.1587
L6	693	71	-	1550	64	7	0.3014
L7	613	59	-	1362	57	2	0.1379
L8	401	41	-	956	37	4	0.1887
L9	260	24	-	624	24		0.0892
Totals	**5856**	**3754**	**-**	**7959**	**542**	**64**	**0.1385**
Adjacent blocks:							
Negomano	268	29	-	545	25	4	0.1185
Majune	427	59	-	837	40	19	0.1417
Mt Mosale	140	13	-	380	13		0.0982
Totals	**835**	**304**	**-**	**1366**	**78**	**23**	**0.1246**
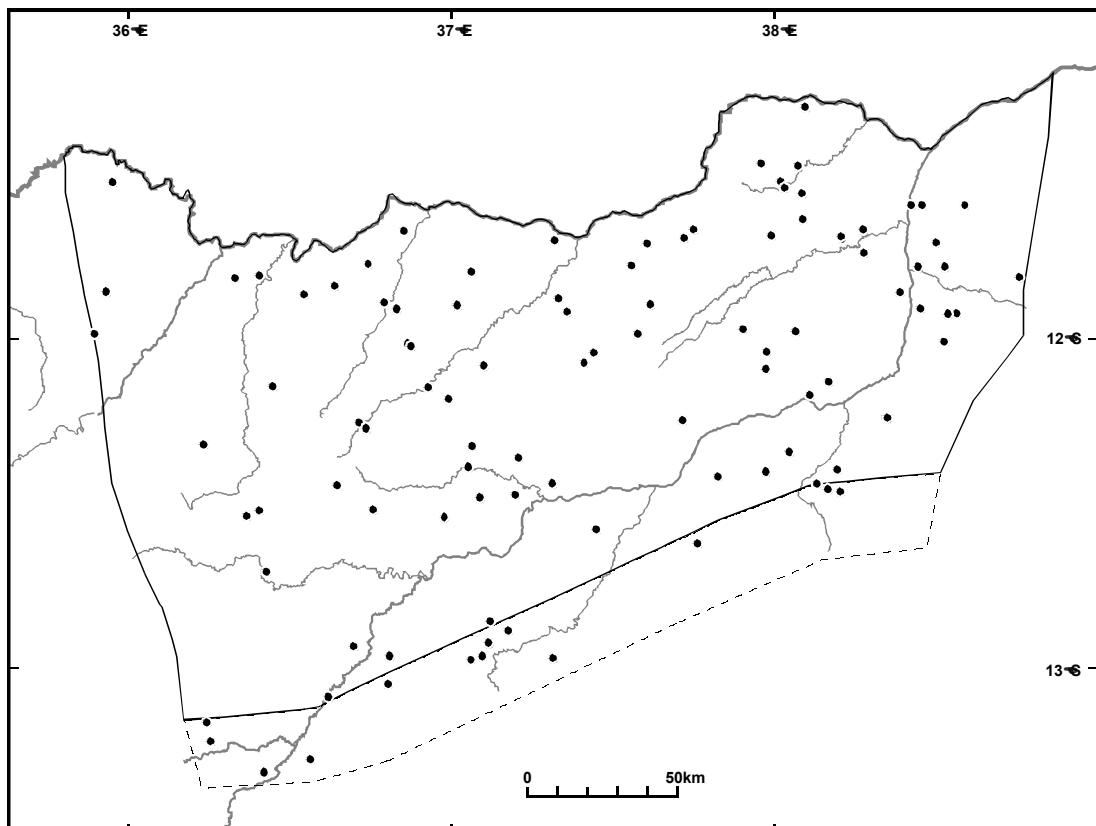
Figure 16: Eland sightings

Table 19: Ground Hornbill

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	90	13	-	192	9	4	0.0261
R2	11	1	-	42	1		0.0047
R3	236	63	-	409	22		0.0883
R4	188	37	-	340	17	3	0.0508
R5	151	14	-	295	14		0.1024
R6	464	201	-	726	43	4	0.1994
Jao	73	7	-	181	7		0.3489
Mecula	43	4	-	124	4		0.1876
L1	171	24	-	317	16		0.0516
L2	116	11	-	232	11		0.0278
L3	230	59	-	400	21		0.0869
L4	193	32	-	355	18		0.0874
L5	291	87	-	494	27		0.1589
L6	692	375	-	1010	64	3	0.3008
L7	430	193	-	668	40		0.0968
L8	424	171	-	678	39		0.1997
L9	547	266	-	828	50		0.1879
Totals	**4350**	**3620**	**-**	**5079**	**403**	**14**	**0.1029**
Adjacent blocks:							
Negomano	385	157	-	614	36	1	0.1706
Majune	75	9	-	157	7	2	0.0248
Mt Mosale	54	5	-	115	5		0.0378
Totals	**514**	**272**	**-**	**756**	**48**	**3**	**0.0767**
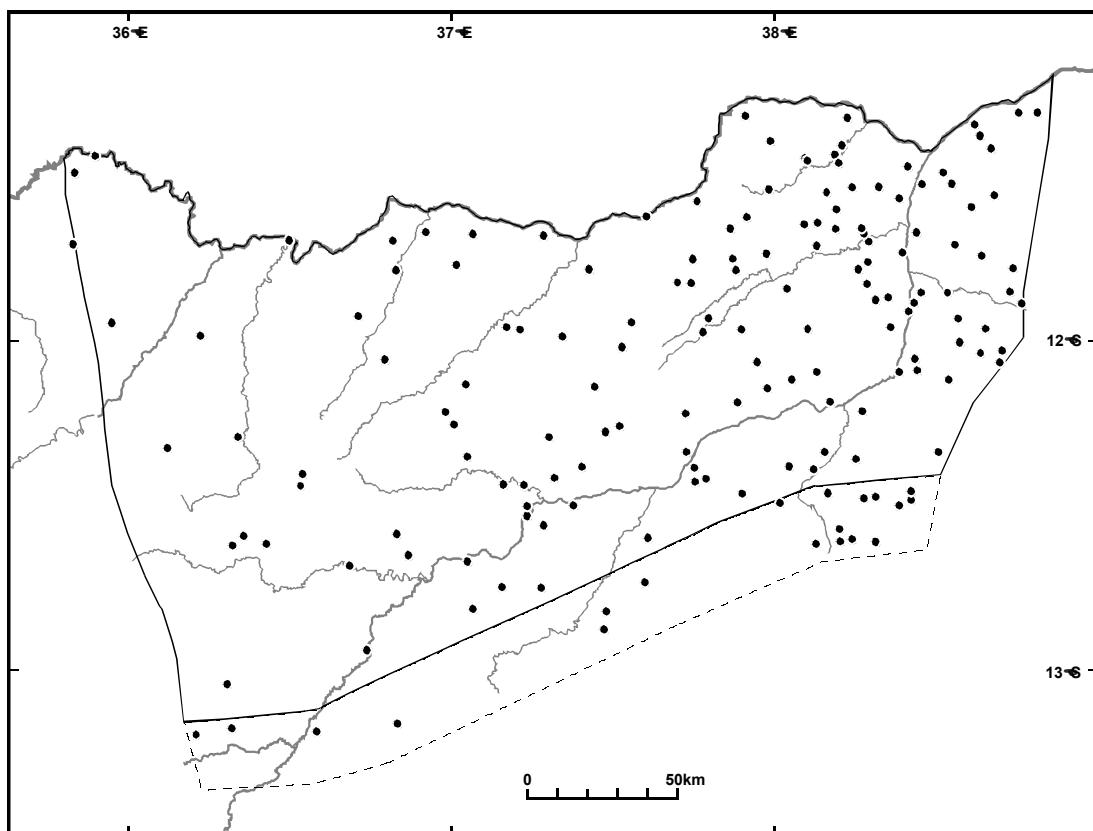
Figure 17: Ground hornbill sightings

Table 20: Hartebeest

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	515	100	-	930	51	11	0.1490
R2	532	95	-	969	51	15	0.2364
R3	589	130	-	1048	55	3	0.2205
R4	987	319	-	1655	90	17	0.2659
R5	567	91	-	1043	53	4	0.3857
R6	107	10	-	242	10		0.0462
Jao							
Mecula							
L1	302	32	-	584	29	3	0.0913
L2	245	23	-	481	23		0.0587
L3	358	42	-	674	32		0.1356
L4	193	18	-	401	18		0.0874
L5							
L6	11	1	-	34	1		0.0047
L7	462	85	-	840	43	9	0.104
L8	120	11	-	268	11		0.0564
L9	21	2	-	60	2		0.0073
Totals	**5011**	**3764**	**-**	**6257**	**469**	**62**	**0.1185**
Adjacent blocks:							
Negomano	407	43	-	1007	38	5	0.1801
Majune	619	131	-	1107	58	20	0.2055
Mt Mosale	32	13	-	98	3	10	0.0227
Totals	**1058**	**306**	**-**	**1810**	**99**	**35**	**0.1579**
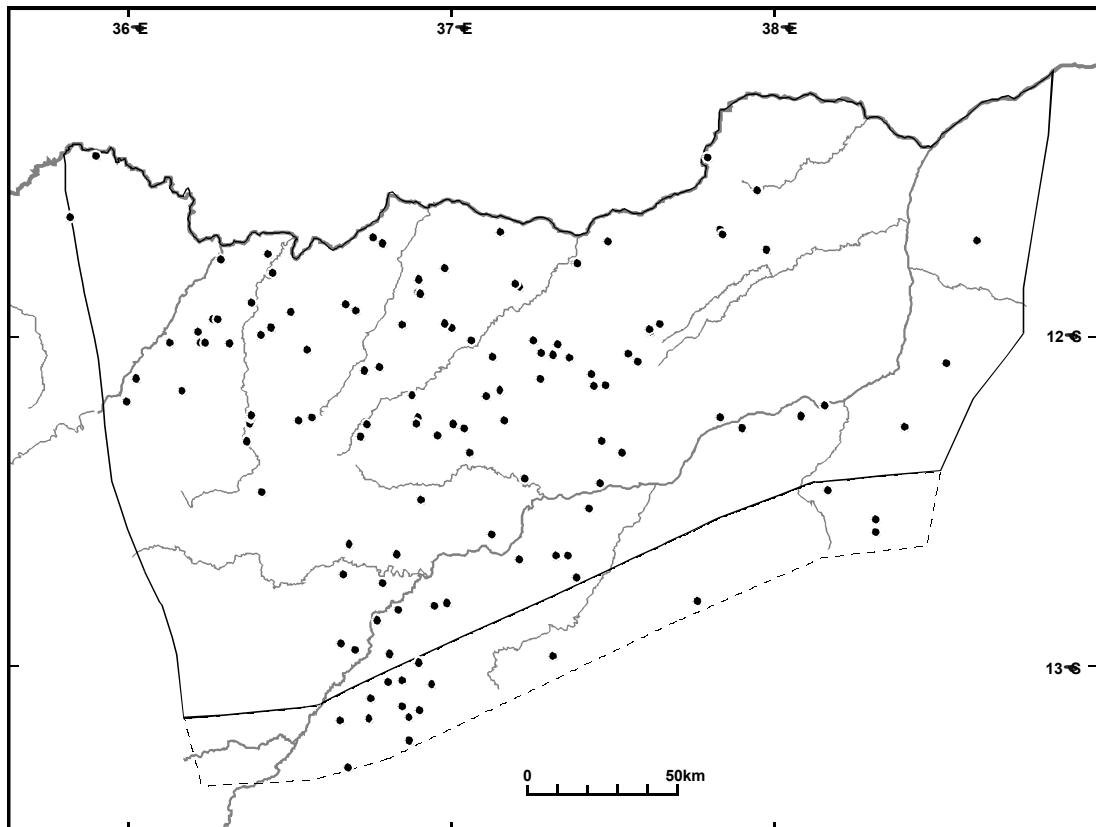
Figure 18: Hartebeest sightings

Table 21: Hippopotamus

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	230	22	-	501	22		0.0666
R6	151	14	-	359	14		0.0647
L2	288	27	-	603	27		0.0689
L3	248	23	-	533	23		0.0938
L4	183	17	-	422	17		0.0825
L7	226	21	-	489	21		0.0508
Totals	**1325**	**701**	**-**	**1949**	**124**		**0.0313**

Table 22: Crocodile

Niassa blocks:	Estimate	Range			No seen	No out	Density
R2	11	1	-	35	1		0.0048
L6	32	3	-	72	3		0.0140
L7	32	3	-	71	3		0.0072
L9	43	4	-	88	4		0.0146
Totals	**118**	**46**	**-**	**190**	**11**		**0.0028**
Adjacent blocks:							
Mt Mosale	11	1	-	33	1		0.0076
Totals	**11**	**1**	**-**	**31**	**1**		**0.0016**
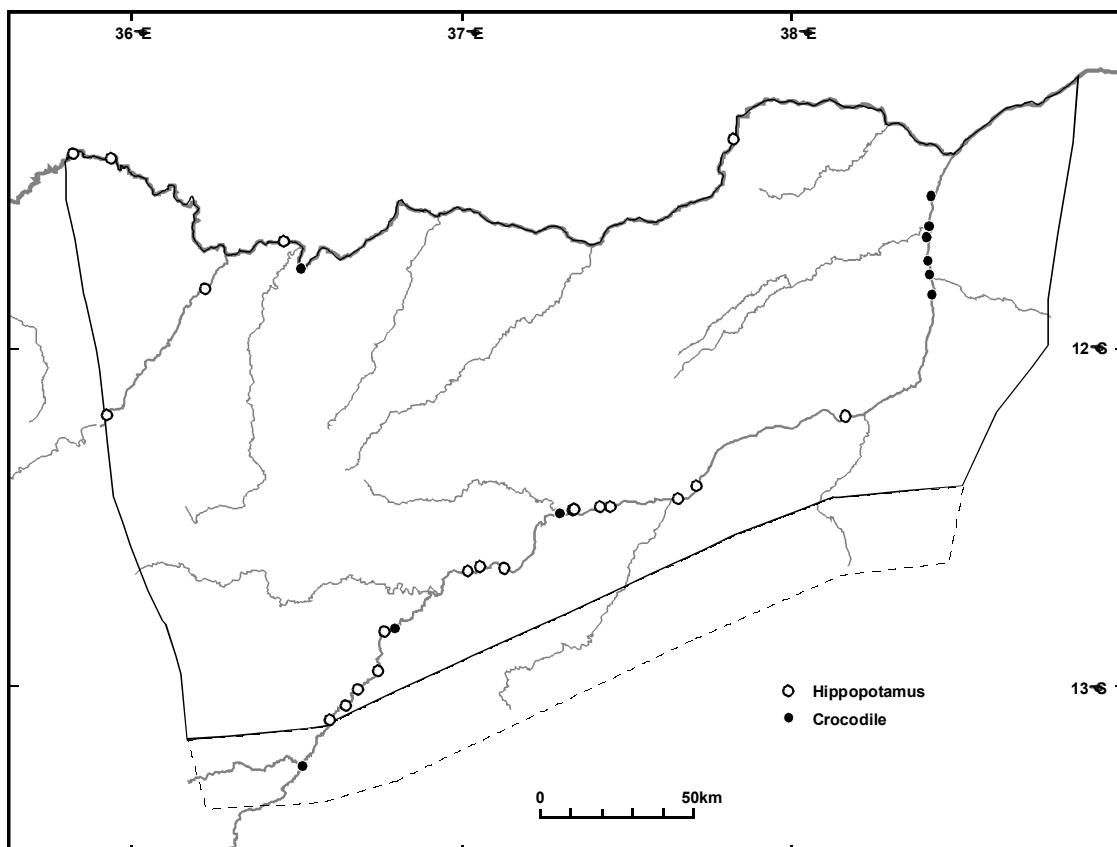
Figure 19: Hippopotamus and crocodile sightings

Table 23: Impala

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1							
R2							
R3							
R4							
R5							
R6	183	17	-	395	17		0.0789
Jao							
Mecula							
L1							
L2	43	4	-	129	4		0.0102
L3	32	3	-	107	3		0.0122
L4	225	21	-	464	21		0.1019
L5	494	117	-	871	46		0.2703
L6	130	12	-	298	12		0.0565
L7	667	247	-	1087	62		0.1501
L8	283	26	-	559	26		0.1333
L9	117	11	-	276	11		0.0401
Totals	**2175**	**1470**	**-**	**2881**	**202**		**0.0515**
Adjacent blocks:							
Negomano							
Majune							
Mt Mosale							
Totals							
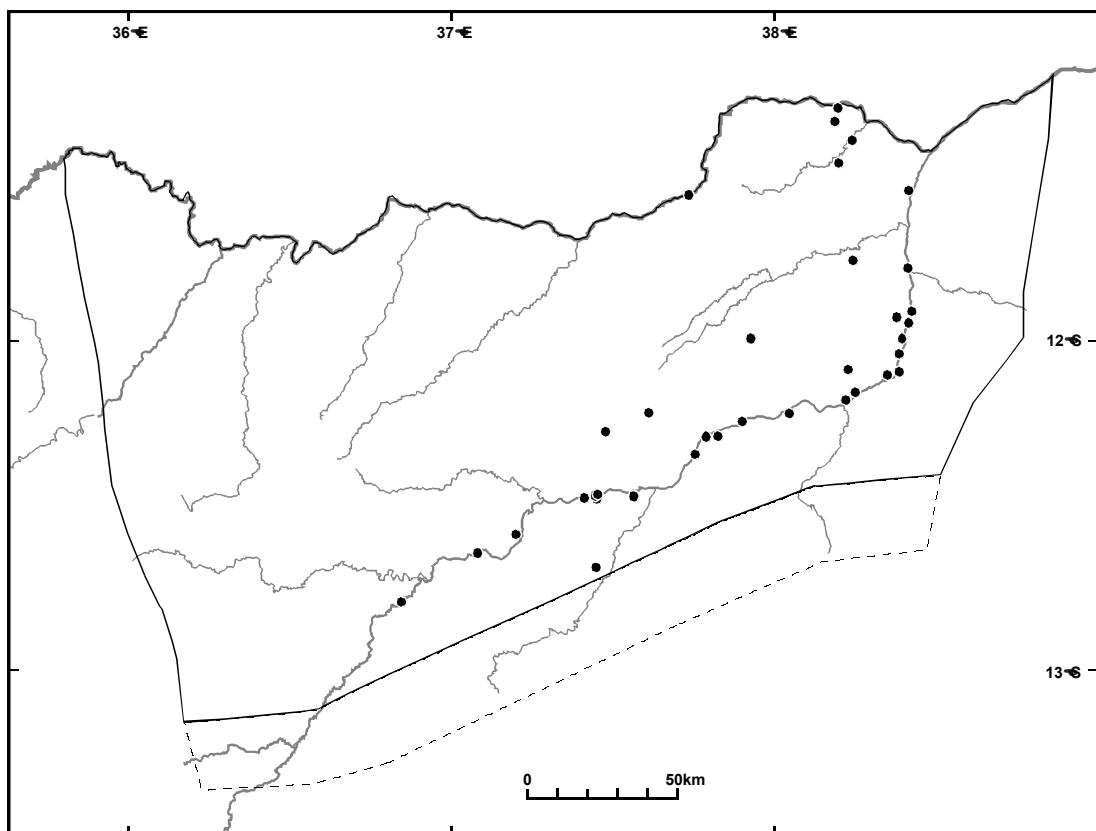
Figure 20: Impala sightings

Table 24: Kudu

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	106	11	-	236	10	1	0.0306
R2	21	2	-	72	2		0.0095
R3	96	9	-	219	9		0.0361
R4	108	10	-	239	10		0.0292
R5	64	6	-	166	6		0.0436
R6	485	140	-	831	45	2	0.2088
Jao							
Mecula							
L1	43	4	-	119	4		0.0131
L2	160	15	-	326	15		0.0382
L3	172	16	-	348	16		0.0653
L4	150	14	-	319	14		0.0680
L5	150	14	-	320	14		0.0823
L6	412	109	-	714	38		0.1789
L7	527	184	-	869	49		0.1185
L8	196	18	-	397	18		0.0923
L9	236	22	-	452	22		0.0810
Totals	**2928**	**2195**	**-**	**3661**	**272**	**3**	**0.0693**
Adjacent blocks:							
Negomano	171	16	-	354	16		0.0758
Majune	171	16	-	381	16		0.0567
Mt Mosale	32	3	-	98	3		0.0227
Totals	**374**	**97**	**-**	**652**	**35**		**0.0559**
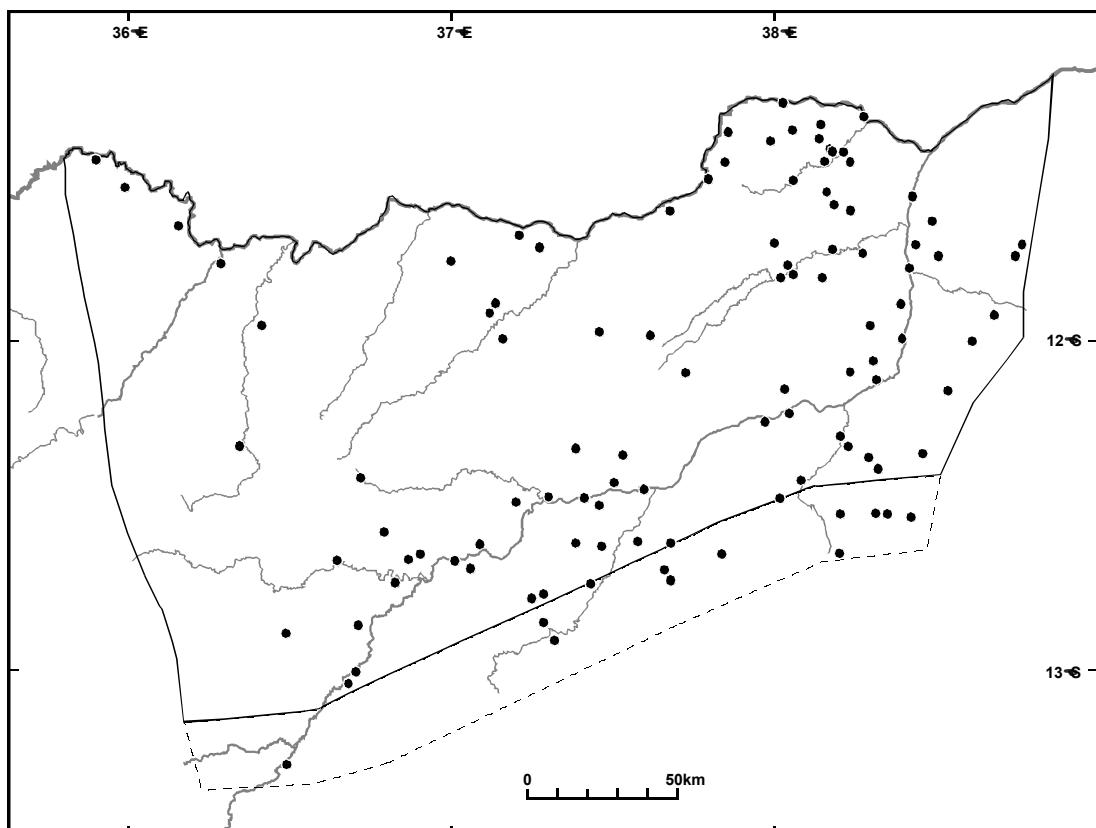
Figure 21: Kudu Sightings

Table 25: Reedbuck

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	691	392	-	990	67	5	0.1999
R2	354	144	-	564	34		0.1572
R3	225	67	-	383	21		0.0843
R4	120	11	-	228	11		0.0322
R5							
R6							
Jao							
Mecula							
L1	116	11	-	226	11		0.0351
L2	277	102	-	453	26		0.0664
L3	65	6	-	142	6		0.0245
L4	43	4	-	107	4		0.0194
L5							
L6							
L7	118	11	-	226	11		0.0266
L8	11	1	-	40	1		0.0051
L9	21	2	-	63	2		0.0073
Totals	**2041**	**1574**	**-**	**2509**	**194**	**5**	**0.0483**
Adjacent blocks:							
Negomano							
Majune	203	68	-	337	19	1	
Mt Mosale	237	66	-	409	22	2	0.0673
Totals	**440**	**233**	**-**	**648**	**41**	**3**	**0.1662**
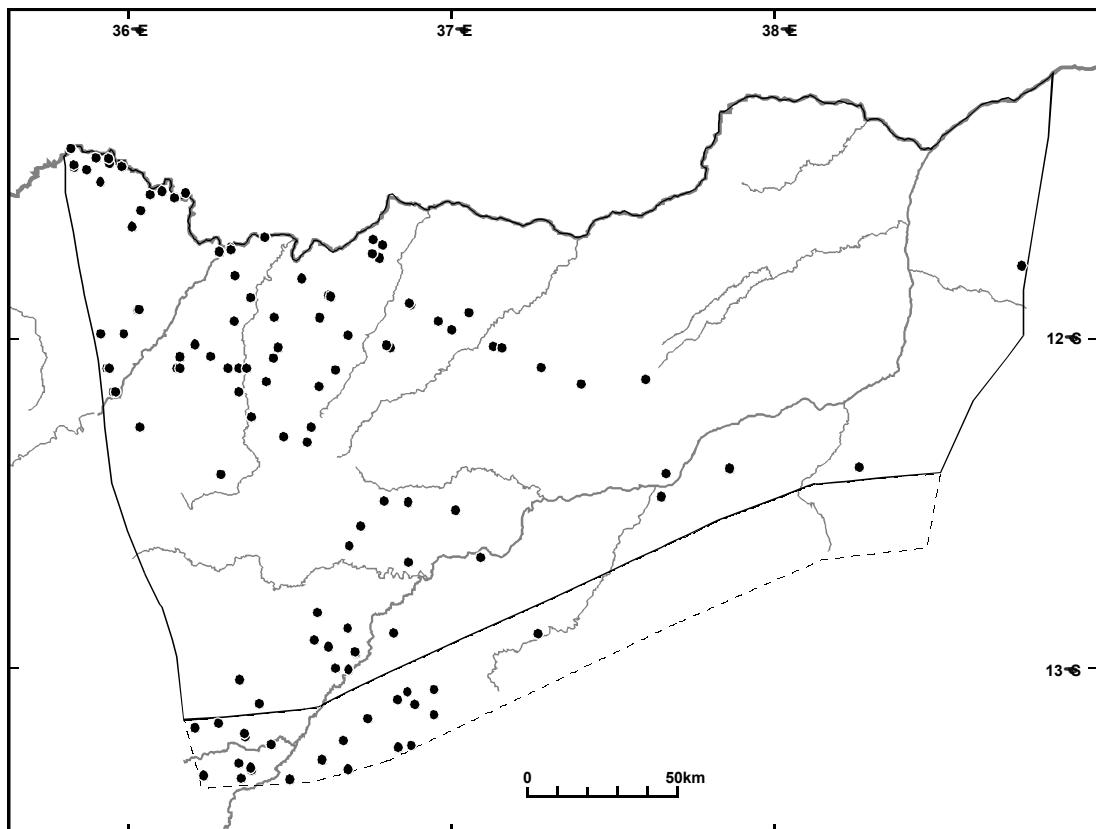
Figure 22: Reedbuck sightings

Table 26: Sable

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	1128	459	-	1797	109	44	0.3263
R2	1259	513	-	2006	118	60	0.5595
R3	1006	391	-	1621	94	21	0.3767
R4	1385	615	-	2154	126	28	0.3731
R5	310	34	-	586	29		0.2110
R6	573	149	-	997	53		0.2464
Jao							
Mecula							
L1	581	165	-	997	54		0.1756
L2	1271	549	-	1994	119	13	0.3042
L3	1008	392	-	1624	93	45	0.3818
L4	752	234	-	1270	70	20	0.3398
L5	1311	527	-	2095	122	8	0.7172
L6	1038	402	-	1674	96	9	0.4513
L7	2208	1129	-	3287	205	27	0.4966
L8	643	175	-	1111	59		0.3025
L9	212	20	-	411	20		0.0728
Totals	**14686**	**12830**	**-**	**16541**	**1367**	**275**	**0.3474**
Adjacent blocks:							
Negomano	653	200	-	1106	61	12	0.2891
Majune	1654	767	-	2541	155	17	0.5493
Mt Mosale	130	20	-	272	12	8	0.0906
Totals	**2436**	**1457**	**-**	**3416**	**228**	**37**	**0.3638**
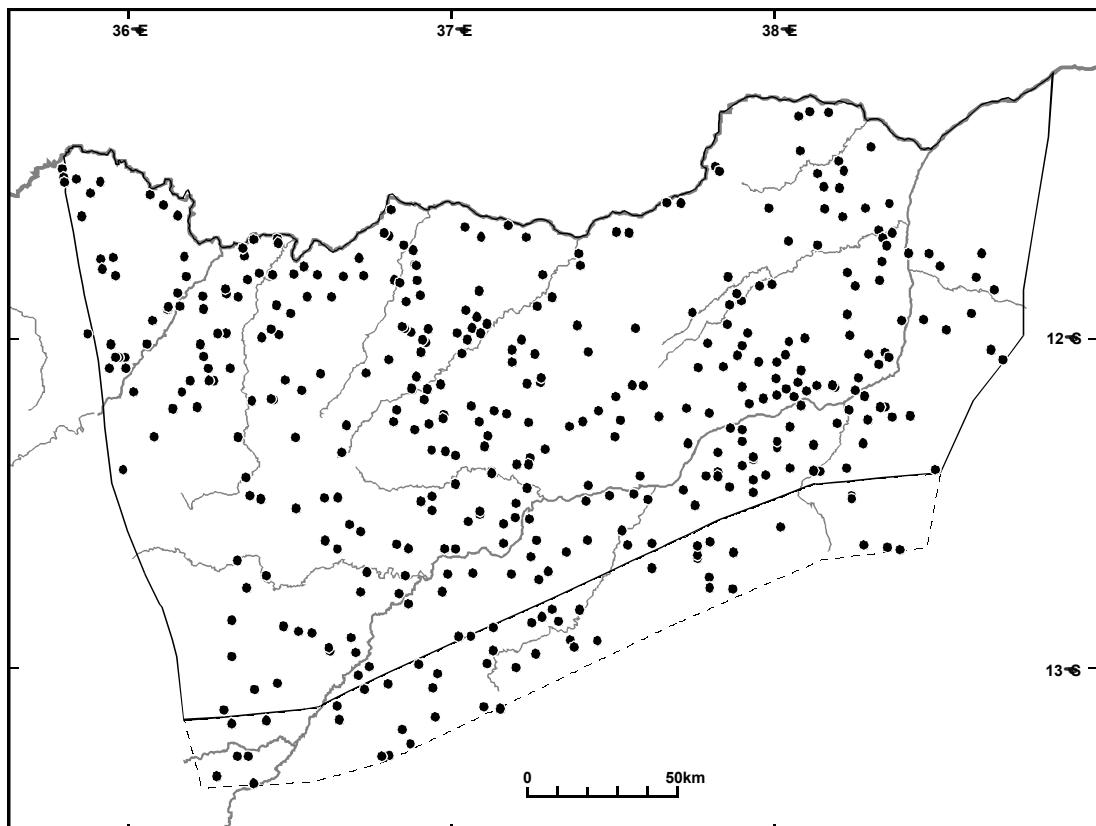
Figure 23: Sable sightings

Table 27: Warthog

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	903	489	-	1316	87	8	0.2611
R2	651	293	-	1009	62		0.289
R3	557	236	-	877	52		0.2084
R4	1080	630	-	1530	99		0.2909
R5	224	21	-	436	21		0.1527
R6	754	362	-	1147	70		0.3245
Jao	21	2	-	88	2		0.0997
Mecula							
L1	180	17	-	358	17		0.0544
L2	448	165	-	731	42	2	0.1072
L3	468	176	-	761	43		0.1774
L4	515	194	-	836	48		0.233
L5	237	22	-	451	22		0.1294
L6	974	539	-	1410	90		0.4234
L7	1591	1041	-	2141	148		0.3578
L8	567	225	-	909	52		0.2667
L9	920	494	-	1345	86		0.3161
Totals	**10089**	**8763**	**-**	**11415**	**941**	**10**	**0.2386**
Adjacent blocks:							
Negomano	1167	678	-	1655	109		0.5166
Majune	1846	1241	-	2451	173	3	0.6131
Mt Mosale	561	225	-	897	52	5	0.3927
Totals	**3574**	**2756**	**-**	**4392**	**334**	**8**	**0.5336**
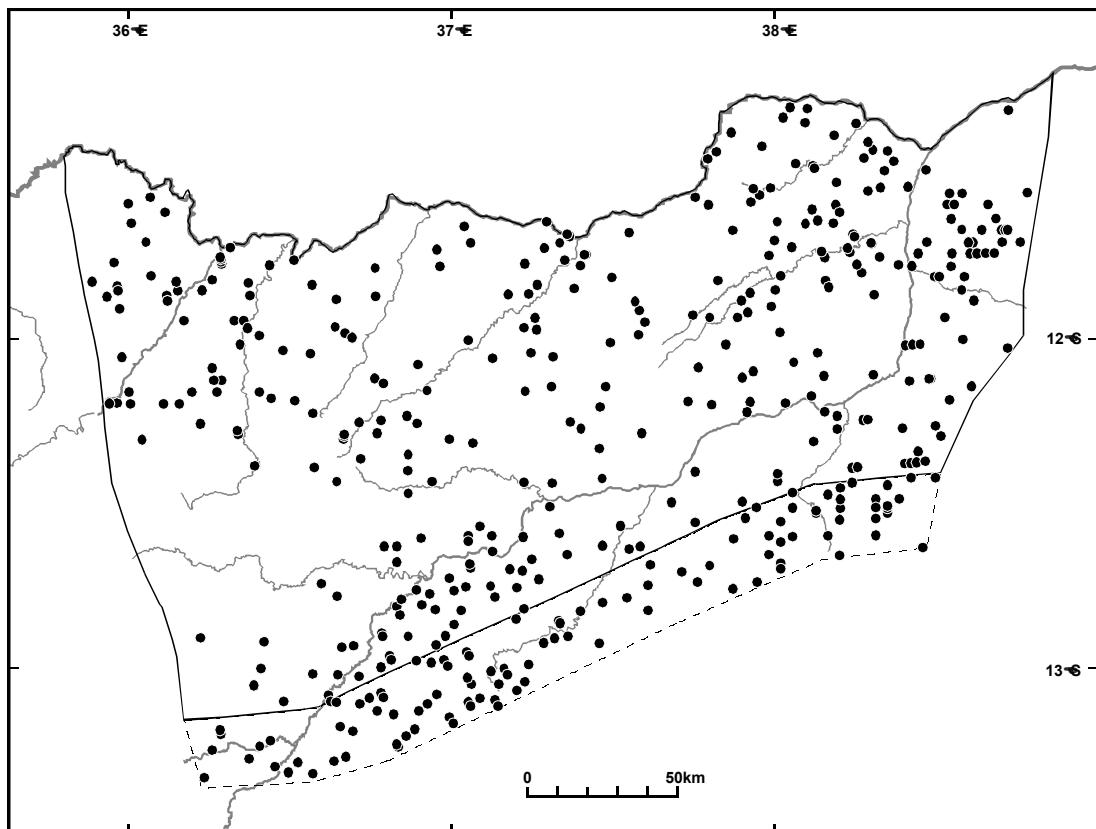
Figure 24: Warthog sightings

Table 28: Waterbuck

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	197	20	-	396	19	1	0.057
R2	184	18	-	381	18		0.082
R3	107	10	-	243	10		0.0401
R4	86	8	-	202	8		0.0231
R5	64	6	-	169	6		0.0437
R6	226	21	-	452	21		0.0971
Jao							
Mecula							
L1	97	9	-	227	9		0.0294
L2	267	29	-	505	25		0.0639
L3	110	10	-	247	10		0.0415
L4	387	71	-	702	36		0.1748
L5	86	8	-	210	8		0.047
L6	238	22	-	464	22		0.1036
L7	752	300	-	1204	70		0.1692
L8	97	9	-	232	9		0.0458
L9	53	5	-	142	5		0.0182
Totals	**2952**	**2177**	**-**	**3727**	**276**	**1**	**0.0698**
Adjacent blocks:							
Negomano	32	3	-	95	3		0.0142
Majune	75	7	-	183	7		0.0249
Mt Mosale	443	122	-	763	41		0.3097
Totals	**549**	**225**	**-**	**874**	**51**		**0.082**
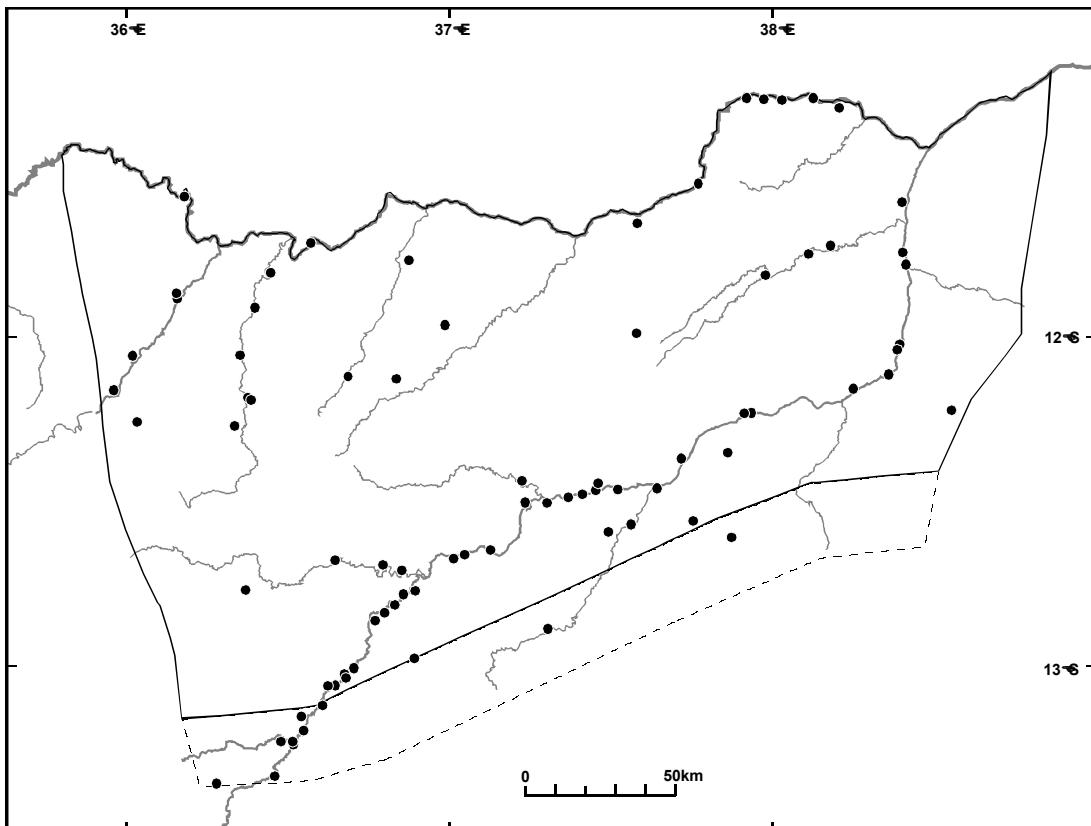
Figure 25: Waterbuck sightings

Table 29: Wildebeest

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1							
R2						1	
R3							
R4	78	12	-	193	7	5	0.0211
R5	203	19	-	488	19		0.138
R6						12	
Jao							
Mecula							
L1							
L2							
L3							
L4							
L5	32	8	-	88	3	5	0.0176
L6	11	1	-	31	1		0.0047
L7	118	26	-	282	11	15	0.0266
L8	98	17	-	247	9	8	0.0462
L9	583	55	-	1269	55		0.2003
Totals	**1124**	**384**	**-**	**1863**	**105**	**46**	**0.0266**
Adjacent blocks:							
Negomano	11	1	-	32	1		0.0047
Majune							
Mt Mosale							
Totals	**11**	**1**	**-**	**31**	**1**		**0.0016**
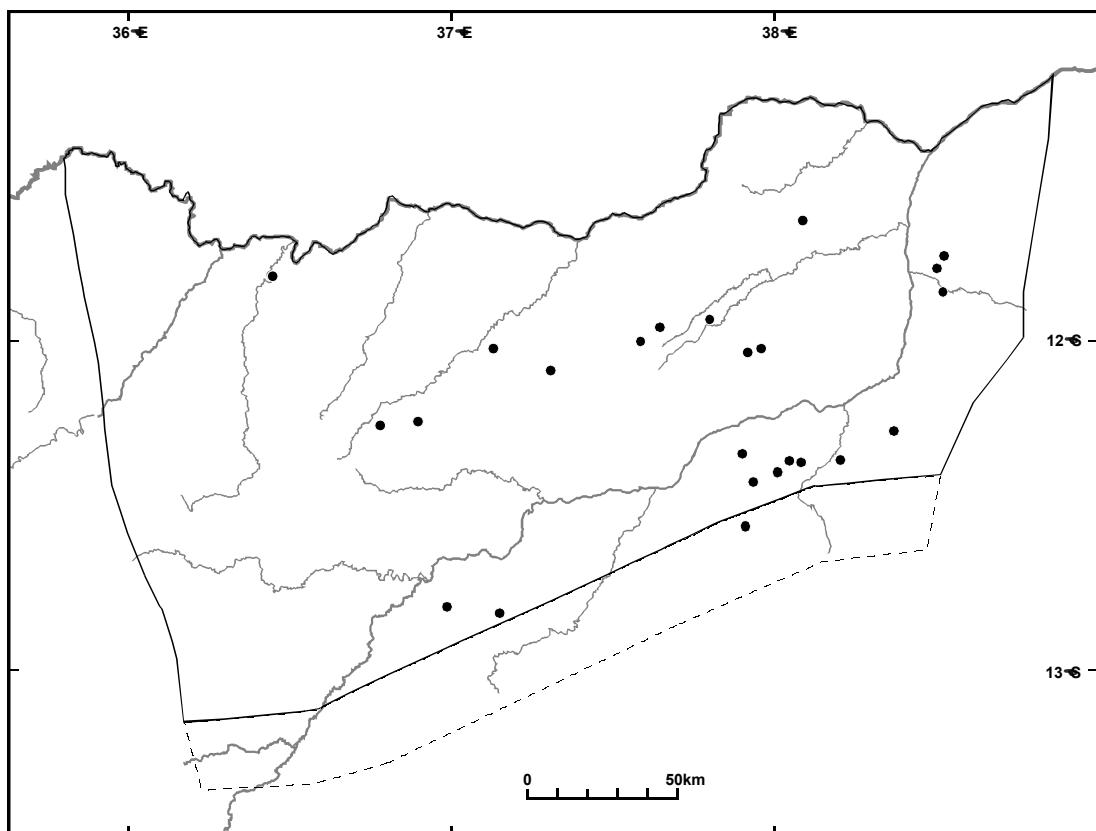
Figure 26: Wildebeest sightings

Table 30: Zebra

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	269	43	-	501	27	16	0.0777
R2	233	22	-	452	22		0.1037
R3	289	45	-	533	27		0.1082
R4	1058	496	-	1619	96	16	0.1082
R5	139	13	-	301	13		0.0946
R6	474	123	-	826	44	6	0.2040
Jao	73	7	-	192	7		0.3489
Mecula	16	2	-	61	2		0.0693
L1							
L2	108	10	-	235	10		0.0258
L3	423	110	-	736	38	3	0.1602
L4	440	105	-	775	41		0.1990
L5	612	195	-	1030	57		0.3350
L6	465	129	-	801	43		0.2020
L7	903	399	-	1408	84	9	0.2032
L8	523	143	-	903	48		0.2461
L9	203	24	-	401	19	5	0.0699
Totals	**6229**	**5033**	**-**	**7425**	**578**	**55**	**0.1473**
Adjacent blocks:							
Negomano	342	73	-	612	32	4	0.1517
Majune	107	37	-	223	10	27	0.0354
Mt Mosale							
Totals	**449**	**165**	**-**	**733**	**42**	**31**	**0.0671**
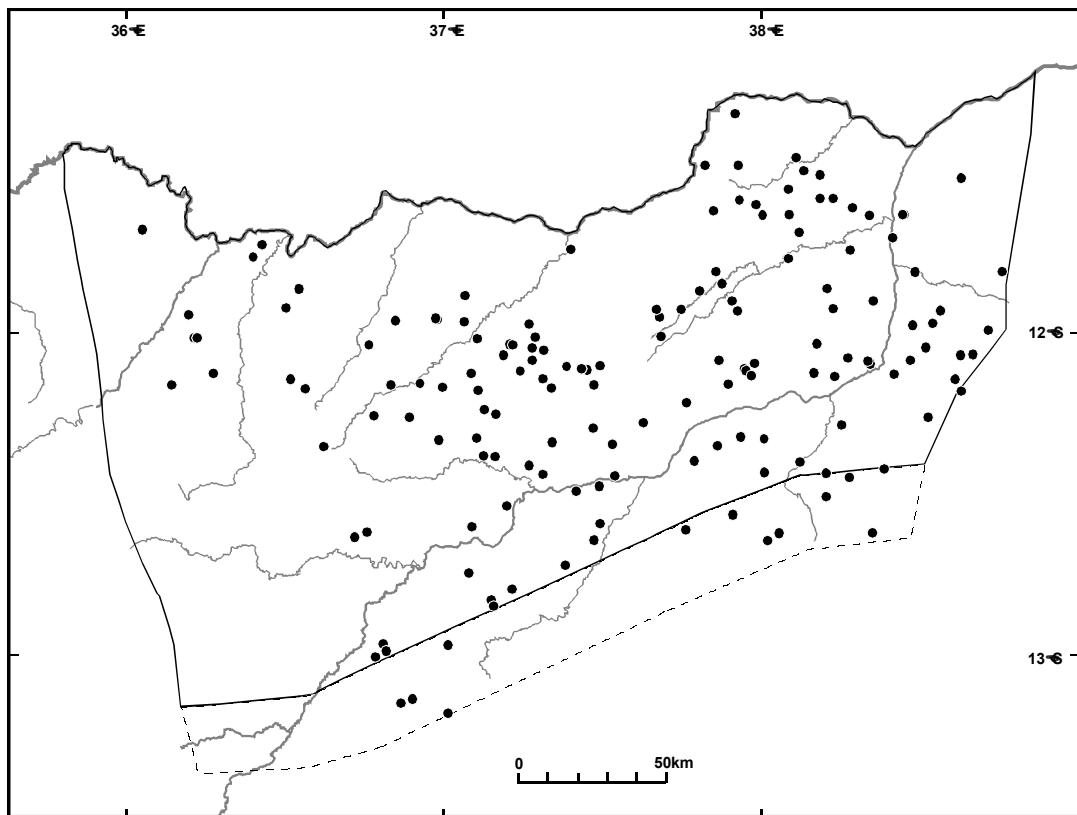
Figure 27: Zebra sightings

Table 31: Leopard

Niassa blocks:	Estimate	Range	No seen	No out	Density
R6	11	1 - 33	1		0.0046
Totals	**11**	**1 - 31**	**1**		**0.0003**

Table 32: Lion

Niassa blocks:	Estimate	Range	No seen	No out	Density
R4	107	10 - 308	10		0.0288
L6	43	4 - 129	4		0.0188
L8	22	2 - 66	2		0.0103
L9				1	
Totals	**172**	**16 - 388**	**16**		**0.0041**

Table 33: Hyaena

Niassa blocks:	Estimate	Range	No seen	No out	Density
R4	11	1 31	1		0.0029
Totals	11	1 30	1		0.0003
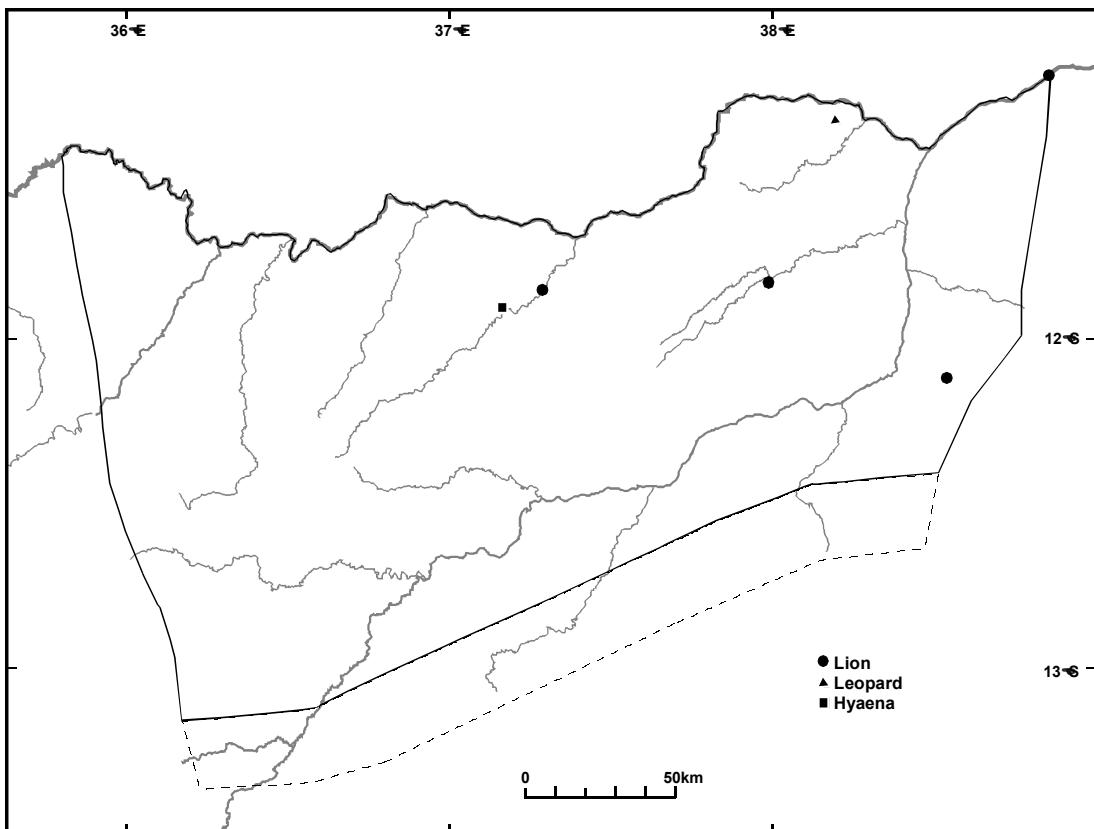
Figure 28: Carnivore sightings

Table 34: Other Carcass stage 1

Niassa blocks:	Estimate	Range			No seen	No out	Density
L3	22	2	-	53	2		0.0083
L6	11	1	-	32	1		0.0047
Totals	**33**	**3**	**-**	**68**	**3**		**0.0008**

Table 35: Other Carcass stage 3

Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	11	1	-	30	1		0.0031
R2	11	1	-	30	1		0.0047
R3	11	1	-	30	1		0.004
R4	22	2	-	50	2		0.0058
R5	11	1	-	31	1		0.0073
R6	11	1	-	31	1		0.0046
L3	11	1	-	31	1		0.0043
L4	21	2	-	51	2		0.0097
L5	21	2	-	52	2		0.0118
L6	22	2	-	51	2		0.0094
L7	65	12	-	117	6		0.0145
L8	22	2	-	52	2		0.0103
Totals	**237**	**145**	**-**	**330**	**22**		**0.0056**
Adjacent blocks:							
Negomano	21	2	-	50	2		0.0095
Majune	11	1	-	31	1		0.0035
Totals	**32**	**3**	**-**	**67**	**3**		**0.0048**

Table 36: Other Carcass stage 4

| Niassa blocks:	Estimate	Range			No seen	No out	Density
R1	21	2	-	53	2		0.0061
R2	10	1	-	31	1		0.0043
R3	43	4	-	90	4		0.016
R4	76	12	-	141	7		0.0206
R5	21	2	-	55	2		0.0145
L3	11	1	-	32	1		0.0041
L4	21	2	-	55	2		0.0097
L5	54	5	-	110	5		0.0294
L6	22	2	-	54	2		0.0094
L7	32	3	-	72	3		0.0073
L9	11	1	-	32	1		0.0036
Totals	**322**	**199**	**-**	**445**	**30**		**0.0076**
Adjacent blocks:							
Majune	32	3	-	67	3		0.0106
Totals	**32**	**3**	**-**	**66**	**3**		**0.0048**
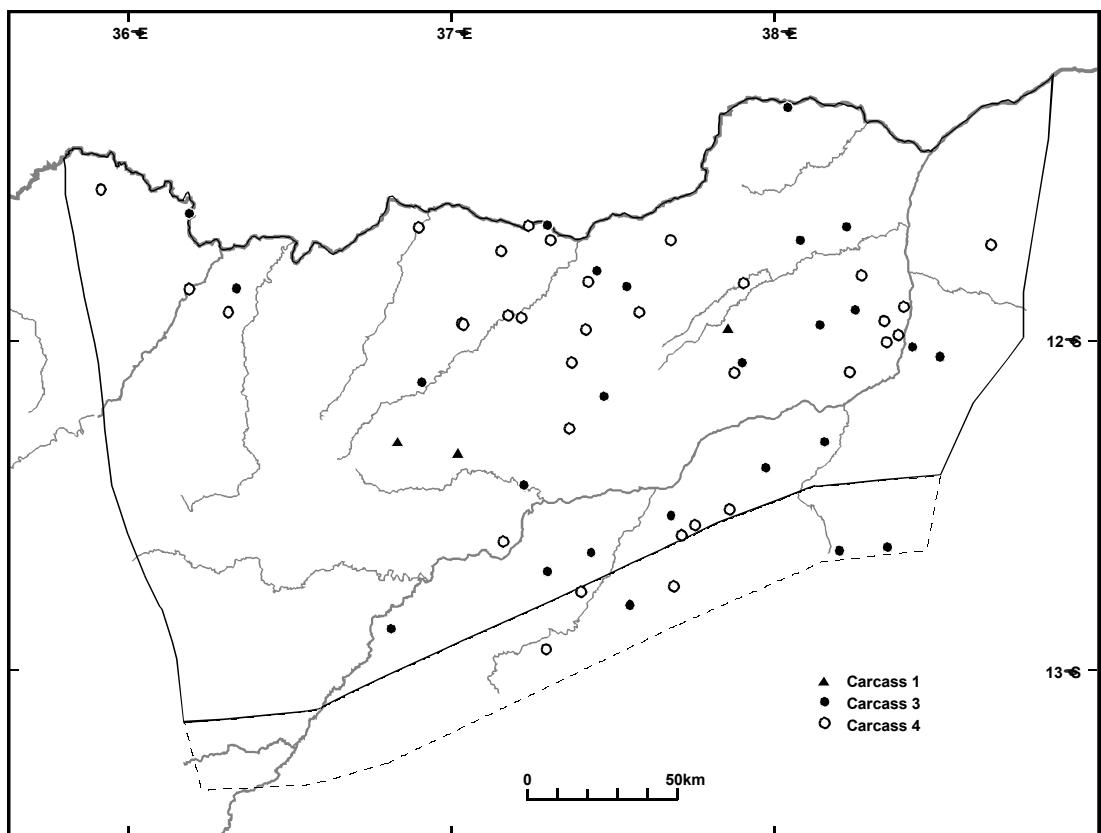
Figure 29: Other (non-elephant) carcasses including unidentified species

3   OTHER OBSERVATIONS

This section describes attributes other than wildlife recorded during the survey.

Fig. 30 and Table 37 show incidence of fires and burned areas at the time of the survey (some areas burned after they had been surveyed).

Occurrences of surface water are reported for the first time (Fig. 31). Records were not made over the Lugenda and Rovuma rivers, which were flowing along their full lengths.

Table 37: Percentage of area burnt

	Hot	Cool	Unburned	total
Niassa Reserve	9.74	53.08	37.18	100
Adjacent blocks	20.3	39.23	40.47	100
Total	**11.18**	**51.19**	**37.63**	**100**

Observations relating to human activities are mapped in figs 32-36.
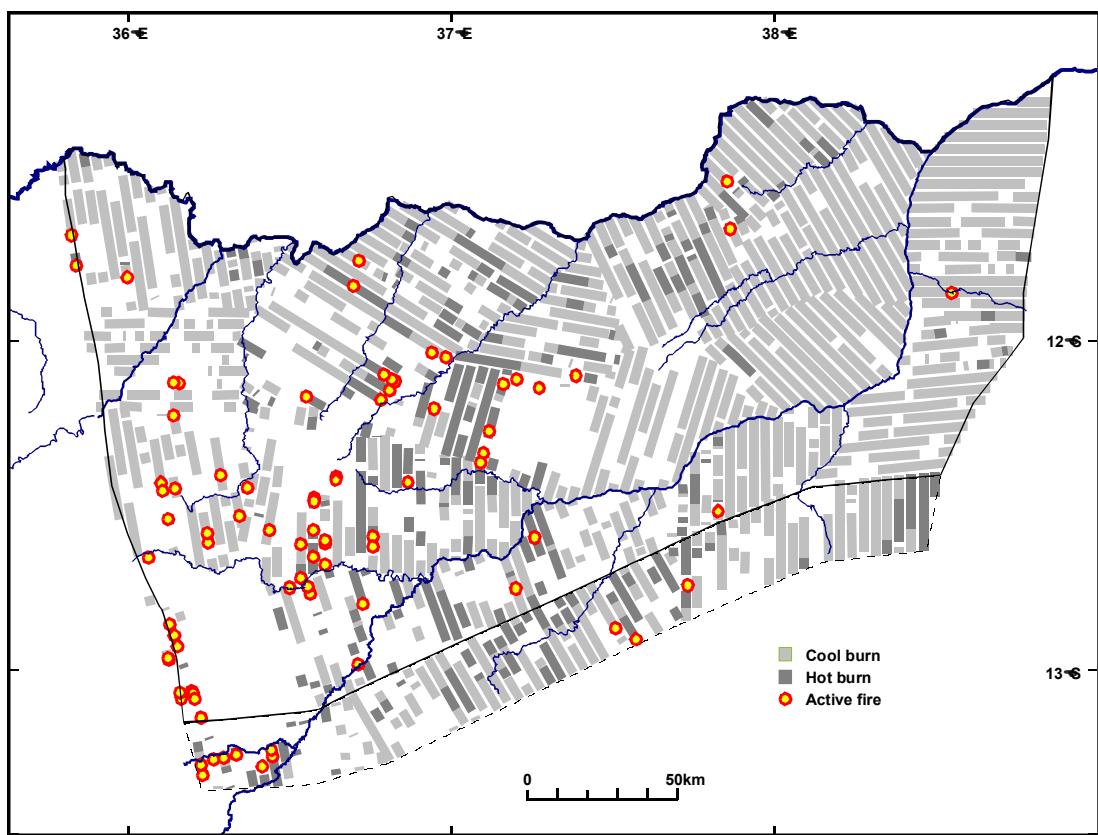
Figure 30: Fire
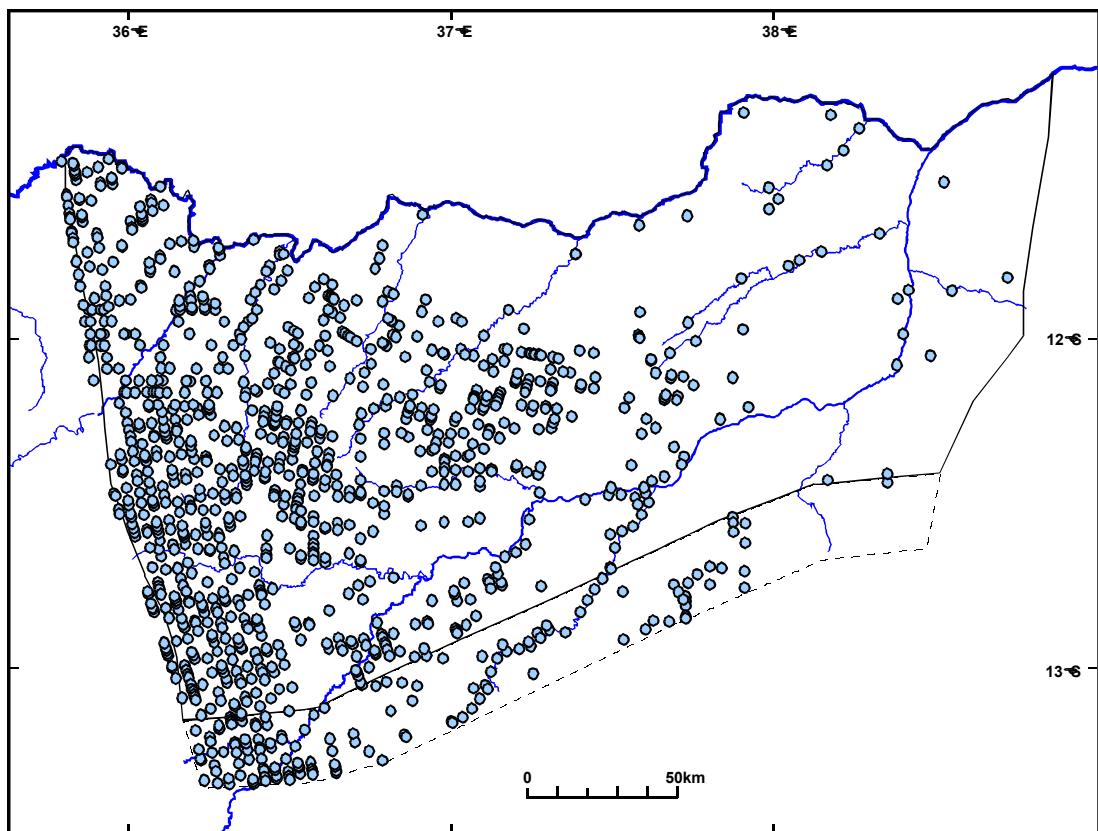
Figure 31: Water
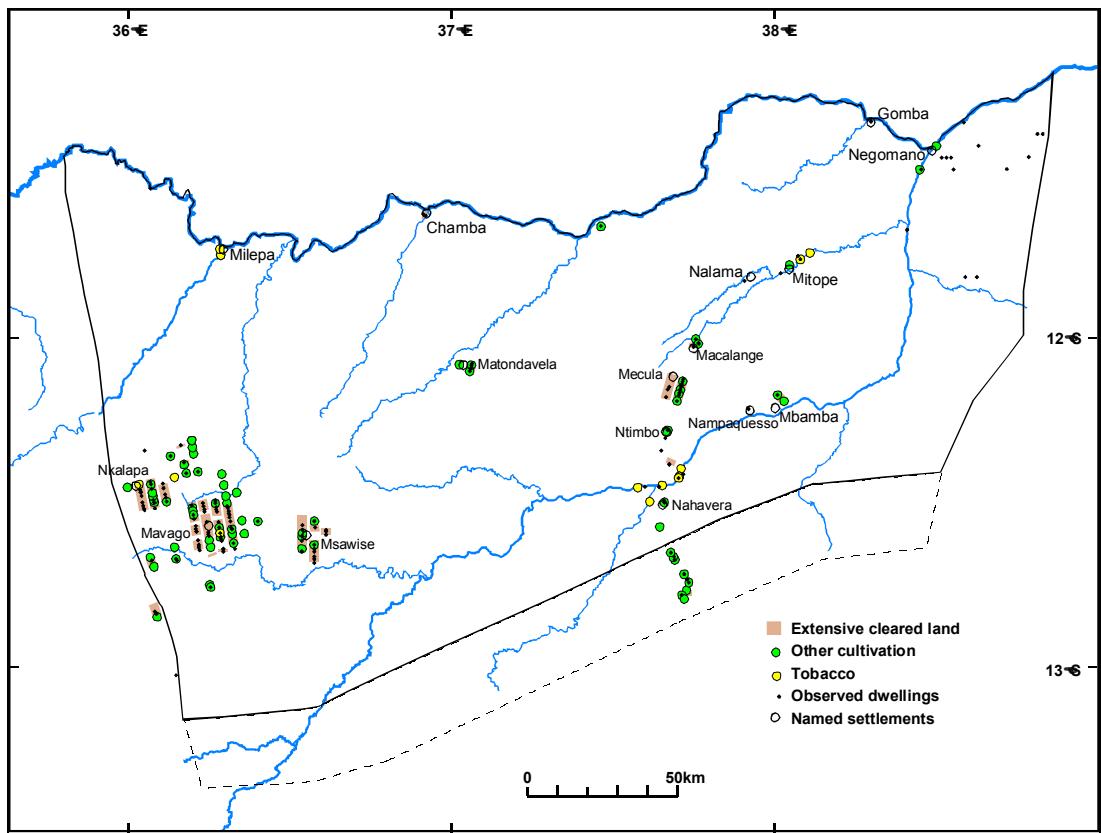
Figure 32: Cultivation and settlement
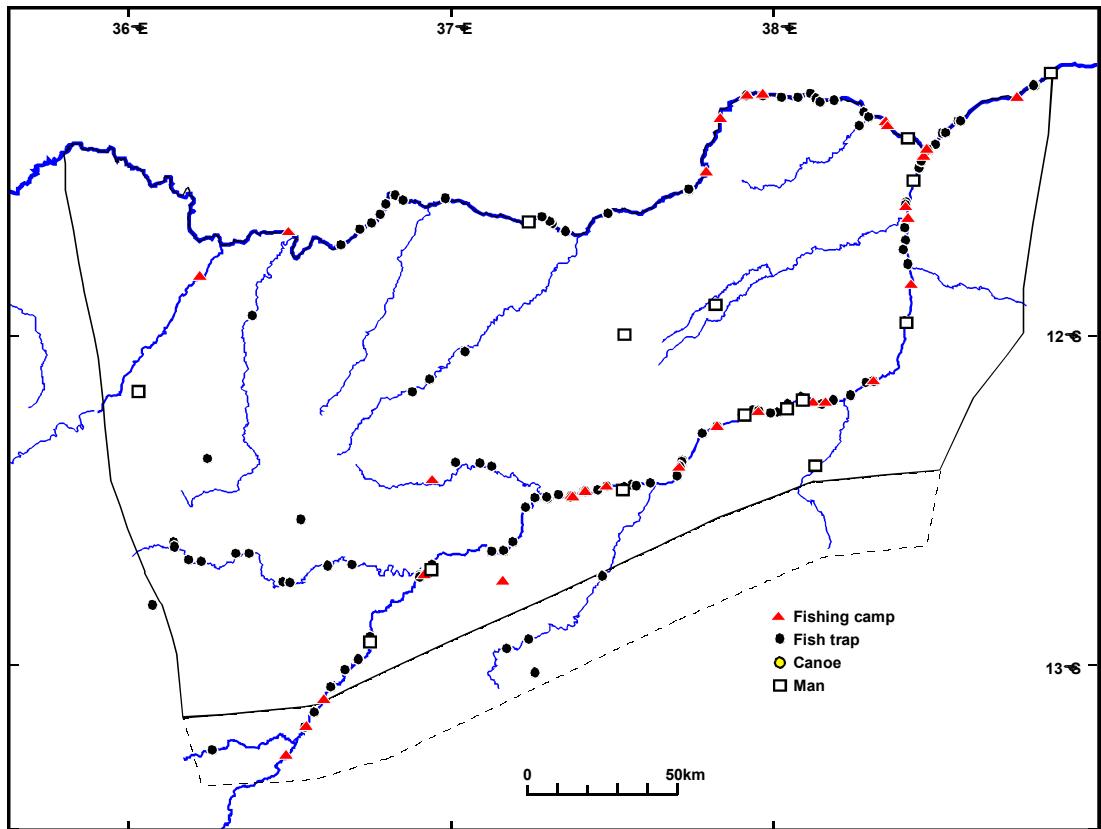
Figure 33: Fishing

Table 38: Small livestock (sheep or goats)

Niassa blocks:	Estimate	Range			No seen	No out	Density
L1	981	98	-	2484	91	7	0.2967
L2	420	39	-	1138	39		0.1005
L4	1235	115	-	3114	115		0.5582
Totals	**2636**	**284**	**-**	**4988**	**245**	**7**	**0.0624**
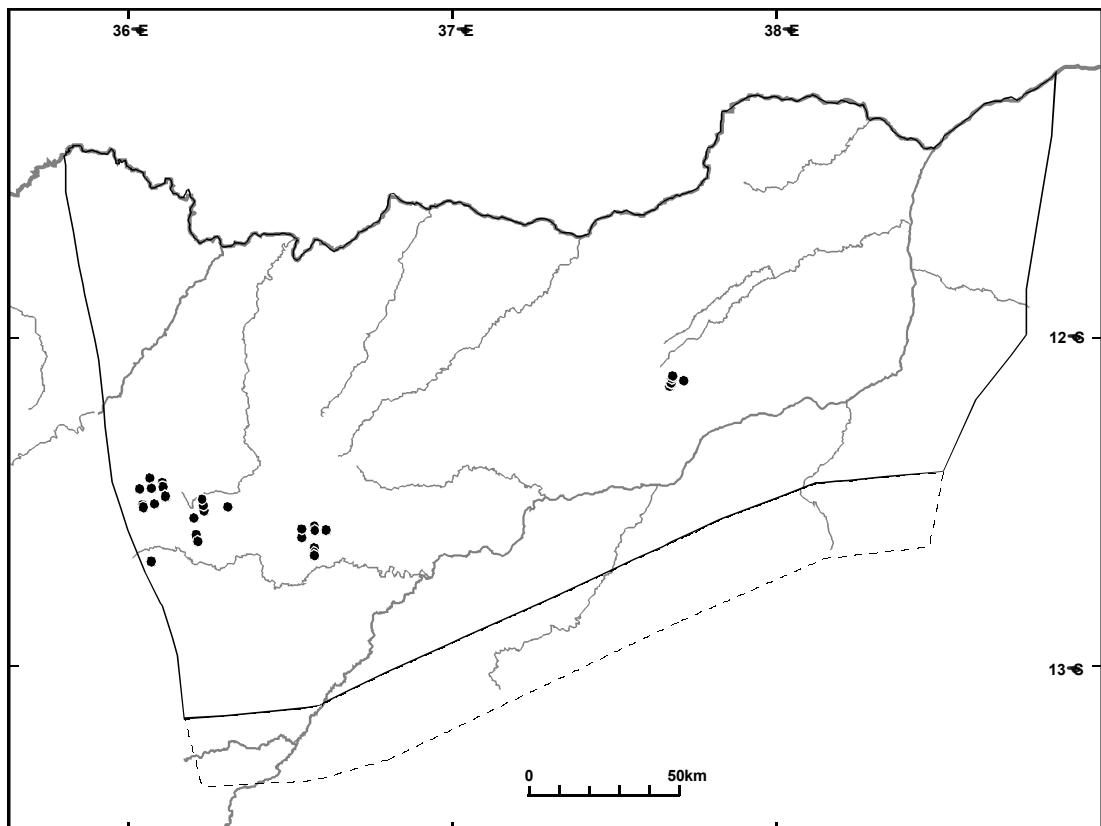
Figure 34: Sheep or goats
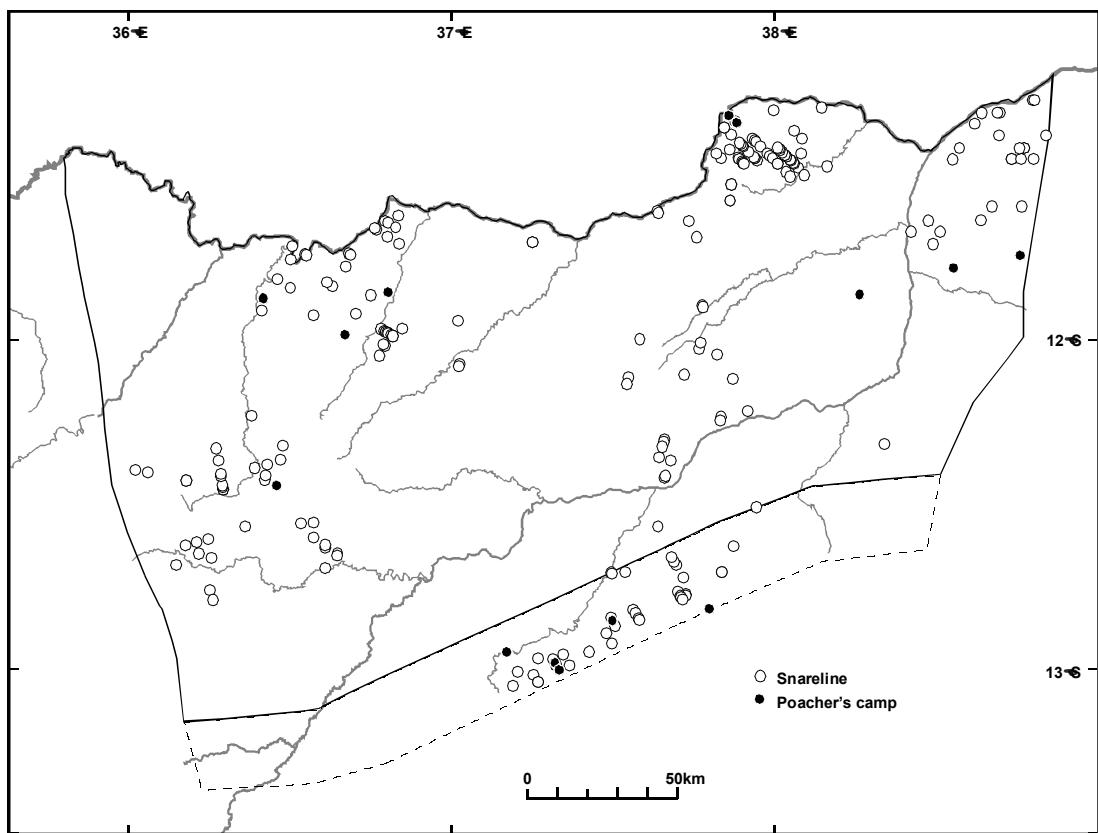
Figure 35: Illegal hunting
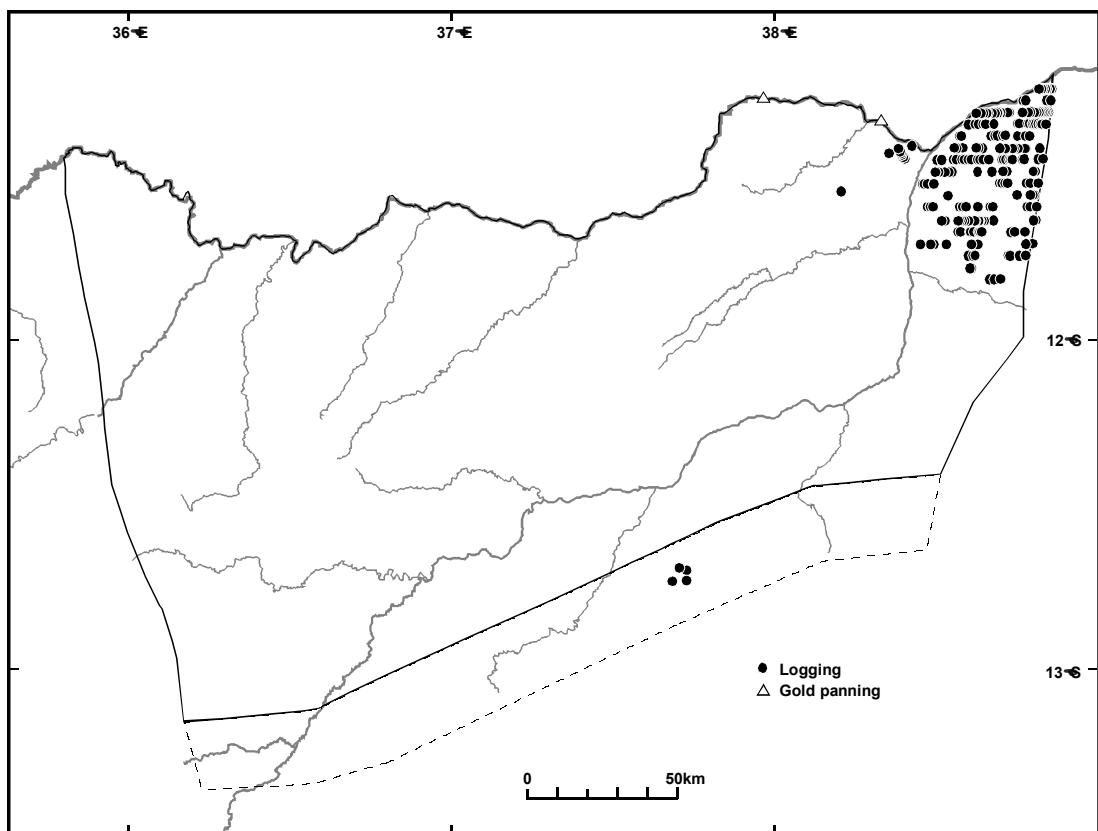
Figure 36: Other illegal activities

4   TRENDS

Trend parameters for wildlife species are given in Table 39. The natural logarithm of the estimates was used in the regressions. In this case the slope of the regression is r, the instantaneous rate of increase. Method was as in the previous report (Craig 2006). The last data point is 3 years from the previous when, ideally, the time points should be evenly spaced. However, this is unlikely to be of major importance.

Confidence intervals for r are given. Any r whose lower confidence interval is less than 0 is not statistically significant. The significance levels (p) of the trends are given. Any p which is less than 0.05 is significant at the 5% level.

Graphs of population changes are shown below for populations where the change is significant (Figs 37 – 49). A graph is provided for Wildebeest in addition. The fitted exponential trend line is shown in each case except for sable.

A significant fit does not necessarily imply the increase really is exponential. However, fitting a more complicated relationship would be difficult to justify with this number of points in the time series.

Change over time is also illustrated for small livestock and snaring (Figs 50 – 51).

Table 39: Wildlife trends

	Estimates						Rate	95% Range of r		Prob	
Species	1998	2000	2002	2004	2006	2009	r	L	U	p	
Elephants	8707	11828	13061	12478	11833	20364	0.058	0.008	0.108	0.033	*
Elephant carcasses	336	644	645	461	588	896	0.059	-0.023	0.141	0.117	
Buffalo	2095	2513	6220	6968	2271	6833	0.078	-0.095	0.251	0.280	
Bushbuck	203	443	733	322	454	366	0.026	-0.116	0.169	0.633	
Bushpig	591	696	1239	1284	505	743	0.002	-0.131	0.135	0.970	
Crocodile	57	97	202	146	31	118	0.002	-0.233	0.236	0.984	
Duiker	5166	16074	16992	12202	23172	22174	0.105	-0.019	0.228	0.078	
Eland	1358	2121	3249	2664	6645	5856	0.138	0.054	0.222	0.010	*
Hartebeest	1531	2504	3984	3382	4404	5074	0.099	0.033	0.165	0.014	*
Hippopotamus	463	305	502	768	1206	1325	0.130	0.045	0.215	0.013	*
Impala	124	530	1231	1095	1335	2175	0.222	0.054	0.391	0.022	*
Kudu	949	1297	2951	1439	3845	2928	0.106	-0.020	0.232	0.080	
Reedbuck	69	363	1673	1096	3879	2041	0.303	0.027	0.579	0.038	*
Sable	7134	9445	13940	13233	13881	14823	0.062	0.010	0.114	0.030	*
Warthog	3681	6312	7550	5614	8660	10132	0.076	0.011	0.141	0.032	*
Waterbuck	334	719	868	1219	2308	2973	0.195	0.139	0.251	0.001	**
Wildebeest	778	777	573	930	1543	1124	0.057	-0.031	0.145	0.148	
Zebra	2854	2788	3773	3609	6222	6294	0.084	0.037	0.131	0.008	**
Ground hornbill	3023	2702	3360	3621	4101	4392	0.042	0.019	0.066	0.007	**
All Wildlife	40241	62215	82766	72541	98300	110716	0.083	0.018	0.846	0.009	**
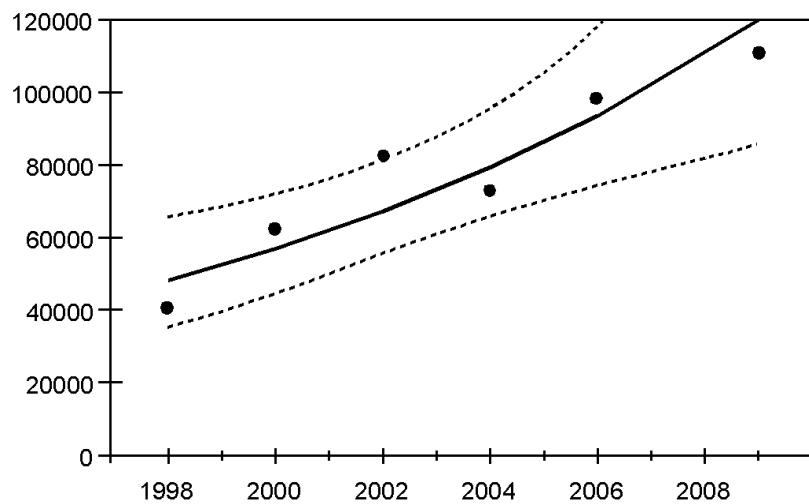
Figure 37: Trend of all wildlife
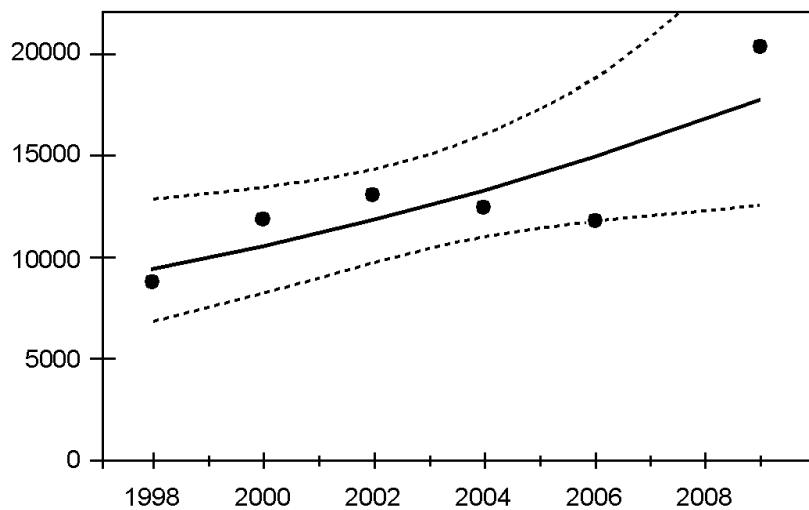
Figure 38: Elephants
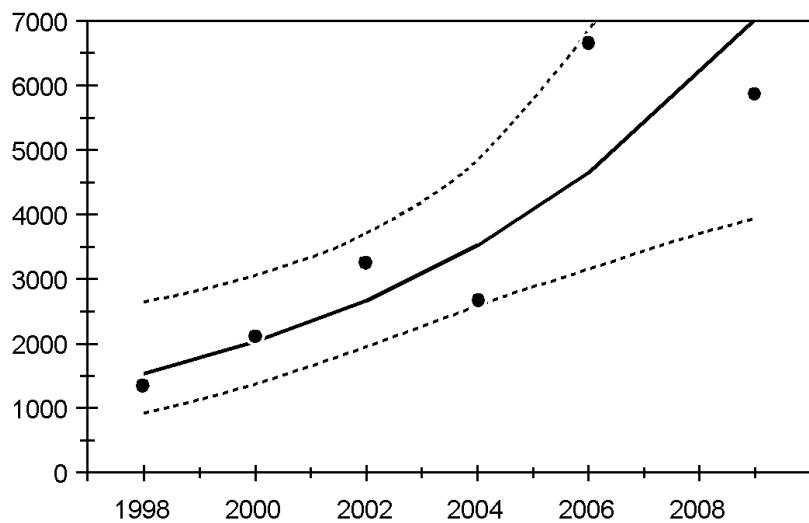
Figure 39: Eland
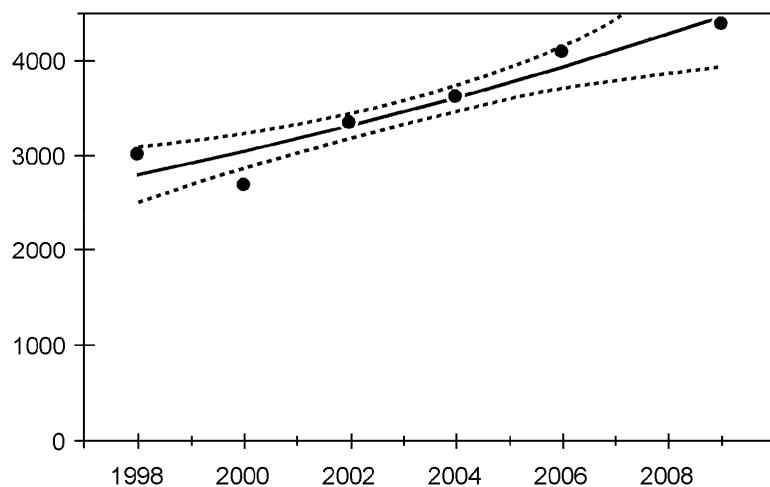
Figure 40: Ground hornbill
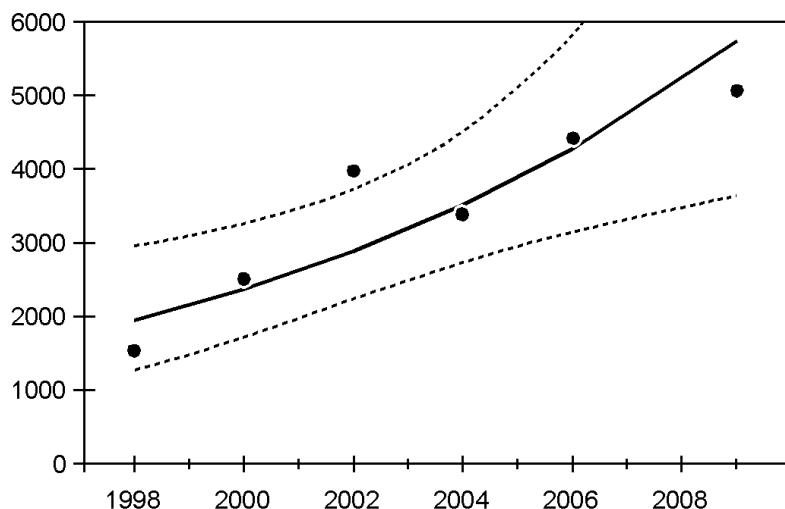
Figure 41: Hartebeest
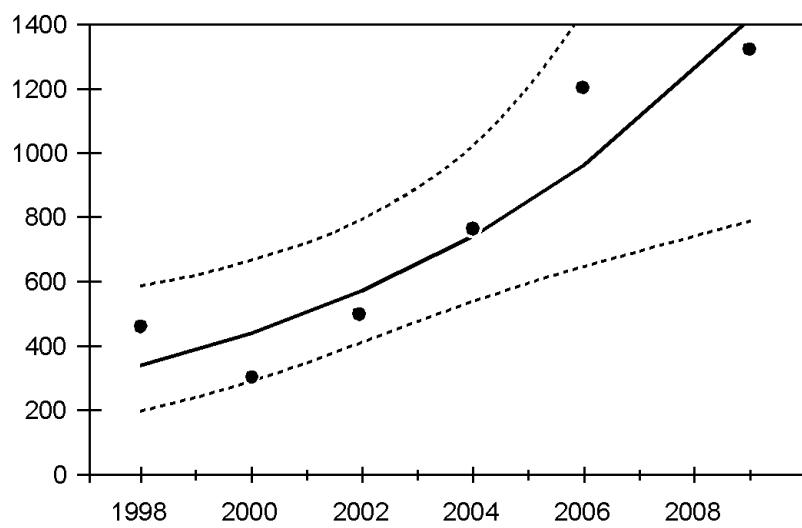
Figure 42: Hippopotamus
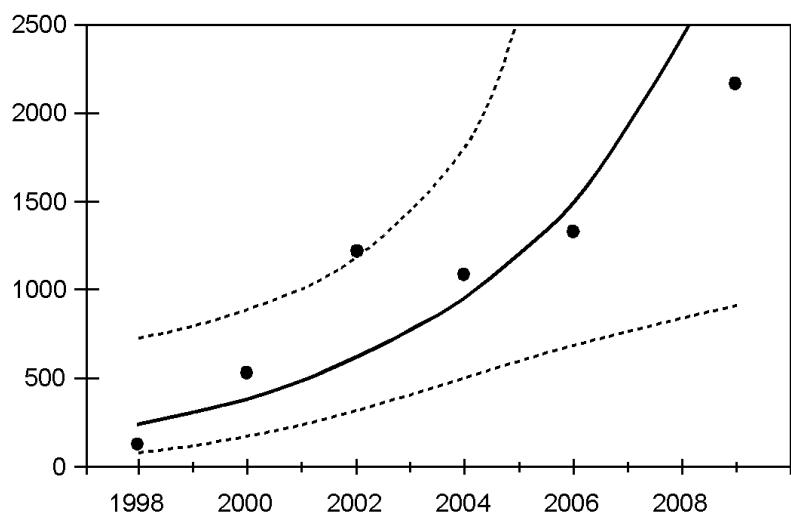
Figure 43: Impala
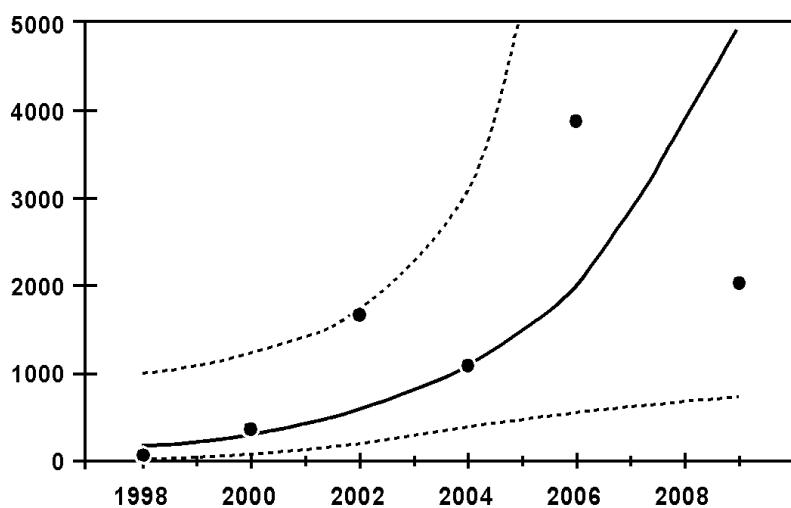
Figure 44: Reedbuck
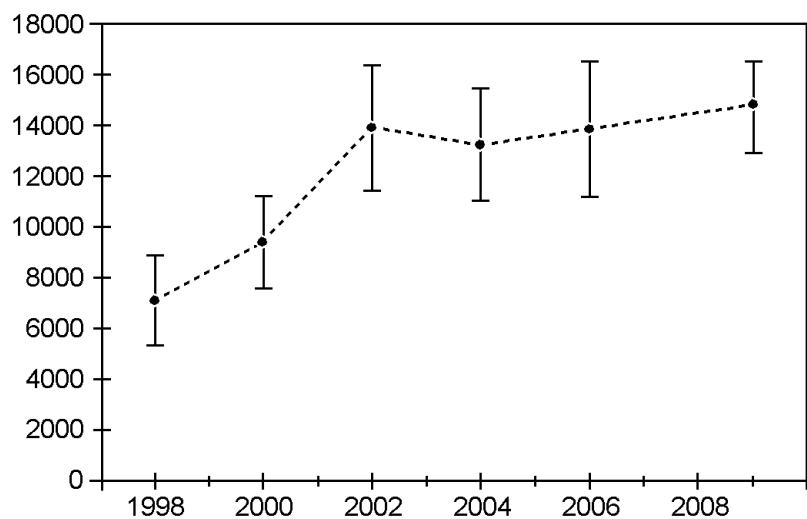
Figure 45: Sable
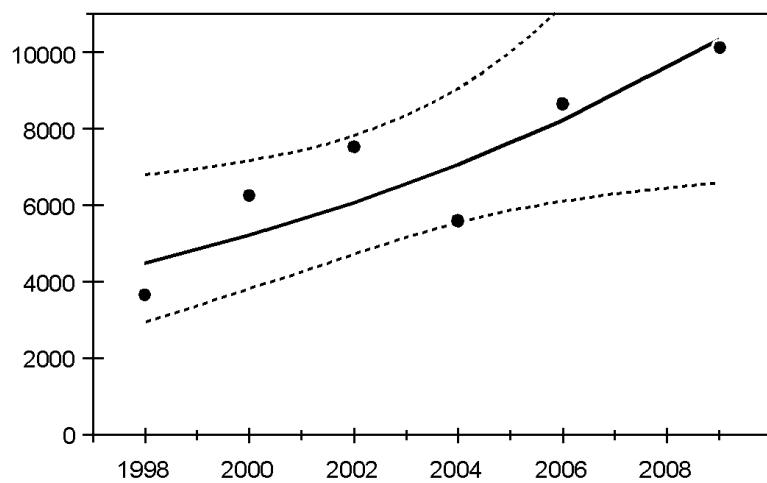
Figure 46: Warthog
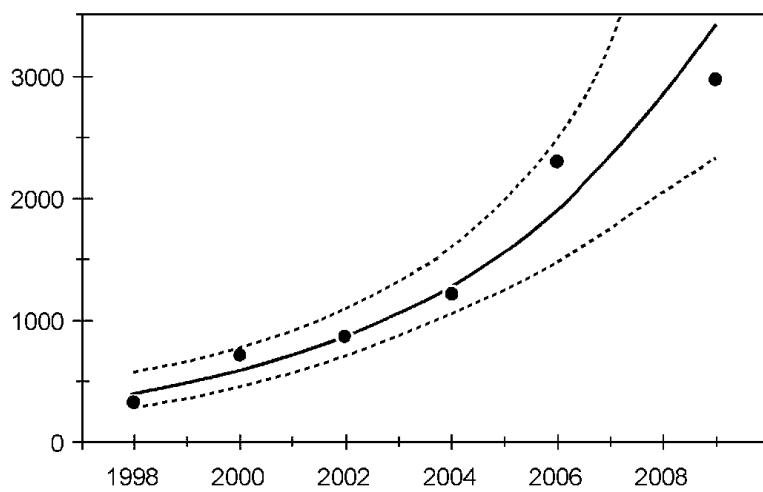
Figure 47: Waterbuck
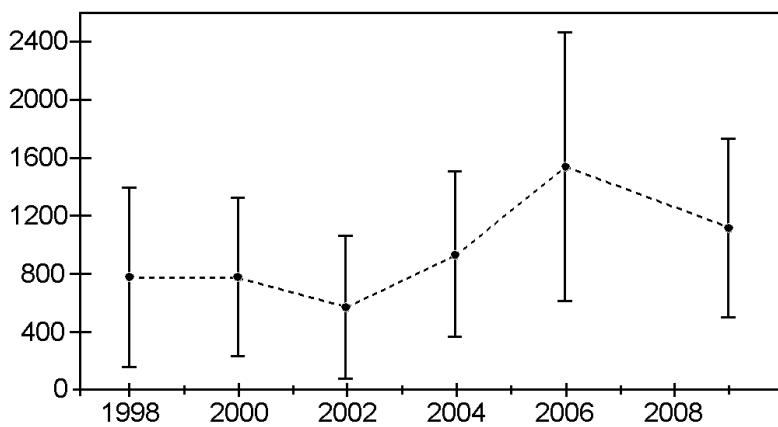
Figure 48: Wildebeest
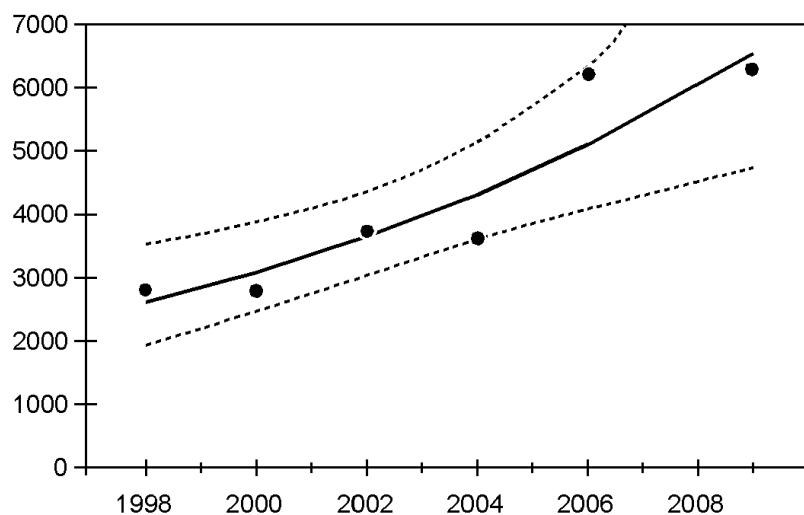
Figure 49: Zebra
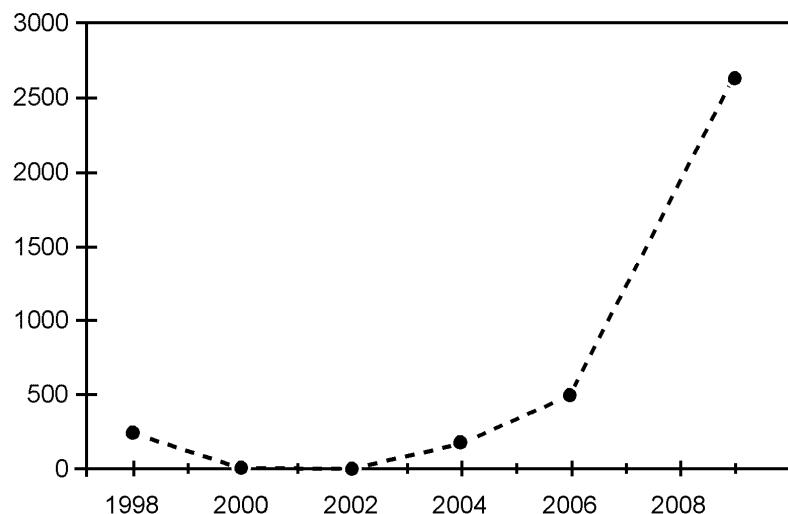
Figure 50: Small livestock (sheep or goats)
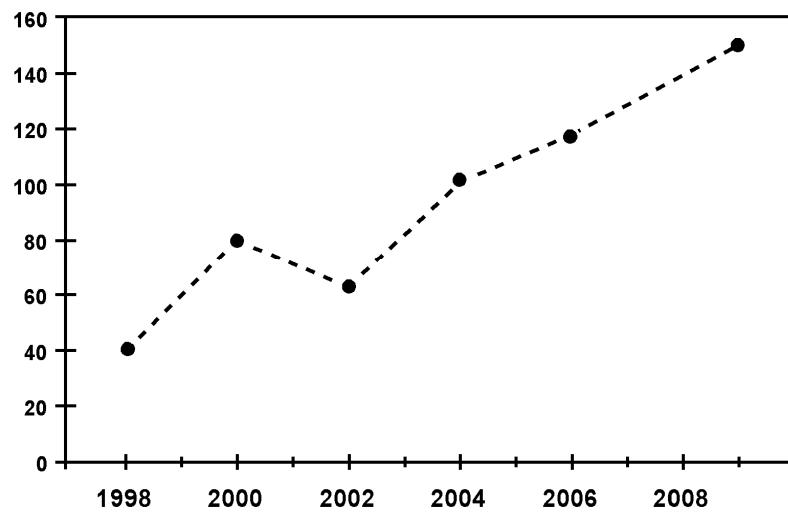
Figure 51: Snarelines seen

5   SUMMARY AND DISCUSSION

The 2009 Niassa survey is the sixth survey of the area since 1998. The data set is improving in its ability to describe trends, as evidenced by the increased number of species for which significant trends have been detected.

There is a large increase in the elephant estimate since 2006. This comes after a run of similar estimates in 2002 – 2006. Numbers could have increased this dramatically if elephants moved into the area; say in response to drought or disturbance elsewhere. The results from the adjacent blocks show the continuity of wildlife distribution with surrounding areas; the system appears to be an open one. On the other hand, the fluctuations perceived could be random variation in the estimates around a steady increase (Fig. 38). Bias in some estimates would aggravate this; say if there was a downward bias in the 2006 result or an upward one in 2009. The overall trend is not significantly different from what would be expected of natural increase. With the information available (i.e. six points on the graph) it is not possible to distinguish between alternatives.

The number of elephant carcasses detected has increased significantly. However, with the increase in the elephant estimates, the overall carcass ratio is similar to previous years (Table 9). Carcass ratios are, however, notably and significantly high in some blocks (R6 and L6). There has also been an apparent increase in recent carcasses (stages 1 and 2): 13 were seen (Tables 4 and 5) as opposed to none in 2006. These also are mainly in blocks R6 and L6. That this increase is due to illegal hunting is suggested by the occurrence, in one instance, of a pair of carcasses at the same location and other instances where carcasses are separated by a short distance.

There has been a significant increase in wildlife estimates overall (fig. 37) and eleven species have increased significantly over the series of surveys. This reflects the build up of information over time. The buffalo estimate increased in this survey but, given the high intrinsic variability of results for buffalo (see 2006 report) it is not possible from these surveys to say what the trend is. Wildebeest estimates also suffer from the problem of variable group size and, in addition, small numbers and therefore little information. However, it can be said that, on the balance of probabilities, wildebeest are likely to be increasing. Sable have increased significantly over the period since 1998, though most of that increase was in the first 4 years. It therefore appears that an exponential curve is not a good description of sable increase, so the fitted curve is not shown on Fig. 45.

Human activities have increased. Fishing only slightly – the big increase was 2004 to 2006 – and it is not possible to say how much of the increase is due to increased attention given to this by the survey crew. The survey detected 1.3% of the area as extensively cleared fields. However, agriculture is concentrated (Fig. 32) and only a few transects cut it, so this is a very crude estimate. A regular dedicated monitoring of this is required. The estimate of small livestock increased markedly (Fig. 50) but, in view of the small number of sightings, any estimate of the real magnitude of that increase is unreliable at this stage.

Snaring has increased (Fig. 51) and is slightly more extensive than in 2006 (Fig. 35). The local increases in elephant carcasses described above are at least partly due to illegal hunting.

Illegal gold panning and logging were detected for the first time (Fig. 36). Logging took place mainly in block L9 where planks were seen being moved illegally across the Rovuma to a storage yard in Tanzania. The survey estimated about 2700 instances of logging in the reserve (240 were recorded). It is not known how many trees or what tonnage of timber each site accounts for. In one case a recently cut tree could be seen to be pod mahogany; *Afzelia quanzensis*. Although fewer wildlife species were seen in block L9 (stratum AN and AS) than in the previous survey this is weak evidence of the effects of increased illegal activity here. Wildlife densities were always low in this block.

The results again emphasize the need for more points in time to measure trends, greater spatial coverage to place Niassa in perspective to its surroundings and more targeted monitoring to obtain better information on surveyed attributes where necessary.

6   ACKNOWLEDGEMENTS

7 REFERENCES

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APPENDIX I: METHODS

The method of stratified systematic transect sampling (Norton Griffiths, 1978) was used throughout the survey.

A Cessna 206 equipped with a radar altimeter and Global Positioning Systems (GPS) was used. Maps of the stratum boundaries and transects were uploaded to a portable GPS and used for accurate navigation along the transects. A height of 300ft above ground level was maintained using the radar altimeter. Positions of the aircraft were recorded at 20 second intervals to record the tracks flown.

The aircraft was flown along the transects at a speed of around 90 knots. A pair of observers seated in the back called out sightings of animals seen within the sampling strip (see Calibration, below). A recorder seated in the front recorded these sightings, noting the species and number seen (herds were not photographed). The position of each sighting was recorded on a second GPS and the record number entered on the data sheet for matching with the sighting during analysis. Previously position was recorded on the data sheet during flight but this survey's method eliminates writing errors and some data input errors, though it has some drawbacks.

Note was made approximately twice a minute of the height above ground, as indicated by the radar altimeter, to allow the calculation of the mean height for each transect. The time at which the flight along each transect was started and ended was also recorded to provide a record of the average speed.

On this survey the aircraft was crewed by D le Poidevin (pilot), W Veal (alternate pilot), C Craig (recorder), N Chitemamuswe (left observer), D Chipesi (right observer).

Stratification and sampling effort

The strata used for the Niassa Reserve were the same as those used in 2004 and 2006 (Craig and Gibson, 2004, Craig, 2006) (Fig. 52). The adjacent survey area was created by taking a 25 km - wide strip along the southern boundary of the reserve, divided into 3 strata corresponding to parts of adjacent hunting concessions.

All strata were sampled at a nominal intensity of 10% by spacing transects at 4km intervals (Fig.53) assuming a total strip width of 400m. Actual sampling intensities are modified by the calibrated strip width and mean height flown. Sampling intensity for each stratum is: total transect area / stratum area. The area of a transect in km^{2}is: transect length in km x (calibrated transect width in metres / 1000) x mean height in feet / 300. Details of realised sampling intensities are given in Appendix II (Table 39).
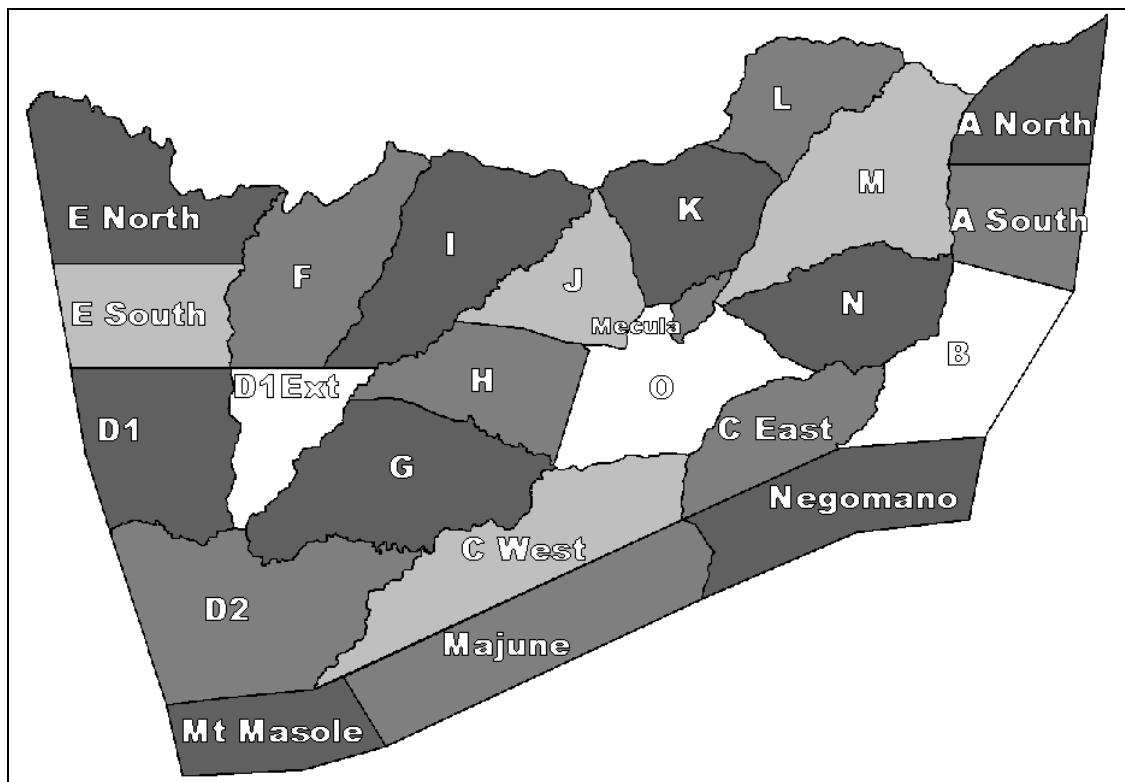
Figure 52: Survey strata
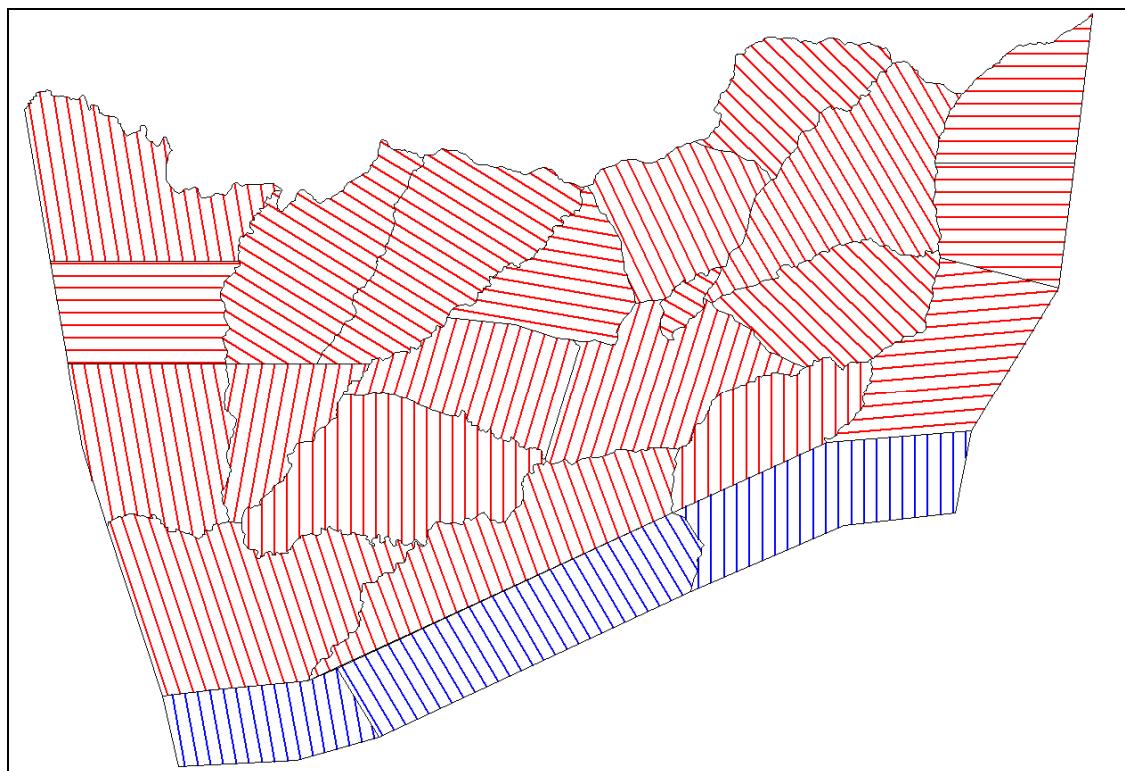
Figure 53: Transects

Transect Selection

Transects are oriented to follow ecological gradients (i.e. more or less at right angles to major rivers) in each stratum and, where possible, to eliminate long positioning flights between transects and to minimise direct approaches to high escarpments. The lateral position of the first transect in a stratum is selected at random and remaining transects are spaced at successive 4 km intervals from that. Each survey uses a new and different selection of transects.

Calibration

The boundaries of strips on each side of the aircraft were defined by a pair of rods attached to the lift struts. The width of the strips was measured empirically by flying at various heights and at right angles across an airstrip on which numbers had been painted at 10m intervals. The observers called out the outermost and innermost numbers seen within the strip, and the difference between the numbers was used to calculate the "calibrated strip width" for 300 ft. above ground. The rods were adjusted to provide a strip width of about 200m per side.

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 three categories according to their estimated time since death (Douglas-Hamilton *et al.* 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 ratios

Carcass ratio is defined as the number of carcasses / (carcasses + live elephants). In Table 9 the range of the ratio estimate has been calculated from the binomial variance of the number of carcasses drawn from a total population with the observed proportion of carcasses. This is a bit of an oversimplification as it gives a lower confidence interval

overlapping zero for small numbers of carcasses (shown as a lower limit of zero in Table 9). However, it serves to identify areas with carcass ratios in excess of 5%, the level at around which the ratio is expected to be in a population with the base natural mortality rate.

Searching rate

The mean searching rate (km^2/min) for each stratum was calculated from the total sample area divided by the total time on transects. This gives an indication of the survey quality (see Appendix II, Table 39).

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. Full details of the method are given in previous survey reports (Gibson 1998, 2000, Craig & Gibson 2002, 2004).

In this survey the actual estimates for the design strata are of less interest than estimates of species in the recently revised management units (Fig. 2). Estimates for the current management units were derived as follows: each sighting was allocated to the *management unit* in which it was made, determined by which map polygon it fell into; the number of animals in a sighting was multiplied by the inverse of the sampling intensity of the *stratum* in which it was seen; the estimate for the management unit was derived as the sum of these products for the sightings within the unit. Approximate species variances for the different management units were derived by partitioning the total survey variance among the management units using weights based on the number seen in the unit and the number/variance relationship over all strata. This conserves both the total estimate and the total variance for each species. Small discrepancies occur because the revised outer boundary of Niaasa does not quite coincide with the survey boundary, which also requires a correction of the adjacent survey area (Fig. 3).

Distribution mapping

Sighting maps were generated for all species and other observations and are represented by symbols placed at the GPS location of sightings.

Contour maps are intended to give an overview of the average densities of animals in different parts of the area at the time of year when surveys are done. Sighting maps do not do this because the number of animals in a sighting (i.e. group size) is not taken into account and only an impression of density of *sightings* is given. However, sighting maps do not gloss over the data and give a direct view of the information collected. In this report only elephants and all species are mapped by density contours. The method is described in the previous survey report (Craig, 2006).

Maps are unprojected (i.e. in geographic coordinates). In all other than those with density contours or topography the x axis has been compressed to equalise the scales on the x and y axes.

Topography was developed from NASA Shuttle Radar Topography data.

APPENDIX II: RESULTS

Survey performance

Flying time, including the additional survey area was 105.48 hours. Of this 75.52 hours (71.9%) were spent counting on transects, 13.25 hours (12.6%) were spent positioning between transects or avoiding obstacles on transects and 16.37 hours (15.5%) were used commuting between survey transects and bases. The survey of the adjacent blocks outside the reserve accounted for 15.2 hrs (14.4%) of the 105.48 survey hours. 1.3 hours was used for calibration. Flights between Niassa and Nampula, were in addition to the above.

Table 40: Survey details

Stratum Niassa:	Dates Flown	No of trans	Area km²	Sample %	T time min	S rate km²/min	G speed Kt
AN	1/10	12	1486	8.89	142.00	0.930	80.9
AS	30/9-1/10	10	1448	9.44	146.00	0.936	81.7
B	30/9	14	2107	9.18	197.00	0.982	85.2
CE	29/9-30/9	15	1590	9.27	154.00	0.957	82.8
CW	8/10-9/10	33	2782	9.31	259.00	1.000	86.6
D1	6/10	12	2345	9.25	210.50	1.031	89.2
D1 ext	7/10	12	1272	9.6	119.00	1.026	87.4
D2	10/10	23	3507	9.4	306.00	1.077	93.7
EN	5/10	20	2571	9.45	237.50	1.023	88.4
ES	5/10-6/10	9	1730	10.24	181.00	0.978	84.9
F	13/10	24	2430	9.32	220.00	1.029	89.7
G	11/10	24	2990	9.28	263.00	1.055	92.1
H	7/10	16	1796	8.89	160.00	0.998	87.0
I	13/10-14/10	24	2699	9.34	250.00	1.009	87.4
J	12/10	12	1433	9.1	119.50	1.091	94.9
K	14/10	14	1810	9.36	161.00	1.053	90.9
L	15/10	16	1477	9.3	133.00	1.033	89.5
M	1/10-2/10	26	2902	9.23	275.00	0.974	85.2
Mecula	3/10	7	200	12.5	17.00	1.470	100.0
N	2/10-3/10	15	1860	9.31	181.25	0.955	83.5
O	3/10	19	2279	9.31	212.00	1.001	86.6
Total		**357**	**42714**	**9.34**	**3943.75**	**1.011**	**87.7**
Ajacent:							
Negomano	18/10	24	2339	9.34	218.00	1.003	86.9
Majune	12,18,19/10	30	2972	9.37	265.00	1.051	91.2
Mt Masole	9/10-10/10	16	1447	9.26	125.00	1.072	93.2
Total		**70**	**6758**	**9.34**	**608.00**	**1.038**	**90.1**
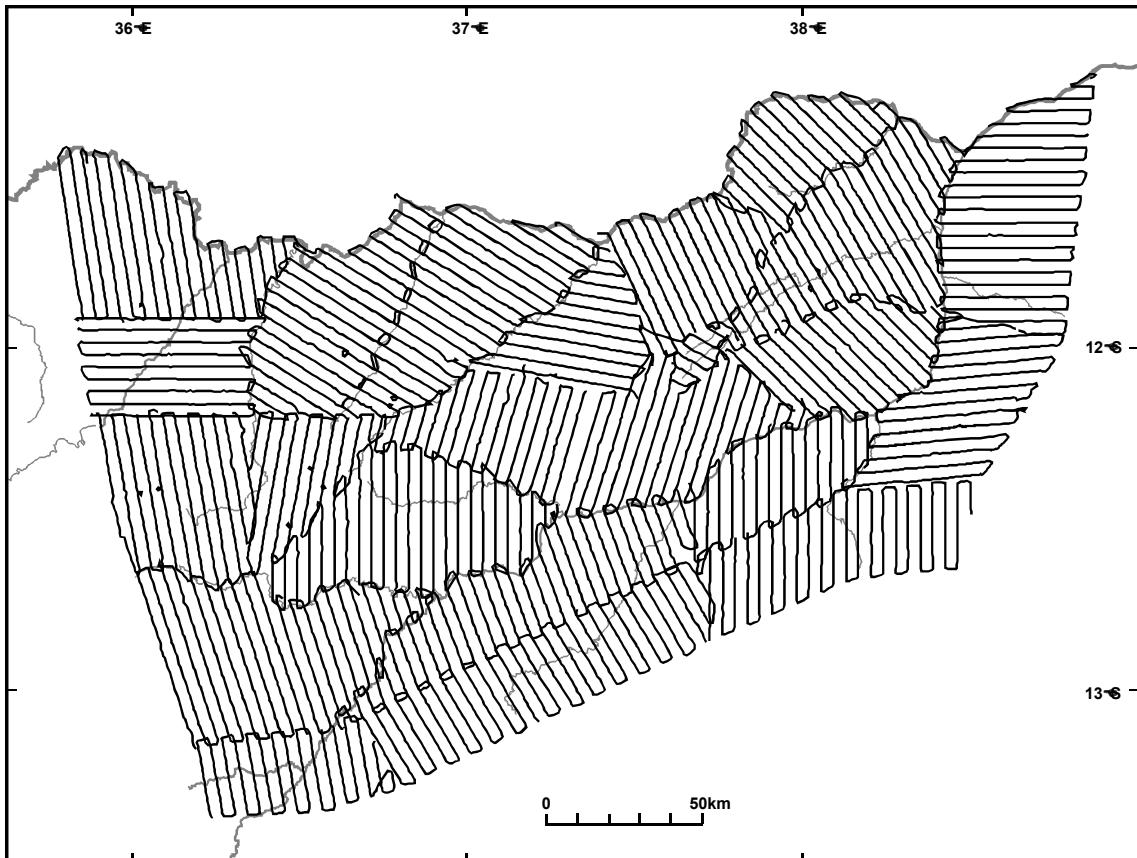
Figure 54: Tracks flown on transects

In Table 40 T time = time actually on transects; S rate = search rate; G speed = mean ground speed. A search rate of 1.5 km^2/minute is considered adequate for elephants, but 1 or less should be aimed at for other species (Gasaway et al. 1986). Search rates and ground speeds were slightly better than in 2006 and sampling intensity slightly less. Sampling intensity is above average in stratum ES because in the randomly selected set of transects the first and last transects are both close to the edge of the stratum.

The GPS "track logs" for all flights on transects are shown in Fig 54. A total of 7098 sightings of species and other attributes were made on transects during the survey.

Species Sightings

The following wildlife species were observed:

Name in text	Full name	Species
Baboon	Yellow baboon	*Papio cynocephalus*
Bushbuck	Bushbuck	*Tragelaphus scriptus*
Bushpig	Bushpig	*Potamochoerus porcus*
Buffalo	Cape buffalo	*Syncerus caffer caffer*
Duiker	Grey duiker	*Sylvicapra grimmia*
Eland	Cape eland	*Taurotragus oryx*
Elephant	African elephant (savanna form)	*Loxodonta africana africana*
Ground Hornbill	Ground Hornbill	*Bucorvus leadbeateri*
Grysbok	Sharpe's grysbok	*Raphicerus sharpei*
Hartebeest	Lichtenstein's hartebeest	*Alcelaphus lichtensteinii*
Hippopotamus	Hippopotamus	*Hippopotamus amphibius*
Hyaena	Spotted Hyaena	*Crocuta crocuta*
Impala	Johnston's impala	*Aepyceros melampus johnstoni*
Jackal	Side-striped jackal	*Canis adustus*
Klipspringer	Klipspringer	*Oreotragus oreotragus*
Kudu	Greater kudu	*Tragelaphus strepsiceros*
Leopard	Leopard	*Panthera pardus*
Lion	Lion	*Panthera leo*
Monkey	Vervet Monkey	*Cercopithecus aethiops*
Reedbuck	Common reedbuck	*Redunca arundinum*
Sable	Sable antelope	*Hippotragus niger*
Warthog	Warthog	*Phacochoerus aethopicus*
Waterbuck	Common waterbuck	*Kobus ellipsiprymnus*
Wildebeest	Johnston's wildebeest	*Connochaetes taurinus johnstoni*
Zebra	Grant's zebra	*Equus burchelli boehmi*
Crocodile	Nile crocodile	*Crocodilus niloticus*

Calibration of Strip Widths

The results of the strip width calibration are given in Table 40. Messrs Chitemamuswe and Chipese were left and right observers respectively.

Table 41: Calibration data

Height (feet)	Adjusted strip – width		
	L	**R**	**Total**
360	158.33	208.33	366.67
260	173.08	219.23	392.31
300	170.00	180.00	350
280	171.43	225.00	396.43
290	175.86	196.55	372.41
295	162.71	203.39	366.1
290	175.86	175.86	351.72
315	161.90	180.95	342.86
310	154.84	212.90	367.74
310	164.52	174.19	338.71
305	177.05	216.39	393.44
300	170.00	180.00	350
295	162.71	203.39	366.1
270	188.89	188.89	377.78
320	206.25	206.25	412.5
300	170.00	170.00	340
360	158.33	200.00	358.33
285	189.47	168.42	357.89
300	170.00	220.00	390
300	170.00	170.00	340
		Mean	**366.55**
		Variance	**461.01**
		SE mean	**4.8**
		95% cl	**10.05**
		CL%	**2.74**

Estimates of numbers, densities and confidence limits

The following tables give the results for each stratum based on the numbers of animals seen in the sample. These are the strictly valid results for the strata that were flown during the survey (Fig. 52), as distinct from the results in the body of the report, which are for management units. Discrepancies between the two sets of results arise because the boundaries of reporting and surveyed areas do not coincide (Fig. 3). Column 6 is the 95% confidence limit expressed as a percentage of the estimate.

Niassa Reserve Overall   Area: 42713 km^2 Mean sampling intensity: 9.43%

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range		Density No/Km^2
Baboon	4757	444	331571	23.8	3624	- 5890	0.111
Buffalo	6833	631	1939291	40.1	4092	- 9573	0.16
Bushbuck	366	34	5399	39.6	221	- 510	0.009
Bushpig	743	72	35086	49.6	374	- 1111	0.017
Crocodile	118	11	1352	61.4	45	- 190	0.003
Duiker	22174	2066	711217	7.5	20515	- 23834	0.519
Eland	5856	542	1143315	35.9	3752	- 7961	0.137
ElephantBull	2479	232	69384	20.9	1961	- 2997	0.058
EleCarcass1	43	4	623	113.6	4	- 92	0.001
EleCarcass2	97	9	1015	64.6	34	- 160	0.002
EleCarcass3	400	37	4562	33.3	267	- 533	0.009
EleCarcass4	356	33	4560	37.3	224	- 489	0.008
ElephantFamily	17885	1660	1860307	15	15200	- 20569	0.419
GroundHornbill	4392	407	137761	16.6	3662	- 5122	0.103
Grysbok	85	8	790	64.8	30	- 141	0.002
Hartebeest	5074	475	401934	24.6	3827	- 6322	0.119
Hippopotamus	1325	124	100717	47.1	701	- 1950	0.031
Impala	2175	202	128799	32.5	1469	- 2881	0.051
Klipspringer	151	14	3019	71.5	43	- 259	0.004
Kudu	2928	272	138897	25	2195	- 3662	0.069
Leopard	11	1	108	190	1	- 31	0
Lion	172	16	12048	125.5	16	- 388	0.004
Monkey	856	80	58561	55.6	380	- 1333	0.02
Reedbuck	2041	194	56478	22.9	1574	- 2509	0.048
Sable	14823	1380	1363447	15.5	12525	- 17121	0.347
Hyaena	11	1	101	184.6	1	- 30	0
Warthog	10132	945	467154	13.3	8787	- 11477	0.237
Waterbuck	2973	278	155557	26.1	2197	- 3749	0.07
Wildebeest	1124	105	141480	65.9	384	- 1864	0.026
Zebra	6294	584	369787	19	5098	- 7491	0.147
Sheep/goats	2636	245	1430922	89.3	282	- 4990	0.062
OtherCarcass1	33	3	328	108.5	3	- 69	0.001
OtherCarcass3	237	22	2207	39	145	- 330	0.006
OtherCarcass4	322	30	3891	38.1	199	- 445	0.008

Stratum AN   Area: 1486 km^2 Sampling intensity: 8.89 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range			Density No/Km^2
Baboon	326	29	38956	133.1	29	-	761	0.219
Duiker	979	87	61767	55.9	432	-	1526	0.659
Eland	90	8	6946	203.8	8	-	273	0.061
EleCarcass3	23	2	183	132.5	2	-	52	0.015
EleCarcass4	11	1	109	204	1	-	34	0.007
Ground Hornbill	293	26	3125	42.1	169	-	416	0.197
Kudu	45	4	1730	203.4	4	-	137	0.03
Monkey	45	4	1776	206.1	4	-	138	0.03
Warthog	146	13	5650	113.1	13	-	312	0.098
Zebra	34	3	979	204	3	-	103	0.023

Stratum AS   Area: 1448 km^2 Sampling intensity: 9.44 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range			Density No/Km^2
Baboon	42	4	1571	211.6	4	-	132	0.029
Buffalo	318	30	37010	136.9	30	-	753	0.22
Bushbuck	32	3	440	149.3	3	-	79	0.022
Bushpig	95	9	8200	214.8	9	-	300	0.066
Crocodile	42	4	228	80.7	8	-	77	0.029
Duiker	1462	138	170906	64	527	-	2398	1.01
Eland	244	23	17860	124	23	-	546	0.169
ElephantBull	159	15	4370	94.1	15	-	308	0.11
EleCarcass4	32	3	274	117.9	3	-	69	0.022
ElephantFamily	371	35	61230	150.9	35	-	931	0.256
GroundHornbill	276	26	16973	107	26	-	570	0.191
Grysbok	11	1	99	212.7	1	-	33	0.008
Hartebeest	21	2	393	211.7	2	-	66	0.015
Impala	117	11	12047	213	11	-	365	0.081
Kudu	191	18	5278	86.2	26	-	355	0.132
Reedbuck	21	2	398	213	2	-	66	0.015
Sable	212	20	11426	114.1	20	-	454	0.146
Warthog	774	73	43026	60.7	304	-	1243	0.535
Waterbuck	53	5	2489	213	5	-	166	0.037
Wildebeest	583	55	101219	123.5	55	-	1303	0.403
Zebra	170	16	6233	105.3	16	-	348	0.117
OtherCarcass4	11	1	98	211.7	1	-	33	0.008

Stratum B   Area 2107 km^2 Sampling intensity: 9.18 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range		Density No/Km^2
Baboon	610	56	40792	71.5	174	- 1047	0.29
Buffalo	719	66	127502	107.3	66	- 1491	0.341
Bushbuck	11	1	109	207.1	1	- 33	0.005
Duiker	708	65	8297	27.8	512	- 905	0.336
Eland	327	30	40529	133	30	- 762	0.155
ElephantBull	392	36	10431	56.2	172	- 613	0.186
EleCarcass3	22	2	194	138	2	- 52	0.01
EleCarcass4	11	1	105	202.7	1	- 33	0.005
ElephantFamily	2899	266	292174	40.3	1731	- 4066	1.376
GroundHornbill	403	37	17482	70.8	118	- 689	0.191
Hartebeest	120	11	5982	139.4	11	- 287	0.057
Impala	283	26	29900	131.9	26	- 657	0.134
Kudu	196	18	4899	77.1	45	- 347	0.093
Lion	22	2	419	202.9	2	- 66	0.01
Reedbuck	11	1	106	203.8	1	- 33	0.005
Sable	643	59	49727	74.9	161	- 1125	0.305
Warthog	567	52	36426	72.8	154	- 979	0.269
Waterbuck	44	4	779	138.4	4	- 104	0.021
Wildebeest	98	9	3974	138.9	9	- 234	0.047
Zebra	588	54	23536	56.3	257	- 920	0.279
OtherCarcass3	22	2	201	140.4	2	- 52	0.01

Stratum CE   Area: 1590 km^2 Sampling intensity: 9.27 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range		Density No/Km^2
Baboon	410	38	18557	71.3	118	- 702	0.258
Buffalo	453	42	163563	191.5	42	- 1320	0.285
Duiker	679	63	13784	37.1	428	- 931	0.427
Eland	140	13	12257	169.4	13	- 378	0.088
ElephantBull	129	12	2760	87.1	17	- 242	0.081
EleCarcass3	22	2	192	137.8	2	- 51	0.014
ElephantFamily	1068	99	47963	44	598	- 1537	0.672
GroundHornbill	173	16	4255	81.1	33	- 312	0.109
Grysbok	11	1	106	204.3	1	- 33	0.007
Hartebeest	140	13	9078	145.8	13	- 345	0.088
Hippopotamus	43	4	1763	208.8	4	- 133	0.027
Impala	313	29	13470	79.6	64	- 562	0.197
Klipspringer	43	4	762	137.3	4	- 102	0.027
Kudu	65	6	894	99.1	6	- 129	0.041
Reedbuck	54	5	2571	201.7	5	- 163	0.034
Sable	1445	134	87123	43.8	812	- 2078	0.909
Warthog	216	20	7110	83.8	35	- 397	0.136
Waterbuck	97	9	5012	156.5	9	- 249	0.061
Wildebeest	65	6	1011	105.4	6	- 133	0.041
Zebra	237	22	8688	84.3	37	- 437	0.149
OtherCarcass3	32	3	294	113.8	3	- 69	0.02
OtherCarcass4	32	3	268	108.6	3	- 67	0.02

Stratum CW   Area: 2782 km^2 Sampling intensity: 9.31 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range			Density No/Km^2
Baboon	763	71	62492	66.8	254	-	1272	0.274
Buffalo	591	55	210369	158.1	55	-	1525	0.212
Bushbuck	21	2	200	134	2	-	50	0.008
Crocodile	11	1	106	195	1	-	32	0.004
Duiker	1880	175	35693	20.5	1495	-	2265	0.676
Eland	473	44	169184	177.2	44	-	1311	0.17
ElephantBull	161	15	3219	71.7	46	-	277	0.058
EleCarcass3	11	1	109	198.4	1	-	32	0.004
EleCarcass4	54	5	653	96.9	5	-	106	0.019
ElephantFamily	698	65	68839	76.5	164	-	1233	0.251
GroundHornbill	258	24	5737	59.8	104	-	412	0.093
Grysbok	11	1	104	193.2	1	-	32	0.004
Hartebeest	322	30	17806	84.3	50	-	594	0.116
Hippopotamus	269	25	16351	97	25	-	529	0.097
Impala	355	33	24744	90.4	34	-	675	0.128
Kudu	462	43	15957	55.7	205	-	719	0.166
Reedbuck	64	6	1238	111.2	6	-	136	0.023
Sable	752	70	63600	68.3	238	-	1266	0.27
Warthog	1418	132	88228	42.7	813	-	2023	0.51
Waterbuck	677	63	29486	51.7	327	-	1027	0.243
Wildebeest	54	5	2597	193.2	5	-	158	0.019
Zebra	666	62	48357	67.2	218	-	1114	0.239
OtherCarcass3	32	3	286	106.8	3	-	67	0.012

Stratum D2   Area: 3507 km^2 Sampling intensity: 9.4 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range			Density No/Km^2
Baboon	447	42	39091	91.7	42	-	857	0.127
Buffalo	74	7	3038	153.5	7	-	189	0.021
Bushpig	106	10	5383	143	10	-	259	0.03
Duiker	958	90	17297	28.5	685	-	1230	0.273
Eland	11	1	105	199.5	1	-	32	0.003
ElephantBull	106	10	6206	153.5	10	-	270	0.03
ElephantFamily	458	43	38276	88.7	52	-	863	0.131
GroundHornbill	43	4	969	151.7	4	-	107	0.012
Grysbok	21	2	196	136.4	2	-	50	0.006
Hartebeest	202	19	9565	100.3	19	-	405	0.058
Hippopotamus	202	19	11918	112	19	-	429	0.058
Impala	43	4	1768	204.9	4	-	130	0.012
Klipspringer	43	4	947	149.9	4	-	106	0.012
Kudu	138	13	6442	120.3	13	-	305	0.039
Monkey	372	35	27034	91.6	35	-	713	0.106
Reedbuck	213	20	9089	92.9	20	-	411	0.061
Sable	660	62	62778	78.8	140	-	1179	0.188
Warthog	362	34	15860	72.2	101	-	623	0.103
Waterbuck	170	16	9020	115.7	16	-	367	0.048
Sheep/goats	149	14	19427	194	14	-	438	0.042

Stratum D1   Area: 2345 km^2 Sampling intensity: 9.25 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range			Density No/Km^2
Baboon	216	20	7190	86.3	30	-	403	0.092
Buffalo	32	3	944	208.5	3	-	100	0.014
Bushpig	22	2	440	213.6	2	-	68	0.009
Duiker	378	35	5859	44.5	210	-	547	0.161
Eland	11	1	103	206.8	1	-	33	0.005
ElephantBull	43	4	1674	208.3	4	-	133	0.018
ElephantFamily	32	3	949	209	3	-	100	0.014
GroundHornbill	108	10	3233	115.8	10	-	233	0.046
Kudu	43	4	1833	218	4	-	137	0.018
Reedbuck	43	4	994	160.5	4	-	113	0.018
Sable	486	45	84643	131.6	45	-	1127	0.207
Warthog	130	12	6423	136	12	-	306	0.055
Waterbuck	97	9	4337	149	9	-	242	0.041
Sheep/goats	832	77	109291	87.4	105	-	1560	0.355

Stratum D1 Extension   Area: 1272 km^2 Sampling intensity: 9.6 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range			Density No/Km^2
Baboon	73	7	4187	195.3	7	-	215	0.057
Duiker	417	40	4597	35.8	267	-	566	0.328
Eland	312	30	50226	157.8	30	-	806	0.245
EleCarcass3	10	1	85	195.3	1	-	31	0.008
ElephantFamily	83	8	5870	202.4	8	-	252	0.065
GroundHornbill	187	18	8687	109.4	18	-	393	0.147
Hartebeest	302	29	27863	121.6	29	-	669	0.237
Reedbuck	73	7	1548	118.7	7	-	160	0.057
Sable	219	21	8378	92.1	21	-	420	0.172
Warthog	167	16	8244	119.9	16	-	367	0.131
Zebra	73	7	5025	214	7	-	229	0.057

Stratum ES   Area: 1730 km^2 Sampling intensity: 10.24 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range			Density No/Km^2
Baboon	322	33	20585	102.6	33	-	653	0.186
Bushbuck	10	1	86	219	1	-	31	0.006
Bushpig	98	10	3422	138.1	10	-	233	0.057
Duiker	860	88	21847	39.6	519	-	1201	0.497
Eland	39	4	1381	219.3	4	-	125	0.023
ElephantBull	10	1	87	219.7	1	-	31	0.006
ElephantFamily	205	21	27094	185	21	-	585	0.118
GroundHornbill	59	6	1545	154.6	6	-	149	0.034
Hartebeest	440	45	34004	96.7	45	-	865	0.254
Hippopotamus	29	3	782	220	3	-	94	0.017
Reedbuck	322	33	5438	52.7	152	-	492	0.186
Sable	361	37	14447	76.7	84	-	639	0.209
Warthog	381	39	11487	64.9	134	-	628	0.22
Waterbuck	137	14	4499	113.1	14	-	291	0.079
Zebra	225	23	9541	100.2	23	-	450	0.13
OtherCarcass4	10	1	83	214.9	1	-	31	0.006

Stratum EN   Area: 2571 km^2 Sampling intensity: 9.45 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range			Density No/Km^2
Baboon	254	24	24961	130.2	24	-	585	0.099
Buffalo	21	2	385	194.1	2	-	62	0.008
Bushbuck	21	2	196	138.6	2	-	51	0.008
Bushpig	201	19	8868	98	19	-	398	0.078
Duiker	1069	101	17519	25.9	792	-	1346	0.416
Eland	265	25	24838	124.7	25	-	594	0.103
ElephantBull	74	7	3597	169.5	7	-	200	0.029
EleCarcass3	11	1	100	197.9	1	-	32	0.004
ElephantFamily	307	29	29647	117.4	29	-	667	0.119
GroundHornbill	85	8	2249	117.2	8	-	184	0.033
Grysbok	11	1	107	204.4	1	-	32	0.004
Hartebeest	339	32	26080	99.8	32	-	677	0.132
Hippopotamus	201	19	12479	116.3	19	-	435	0.078
Kudu	106	10	2365	96.2	10	-	208	0.041
Monkey	106	10	10606	203.7	10	-	321	0.041
Reedbuck	497	47	10400	42.9	284	-	711	0.193
Sable	1037	98	79690	57	446	-	1628	0.403
Warthog	773	73	35337	50.9	379	-	1166	0.301
Waterbuck	148	14	14804	171.9	14	-	403	0.058
Zebra	116	11	4468	120.2	11	-	256	0.045
OtherCarcass3	21	2	222	147.4	2	-	52	0.008
OtherCarcass4	21	2	180	132.5	2	-	49	0.008

Stratum F Area: 2430 km^2 Sampling intensity: 9.32 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range			Density No/Km^2
Baboon	279	26	10342	75.4	69	-	489	0.115
Buffalo	75	7	2206	129.4	7	-	172	0.031
Crocodile	11	1	101	193.4	1	-	31	0.005
Duiker	1781	166	61816	28.9	1267	-	2295	0.733
Eland	504	47	72880	110.7	47	-	1063	0.207
ElephantBull	54	5	1643	156.3	5	-	138	0.022
EleCarcass4	21	2	200	136.4	2	-	51	0.009
ElephantFamily	225	21	29519	157.7	21	-	581	0.093
GroundHornbill	129	12	5046	114.1	12	-	276	0.053
Hartebeest	451	42	58908	111.4	42	-	953	0.186
Kudu	21	2	405	193.9	2	-	63	0.009
Reedbuck	343	32	10329	61.2	133	-	554	0.141
Sable	1212	113	119724	59	497	-	1928	0.499
Warthog	558	52	23681	57.1	240	-	876	0.23
Waterbuck	97	9	2652	110.3	9	-	203	0.04
Zebra	161	15	8527	118.7	15	-	352	0.066

Stratum G Area: 2990 km^2 Sampling intensity: 9.28 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range			Density No/Km^2
Baboon	302	28	13041	78.3	65	-	538	0.101
Buffalo	140	13	3348	85.5	20	-	260	0.047
Bushbuck	65	6	1066	104.5	6	-	132	0.022
Duiker	1153	107	9332	17.3	953	-	1352	0.386
Eland	377	35	76088	151.4	35	-	948	0.126
ElephantBull	237	22	12533	97.7	22	-	469	0.079
EleCarcass4	11	1	102	194	1	-	32	0.004
ElephantFamily	1314	122	163987	63.7	476	-	2152	0.439
GroundHornbill	172	16	4036	76.3	41	-	304	0.058
Hartebeest	162	15	5816	97.6	15	-	319	0.054
Hippopotamus	248	23	22648	125.7	23	-	559	0.083
Impala	32	3	980	200.4	3	-	97	0.011
Kudu	194	18	4826	74.1	50	-	338	0.065
Monkey	43	4	1688	197.3	4	-	128	0.014
Reedbuck	129	12	3109	89.2	14	-	245	0.043
Sable	1422	132	126224	51.7	687	-	2157	0.476
Warthog	431	40	15417	59.6	174	-	688	0.144
Waterbuck	162	15	7023	107.3	15	-	335	0.054
Zebra	205	19	11662	109.2	19	-	428	0.069
Sheep/goats	420	39	74931	134.8	39	-	986	0.14
OtherCarcass1	11	1	102	193.6	1	-	32	0.004
OtherCarcass4	11	1	107	199	1	-	32	0.004

Stratum H   Area: 1796 km^2 Sampling intensity: 8.89 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range			Density No/Km^2
Baboon	34	3	1024	202.2	3	-	102	0.019
Buffalo	304	27	24890	110.8	27	-	640	0.169
Bushbuck	22	2	494	210.5	2	-	70	0.012
Bushpig	79	7	3080	150.3	7	-	197	0.044
Duiker	967	86	37996	43	552	-	1383	0.538
Eland	821	73	409464	166.1	73	-	2185	0.457
ElephantBull	22	2	494	210.5	2	-	70	0.012
ElephantFamily	900	80	139213	88.4	104	-	1695	0.501
GroundHornbill	180	16	8838	111.4	16	-	380	0.1
Hartebeest	675	60	32692	57.1	289	-	1060	0.376
Klipspringer	22	2	479	207.4	2	-	69	0.012
Sable	618	55	32605	62.2	234	-	1003	0.344
Warthog	304	27	10778	72.9	82	-	525	0.169
Waterbuck	45	4	1759	198.7	4	-	134	0.025
Wildebeest	67	6	3114	176.3	6	-	186	0.037
Zebra	596	53	20292	50.9	292	-	900	0.332
OtherCarcass1	11	1	114	202.2	1	-	34	0.006
OtherCarcass3	11	1	110	198.7	1	-	34	0.006

Stratum I   Area: 2699 km^2 Sampling intensity: 9.34 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range			Density No/Km^2
Baboon	235	22	14958	107.5	22	-	488	0.087
Buffalo	118	11	2868	94.1	11	-	229	0.044
Bushbuck	11	1	105	198.3	1	-	32	0.004
Duiker	2344	219	89817	26.5	1724	-	2964	0.868
Eland	289	27	26233	116	27	-	624	0.107
ElephantBull	64	6	1635	130.3	6	-	148	0.024
EleCarcass2	11	1	105	197.9	1	-	32	0.004
EleCarcass3	11	1	108	200.6	1	-	32	0.004
ElephantFamily	995	93	86194	61	388	-	1603	0.369
GroundHornbill	107	10	1920	84.7	16	-	198	0.04
Hartebeest	717	67	69426	76	172	-	1262	0.266
Klipspringer	21	2	430	200.4	2	-	64	0.008
Kudu	150	14	4608	93.7	14	-	290	0.056
Lion	107	10	9899	192.3	10	-	313	0.04
Monkey	75	7	4851	192.3	7	-	219	0.028
Reedbuck	128	12	7360	138.2	12	-	306	0.047
Sable	1177	110	118892	60.6	464	-	1891	0.436
Hyaena	11	1	101	194	1	-	31	0.004
Warthog	653	61	45549	67.6	211	-	1094	0.242
Waterbuck	193	18	10407	109.5	18	-	404	0.072
Zebra	428	40	31276	85.5	62	-	794	0.159
OtherCarcass3	21	2	210	140.1	2	-	51	0.008
OtherCarcass4	64	6	892	96.2	6	-	126	0.024

Stratum J　　　Area: 1433 km^2　　Sampling intensity: 9.1 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range			Density No/Km^2
Buffalo	682	62	229477	154.7	62	-	1736	0.476
Bushbuck	33	3	569	159.2	3	-	85	0.023
Duiker	1056	96	53243	48.1	548	-	1563	0.737
Eland	121	11	2813	96.5	11	-	238	0.084
ElephantBull	121	11	2033	82.1	22	-	220	0.084
EleCarcass4	22	2	197	140.3	2	-	53	0.015
ElephantFamily	902	82	54370	56.9	388	-	1415	0.629
GroundHornbill	88	8	3975	157.8	8	-	227	0.061
Hartebeest	220	20	15658	125.2	20	-	495	0.154
Kudu	55	5	1658	163	5	-	145	0.038
Reedbuck	66	6	2437	164.7	6	-	175	0.046
Sable	583	53	27427	62.6	218	-	947	0.407
Warthog	550	50	19067	55.3	246	-	854	0.384
Wildebeest	11	1	101	201.7	1	-	33	0.008
Zebra	649	59	88359	100.9	59	-	1303	0.453
OtherCarcass3	11	1	124	223.1	1	-	36	0.008
OtherCarcass4	55	5	1007	127.1	5	-	125	0.038

Stratum K　　　Area: 1810 km^2　　Sampling intensity: 9.36 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range			Density No/Km^2
Buffalo	32	3	1044	217.9	3	-	102	0.018
Bushbuck	75	7	1383	107.5	7	-	155	0.041
Duiker	1516	142	34032	26.3	1118	-	1915	0.838
Eland	256	24	15871	106.2	24	-	528	0.141
ElephantBull	139	13	2695	80.8	27	-	251	0.077
EleCarcass3	21	2	201	143.6	2	-	52	0.012
ElephantFamily	1420	133	123690	53.5	660	-	2180	0.785
GroundHornbill	214	20	6230	79.8	43	-	384	0.118
Grysbok	21	2	178	135	2	-	50	0.012
Hartebeest	427	40	63092	127	40	-	970	0.236
Kudu	53	5	1581	160.9	5	-	139	0.029
Monkey	64	6	3812	208.2	6	-	197	0.035
Sable	363	34	16790	77.1	83	-	643	0.201
Warthog	288	27	9742	74	75	-	502	0.159
Waterbuck	43	4	932	154.4	4	-	109	0.024
Wildebeest	203	19	28435	179.5	19	-	567	0.112
Zebra	224	21	10241	97.5	21	-	443	0.124
OtherCarcass3	11	1	98	200.4	1	-	32	0.006
OtherCarcass4	21	2	174	133.6	2	-	50	0.012

Stratum L   Area: 1477 km^2 Sampling intensity: 9.3 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range		Density No/Km^2
Baboon	151	14	9148	135.4	14	- 354	0.102
Buffalo	11	1	103	201.1	1	- 32	0.007
Bushbuck	11	1	102	200.4	1	- 32	0.007
Bushpig	65	6	2541	166.5	6	- 172	0.044
Duiker	785	73	23492	41.6	458	- 1112	0.531
Eland	75	7	1730	117.8	7	- 164	0.051
ElephantBull	32	3	471	143.4	3	- 79	0.022
EleCarcass1	11	1	101	199.2	1	- 32	0.007
EleCarcass2	22	2	183	134	2	- 50	0.015
EleCarcass3	43	4	514	112.3	4	- 91	0.029
EleCarcass4	32	3	324	118.9	3	- 71	0.022
ElephantFamily	817	76	86820	76.9	189	- 1445	0.553
GroundHornbill	247	23	5335	63	92	- 403	0.167
Hartebeest	97	9	5166	158.3	9	- 250	0.066
Hippopotamus	151	14	20036	200.4	14	- 452	0.102
Impala	97	9	4835	153.2	9	- 245	0.066
Kudu	290	27	9004	69.7	88	- 493	0.196
Leopard	11	1	108	205.8	1	- 33	0.007
Monkey	86	8	6664	202.3	8	- 260	0.058
Sable	183	17	8414	107	17	- 378	0.124
Warthog	473	44	18954	62	180	- 767	0.32
Waterbuck	247	23	8665	80.2	49	- 446	0.167
Zebra	183	17	8033	104.5	17	- 374	0.124
OtherCarcass3	11	1	104	202.3	1	- 33	0.007

Stratum Mecula   Area: 200 km^2 Sampling intensity: 12.5 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range		Density No/Km^2
Bushpig	56	7	2759	229.5	7	- 185	0.28
ElephantBull	56	7	1508	169.6	7	- 151	0.28
ElephantFamily	72	9	1719	140.9	9	- 173	0.36
Zebra	16	2	189	210.4	2	- 50	0.08

Stratum M Area: 2902 km^2 Sampling intensity: 9.23 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range			Density No/Km^2
Baboon	293	27	24678	110.6	27	-	616	0.101
Buffalo	2221	205	848928	85.4	324	-	4119	0.765
Bushbuck	43	4	545	110.9	4	-	91	0.015
Crocodile	33	3	506	142.5	3	-	79	0.011
Duiker	1625	150	27043	20.8	1287	-	1964	0.56
Eland	997	92	155041	81.3	186	-	1808	0.344
ElephantBull	195	18	5076	75.2	48	-	342	0.067
EleCarcass1	33	3	522	144.8	3	-	80	0.011
EleCarcass2	54	5	617	94.4	5	-	105	0.019
EleCarcass3	163	15	2144	58.7	67	-	258	0.056
EleCarcass4	141	13	2391	71.5	40	-	242	0.049
ElephantFamily	1907	176	216730	50.3	948	-	2866	0.657
GroundHornbill	910	84	29513	38.9	556	-	1264	0.314
Hartebeest	11	1	108	197.4	1	-	32	0.004
Impala	217	20	9034	90.3	21	-	412	0.075
Klipspringer	22	2	401	190.2	2	-	63	0.008
Kudu	618	57	69279	87.8	76	-	1160	0.213
Lion	43	4	1730	197.7	4	-	129	0.015
Monkey	65	6	2130	146.2	6	-	160	0.022
Sable	1344	124	192297	67.2	441	-	2247	0.463
Warthog	1192	110	27476	28.6	851	-	1533	0.411
Waterbuck	238	22	9538	84.4	37	-	440	0.082
Wildebeest	11	1	114	202.9	1	-	33	0.004
Zebra	618	57	34604	62	235	-	1001	0.213
OtherCarcass1	11	1	113	201.8	1	-	33	0.004
OtherCarcass3	22	2	190	131	2	-	50	0.008
OtherCarcass4	22	2	200	134.2	2	-	51	0.008

Stratum N Area: 1860 km^2 Sampling intensity: 9.31 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range		Density No/Km^2
Buffalo	215	20	9785	98.7	20	- 427	0.116
Bushbuck	11	1	104	203.4	1	- 33	0.006
Duiker	763	71	3195	15.9	642	- 884	0.41
Eland	290	27	32982	134.3	27	- 680	0.156
ElephantBull	161	15	3652	80.4	32	- 291	0.087
EleCarcass2	11	1	110	209.4	1	- 33	0.006
EleCarcass3	54	5	628	100	5	- 107	0.029
EleCarcass4	11	1	102	202	1	- 32	0.006
ElephantFamily	1375	128	199834	69.7	416	- 2334	0.739
GroundHornbill	236	22	5709	68.6	74	- 398	0.127
Impala	494	46	19553	60.7	194	- 794	0.266
Kudu	150	14	3362	82.7	26	- 275	0.081
Sable	1257	117	194244	75.2	312	- 2202	0.676
Warthog	279	26	12017	84.2	44	- 514	0.15
Waterbuck	140	13	5735	116.3	13	- 302	0.075
Wildebeest	32	3	916	201.4	3	- 97	0.017
Zebra	645	60	31887	59.4	262	- 1028	0.347
OtherCarcass3	32	3	265	108.4	3	- 67	0.017
OtherCarcass4	64	6	779	92.9	6	- 124	0.034

Stratum O Area: 2279 km^2 Sampling intensity: 9.31%

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range		Density No/Km^2
Buffalo	827	77	273832	133	77	- 1926	0.363
Bushpig	21	2	393	194	2	- 63	0.009
Crocodile	21	2	411	198.3	2	- 64	0.009
Duiker	795	74	13685	30.9	549	- 1040	0.349
Eland	215	20	26784	160.1	20	- 559	0.094
ElephantBull	322	30	5302	47.5	169	- 475	0.141
EleCarcass3	11	1	103	198.8	1	- 32	0.005
EleCarcass4	11	1	103	198.8	1	- 32	0.005
ElephantFamily	1836	171	186190	49.4	930	- 2743	0.806
GroundHornbill	225	21	2902	50.2	112	- 339	0.099
Hartebeest	430	40	20297	69.7	130	- 729	0.189
Hippopotamus	183	17	14740	139.7	17	- 438	0.08
Impala	225	21	12468	104	21	- 460	0.099
Kudu	150	14	4778	96.6	14	- 296	0.066
Reedbuck	75	7	1462	106.9	7	- 155	0.033
Sable	848	79	65017	63.2	313	- 1384	0.372
Warthog	472	44	26681	72.6	129	- 816	0.207
Waterbuck	387	36	38419	106.5	36	- 798	0.17
Zebra	462	43	17890	60.9	181	- 743	0.203
Sheep/goats	1235	115	1227272	188.5	115	- 3562	0.542
OtherCarcass3	11	1	103	198.3	1	- 32	0.005
OtherCarcass4	11	1	103	198.3	1	- 32	0.005

Adjacent areas overall   Area: 6758 km^2 Mean sampling intensity: 9.34 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range		Density No/Km^2
Baboon	1242	116	78791	45.1	681	1802	0.184
Buffalo	119	11	10582	173.1	11 - 324		0.018
Bushbuck	107	10	2377	90.8	10 - 204		0.016
Bushpig	246	23	13191	93.1	23 - 476		0.036
Crocodile	11	1	104	188.9	1 - 31		0.002
Duiker	4858	454	129295	14.8	4140 - 5576		0.719
Eland	835	78	70769	63.6	304 - 1366		0.124
ElephantBull	139	13	3327	82.6	24 - 254		0.021
EleCarcass4	96	9	1440	78.7	20 - 172		0.014
ElephantFamily	2408	225	441386	55.1	1082 - 3734		0.356
GroundHornbill	514	48	14678	47.1	272 - 756		0.076
Grysbok	54	5	706	99	5 - 107		0.008
Hartebeest	1058	99	142071	71.1	306 - 1810		0.157
Klipspringer	64	6	1753	130.1	6 - 148		0.009
Kudu	374	35	19284	74	97 - 652		0.055
Monkey	107	10	5154	133.9	10 - 250		0.016
Reedbuck	440	41	10824	47.2	233 - 648		0.065
Sable	2447	229	292885	44.1	1367 - 3527		0.362
Warthog	3531	330	155356	22.3	2744 - 4318		0.522
Waterbuck	528	49	26168	61.2	205 - 851		0.078
Wildebeest	11	1	103	188.9	1 - 31		0.002
Zebra	449	42	20200	63.2	165 - 733		0.066
OtherCarcass3	32	3	300	107.7	3 - 67		0.005
OtherCarcass4	32	3	290	106.2	3 - 66		0.005

Stratum P (Negomano)   Area: 2339 km^2 Sampling intensity: 9.34 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range		Density No/Km^2
Baboon	460	43	30286	78.2	100 - 820		0.197
Bushbuck	64	6	1983	143.5	6 - 156		0.027
Duiker	1926	180	47599	23.4	1475 - 2378		0.823
Eland	268	25	17923	103.5	25 - 545		0.115
ElephantBull	118	11	2909	94.8	11 - 229		0.050
EleCarcass4	54	5	1070	126.5	5 - 121		0.023
ElephantFamily	1873	175	370890	67.3	613 - 3133		0.801
GroundHornbill	385	36	12222	59.4	157 - 614		0.165
Grysbok	32	3	498	143.8	3 - 78		0.014
Hartebeest	407	38	84115	147.5	38 - 1007		0.174
Klipspringer	64	6	1753	134.9	6 - 151		0.027
Kudu	171	16	7796	106.7	16 - 354		0.073
Monkey	107	10	5154	138.8	10 - 256		0.046
Sable	664	62	111327	104	62 - 1354		0.284
Warthog	1167	109	55666	41.8	678 - 1655		0.499
Waterbuck	32	3	925	195.9	3 - 95		0.014
Wildebeest	11	1	103	195.8	1 - 32		0.005
Zebra	342	32	16942	78.6	73 - 612		0.146
OtherCarcass3	21	2	197	135.5	2 - 50		0.009

Stratum Q (Majune)   Area: 2972 km^2 Sampling intensity: 9.37 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range		Density No/Km^2
Baboon	566	53	39306	71.7	160	- 971	0.190
Buffalo	11	1	103	194.5	1	- 31	0.004
Bushbuck	21	2	199	135.1	2	- 50	0.007
Bushpig	171	16	10787	124.4	16	- 383	0.058
Duiker	2241	210	73291	24.7	1687	- 2794	0.754
Eland	427	40	40213	96.1	40	- 837	0.144
EleCarcass4	43	4	369	92.1	4	- 82	0.014
ElephantFamily	384	36	48853	117.7	36	- 836	0.129
GroundHornbill	75	7	1629	110.5	7	- 157	0.025
Grysbok	11	1	103	194.7	1	- 31	0.004
Hartebeest	619	58	57013	78.9	131	- 1107	0.208
Kudu	171	16	10549	123	16	- 381	0.058
Reedbuck	203	19	4325	66.3	68	- 337	0.068
Sable	1633	153	177059	52.7	772	- 2493	0.549
Warthog	1825	171	85935	32.9	1225	- 2424	0.614
Waterbuck	53	5	2573	194.5	5	- 157	0.018
Zebra	107	10	3258	109.4	10	- 223	0.036
OtherCarcass3	11	1	103	194.6	1	- 31	0.004
OtherCarcass4	32	3	290	108.8	3	- 67	0.011

Stratum R (Mt Mosale)   Area: 1447 Km2   Sampling intensity: 9.26 %

SPECIES	Pop. est.	No. seen	Variance	95%cl %est.	95%Range		Density No/Km^2
Baboon	216	20	9200	94.7	20	- 420	0.149
Buffalo	108	10	10479	202.1	10	- 326	0.075
Bushbuck	22	2	195	137.8	2	- 51	0.015
Bushpig	76	7	2405	138.3	7	- 180	0.053
Crocodile	11	1	104	201.8	1	- 33	0.008
Duiker	691	64	8405	28.3	495	- 886	0.478
Eland	140	13	12633	170.7	13	- 380	0.097
ElephantBull	22	2	418	201.8	2	- 65	0.015
ElephantFamily	151	14	21643	207.5	14	- 465	0.104
GroundHornbill	54	5	827	113.5	5	- 115	0.037
Grysbok	11	1	104	201.8	1	- 33	0.008
Hartebeest	32	3	943	202.1	3	- 98	0.022
Kudu	32	3	939	201.7	3	- 98	0.022
Reedbuck	237	22	6499	72.4	66	- 409	0.164
Sable	151	14	4499	94.6	14	- 294	0.104
Warthog	540	50	13755	46.3	290	- 790	0.373
Waterbuck	443	41	22670	72.5	122	- 763	0.306