Report on an Aerial Survey of Etosha National Park, 6 to 17 August 2010

Holger Kolberg
Directorate Scientific Services

1. Introduction

Conducting aerial surveys is one of the core functions of the Ministry of Environment and Tourism. The surveys are essential management tools, allowing for informed decision making.

Aerial surveys have been conducted in Etosha National Park since 1968. Apart from a series of elephant surveys, these surveys were strictly speaking not comparable as they were undertaken at irregular intervals with different sampling intensities and area cover. The first comprehensive multi-species sample count was conducted in 1995, and repeated in 1998, 2000, 2002, 2004, 2005 and 2010.

The objectives of the 2012 aerial survey were:

1. To provide comparable estimates and trend data for some key species in support of species and park management,
2. To obtain a population estimate of elephants as required within the MIKE program and for CITES,
3. To update the population estimate of black rhino in support of the black rhino National Management Plan.

The survey was conducted from 6 to 17 August 2012 using the Ministry's aircraft, a Cessna 182 (V5-ISE).

2. Survey Design and Methodology

The survey was planned to cover an area of 18551 km², excluding the Etosha pan. The survey area was stratified according to the expected distribution of wildlife, conforming largely to the sampling design used in 2004 and 2005. The survey zone was stratified into seventeen blocks (Figure 1) according to the availability of permanent water. Areas within ten kilometers of perennial water points were counted at a planned sampling intensity of 40%, except blocks 8 (Narawandu) and 9 (Eindpaal), which were sampled at 20% intensity due to a lower observed density of animals in the surrounding areas. The remaining areas would be sampled at 10%.

Transects in each block were selected at the required transect spacing. At a strip width of 500m, transect intervals were 1.25 km for 40% intensity, 2.5km for 20% and 5 km for 10%. The transects were orientated in a north-south direction, except block 2 where the transects run east-west and blocks 1 and 14 where the transects were laid out in a NW-SE direction.

Time constraints resulted in some of the low density blocks not being covered. This meant that the actual area surveyed was reduced to 14494 km². The areas surveyed and the actual flight paths for the survey are presented in Figure 2. A summary of the block data is presented in Table 1.

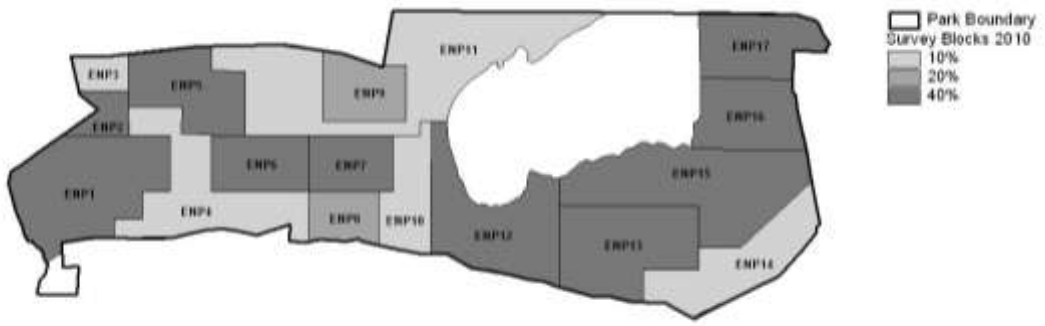

Figure 1: Layout of survey blocks and proposed intensity for the 2012 aerial survey.

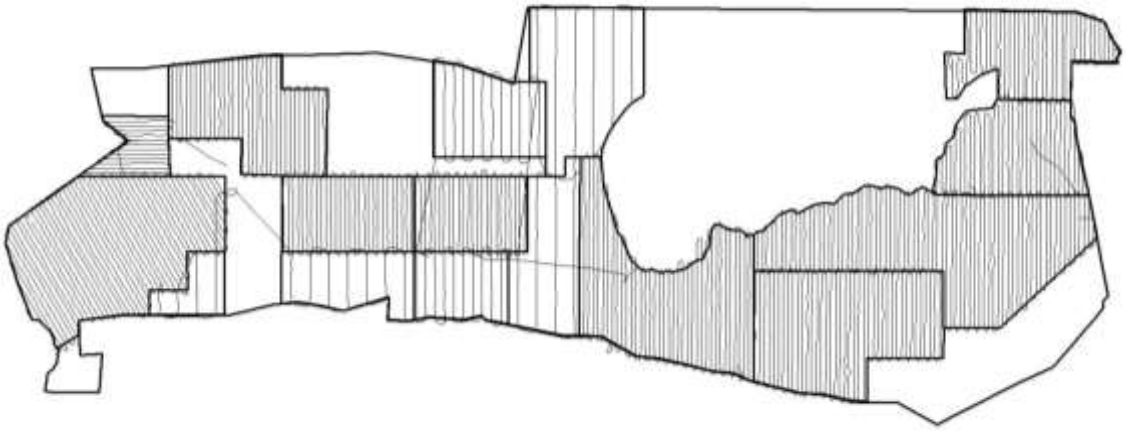

Figure 2: Actual flight paths for the 2012 aerial survey.

Table 1: Summary of data for the Etosha survey blocks.

Block	Transect Spacing (km)	Block Area (km^2)	Area searched (km^2)	Percent searched	Time searched (min)	Search Rate (km^2/min)
ENP1	1.25	1774.683	691.2711	38.95%	397.7	1.74
ENP2	1.25	259.178	93.58964	36.11%	65.8	1.42
ENP4, 10 & 11	5.00	2440.567	242.979	9.96%	155.1	1.57
ENP5	1.25	1004.716	383.247	38.14%	218.2	1.76
ENP6	1.25	699.869	277.2432	39.61%	162.1	1.71
ENP7	1.25	599.877	235.7177	39.29%	142.5	1.65
ENP8 & 9	2.50	1105.839	215.6624	19.50%	135.5	1.59
ENP12	1.25	1488.261	563.5534	37.87%	325.4	1.73
ENP13	1.25	1426.942	558.4855	39.14%	314.2	1.78
ENP15	1.25	2038.083	790.5686	38.79%	453.6	1.74
ENP16	1.25	856.535	331.7133	38.73%	188.6	1.76
ENP17	1.25	799.892	310.2219	38.78%	173.3	1.79
		14494.442	***4694.253***	***32.39%***	***2731.9***	***1.72***

The survey was designed to calibrate the observers at a strip width of 250 metres on either side of the aircraft, following standard procedures. The boundaries of the strips on either side of the aircraft were delimited by a pair of streamers fixed to the lift struts of the wing.

The aircraft used in the survey were each equipped with two Garmin GPS 12 XL models. This ensured accurate navigation along the pre-determined transects, which had been downloaded as route files. Two observers called out the sightings of animals within the demarcated strips. The front seat recorder noted waypoints for each sighting, which included the species and number. The recorder also noted the height *above ground level* from the radar altimeter to allow for the calculation of the average height for each survey block, and additionally recorded the start and end times of each transect. The waypoint and flight data were downloaded to a personal computer using Ozi Explorer® software, after each flying session.

The localities of each sighting were plotted on maps using the Geographical Information System, ArcView® (Figure 3).

Figure 3: All sightings recorded during the 2012 aerial survey.

Jolly's method number 2 for unequal-sized sampling blocks was applied to the data. A spreadsheet model was used to calculate total population size, 95% confidence limits and the range for each species per stratum at 95% confidence limits. If the confidence limits were larger than 100%, the actual number of animals seen within the block was taken as the lower limit of the 95% range.

3. Results

Overall estimates of numbers of the most important species are summarised in Table 2. These species are those that can be counted through aerial survey sampling techniques with a reasonable degree of accuracy and precision. Table 2 includes population estimates, their 95% range, the actual number seen, and the densities for the whole of Etosha National Park.

Table 2: Summary of estimates and density of all species.

Species	No seen	Lower	Estimate	Upper	Variance	SE	95% CI	CI as %	Density
Red Hartebeest	488	963	1338	1713	29070.9	170.502	375	28.05%	0.092
Springbok	4581	10110	12267	14424	960109.9	979.852	2157	17.58%	0.846
Blue Wildebeest	918	1622	2482	3342	152669.8	390.730	860	34.65%	0.171
Black Rhino	346	748	862	976	2678.4	51.753	114	13.21%	0.059
Plains Zebra	6391	13310	16174	19038	1692927.4	1301.125	2864	17.71%	1.116
Mountain Zebra	313	367	685	1004	24848.6	157.635	319	46.48%	0.386
Giraffe	1221	2862	3293	3724	38353.8	195.841	431	13.09%	0.227
Elephant	1151	2042	2810	3578	121831.7	349.044	768	27.34%	0.194
Oryx	1882	4356	5298	6240	183225.5	428.048	942	17.78%	0.366
Ostrich	606	1521	1773	2025	13057.2	114.268	252	14.19%	0.122
Eland	670	1081	1757	2433	94210.5	306.937	676	38.45%	0.121

Table 3 to Table 13 summarise the estimates and summary data for selected species seen in each block. Figure 4 to Figure 14 present distribution and herd size maps, based on all sightings, for each species.

Table 3: Summary of estimates and density of red hartebeest.

Block	No seen	Lower	Estimate	Upper	Variance	SE	95% CI	CI as %	Density
ENP1	151	211	388	564	7620.3	87.295	176	45.51%	0.218
ENP2	23	23	64	105	357.4	18.905	42	65.33%	0.246
ENP41011*	2	2	20	48	183.4	13.541	28	140.61%	0.008
ENP5	213	327	558	790	12848.0	113.349	231	41.45%	0.556
ENP6	14	14	35	75	381.5	19.533	40	113.41%	0.051
ENP7	0								
ENP89	21	21	108	269	6011.3	77.533	161	149.77%	0.097
ENP12	4	4	11	21	24.7	4.967	10	96.02%	0.007
ENP13	30	30	77	134	802.2	28.323	57	74.68%	0.054
ENP15	30	30	77	135	842.1	29.020	58	75.04%	0.038
ENP16	0								
ENP17	0								
Total	***488***	***963***	***1338***	***1713***	***29070.9***	***170.502***	***375***	***28.05%***	***0.092***

* Blocks 4, 10 and 11, and 8 and 9 were combined for analysis.

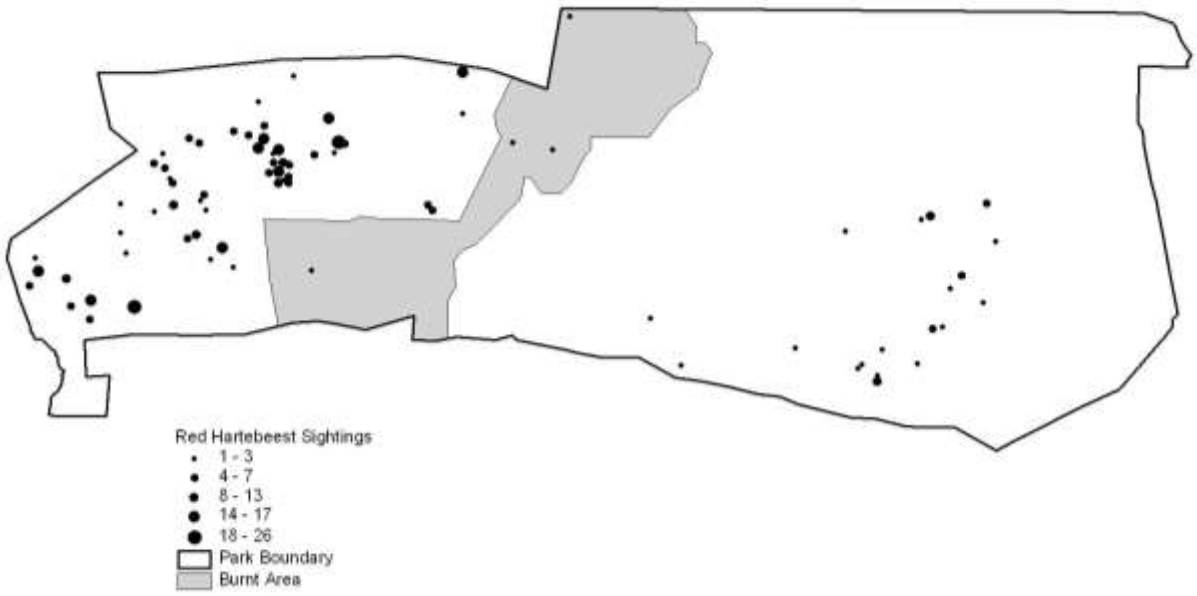

Figure 4: Distribution and herd size of red hartebeest. The grey shaded area is an approximation of the area burnt in June 2012.

Table 4: Summary of estimates and density of springbok.

Block	No seen	Lower	Estimate	Upper	Variance	SE	95% CI	CI as %	Density
ENP1	462	685	1186	1687	61359.1	247.708	501	42.21%	0.668
ENP2	28	28	78	207	3445.6	58.699	129	166.62%	0.299
ENP41011	7	7	70	133	911.6	30.192	63	89.58%	0.029
ENP5	1073	1756	2813	3870	267743.8	517.440	1057	37.56%	2.800
ENP6	144	144	364	593	12528.2	111.930	230	63.18%	0.519
ENP7	62	62	158	291	4133.0	64.288	133	84.30%	0.263
ENP89	106	190	544	897	28920.9	170.062	354	65.08%	0.492
ENP12	1597	2980	4217	5455	367191.4	605.963	1237	29.34%	2.834
ENP13	182	182	465	767	22323.1	149.409	302	64.93%	0.326
ENP15	580	729	1495	2261	146608.2	382.894	766	51.22%	0.734
ENP16	246	246	635	1029	37126.0	192.681	393	61.94%	0.742
ENP17	94	64	242	421	7819.0	88.425	179	73.73%	0.303
Total	***4581***	***10110***	***12267***	***14424***	***960109.9***	***979.852***	***2157***	***17.58%***	***0.846***

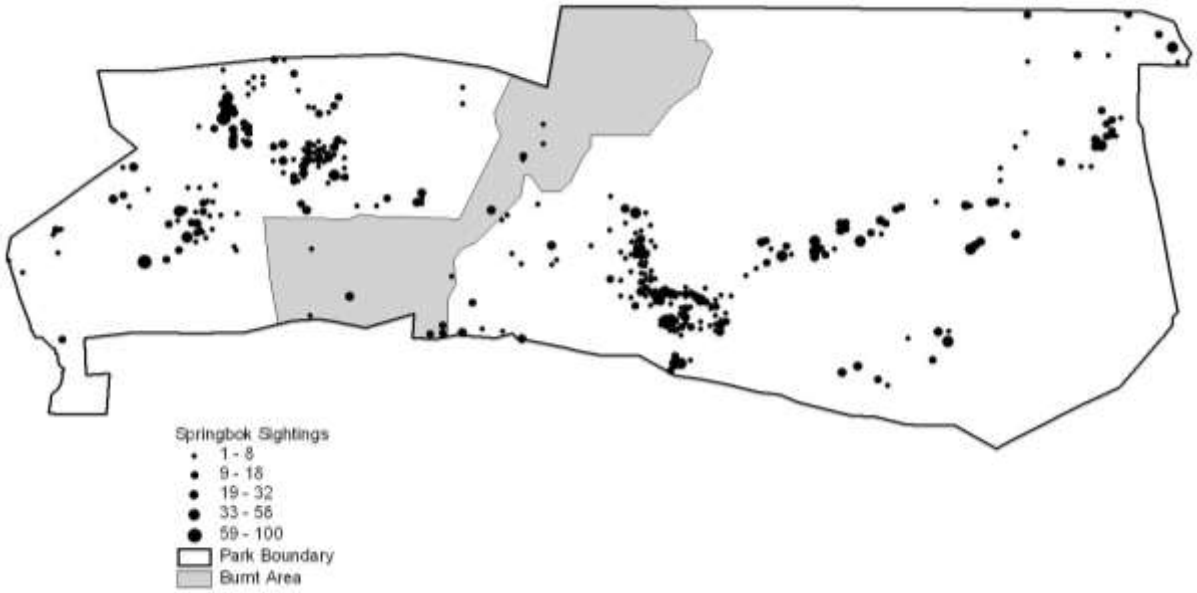

Figure 5: Distribution and herd size of springbok.

Table 5: Summary of estimates and density of blue wildebeest.

Block	No seen	Lower	Estimate	Upper	Variance	SE	95% CI	CI as %	Density
ENP1	105	105	270	479	10790.0	103.875	210	77.88%	0.152
ENP2	9	9	25	66	356.0	18.868	42	166.62%	0.096
ENP41011	2	2	20	45	147.1	12.130	25	125.96%	0.008
ENP5	115	115	301	529	12431.1	111.495	228	75.52%	0.300
ENP6	37	37	93	189	2172.2	46.606	96	102.39%	0.133
ENP7	172	172	438	890	47825.2	218.690	452	103.37%	0.730
ENP89	35	35	179	422	13590.8	116.579	242	135.11%	0.162
ENP12	211	211	557	920	31616.3	177.810	363	65.16%	0.374
ENP13	3	3	8	15	11.5	3.394	7	89.49%	0.005
ENP15	78	78	201	418	11778.7	108.530	217	107.94%	0.099
ENP16	148	148	382	684	21913.8	148.033	302	79.10%	0.446
ENP17	3	3	8	20	37.1	6.090	12	159.10%	0.010
Total	***918***	***1622***	***2482***	***3342***	***152669.8***	***390.730***	***860***	***34.65%***	***0.171***

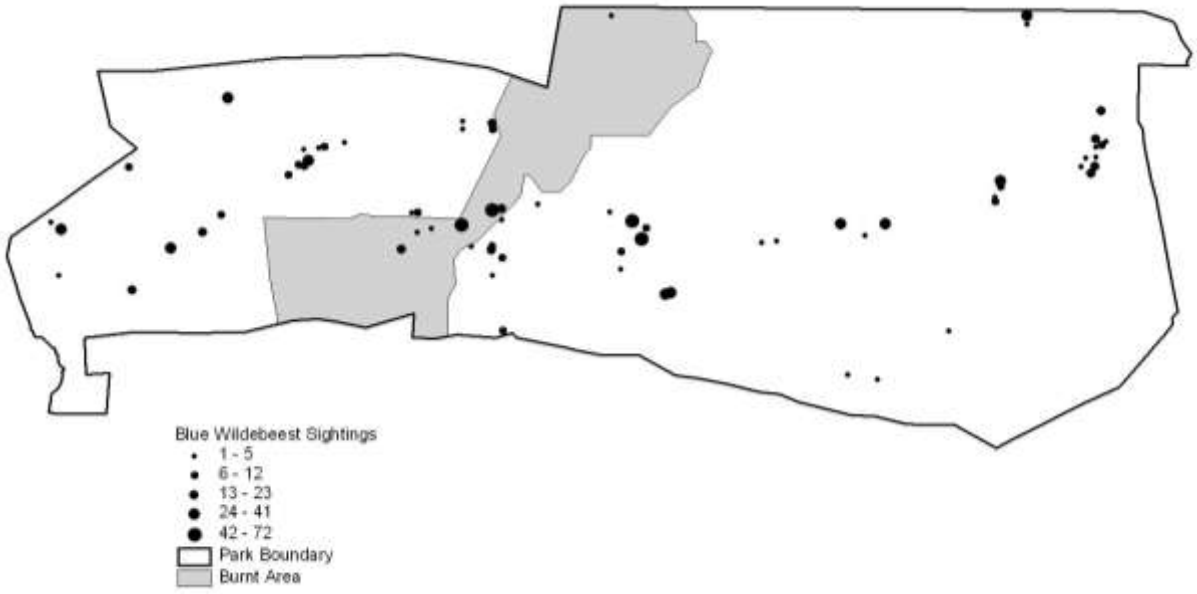

Figure 6: Distribution and herd size of blue wildebeest.

Table 6: Summary of estimates and density of black rhino.

Block	No seen	Lower	Estimate	Upper	Variance	SE	95% CI	CI as %	Density
ENP1	85	166	211	255	487.2	22.073	45	21.19%	0.119
ENP2	21	21	58	98	327.6	18.100	40	68.50%	0.224
ENP41011	2	2	10	30	94.2	9.704	20	201.54%	0.004
ENP5	27	32	66	99	273.4	16.534	34	51.52%	0.065
ENP6	4	4	8	17	19.6	4.429	9	119.99%	0.011
ENP7	6	6	15	30	53.3	7.304	15	98.97%	0.025
ENP89	11	11	31	59	190.0	13.783	29	93.18%	0.028
ENP12	51	92	124	156	244.0	15.622	32	25.70%	0.083
ENP13	46	77	115	153	347.1	18.630	38	32.75%	0.081
ENP15	48	72	108	144	325.7	18.046	36	33.33%	0.053
ENP16	28	45	72	99	172.7	13.140	27	37.11%	0.084
ENP17	17	20	44	68	143.6	11.982	24	55.24%	0.055
Total	***346***	***748***	***862***	***976***	***2678.4***	***51.753***	***114***	***13.21%***	***0.059***

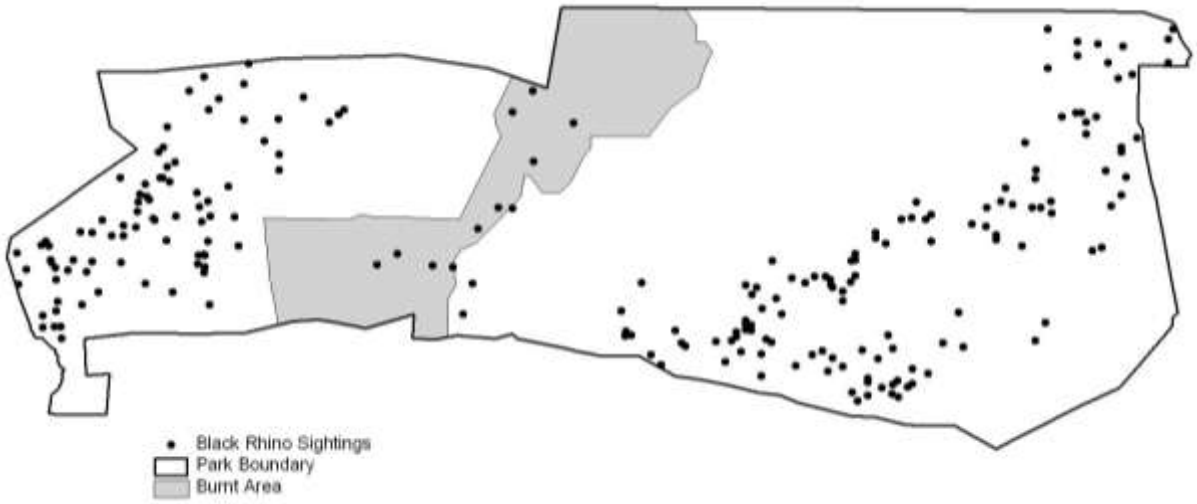

Figure 7: Distribution of black rhino.

Table 7: Summary of estimates and density of plains zebra.

Block	No seen	Lower	Estimate	Upper	Variance	SE	95% CI	CI as %	Density
ENP1	1439	2751	3661	4571	202600.0	450.111	910	24.85%	2.063
ENP2	157	188	435	682	12571.7	112.124	247	56.76%	1.678
ENP41011	2	2	20	49	189.9	13.780	29	143.09%	0.008
ENP5	417	640	1093	1546	49274.8	221.979	453	41.46%	1.088
ENP6	313	313	790	1330	69326.2	263.299	540	68.38%	1.129
ENP7	218	218	555	1051	57468.9	239.727	496	89.40%	0.925
ENP89	102	229	523	817	19969.4	141.313	294	56.20%	0.473
ENP12	1697	2292	3832	5371	568327.9	753.875	1539	40.17%	2.575
ENP13	534	534	1364	2291	210055.2	458.318	926	67.89%	0.956
ENP15	709	779	1828	2877	275018.6	524.422	1049	57.38%	0.897
ENP16	641	709	1655	2601	214683.3	463.339	946	57.16%	1.932
ENP17	162	183	418	652	13441.5	115.937	234	56.09%	0.522
Total	***6391***	***13310***	***16174***	***19038***	***1692927.4***	***1301.125***	***2864***	***17.71%***	***1.116***

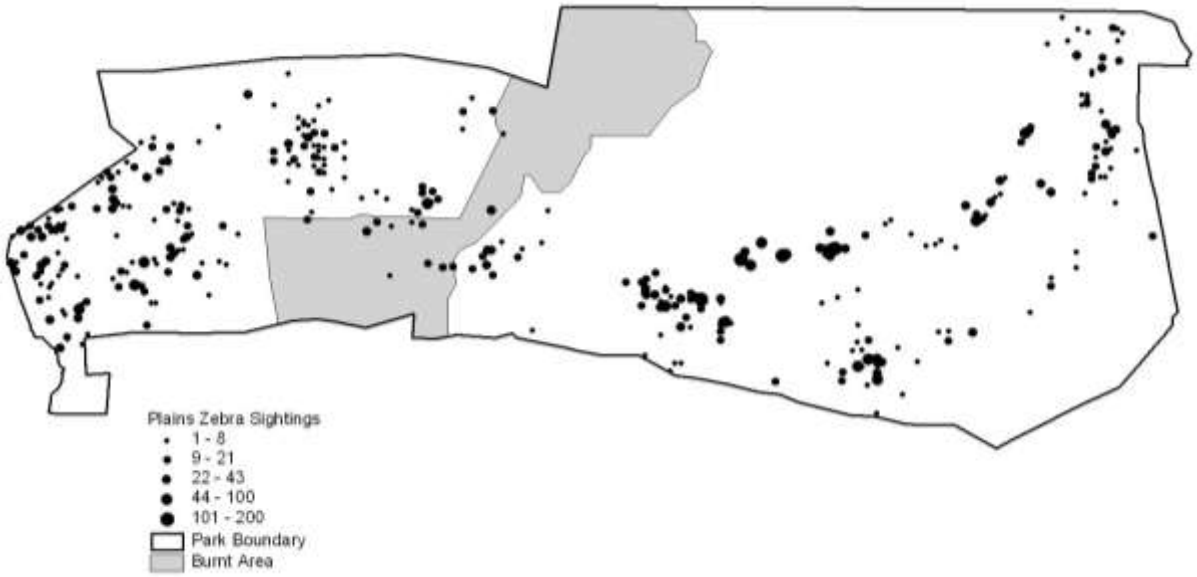

Figure 8: Distribution and herd size of plains zebra.

Table 8: Summary of estimates and density of mountain zebra.

Block	No seen	Lower	Estimate	Upper	Variance	SE	95% CI	CI as %	Density
ENP1	313	367	685	1004	24848.6	157.635	319	46.48%	0.386

Mountain zebra were only recorded in block ENP1.

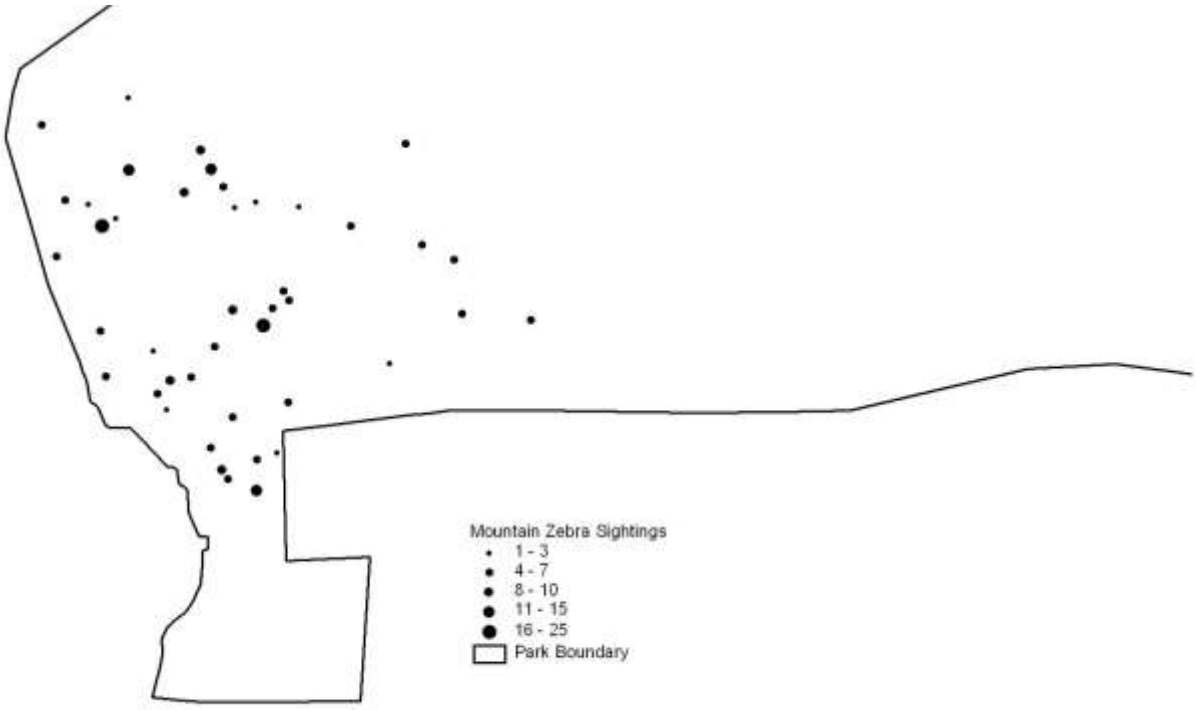

Figure 9: Distribution and herd size of mountain zebra.

Table 9: Summary of estimates and density of giraffe.

Block	No seen	Lower	Estimate	Upper	Variance	SE	95% CI	CI as %	Density
ENP1	258	477	647	816	7037.4	83.889	170	26.21%	0.365
ENP2	50	50	138	244	2281.0	47.760	105	75.92%	0.534
ENP41011	11	39	110	182	1170.1	34.207	71	64.58%	0.045
ENP5	47	60	123	186	953.4	30.877	63	51.17%	0.123
ENP6	18	18	45	92	513.3	22.655	46	102.31%	0.065
ENP7	24	24	61	107	486.7	22.062	46	74.73%	0.102
ENP89	25	32	128	224	2142.4	46.286	96	75.10%	0.116
ENP12	169	235	446	657	10672.6	103.308	211	47.27%	0.300
ENP13	73	127	187	246	861.0	29.343	59	31.79%	0.131
ENP15	142	267	366	465	2450.9	49.506	99	27.05%	0.180
ENP16	167	300	431	562	4131.2	64.274	131	30.44%	0.503
ENP17	237	459	611	763	5653.8	75.192	152	24.87%	0.764
Total	***1221***	***2862***	***3293***	***3724***	***38353.8***	***195.841***	***431***	***13.09%***	***0.227***

Figure 10: Distribution and herd size of giraffe.

Table 10: Summary of estimates and density of elephant.

Block	No seen	Lower	Estimate	Upper	Variance	SE	95% CI	CI as %	Density
ENP1	236	367	603	839	13632.6	116.759	236	39.11%	0.340
ENP2	2	2	6	15	16.9	4.107	9	163.21%	0.021
ENP41011	0								
ENP5	69	25	163	300	4520.5	67.235	137	84.47%	0.162
ENP6	18	18	45	116	1166.8	34.159	70	154.26%	0.065
ENP7	1	1	3	7	4.1	2.022	4	164.42%	0.004
ENP89	22	22	97	280	7681.6	87.645	182	187.12%	0.088
ENP12	103	103	214	425	10670.6	103.299	211	98.61%	0.144
ENP13	35	35	59	118	864.3	29.400	59	101.11%	0.041
ENP15	276	276	616	1014	39659.5	199.147	398	64.64%	0.302
ENP16	140	140	362	646	19396.8	139.272	284	78.67%	0.422
ENP17	249	328	642	957	24218.0	155.621	315	48.99%	0.803
Total	***1151***	***2042***	***2810***	***3578***	***121831.7***	***349.044***	***768***	***27.34%***	***0.194***

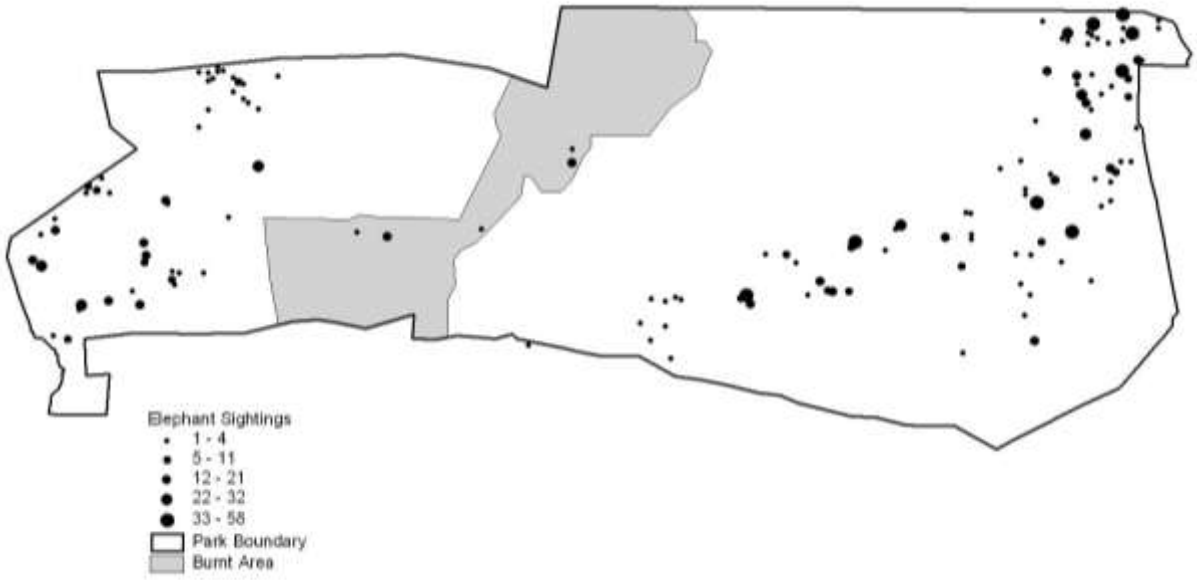

Figure 11: Distribution and herd size of elephant.

Table 11: Summary of estimates and density of oryx.

Block	No seen	Lower	Estimate	Upper	Variance	SE	95% CI	CI as %	Density
ENP1	374	644	857	1071	11156.7	105.625	213	24.90%	0.483
ENP2	84	86	233	379	4428.9	66.550	146	62.97%	0.898
ENP41011	22	97	211	325	2965.1	54.452	114	53.85%	0.086
ENP5	343	748	899	1051	5498.2	74.150	151	16.84%	0.895
ENP6	148	192	374	556	7860.8	88.661	182	48.70%	0.534
ENP7	150	193	382	570	8285.6	91.025	188	49.34%	0.636
ENP89	139	139	713	1307	81627.7	285.706	594	83.38%	0.645
ENP12	413	637	1091	1545	49395.2	222.250	454	41.61%	0.733
ENP13	27	39	69	99	215.7	14.687	30	43.03%	0.048
ENP15	41	41	106	170	1033.3	32.145	64	60.82%	0.052
ENP16	78	78	201	400	9502.3	97.480	199	98.83%	0.235
ENP17	63	91	162	234	1256.0	35.440	72	44.09%	0.203
Total	***1882***	***4356***	***5298***	***6240***	***183225.5***	***428.048***	***942***	***17.78%***	***0.366***

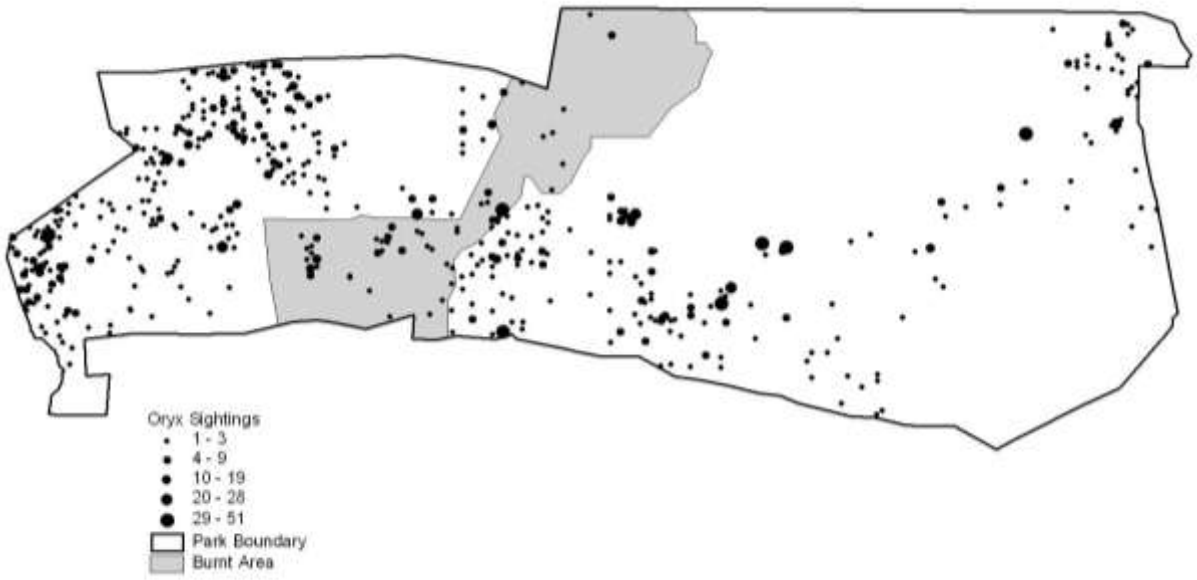

Figure 12: Distribution and herd size of oryx.

Table 12: Summary of estimates and density of ostrich.

Block	No seen	Lower	Estimate	Upper	Variance	SE	95% CI	CI as %	Density
ENP1	113	204	290	376	1798.0	42.403	86	29.54%	0.163
ENP2	17	17	47	81	244.0	15.621	34	73.03%	0.182
ENP41011	25	141	221	301	1467.7	38.310	80	36.16%	0.091
ENP5	135	219	354	489	4345.3	65.919	135	38.03%	0.352
ENP6	31	43	78	113	287.9	16.968	35	44.49%	0.112
ENP7	53	82	135	188	649.9	25.493	53	39.10%	0.225
ENP89	18	40	92	145	630.6	25.112	52	56.59%	0.083
ENP12	89	146	235	324	1906.7	43.666	89	37.94%	0.158
ENP13	37	68	95	121	166.7	12.911	26	27.60%	0.066
ENP15	42	42	108	176	1153.3	33.961	68	62.73%	0.053
ENP16	16	16	41	66	148.2	12.172	25	60.16%	0.048
ENP17	30	45	77	110	258.9	16.091	33	42.04%	0.097
Total	***606***	***1521***	***1773***	***2025***	***13057.2***	***114.268***	***252***	***14.19%***	***0.122***

Figure 13: Distribution and flock size of ostrich.

Table 13: Summary of estimates and density of eland.

Block	No seen	Lower	Estimate	Upper	Variance	SE	95% CI	CI as %	Density
ENP1	108	108	277	534	16102.6	126.896	256	92.50%	0.156
ENP2	27	27	75	144	984.0	31.368	69	92.34%	0.288
ENP41011	0								
ENP5	393	518	1030	1543	63004.2	251.006	513	49.75%	1.025
ENP6	0								
ENP7	0								
ENP89	4	4	21	47	159.9	12.643	26	128.22%	0.019
ENP12	0								
ENP13	81	81	207	416	10744.4	103.655	209	101.22%	0.145
ENP15	5	5	13	33	104.2	10.207	20	158.37%	0.006
ENP16	23	23	59	157	2305.8	48.018	98	165.10%	0.069
ENP17	29	29	75	132	805.4	28.380	57	76.70%	0.093
Total	***670***	***1081***	***1757***	***2433***	***94210.5***	***306.937***	***676***	***38.45%***	***0.121***

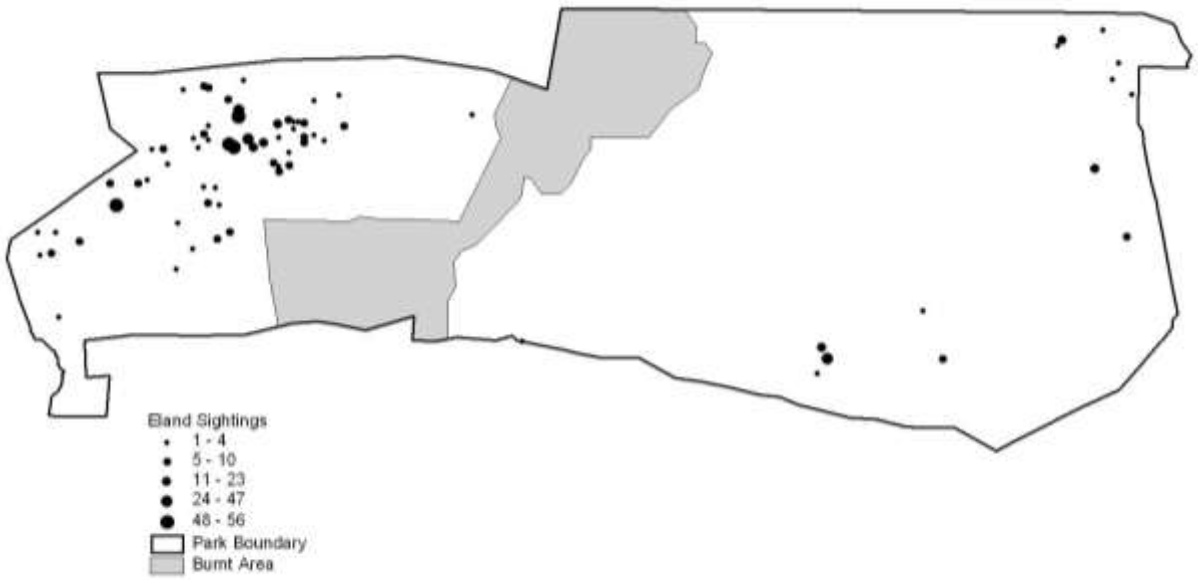

Figure 14: Distribution and herd size of eland.

Figure 15 to Figure 24 present comparative population estimates and the 95% range for each species for aerial sample counts conducted during the dry periods of 1995, 1998, 2000, 2002, 2004, 2005 and 2012. The sampling intensities of the 1998 survey were the lowest of the surveys, and the population estimates reflect those. The data from the survey conducted in 2010 was not included because the results of that survey were not satisfactory.

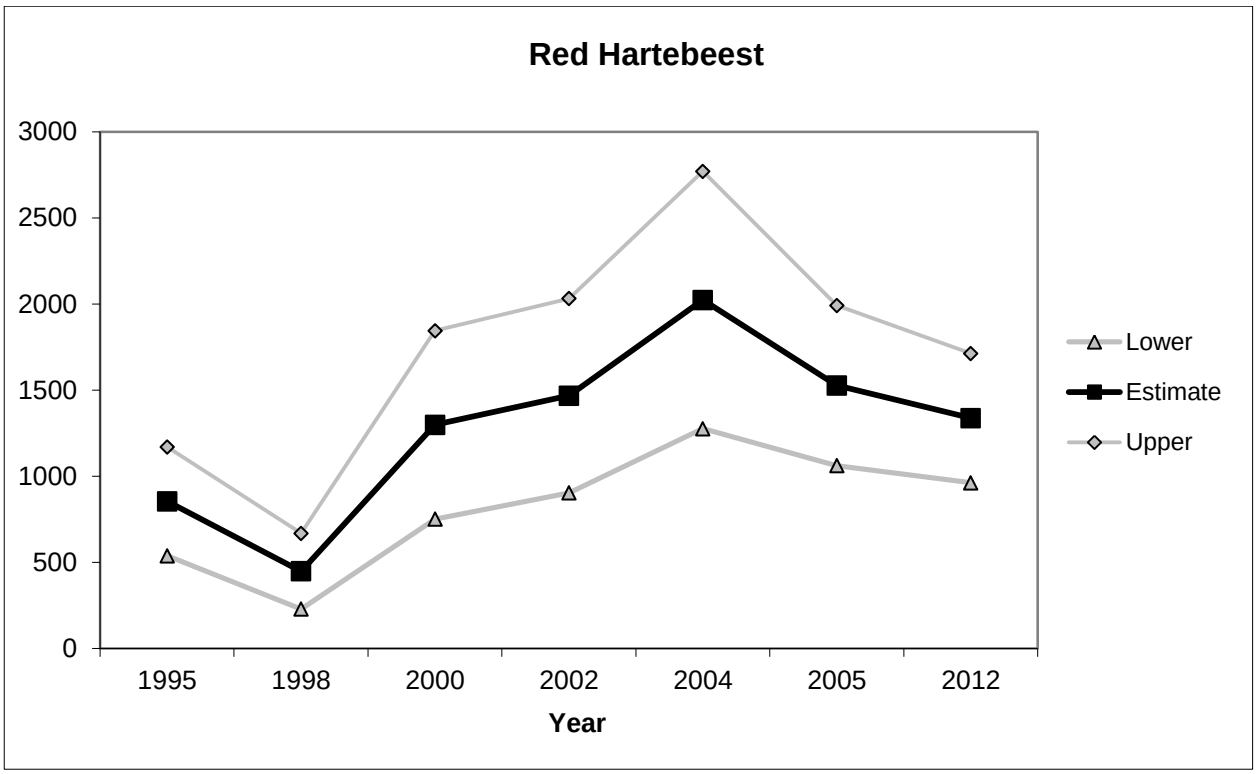

Figure 15: Population trends for red hartebeest.

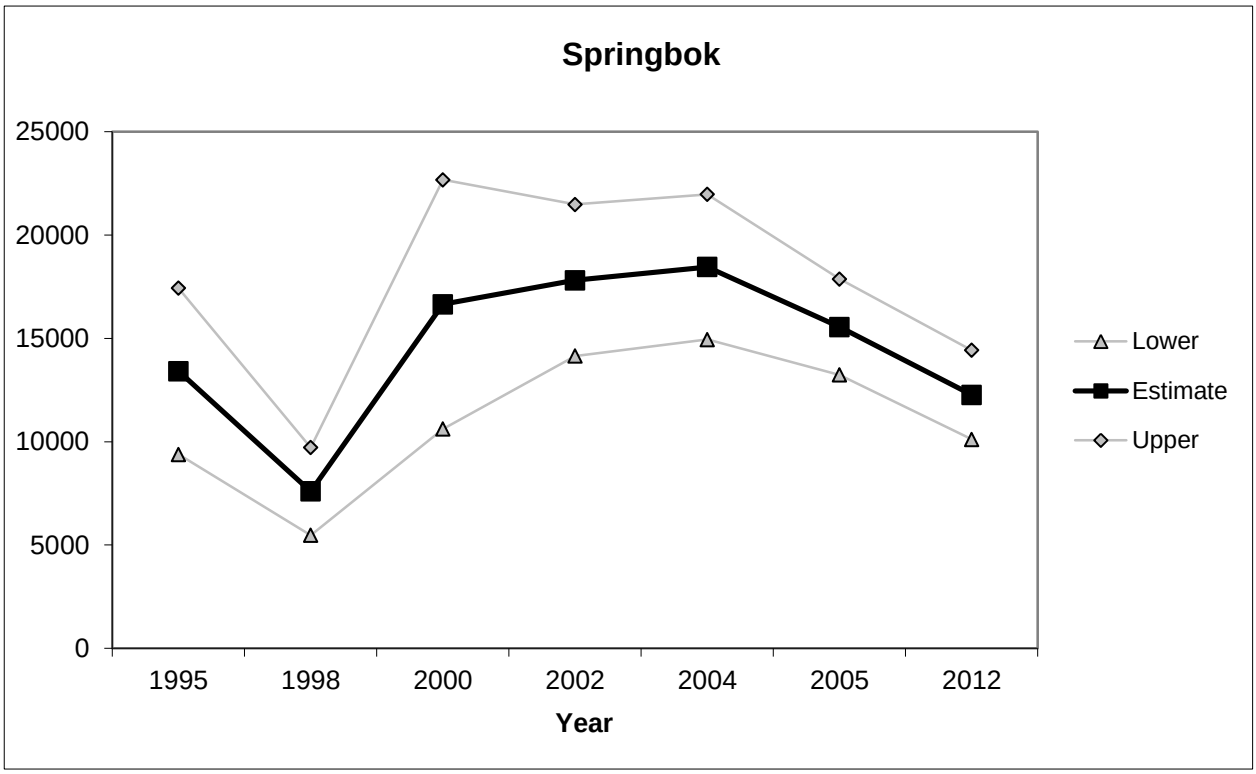

Figure 16: Population trends for springbok.

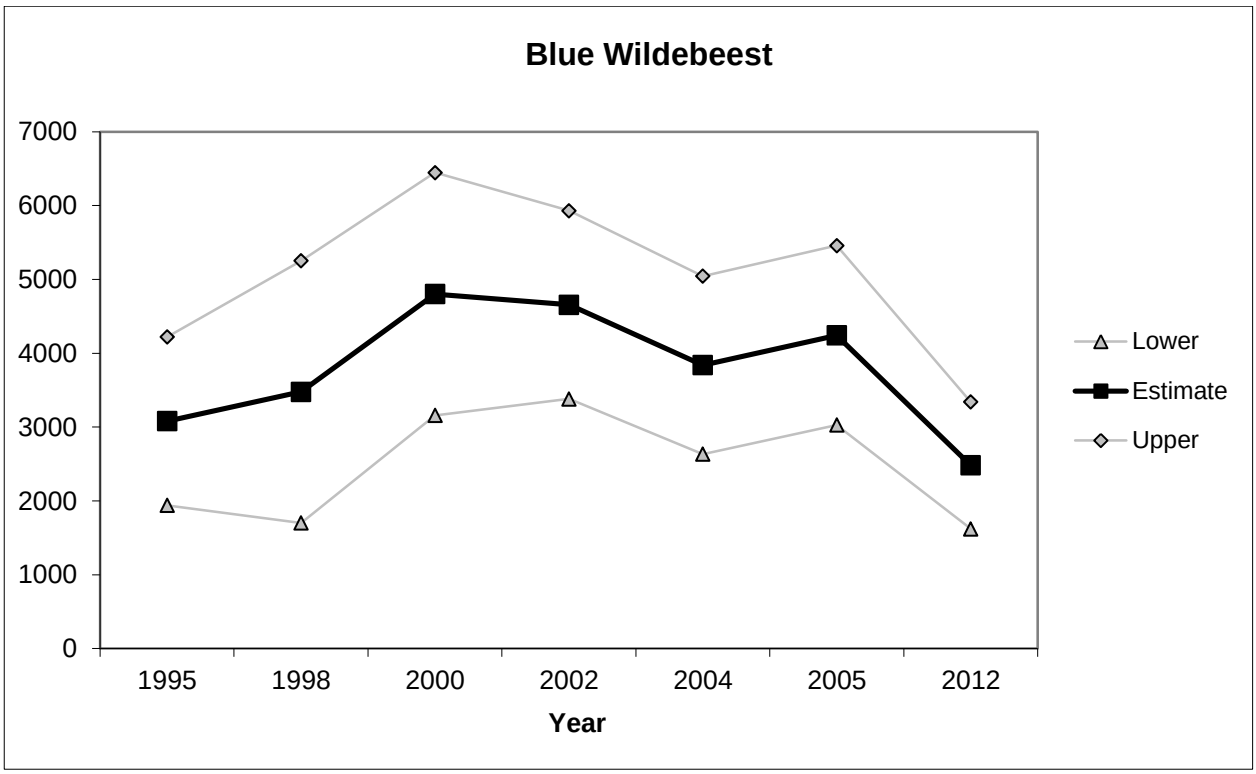

Figure 17: Population trends for blue wildebeest.

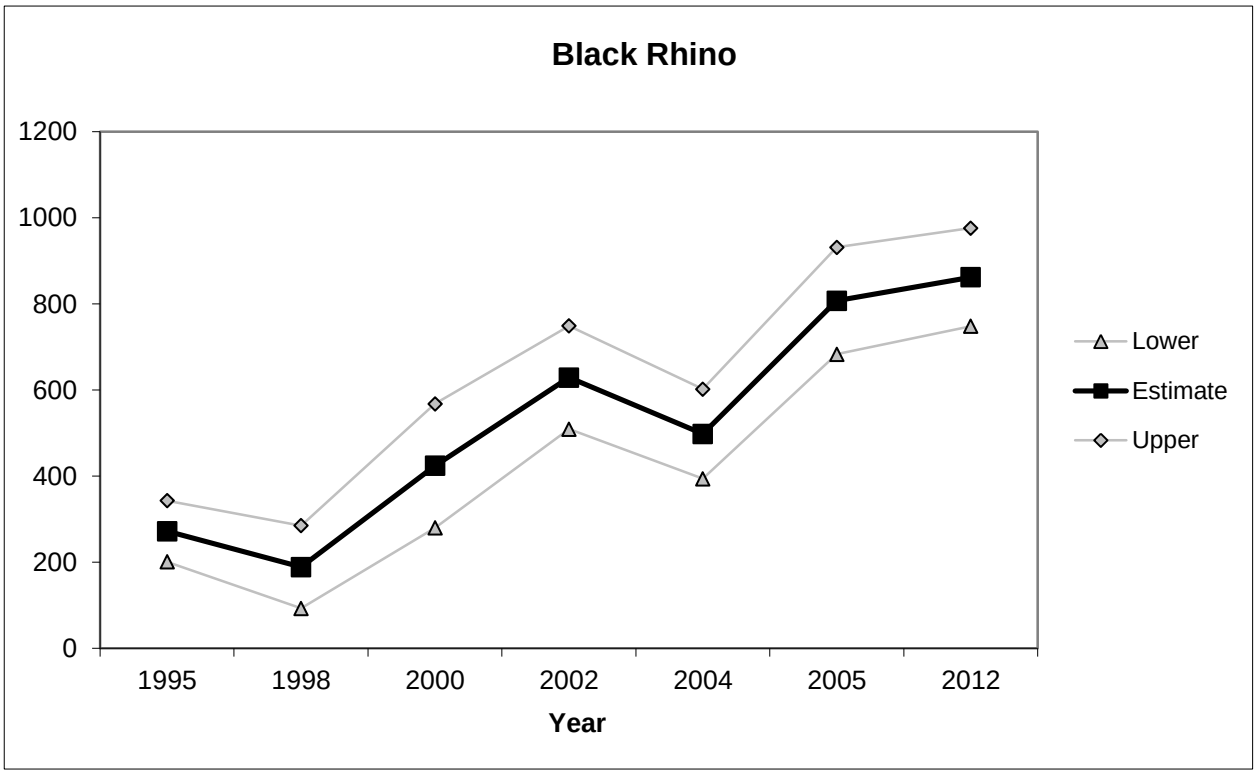

Figure 18: Population trends for black rhino.

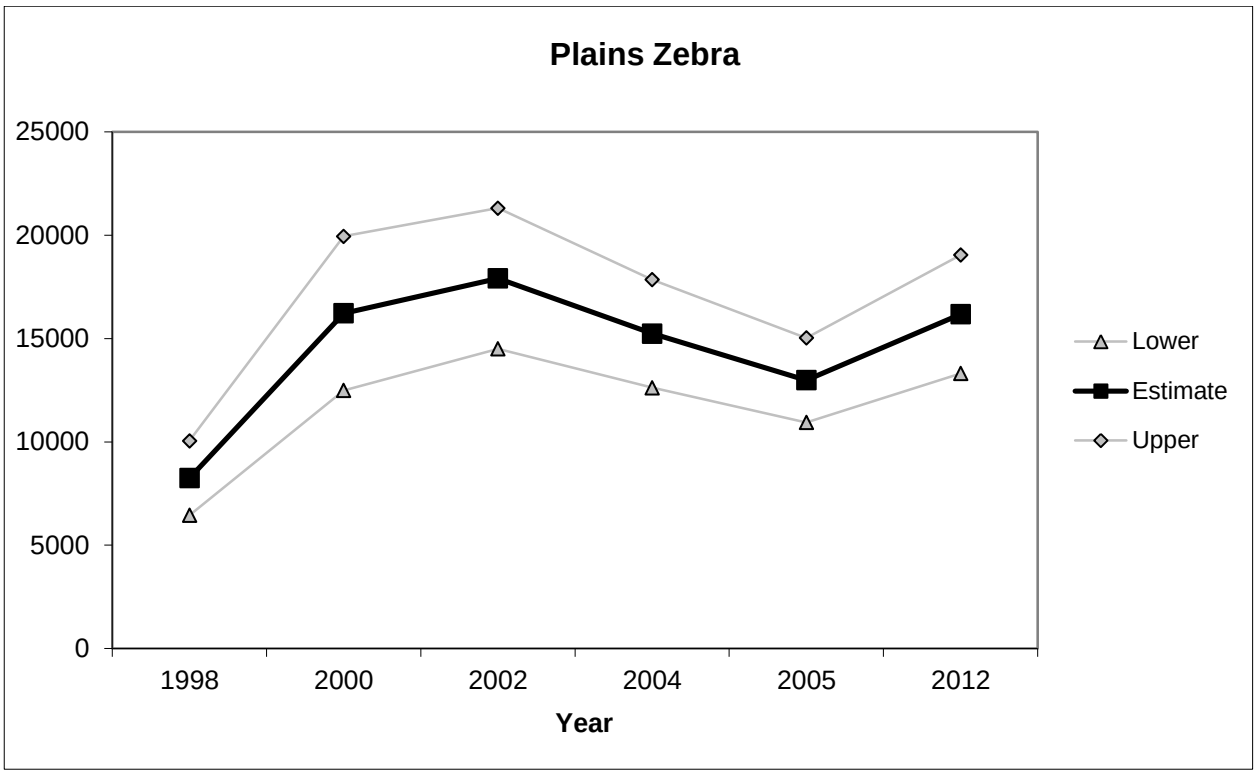

Figure 19: Population trends for plains zebra.

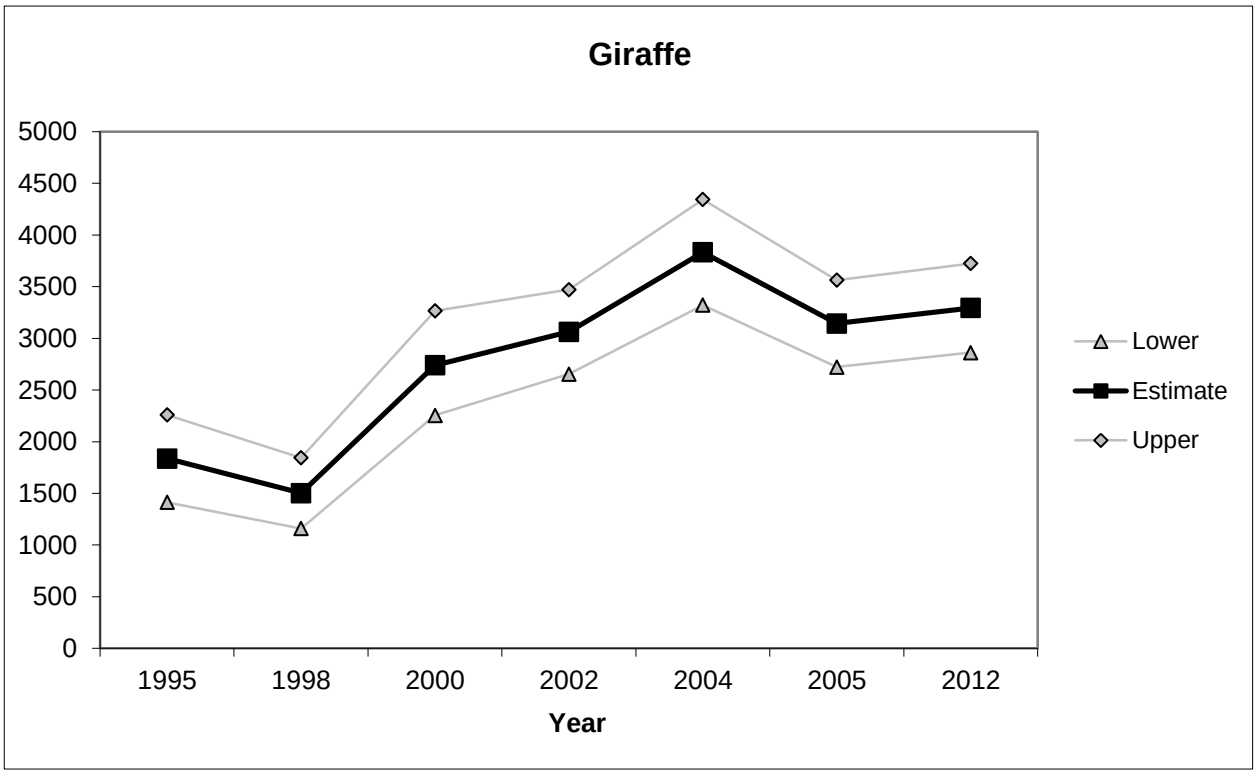

Figure 20: Population trends for giraffe.

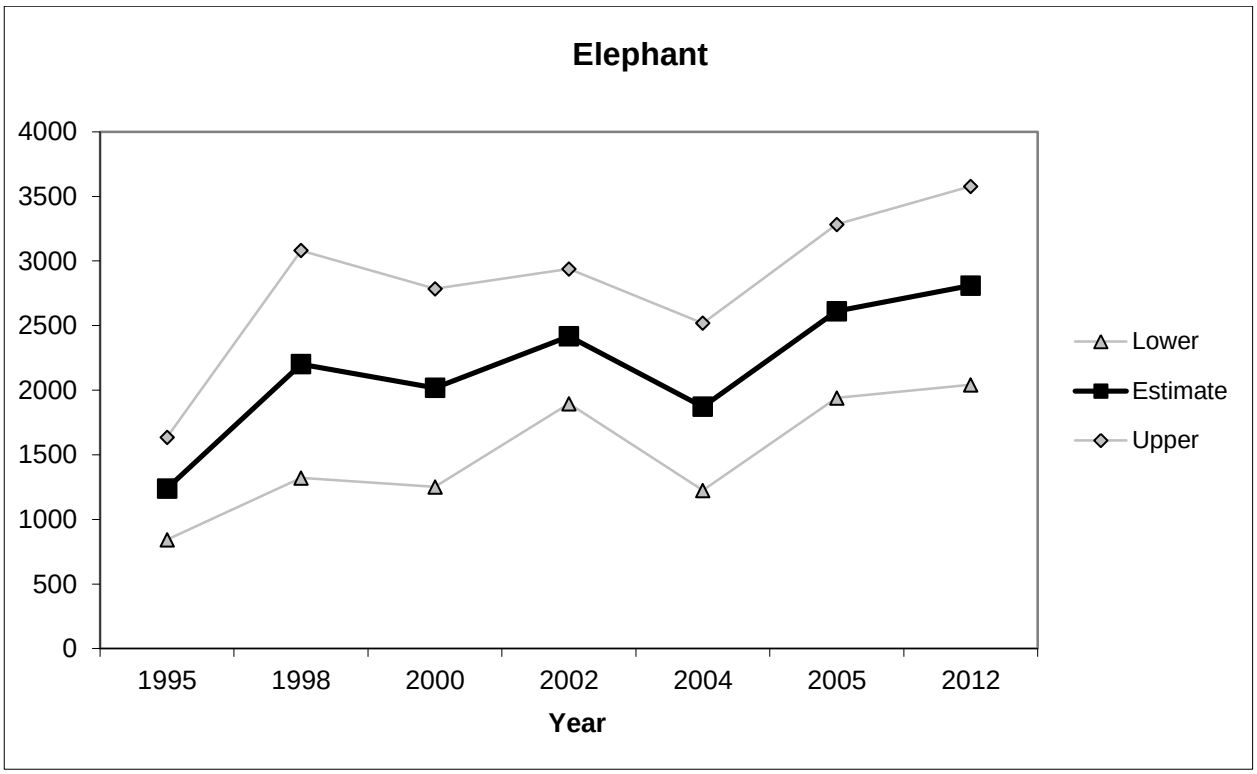

Figure 21: Population trends for elephant.

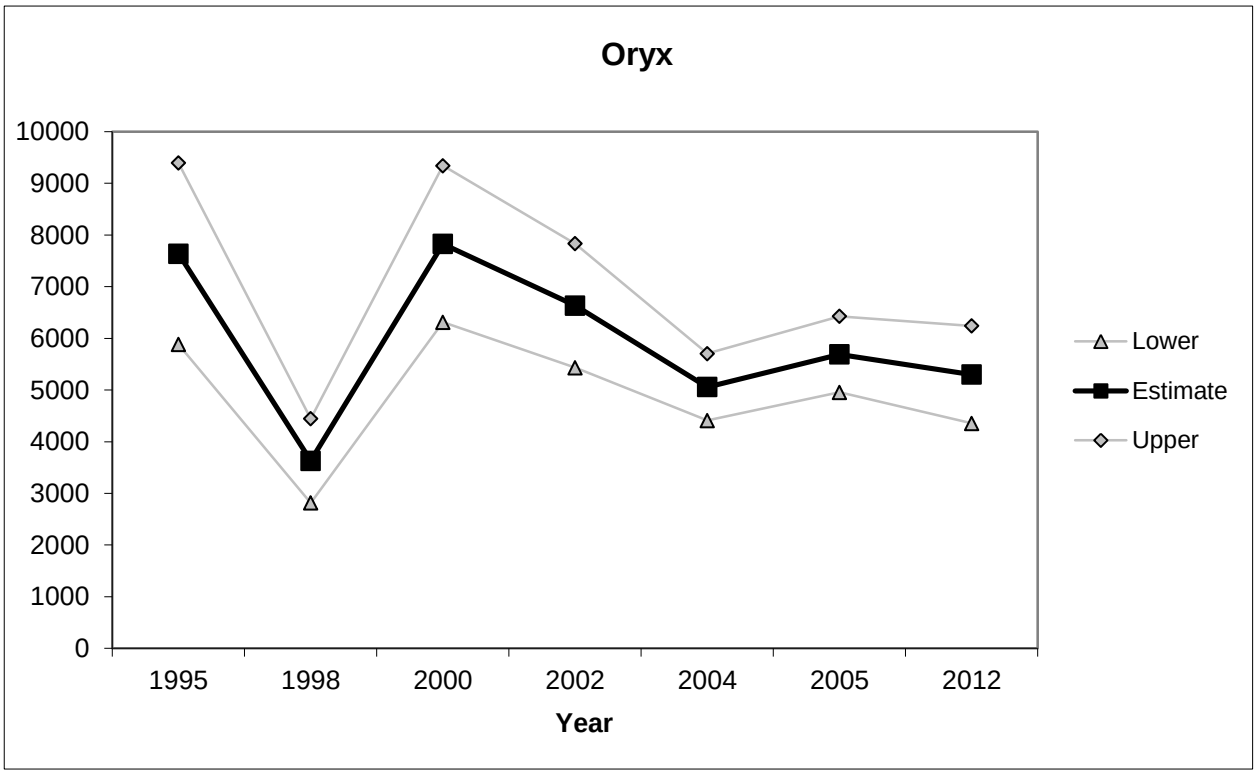

Figure 22: Population trends for oryx.

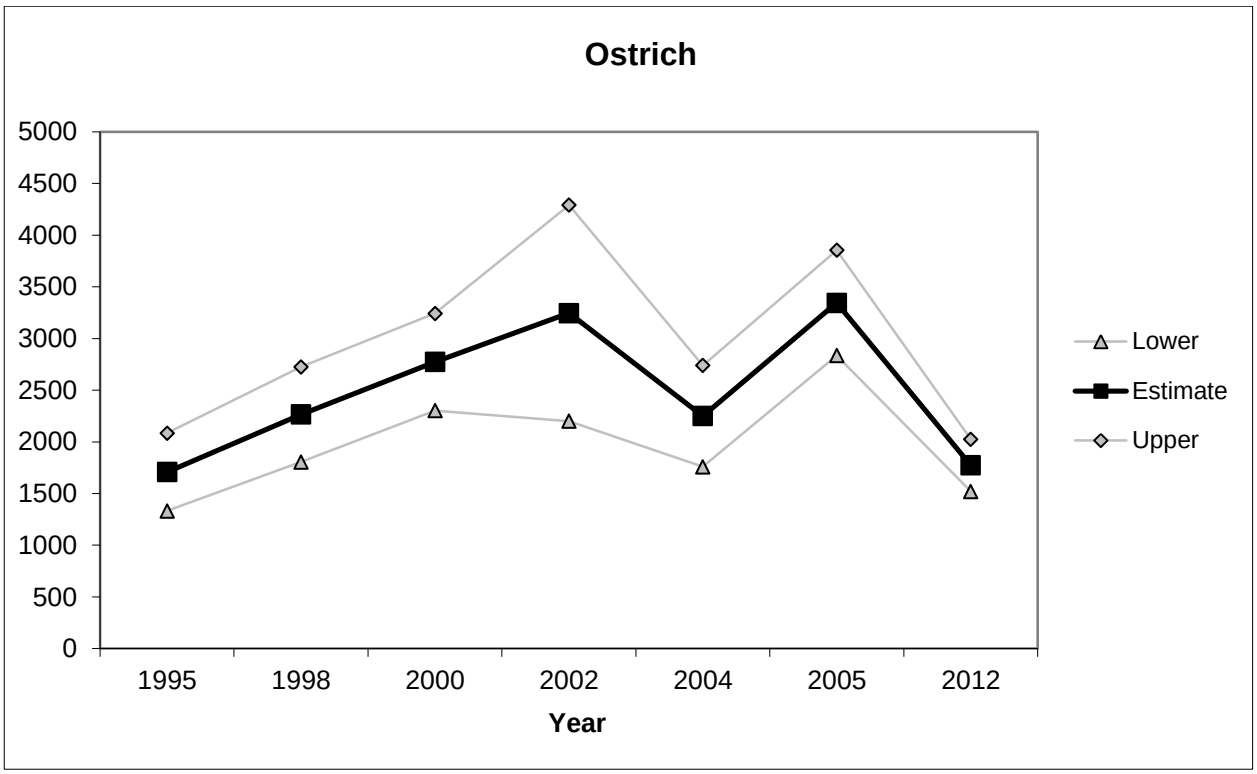

Figure 23: Population trends for ostrich.

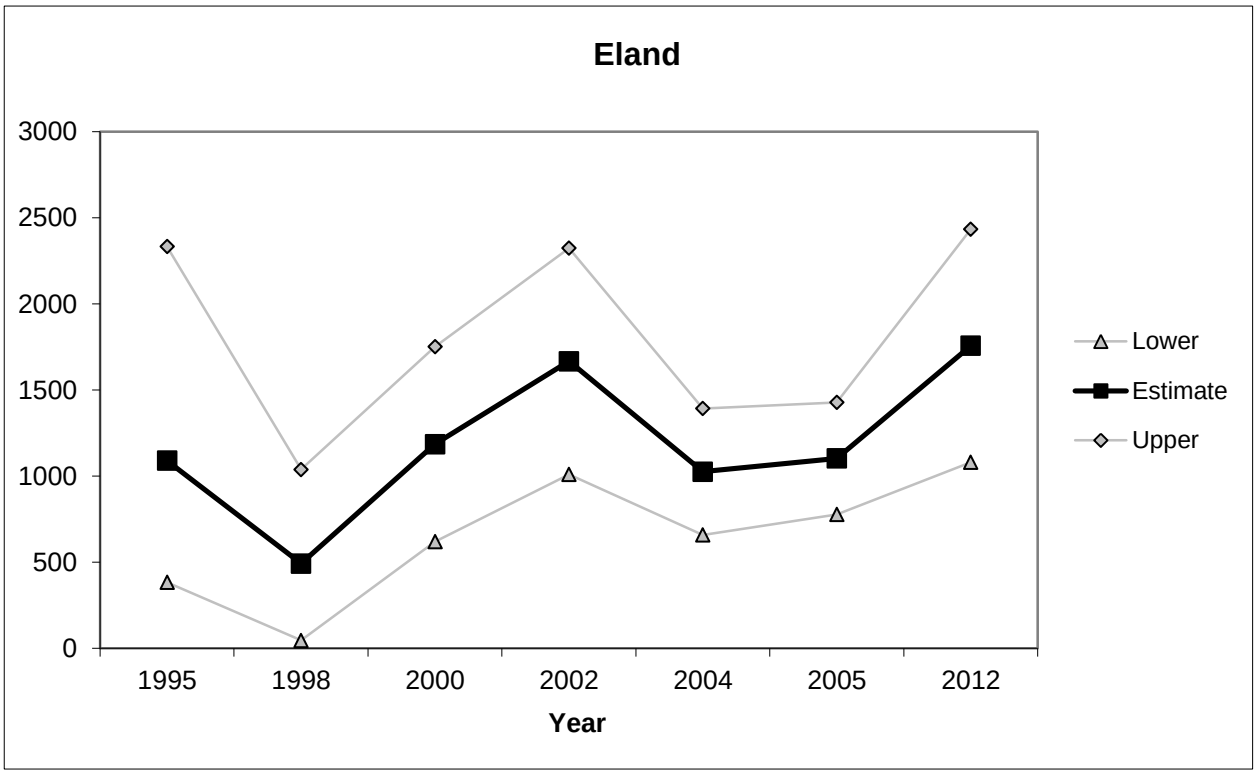

Figure 24: Population trends for eland.

Table 14: Numbers of other animals seen during the survey.

Block	Black-faced Impala	Spotted Hyaena	White Rhino	Ratel	Damara Dik-dik	Warthog	Steenbok	Duiker	Kudu
ENP1	5					39	18		90
ENP12	127					5	2		105
ENP13	9								50
ENP15	154		5	3			1		145
ENP16	77		5		1	6			43
ENP17			7			6	2		80
ENP2			3			2	1		17
ENP41011						7	1		6
ENP5				3		42	11	4	
ENP6				2		9			
ENP7						7	3		
ENP89		2				7	1		23
Total	***372***	***2***	***20***	***8***	***1***	***##***	***40***	***4***	***559***