



AFRICAN WILDLIFE FOUNDATION®

Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland (Zimbabwe, Mozambique and Zambia): 2003

A Report for African Wildlife Foundation
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SUMMARY:

During September 2003, elephants and other large herbivores, wild and domestic, were surveyed from the air in the Zambezi Heartland between Lakes Kariba and Cabora Bassa in Zimbabwe, Mozambique and Zambia. The census was commissioned by the African Wildlife Foundation. This was the first time that there were co-ordinated surveys within the three countries that contribute to the Zambezi Heartland. The surveys in Zimbabwe and Mozambique were conducted by the Parks and Wildlife Management Authority (Zimbabwe) and the Zambezi Society, and the survey in Zambia by the Zambia Wildlife Authority and Conservation Lower Zambezi. Fixed-wing aircraft were used to conduct transect surveys over the Zambezi Valley floor, and block counts in the escarpment hills. The methods were generally similar to those used during previous surveys in Zimbabwe and the Magoe section of Mozambique. The overall sampling intensity was 15.3 % and the area surveyed totalled 31656 km². However, at least 3754 km² of known elephant range was not surveyed.

The survey was designed to estimate the number of elephants. Some large herbivores are not easily seen from the air and their numbers were undoubtedly underestimated. Nonetheless, population estimates are given for these species, because the estimates provide useful indices of abundance (with measures of precision) that can be used to determine spatial distribution, as well as temporal trends in population number. No corrections have been applied to any of the estimates to compensate for any undercounting or missed animals.

The estimated population numbers of the principal large herbivores in the Zambezi Heartland were: elephant 23221 (95% confidence interval (CI) 11.4 %); buffalo 27747 (CI 35.5 %); impala 19577 (CI 21.1 %); kudu 2006 (CI 26.2 %); zebra 1676 (CI 28.4 %); waterbuck 1563 (CI 32.6 %); sable 1262 (CI 48.7 %); eland 333 (CI 84.3 %); roan 57 (CI 107.6 %); cattle 20494 (CI 30.4 %); and sheep and goats 27037 (CI 28.2 %). Most domestic livestock were in the communal lands, but some were counted in Charara Safari Area (Zimbabwe) and Lower Zambezi National Park (Zambia).

The elephant carcass 'ratio' varied from 1.4 % in Zambia and 2.1 % in Zimbabwe, to 8.3 % in Mozambique. No fresh carcasses of elephants were recorded and just one recent carcass of an elephant was counted in the Heartland.

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INTRODUCTION

During 2003, the African Wildlife Foundation commissioned two teams to conduct aerial surveys of the populations of elephants and other large herbivores, wild and domestic, in the Zambezi Heartland, which covers the Middle Zambezi Valley between Lakes Kariba and Cabora Bassa and includes parts of three countries, Zimbabwe, Mozambique and Zambia (Map 1). Previously, there had been co-ordinated surveys of the Zimbabwean part of the Zambezi Valley and the Magoe section of Mozambique, but this was the first time that there had been co-ordinated surveys in the three countries. The surveys in Zimbabwe and Mozambique were conducted by the Parks and Wildlife Management Authority (Zimbabwe) and the Zambezi Society, and the survey in Zambia by the Zambian Wildlife Authority and Conservation Lower Zambezi.



The purpose of this report is to combine the results from the three countries in order to produce population estimates for the Zambezi Heartland. The procedures used for survey planning and data analysis are summarised here. Where there were differences between the methods used by the two teams, these are noted, first to ensure that the most appropriate analytical techniques are used, and secondly to facilitate the adoption of common standards during any future cross-border surveys in the Zambezi Heartland. While I was able to review some survey plans and data analyses, I played no role in the strip width calibrations or data collection and hence I was unable to review these aspects.

SURVEY AREA

The study area covered 33 349 km² (Map 1), but 1693 km² of this were not surveyed (Map 2). Hence, the survey area covered a total of 31 656 km² and was divided into 38 strata (Map 2, Table 1).

In Zimbabwe, the survey area was the same as that covered during the 2001 survey (Mackie 2002), except that, owing to logistical constraints, the Chewore II, Chewore IV, Mukwichi, Kanyurira Highlands, Doma and Mavuradonha strata were not surveyed during 2003. The survey area included the Parks & Wild Life lands of Mana Pools National Park, Hurungwe Safari Area, Sapi Safari Area, Charara Safari Area, Dande Safari Area

and the valley floor section of Chewore Safari Area; as well as some of the Guruve District communal lands.

In Mozambique, 2621 km² of communal land in the Magoe area south of Lake Cabora Bassa were surveyed as during 2001 (Mackie 2001). In addition, 3708 km² of communal land to the north of Lake Cabora Bassa and immediately east of the Luangwa River were formally surveyed for the first time.

In Zambia, 11 954 km² between Lake Kariba and the Luangwa River were surveyed. Here, the survey area included Lower Zambezi National Park, Chiawa Game Management Area, Rufunsa Game Management Area and Tonga-Sikongo communal land.

METHODS

Survey Design

The procedures used followed those well established for aerial surveys of African large herbivores (Norton Griffiths 1978) and utilised during earlier surveys of large herbivores in Mozambique, Zimbabwe and Zambia (Price Waterhouse 1996, Mackie 2000, 2001, Dunham & Mackie 2002). Over the floor of the Zambezi Valley, where the ground was flattish, transect surveys were flown. But in hilly country, such as that found behind the Zambezi escarpments, it is impossible to fly safely in straight lines at low-level and so a different technique - block counts - was used here.

Strata boundaries were drawn so that elephant density within a stratum was approximately spatially uniform. For most Zimbabwe strata, the strata boundaries are the same as those used during previous surveys. Minor changes were made to the borders of those strata (Magoe strata 1, 4, 5 and 6, and Zimbabwe strata Dande, Chisunga and Kadze) that coincided with the Zimbabwe/Mozambique international boundary because I discovered during survey planning that the strata boundaries used during previous surveys did not match exactly along the international border. Also, the lakeside borders of Magoe strata 1, 2, 3 and 6 were adjusted to take account of the high water level in Lake Cabora Bassa, thereby reducing the size of the Magoe survey area, compared with 2001. ZAWA staff planned the survey in Zambia. There remains a need for the realignment of strata borders that coincide with the Zimbabwe/Zambia international boundary, to remove obvious discrepancies where Zimbabwean and Zambian



strata meet – or are supposed to – along the Zambezi River (see, for example, Map 3).

The area of each stratum was determined using the software CARTALINX (Hagan, Eastman & Auble 1998). For the Zimbabwean and Mozambican survey areas, digital files containing the co-ordinates (in degrees latitude and longitude) of strata boundaries were converted into bna-format computer files that could be used by the WWF SARPO software for designing transect surveys.

Transect Surveys: Regularly spaced, parallel transects were positioned across each valley-floor stratum. In Zimbabwe and Mozambique, transects were arranged at right angles to the principal environmental feature within a stratum – for example, transects crossed major river systems (see Table 1 for transect orientations). The distance between adjacent transects varied between strata, according to the planned sampling intensity in each stratum. The transect spacings used are given in Table 1. Overall sampling intensity was planned to be 12 % and the planned sampling intensity in each stratum was determined by using the mean of the elephant densities observed in each stratum during 1998, 1999 and 2001 (for Zimbabwe), or 2000 and 2001 (for the Magoe section of Mozambique) (Gibson 1999, Davies 1999, Mackie 2000, 2001, 2002) as the predicted elephant densities in equation 1 of Gibson (1989). As a consequence, strata expected to contain large numbers of elephants were sampled more intensively than strata expected to contain few elephants. The result of this was to minimise the variance of the overall population estimate for elephants.

Mozambique north of Lake Cabora Bassa had not been surveyed previously and so transects were uniformly spaced 2.5 km apart (to give a sampling intensity of 12 % with the planned combined strip width of 300 m).

The Zimbabwean and Mozambican surveys were designed using WWF SARPO's custom software (AIRDES, version dated 29/05/97). Given a stratum boundary in the form of a bna computer file, and the transect orientation and spacing, this software generates flight lines (the transects), with the first flight line offset from the end of the stratum by a random number entered as the "offset".

In Zambia, the survey was designed manually. Here, all transects were orientated north-south, with the first

transect located randomly, and the distance between transects (2.5 km) constant across the survey area.

In all countries, the start and end points for each transect were transferred as waypoints to a GPS receiver in the plane prior to flying each stratum.

Block counts: In areas of hilly country in Zimbabwe and Mozambique, blocks for census were defined on maps of scale 1:50000 (Zimbabwe) or 1:250000 (Mozambique) using features (e.g. streamlines, watersheds, vehicle tracks) which were navigable from the air. The size of the blocks was usually in the range of 5-25 km² in Zimbabwe and 15-35 km² in Mozambique. Blocks to be counted were selected by using random numbers as map co-ordinates. Consequently, the probability of a block being selected for survey was proportional to its area (Caughley 1977). Blocks to be searched were selected with replacement (Caughley & Sinclair 1994). In other words, a block could be selected more than once (and included more than once in the analysis), although it was searched just once.

In areas of hilly country in Zambia, blocks for census were defined on maps of scale 1:250000 using ground features and north-south, or east-west, straight lines drawn between two map points. The size of the blocks was usually in the range of 30-100 km². All blocks in a stratum were numbered and random numbers were used to select blocks to be searched. Consequently, each block in a stratum had the same probability of being selected for survey irrespective of its size. Sampling was done without replacement (i.e. once a block was selected for searching, it was removed from the pool of blocks available for further selection).

Flight Procedure

Transect Surveys: The aircraft used was a Cessna 206. It was fitted with a radar altimeter and Trimble GPS100 GPS receiver. During surveys, the aircraft was flown at approximately 160 km per hour at about 300 feet above ground level. Waypoints denoting the start and end points of transects were entered into the GPS receiver and navigation along the transects was undertaken by the pilot, with reference to the GPS receiver and a course deviation indicator mounted in the aircraft's instrument panel.

The aircraft crew included a pilot, a recorder who sat next to the pilot, and two observers who sat behind the pilot and recorder. All observers in the two survey teams had previous experience of observing during aerial



surveys. All four crew could talk to one another through an intercom system.

All animals seen by the observers within the strips (see section Strip Width and Calibration for Transect Surveys below) were called to the recorder, who wrote down the species, the number of individuals of the group that was within the strip, and the GPS location against the time (to the nearest 30 seconds) after the start of the transect. To simplify recording, location was noted solely as latitude or longitude. The recorder used a stopwatch to record the time (to the nearest second) taken to fly each transect.

During the surveys in Zimbabwe and Mozambique, the actual height above ground level (agl) was recorded from the radar altimeter every 30 seconds (of time) while flying along transects. Later the mean height agl for each transect was calculated.

During the survey in Zambia, the recorder did not record the actual heights. Hence, for the analyses that follow, I have presumed (after discussion with the pilot (J. Cadd, pers. comm.)) that the mean height of the aircraft when flying all transects in Zambia was the same as its mean height when flying transects in Mozambique (which was calculated for this purpose and was 305 feet). This presumption is justified because the same aircraft and pilot were used for strip counts in both countries.

Block counts: After navigating directly to a grid reference, which marked a distinctive point in the block, the pilot and one observer in a small aircraft searched the block until they believed that all animals within it had been seen and recorded. In Zimbabwe and Mozambique, the aircraft used was a Piper Super Cub, and in Zambia it was a Bianca Scout. These aircraft can safely fly slower than the plane used for the strip counts. The time taken to search each block was recorded. Prior to the surveys, the pilot and observer were advised to search each block for a period equivalent to approximately one minute per square kilometre.

Observations

Although the surveys were designed especially to count elephants, all wild herbivores larger than impala were counted, together with domestic cattle, goats, sheep and donkeys (except donkeys were not counted in Zambia). Sheep and goats could not be differentiated from the air and were lumped together as “sheep and goats”. If any group in the transect was too large for all the individuals within it to be counted, group size was estimated by the observer.

During the surveys in Zimbabwe and Mozambique, groups of elephant bulls were differentiated from elephant cow herds (i.e. herds containing calves), although the latter may have included some bulls. During the survey in Zambia, the recorder did not distinguish between bull groups and cow herds.

Elephant carcasses were classified and recorded as:

Carcass Category	Definition
1	Fresh: intact; white droppings of vultures visible; vegetation trampled; fluid stain visible on ground around carcass (animal likely to have died within the last 3 months).
2	Recent: pieces of hide still attached; skeleton still partly articulated; no vulture droppings; no trampled vegetation; no fluid stain evident (less than 1 year old, but generally since the last rainy season, i.e. 3 to 8 months since death).
3	Old: bones scattered and bleached (probably died during or before the last rainy season, i.e. more than 8 months old, but generally more than 1 year old and up to several years old).

The carcass “ratio”, sensu Douglas-Hamilton et al. (1992), (although it is not a ratio, but a percentage) was calculated as the estimated number of all elephant carcasses (i.e. age categories 1, 2 and 3) as a percentage of the estimated number of all elephants (i.e. live + dead).

In Zimbabwe and Mozambique, carcasses that could not be identified as elephant carcasses were counted as “unidentified carcasses”. Ground hornbills are large and conspicuous birds and any seen during the surveys in Zimbabwe and Mozambique were counted. Hippos and poachers’ camps were also counted in Zimbabwe and Mozambique. Poachers’ camps can be identified by the presence of meat racks (horizontal branches mounted above the ground), with or without meat, or meat hanging in trees.

All strata were surveyed during the period 7-24 September 2003 (Table 1).

Strip Width and Calibration for Transect Surveys

For the transect surveys, two fishing rods were attached with custom brackets to each wing strut, so that the rods pointed backwards and parallel to the ground during level flight. The distance between the rods on each strut was arranged so that, when the aircraft was flying at 300 feet agl, this distance represented a strip about 150 m



wide on the ground. Each rod was marked with a small piece of tape to provide the observers with a “decision point” (it was at this point that the observer decided whether an animal was inside the strip). When deciding whether animals were inside or outside the strip, each observer moved his or her eye so as to align the tape on the outer rod with a small piece of tape on his or her window, thereby ensuring that all his or her decisions were made at the same viewing angle.

The strip widths were calibrated by flying the aircraft at right angles across an airstrip that had two sets of large-sized numbers (from 0 to 35) arranged at 10-meter intervals along the side of the airstrip. The numbers were arranged as 35 34 33.....2 1 0 1 2.....33 34 35, with 0 near the centre of the airstrip. Each observer noted the largest and smallest number within his strip and the recorder noted the aircraft’s height above ground level. (Ideally, the flights across the airstrip should be made at differing heights above the ground, within the approximate range 250 - 350 feet above ground level.) The combined strip widths (in meters) were adjusted to 300 feet above ground level:

Combined strip width at 300 feet =	Actual combined strip width x 300
	Actual flying height

The combined strip widths, after adjustment to 300 feet above ground level, were then averaged to give the nominal (calibrated) combined strip width at 300 feet. This was 355 m for the surveys in Zimbabwe and Mozambique and 340 m for the survey in Zambia.

Data Analysis

Transect surveys: Population estimates and confidence intervals for individual transect strata were calculated with WWF SARPO’s custom software (AIRSURVW, version dated 22/05/97), which uses Jolly’s (1969) method 2 for unequal-sized sample units. Given the mean combined strip width when the plane was flying at 300 feet and the mean flying height for each transect¹, the software determined the actual combined strip width for each transect. The actual combined strip width was the product of the nominal strip width at 300 ft and the mean height for the transect, divided by 300. The area of each transect was calculated as the product of the actual combined strip width and the transect length. Transects near the boundary of a stratum were often broken into two or more sections, with land outside the stratum between the sections. For the purposes of analysis, data for all sections of the same transect were combined and entered into the program as one transect. Calculation of the variance of a population estimate requires the calculation of N, the total number of

transects that could have been used in the survey of a stratum. The value of N for a stratum is found by dividing the baseline length by the mean actual strip width for that stratum (see Price Waterhouse 1996, appendix 1, page 5).

Thus, for each stratum, N was calculated as:

N =	Baseline length x 1000 x 300
	Nominal strip width x Average flying height

where:

Baseline length = length (in km) of a straight line aligned at right angles to the orientation of the transects, and running from one end of the stratum to the far end;

Nominal strip width = calibrated combined strip width (in m) when flying at 300 feet agl; and

Average flying height = Mean of the mean flying heights (in feet) for all transects in the stratum.

The value of Student’s t used to calculate the confidence interval of a population estimate was t_{n-1} for P = 0.05 (Rohlf & Sokal 1981), where n = number of transects in stratum.

Block counts: For block count strata in Zimbabwe and Mozambique, population estimates and confidence intervals for individual strata were calculated using Jolly’s (1969) method 3 for unequal-sized sample units selected randomly with a probability proportional to their area.

For block count strata in Zambia, population estimates and confidence intervals for individual strata were calculated using Jolly’s (1969) method 2 for unequal-sized sample units selected randomly, with all sample units having the same probability of selection irrespective of their size.

For all block count strata, n = number of blocks surveyed in stratum. When block selection was with replacement (Zimbabwe and Mozambique) and one or more blocks were selected more than once, these blocks were included more than once in the analysis, although they were searched just once (Jolly 1969). In these circumstances, n = number of blocks selected, which was greater than the number searched.

Combining population estimates from several strata:

A population estimate for the entire study area, and for various land units (e.g. national parks, safari areas) within it, was calculated as the sum of the estimates for the individual strata within the study area or land unit. The

confidence interval for such a population estimate was calculated as:

$t \times$ square root of (Sum of Variances for individual strata) where:

v = the degrees of freedom estimated by Satterthwaite's rule (Snedecor & Cochran 1980, Gasaway *et al.* 1986). v was an integer, calculated using the formula:

$v =$	(Sum of Variances for individual strata) ²
	Sum of [(Variance for individual stratum) ² / (n-1)]

with the outcome of this formula rounded down to the nearest integer. Calculations were undertaken in a spreadsheet and t_v was calculated using the EXCEL function TINV(0.05, v).

Search intensity: Search intensity (in minutes per square kilometre) for a stratum was defined as the total time spent flying all transects (or blocks) within that stratum, divided by the total area of those same transects (or blocks). The greater the search intensity, the greater the probability that the observers saw all the animals that were within the strips (or blocks).

Some large herbivores, e.g. kudu, are not easily seen from the air and their numbers were undoubtedly underestimated. Nonetheless, population estimates are given for these species, because the estimates provide useful indices of abundance (with measures of precision) that can be used to determine spatial distribution, as well as temporal trends in population number. No corrections have been applied to any of the estimates to compensate for any undercounting or missed animals.

RESULTS

The estimated numbers of elephants, old carcasses of elephants, buffalo, sable, zebra, waterbuck, kudu, eland, roan antelope, impala, warthog, cattle, sheep and goats in the Zambezi Heartland are given in Tables 2 to 14. The estimated numbers of elephant bulls in bull groups, elephants in cow herds, hippos, donkeys, poachers' camps, ground hornbills and unidentified carcasses in the Zimbabwean and Mozambican sections of the survey area are given in Tables 15 to 21.

Estimates are given for each stratum, for each country and for the Zambezi Heartland. Separate estimates are provided for Mana Pools National Park, Lower Zambezi National Park, Charara Safari Area, Hurungwe Safari

Area, Sapi Safari Area and Chiawa Game Management Area. Only part of Chewore Safari Area was surveyed. Confidence intervals (CI) and confidence limits (CL) are 95 % confidence intervals and limits. "No. seen" is the number seen in the strips during the survey. There may appear to be small errors in the sums given in some tables, but these are simply rounding errors: population estimates, variances and sums were calculated with great precision in a spreadsheet before being rounded to zero decimal places. The spatial variation in the density of the principal wildlife species within the Zambezi Heartland is shown in Maps 3 to 15. To facilitate comparisons, these maps follow the same format as that used to report the results of previous surveys in the Heartland (Mackie 2001, 2002).

DISCUSSION

Search Intensity

Overall, search intensity averaged 0.83 minutes km⁻² (Table 1). However, search intensity was particularly high in the five Zimbabwean strata surveyed by block counts and when the search times for these strata are excluded from the calculation, the overall mean search intensity declined to 0.69 minutes km⁻². Search intensity was less during 2003 than during similar surveys during 2001 (Mackie 2001, 2002).

Elephants

There were estimated to be 23,221 elephants in the Heartland survey area (Table 2). However, some strata that were included in the 2001 survey were not surveyed during 2003 and these strata contained an estimated 2,859 elephants during 2001 (Mackie 2002). If these strata contained a similar number of elephants during 2003, this suggests that the Zambezi Heartland contained a population of about 26,000 elephants during the 2003 dry season.

Elephant Carcasses

No fresh carcasses (category 1) of elephants were counted during the survey. Just one recent carcass (category 2) of an elephant was counted, in the Rifa stratum. This observation produced an estimate of 8 recent carcasses in both the Rifa stratum (variance = 52, % CI = 206.7, LCL = 0, UCL = 23, density = 0.01 km⁻²) and in the Heartland. Elephant carcass 'ratios' were generally below 8 %, except in some communal land strata where few or no live elephants were seen (Map 4), but the 'ratio' was 14.3 % in the Rifa stratum. The Rifa stratum was also the only Zimbabwean stratum with a high carcass 'ratio' during 2001 (Mackie 2002).



Domestic Livestock

Most domestic livestock were in the communal lands, but some cattle were counted in Lower Zambezi National Park, and cattle, sheep and goats were observed in Charara Safari Area.

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- The WWF SARPO is thanked for permitting its survey design and analysis software to be used, thereby ensuring that the analytical methods were identical to those used during previous surveys within the Zambezi Heartland.



Table 1. Sampling statistics for the 2003 aerial survey of large herbivores in the Zambezi Heartland

(^a weighted mean)

Stratum	Area (km ²)	Transect spacing (km)	Transect orientation (°)	Number of transects or blocks (= n)	Percent of stratum sampled	Time and Date sampled (September)	Flying time (hours) for transects or blocks	Search intensity (minutes per km ²)
Zimbabwe								
Rifa	619	2.9	90	13	13.2	pm 9	1.02	0.75
Hurungwe	1234	2.1	0	27	17.6	am 10	2.67	0.77
Mana I	325	2	0	25	18.6	pm 10	0.66	0.66
Mana II	1361	2.4	90	19	15.4	am 11	2.48	0.71
Sapi South	782	2.4	90	16	15.4	pm 12	1.43	0.71
Sapi North	321	2	0	17	18.3	pm 11	0.75	0.77
Chewore I	840	2	90	20	19.5	am 18	1.86	0.68
Chewore III	897	2	90	19	18.6	am 11	1.97	0.71
Dande	981	2	0	20	18.7	am 17	2.35	0.77
Chapoto	267	2.9	90	9	13.2	pm 17	0.47	0.8
Chisunga	768	7.4	90	5	4.9	pm 16	0.52	0.82
Kanyurira	227	4.2	90	4	9.5	pm 16	0.27	0.75
Kadze	1379	4.5	90	7	8.7	am 16	1.63	0.82
Charara	726			9	17.9	am/pm 7/8/9	5.47	2.52
Hurungwe I	674			13	16.8	am/pm 11/12	3.27	1.73
Hurungwe II	527			8	21.8	am/pm 10/14	2.07	1.08
Charara South	944			16	16.8	pm 10	4.33	1.64
Mana Pools III	501			12	18.9	am/pm 17/18	2.82	1.74
National Total / Mean	13373				15.6^a			1.02
Mozambique								
Magoe 1	348	2	0	13	18.2	pm 21	0.83	0.79
Magoe 2	343	2	0	15	18.4	pm 21	0.88	0.84
Magoe 3	135	4	0	5	9.2	pm 19	0.18	0.87
Magoe 4	656	3.7	90	7	8.8	am 21	0.72	0.75
Magoe 5	747	2.3	90	11	16.4	pm 22	1.47	0.72
Magoe 6	392	5	90	5	7	pm 19	0.3	0.66
Metamboa	464	2.5	90	9	14.8	am 23	1.05	0.92
Mecucoe	755	2.5	0	19	14.8	am 22	1.38	0.74
Tongoe	332	2.5	90	9	14.4	am 23	0.63	0.79
Luangwa	1171	2.5	90	23	14.4	am 19	2.27	0.81
Zumbo	247	2.5	0	17	14.6	pm 21	0.45	0.75
NCB 7	739			10	29.1	21/22	3.17	0.88
National Total / Mean	6329				15.7^a			0.79



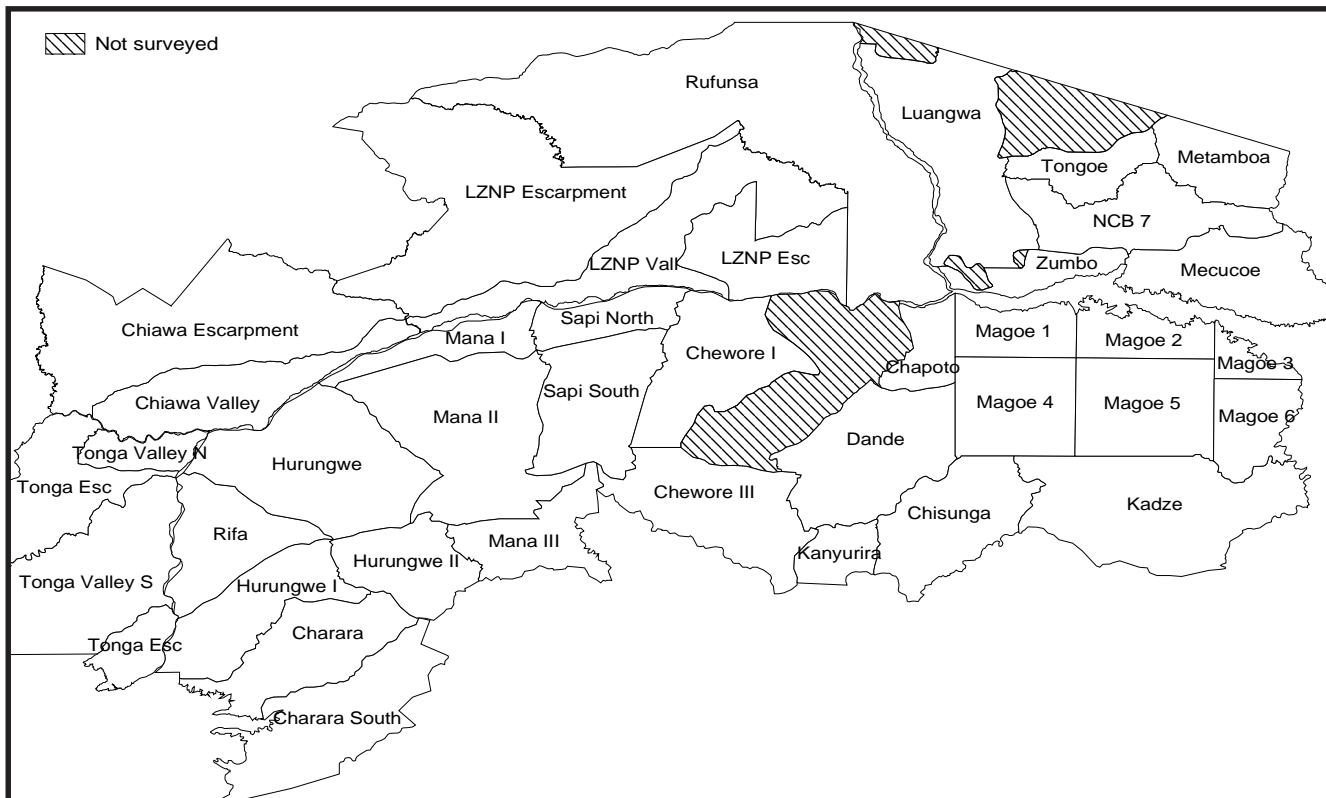
Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Area (km ²)	Transect spacing (km)	Transect orientation (°)	Number of transects or blocks (= n)	Percent of stratum sampled	Time and Date sampled (September)	Flying time (hours) for transects or blocks	Search intensity (minutes per km ²)
Zambia								
Lower Zambezi NP Valley	1107	2.5	0	41	12.4	pm 7/8	1.95	0.85
Chiawa Valley	761	2.5	0	27	13.3	am 8	1.45	0.86
Tonga-Sikongo Valley North	212	2.5	0	11	14.1	am 7	2.33	0.79
Tonga-Sikongo Valley South	1117	2.5	0	14	13.1	am 7		
Lower Zambezi NP Escarpment	2977			8	19.5	pm 22/ am 23/ am 24	4.82	0.5
Chiawa Escarpment	1779			4	10.2	pm 16/17/18	2.13	0.71
Tonga-Sikongo Escarpment	873			2	24.8	am 18	1.33	0.37
Rufunsa GMA	3128			5	11.8	am 19/ pm 23/ am 24	3.48	0.57
National Total / Mean	11954				14.7^a			0.66
Heartland Total / Mean	31656				15.3^a			0.83^a

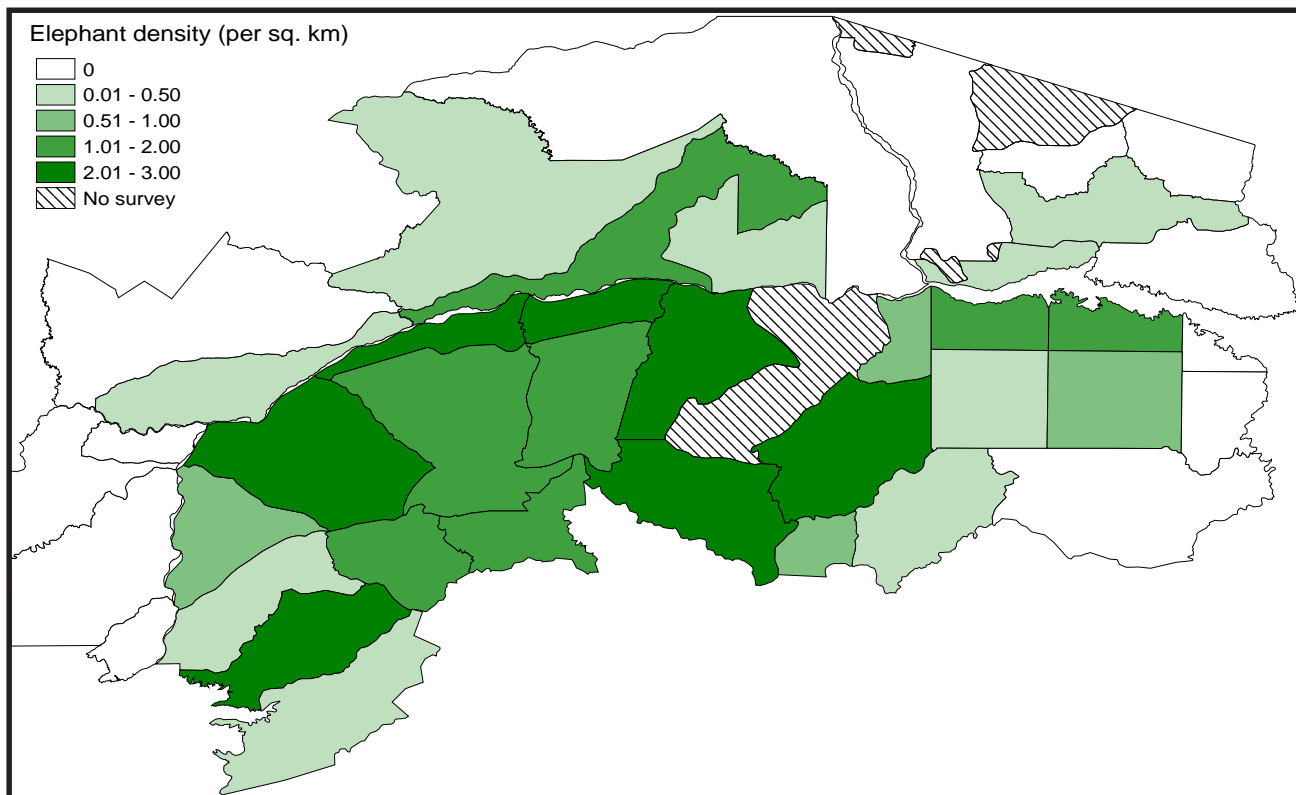
Map 1. Land use within the Zambezi Heartland study area.



Map 2. Strata for the 2003 survey of the Zambezi Heartland



Map 3. Distribution of elephants in the Zambezi Heartland during September 2003



Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	889	165	41717	47.4	467	1310	2.74
Mana Pools II	2399	370	161464	35.2	1555	3243	1.76
Mana Pools III	998	177	81473	63	370	1626	1.95
Subtotals	4285	712	284653	25.2	3205	5365	1.96
Hurungwe Safari Area							
Rifa	591	78	42460	76	142	1040	0.95
Hurungwe	3225	566	305489	35.2	2088	4361	2.61
Hurungwe I	305	47	20860	103.3	0	619	0.45
Hurungwe II	612	138	25046	61.2	238	986	1.16
Subtotals	4732	829	393856	26.8	3463	6000	1.55
Sapi Safari Area							
Sapi North	873	160	63752	61.3	338	1408	2.72
Sapi South	1317	203	85845	47.4	693	1941	1.68
Subtotals	2190	363	149597	36.1	1400	2980	1.99
Chewore Safari Area							
Chewore I	1801	351	103022	37.3	1129	2473	2.14
Chewore III	2310	430	99121	28.6	1648	2971	2.58
Subtotals	4111	781	202143	22.2	3199	5023	2.37
Charara Safari Area							
Charara	1577	213	174468	55.9	696	2458	2.17
Charara South	236	40	10207	91.1	21	452	0.25
Subtotals	1813	253	184675	49.8	911	2716	1.09
Dande Safari Area and Guruve District communal lands							
Chapoto	160	21	9555	141.2	0	385	0.6
Dande	2257	422	213478	42.8	1290	3224	2.3
Kanyurira	169	16	7122	158.8	0	438	0.75
Chisunga	264	13	44820	222.7	0	852	0.34
Kadze	0	0	0	0	0	0	0
Subtotals	2850	472	274975	37.9	1770	3930	0.79
National Subtotals	19981	3410	1489899	12.1	17572	22390	1.49
MOZAMBIQUE							
Magoe District							
Magoe 1	468	85	40291	93.5	30	905	1.34
Magoe 2	545	100	87858	116.7	0	1181	1.59
Magoe 3	0	0	0	0	0	0	0
Magoe 4	171	15	11174	151.1	0	430	0.26
Magoe 5	444	73	24589	78.7	95	793	0.59
Magoe 6	0	0	0	0	0	0	0
Subtotals	1628	273	163911	50.5	805	2451	0.62
North of Lake Cabora Bassa							
Luangwa	0	0	0	0	0	0	0
Tongoe	0	0	0	0	0	0	0
Metamboia	0	0	0	0	0	0	0
NCB 7	15	4	218	226.2	0	48	0.02
Zumbo	76	11	5528	208.5	0	233	0.31
Mecucoc	0	0	0	0	0	0	0
Subtotals	90	15	5747	176.9	0	250	0.02
National Subtotals	1718	288	169658	48.6	884	2553	0.27
ZAMBIA							
Lower Zambezi National Park							
LZNP Valley	1216	151	105390	54	560	1872	1.1
LZNP Escarpment	261	51	38766	178.3	0	727	0.09
Subtotals	1477	202	144156	51.9	711	2243	0.37
Chiawa Game Management Area							
Chiawa Valley	45	6	742	124.2	0	101	0.06
Chiawa Escarpment	0	0	0	0	0	0	0
Subtotals	45	6	742	124.2	0	101	0.02
Rufunsa Game Management Area							
Rufunsa	0	0	0	0	0	0	0
Tongo communal lands							
Tongo Valley North	0	0	0	0	0	0	0
Tongo Valley South	0	0	0	0	0	0	0
Tongo Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	1522	208	144898	50.5	754	2290	0.13
Heartland Totals	23221	3906	1804455	11.4	20575	25868	0.73

Table 2. Population estimates and statistics for Elephant in the Zambezi Heartland.

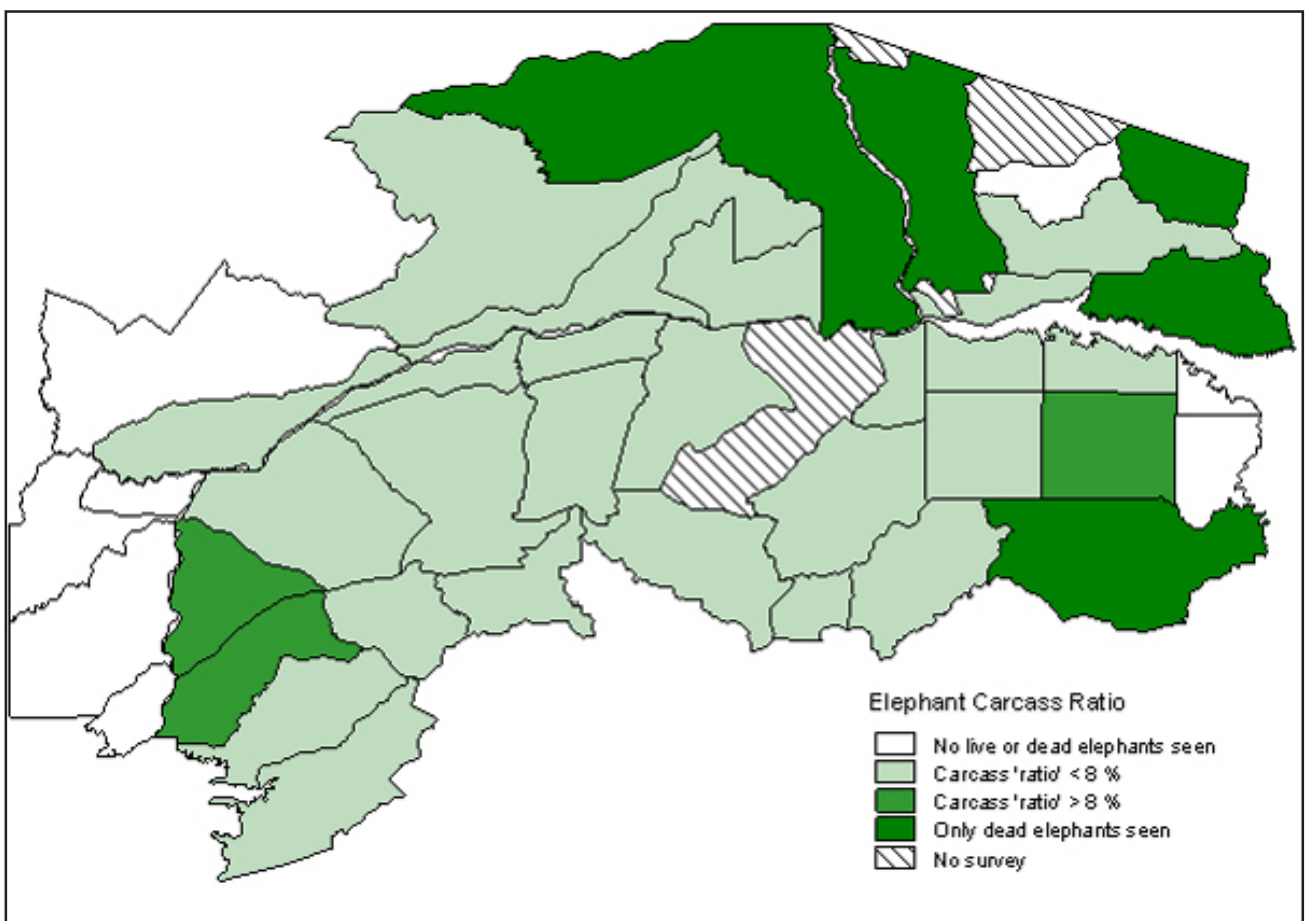


Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)	Carcass Ratio
ZIMBABWE								
Mana Pools National Park								
Mana Pools I	11	2	45	128.5	0	25	0.03	1.2
Mana Pools II	78	12	217	39.8	47	109	0.06	3.14
Mana Pools III	0	0	0	0	0	0	0	0
Subtotals	89	14	262	37.7	55	122	0.04	2.02
Hurungwe Safari Area								
Rifa	91	12	568	57.2	39	143	0.15	14.29
Hurungwe	57	10	361	68.6	18	96	0.05	1.74
Hurungwe I	30	4	429	149.3	0	75	0.04	9.03
Hurungwe II	11	3	65	167.6	0	31	0.02	1.83
Subtotals	189	29	1424	40.2	113	266	0.06	4
Sapi Safari Area								
Sapi North	5	1	27	202.1	0	16	0.02	0.62
Sapi South	19	3	88	102.5	0	39	0.03	1.46
Subtotals	25	4	115	88.9	3	47	0.02	1.13
Chewore Safari Area								
Chewore I	21	4	73	86.8	3	38	0.02	1.13
Chewore III	27	5	367	149.8	0	67	0.03	1.15
Subtotals	47	9	439	91.3	4	91	0.03	1.14
Charara Safari Area								
Charara	10	2	43	145	0	23	0.01	0.6
Charara South	5	1	24	213.1	0	15	0.01	2.04
Subtotals	14	3	67	115.8	0	31	0.01	0.79
Dande Safari Area and Guruve District communal lands								
Chapoto	0	0	0	0	0	0	0	0
Dande	27	5	155	97.5	1	53	0.03	1.17
Kanyurira	0	0	0	0	0	0	0	0
Chisunga	20	1	451	290.4	0	79	0.03	7.14
Kadze	12	1	139	249.6	0	40	0.01	100
Subtotals	59	7	745	103.8	0	119	0.02	2.01
National Subtotals	423	66	3052	26	313	533	0.03	2.11
MOZAMBIQUE								
Magoe District								
Magoe 1	28	5	139	93.4	2	53	0.08	5.56
Magoe 2	33	6	104	66.9	11	55	0.1	5.66
Magoe 3	0	0	0	0	0	0	0	0
Magoe 4	0	0	0	0	0	0	0	0
Magoe 5	43	7	171	68.4	13	72	0.06	8.75
Magoe 6	0	0	0	0	0	0	0	0
Subtotals	103	18	414	40.3	61	144	0.04	5.94
North of Lake Cabora Bassa								
Luangwa	42	6	422	102	0	84	0.04	100
Tongoe	0	0	0	0	0	0	0	0
Metamboia	7	1	41	217.6	0	22	0.02	100
NCB 7	0	0	0	0	0	0	0	0
Zumbo	0	0	0	0	0	0	0	0
Mecucocoe	7	1	37	188.3	0	20	0.01	100
Subtotals	55	8	500	82.7	10	101	0.01	37.97
National Subtotals	158	26	914	38.2	98	219	0.02	8.43
ZAMBIA								
Lower Zambezi National Park								
LZNP Valley	8	1	39	156.8	0	21	0.01	0.66
LZNP Escarpment	5	1	18	196.9	0	15	0	1.92
Subtotals	13	2	57	116.2	0	28	0	0.88
Chiawa Game Management Area								
Chiawa Valley	0	0	0	0	0	0	0	0
Chiawa Escarpment	0	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0	0
Rufunsa Game Management Area								
Rufunsa	8	1	40	205.9	0	26	0	100
Tongo communal lands								
Tongo Valley North	0	0	0	0	0	0	0	0
Tongo Valley South	0	0	0	0	0	0	0	0
Tongo Escarpment	0	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0	0
National Subtotals	22	3	97	95.1	1	42	0	1.4
Heartland Totals	603	95	4062	20.9	477	729	0.02	2.56

Table 3. Population estimates and statistics for Elephant Carcasses 3 and carcass ratios (for all elephant carcasses) in the Zambezi Heartland

Map 4. Distribution of elephant carcasses in the Zambezi Heartland during September 2003

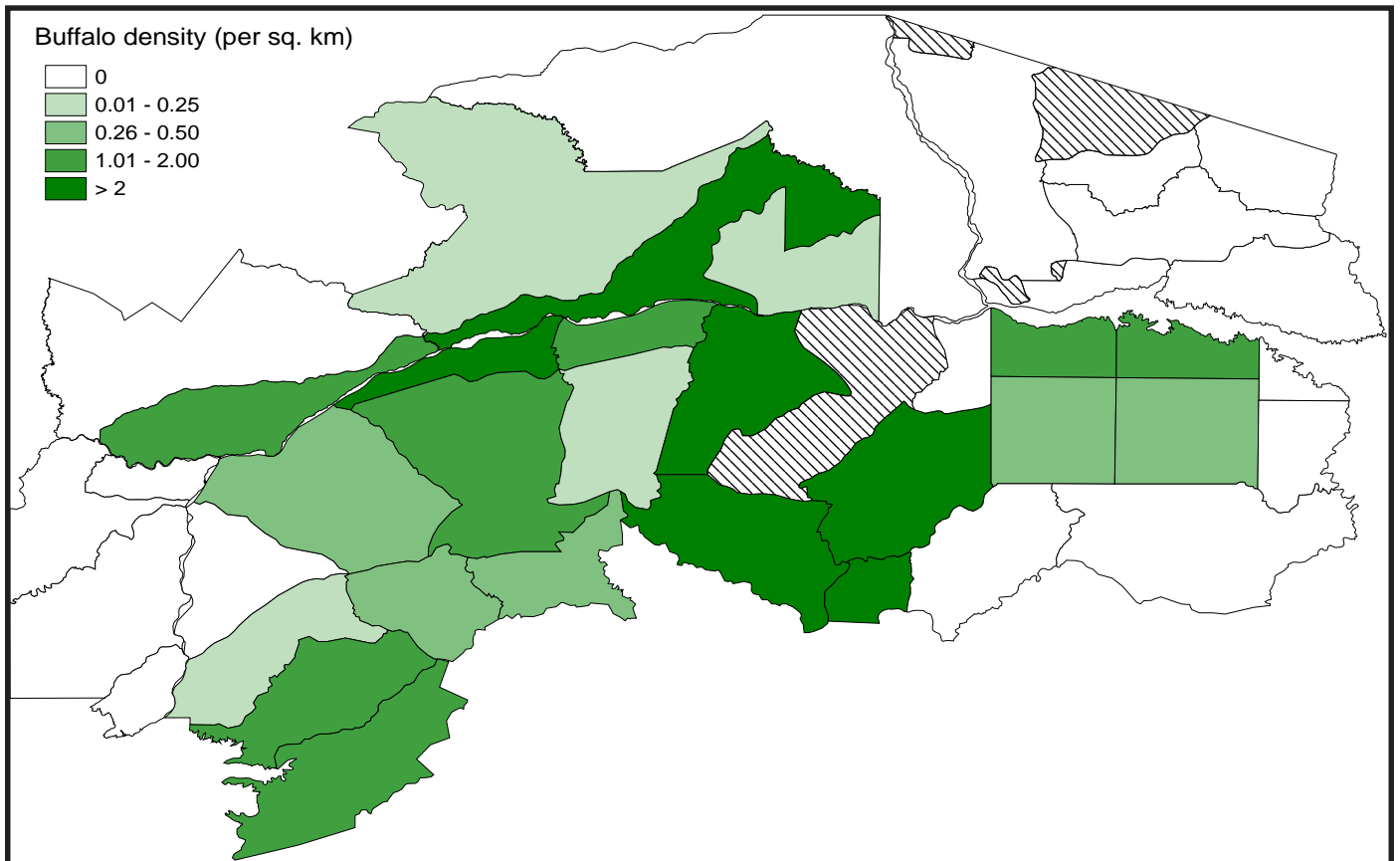


Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	2655	493	2021489	110.5	0	5590	8.17
Mana Pools II	2075	320	967572	99.6	8	4141	1.52
Mana Pools III	241	55	12895	103.8	0	491	0.47
Subtotals	4971	868	3001956	70.4	1469	8473	2.27
Hurungwe Safari Area							
Rifa	0	0	0	0	0	0	0
Hurungwe	536	94	89259	114.7	0	1150	0.43
Hurungwe I	10	2	48	158.4	0	25	0.01
Hurungwe II	165	40	27122	236.5	0	554	0.31
Subtotals	710	136	116429	97.9	15	1405	0.23
Sapi Safari Area							
Sapi North	568	104	113371	125.8	0	1281	1.77
Sapi South	39	6	635	138	0	93	0.05
Subtotals	606	110	114006	118	0	1322	0.55
Chewore Safari Area							
Chewore I	2273	443	1205078	101.1	0	4571	2.71
Chewore III	2804	522	2715614	123.5	0	6266	3.13
Subtotals	5077	965	3920692	79.5	1039	9115	2.92
Charara Safari Area							
Charara	971	208	236325	105.6	0	1997	1.34
Charara South	1490	260	775900	126	0	3367	1.58
Subtotals	2461	468	1012225	84.6	380	4542	1.47
Dande Safari Area and Guruve District communal lands							
Chapoto	0	0	0	0	0	0	0
Dande	4878	912	4026347	86.1	678	9077	4.97
Kanyurira	824	78	721427	327.9	0	3527	3.63
Chisunga	0	0	0	0	0	0	0
Kadze	0	0	0	0	0	0	0
Subtotals	5702	990	4747774	79.5	1171	10233	1.57
National Subtotals	19527	3537	12913082	36.5	12391	26663	1.46
MOZAMBIQUE							
Magoe District							
Magoe 1	578	105	274787	197.6	0	1720	1.66
Magoe 2	599	110	126799	127.5	0	1363	1.75
Magoe 3	0	0	0	0	0	0	0
Magoe 4	171	15	20729	205.8	0	523	0.26
Magoe 5	213	35	41892	214.2	0	669	0.29
Magoe 6	0	0	0	0	0	0	0
Subtotals	1561	265	464207	89.4	166	2957	0.6
North of Lake Cabora Bassa							
Luangwa	0	0	0	0	0	0	0
Tongoe	0	0	0	0	0	0	0
Metambo	0	0	0	0	0	0	0
NCB 7	0	0	0	0	0	0	0
Zumbo	0	0	0	0	0	0	0
Mecucoe	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	1561	265	464207	89.4	166	2957	0.25
ZAMBIA							
Lower Zambezi National Park							
LZNP Valley	5629	699	10607285	116.9	0	12211	5.09
LZNP Escarpment	128	25	9551	180.6	0	359	0.04
Subtotals	5757	724	10616836	114.4	0	12342	1.45
Chiawa Game Management Area							
Chiawa Valley	902	120	758605	198.6	0	2692	1.19
Chiawa Escarpment	0	0	0	0	0	0	0
Subtotals	902	120	758605	198.6	0	2692	0.36
Rufunsa Game Management Area							
Rufunsa	0	0	0	0	0	0	0
Tongo communal lands							
Tongo Valley North	0	0	0	0	0	0	0
Tongo Valley South	0	0	0	0	0	0	0
Tongo Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	6658	844	11375441	102	0	13451	0.56
Heartland Totals	27747	4646	24752730	35.5	17905	37588	0.88

Table 4. Population estimates and statistics for Buffalo in the Zambezi Heartland

Map 5. Distribution of buffaloes in the Zambezi Heartland during September 2003

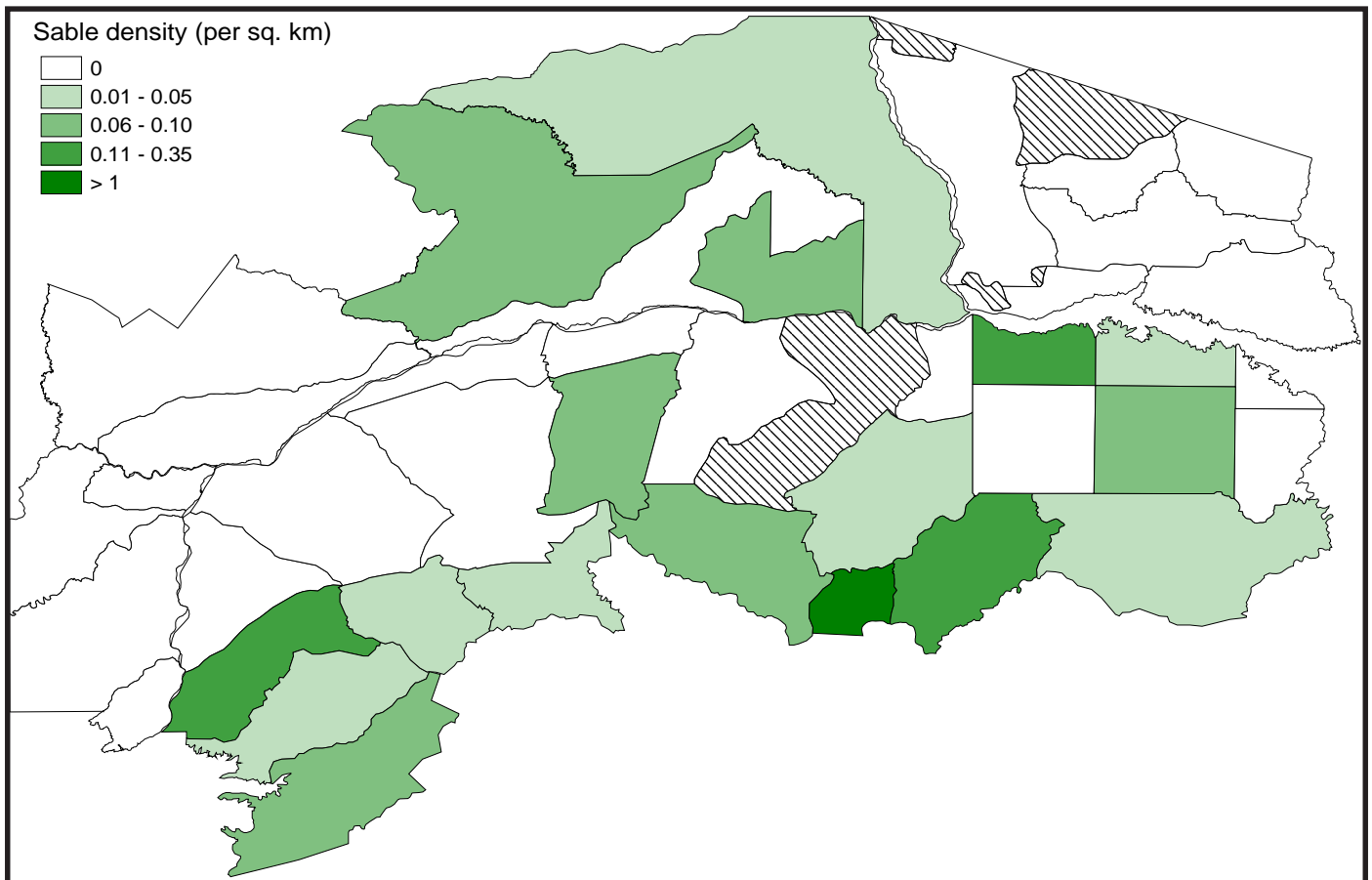


Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	0	0	0	0	0	0	0
Mana Pools II	0	0	0	0	0	0	0
Mana Pools III	23	6	542	220.1	0	74	0.05
Subtotals	23	6	542	220.1	0	74	0.01
Hurungwe Safari Area							
Rifa	0	0	0	0	0	0	0
Hurungwe	0	0	0	0	0	0	0
Hurungwe I	170	36	8242	116.3	0	368	0.25
Hurungwe II	26	7	656	236.5	0	86	0.05
Subtotals	196	43	8898	104.1	0	400	0.06
Sapi Safari Area							
Sapi North	0	0	0	0	0	0	0
Sapi South	58	9	853	106.6	0	121	0.08
Subtotals	58	9	853	106.6	0	121	0.05
Chewore Safari Area							
Chewore I	0	0	0	0	0	0	0
Chewore III	48	9	1719	180.2	0	135	0.05
Subtotals	48	9	1719	180.2	0	135	0.03
Charara Safari Area							
Charara	28	5	543	175	0	77	0.04
Charara South	79	16	6188	213.1	0	246	0.08
Subtotals	107	21	6731	162.1	0	280	0.06
Dande Safari Area and Guruve District communal lands							
Chapoto	0	0	0	0	0	0	0
Dande	37	7	1199	193.6	0	110	0.04
Kanyurira	233	22	22643	205.9	0	711	1.02
Chisunga	142	7	19839	275.2	0	533	0.19
Kadze	12	1	144	254.2	0	41	0.01
Subtotals	424	37	43825	116.9	0	919	0.12
National Subtotals	856	125	62567	62.7	320	1393	0.06
MOZAMBIQUE							
Magoe District							
Magoe 1	110	20	6881	164.2	0	291	0.32
Magoe 2	5	1	24	192.9	0	16	0.02
Magoe 3	0	0	0	0	0	0	0
Magoe 4	0	0	0	0	0	0	0
Magoe 5	67	11	3365	193.1	0	196	0.09
Magoe 6	0	0	0	0	0	0	0
Subtotals	182	32	10269	115.9	0	394	0.07
North of Lake Cabora Bassa							
Luangwa	0	0	0	0	0	0	0
Tongoe	0	0	0	0	0	0	0
Metamboia	0	0	0	0	0	0	0
NCB 7	0	0	0	0	0	0	0
Zumbo	0	0	0	0	0	0	0
Mecucoe	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	182	32	10269	115.9	0	394	0.03
ZAMBIA							
Lower Zambezi National Park							
LZNP Valley	0	0	0	0	0	0	0
LZNP Escarpment	215	42	15640	137.5	0	511	0.07
Subtotals	215	42	15640	137.5	0	511	0.05
Chiawa Game Management Area							
Chiawa Valley	0	0	0	0	0	0	0
Chiawa Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Rufunsa Game Management Area							
Rufunsa	8	1	41	208.8	0	26	0
Tongo communal lands							
Tongo Valley North	0	0	0	0	0	0	0
Tongo Valley South	0	0	0	0	0	0	0
Tongo Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	224	43	15681	132.5	0	520	0.02
Heartland Totals	1262	200	88518	48.7	648	1876	0.04

Table 5. Population estimates and statistics for Sable in the Zambezi Heartland

Map 6. Distribution of sable antelopes in the Zambezi Heartland during September 2003

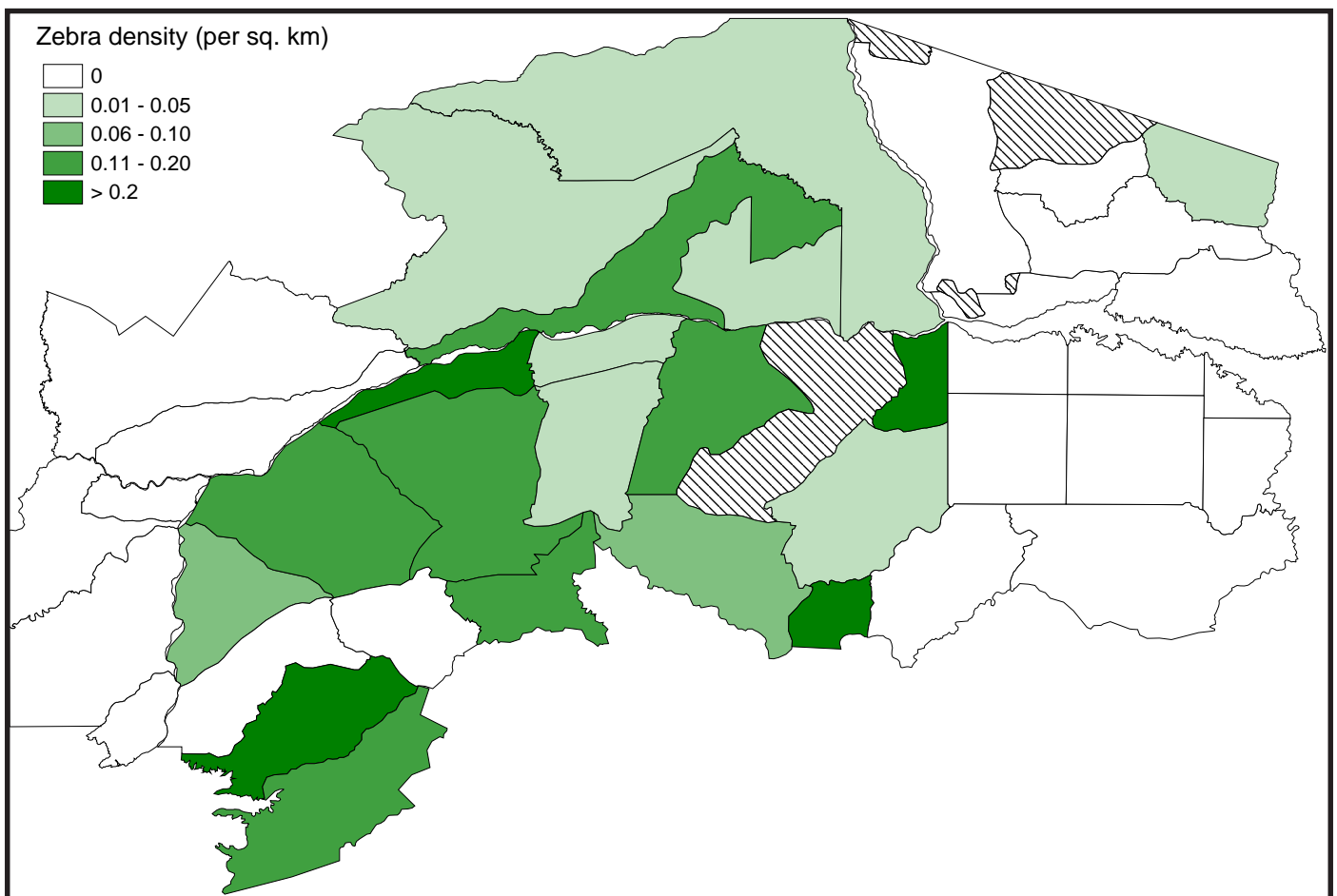


Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	285	53	5424	53.2	133	437	0.88
Mana Pools II	194	30	10956	113.1	0	414	0.14
Mana Pools III	64	12	1862	148.4	0	159	0.13
Subtotals	544	95	18242	50.2	271	817	0.25
Hurungwe Safari Area							
Rifa	38	5	857	168.5	0	102	0.06
Hurungwe	171	30	5127	86.1	24	318	0.14
Hurungwe I	0	0	0	0	0	0	0
Hurungwe II	0	0	0	0	0	0	0
Subtotals	209	35	5984	75.4	51	366	0.07
Sapi Safari Area							
Sapi North	16	3	243	201.8	0	49	0.05
Sapi South	39	6	1177	187.8	0	112	0.05
Subtotals	55	9	1420	142.1	0	134	0.05
Chewore Safari Area							
Chewore I	113	22	1677	75.9	27	199	0.13
Chewore III	64	12	1284	116.8	0	140	0.07
Subtotals	177	34	2961	62.2	67	288	0.1
Charara Safari Area							
Charara	149	27	9928	141.1	0	359	0.21
Charara South	107	10	7948	178.1	0	297	0.11
Subtotals	256	37	17876	106.6	0	528	0.15
Dande Safari Area and Gुरुve District communal lands							
Chapoto	137	18	4734	115.9	0	296	0.51
Dande	16	3	225	195.7	0	47	0.02
Kanyurira	53	5	954	186	0	151	0.23
Chisunga	0	0	0	0	0	0	0
Kadze	0	0	0	0	0	0	0
Subtotals	206	26	5913	82.3	36	375	0.06
National Subtotals	1447	236	52395	31.3	994	1900	0.11
MOZAMBIQUE							
Magoé District							
Magoé 1	0	0	0	0	0	0	0
Magoé 2	0	0	0	0	0	0	0
Magoé 3	0	0	0	0	0	0	0
Magoé 4	0	0	0	0	0	0	0
Magoé 5	0	0	0	0	0	0	0
Magoé 6	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
North of Lake Cabora Bassa							
Luangwa	0	0	0	0	0	0	0
Tongoe	0	0	0	0	0	0	0
Metamboá	20	3	418	231.9	0	68	0.04
NCB 7	0	0	0	0	0	0	0
Zumbo	0	0	0	0	0	0	0
Mecucóe	0	0	0	0	0	0	0
Subtotals	20	3	418	231.9	0	68	0.01
National Subtotals	20	3	418	231.9	0	68	0
ZAMBIA							
Lower Zambezi National Park							
LZNP Valley	161	20	4193	81.3	30	292	0.15
LZNP Escarpment	5	1	18	196.9	0	15	0
Subtotals	166	21	4211	78.9	35	297	0.04
Chiawa Game Management Area							
Chiawa Valley	0	0	0	0	0	0	0
Chiawa Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Rufunsa Game Management Area							
Rufunsa	42	5	988	205.9	0	130	0.01
Tongo communal lands							
Tongo Valley North	0	0	0	0	0	0	0
Tongo Valley South	0	0	0	0	0	0	0
Tongo Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	209	26	5200	69.9	63	354	0.02
Heartland Totals	1676	265	58013	28.4	1200	2152	0.05

Table 6. Population estimates and statistics for Zebra in the Zambezi Heartland

Map 7. Distribution of zebras in the Zambezi Heartland during September 2003

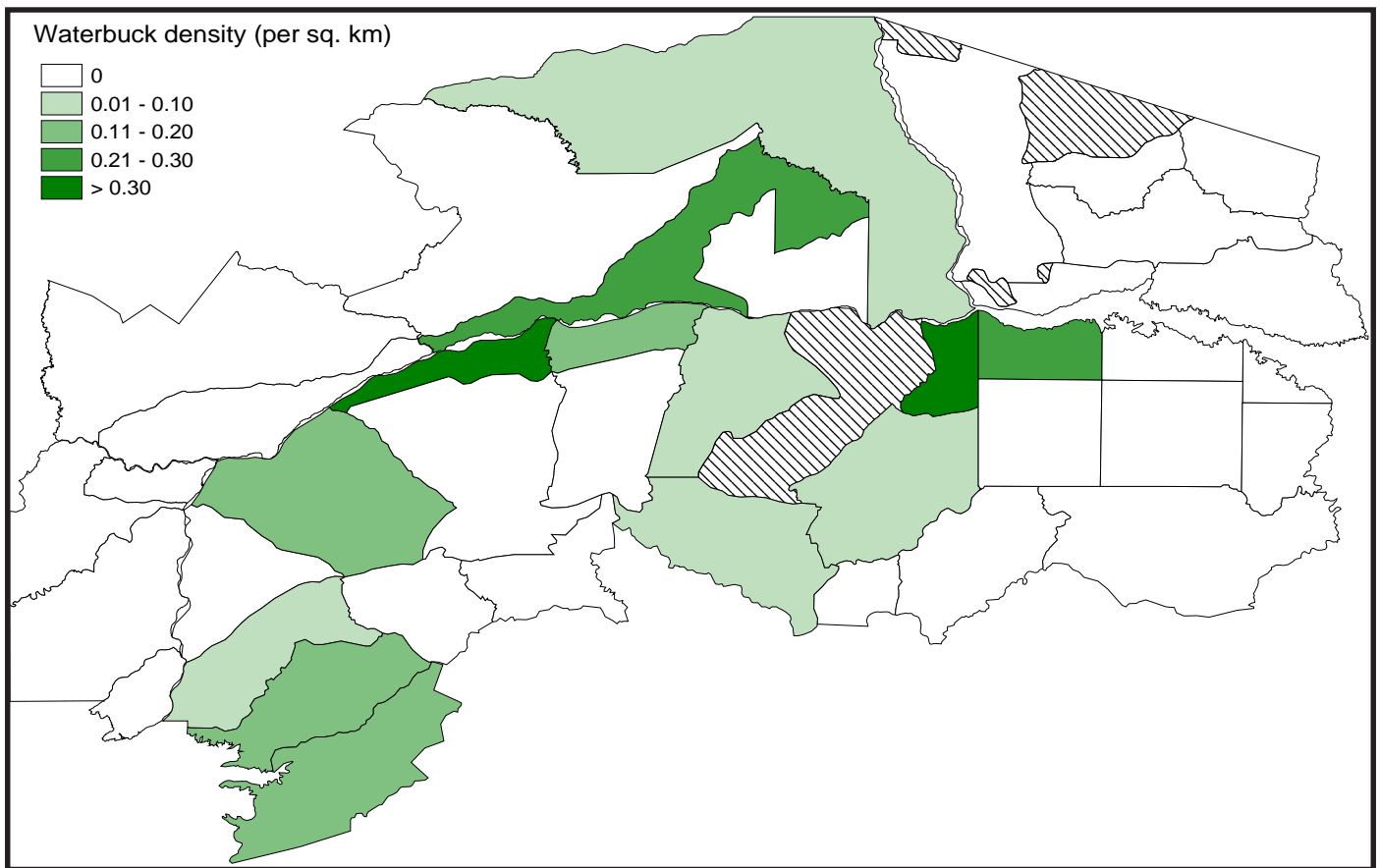


Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	463	86	11764	48.3	239	687	1.43
Mana Pools II	0	0	0	0	0	0	0
Mana Pools III	0	0	0	0	0	0	0
Subtotals	463	86	11764	48.3	239	687	0.21
Hurungwe Safari Area							
Rifa	0	0	0	0	0	0	0
Hurungwe	137	24	3301	86.4	19	255	0.11
Hurungwe I	3	1	11	217.9	0	10	0
Hurungwe II	0	0	0	0	0	0	0
Subtotals	140	25	3312	84.5	22	258	0.05
Sapi Safari Area							
Sapi North	55	10	1359	143.2	0	133	0.17
Sapi South	0	0	0	0	0	0	0
Subtotals	55	10	1359	143.2	0	133	0.05
Chewore Safari Area							
Chewore I	36	7	1086	192	0	105	0.04
Chewore III	81	15	2416	128.2	0	184	0.09
Subtotals	116	22	3502	103.6	0	237	0.07
Charara Safari Area							
Charara	133	23	17563	211	0	412	0.18
Charara South	132	25	8451	148.7	0	328	0.14
Subtotals	264	48	26014	124.8	0	594	0.16
Dande Safari Area and Guruve District communal lands							
Chapoto	122	16	11424	202.6	0	368	0.46
Dande	48	9	1070	142.3	0	117	0.05
Kanyurira	0	0	0	0	0	0	0
Chisunga	0	0	0	0	0	0	0
Kadze	0	0	0	0	0	0	0
Subtotals	170	25	12494	148.9	0	423	0.05
National Subtotals	1208	216	58445	39.9	727	1690	0.09
MOZAMBIQUE							
Magoe District							
Magoe 1	88	16	2010	110.9	0	186	0.25
Magoe 2	0	0	0	0	0	0	0
Magoe 3	0	0	0	0	0	0	0
Magoe 4	0	0	0	0	0	0	0
Magoe 5	0	0	0	0	0	0	0
Magoe 6	0	0	0	0	0	0	0
Subtotals	88	16	2010	110.9	0	186	0.03
North of Lake Cabora Bassa							
Luangwa	0	0	0	0	0	0	0
Tongoe	0	0	0	0	0	0	0
Metamboia	0	0	0	0	0	0	0
NCB 7	0	0	0	0	0	0	0
Zumbo	0	0	0	0	0	0	0
Mecucoe	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	88	16	2010	110.9	0	186	0.01
ZAMBIA							
Lower Zambezi National Park							
LZNP Valley	250	31	5026	57.4	106	393	0.23
LZNP Escarpment	0	0	0	0	0	0	0
Subtotals	250	31	5026	57.4	106	393	0.06
Chiawa Game Management Area							
Chiawa Valley	0	0	0	0	0	0	0
Chiawa Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Rufunsa Game Management Area							
Rufunsa	17	2	163	208.8	0	52	0.01
Tongo communal lands							
Tongo Valley North	0	0	0	0	0	0	0
Tongo Valley South	0	0	0	0	0	0	0
Tongo Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	267	33	5188	54.5	121	412	0.02
Heartland Totals	1563	265	65643	32.6	1054	2072	0.05

Table 7. Population estimates and statistics for Waterbuck in the Zambezi Heartland

Map 8. Distribution of waterbucks in the Zambezi Heartland during September 2003

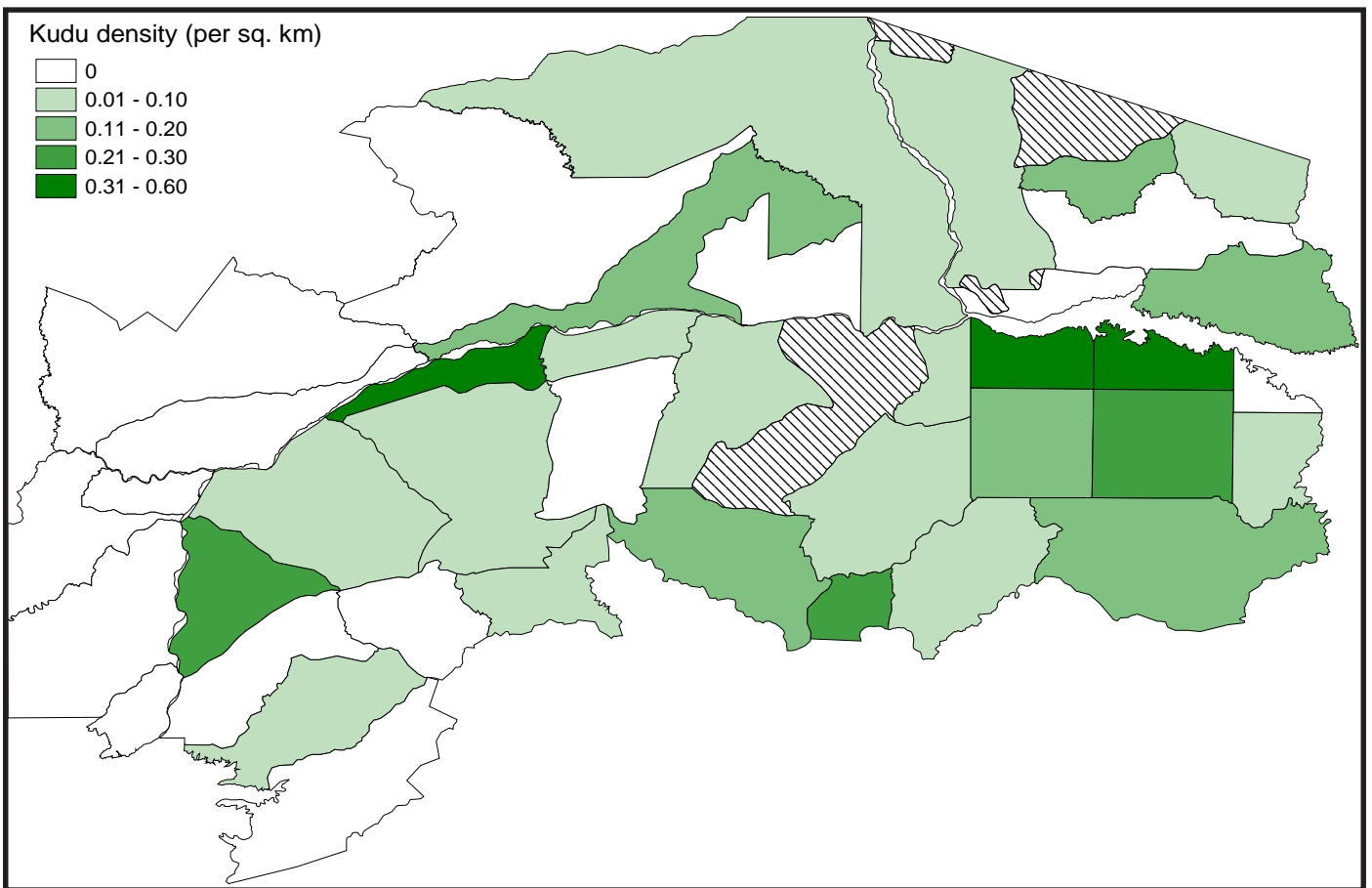


Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	102	19	1632	81.5	19	186	0.32
Mana Pools II	39	6	349	100.9	0	78	0.03
Mana Pools III	27	7	737	220.1	0	87	0.05
Subtotals	168	32	2718	62.4	63	273	0.08
Hurungwe Safari Area							
Rifa	129	17	2232	80	26	232	0.21
Hurungwe	80	14	1107	85.8	11	148	0.07
Hurungwe I	0	0	0	0	0	0	0
Hurungwe II	0	0	0	0	0	0	0
Subtotals	208	31	3339	57.2	89	328	0.07
Sapi Safari Area							
Sapi North	27	5	155	96.6	1	54	0.09
Sapi South	0	0	0	0	0	0	0
Subtotals	27	5	155	96.6	1	54	0.02
Chewore Safari Area							
Chewore I	36	7	449	123.5	0	80	0.04
Chewore III	91	17	868	67.8	29	153	0.1
Subtotals	127	24	1317	58	53	201	0.07
Charara Safari Area							
Charara	18	4	321	211	0	56	0.02
Charara South	0	0	0	0	0	0	0
Subtotals	18	4	321	211	0	56	0.01
Dande Safari Area and Gुरुve District communal lands							
Chapoto	23	3	370	194.4	0	67	0.09
Dande	86	16	1926	107.3	0	177	0.09
Kanyurira	63	6	2144	232.3	0	211	0.28
Chisunga	41	2	1318	248.2	0	141	0.05
Kadze	242	21	26270	163.7	0	639	0.18
Subtotals	455	48	32028	90.8	42	867	0.13
National Subtotals	1004	144	39878	43	573	1435	0.08
MOZAMBIQUE							
Magoé District							
Magoé 1	127	23	4211	111.7	0	268	0.36
Magoé 2	174	32	5354	90	17	331	0.51
Magoé 3	0	0	0	0	0	0	0
Magoé 4	80	7	1970	136	0	188	0.12
Magoé 5	158	26	3834	87.2	20	296	0.21
Magoé 6	14	1	199	274.3	0	53	0.04
Subtotals	553	89	15568	45.5	301	805	0.21
North of Lake Cabora Bassa							
Luangwa	97	14	1349	78.2	21	174	0.08
Tongoe	42	6	1642	224.4	0	135	0.13
Metamboá	27	4	358	160.8	0	71	0.06
NCB 7	0	0	0	0	0	0	0
Zumbo	0	0	0	0	0	0	0
Mecucoé	88	13	2356	115.7	0	190	0.12
Subtotals	254	37	5705	59.9	102	407	0.07
National Subtotals	808	126	21273	36	517	1098	0.13
ZAMBIA							
Lower Zambezi National Park							
LZNP Valley	177	22	5917	87.8	22	333	0.16
LZNP Escarpment	0	0	0	0	0	0	0
Subtotals	177	22	5917	87.8	22	333	0.04
Chiawa Game Management Area							
Chiawa Valley	0	0	0	0	0	0	0
Chiawa Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Rufunsa Game Management Area							
Rufunsa	17	2	158	205.9	0	52	0.01
Tongo communal lands							
Tongo Valley North	0	0	0	0	0	0	0
Tongo Valley South	0	0	0	0	0	0	0
Tongo Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	194	24	6075	81.1	37	352	0.02
Heartland Totals	2006	294	67226	26.2	1480	2532	0.06

Table 8. Population estimates and statistics for Kudu in the Zambezi Heartland

Map 9. Distribution of kudus in the Zambezi Heartland during September 2003

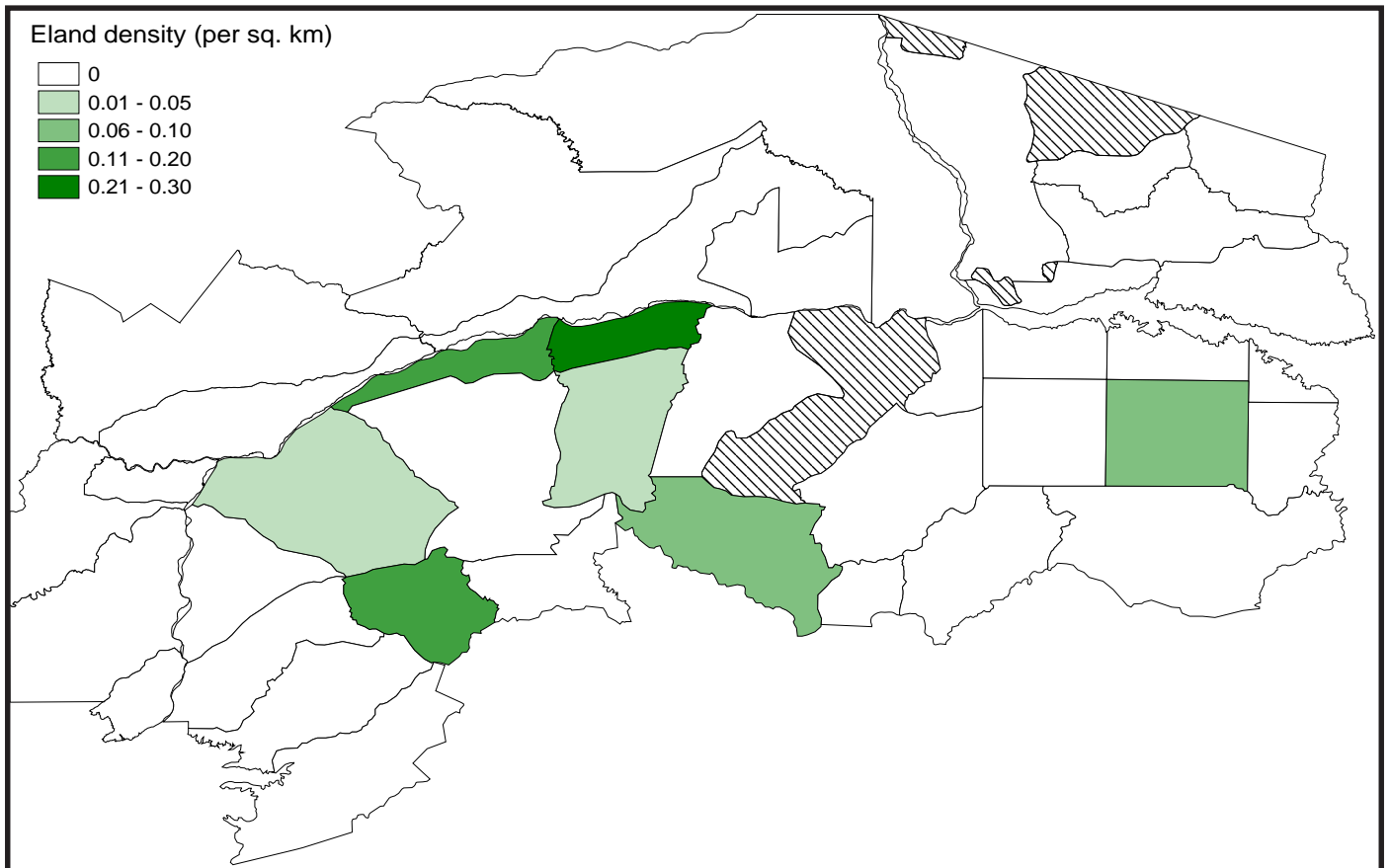


Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	38	7	310	96.3	1	74	0.12
Mana Pools II	0	0	0	0	0	0	0
Mana Pools III	0	0	0	0	0	0	0
Subtotals	38	7	310	96.3	1	74	0.02
Hurungwe Safari Area							
Rifa	0	0	0	0	0	0	0
Hurungwe	6	1	28	190.6	0	17	0.01
Hurungwe I	0	0	0	0	0	0	0
Hurungwe II	105	27	10946	236.5	0	352	0.2
Subtotals	110	28	10974	224.5	0	358	0.04
Sapi Safari Area							
Sapi North	65	12	3725	197.6	0	195	0.2
Sapi South	6	1	33	187.5	0	19	0.01
Subtotals	72	13	3758	180.6	0	202	0.07
Chewore Safari Area							
Chewore I	0	0	0	0	0	0	0
Chewore III	64	12	1055	105.9	0	133	0.07
Subtotals	64	12	1055	105.9	0	133	0.04
Charara Safari Area							
Charara	0	0	0	0	0	0	0
Charara South	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Dande Safari Area and Guruve District communal lands							
Chapoto	0	0	0	0	0	0	0
Dande	0	0	0	0	0	0	0
Kanyurira	0	0	0	0	0	0	0
Chisunga	0	0	0	0	0	0	0
Kadze	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	284	60	16096	95.7	12	557	0.02
MOZAMBIQUE							
Magoe District							
Magoe 1	0	0	0	0	0	0	0
Magoe 2	0	0	0	0	0	0	0
Magoe 3	0	0	0	0	0	0	0
Magoe 4	0	0	0	0	0	0	0
Magoe 5	49	8	1633	185	0	139	0.07
Magoe 6	0	0	0	0	0	0	0
Subtotals	49	8	1633	185.1	0	139	0.02
North of Lake Cabora Bassa							
Luangwa	0	0	0	0	0	0	0
Tongoe	0	0	0	0	0	0	0
Metamboia	0	0	0	0	0	0	0
NCB 7	0	0	0	0	0	0	0
Zumbo	0	0	0	0	0	0	0
Mecucoe	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	49	8	1633	185.1	0	139	0.01
ZAMBIA							
Lower Zambezi National Park							
LZNP Valley	0	0	0	0	0	0	0
LZNP Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Chiawa Game Management Area							
Chiawa Valley	0	0	0	0	0	0	0
Chiawa Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Rufunsa Game Management Area							
Rufunsa	0	0	0	0	0	0	0
Tongo communal lands							
Tongo Valley North	0	0	0	0	0	0	0
Tongo Valley South	0	0	0	0	0	0	0
Tongo Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	0	0	0	0	0	0	0
Heartland Totals	333	68	17730	84.3	52	614	0.01

Table 9. Population estimates and statistics for Eland in the Zambezi Heartland

Map 10. Distribution of Elands in the Zambezi Heartland during September 2003



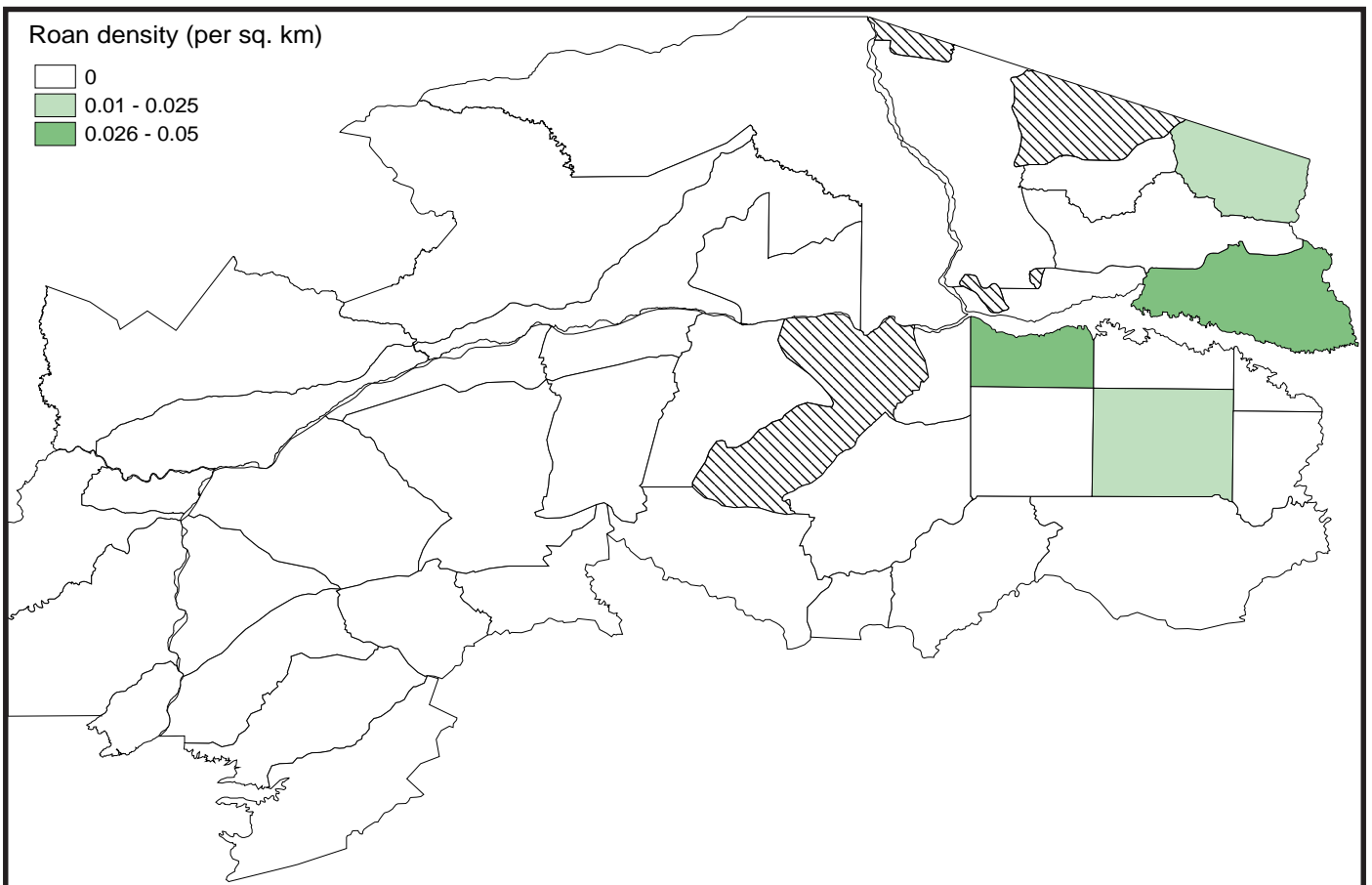
Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	0	0	0	0	0	0	0
Mana Pools II	0	0	0	0	0	0	0
Mana Pools III	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Hurungwe Safari Area							
Rifa	0	0	0	0	0	0	0
Hurungwe	0	0	0	0	0	0	0
Hurungwe I	0	0	0	0	0	0	0
Hurungwe II	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Sapi Safari Area							
Sapi North	0	0	0	0	0	0	0
Sapi South	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Chewore Safari Area							
Chewore I	0	0	0	0	0	0	0
Chewore III	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Charara Safari Area							
Charara	0	0	0	0	0	0	0
Charara South	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Dande Safari Area and Guruve District communal lands							
Chapoto	0	0	0	0	0	0	0
Dande	0	0	0	0	0	0	0
Kanyurira	0	0	0	0	0	0	0
Chisunga	0	0	0	0	0	0	0
Kadze	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	0	0	0	0	0	0	0
MOZAMBIQUE							
Magoe District							
Magoe 1	17	3	224	197.6	0	49	0.05
Magoe 2	0	0	0	0	0	0	0
Magoe 3	0	0	0	0	0	0	0
Magoe 4	0	0	0	0	0	0	0
Magoe 5	6	1	34	214.4	0	19	0.01
Magoe 6	0	0	0	0	0	0	0
Subtotals	23	4	259	151.7	0	57	0.01
North of Lake Cabora Bassa							
Luangwa	0	0	0	0	0	0	0
Tongoe	0	0	0	0	0	0	0
Metamboa	7	1	44	225	0	22	0.02
NCB 7	0	0	0	0	0	0	0
Zumbo	0	0	0	0	0	0	0
Mecucocoe	27	4	591	188.3	0	78	0.04
Subtotals	34	5	635	155	0	86	0.01
National Subtotals	57	9	893	107.6	0	117	0.01
ZAMBIA							
Lower Zambezi National Park							
LZNP Valley	0	0	0	0	0	0	0
LZNP Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Chiawa Game Management Area							
Chiawa Valley	0	0	0	0	0	0	0
Chiawa Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Rufusa Game Management Area							
Rufusa	0	0	0	0	0	0	0
Tongo communal lands							
Tongo Valley North	0	0	0	0	0	0	0
Tongo Valley South	0	0	0	0	0	0	0
Tongo Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	0	0	0	0	0	0	0
Heartland Totals	57	9	893	107.6	0	117	0

Table 10. Population estimates and statistics for Roan in the Zambezi Heartland



Map 11. Distribution of Roan antelopes in the Zambezi Heartland during September 2003



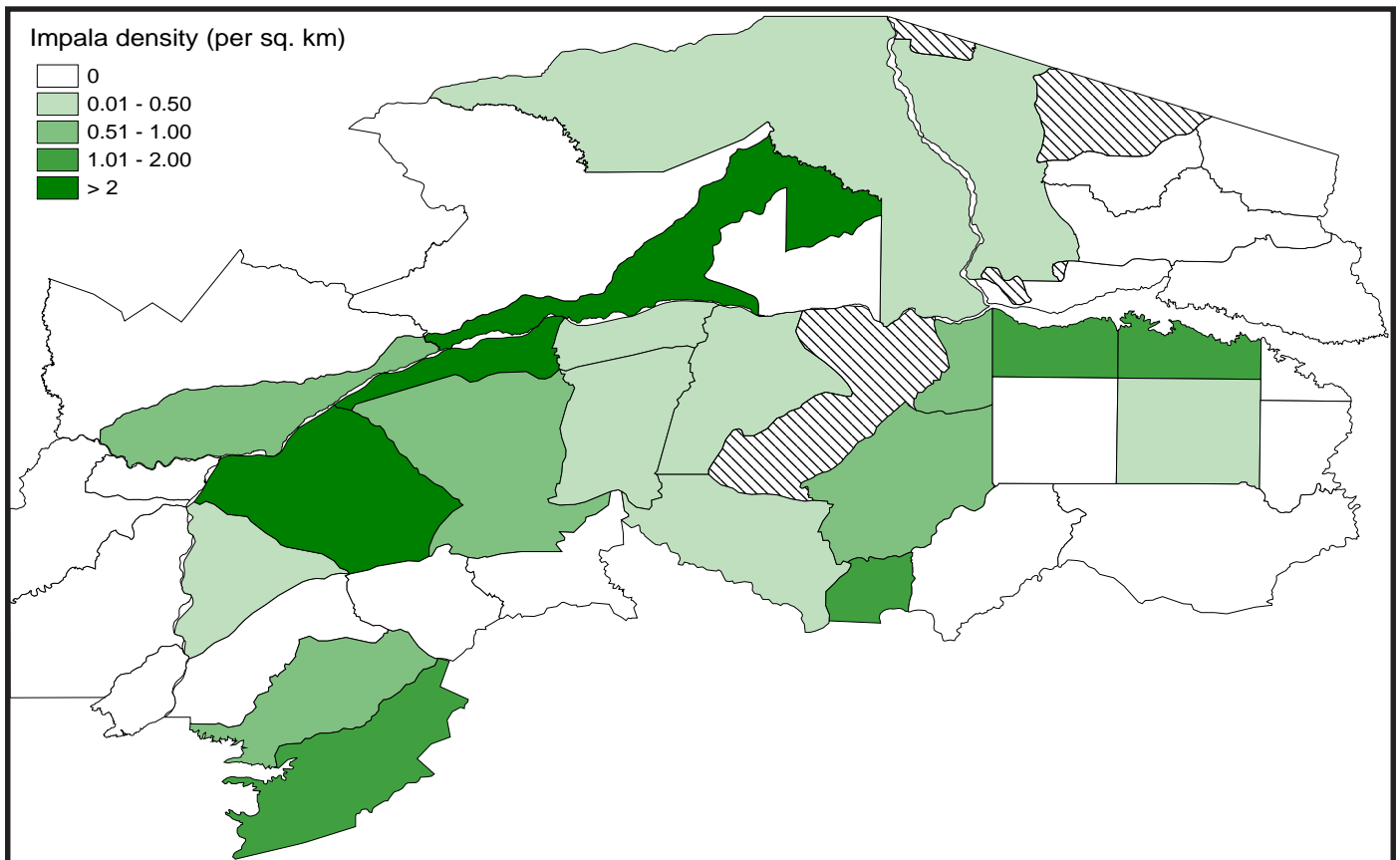
Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	1422	264	83883	42	824	2020	4.38
Mana Pools II	1070	165	49947	43.9	600	1539	0.79
Mana Pools III	0	0	0	0	0	0	0
Subtotals	2492	429	133831	29.7	1753	3231	1.14
Hurungwe Safari Area							
Rifa	257	34	23993	131.1	0	595	0.42
Hurungwe	3401	597	374809	37	2143	4660	2.76
Hurungwe I	0	0	0	0	0	0	0
Hurungwe II	0	0	0	0	0	0	0
Subtotals	3659	631	398801	35.3	2367	4950	1.2
Sapi Safari Area							
Sapi North	142	26	5232	108.1	0	295	0.44
Sapi South	331	51	25975	103.8	0	674	0.42
Subtotals	473	77	31208	77.9	104	841	0.43
Chewore Safari Area							
Chewore I	277	54	6737	62	105	449	0.33
Chewore III	446	83	16833	61.1	173	718	0.5
Subtotals	723	137	23569	43.4	409	1036	0.42
Charara Safari Area							
Charara	667	122	249432	158	0	1721	0.92
Charara South	1234	251	1522962	213.1	0	3864	1.31
Subtotals	1901	373	1772394	146.6	0	4687	1.14
Dande Safari Area and Guruve District communal lands							
Chapoto	175	23	9395	127.8	0	398	0.66
Dande	599	112	35145	65.5	207	991	0.61
Kanyurira	412	39	63769	195	0	1216	1.82
Chisunga	0	0	0	0	0	0	0
Kadze	0	0	0	0	0	0	0
Subtotals	1186	174	108310	64	427	1945	0.33
National Subtotals	10433	1821	2468112	30.5	7247	13619	0.78
MOZAMBIQUE							
Magoé District							
Magoé 1	380	69	14558	69.2	117	643	1.09
Magoé 2	654	120	40696	66.2	221	1086	1.91
Magoé 3	0	0	0	0	0	0	0
Magoé 4	0	0	0	0	0	0	0
Magoé 5	225	37	13877	116.6	0	488	0.3
Magoé 6	0	0	0	0	0	0	0
Subtotals	1259	226	69131	42.7	722	1795	0.48
North of Lake Cabora Bassa							
Luangwa	77	11	3063	149.9	0	191	0.07
Tongoe	0	0	0	0	0	0	0
Metamboá	0	0	0	0	0	0	0
NCB 7	0	0	0	0	0	0	0
Zumbo	0	0	0	0	0	0	0
Mecucoé	0	0	0	0	0	0	0
Subtotals	77	11	3063	149.9	0	191	0.02
National Subtotals	1335	237	72194	40.9	788	1882	0.21
ZAMBIA							
Lower Zambezi National Park							
LZNP Valley	7054	876	1632093	36.6	4472	9636	6.37
LZNP Escarpment	0	0	0	0	0	0	0

Table 11. Population estimates and statistics for Impala in the Zambezi Heartland



Map 12. Distribution of impalas in the Zambezi Heartland during September 2003

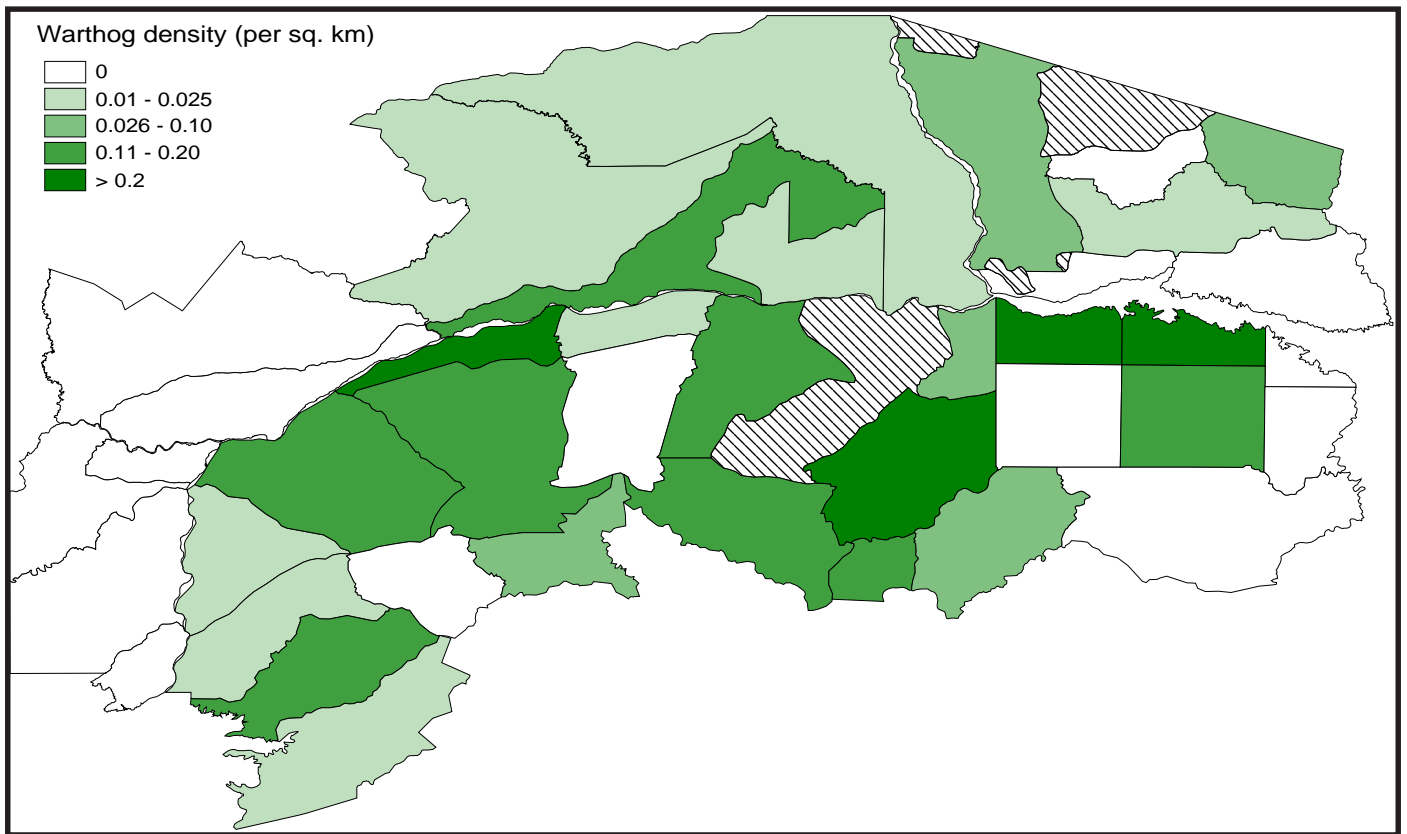


Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	269	50	8218	69.5	82	456	0.83
Mana Pools II	253	39	4689	56.9	109	397	0.19
Mana Pools III	28	2	809	220.1	0	91	0.06
Subtotals	551	91	13716	42.8	315	786	0.25
Hurungwe Safari Area							
Rifa	15	2	210	208.5	0	47	0.02
Hurungwe	216	38	4603	64.4	77	356	0.18
Hurungwe I	6	2	37	217.9	0	19	0.01
Hurungwe II	0	0	0	0	0	0	0
Subtotals	238	42	4850	60	95	380	0.08
Sapi Safari Area							
Sapi North	5	1	27	202.4	0	17	0.02
Sapi South	0	0	0	0	0	0	0
Subtotals	5	1	27	202.4	0	17	0
Chewore Safari Area							
Chewore I	92	18	1306	81.9	17	168	0.11
Chewore III	150	28	1743	58.3	63	238	0.17
Subtotals	243	46	3049	46.2	131	355	0.14
Charara Safari Area							
Charara	81	5	3062	144.7	0	197	0.11
Charara South	24	4	557	213.1	0	74	0.03
Subtotals	104	9	3619	119.7	0	229	0.06
Dande Safari Area and Gurube District communal lands							
Chapoto	23	3	406	203.8	0	69	0.09
Dande	198	37	3349	61.2	77	319	0.2
Kanyurira	32	3	899	300.9	0	127	0.14
Chisunga	41	2	1620	275.2	0	152	0.05
Kadze	0	0	0	0	0	0	0
Subtotals	293	45	6273	55.7	130	456	0.08
National Subtotals	1434	234	31535	24.5	1083	1785	0.11
MOZAMBIQUE							
Magoe District							
Magoe 1	204	37	3977	67.5	66	341	0.59
Magoe 2	196	36	3957	68.8	61	331	0.57
Magoe 3	0	0	0	0	0	0	0
Magoe 4	0	0	0	0	0	0	0
Magoe 5	97	16	1785	96.7	3	191	0.13
Magoe 6	0	0	0	0	0	0	0
Subtotals	497	89	9718	40.3	297	697	0.19
North of Lake Cabora Bassa							
Luangwa	42	6	743	135.3	0	98	0.04
Tongoe	0	0	0	0	0	0	0
Metamboia	20	3	394	225	0	66	0.04
NCB 7	10	3	93	226.2	0	31	0.01
Zumbo	0	0	0	0	0	0	0
Mecucoe	0	0	0	0	0	0	0
Subtotals	72	12	1229	99.4	0	143	0.02
National Subtotals	569	101	10948	37.1	358	780	0.09
ZAMBIA							
Lower Zambezi National Park							
LZNP Valley	121	15	1895	72.8	33	209	0.11
LZNP Escarpment	46	9	1507	199.2	0	138	0.02
Subtotals	167	24	3402	71.7	47	287	0.04
Chiawa Game Management Area							
Chiawa Valley	0	0	0	0	0	0	0
Chiawa Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Rufunsa Game Management Area							
Rufunsa	17	2	160	207.4	0	52	0.01
Tongo communal lands							
Tongo Valley North	0	0	0	0	0	0	0
Tongo Valley South	0	0	0	0	0	0	0
Tongo Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	184	26	3562	66.3	62	306	0.02
Heartland Totals	2186	361	46044	19.4	1763	2610	0.07

Table 12. Population estimates and statistics for Warthog in the Zambezi Heartland

Map 13. Distribution of warthogs in the Zambezi Heartland during September 2003

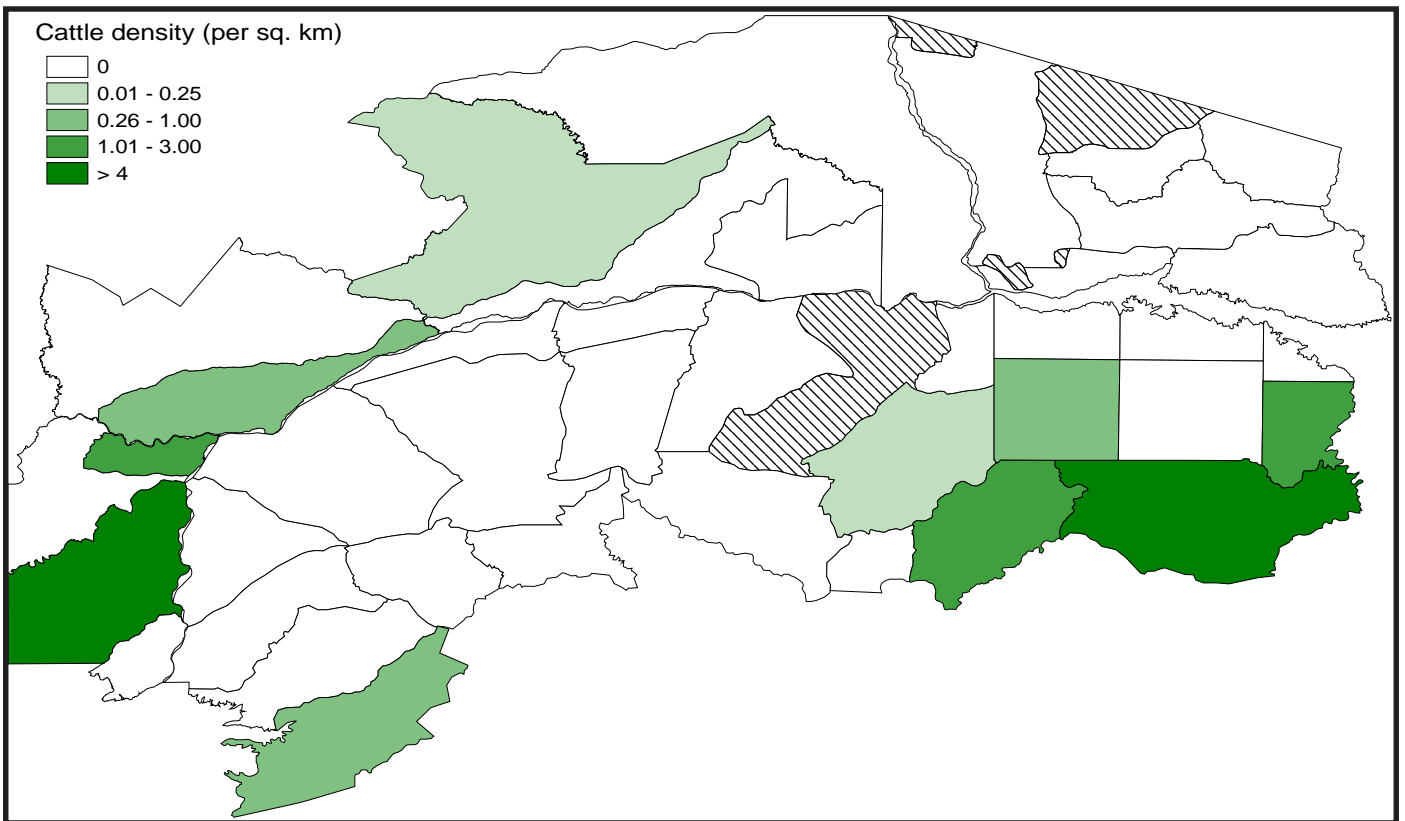


Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	0	0	0	0	0	0	0
Mana Pools II	0	0	0	0	0	0	0
Mana Pools III	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Hurungwe Safari Area							
Rifa	0	0	0	0	0	0	0
Hurungwe	0	0	0	0	0	0	0
Hurungwe I	0	0	0	0	0	0	0
Hurungwe II	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Sapi Safari Area							
Sapi North	0	0	0	0	0	0	0
Sapi South	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Chewore Safari Area							
Chewore I	0	0	0	0	0	0	0
Chewore III	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Charara Safari Area							
Charara	0	0	0	0	0	0	0
Charara South	535	113	135512	146.7	0	1319	0.57
Subtotals	535	113	135512	146.7	0	1319	0.32
Dande Safari Area and Gurube District communal lands							
Chapoto	0	0	0	0	0	0	0
Dande	21	4	407	197.4	0	64	0.02
Kanyurira	0	0	0	0	0	0	0
Chisunga	2050	101	1954864	189.3	0	5932	2.67
Kadze	11332	982	4192296	44.2	6322	16342	8.22
Subtotals	13404	1087	6147566	41.8	7795	19013	3.7
National Subtotals	13938	1200	6283078	40.1	8353	19524	1.04
MOZAMBIQUE							
Magoe District							
Magoe 1	0	0	0	0	0	0	0
Magoe 2	0	0	0	0	0	0	0
Magoe 3	0	0	0	0	0	0	0
Magoe 4	377	33	81106	185.1	0	1073	0.57
Magoe 5	0	0	0	0	0	0	0
Magoe 6	642	45	218448	202	0	1940	1.64
Subtotals	1019	78	299554	131.4	0	2358	0.39
North of Lake Cabora Bassa							
Luangwa	0	0	0	0	0	0	0
Tongoe	0	0	0	0	0	0	0
Metamboia	0	0	0	0	0	0	0
NCB 7	0	0	0	0	0	0	0
Zumbo	0	0	0	0	0	0	0
Mecucocoe	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	1019	78	299554	131.4	0	2358	0.16
ZAMBIA							
Lower Zambezi National Park							
LZNP Valley	0	0	0	0	0	0	0
LZNP Escarpment	138	27	13364	197.8	0	412	0.05
Subtotals	138	27	13364	197.7	0	412	0.03
Chiawa Game Management Area							
Chiawa Valley	353	47	23405	89.1	39	668	0.46
Chiawa Escarpment	0	0	0	0	0	0	0
Subtotals	353	47	23405	89	39	668	0.14
Rufunsa Game Management Area							
Rufunsa	0	0	0	0	0	0	0
Tongo communal lands							
Tongo Valley North	447	63	61840	124	0	1001	2.11
Tongo Valley South	4599	602	2013951	66.7	1534	7664	4.12
Tongo Escarpment	0	0	0	0	0	0	0
Subtotals	5046	665	2075791	61.7	1933	8158	2.29
National Subtotals	5537	739	2112561	56.3	2420	8654	0.46
Heartland Totals	20494	2017	8695193	30.4	14273	26716	0.65

Table 13. Population estimates and statistics for Cattle in the Zambezi Heartland

Map 14. Distribution of cattle in the Zambezi Heartland during September 2003

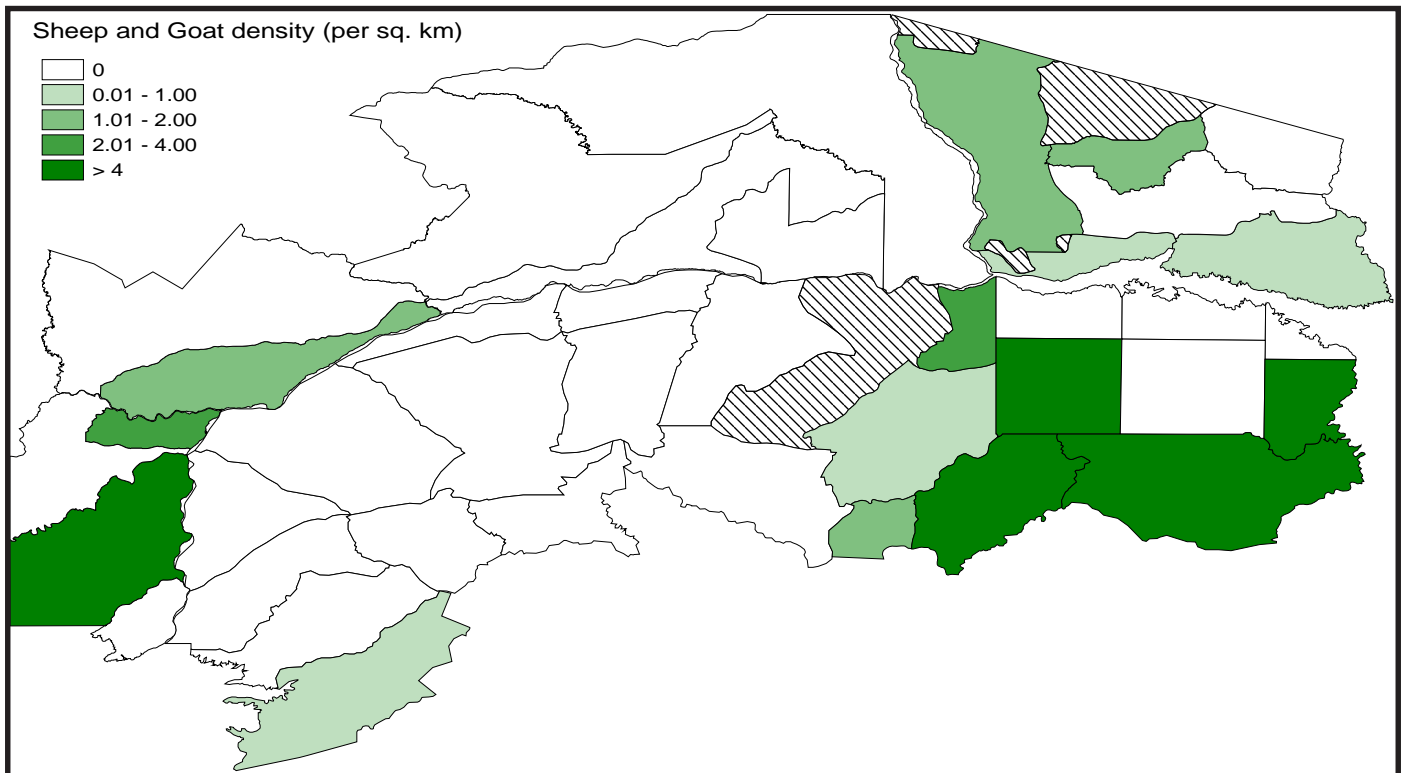


Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	0	0	0	0	0	0	0
Mana Pools II	0	0	0	0	0	0	0
Mana Pools III	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Hurungwe Safari Area							
Rifa	0	0	0	0	0	0	0
Hurungwe	0	0	0	0	0	0	0
Hurungwe I	0	0	0	0	0	0	0
Hurungwe II	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Sapi Safari Area							
Sapi North	0	0	0	0	0	0	0
Sapi South	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Chewore Safari Area							
Chewore I	0	0	0	0	0	0	0
Chewore III	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Charara Safari Area							
Charara	0	0	0	0	0	0	0
Charara South	230	32	48766	204.3	0	701	0.24
Subtotals	230	32	48766	204.4	0	701	0.14
Dande Safari Area and Gुरुve District communal lands							
Chapoto	806	106	230479	137.4	0	1913	3.02
Dande	412	77	69140	133.6	0	962	0.42
Kanyurira	285	27	88658	332	0	1233	1.26
Chisunga	3370	166	1958787	115.3	0	7255	4.39
Kadze	6901	598	2508806	56.2	3025	10777	5
Subtotals	11774	974	4855871	41.2	6924	16624	3.25
National Subtotals	12004	1006	4904637	40.6	7130	16878	0.9
MOZAMBIQUE							
Magoe District							
Magoe 1	0	0	0	0	0	0	0
Magoe 2	0	0	0	0	0	0	0
Magoe 3	0	0	0	0	0	0	0
Magoe 4	4096	359	3472967	111.3	0	8657	6.24
Magoe 5	0	0	0	0	0	0	0
Magoe 6	1656	116	1024343	169.7	0	4465	4.22
Subtotals	5752	475	4497310	85	862	10642	2.19
North of Lake Cabora Bassa							
Luangwa	1928	277	344810	63.2	710	3146	1.65
Tongoe	382	55	75805	166.3	0	1017	1.15
Metamboia	0	0	0	0	0	0	0
NCB 7	0	0	0	0	0	0	0
Zumbo	213	31	18777	136.3	0	504	0.86
Mecucoe	61	9	1545	135.3	0	144	0.08
Subtotals	2584	372	440937	52.4	1229	3938	0.7
National Subtotals	8336	847	4938247	59.4	3384	13287	1.32
ZAMBIA							
Lower Zambezi National Park							
LZNP Valley	0	0	0	0	0	0	0
LZNP Escarpment	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Chiawa Game Management Area							
Chiawa Valley	1037	138	265952	102.3	0	2097	1.36
Chiawa Escarpment	0	0	0	0	0	0	0
Subtotals	1037	138	265952	102.2	0	2097	0.42
Rufunsa Game Management Area							
Rufunsa	0	0	0	0	0	0	0
Tongo communal lands							
Tongo Valley North	496	70	34465	83.3	83	910	2.34
Tongo Valley South	5164	676	3967416	83.3	862	9467	4.62
Tongo Escarpment	0	0	0	0	0	0	0
Subtotals	5661	746	4001881	76.3	1339	9982	2.57
National Subtotals	6697	884	4267833	65.7	2294	11101	0.56
Heartland Totals	27037	2737	14110716	28.2	19419	34656	0.85

Table 14. Population estimates and statistics for Sheep and Goats in the Zambezi Heartland

Map 15. Distribution of sheep and goats in the Zambezi Heartland during September 2003



Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	312	58	11094	69.6	95	530	0.96
Mana Pools II	363	56	5182	41.7	212	514	0.27
Mana Pools III	65	15	542	79.1	14	116	0.13
Subtotals	740	129	16817	35.4	479	1002	0.34
Hurungwe Safari Area							
Rifa	98	13	1033	71.2	28	168	0.16
Hurungwe	256	45	4619	54.5	117	396	0.21
Hurungwe I	0	0	0	0	0	0	0
Hurungwe II	89	22	1639	107.5	0	185	0.17
Subtotals	444	80	7291	38.9	271	616	0.15
Sapi Safari Area							
Sapi North	33	6	353	121.6	0	73	0.1
Sapi South	195	30	2484	54.6	88	301	0.25
Subtotals	227	36	2837	49	116	339	0.21
Chewore Safari Area							
Chewore I	128	25	1020	52.1	61	195	0.15
Chewore III	156	29	1123	45.2	85	226	0.17
Subtotals	284	54	2143	33.1	190	378	0.16
Charara Safari Area							
Charara	268	36	12463	87.7	33	504	0.37
Charara South	92	18	3574	138.3	0	220	0.1
Subtotals	361	54	16037	72.3	100	621	0.22
Dande Safari Area and Guruve District communal lands							
Chapoto	0	0	0	0	0	0	0
Dande	160	30	2713	67.9	51	269	0.16
Kanyurira	0	0	0	0	0	0	0
Chisunga	20	1	405	275.2	0	76	0.03
Kadze	0	0	0	0	0	0	0
Subtotals	181	31	3118	64.1	65	297	0.05
National Subtotals	2237	384	48243	19.4	1802	2672	0.17
MOZAMBIQUE							
Magoe District							
Magoe 1	11	2	48	136.5	0	26	0.03
Magoe 2	54	10	722	105.8	0	112	0.16
Magoe 3	0	0	0	0	0	0	0
Magoe 4	0	0	0	0	0	0	0
Magoe 5	30	5	252	116.3	0	66	0.04
Magoe 6	0	0	0	0	0	0	0
Subtotals	96	17	1022	69	30	162	0.04
North of Lake Cabora Bassa							
Luangwa	0	0	0	0	0	0	0
Tongoe	0	0	0	0	0	0	0
Metamboia	0	0	0	0	0	0	0
NCB 7	15	4	218	226.2	0	48	0.02
Zumbo	0	0	0	0	0	0	0
Mecucoie	0	0	0	0	0	0	0
Subtotals	15	4	218	226.2	0	48	0
National Subtotals	111	21	1240	64.9	39	182	0.02
Two Country Totals	2347	405	49483	18.7	1907	2788	0.12

Table 15. Population estimates and statistics for Elephant Bulls in the Zimbabwe and Mozambique sections of the Zambezi Heartland

Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	576	107	30623	62.7	215	938	1.77
Mana Pools II	2036	314	156282	40.8	1205	2866	1.5
Mana Pools III	933	162	79114	66.3	314	1552	1.82
Subtotals	3545	583	266019	29.5	2499	4591	1.62
Hurungwe Safari Area							
Rifa	492	65	41427	90.1	49	936	0.8
Hurungwe	2968	521	300870	38	1840	4096	2.41
Hurungwe I	305	47	20860	103.3	0	619	0.45
Hurungwe II	523	116	24530	70.8	152	893	0.99
Subtotals	4288	749	387688	29.3	3029	5546	1.4
Sapi Safari Area							
Sapi North	840	154	63400	63.5	307	1374	2.62
Sapi South	1122	173	83360	54.8	507	1738	1.44
Subtotals	1963	327	146760	39.9	1180	2745	1.78
Chewore Safari Area							
Chewore I	1673	326	102002	40	1004	2341	1.99
Chewore III	2154	401	97998	30.5	1496	2812	2.4
Subtotals	3827	727	200000	23.7	2920	4734	2.2
Charara Safari Area							
Charara	1309	177	142470	60.9	512	2105	1.8
Charara South	144	22	8106	133.1	0	336	0.15
Subtotals	1453	199	150576	56.1	638	2268	0.87
Dande Safari Area and Guruve District communal lands							
Chapoto	160	21	9555	141.2	0	385	0.6
Dande	2096	392	210765	45.8	1136	3057	2.14
Kanyurira	169	16	7122	158.8	0	438	0.75
Chisunga	244	12	44415	240.2	0	829	0.32
Kadze	0	0	0	0	0	0	0
Subtotals	2669	441	271857	40.2	1595	3743	0.74
National Subtotals	17744	3026	1422899	13.3	15390	20099	1.33
MOZAMBIQUE							
Magoe District							
Magoe 1	457	83	40243	95.7	20	894	1.31
Magoe 2	490	90	87136	129.2	0	1123	1.43
Magoe 3	0	0	0	0	0	0	0
Magoe 4	171	15	11174	151.1	0	430	0.26
Magoe 5	414	68	24337	84	66	761	0.55
Magoe 6	0	0	0	0	0	0	0
Subtotals	1532	256	162890	53.5	713	2351	0.58
North of Lake Cabora Bassa							
Luangwa	0	0	0	0	0	0	0
Tongoe	0	0	0	0	0	0	0
Metambo	0	0	0	0	0	0	0
NCB 7	0	0	0	0	0	0	0
Zumbo	76	11	5528	208.5	0	233	0.31
Mecuco	0	0	0	0	0	0	0
Subtotals	76	11	5528	208.5	0	233	0.02
National Subtotals	1607	267	168418	51.7	776	2439	0.25
Two Country Totals	19352	3293	1591317	12.9	16865	21839	0.98

Table 16. Population estimates and statistics for Elephant cow herds in the Zimbabwe and Mozambique sections of the Zambezi Heartland

Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	2467	458	148737	32.3	1671	3263	7.59
Mana Pools II	0	0	0	0	0	0	0
Mana Pools III	0	0	0	0	0	0	0
Subtotals	2467	458	148737	32.3	1671	3263	1.13
Hurungwe Safari Area							
Rifa	999	132	142294	82.2	177	1821	1.62
Hurungwe	581	102	57645	84.9	87	1075	0.47
Hurungwe I	0	0	0	0	0	0	0
Hurungwe II	0	0	0	0	0	0	0
Subtotals	1581	234	199938	58.7	653	2508	0.52
Sapi Safari Area							
Sapi North	518	95	25070	64.7	183	854	1.62
Sapi South	0	0	0	0	0	0	0
Subtotals	518	95	25070	64.7	183	854	0.47
Chewore Safari Area							
Chewore I	21	4	355	192	0	60	0.02
Chewore III	0	0	0	0	0	0	0
Subtotals	21	4	355	192	0	60	0.01
Charara Safari Area							
Charara	134	30	8506	144.7	0	329	0.19
Charara South	0	0	0	0	0	0	0
Subtotals	134	30	8506	144.7	0	329	0.08
Dande Safari Area and Guruve District communal lands							
Chapoto	30	4	714	202.6	0	92	0.11
Dande	0	0	0	0	0	0	0
Kanyurira	0	0	0	0	0	0	0
Chisunga	0	0	0	0	0	0	0
Kadze	0	0	0	0	0	0	0
Subtotals	30	4	714	202.6	0	92	0.01
National Subtotals	4751	825	383319	26.1	3509	5994	0.36
MOZAMBIQUE							
Magoë District							
Magoë 1	330	60	65457	168.8	0	888	0.95
Magoë 2	196	36	9303	105.5	0	403	0.57
Magoë 3	163	15	15791	214.1	0	512	1.21
Magoë 4	0	0	0	0	0	0	0
Magoë 5	0	0	0	0	0	0	0
Magoë 6	0	0	0	0	0	0	0
Subtotals	689	111	90550	91.4	59	1319	0.26
North of Lake Cabora Bassa							
Luangwa	0	0	0	0	0	0	0
Tongoe	0	0	0	0	0	0	0
Metamboá	0	0	0	0	0	0	0
NCB 7	67	20	4513	226.2	0	219	0.09
Zumbo	0	0	0	0	0	0	0
Mecucoë	14	2	72	131.9	0	31	0.02
Subtotals	81	22	4586	189.7	0	234	0.02
National Subtotals	770	133	95136	83.3	129	1411	0.12
Two Country Totals	5521	958	478455	25	4142	6901	0.28

Table 17. Population estimates and statistics for Hippo in the Zimbabwe and Mozambique sections of the Zambezi Heartland



Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	0	0	0	0	0	0	0
Mana Pools II	0	0	0	0	0	0	0
Mana Pools III	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Hurungwe Safari Area							
Rifa	0	0	0	0	0	0	0
Hurungwe	0	0	0	0	0	0	0
Hurungwe I	0	0	0	0	0	0	0
Hurungwe II	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Sapi Safari Area							
Sapi North	0	0	0	0	0	0	0
Sapi South	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Chewore Safari Area							
Chewore I	0	0	0	0	0	0	0
Chewore III	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Charara Safari Area							
Charara	0	0	0	0	0	0	0
Charara South	4	1	14	213.1	0	12	0
Subtotals	4	1	14	213.1	0	12	0
Dande Safari Area and Guruve District communal lands							
Chapoto	0	0	0	0	0	0	0
Dande	32	6	916	197.4	0	95	0.03
Kanyurira	0	0	0	0	0	0	0
Chisunga	0	0	0	0	0	0	0
Kadze	69	6	1170	120.9	0	153	0.05
Subtotals	101	12	2087	96.1	4	199	0.03
National Subtotals	105	13	2100	92.5	8	202	0.01
MOZAMBIQUE							
Magoe District							
Magoe 1	0	0	0	0	0	0	0
Magoe 2	0	0	0	0	0	0	0
Magoe 3	0	0	0	0	0	0	0
Magoe 4	46	4	875	158.6	0	118	0.07
Magoe 5	0	0	0	0	0	0	0
Magoe 6	171	12	18050	217.7	0	544	0.44
Subtotals	217	16	18925	176.1	0	599	0.08
North of Lake Cabora Bassa							
Luangwa	0	0	0	0	0	0	0
Tongoe	0	0	0	0	0	0	0
Metamboia	0	0	0	0	0	0	0
NCB 7	0	0	0	0	0	0	0
Zumbo	0	0	0	0	0	0	0
Mecucoe	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	217	16	18925	176.1	0	599	0.03
Two Country Totals	322	29	21025	115.8	0	695	0.02

Table 18. Population estimates and statistics for Donkeys in the Zimbabwe and Mozambique sections of the Zambezi Heartland



Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	0	0	0	0	0	0	0
Mana Pools II	0	0	0	0	0	0	0
Mana Pools III	11	2	52	148.4	0	26	0.02
Subtotals	11	2	52	148.4	0	26	0
Hurungwe Safari Area							
Rifa	0	0	0	0	0	0	0
Hurungwe	0	0	0	0	0	0	0
Hurungwe I	0	0	0	0	0	0	0
Hurungwe II	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Sapi Safari Area							
Sapi North	0	0	0	0	0	0	0
Sapi South	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Chewore Safari Area							
Chewore I	0	0	0	0	0	0	0
Chewore III	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Charara Safari Area							
Charara	0	0	0	0	0	0	0
Charara South	5	1	24	213.1	0	15	0.01
Subtotals	5	1	24	213.1	0	15	0
Dande Safari Area and Guruve District communal lands							
Chapoto	0	0	0	0	0	0	0
Dande	5	1	24	191.2	0	16	0.01
Kanyurira	0	0	0	0	0	0	0
Chisunga	0	0	0	0	0	0	0
Kadze	0	0	0	0	0	0	0
Subtotals	5	1	24	191.2	0	16	0
National Subtotals	21	4	100	97.3	1	41	0
MOZAMBIQUE							
Magoe District							
Magoe 1	0	0	0	0	0	0	0
Magoe 2	0	0	0	0	0	0	0
Magoe 3	0	0	0	0	0	0	0
Magoe 4	0	0	0	0	0	0	0
Magoe 5	0	0	0	0	0	0	0
Magoe 6	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
North of Lake Cabora Bassa							
Luangwa	0	0	0	0	0	0	0
Tongoe	0	0	0	0	0	0	0
Metamboa	0	0	0	0	0	0	0
NCB 7	0	0	0	0	0	0	0
Zumbo	0	0	0	0	0	0	0
Mecucoe	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
National Subtotals	0	0	0	0	0	0	0
Two Country Totals	21	4	100	97.3	1	41	0

Table 19. Population estimates and statistics for Poachers' Camps in the Zimbabwe and Mozambique sections of the Zambezi Heartland



Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	0	0	0	0	0	0	0
Mana Pools II	78	12	2827	143.6	0	190	0.06
Mana Pools III	0	0	0	0	0	0	0
Subtotals	78	12	2827	143.6	0	189	0.04
Hurungwe Safari Area							
Rifa	38	5	1110	191.7	0	110	0.06
Hurungwe	23	4	138	106	0	47	0.02
Hurungwe I	0	0	0	0	0	0	0
Hurungwe II	0	0	0	0	0	0	0
Subtotals	61	9	1248	124.1	0	136	0.02
Sapi Safari Area							
Sapi North	16	3	243	201.8	0	49	0.05
Sapi South	19	3	293	187.5	0	56	0.03
Subtotals	36	6	536	132	0	83	0.03
Chewore Safari Area							
Chewore I	21	4	338	187.4	0	59	0.02
Chewore III	70	13	600	73.7	18	121	0.08
Subtotals	90	17	938	69	28	153	0.05
Charara Safari Area							
Charara	0	0	0	0	0	0	0
Charara South	15	3	218	213.1	0	46	0.02
Subtotals	15	3	218	213.1	0	46	0.01
Dande Safari Area and Guruve District communal lands							
Chapoto	0	0	0	0	0	0	0
Dande	48	9	1086	143.3	0	117	0.05
Kanyurira	0	0	0	0	0	0	0
Chisunga	0	0	0	0	0	0	0
Kadze	23	2	554	249.6	0	81	0.02
Subtotals	71	11	1640	117.6	0	155	0.02
National Subtotals	351	58	7406	48.9	179	522	0.03
MOZAMBIQUE							
Magoe District							
Magoe 1	99	18	1233	77.2	23	176	0.29
Magoe 2	65	12	796	92.6	5	126	0.19
Magoe 3	22	2	281	214.1	0	68	0.16
Magoe 4	46	4	805	152.1	0	115	0.07
Magoe 5	36	6	619	151.8	0	92	0.05
Magoe 6	0	0	0	0	0	0	0
Subtotals	268	42	3733	46	145	392	0.1
North of Lake Cabora Bassa							
Luangwa	0	0	0	0	0	0	0
Tongoe	35	5	440	139.3	0	83	0.11
Metamboa	0	0	0	0	0	0	0
NCB 7	0	0	0	0	0	0	0
Zumbo	14	2	183	208.5	0	42	0.06
Mecucocoe	27	4	596	189	0	78	0.04
Subtotals	76	11	1218	94.1	4	147	0.02
National Subtotals	344	53	4951	40.9	203	484	0.05
Two Country Totals	694	111	12357	31.6	475	914	0.04

Table 20. Population estimates and statistics for Ground Hornbills in the Zimbabwe and Mozambique sections of the Zambezi Heartland



Aerial Survey of Elephants and Other Large Herbivores in the Zambezi Heartland: 2003

Stratum	Estimate	No. Seen	Variance	% CI	Lower CL	Upper CL	Density (km ⁻²)
ZIMBABWE							
Mana Pools National Park							
Mana Pools I	5	1	23	182.1	0	15	0.02
Mana Pools II	32	5	193	90.1	3	62	0.02
Mana Pools III	107	20	5172	148.4	0	265	0.21
Subtotals	144	26	5387	111.8	0	306	0.07
Hurungwe Safari Area							
Rifa	53	7	371	79.2	11	95	0.09
Hurungwe	57	10	477	78.8	12	102	0.05
Hurungwe I	0	0	0	0	0	0	0
Hurungwe II	4	1	15	236.5	0	13	0.01
Subtotals	114	18	863	52.3	54	173	0.04
Sapi Safari Area							
Sapi North	0	0	0	0	0	0	0
Sapi South	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Chewore Safari Area							
Chewore I	5	1	20	183.4	0	15	0.01
Chewore III	32	6	118	70.8	9	55	0.04
Subtotals	37	7	138	64.9	13	62	0.02
Charara Safari Area							
Charara	0	0	0	0	0	0	0
Charara South	0	0	0	0	0	0	0
Subtotals	0	0	0	0	0	0	0
Dande Safari Area and Guruve District communal lands							
Chapoto	8	1	46	206	0	23	0.03
Dande	11	2	46	132.5	0	25	0.01
Kanyurira	0	0	0	0	0	0	0
Chisunga	0	0	0	0	0	0	0
Kadze	0	0	0	0	0	0	0
Subtotals	18	3	92	108.7	0	38	0.01
National Subtotals	314	54	6480	54.1	144	484	0.02
MOZAMBIQUE							
Magoe District							
Magoe 1	17	3	65	106.6	0	34	0.05
Magoe 2	5	1	23	190.7	0	16	0.02
Magoe 3	0	0	0	0	0	0	0
Magoe 4	23	2	222	159.8	0	59	0.04
Magoe 5	36	6	178	81.4	7	66	0.05
Magoe 6	0	0	0	0	0	0	0
Subtotals	81	12	488	56.7	35	127	0.03
North of Lake Cabora Bassa							
Luangwa	28	4	210	107.8	0	58	0.02
Tongoe	0	0	0	0	0	0	0
Metamboa	20	3	79	100.5	0	41	0.04
NCB 7	5	1	24	226.2	0	16	0.01
Zumbo	7	1	45	207.2	0	21	0.03
Mecucoe	0	0	0	0	0	0	0
Subtotals	60	9	358	63.6	22	98	0.02
National Subtotals	141	21	846	41.4	83	200	0.02
Two Country Totals	455	75	7326	39.1	277	633	0.02

Table 21. Population estimates and statistics for Unidentified Carcasses in the Zimbabwe and Mozambique sections of the Zambezi Heartland



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