

**AERIAL CENSUS OF
ELEPHANTS AND OTHER
LARGE HERBIVORES IN
SOUTH LUANGWA NP &
LUPANDE GMA,
ZAMBIA: 2002**

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reflect the views of NORAD, ZAWA, or WWF.

SUMMARY

Elephants and other large herbivores, wild and domestic, in South Luangwa National Park and Lupande Game Management Area, Zambia, were surveyed from the air during the period 12-19 August 2002. The area surveyed totalled 13 407 km². The overall sampling intensity was 8.3 %. The mean search intensity was 0.98 minutes per square kilometre.

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 were: elephant 5434 (95% confidence interval (CI) 30.5 %); impala 11 814 (CI 30 %); buffalo 9306 (CI 90 %); puku 5659 (CI 44 %); zebra 3250 (CI 30 %); roan antelope 632 (CI 84 %); waterbuck 575 (CI 48 %); kudu 505 (CI 71 %); Lichtenstein's Hartebeest 283 (71 %); Thornicroft's giraffe 236 (CI 61 %); reedbuck 225 (CI 63 %); eland 202 (CI 96 %); and sheep and goats 1175 (CI 81 %). The sheep and goats were confined to the Lupande GMA.

The mean carcass ratio for elephants was 1.3 %. There were an estimated 60 (CI 74 %) poachers' camps in South Luangwa NP.

A comparison of the sighting rates of the two observers revealed that one observer saw significantly less animals than the second observer: if the two observers had seen animals at the same rate, the estimated number of elephants would have been 28.5% greater than the above figure. Estimates for most other species would also have been greater.

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INTRODUCTION

Large wild and domestic herbivores were censused during August 2002 in the central Luangwa Valley, Zambia, as part of the background to a land-use study in the Lupande Game Management Area (GMA).

METHODS

Survey Area

The survey area covered 13407 km² and was divided into 14 strata (see Map 1 and Table 1). The survey area included South Luangwa National Park (SLNP) and Lupande GMA.

The strata boundaries were generally similar to those used during the 1999 survey (Jachmann & Phiri 1999), as determined after examination by the authors of the survey maps held in the Lusaka offices of the Wildlife Resource Monitoring Unit of the Environmental Council of Zambia. These survey maps showed the survey boundaries for the GMAs, but not for SLNP. The same maps had been used for several surveys during different years and the strata boundaries often varied between years. Hence, it was often not easy to determine which boundaries were used during 1999. Consequently, there may be minor variations between the boundaries of survey strata used during 1999 and those used during 2002. The provision of information on the abundance and distribution of wildlife in Lupande GMA was a major aim of the 2002 survey and so almost the entire GMA was surveyed during 2002, although only 1500 km² of this GMA was surveyed during 1999.

In the south-west of SLNP, 166 km² between the lip of the Muchinga Escarpment (which here is the park boundary) and the base of the escarpment was not surveyed during 2002, because this could not be done safely over this rapidly-rising ground with the survey technique used here. A small area (146 km²) of hilly ground in the south-east of Lupande GMA (to the south of the East Lupande stratum) was also excluded from the survey.

Strata boundaries were digitised from 1:250 000 scale maps purchased from the Surveyor General's Department in Lusaka. A digital file containing the co-ordinates (in decimal degrees latitude and longitude) of the boundaries of the strata was converted into bna-format that could be used by the WWF software for designing aerial surveys. The bna file was imported into the CARTALINX software (Hagan, Eastman & Auble 1998) and the area of each stratum determined.

The total area of SLNP (i.e. the sum of the areas of eight strata, numbers 1 to 8, and the unsurveyed 166 km²) was calculated as 8614 km², which compares with 9050 km², which is the official estimate of the park's area and the area used by Jachmann & Phiri (1999) in their analysis. This difference of 436 km² is in agreement with Astle's (1999, p.116) observation that the official estimate of the size of SLNP appears to overestimate the true size by about 300 km². There was also a discrepancy between Jachmann & Phiri's (1999) estimate of the area of Lupande GMA (4500 km²), the area stated in Statutory Instrument 174 (4840 km² (Astle 1999)) and the area calculated by us from the digitised boundaries shown on 1:250 000 scale maps (5106 km²).

In order to reduce the potential for observer fatigue during flights, transect lengths were reduced (cf. previous surveys in this area) by dividing the portion of SLNP that lies to the west of the Luangwa River into six strata. The boundaries between strata were chosen so as to minimise the heterogeneity of elephant density within individual strata, as determined by visual inspection of a map of elephant distribution within SLNP during the dry seasons of

1993-1999 (Jachmann & Phiri (1999, Figure 20)).

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 Zambia.

Systematic, parallel transects were positioned across each stratum. Transects were arranged approximately at right angles to the principal environmental feature within a stratum (see Map 1 and Table 1 for transect orientations). The distance between adjacent transects varied between strata, according to the planned sampling intensity in each stratum. Overall sampling intensity was planned to be about 8 %. The planned sampling intensity in each stratum was determined by using the mean of the elephant densities in each stratum during 1998 and 1999 when these were known (Jachmann & Phiri 1999) as the predicted elephant densities in equation 1 of Gibson (1992). Absolute elephant densities in the strata within SLNP were not known, but relative density estimates were provided by Jachmann & Phiri's map of elephant distribution during previous surveys. East Lupande stratum and Machinje stratum, both in Lupande GMA, were expected to contain few elephants. The Lupande Hills reportedly contained significant numbers of wildlife (M. Jones, pers. comm.) and so sampling intensity was relatively high in this stratum.

As a consequence of these procedures, those strata expected to contain large numbers of elephants were sampled more intensively than strata expected to contain few elephants. The transect spacings used are given in Table 1.

Surveys were designed using WWF's custom software (AIRDESW, version dated 29/05/97). Given a stratum boundary in the form of a bna file, and the transect orientation and spacing, this software generated flight lines (the transects), with the first flight line offset from the end of the stratum by the random number entered as the "offset". The start and end points for each transect were transferred as waypoints to a GPS receiver in the plane prior to flying each stratum.

Flight Procedure

The aircraft used was a Cessna 206. It was fitted with a radar altimeter and a Trimble GPS100 GPS receiver. During surveys, the aircraft was flown at approximately 160 km per hour at about 300 feet above ground level. The actual height above ground level (agl) was recorded from the radar altimeter every 30 seconds (of time) while flying along transects and later the mean height above ground level was calculated for each transect. Navigation along the transects was undertaken by the pilot, with reference to the GPS receiver and its course deviation indicator.

The aircraft crew included a pilot (Jon Cadd), a recorder (Hopeson Simwanza) who sat next to the pilot, and two observers (Paul Zyambo and Wilfred Moonga) who sat behind the pilot and recorder. Both observers 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* below) were called to the recorder, who wrote down the species, the number of individuals of the group that were within the strip, and the GPS location against the time (to the nearest 30 seconds) after the start of the transect. Location was recorded as longitude when flying north-

south and as latitude when flying east-west. The recorder used a stopwatch to record the time (to the nearest second) taken to fly each transect.

Although the survey was designed especially to count elephants, all wild herbivores larger than impala were counted, together with domestic cattle, sheep, goats, pigs and donkeys. Sheep and goats could not be distinguished from the air and were lumped together as “sheep and goats”. It is not always easy to differentiate between impala and puku from the air and possibly these two species were confused occasionally by observers.

During the survey, groups of elephant bulls were differentiated from elephant cow herds, although the latter may have included some bulls. Elephant carcasses were recorded and classified as:

| Carcass category | Definition |
|-------------------------|--|
| 1 | Fresh: intact; white droppings of vultures visible; vegetation trampled; fluid stain on ground around carcass visible (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 old). |
| 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, Michelmore & Inamdar (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). Carcasses that could not be identified as elephant carcasses were recorded as “unidentified carcasses”.

Ground hornbills are large and conspicuous birds and any seen during the survey were recorded.

Poachers’ camps were also recorded. They were identified by the presence of meat racks (horizontal branches mounted above the ground), with or without meat, or meat hanging in trees.

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.

All strata were flown during the period 12 - 19 August 2002 (Table 1).

Strip Width and Calibration

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 above ground level, the 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).

The strip widths were calibrated by flying the aircraft at right angles across a disused airstrip that had two sets of large-sized numbers (from 1 to 35) arranged at 10 meter intervals along the length of the airstrip. The numbers were arranged as 35, 34, 331, 0, 1,33, 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, which varied between 250 and 350 feet.

The nominal combined strip width at 300 feet agl was determined by averaging the combined strip widths, after adjusting these to 300 feet agl (see Appendix 1 for data and calculations).

Data Analysis

Population estimates and confidence intervals for individual strata were calculated with WWF’s custom software (AIRSURVW, version dated 22/05/97), which uses Jolly’s (1969) method 2 for unequal-sized sample units. Given the combined strip width when the plane was flying at 300 feet agl, and the mean height agl for each transect, the software determined the actual combined strip width for each transect. The area of each transect was calculated as the product of the actual combined strip width and the transect length (provided by AIRDESW). Search intensity (in minutes km⁻²) for a stratum was defined as the total time spent flying all transects within that stratum, divided by the total area of those same transects. The greater the search intensity, the greater the probability that observers observed animals that were within the strips.

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

Population estimates for SLNP, Lupande GMA and the entire study area were calculated as the sum of the estimates for the strata within each of these three land units. The confidence interval for each population estimate for the entire study area, for SLNP and for Lupande GMA was calculated as:

$$t_v \cdot \sqrt{\text{(Sum of Variances)}}$$

where:

v = the degrees of freedom estimated by Satterthwaite’s rule (Gasaway *et al.* 1986).

i.e.

$$v = \frac{\text{(Sum of Variances)}^2}{\text{Sum of } [(\text{Variance for individual stratum})^2 / (n-1)]}.$$

RESULTS

The estimated numbers of elephants, elephant bulls in bull groups, elephants in cow herds, old carcasses (category 3) of elephants, unidentified carcasses, buffalo, eland, Thornicroft's giraffe, Lichtenstein's hartebeest, impala, kudu, reedbuck, roan antelope, warthog, waterbuck, Cookson's wildebeest, warthog, zebra, ground hornbill, sheep and goats, and poachers' camps is given in Tables 3 to 23. Estimates are given for each stratum and for the entire survey area. Separate estimates are provided for South Luangwa National Park and Lupande GMA. 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 at the foot of some tables: these are rounding errors: estimates, variances and sums were calculated with great precision in a spreadsheet, before being rounded to zero decimal places. A summary of the population estimates and sampling statistics for the survey is given below.

Small numbers of lion, bushbuck, common duiker and domestic pigs were seen during the survey, but no attempt has been made to estimate the numbers of these species. No fresh (category 1) or recent (category 2) carcasses of elephants were seen. No domestic cattle or donkeys were seen.

The spatial variation in the density of the principal wildlife species within the survey area is shown in Maps 2 to 16.

Summary Table: Population estimates and statistics for large mammals, ground hornbills, carcasses and poachers' camps in South Luangwa NP and Lupande GMA

| Species / Object | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km ⁻²) |
|---------------------------|----------|----------|----------|-------|----------|----------|-----------------------------|
| Elephant | 5434 | 596 | 690362 | 30.5 | 3775 | 7093 | 0.41 |
| Buffalo | 9306 | 1091 | 16814949 | 90.1 | 920 | 17692 | 0.69 |
| Eland | 204 | 24 | 8839 | 95.7 | 9 | 399 | 0.02 |
| Thornicroft's Giraffe | 236 | 27 | 5139 | 61.0 | 92 | 379 | 0.02 |
| Lichtenstein's Hartebeest | 283 | 26 | 9220 | 70.7 | 83 | 484 | 0.02 |
| Impala | 11814 | 1330 | 2984060 | 29.5 | 8330 | 15299 | 0.88 |
| Kudu | 505 | 46 | 30559 | 70.6 | 148 | 861 | 0.04 |
| Puku | 5659 | 623 | 1185579 | 44.4 | 3149 | 8170 | 0.42 |
| Reedbuck | 225 | 24 | 4860 | 62.6 | 84 | 365 | 0.02 |
| Roan Antelope | 632 | 42 | 58195 | 84.1 | 101 | 1163 | 0.05 |
| Waterbuck | 575 | 63 | 19214 | 48.1 | 298 | 852 | 0.04 |
| Cookson's Wildebeest | 527 | 41 | 284365 | 280.8 | 0 | 2008 | 0.04 |
| Warthog | 1129 | 120 | 36853 | 34.1 | 744 | 1514 | 0.08 |
| Zebra | 3250 | 373 | 231737 | 30.0 | 2275 | 4226 | 0.24 |
| Ground Hornbill | 457 | 37 | 17301 | 59.2 | 187 | 728 | 0.03 |
| Sheep & goats | 1175 | 52 | 205567 | 81.1 | 222 | 2127 | 0.09 |
| Elephant carcasses | 71 | 5 | 1827 | 130.4 | 0 | 163 | 0.01 |
| Unidentified carcasses | 36 | 4 | 286 | 94.9 | 2 | 71 | 0.003 |
| Poachers' camps | 60 | 7 | 489 | 74.1 | 15 | 104 | 0.004 |

DISCUSSION

Elephant Carcasses

Carcass “ratios” of 2-8 % are regarded as indicative of elephant populations that are stable or increasing in number, while “ratios” greater than 8 % suggest that population number is declining (Douglas-Hamilton *et al.* 1992). The “ratio” in this study area was low, with a mean for the entire study area of 1.3 %. The “ratio” varied from 0.5 % in SLNP to 4.9 % in Lupande GMA.

Comparison between observers

The right observer, despite searching a narrower strip than the left observer, saw more groups and more individuals of most species than did the left observer (Table 2). If the two observers had seen similar densities of elephants in their search strips, the estimate of the number of elephants in the study area would be 28.5 % greater than that calculated in Table 3. The estimated populations numbers of most other species would also be greater by the factors given in Table 2.

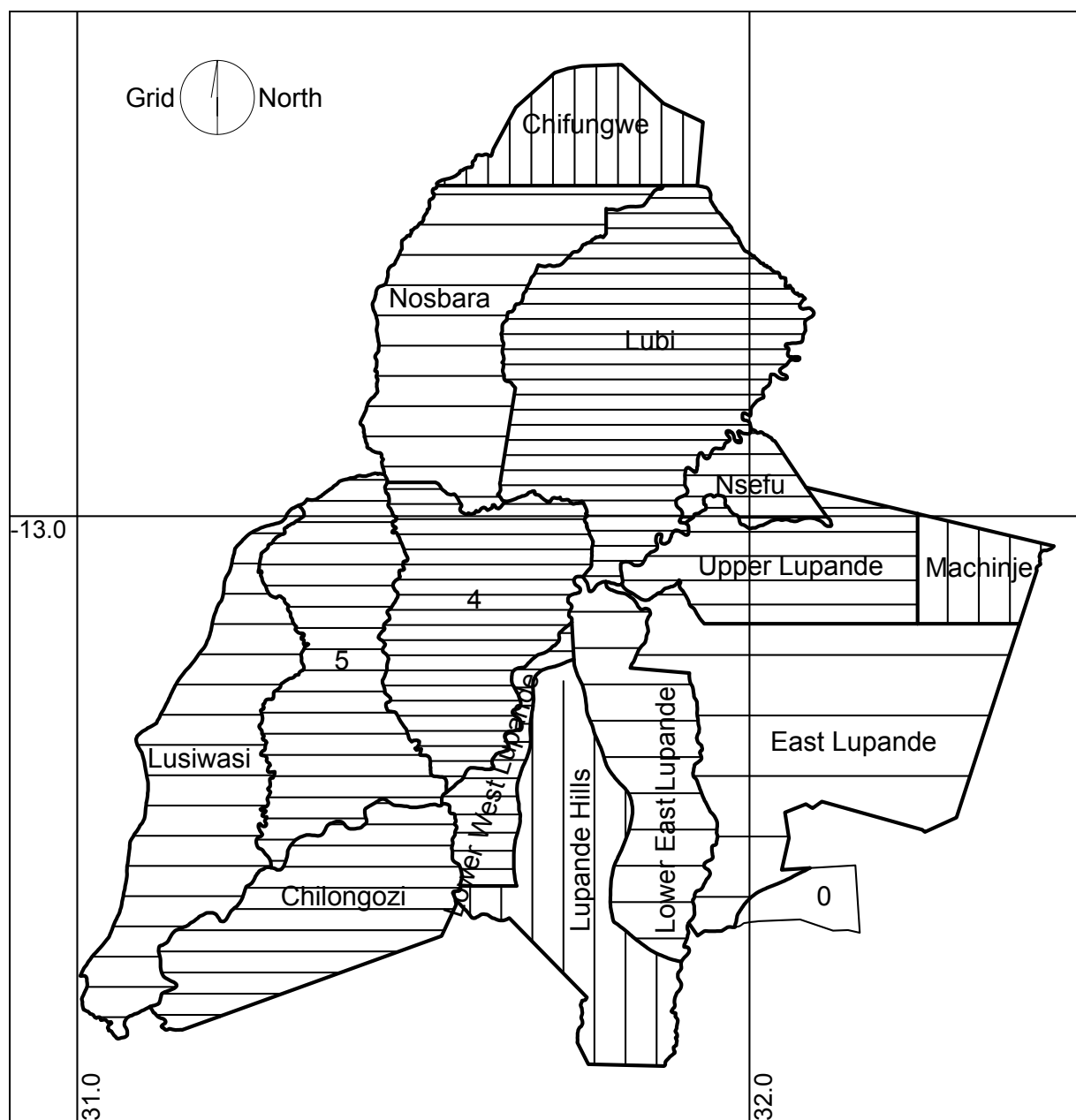
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Map 1. The survey area in the central Luangwa Valley, Zambia. Strata names, strata boundaries (bold lines) and transects (thin, parallel lines) are shown. A small section of hilly terrain in Lupande GMA (0) was not surveyed.

Table 1: Sampling statistics for the 2002 aerial survey of elephants and other large herbivores in the central Luangwa Valley

| Stratum number and name | Area (km ²) | Transect spacing (km) | Transect orientation (°) | Number of transects (= n) | Percent of stratum sampled | Time and Date sampled | Hours flown | | | Search intensity (mins km ⁻²) |
|-------------------------------------|-----------------------------|-----------------------|--------------------------|---------------------------|----------------------------|-----------------------|---------------|---------|--------------------|---|
| | | | | | | | Transects | Stratum | Total ¹ | |
| South Luangwa National Park | | | | | | | | | | |
| 1 Chifungwe | 556 | 3.5 | 0 | 12 | 9.09 | am 13/8 | 0.83 | 1.22 | 3.73 ^a | 0.98 |
| 2 Nosbara | 1222 | 5.0 | 90 | 11 | 6.62 | am 13/8 | 1.31 | 1.78 | ^a | 0.97 |
| 3 Lubi | 1961 | 2.5 | 90 | 27 | 13.14 | am & pm 14/8 | 4.14 | 5.45 | 6.55 | 0.96 |
| 4 Stratum Four | 1128 | 2.5 | 90 | 21 | 13.02 | am & pm 15/8 | 2.38 | 2.87 | 4.77 ^b | 0.97 |
| 5 Stratum Five | 1127 | 3.5 | 90 | 19 | 9.31 | am 17/8 | 1.78 | 2.62 | 3.35 | 1.02 |
| 6 Lusiwasi | 1224 | 5.0 | 90 | 17 | 6.53 | am 19/8 | 1.37 | 2.02 | 3.07 | 1.03 |
| 7 Chilongozi | 1004 | 3.5 | 90 | 11 | 9.39 | am 18/8 | 1.50 | 1.92 | ^d | 0.96 |
| 8 Nsefu | 226 | 3.5 | 90 | 5 | 9.80 | pm 18/8 | 0.41 | 0.68 | 1.23 | 1.12 |
| Lupande Game Management Area | | | | | | | | | | |
| 9 Upper Lupande | 765 | 4.0 | 90 | 5 | 7.75 | pm 17/8 | 1.00 | 1.28 | ^c | 1.01 |
| 10 West Lower Lupande | 274 | 3.0 | 90 | 14 | 10.39 | am 15/8 | 0.45 | 0.85 | ^b | 0.95 |
| 11 East Lower Lupande | 816 | 6.0 | 90 | 10 | 5.40 | pm 13/8 | 0.74 | 1.17 | 1.55 | 1.01 |
| 12 Machinje | 295 | 5.0 | 0 | 4 | 5.43 | pm 17/8 | 0.26 | 0.38 | 2.28 ^c | 0.97 |
| 13 East Lupande | 1797 | 10.0 | 90 | 6 | 3.23 | pm 12/8 | 0.89 | 1.28 | 1.63 | 0.92 |
| 14 Lupande Hills | 1012 | 5.0 | 0 | 7 | 6.99 | am 18/8 | 1.07 | 1.47 | 4.33 ^d | 0.91 |
| Total | 13407 km² | | | | Overall | | 8.31 % | | Mean | 0.98 |

¹ Strata with the same superscript were surveyed during the same flight

Table 2: Number of groups and animals of the major species seen by the two observers, and the number of groups that they would be expected to have seen if they were equally efficient at spotting animals from the plane.

The left observer searched a strip 171 m wide and the right observer searched a strip 147 m wide. Hence, the number of groups of a given species that a particular observer was expected to have seen was calculated as:

$$(\text{Total number of groups of that species seen by both observers}) \times (\text{Given observer's strip width}) / (\text{Left strip width} + \text{Right strip width})$$

Each chi-squared value is for a test comparing observed and expected numbers of groups for the given species and has 1 degree of freedom.

The multiplication factor is a number which, when multiplied by the calculated population estimate (Tables 3 and onwards), reveals what the population estimate would have been if both observers had found animals, in their search strips, at the same density as the right observer did. The multiplication factor for each species was calculated as:

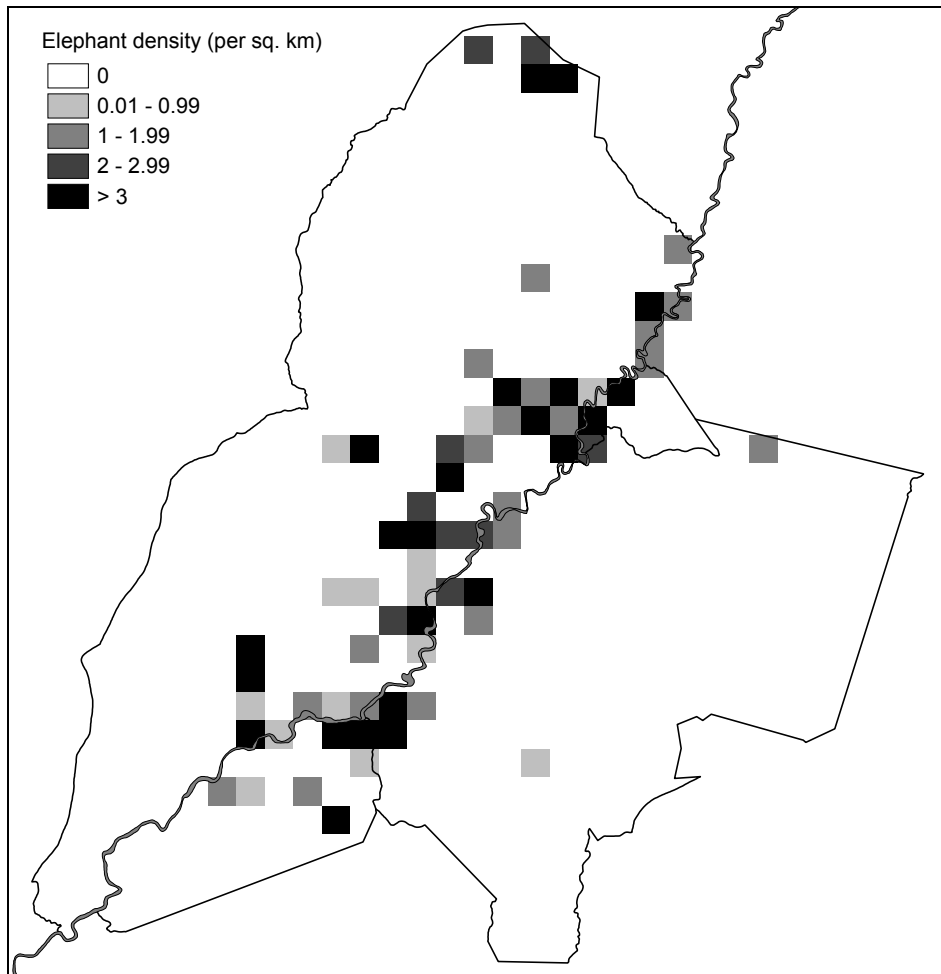
$$[(\text{Left strip width} + \text{Right strip width}) / \text{Right strip width}] \times (\text{Number of animals seen by right observer}) / (\text{Total number of animals seen by both observers})$$

| Species | Left Observer | | | Right Observer | | | χ^2 | P | Multiplication factor |
|------------|----------------------------|---------------------------|---------------------------|----------------------------|---------------------------|---------------------------|----------|---------|-----------------------|
| | Number of animals observed | Number of groups observed | Number of groups expected | Number of animals observed | Number of groups observed | Number of groups expected | | | |
| Buffalo | 314 | 14 | 17 | 777 | 17 | 14 | 1.17 | NS | 1 ^a |
| Eland | 19 | 5 | 3 | 5 | 1 | 3 | 2.667 | NS | 1 |
| Elephant | 242 | 43 | 61 | 354 | 71 | 53 | 11.425 | < 0.001 | 1.285 |
| Giraffe | 10 | 5 | 8 | 17 | 9 | 6 | 2.625 | NS | 1.344 |
| Hartebeest | 14 | 4 | 4 | 12 | 4 | 4 | - | NS | 1 |
| Impala | 616 | 88 | 83 | 714 | 67 | 72 | 0.648 | NS | 1.146 |
| Kudu | 9 | 3 | 7 | 37 | 10 | 6 | 4.952 | < 0.05 | 1.717 |
| Puku | 276 | 43 | 54 | 347 | 57 | 46 | 4.871 | < 0.05 | 1.189 |
| Reedbuck | 7 | 4 | 5 | 17 | 6 | 5 | 0.400 | NS | 1.512 |
| Roan | 1 | 1 | 6 | 41 | 10 | 5 | 9.167 | < 0.005 | 2.083 |
| Warthog | 50 | 18 | 26 | 70 | 31 | 23 | 5.244 | < 0.025 | 1.245 |
| Waterbuck | 34 | 15 | 13 | 29 | 10 | 12 | 0.641 | NS | 1 |
| Zebra | 118 | 25 | 42 | 255 | 54 | 37 | 14.692 | < 0.001 | 1.459 |

^a buffalo herd sizes are very variable in the field and this may account for the difference in the number of animals seen by the two observers

Table 3 : Population estimates and statistics for Elephants in South Luangwa National Park and Lupande Game Management Area

| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|-------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 781 | 71 | 178751 | 119.2 | 0 | 1711 | 1.40 |
| Nosbara | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lubi | 1681 | 221 | 310541 | 68.1 | 536 | 2827 | 0.86 |
| Stratum 4 | 852 | 111 | 34385 | 45.4 | 466 | 1239 | 0.76 |
| Stratum 5 | 526 | 49 | 34152 | 73.8 | 138 | 915 | 0.47 |
| Lusiwasi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Chilongozi | 394 | 37 | 36099 | 107.4 | 0 | 817 | 0.39 |
| Nsefu | 224 | 22 | 6893 | 102.7 | 0 | 455 | 0.99 |
| Subtotals | 4459 | 511 | 600821 | 34.9 | 2905 | 6014 | 0.53 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 103 | 8 | 7106 | 226.6 | 0 | 337 | 0.14 |
| West Lower Lupande | 578 | 60 | 39605 | 74.4 | 148 | 1008 | 2.11 |
| East Lower Lupande | 222 | 12 | 38447 | 199.6 | 0 | 666 | 0.27 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 72 | 5 | 4383 | 226.4 | 0 | 234 | 0.07 |
| Subtotals | 975 | 85 | 89541 | 63.1 | 359 | 1590 | 0.20 |
| Totals | 5434 | 596 | 690362 | 30.5 | 3775 | 7093 | 0.41 |

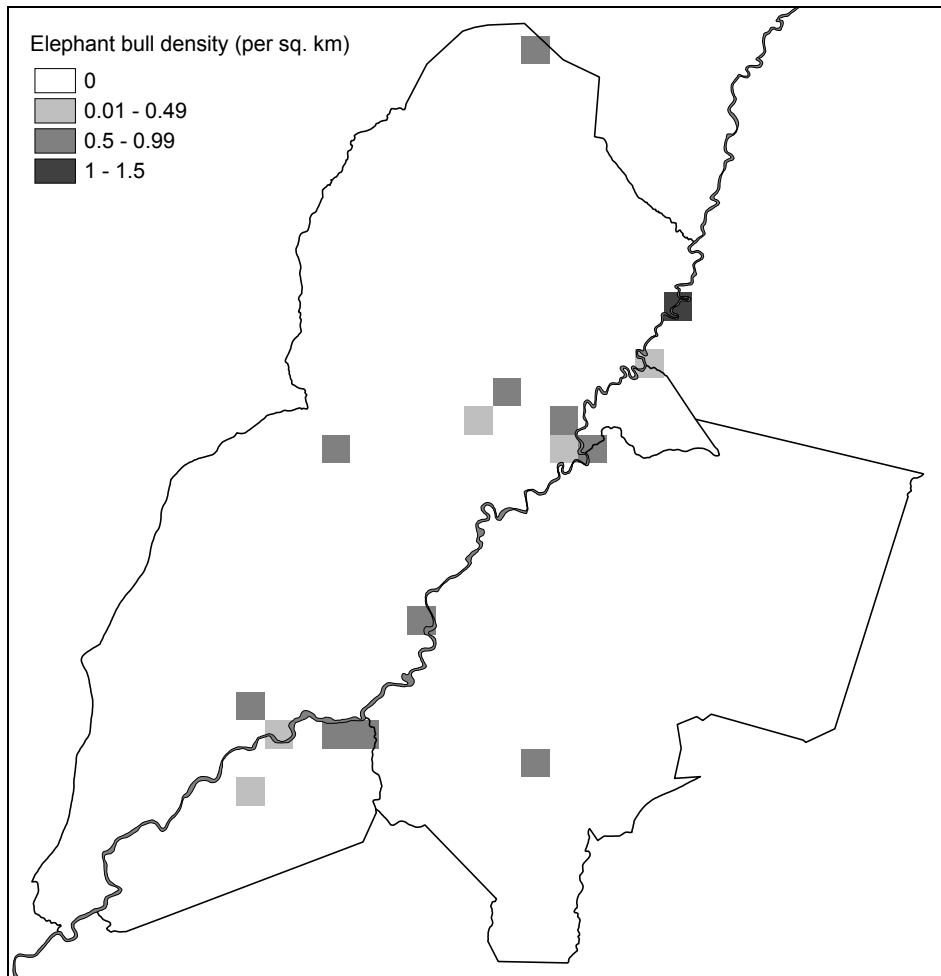


Map 2. Distribution of elephants in the central Luangwa Valley during August 2002

The Luangwa River, the boundary of the study area and the borders between South Luangwa NP and Lupande GMA are also shown. Elephant density is shown for each 5 km x 5 km map square in the study area.

Table 4 : Population estimates and statistics for Elephant bulls in South Luangwa National Park and Lupande Game Management Area

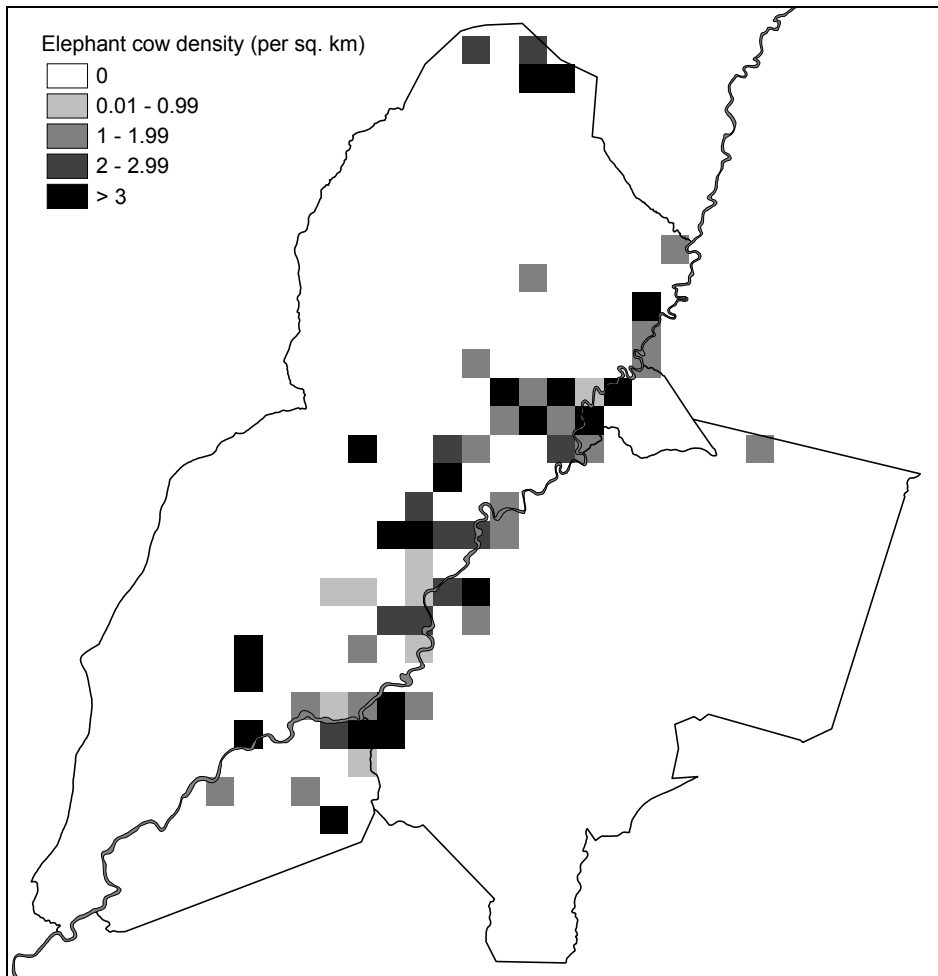
| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 22 | 2 | 413 | 203.4 | 0 | 67 | 0.04 |
| Nosbara | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lubi | 53 | 7 | 696 | 101.8 | 0 | 107 | 0.03 |
| Stratum 4 | 31 | 4 | 257 | 108.9 | 0 | 64 | 0.03 |
| Stratum 5 | 32 | 3 | 886 | 194.0 | 0 | 95 | 0.03 |
| Lusiwasi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Chilongozi | 43 | 4 | 1055 | 169.9 | 0 | 115 | 0.04 |
| Nsefu | 10 | 1 | 132 | 312.3 | 0 | 42 | 0.05 |
| Subtotals | 191 | 21 | 3438 | 61.4 | 74 | 308 | 0.02 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 26 | 2 | 711 | 286.7 | 0 | 100 | 0.03 |
| West Lower Lupande | 10 | 1 | 91 | 213.8 | 0 | 30 | 0.04 |
| East Lower Lupande | 37 | 2 | 1440 | 231.7 | 0 | 123 | 0.05 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 72 | 5 | 2241 | 140.1 | 0 | 174 | 0.01 |
| Totals | 263 | 26 | 5680 | 57.2 | 113 | 414 | 0.02 |



Map 3. Distribution of elephant bulls in the central Luangwa Valley during August 2002

Table 5 : Population estimates and statistics for Elephants cows in South Luangwa National Park and Lupande Game Management Area

| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|-------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 759 | 69 | 178338 | 122.5 | 0 | 1688 | 1.37 |
| Nosbara | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lubi | 1628 | 214 | 309846 | 70.3 | 484 | 2773 | 0.83 |
| Stratum 4 | 822 | 107 | 34128 | 46.9 | 436 | 1207 | 0.73 |
| Stratum 5 | 494 | 46 | 33266 | 77.5 | 111 | 877 | 0.44 |
| Lusiwasi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Chilongozi | 351 | 33 | 35044 | 118.7 | 0 | 768 | 0.35 |
| Nsefu | 214 | 21 | 6761 | 106.5 | 0 | 443 | 0.95 |
| Subtotals | 4268 | 490 | 597382 | 36.3 | 2718 | 5819 | 0.51 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 77 | 6 | 6396 | 286.7 | 0 | 299 | 0.10 |
| West Lower Lupande | 568 | 59 | 39514 | 75.6 | 139 | 997 | 2.07 |
| East Lower Lupande | 185 | 10 | 37007 | 234.9 | 0 | 620 | 0.23 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 72 | 5 | 4383 | 226.4 | 0 | 234 | 0.07 |
| Subtotals | 902 | 80 | 87300 | 67.3 | 295 | 1510 | 0.18 |
| Totals | 5171 | 570 | 684682 | 32.0 | 3518 | 6823 | 0.39 |



Map 4. Distribution of elephant cows in the central Luangwa Valley during August 2002

Table 6 : Population estimates and statistics for Elephant carcasses (age category 3) in South Luangwa National Park and Lupande Game Management Area

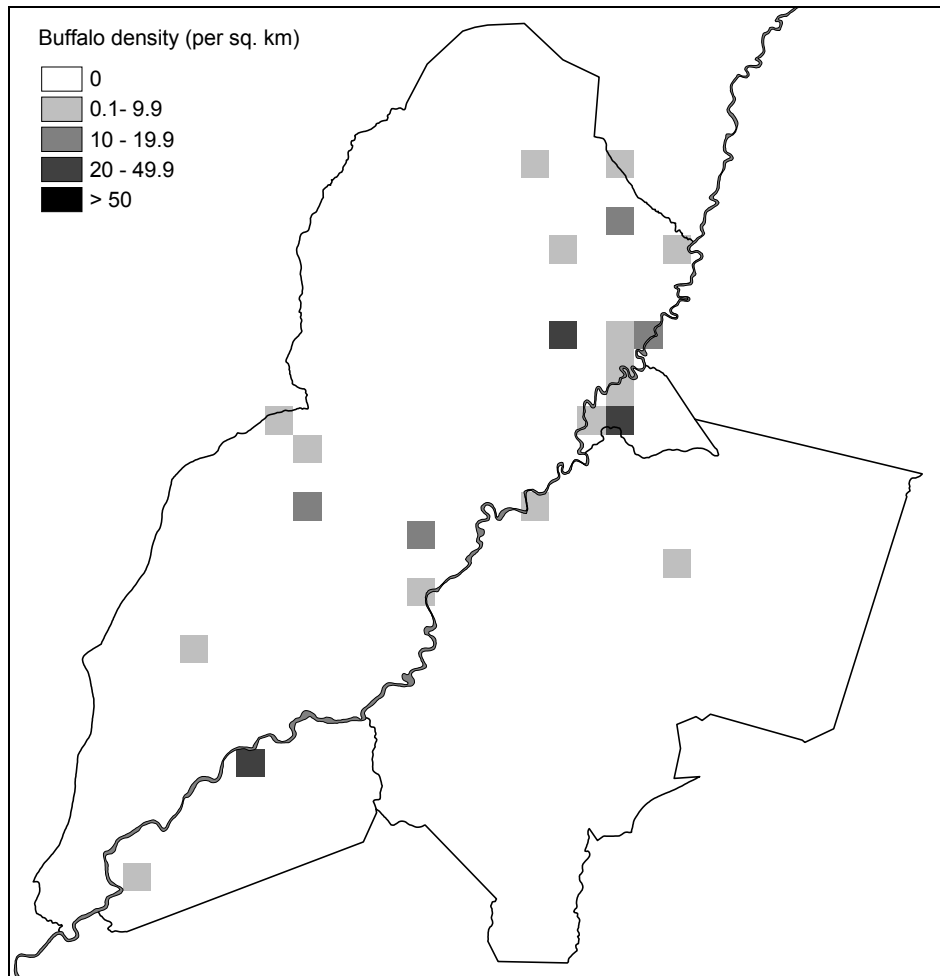
| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Nosbara | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lubi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Stratum 4 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Stratum 5 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lusiwasi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Chilongozi | 11 | 1 | 102 | 211.8 | 0 | 33 | 0.01 |
| Nsefu | 10 | 1 | 84 | 248.9 | 0 | 36 | 0.05 |
| Subtotals | 21 | 2 | 186 | 142.6 | 0 | 51 | 0.002 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 13 | 1 | 160 | 272.4 | 0 | 48 | 0.02 |
| West Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lower Lupande | 37 | 2 | 1480 | 234.9 | 0 | 124 | 0.05 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 50 | 3 | 1641 | 180.7 | 0 | 140 | 0.01 |
| Totals | 71 | 5 | 1827 | 130.4 | 0 | 163 | 0.01 |

Table 7 : Population estimates and statistics for unidentified carcasses in South Luangwa National Park and Lupande Game Management Area

| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|-------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 11 | 1 | 105 | 205.1 | 0 | 34 | 0.02 |
| Nosbara | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lubi | 8 | 1 | 50 | 190.9 | 0 | 22 | 0.00 |
| Stratum 4 | 8 | 1 | 49 | 190.3 | 0 | 22 | 0.01 |
| Stratum 5 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lusiwasi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Chilongozi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Nsefu | 10 | 1 | 82 | 246.0 | 0 | 35 | 0.05 |
| Subtotals | 36 | 4 | 286 | 94.9 | 2 | 71 | 0.004 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| West Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Totals | 36 | 4 | 286 | 94.9 | 2 | 71 | 0.003 |

Table 8 : Population estimates and statistics for Buffalo in South Luangwa National Park and Lupande Game Management Area

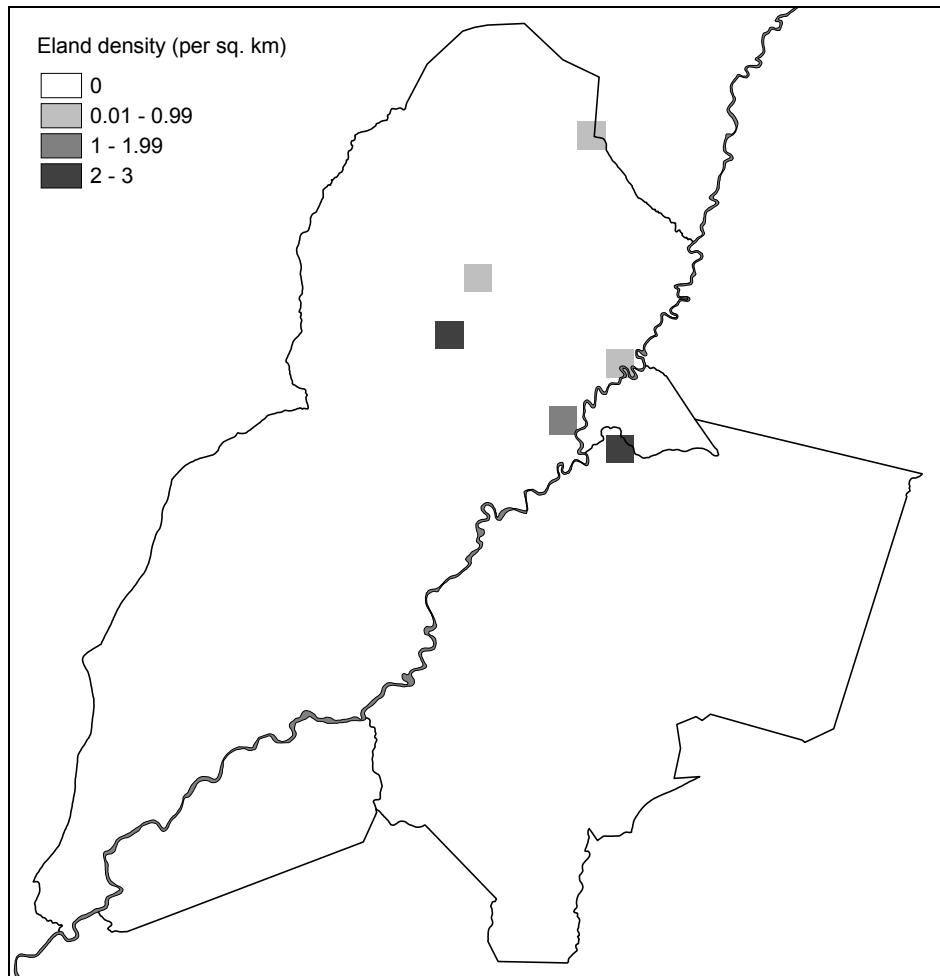
| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Nosbara | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lubi | 6041 | 794 | 15695965 | 134.8 | 0 | 14186 | 3.08 |
| Stratum 4 | 584 | 76 | 128877 | 128.3 | 0 | 1332 | 0.52 |
| Stratum 5 | 430 | 40 | 122473 | 171.1 | 0 | 1165 | 0.38 |
| Lusiwasi | 92 | 6 | 8406 | 211.7 | 0 | 286 | 0.08 |
| Chilongozi | 618 | 58 | 254993 | 182.2 | 0 | 1743 | 0.62 |
| Nsefu | 561 | 55 | 194818 | 218.3 | 0 | 1786 | 2.48 |
| Subtotals | 8325 | 1029 | 16405532 | 99.6 | 30 | 16620 | 0.99 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 671 | 52 | 351629 | 245.3 | 0 | 2317 | 0.88 |
| West Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 310 | 10 | 57788 | 199.3 | 0 | 928 | 0.17 |
| Lupande Hills | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 981 | 62 | 409417 | 167.7 | 0 | 2626 | 0.20 |
| Totals | 9306 | 1091 | 16814949 | 90.1 | 920 | 17692 | 0.69 |



Map 5. Distribution of buffalo in the central Luangwa Valley during August 2002

Table 9 : Population estimates and statistics for Eland in South Luangwa National Park and Lupande Game Management Area

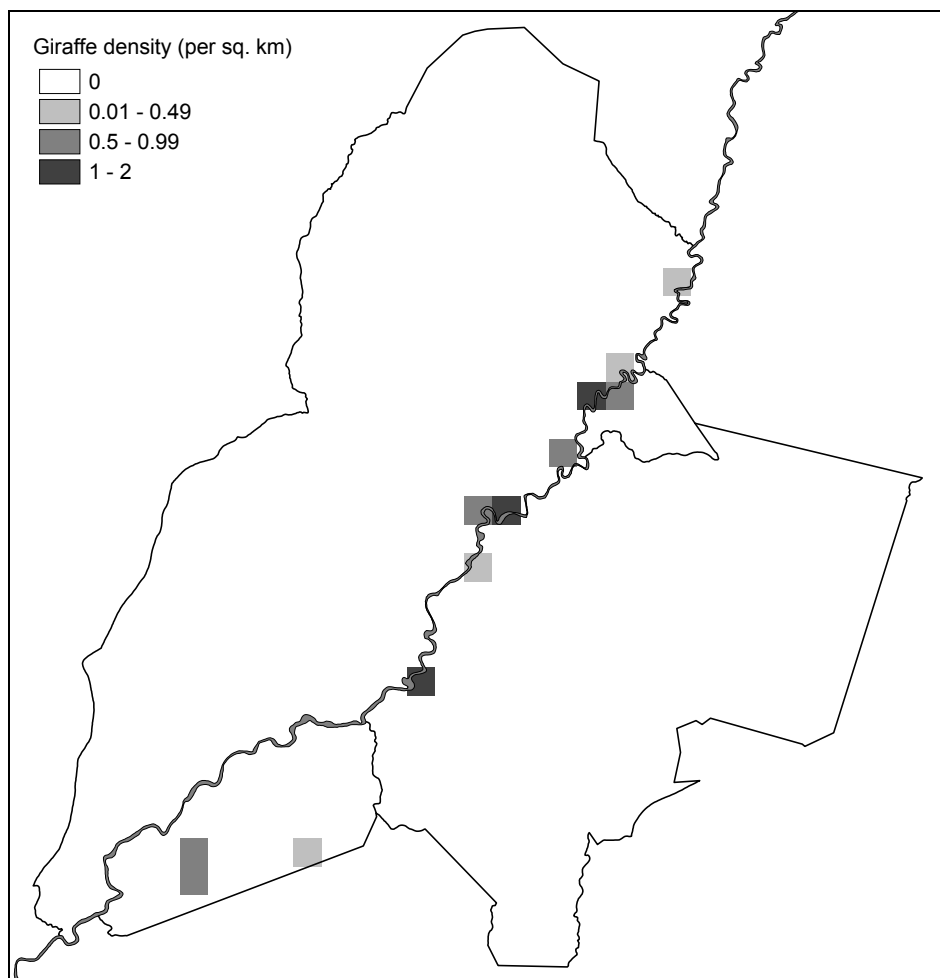
| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Nosbara | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lubi | 152 | 20 | 5997 | 104.6 | 0 | 311 | 0.08 |
| Stratum 4 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Stratum 5 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lusiwasi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Chilongozi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Nsefu | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 152 | 20 | 5997 | 104.6 | 0 | 311 | 0.02 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 52 | 4 | 2842 | 286.7 | 0 | 200 | 0.07 |
| West Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 52 | 4 | 2842 | 286.7 | 0 | 200 | 0.01 |
| Totals | 204 | 24 | 8839 | 95.7 | 9 | 399 | 0.02 |



Map 6. Distribution of eland in the central Luangwa Valley during August 2002

Table 10 : Population estimates and statistics for Thornicroft's Giraffe in South Luangwa National Park and Lupande Game Management Area

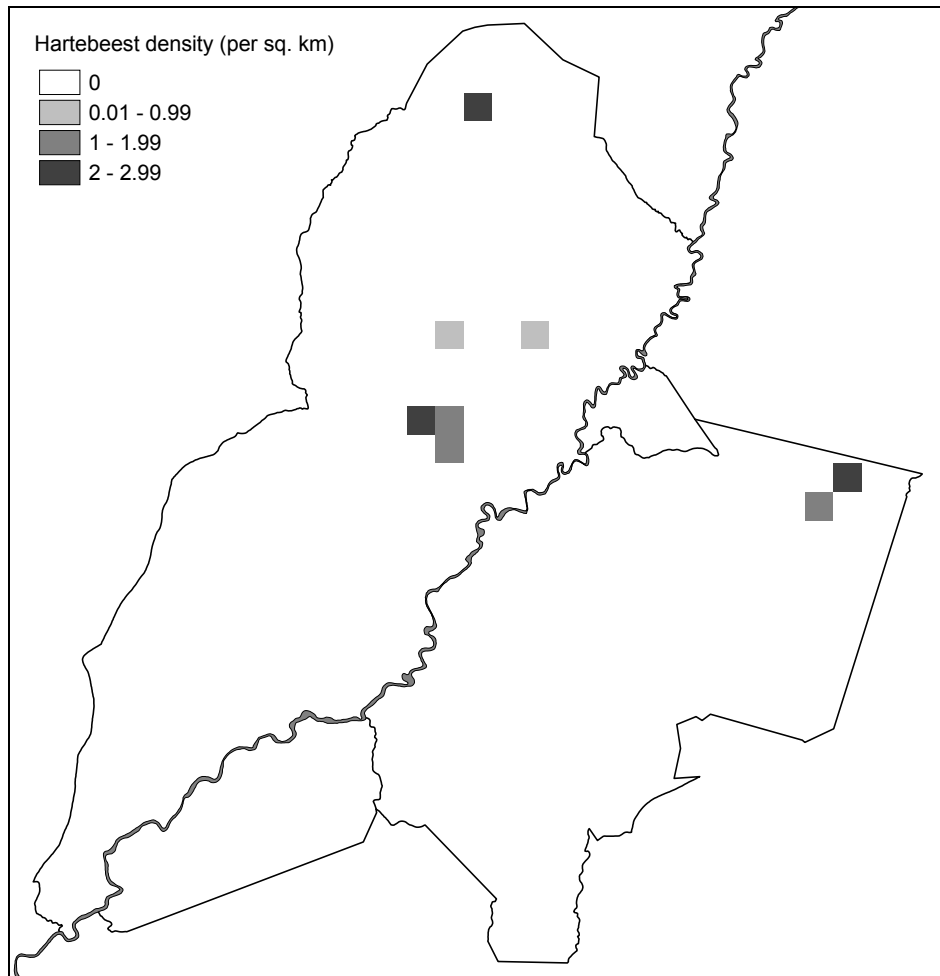
| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Nosbara | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lubi | 99 | 13 | 2553 | 105.0 | 0 | 203 | 0.05 |
| Stratum 4 | 15 | 2 | 186 | 185.1 | 0 | 44 | 0.01 |
| Stratum 5 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lusiwasi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Chilongozi | 43 | 4 | 393 | 103.7 | 0 | 87 | 0.04 |
| Nsefu | 31 | 3 | 536 | 209.9 | 0 | 95 | 0.14 |
| Subtotals | 187 | 22 | 3667 | 65.4 | 65 | 310 | 0.02 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| West Lower Lupande | 48 | 5 | 1471 | 172.1 | 0 | 131 | 0.18 |
| East Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 48 | 5 | 1471 | 172.1 | 0 | 131 | 0.01 |
| Totals | 236 | 27 | 5139 | 61.0 | 92 | 379 | 0.02 |



Map 7. Distribution of Thornicroft's giraffe in the central Luangwa Valley during August 2002

Table 11 : Population estimates and statistics for Lichtenstein's Hartebeest in South Luangwa National Park and Lupande Game Management Area

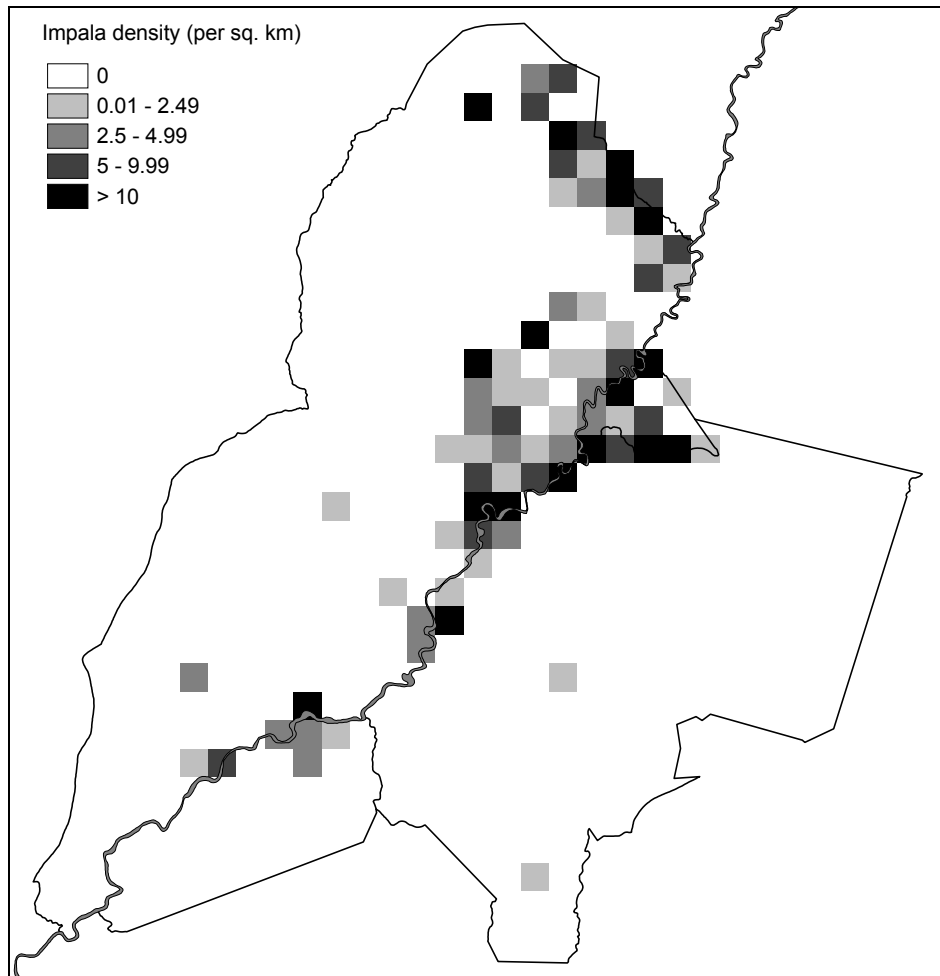
| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 66 | 6 | 3765 | 204.7 | 0 | 201 | 0.12 |
| Nosbara | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lubi | 76 | 10 | 1840 | 115.9 | 0 | 164 | 0.04 |
| Stratum 4 | 31 | 4 | 760 | 187.2 | 0 | 88 | 0.03 |
| Stratum 5 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lusiwasi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Chilongozi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Nsefu | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 173 | 20 | 6365 | 94.7 | 9 | 336 | 0.02 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| West Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Machinje | 111 | 6 | 2855 | 153.8 | 0 | 281 | 0.38 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 111 | 6 | 2855 | 153.8 | 0 | 281 | 0.02 |
| Totals | 283 | 26 | 9220 | 70.7 | 83 | 484 | 0.02 |



Map 8. Distribution of Lichtenstein's hartebeest in the central Luangwa Valley during August 2002

Table 12 : Population estimates and statistics for Impala in South Luangwa National Park and Lupande Game Management Area

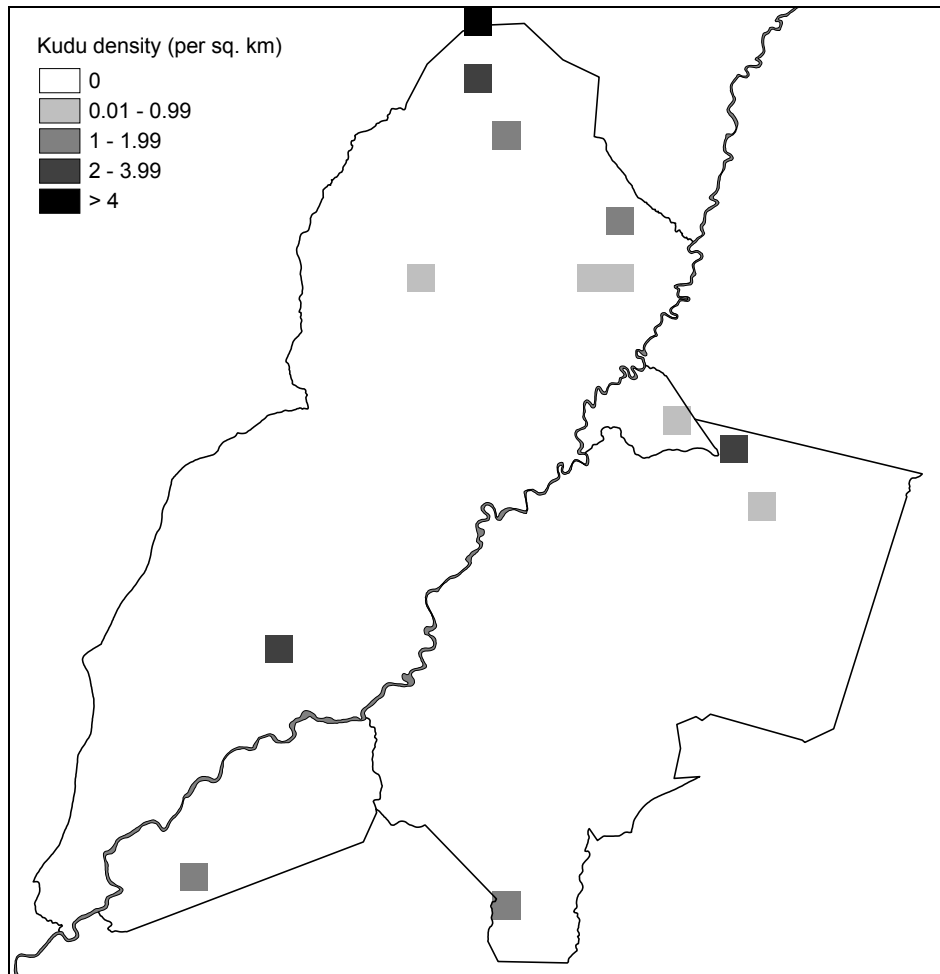
| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 1342 | 122 | 348046 | 96.8 | 43 | 2640 | 2.41 |
| Nosbara | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lubi | 5554 | 730 | 1024153 | 37.5 | 3473 | 7635 | 2.83 |
| Stratum 4 | 868 | 113 | 106757 | 78.5 | 186 | 1549 | 0.77 |
| Stratum 5 | 333 | 31 | 33495 | 115.5 | 0 | 718 | 0.30 |
| Lusiwasi | 168 | 11 | 18255 | 170.2 | 0 | 455 | 0.14 |
| Chilongozi | 788 | 74 | 389484 | 176.5 | 0 | 2178 | 0.79 |
| Nsefu | 1214 | 119 | 230297 | 109.7 | 0 | 2546 | 5.37 |
| Subtotals | 10267 | 1200 | 2150487 | 28.6 | 7331 | 13203 | 1.22 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 813 | 63 | 705116 | 286.7 | 0 | 3144 | 1.06 |
| West Lower Lupande | 539 | 56 | 112626 | 134.5 | 0 | 1264 | 1.97 |
| East Lower Lupande | 167 | 9 | 14960 | 166.0 | 0 | 443 | 0.20 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 29 | 2 | 871 | 252.3 | 0 | 101 | 0.03 |
| Subtotals | 1548 | 130 | 833572 | 151.7 | 0 | 3895 | 0.31 |
| Totals | 11814 | 1330 | 2984060 | 29.5 | 8330 | 15299 | 0.88 |



Map 9. Distribution of impala in the central Luangwa Valley during August 2002

Table 13 : Population estimates and statistics for Kudu in South Luangwa National Park and Lupande Game Management Area

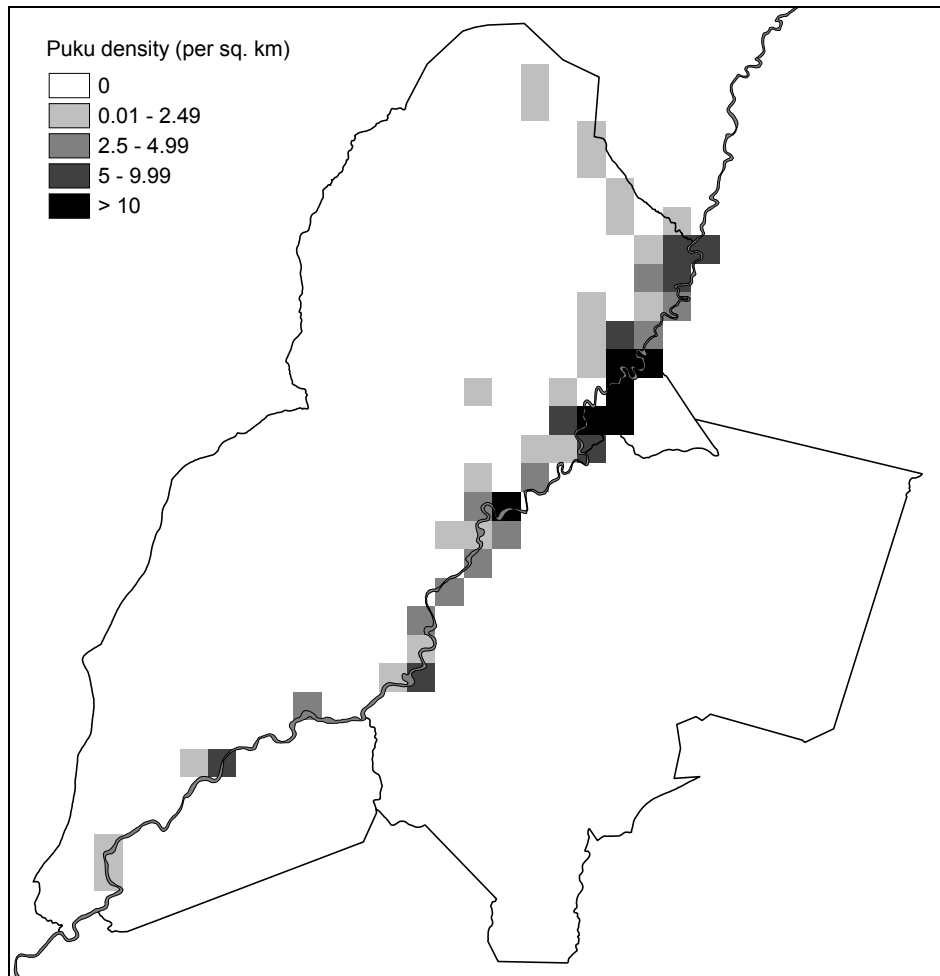
| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 110 | 10 | 10459 | 204.7 | 0 | 335 | 0.20 |
| Nosbara | 76 | 5 | 4956 | 207.5 | 0 | 232 | 0.06 |
| Lubi | 91 | 12 | 2304 | 108.1 | 0 | 190 | 0.05 |
| Stratum 4 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Stratum 5 | 64 | 6 | 3603 | 195.6 | 0 | 191 | 0.06 |
| Lusiwasi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Chilongozi | 21 | 2 | 401 | 209.6 | 0 | 66 | 0.02 |
| Nsefu | 10 | 1 | 82 | 246.0 | 0 | 35 | 0.05 |
| Subtotals | 373 | 36 | 21804 | 80.4 | 73 | 673 | 0.04 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 103 | 8 | 8107 | 242.1 | 0 | 353 | 0.14 |
| West Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 29 | 2 | 648 | 217.6 | 0 | 91 | 0.03 |
| Subtotals | 132 | 10 | 8755 | 197.0 | 0 | 392 | 0.03 |
| Totals | 505 | 46 | 30559 | 70.6 | 148 | 861 | 0.04 |



Map 10. Distribution of kudu in the central Luangwa Valley during August 2002

Table 14 : Population estimates and statistics for Puku in South Luangwa National Park and Lupande Game Management Area

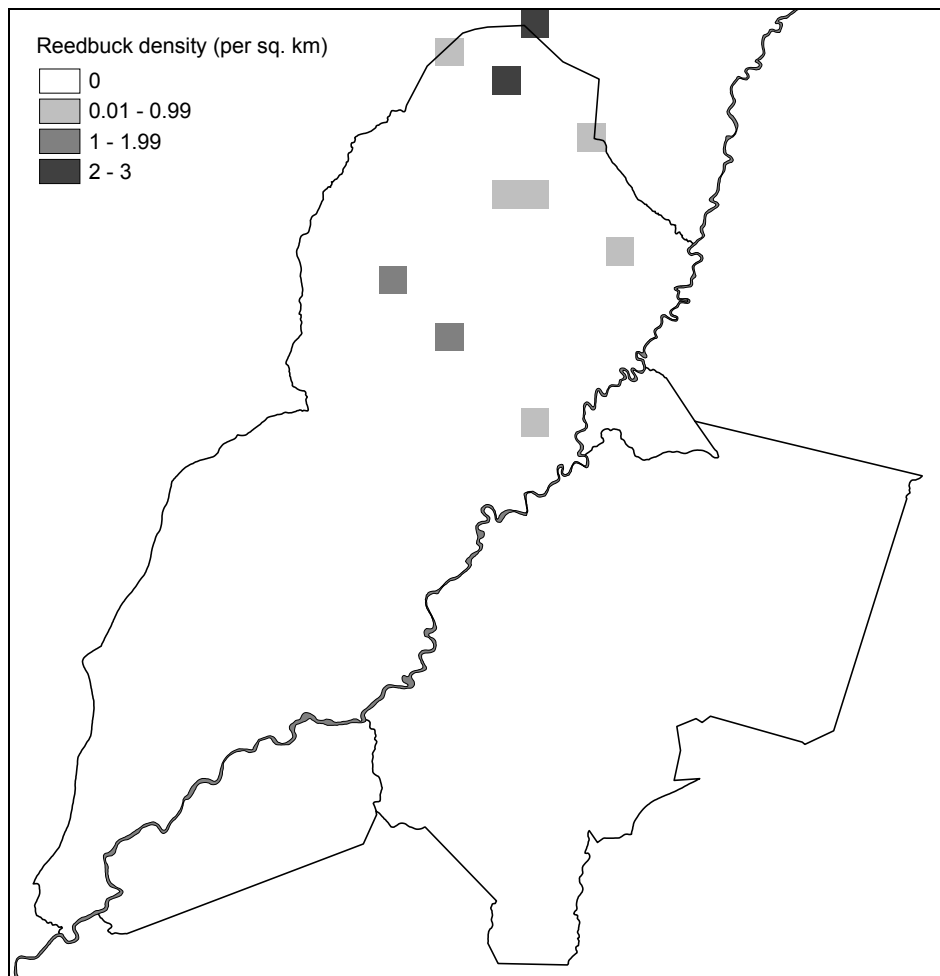
| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 88 | 8 | 6612 | 203.4 | 0 | 267 | 0.16 |
| Nosbara | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lubi | 2047 | 269 | 152666 | 39.3 | 1243 | 2850 | 1.04 |
| Stratum 4 | 323 | 42 | 14506 | 77.9 | 71 | 574 | 0.29 |
| Stratum 5 | 215 | 20 | 16832 | 126.9 | 0 | 487 | 0.19 |
| Lusiwasi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Chilongozi | 75 | 7 | 1777 | 126.0 | 0 | 168 | 0.07 |
| Nsefu | 2020 | 198 | 804954 | 123.3 | 0 | 4511 | 8.94 |
| Subtotals | 4767 | 544 | 997346 | 51.3 | 2323 | 7211 | 0.56 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 310 | 24 | 102330 | 286.7 | 0 | 1198 | 0.41 |
| West Lower Lupande | 472 | 49 | 72581 | 123.4 | 0 | 1054 | 1.72 |
| East Lower Lupande | 111 | 6 | 13322 | 234.9 | 0 | 372 | 0.14 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 893 | 79 | 188233 | 107.0 | 0 | 1848 | 0.18 |
| Totals | 5659 | 623 | 1185579 | 44.4 | 3149 | 8170 | 0.42 |



Map 11. Distribution of puku in the central Luangwa Valley during August 2002

Table 15 : Population estimates and statistics for Reedbuck in South Luangwa National Park and Lupande Game Management Area

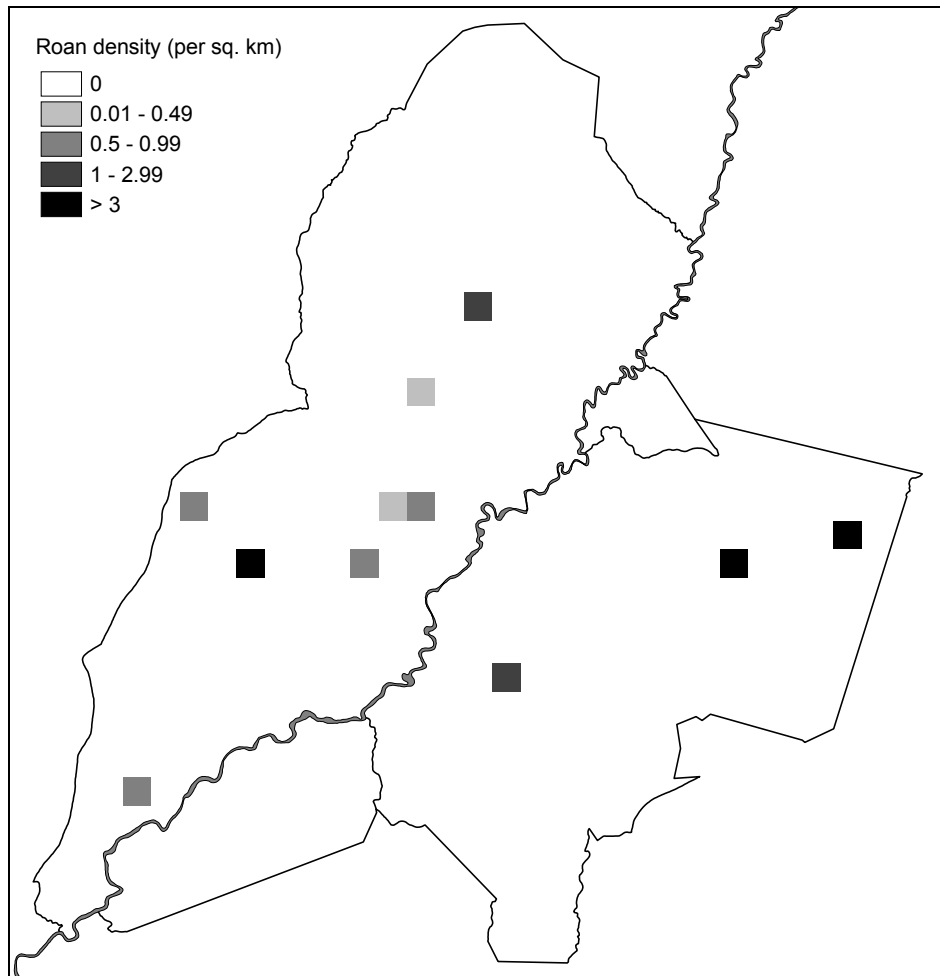
| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|-------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 88 | 8 | 1780 | 105.5 | 0 | 181 | 0.16 |
| Nosbara | 30 | 2 | 914 | 222.8 | 0 | 98 | 0.03 |
| Lubi | 107 | 14 | 2167 | 89.8 | 11 | 202 | 0.05 |
| Stratum 4 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Stratum 5 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lusiwasi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Chilongozi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Nsefu | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 225 | 24 | 4860 | 62.6 | 84 | 365 | 0.03 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| West Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Totals | 225 | 24 | 4860 | 62.6 | 84 | 365 | 0.02 |



Map 12. Distribution of reedbuck in the central Luangwa Valley during August 2002

Table 16 : Population estimates and statistics for Roan Antelope in South Luangwa National Park and Lupande Game Management Area

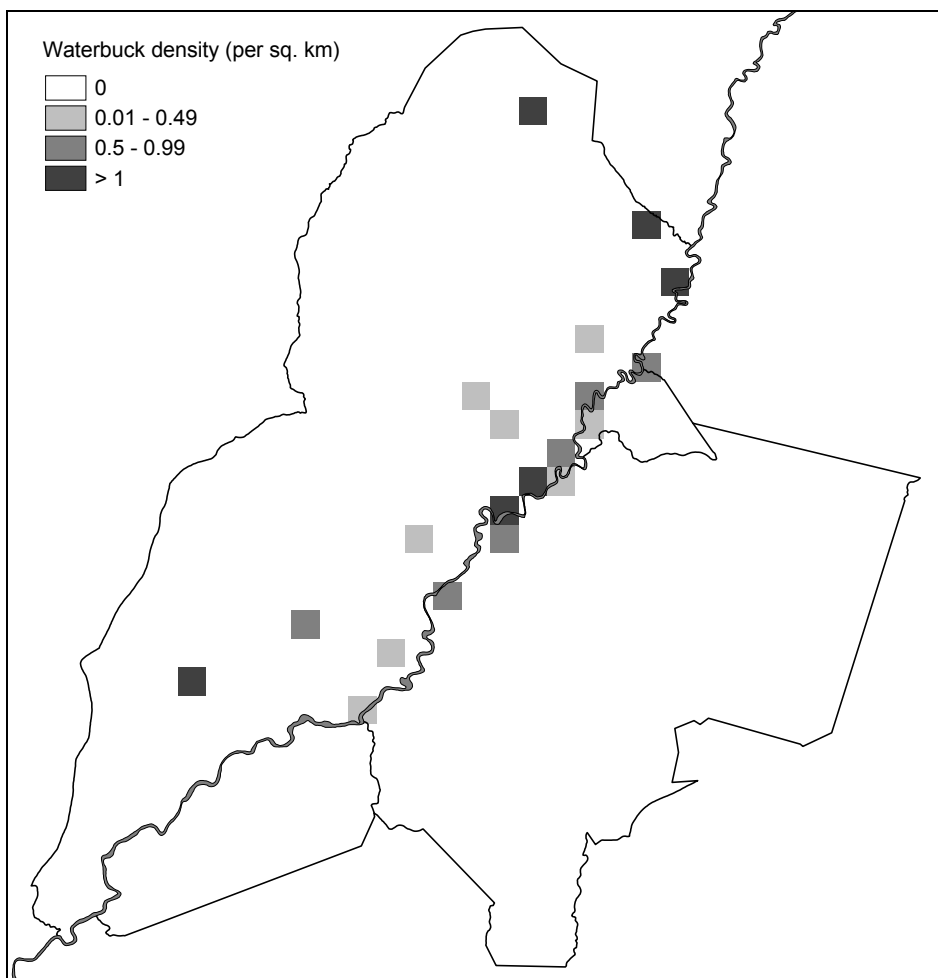
| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Nosbara | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lubi | 76 | 10 | 3881 | 168.3 | 0 | 204 | 0.04 |
| Stratum 4 | 38 | 5 | 374 | 105.1 | 0 | 79 | 0.03 |
| Stratum 5 | 86 | 8 | 5239 | 176.9 | 0 | 238 | 0.08 |
| Lusiwasi | 15 | 1 | 219 | 205.2 | 0 | 47 | 0.01 |
| Chilongozi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Nsefu | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 216 | 24 | 9713 | 92.1 | 17 | 414 | 0.03 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| West Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Machinje | 111 | 6 | 8906 | 271.6 | 0 | 411 | 0.38 |
| East Lupande | 248 | 8 | 36984 | 199.3 | 0 | 742 | 0.14 |
| Lupande Hills | 57 | 4 | 2591 | 217.6 | 0 | 182 | 0.06 |
| Subtotals | 416 | 18 | 48482 | 125.2 | 0 | 937 | 0.08 |
| Totals | 632 | 42 | 58195 | 84.1 | 101 | 1163 | 0.05 |



Map 13. Distribution of roan antelope in the central Luangwa Valley during August 2002

Table 17 : Population estimates and statistics for Waterbuck in South Luangwa National Park and Lupande Game Management Area

| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 88 | 8 | 3938 | 157.0 | 0 | 226 | 0.16 |
| Nosbara | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lubi | 312 | 41 | 8959 | 62.4 | 117 | 507 | 0.16 |
| Stratum 4 | 15 | 2 | 94 | 131.6 | 0 | 36 | 0.01 |
| Stratum 5 | 32 | 3 | 914 | 197.1 | 0 | 96 | 0.03 |
| Lusiwasi | 61 | 4 | 3604 | 207.9 | 0 | 188 | 0.05 |
| Chilongozi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Nsefu | 10 | 1 | 82 | 246.0 | 0 | 35 | 0.05 |
| Subtotals | 519 | 59 | 17591 | 51.2 | 253 | 784 | 0.06 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| West Lower Lupande | 19 | 2 | 143 | 134.0 | 0 | 45 | 0.07 |
| East Lower Lupande | 37 | 2 | 1480 | 234.9 | 0 | 124 | 0.05 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 56 | 4 | 1623 | 159.4 | 0 | 146 | 0.01 |
| Totals | 575 | 63 | 19214 | 48.1 | 298 | 852 | 0.04 |



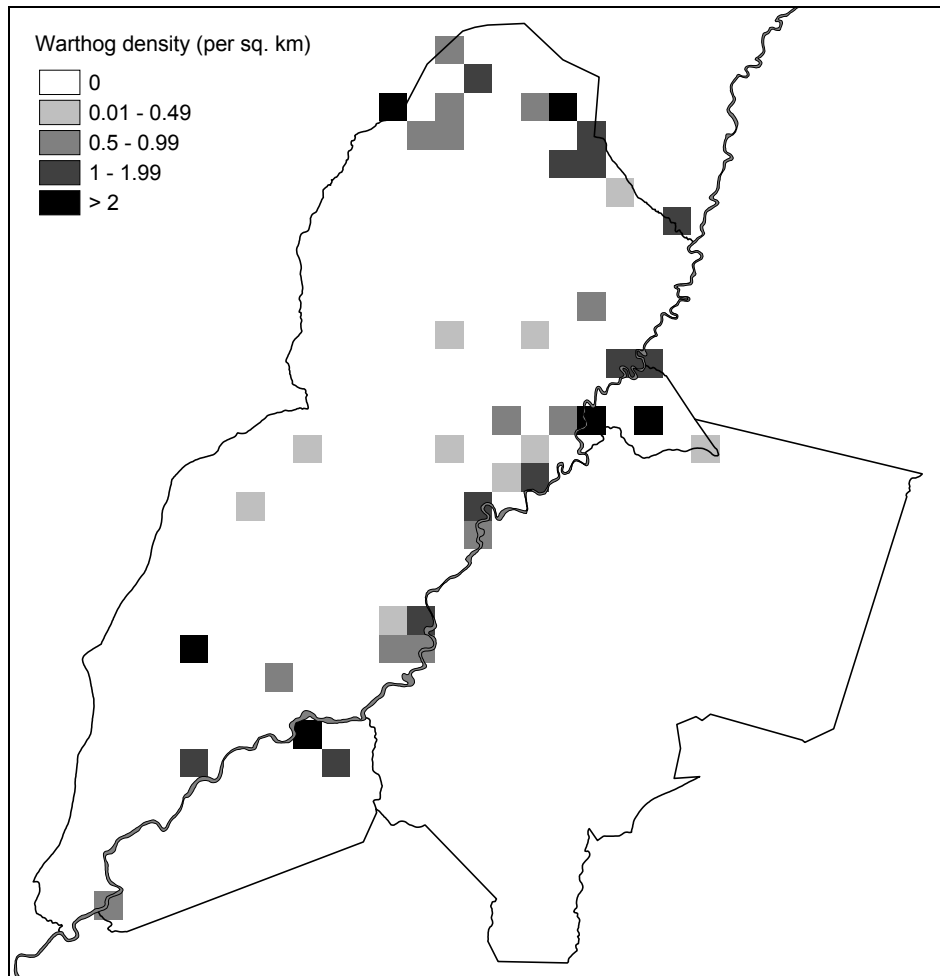
Map 14. Distribution of waterbuck in the central Luangwa Valley during August 2002

Table 18 : Population estimates and statistics for Cookson's Wildebeest in South Luangwa National Park and Lupande Game Management Area

| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 11 | 1 | 115 | 215.0 | 0 | 35 | 0.02 |
| Nosbara | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lubi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Stratum 4 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Stratum 5 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lusiwasi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Chilongozi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Nsefu | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 11 | 1 | 115 | 215.0 | 0 | 35 | 0.001 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 516 | 40 | 284249 | 286.7 | 0 | 1996 | 0.68 |
| West Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 516 | 40 | 284249 | 286.7 | 0 | 1996 | 0.10 |
| Totals | 527 | 41 | 284365 | 280.8 | 0 | 2008 | 0.04 |

Table 19 : Population estimates and statistics for Warthog in South Luangwa National Park and Lupande Game Management Area

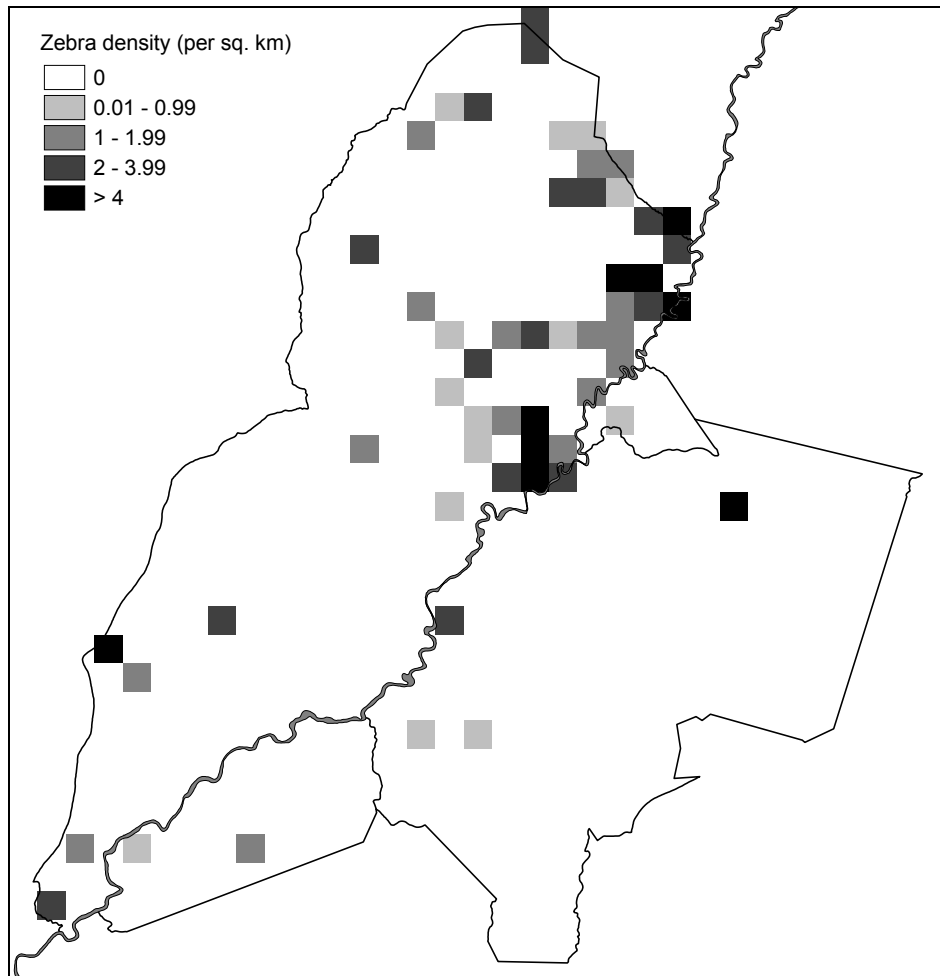
| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 275 | 25 | 13433 | 92.8 | 20 | 530 | 0.49 |
| Nosbara | 30 | 2 | 793 | 207.5 | 0 | 93 | 0.03 |
| Lubi | 304 | 40 | 8096 | 60.8 | 119 | 489 | 0.16 |
| Stratum 4 | 154 | 20 | 4241 | 88.5 | 18 | 289 | 0.14 |
| Stratum 5 | 64 | 6 | 1214 | 113.6 | 0 | 138 | 0.06 |
| Lusiwasi | 61 | 4 | 1769 | 145.7 | 0 | 150 | 0.05 |
| Chilongozi | 75 | 7 | 3037 | 164.7 | 0 | 197 | 0.07 |
| Nsefu | 143 | 14 | 4003 | 123.0 | 0 | 318 | 0.63 |
| Subtotals | 1106 | 118 | 36586 | 34.7 | 722 | 1490 | 0.13 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 13 | 1 | 178 | 286.7 | 0 | 50 | 0.02 |
| West Lower Lupande | 10 | 1 | 89 | 211.9 | 0 | 30 | 0.04 |
| East Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 23 | 2 | 267 | 167.2 | 0 | 60 | 0.005 |
| Totals | 1129 | 120 | 36853 | 34.1 | 744 | 1514 | 0.08 |



Map 15. Distribution of warthog in the central Luangwa Valley during August 2002

Table 20 : Population estimates and statistics for Zebra in South Luangwa National Park and Lupande Game Management Area

| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 231 | 21 | 14429 | 114.5 | 0 | 495 | 0.42 |
| Nosbara | 136 | 9 | 7363 | 140.5 | 0 | 327 | 0.11 |
| Lubi | 2130 | 280 | 138822 | 36.0 | 1364 | 2896 | 1.09 |
| Stratum 4 | 69 | 9 | 994 | 95.2 | 3 | 135 | 0.06 |
| Stratum 5 | 54 | 5 | 2539 | 197.1 | 0 | 160 | 0.05 |
| Lusiwasi | 230 | 15 | 12758 | 104.3 | 0 | 469 | 0.19 |
| Chilongozi | 96 | 9 | 2889 | 125.0 | 0 | 216 | 0.10 |
| Nsefu | 10 | 1 | 84 | 248.9 | 0 | 36 | 0.05 |
| Subtotals | 2956 | 349 | 179877 | 29.0 | 2099 | 3812 | 0.35 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 232 | 18 | 50613 | 268.8 | 0 | 857 | 0.30 |
| West Lower Lupande | 48 | 5 | 1071 | 146.8 | 0 | 119 | 0.18 |
| East Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 14 | 1 | 175 | 226.4 | 0 | 47 | 0.01 |
| Subtotals | 295 | 24 | 51859 | 214.5 | 0 | 927 | 0.06 |
| Totals | 3250 | 373 | 231737 | 30.0 | 2275 | 4226 | 0.24 |



Map 16. Distribution of zebra in the central Luangwa Valley during August 2002

Table 21 : Population estimates and statistics for Ground Hornbill in South Luangwa National Park and Lupande Game Management Area

| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 44 | 4 | 1737 | 208.5 | 0 | 136 | 0.08 |
| Nosbara | 45 | 3 | 1989 | 219.1 | 0 | 145 | 0.04 |
| Lubi | 114 | 15 | 2730 | 94.1 | 7 | 222 | 0.06 |
| Stratum 4 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Stratum 5 | 43 | 4 | 959 | 151.4 | 0 | 108 | 0.04 |
| Lusiwasi | 46 | 3 | 2098 | 211.5 | 0 | 143 | 0.04 |
| Chilongozi | 21 | 2 | 410 | 211.8 | 0 | 66 | 0.02 |
| Nsefu | 10 | 1 | 84 | 248.9 | 0 | 36 | 0.05 |
| Subtotals | 324 | 32 | 10007 | 61.5 | 125 | 523 | 0.04 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| West Lower Lupande | 10 | 1 | 76 | 195.0 | 0 | 28 | 0.04 |
| East Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 124 | 4 | 7219 | 176.1 | 0 | 342 | 0.07 |
| Lupande Hills | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 134 | 5 | 7294 | 164.3 | 0 | 353 | 0.03 |
| Totals | 457 | 37 | 17301 | 59.2 | 187 | 728 | 0.03 |

Table 22 : Population estimates and statistics for Sheep and Goats in South Luangwa National Park and Lupande Game Management Area

| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|-------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Nosbara | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lubi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Stratum 4 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Stratum 5 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lusiwasi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Chilongozi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Nsefu | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| West Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lower Lupande | 278 | 15 | 82981 | 234.5 | 0 | 929 | 0.34 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 682 | 22 | 73598 | 102.3 | 0 | 1380 | 0.38 |
| Lupande Hills | 215 | 15 | 48988 | 252.3 | 0 | 756 | 0.21 |
| Subtotals | 1175 | 52 | 205567 | 81.1 | 222 | 2127 | 0.24 |
| Totals | 1175 | 52 | 205567 | 81.1 | 222 | 2127 | 0.09 |

Table 23 : Population estimates and statistics for Poachers' Camps in South Luangwa National Park and Lupande Game Management Area

| Stratum | Estimate | No. Seen | Variance | % CI | Lower CL | Upper CL | Density (km⁻²) |
|-------------------------|-----------------|-----------------|-----------------|-------------|-----------------|-----------------|----------------------------------|
| South Luangwa NP | | | | | | | |
| Chifungwe | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Nosbara | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lubi | 23 | 3 | 228 | 136.0 | 0 | 54 | 0.01 |
| Stratum 4 | 15 | 2 | 88 | 127.3 | 0 | 35 | 0.01 |
| Stratum 5 | 21 | 2 | 173 | 128.6 | 0 | 49 | 0.02 |
| Lusiwasi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Chilongozi | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Nsefu | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 60 | 7 | 489 | 74.1 | 15 | 104 | 0.01 |
| Lupande GMA | | | | | | | |
| Upper Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| West Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lower Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Machinje | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| East Lupande | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Lupande Hills | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Subtotals | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.00 |
| Totals | 60 | 7 | 489 | 74.1 | 15 | 104 | 0.004 |

Appendix 1. Calibration to determine strip width

Strip width (in meters) for one observer = 10 x (Difference between outer and inner + 1).

Combined strip width (in meters) = 10 x (Difference_{left} + Difference_{right} + 2).

Combined strip width at 300 feet agl¹ = Combined strip width x 300 / (Height agl)

¹ agl: above ground level

| Run no. | Left observer: Paul Zyambo | | | Right observer: Wilfred Moonga | | | Combined strip width (in meters) at actual height | Height agl (feet) | Combined strip width (in meters) at 300 feet agl |
|---------|-------------------------------|--------------|-----------------|-----------------------------------|--------------|-----------------|--|----------------------|--|
| | Outer Marker | Inner Marker | Strip Width (m) | Outer Marker | Inner Marker | Strip Width (m) | | | |
| 1 | 30 | 13 | 180 | 29 | 16 | 140 | 320 | 300 | 320 |
| 2 | 26 | 10 | 170 | 30 | 17 | 140 | 310 | 300 | 310 |
| 3 | 30 | 14 | 170 | 28 | 14 | 150 | 320 | 300 | 320 |
| 4 | 29 | 12 | 180 | 28 | 14 | 150 | 330 | 300 | 330 |
| 5 | 28 | 12 | 170 | 27 | 14 | 140 | 310 | 300 | 310 |
| 6 | 26 | 10 | 170 | 32 | 17 | 160 | 330 | 300 | 330 |
| 7 | 27 | 11 | 170 | 29 | 15 | 150 | 320 | 300 | 320 |
| 8 | 27 | 11 | 170 | 32 | 16 | 170 | 340 | 310 | 329 |
| 9 | 30 | 14 | 170 | 28 | 14 | 150 | 320 | 310 | 310 |
| 10 | 23 | 9 | 150 | 28 | 14 | 150 | 300 | 280 | 321 |
| 11 | 27 | 11 | 170 | 34 | 18 | 170 | 340 | 340 | 300 |
| 12 | 28 | 12 | 170 | 27 | 13 | 150 | 320 | 300 | 320 |
| 13 | 30 | 13 | 180 | 29 | 15 | 150 | 330 | 300 | 330 |
| 14 | 27 | 11 | 170 | 30 | 16 | 150 | 320 | 330 | 291 |
| 15 | 28 | 12 | 170 | 30 | 16 | 150 | 320 | 340 | 282 |
| 16 | 26 | 10 | 170 | 28 | 14 | 150 | 320 | 300 | 320 |
| 17 | >35 | 16 | | 25 | 12 | 140 | | 330 | |
| 18 | 27 | 11 | 170 | 28 | 14 | 150 | 320 | 300 | 320 |
| 19 | 29 | 13 | 170 | 29 | 15 | 150 | 320 | 300 | 320 |
| 20 | 20 | 9 | 120 | 27 | 13 | 150 | 270 | 250 | 324 |
| 21 | 30 | 18 | 130 | 29 | 13 | 170 | 300 | 300 | 300 |
| 22 | 28 | 13 | 160 | 28 | 13 | 160 | 320 | 300 | 320 |
| 23 | >35 | 18 | | 32 | 14 | 190 | | 350 | |
| 24 | 27 | 10 | 180 | 31 | 18 | 140 | 320 | 340 | 282 |
| 25 | 28 | 12 | 170 | 20 | 9 | 120 | 290 | 250 | 348 |
| 26 | 29 | 11 | 190 | 29 | 16 | 140 | 330 | 300 | 330 |
| 27 | 35 | 16 | 200 | 23 | 10 | 140 | 340 | 300 | 340 |
| 28 | 28 | 10 | 190 | 35 | 16 | 200 | 390 | 330 | 355 |
| 29 | >35 | 18 | | 27 | 12 | 160 | | 340 | |
| 30 | 27 | 10 | 180 | 29 | 15 | 150 | 330 | 300 | 330 |
| 31 | 32 | 16 | 170 | 25 | 11 | 150 | 320 | 310 | 310 |
| 32 | 26 | 10 | 170 | 28 | 15 | 140 | 310 | 290 | 321 |

| Run no. | Left observer: Paul Zyambo | | | Right observer: Wilfred Moonga | | | Combined strip width (in meters) at actual height | Height agl (feet) | Combined strip width (in meters) at 300 feet agl |
|--|-------------------------------|--------------|-----------------|-----------------------------------|--------------|-----------------|--|----------------------|--|
| | Outer Marker | Inner Marker | Strip Width (m) | Outer Marker | Inner Marker | Strip Width (m) | | | |
| 33 | 25 | 10 | 160 | 22 | 11 | 120 | 280 | 250 | 336 |
| 34 | 26 | 10 | 170 | 29 | 15 | 150 | 320 | 300 | 320 |
| 35 | 31 | 13 | 190 | 23 | 10 | 140 | 330 | 290 | 341 |
| 36 | 28 | 13 | 160 | 28 | 14 | 150 | 310 | 310 | 300 |
| 37 | >35 | 17 | | 29 | 14 | 160 | | 350 | |
| 38 | 24 | 10 | 150 | 24 | 10 | 150 | 300 | 250 | 360 |
| 39 | 27 | 13 | 150 | 19 | 9 | 110 | 260 | 260 | 300 |
| 40 | 29 | 12 | 180 | 26 | 14 | 130 | 310 | 300 | 310 |
| 41 | 25 | 11 | 150 | 24 | 12 | 130 | 280 | 260 | 323 |
| 42 | 30 | 14 | 170 | 24 | 12 | 130 | 300 | 300 | 300 |
| 43 | 27 | 10 | 180 | 31 | 18 | 140 | 320 | 340 | 282 |
| 44 | 31 | 13 | 190 | 32 | 15 | 180 | 370 | 300 | 370 |
| 45 | 29 | 12 | 180 | 29 | 19 | 110 | 290 | 290 | 300 |
| 46 | 31 | 14 | 180 | 27 | 13 | 150 | 330 | 320 | 309 |
| 47 | 26 | 11 | 160 | 24 | 14 | 110 | 270 | 290 | 279 |
| Mean combined strip width (in meters) at 300 feet agl = | | | | | | | | | 318 |

Appendix 2. Aerial survey flight summary

| Date | Time | Flight time (hours:minutes) | Duty |
|-------------|-------------|--|-----------------------------------|
| 10-Aug-02 | pm | 2:30 approx. | Positioning, Harare to Mfuwe |
| 11-Aug-02 | pm | 0:07 | Calibration |
| 11-Aug-02 | pm | 0:07 | Calibration |
| 11-Aug-02 | pm | 0:37 | Calibration |
| 11-Aug-02 | pm | 0:09 | Calibration |
| 12-Aug-02 | pm | 0:33 | Calibration |
| 12-Aug-02 | am | 0:50 | Calibration |
| 12-Aug-02 | am | 0:56 | Calibration |
| 12-Aug-02 | pm | 1:38 | Stratum East Lupande |
| 13-Aug-02 | am | 3:44 | Strata Chifungwe & Nosbara |
| 13-Aug-02 | pm | 1:33 | Stratum East Lower Lupande |
| 14-Aug-02 | am | 4:22 | Stratum Lubi |
| 14-Aug-02 | pm | 2:11 | Stratum Lubi continued |
| 15-Aug-02 | am | 3:18 | Strata 4 & Lower West Lupande |
| 15-Aug-02 | pm | 1:28 | Stratum 4 continued |
| 17-Aug-02 | am | 3:21 | Stratum 5 |
| 17-Aug-02 | pm | 2:17 | Strata Machinje & Upper Lupande |
| 18-Aug-02 | am | 4:20 | Strata Lupande Hills & Chilongozi |
| 18-Aug-02 | pm | 1:14 | Stratum Nsefu |
| 19-Aug-02 | am | 3:04 | Stratum Lusiwasi |
| 19-Aug-02 | pm | 2:30 approx. | Positioning, Mfuwe to Harare |

Appendix 3. Transect start and end points.

1 Chifungwe

Number of transects : 12
 Transect Bearing : 0.00 Degrees
 Transect Spacing : 3.50 km

Transect # : 1
 Start Lat : S 12 : 30.472 Start Lon : E 31 : 54.067
 Finish Lat : S 12 : 23.965 Finish Lon : E 31 : 54.067
 Length : 12.05 km

Transect # : 2
 Start Lat : S 12 : 22.954 Start Lon : E 31 : 52.133
 Finish Lat : S 12 : 30.472 Finish Lon : E 31 : 52.133
 Length : 13.92 km

Transect # : 3
 Start Lat : S 12 : 30.472 Start Lon : E 31 : 50.199
 Finish Lat : S 12 : 21.162 Finish Lon : E 31 : 50.199
 Length : 17.24 km

Transect # : 4
 Start Lat : S 12 : 19.693 Start Lon : E 31 : 48.266
 Finish Lat : S 12 : 30.472 Finish Lon : E 31 : 48.266
 Length : 19.96 km

Transect # : 5
 Start Lat : S 12 : 30.472 Start Lon : E 31 : 46.332
 Finish Lat : S 12 : 19.762 Finish Lon : E 31 : 46.332
 Length : 19.83 km

Transect # : 6
 Start Lat : S 12 : 19.919 Start Lon : E 31 : 44.399
 Finish Lat : S 12 : 30.472 Finish Lon : E 31 : 44.399
 Length : 19.54 km

Transect # : 7
 Start Lat : S 12 : 30.472 Start Lon : E 31 : 42.465
 Finish Lat : S 12 : 20.529 Finish Lon : E 31 : 42.465
 Length : 18.41 km

Transect # : 8
 Start Lat : S 12 : 22.258 Start Lon : E 31 : 40.532
 Finish Lat : S 12 : 30.472 Finish Lon : E 31 : 40.532
 Length : 15.21 km

Transect # : 9
 Start Lat : S 12 : 30.472 Start Lon : E 31 : 38.598
 Finish Lat : S 12 : 24.508 Finish Lon : E 31 : 38.598
 Length : 11.04 km

Transect # : 10
 Start Lat : S 12 : 27.736 Start Lon : E 31 : 36.664
 Finish Lat : S 12 : 30.472 Finish Lon : E 31 : 36.664
 Length : 5.07 km

Transect # : 11
 Start Lat : S 12 : 30.472 Start Lon : E 31 : 34.731
 Finish Lat : S 12 : 28.901 Finish Lon : E 31 : 34.731
 Length : 2.91 km

Transect # : 12
 Start Lat : S 12 : 29.923 Start Lon : E 31 : 32.797
 Finish Lat : S 12 : 30.472 Finish Lon : E 31 : 32.797
 Length : 1.02 km

2 Nosbara

Number of transects : 11
 Transect Bearing : 90.00 Degrees
 Transect Spacing : 5.00 km

Transect # : 1
 Start Lat : S 12 : 31.262 Start Lon : E 31 : 31.856
 Finish Lat : S 12 : 31.262 Finish Lon : E 31 : 51.281
 Length : 35.12 km

Transect # : 2
 Start Lat : S 12 : 33.962 Start Lon : E 31 : 47.202
 Finish Lat : S 12 : 33.962 Finish Lon : E 31 : 30.478
 Length : 30.24 km

Transect # : 3
 Start Lat : S 12 : 36.662 Start Lon : E 31 : 28.716
 Finish Lat : S 12 : 36.662 Finish Lon : E 31 : 44.035
 Length : 27.70 km

Transect # : 4
 Start Lat : S 12 : 39.362 Start Lon : E 31 : 40.253
 Finish Lat : S 12 : 39.362 Finish Lon : E 31 : 27.368
 Length : 23.30 km

Transect # : 5
 Start Lat : S 12 : 42.062 Start Lon : E 31 : 26.648
 Finish Lat : S 12 : 42.062 Finish Lon : E 31 : 38.390
 Length : 21.23 km

Transect # : 6
 Start Lat : S 12 : 44.762 Start Lon : E 31 : 38.031
 Finish Lat : S 12 : 44.762 Finish Lon : E 31 : 26.925

Length : 20.08 km

Transect # : 7

Start Lat : S 12 : 47.462 Start Lon : E 31 : 26.702
Finish Lat : S 12 : 47.462 Finish Lon : E 31 : 38.096
Length : 20.60 km

Transect # : 8

Start Lat : S 12 : 50.162 Start Lon : E 31 : 38.837
Finish Lat : S 12 : 50.162 Finish Lon : E 31 : 25.863
Length : 23.46 km

Transect # : 9

Start Lat : S 12 : 52.862 Start Lon : E 31 : 25.619
Finish Lat : S 12 : 52.862 Finish Lon : E 31 : 38.403
Length : 23.12 km

Transect # : 10

Start Lat : S 12 : 55.562 Start Lon : E 31 : 37.969
Finish Lat : S 12 : 55.562 Finish Lon : E 31 : 27.237
Length : 19.41 km

Transect # : 11

Start Lat : S 12 : 58.262 Start Lon : E 31 : 33.858
Finish Lat : S 12 : 58.262 Finish Lon : E 31 : 37.727
Length : 7.00 km

3 Lubi

Number of transects : 27

Transect Bearing : 90.00 Degrees

Transect Spacing : 2.50 km

Transect # : 1

Start Lat : S 12 : 31.582 Start Lon : E 31 : 56.511
Finish Lat : S 12 : 31.582 Finish Lon : E 31 : 51.046
Length : 9.88 km

Transect # : 2

Start Lat : S 12 : 32.932 Start Lon : E 31 : 47.202
Finish Lat : S 12 : 32.932 Finish Lon : E 31 : 57.312
Length : 18.28 km

Transect # : 3

Start Lat : S 12 : 34.282 Start Lon : E 31 : 58.403
Finish Lat : S 12 : 34.282 Finish Lon : E 31 : 47.202
Length : 20.25 km

Transect # : 4

Start Lat : S 12 : 35.632 Start Lon : E 31 : 45.453
Finish Lat : S 12 : 35.632 Finish Lon : E 31 : 59.201
Length : 24.86 km

Transect # : 5

Start Lat : S 12 : 36.982 Start Lon : E 32 : 0.593
Finish Lat : S 12 : 36.982 Finish Lon : E 31 : 43.713
Length : 30.52 km

Transect # : 6

Start Lat : S 12 : 38.332 Start Lon : E 31 : 40.835
Finish Lat : S 12 : 38.332 Finish Lon : E 32 : 2.649
Length : 39.45 km

Transect # : 7

Start Lat : S 12 : 39.682 Start Lon : E 32 : 3.813
Finish Lat : S 12 : 39.682 Finish Lon : E 31 : 40.101
Length : 42.88 km

Transect # : 8

Start Lat : S 12 : 41.032 Start Lon : E 31 : 39.413
Finish Lat : S 12 : 41.032 Finish Lon : E 32 : 4.537

Length : 45.43 km

Transect # : 9

Start Lat : S 12 : 42.382 Start Lon : E 32 : 5.171
Finish Lat : S 12 : 42.382 Finish Lon : E 31 : 38.339
Length : 48.52 km

Transect # : 10

Start Lat : S 12 : 43.732 Start Lon : E 31 : 37.829
Finish Lat : S 12 : 43.732 Finish Lon : E 32 : 4.836
Length : 48.84 km

Transect # : 11

Start Lat : S 12 : 45.082 Start Lon : E 32 : 3.501
Finish Lat : S 12 : 45.082 Finish Lon : E 31 : 37.964
Length : 46.18 km

Transect # : 12

Start Lat : S 12 : 46.432 Start Lon : E 31 : 38.051
Finish Lat : S 12 : 46.432 Finish Lon : E 32 : 3.335
Length : 45.72 km

Transect # : 13

Start Lat : S 12 : 47.782 Start Lon : E 32 : 1.862
Finish Lat : S 12 : 47.782 Finish Lon : E 31 : 38.133
Length : 42.91 km

Transect # : 14

Start Lat : S 12 : 49.132 Start Lon : E 31 : 39.003
Finish Lat : S 12 : 49.132 Finish Lon : E 32 : 1.225
Length : 40.18 km

Transect # : 15

Start Lat : S 12 : 50.482 Start Lon : E 32 : 0.120
Finish Lat : S 12 : 50.482 Finish Lon : E 31 : 38.786
Length : 38.58 km

Transect # : 16

Start Lat : S 12 : 51.832 Start Lon : E 31 : 38.569
 Finish Lat : S 12 : 51.832 Finish Lon : E 32 : 0.067
 Length : 38.87 km

Transect # : 17A
 Start Lat : S 12 : 53.182 Start Lon : E 31 : 59.256
 Finish Lat : S 12 : 53.182 Finish Lon : E 31 : 58.689
 Length : 1.02 km

Transect # : 17B
 Start Lat : S 12 : 53.182 Start Lon : E 31 : 58.252
 Finish Lat : S 12 : 53.182 Finish Lon : E 31 : 38.352
 Length : 35.98 km

Transect # : 18A
 Start Lat : S 12 : 54.532 Start Lon : E 31 : 38.135
 Finish Lat : S 12 : 54.532 Finish Lon : E 31 : 55.478
 Length : 31.36 km

Transect # : 18B
 Start Lat : S 12 : 54.532 Start Lon : E 31 : 55.858
 Finish Lat : S 12 : 54.532 Finish Lon : E 31 : 56.486
 Length : 1.13 km

Transect # : 19A
 Start Lat : S 12 : 55.882 Start Lon : E 31 : 55.288
 Finish Lat : S 12 : 55.882 Finish Lon : E 31 : 54.872
 Length : 0.75 km

Transect # : 19B
 Start Lat : S 12 : 55.882 Start Lon : E 31 : 54.300
 Finish Lat : S 12 : 55.882 Finish Lon : E 31 : 37.918
 Length : 29.62 km

Transect # : 20
 Start Lat : S 12 : 57.232 Start Lon : E 31 : 37.751
 Finish Lat : S 12 : 57.232 Finish Lon : E 31 : 54.241
 Length : 29.82 km

Transect # : 21A
 Start Lat : S 12 : 58.582 Start Lon : E 31 : 53.456
 Finish Lat : S 12 : 58.582 Finish Lon : E 31 : 43.898
 Length : 17.28 km

Transect # : 21B
 Start Lat : S 12 : 58.582 Start Lon : E 31 : 42.284
 Finish Lat : S 12 : 58.582 Finish Lon : E 31 : 41.775
 Length : 0.92 km

Transect # : 21C
 Start Lat : S 12 : 58.582 Start Lon : E 31 : 38.736
 Finish Lat : S 12 : 58.582 Finish Lon : E 31 : 37.953
 Length : 1.42 km

Transect # : 22
 Start Lat : S 12 : 59.932 Start Lon : E 31 : 45.568
 Finish Lat : S 12 : 59.932 Finish Lon : E 31 : 54.012
 Length : 15.27 km

Transect # : 23A
 Start Lat : S 13 : 1.282 Start Lon : E 31 : 54.576
 Finish Lat : S 13 : 1.282 Finish Lon : E 31 : 53.644
 Length : 1.69 km

Transect # : 23B
 Start Lat : S 13 : 1.282 Start Lon : E 31 : 53.325
 Finish Lat : S 13 : 1.282 Finish Lon : E 31 : 45.639
 Length : 13.90 km

Transect # : 24
 Start Lat : S 13 : 2.632 Start Lon : E 31 : 45.982
 Finish Lat : S 13 : 2.632 Finish Lon : E 31 : 51.775
 Length : 10.48 km

Transect # : 25
 Start Lat : S 13 : 3.982 Start Lon : E 31 : 50.593
 Finish Lat : S 13 : 3.982 Finish Lon : E 31 : 45.907
 Length : 8.47 km

Transect # : 26
 Start Lat : S 13 : 5.332 Start Lon : E 31 : 45.199
 Finish Lat : S 13 : 5.332 Finish Lon : E 31 : 48.610
 Length : 6.17 km

Transect # : 27
 Start Lat : S 13 : 6.682 Start Lon : E 31 : 45.906
 Finish Lat : S 13 : 6.682 Finish Lon : E 31 : 45.702
 Length : 0.37 km

4 Stratum

Number of transects : 21
 Transect Bearing : 90.00 Degrees
 Transect Spacing : 2.50 km

Transect # : 1

Start Lat : S 12 : 57.556 Start Lon : E 31 : 32.520
 Finish Lat : S 12 : 57.556 Finish Lon : E 31 : 27.481
 Length : 9.09 km

Transect # : 2A

Start Lat : S 12 : 58.906 Start Lon : E 31 : 27.757
 Finish Lat : S 12 : 58.906 Finish Lon : E 31 : 34.251
 Length : 11.72 km

Transect # : 2B

Start Lat : S 12 : 58.906 Start Lon : E 31 : 37.999
 Finish Lat : S 12 : 58.906 Finish Lon : E 31 : 44.266
 Length : 11.31 km

Transect # : 2C

Start Lat : S 12 : 58.906 Start Lon : E 31 : 44.268
 Finish Lat : S 12 : 58.906 Finish Lon : E 31 : 45.223
 Length : 1.72 km

Transect # : 3

Start Lat : S 13 : 0.256 Start Lon : E 31 : 45.296
 Finish Lat : S 13 : 0.256 Finish Lon : E 31 : 28.474
 Length : 30.36 km

Transect # : 4

Start Lat : S 13 : 1.606 Start Lon : E 31 : 28.578
 Finish Lat : S 13 : 1.606 Finish Lon : E 31 : 45.728
 Length : 30.96 km

Transect # : 5

Start Lat : S 13 : 2.956 Start Lon : E 31 : 45.934
 Finish Lat : S 13 : 2.956 Finish Lon : E 31 : 29.163
 Length : 30.27 km

Transect # : 6

Start Lat : S 13 : 4.306 Start Lon : E 31 : 29.067
 Finish Lat : S 13 : 4.306 Finish Lon : E 31 : 45.895
 Length : 30.38 km

Transect # : 7

Start Lat : S 13 : 5.656 Start Lon : E 31 : 44.344
 Finish Lat : S 13 : 5.656 Finish Lon : E 31 : 28.524
 Length : 28.55 km

Transect # : 8

Start Lat : S 13 : 7.006 Start Lon : E 31 : 28.616
 Finish Lat : S 13 : 7.006 Finish Lon : E 31 : 44.088
 Length : 27.93 km

Transect # : 9

Start Lat : S 13 : 8.356 Start Lon : E 31 : 44.016
 Finish Lat : S 13 : 8.356 Finish Lon : E 31 : 27.791
 Length : 29.29 km

Transect # : 10

Start Lat : S 13 : 9.706 Start Lon : E 31 : 27.367
 Finish Lat : S 13 : 9.706 Finish Lon : E 31 : 43.862
 Length : 29.77 km

Transect # : 11

Start Lat : S 13 : 11.056 Start Lon : E 31 : 43.017
 Finish Lat : S 13 : 11.056 Finish Lon : E 31 : 27.160
 Length : 28.62 km

Transect # : 12

Start Lat : S 13 : 12.406 Start Lon : E 31 : 27.652
 Finish Lat : S 13 : 12.406 Finish Lon : E 31 : 41.065
 Length : 24.21 km

Transect # : 13

Start Lat : S 13 : 13.756 Start Lon : E 31 : 38.979
 Finish Lat : S 13 : 13.756 Finish Lon : E 31 : 27.622
 Length : 20.50 km

Transect # : 14

Start Lat : S 13 : 15.106 Start Lon : E 31 : 27.332
 Finish Lat : S 13 : 15.106 Finish Lon : E 31 : 38.905
 Length : 20.89 km

Transect # : 15

Start Lat : S 13 : 16.456 Start Lon : E 31 : 39.541
 Finish Lat : S 13 : 16.456 Finish Lon : E 31 : 27.939
 Length : 20.94 km

Transect # : 16

Start Lat : S 13 : 17.806 Start Lon : E 31 : 28.607
 Finish Lat : S 13 : 17.806 Finish Lon : E 31 : 39.047
 Length : 18.84 km

Transect # : 17

Start Lat : S 13 : 19.156 Start Lon : E 31 : 38.988
 Finish Lat : S 13 : 19.156 Finish Lon : E 31 : 29.405
 Length : 17.30 km

Transect # : 18

Start Lat : S 13 : 20.506 Start Lon : E 31 : 30.413
 Finish Lat : S 13 : 20.506 Finish Lon : E 31 : 38.502
 Length : 14.60 km

Transect # : 19

Start Lat : S 13 : 21.856 Start Lon : E 31 : 37.031
 Finish Lat : S 13 : 21.856 Finish Lon : E 31 : 31.514
 Length : 9.96 km

Transect # : 20

Start Lat : S 13 : 23.206 Start Lon : E 31 : 31.812
 Finish Lat : S 13 : 23.206 Finish Lon : E 31 : 34.528

Length : 4.90 km

Transect # : 21

Start Lat : S 13 : 24.556 Start Lon : E 31 : 33.054
 Finish Lat : S 13 : 24.556 Finish Lon : E 31 : 32.968
 Length : 0.16 km

5 Stratum

Number of transects : 19

Transect Bearing : 90.00 Degrees

Transect Spacing : 3.50 km

Transect # : 1

Start Lat : S 12 : 56.739 Start Lon : E 31 : 27.663
 Finish Lat : S 12 : 56.739 Finish Lon : E 31 : 23.840
 Length : 6.90 km

Transect # : 2

Start Lat : S 12 : 58.629 Start Lon : E 31 : 20.408
 Finish Lat : S 12 : 58.629 Finish Lon : E 31 : 27.840
 Length : 13.42 km

Transect # : 3

Start Lat : S 13 : 0.519 Start Lon : E 31 : 28.133
 Finish Lat : S 13 : 0.519 Finish Lon : E 31 : 19.432
 Length : 15.71 km

Transect # : 4

Start Lat : S 13 : 2.409 Start Lon : E 31 : 17.360
 Finish Lat : S 13 : 2.409 Finish Lon : E 31 : 28.949
 Length : 20.92 km

Transect # : 5

Start Lat : S 13 : 4.299 Start Lon : E 31 : 29.068
 Finish Lat : S 13 : 4.299 Finish Lon : E 31 : 16.266
 Length : 23.11 km

Transect # : 6

Start Lat : S 13 : 6.189 Start Lon : E 31 : 16.788
 Finish Lat : S 13 : 6.189 Finish Lon : E 31 : 28.180
 Length : 20.57 km

Transect # : 7

Start Lat : S 13 : 8.079 Start Lon : E 31 : 28.076
 Finish Lat : S 13 : 8.079 Finish Lon : E 31 : 18.833
 Length : 16.69 km

Transect # : 8

Start Lat : S 13 : 9.969 Start Lon : E 31 : 19.494
 Finish Lat : S 13 : 9.969 Finish Lon : E 31 : 27.408
 Length : 14.29 km

Transect # : 9

Start Lat : S 13 : 11.859 Start Lon : E 31 : 27.267
 Finish Lat : S 13 : 11.859 Finish Lon : E 31 : 20.228
 Length : 12.71 km

Transect # : 10

Start Lat : S 13 : 13.749 Start Lon : E 31 : 20.129

Finish Lat : S 13 : 13.749 Finish Lon : E 31 : 27.625
 Length : 13.53 km

Transect # : 11

Start Lat : S 13 : 15.639 Start Lon : E 31 : 27.447
 Finish Lat : S 13 : 15.639 Finish Lon : E 31 : 17.593
 Length : 17.79 km

Transect # : 12

Start Lat : S 13 : 17.529 Start Lon : E 31 : 16.426
 Finish Lat : S 13 : 17.529 Finish Lon : E 31 : 28.425
 Length : 21.66 km

Transect # : 13

Start Lat : S 13 : 19.419 Start Lon : E 31 : 29.484
 Finish Lat : S 13 : 19.419 Finish Lon : E 31 : 16.493
 Length : 23.45 km

Transect # : 14

Start Lat : S 13 : 21.309 Start Lon : E 31 : 16.416
 Finish Lat : S 13 : 21.309 Finish Lon : E 31 : 30.596
 Length : 25.60 km

Transect # : 15

Start Lat : S 13 : 23.199 Start Lon : E 31 : 31.794
 Finish Lat : S 13 : 23.199 Finish Lon : E 31 : 17.533
 Length : 25.74 km

Transect # : 16

Start Lat : S 13 : 25.089 Start Lon : E 31 : 17.014
 Finish Lat : S 13 : 25.089 Finish Lon : E 31 : 32.554
 Length : 28.05 km

Transect # : 17

Start Lat : S 13 : 26.979 Start Lon : E 31 : 25.775
 Finish Lat : S 13 : 26.979 Finish Lon : E 31 : 16.898
 Length : 16.02 km

Transect # : 18

Start Lat : S 13 : 28.869 Start Lon : E 31 : 15.998
 Finish Lat : S 13 : 28.869 Finish Lon : E 31 : 19.529
 Length : 6.37 km

Transect # : 19

Start Lat : S 13 : 30.759 Start Lon : E 31 : 18.614
 Finish Lat : S 13 : 30.759 Finish Lon : E 31 : 17.226
 Length : 2.51 km

6 Lusiwasi

Number of transects : 17
 Transect Bearing : 90.00 Degrees
 Transect Spacing : 5.00 km

Transect # : 1
 Start Lat : S 13 : 1.518 Start Lon : E 31 : 18.520
 Finish Lat : S 13 : 1.518 Finish Lon : E 31 : 15.444
 Length : 5.55 km

Transect # : 2
 Start Lat : S 13 : 4.218 Start Lon : E 31 : 13.780
 Finish Lat : S 13 : 4.218 Finish Lon : E 31 : 16.281
 Length : 4.51 km

Transect # : 3
 Start Lat : S 13 : 6.918 Start Lon : E 31 : 17.121
 Finish Lat : S 13 : 6.918 Finish Lon : E 31 : 13.038
 Length : 7.37 km

Transect # : 4
 Start Lat : S 13 : 9.618 Start Lon : E 31 : 12.036
 Finish Lat : S 13 : 9.618 Finish Lon : E 31 : 19.344
 Length : 13.19 km

Transect # : 5
 Start Lat : S 13 : 12.318 Start Lon : E 31 : 19.978
 Finish Lat : S 13 : 12.318 Finish Lon : E 31 : 10.835
 Length : 16.50 km

Transect # : 6
 Start Lat : S 13 : 15.018 Start Lon : E 31 : 8.803
 Finish Lat : S 13 : 15.018 Finish Lon : E 31 : 18.185
 Length : 16.94 km

Transect # : 7
 Start Lat : S 13 : 17.718 Start Lon : E 31 : 16.484
 Finish Lat : S 13 : 17.718 Finish Lon : E 31 : 7.428
 Length : 16.35 km

Transect # : 8
 Start Lat : S 13 : 20.418 Start Lon : E 31 : 5.367
 Finish Lat : S 13 : 20.418 Finish Lon : E 31 : 16.800
 Length : 20.64 km

Transect # : 9
 Start Lat : S 13 : 23.118 Start Lon : E 31 : 17.565
 Finish Lat : S 13 : 23.118 Finish Lon : E 31 : 6.187
 Length : 20.54 km

Transect # : 10
 Start Lat : S 13 : 25.818 Start Lon : E 31 : 6.145
 Finish Lat : S 13 : 25.818 Finish Lon : E 31 : 16.970
 Length : 19.54 km

Transect # : 11
 Start Lat : S 13 : 28.518 Start Lon : E 31 : 16.466
 Finish Lat : S 13 : 28.518 Finish Lon : E 31 : 5.025
 Length : 20.65 km

Transect # : 12
 Start Lat : S 13 : 31.218 Start Lon : E 31 : 4.458
 Finish Lat : S 13 : 31.218 Finish Lon : E 31 : 17.295
 Length : 23.17 km

Transect # : 13
 Start Lat : S 13 : 33.918 Start Lon : E 31 : 14.788
 Finish Lat : S 13 : 33.918 Finish Lon : E 31 : 4.110
 Length : 19.27 km

Transect # : 14
 Start Lat : S 13 : 36.618 Start Lon : E 31 : 3.201
 Finish Lat : S 13 : 36.618 Finish Lon : E 31 : 9.689
 Length : 11.71 km

Transect # : 15
 Start Lat : S 13 : 39.318 Start Lon : E 31 : 7.383
 Finish Lat : S 13 : 39.318 Finish Lon : E 31 : 1.315
 Length : 10.95 km

Transect # : 16
 Start Lat : S 13 : 42.018 Start Lon : E 31 : 0.870
 Finish Lat : S 13 : 42.018 Finish Lon : E 31 : 8.805
 Length : 14.32 km

Transect # : 17A
 Start Lat : S 13 : 44.718 Start Lon : E 31 : 4.521
 Finish Lat : S 13 : 44.718 Finish Lon : E 31 : 1.914
 Length : 4.71 km

Transect # : 17B
 Start Lat : S 13 : 44.718 Start Lon : E 31 : 1.849
 Finish Lat : S 13 : 44.718 Finish Lon : E 31 : 1.569
 Length : 0.51 km

7 Chilongozi

Number of transects : 11
 Transect Bearing : 90.00 Degrees
 Transect Spacing : 3.50 km

Transect # : 1 Start Lat : S 13 : 25.616 Start Lon : E 31 : 27.969

Finish Lat : S 13 : 25.616 Finish Lon : E 31 : 26.523
Length : 2.61 km

Transect # : 2A

Start Lat : S 13 : 27.506 Start Lon : E 31 : 22.461
Finish Lat : S 13 : 27.506 Finish Lon : E 31 : 23.855
Length : 2.51 km

Transect # : 2B

Start Lat : S 13 : 27.506 Start Lon : E 31 : 25.655
Finish Lat : S 13 : 27.506 Finish Lon : E 31 : 33.688
Length : 14.48 km

Transect # : 3

Start Lat : S 13 : 29.396 Start Lon : E 31 : 33.476
Finish Lat : S 13 : 29.396 Finish Lon : E 31 : 19.037
Length : 26.02 km

Transect # : 4

Start Lat : S 13 : 31.286 Start Lon : E 31 : 18.392
Finish Lat : S 13 : 31.286 Finish Lon : E 31 : 34.150
Length : 28.40 km

Transect # : 5

Start Lat : S 13 : 33.176 Start Lon : E 31 : 34.197
Finish Lat : S 13 : 33.176 Finish Lon : E 31 : 15.038
Length : 34.53 km

Transect # : 6

Start Lat : S 13 : 35.066 Start Lon : E 31 : 13.922
Finish Lat : S 13 : 35.066 Finish Lon : E 31 : 33.643
Length : 35.54 km

Transect # : 7

Start Lat : S 13 : 36.956 Start Lon : E 31 : 32.758
Finish Lat : S 13 : 36.956 Finish Lon : E 31 : 8.818
Length : 43.14 km

Transect # : 8

Start Lat : S 13 : 38.846 Start Lon : E 31 : 7.262
Finish Lat : S 13 : 38.846 Finish Lon : E 31 : 28.712
Length : 38.65 km

Transect # : 9

Start Lat : S 13 : 40.736 Start Lon : E 31 : 23.495
Finish Lat : S 13 : 40.736 Finish Lon : E 31 : 7.536
Length : 28.76 km

Transect # : 10

Start Lat : S 13 : 42.626 Start Lon : E 31 : 7.542
Finish Lat : S 13 : 42.626 Finish Lon : E 31 : 18.278
Length : 19.35 km

Transect # : 11

Start Lat : S 13 : 44.516 Start Lon : E 31 : 13.061
Finish Lat : S 13 : 44.516 Finish Lon : E 31 : 7.042
Length : 10.85 km

8 Nsefu

Number of transects : 5

Transect Bearing : 90.00 Degrees

Transect Spacing : 3.50 km

Transect # : 1A

Start Lat : S 13 : 0.123 Start Lon : E 31 : 53.919
Finish Lat : S 13 : 0.123 Finish Lon : E 31 : 54.961
Length : 1.88 km

Transect # : 1B

Start Lat : S 13 : 0.123 Start Lon : E 31 : 59.052
Finish Lat : S 13 : 0.123 Finish Lon : E 32 : 6.991
Length : 14.34 km

Transect # : 2A

Start Lat : S 12 : 58.233 Start Lon : E 32 : 5.623
Finish Lat : S 12 : 58.233 Finish Lon : E 31 : 57.716
Length : 14.28 km

Transect # : 2B

Start Lat : S 12 : 58.233 Start Lon : E 31 : 56.872
Finish Lat : S 12 : 58.233 Finish Lon : E 31 : 56.766
Length : 0.19 km

Transect # : 2C

Start Lat : S 12 : 58.233 Start Lon : E 31 : 56.096
Finish Lat : S 12 : 58.233 Finish Lon : E 31 : 53.975

Length : 3.83 km

Transect # : 3

Start Lat : S 12 : 56.343 Start Lon : E 31 : 54.240
Finish Lat : S 12 : 56.343 Finish Lon : E 32 : 4.327
Length : 18.22 km

Transect # : 4A

Start Lat : S 12 : 54.453 Start Lon : E 32 : 3.059
Finish Lat : S 12 : 54.453 Finish Lon : E 31 : 56.514
Length : 11.82 km

Transect # : 4B

Start Lat : S 12 : 54.453 Start Lon : E 31 : 55.828
Finish Lat : S 12 : 54.453 Finish Lon : E 31 : 55.510
Length : 0.57 km

Transect # : 5A

Start Lat : S 12 : 52.563 Start Lon : E 31 : 57.928
Finish Lat : S 12 : 52.563 Finish Lon : E 31 : 58.472
Length : 0.98 km

Transect # : 5B

Start Lat : S 12 : 52.563 Start Lon : E 31 : 58.983
 Finish Lat : S 12 : 52.563 Finish Lon : E 31 : 59.371
 Length : 0.70 km

Transect # : 5C
 Start Lat : S 12 : 52.563 Start Lon : E 32 : 0.042
 Finish Lat : S 12 : 52.563 Finish Lon : E 32 : 1.185
 Length : 2.06 km

9 Upper Lupande

Number of transects : 5
 Transect Bearing : 90.00 Degrees
 Transect Spacing : 4.00 km

Transect # : 1
 Start Lat : S 13 : 7.873 Start Lon : E 32 : 15.000
 Finish Lat : S 13 : 7.873 Finish Lon : E 31 : 54.651
 Length : 36.75 km

Transect # : 4A
 Start Lat : S 13 : 1.393 Start Lon : E 31 : 53.199
 Finish Lat : S 13 : 1.393 Finish Lon : E 31 : 53.855
 Length : 1.18 km

Transect # : 2A
 Start Lat : S 13 : 5.713 Start Lon : E 31 : 48.679
 Finish Lat : S 13 : 5.713 Finish Lon : E 31 : 53.712
 Length : 9.09 km

Transect # : 4B
 Start Lat : S 13 : 1.393 Start Lon : E 31 : 54.572
 Finish Lat : S 13 : 1.393 Finish Lon : E 32 : 15.000
 Length : 36.89 km

Transect # : 2B
 Start Lat : S 13 : 5.713 Start Lon : E 31 : 53.751
 Finish Lat : S 13 : 5.713 Finish Lon : E 32 : 15.000
 Length : 38.37 km

Transect # : 5A
 Start Lat : S 12 : 59.233 Start Lon : E 32 : 12.729
 Finish Lat : S 12 : 59.233 Finish Lon : E 32 : 6.328
 Length : 11.56 km

Transect # : 3
 Start Lat : S 13 : 3.553 Start Lon : E 32 : 15.000
 Finish Lat : S 13 : 3.553 Finish Lon : E 31 : 50.817
 Length : 43.67 km

Transect # : 5B
 Start Lat : S 12 : 59.233 Start Lon : E 31 : 58.139
 Finish Lat : S 12 : 59.233 Finish Lon : E 31 : 56.141
 Length : 3.61 km

10 West Lower Lupande

Number of transects : 14
 Transect Bearing : 90.00 Degrees
 Transect Spacing : 3.00 km

Transect # : 1
 Start Lat : S 13 : 31.484 Start Lon : E 31 : 34.219
 Finish Lat : S 13 : 31.484 Finish Lon : E 31 : 38.969
 Length : 8.57 km

Transect # : 5
 Start Lat : S 13 : 25.004 Start Lon : E 31 : 32.583
 Finish Lat : S 13 : 25.004 Finish Lon : E 31 : 39.299
 Length : 12.11 km

Transect # : 2
 Start Lat : S 13 : 29.864 Start Lon : E 31 : 38.977
 Finish Lat : S 13 : 29.864 Finish Lon : E 31 : 33.484
 Length : 9.91 km

Transect # : 6
 Start Lat : S 13 : 23.384 Start Lon : E 31 : 39.420
 Finish Lat : S 13 : 23.384 Finish Lon : E 31 : 34.433
 Length : 8.99 km

Transect # : 3
 Start Lat : S 13 : 28.244 Start Lon : E 31 : 33.708
 Finish Lat : S 13 : 28.244 Finish Lon : E 31 : 39.298
 Length : 10.08 km

Transect # : 7
 Start Lat : S 13 : 21.764 Start Lon : E 31 : 37.044
 Finish Lat : S 13 : 21.764 Finish Lon : E 31 : 40.042
 Length : 5.41 km

Transect # : 4
 Start Lat : S 13 : 26.624 Start Lon : E 31 : 39.539
 Finish Lat : S 13 : 26.624 Finish Lon : E 31 : 33.683
 Length : 10.56 km

Transect # : 8
 Start Lat : S 13 : 20.144 Start Lon : E 31 : 40.463
 Finish Lat : S 13 : 20.144 Finish Lon : E 31 : 38.351
 Length : 3.81 km

Transect # : 9
 Start Lat : S 13 : 18.524 Start Lon : E 31 : 39.558
 Finish Lat : S 13 : 18.524 Finish Lon : E 31 : 40.447
 Length : 1.60 km

Transect # : 10
 Start Lat : S 13 : 16.904 Start Lon : E 31 : 40.682
 Finish Lat : S 13 : 16.904 Finish Lon : E 31 : 39.562
 Length : 2.02 km

Transect # : 11
 Start Lat : S 13 : 15.284 Start Lon : E 31 : 39.014
 Finish Lat : S 13 : 15.284 Finish Lon : E 31 : 40.668
 Length : 2.98 km

Transect # : 12
 Start Lat : S 13 : 13.664 Start Lon : E 31 : 41.658
 Finish Lat : S 13 : 13.664 Finish Lon : E 31 : 39.091
 Length : 4.63 km

Transect # : 13
 Start Lat : S 13 : 12.044 Start Lon : E 31 : 41.956
 Finish Lat : S 13 : 12.044 Finish Lon : E 31 : 44.290
 Length : 4.21 km

Transect # : 14
 Start Lat : S 13 : 10.424 Start Lon : E 31 : 44.198
 Finish Lat : S 13 : 10.424 Finish Lon : E 31 : 43.035
 Length : 2.10 km

11 East Lower Lupande

Number of transects : 10
 Transect Bearing : 90.00 Degrees
 Transect Spacing : 6.00 km

Transect # : 1
 Start Lat : S 13 : 37.687 Start Lon : E 31 : 54.425
 Finish Lat : S 13 : 37.687 Finish Lon : E 31 : 49.756
 Length : 8.42 km

Transect # : 2
 Start Lat : S 13 : 34.447 Start Lon : E 31 : 47.578
 Finish Lat : S 13 : 34.447 Finish Lon : E 31 : 54.956
 Length : 13.31 km

Transect # : 3
 Start Lat : S 13 : 31.207 Start Lon : E 31 : 55.949
 Finish Lat : S 13 : 31.207 Finish Lon : E 31 : 47.921
 Length : 14.48 km

Transect # : 4
 Start Lat : S 13 : 27.967 Start Lon : E 31 : 49.266
 Finish Lat : S 13 : 27.967 Finish Lon : E 31 : 57.082
 Length : 14.10 km

Transect # : 5
 Start Lat : S 13 : 24.727 Start Lon : E 31 : 55.721
 Finish Lat : S 13 : 24.727 Finish Lon : E 31 : 49.194
 Length : 11.77 km

Transect # : 6
 Start Lat : S 13 : 21.487 Start Lon : E 31 : 47.005
 Finish Lat : S 13 : 21.487 Finish Lon : E 31 : 55.707
 Length : 15.70 km

Transect # : 7
 Start Lat : S 13 : 18.247 Start Lon : E 31 : 55.409
 Finish Lat : S 13 : 18.247 Finish Lon : E 31 : 45.779
 Length : 17.37 km

Transect # : 8
 Start Lat : S 13 : 15.007 Start Lon : E 31 : 45.056
 Finish Lat : S 13 : 15.007 Finish Lon : E 31 : 54.792
 Length : 17.56 km

Transect # : 9
 Start Lat : S 13 : 11.767 Start Lon : E 31 : 50.228
 Finish Lat : S 13 : 11.767 Finish Lon : E 31 : 44.274
 Length : 10.74 km

Transect # : 10
 Start Lat : S 13 : 8.527 Start Lon : E 31 : 43.928
 Finish Lat : S 13 : 8.527 Finish Lon : E 31 : 51.112
 Length : 12.96 km

12 Machinje

Number of transects : 4
 Transect Bearing : 0.00 Degrees
 Transect Spacing : 5.00 km

Transect # : 1
 Start Lat : S 13 : 3.227 Start Lon : E 32 : 26.009
 Finish Lat : S 13 : 2.385 Finish Lon : E 32 : 26.009
 Length : 1.56 km

Transect # : 2

Start Lat : S 13 : 1.727 Start Lon : E 32 : 23.238
 Finish Lat : S 13 : 9.589 Finish Lon : E 32 : 23.238
 Length : 14.56 km

Transect # : 3
 Start Lat : S 13 : 9.589 Start Lon : E 32 : 20.468

Finish Lat : S 13 : 1.070 Finish Lon : E 32 : 20.468
Length : 15.78 km

Transect # : 4

Start Lat : S 13 : 0.412 Start Lon : E 32 : 17.697
Finish Lat : S 13 : 9.589 Finish Lon : E 32 : 17.697
Length : 16.99 km

13 East Lupande

Number of transects : 6
Transect Bearing : 90.00 Degrees
Transect Spacing : 10.00 km

Transect # : 1
Start Lat : S 13 : 33.985 Start Lon : E 32 : 0.187
Finish Lat : S 13 : 33.985 Finish Lon : E 31 : 55.094
Length : 9.19 km

Transect # : 2
Start Lat : S 13 : 28.585 Start Lon : E 31 : 57.155
Finish Lat : S 13 : 28.585 Finish Lon : E 32 : 3.494
Length : 11.44 km

Transect # : 3
Start Lat : S 13 : 23.185 Start Lon : E 32 : 19.684
Finish Lat : S 13 : 23.185 Finish Lon : E 31 : 54.992
Length : 44.55 km

Transect # : 4
Start Lat : S 13 : 17.785 Start Lon : E 31 : 55.343

Finish Lat : S 13 : 17.785 Finish Lon : E 32 : 21.441
Length : 47.09 km

Transect # : 5
Start Lat : S 13 : 12.385 Start Lon : E 32 : 23.198
Finish Lat : S 13 : 12.385 Finish Lon : E 31 : 49.910
Length : 60.06 km

Transect # : 6A
Start Lat : S 13 : 6.985 Start Lon : E 31 : 49.060
Finish Lat : S 13 : 6.985 Finish Lon : E 31 : 49.725
Length : 1.20 km

Transect # : 6B
Start Lat : S 13 : 6.985 Start Lon : E 31 : 51.670
Finish Lat : S 13 : 6.985 Finish Lon : E 31 : 54.250
Length : 4.66 km

14 Lupande Hills

Number of transects : 7
Transect Bearing : 0.00 Degrees
Transect Spacing : 5.00 km

Transect # : 1
Start Lat : S 13 : 39.019 Start Lon : E 31 : 51.703
Finish Lat : S 13 : 49.065 Finish Lon : E 31 : 51.703
Length : 18.60 km

Transect # : 2A
Start Lat : S 13 : 48.999 Start Lon : E 31 : 48.930
Finish Lat : S 13 : 36.981 Finish Lon : E 31 : 48.930
Length : 22.26 km

Transect # : 2B
Start Lat : S 13 : 28.883 Start Lon : E 31 : 48.930
Finish Lat : S 13 : 24.349 Finish Lon : E 31 : 48.930
Length : 8.40 km

Transect # : 3
Start Lat : S 13 : 19.357 Start Lon : E 31 : 46.157
Finish Lat : S 13 : 48.933 Finish Lon : E 31 : 46.157
Length : 54.77 km

Transect # : 4
Start Lat : S 13 : 40.806 Start Lon : E 31 : 43.384
Finish Lat : S 13 : 14.720 Finish Lon : E 31 : 43.384
Length : 48.09 km

Transect # : 5
Start Lat : S 13 : 17.337 Start Lon : E 31 : 40.612
Finish Lat : S 13 : 37.971 Finish Lon : E 31 : 40.612
Length : 38.21 km

Transect # : 6
Start Lat : S 13 : 36.092 Start Lon : E 31 : 37.839
Finish Lat : S 13 : 33.000 Finish Lon : E 31 : 37.839
Length : 5.73 km

Transect # : 7
Start Lat : S 13 : 33.000 Start Lon : E 31 : 35.066
Finish Lat : S 13 : 35.641 Finish Lon : E 31 : 35.066
Length : 4.89 km

Appendix 4. Transect Summaries.

Species codes:

| Code | Species |
|-------------|----------------------------------|
| Bbk | Bushbuck |
| Buff | Buffalo |
| Dkr | Common Duiker |
| EIC3 | Elephant carcass, age category 3 |
| Eld | Eland |
| EleF | Elephant cow |
| EleM | Elephant bull |
| Ghb | Ground hornbill |
| Grf | Thornicroft's Giraffe |
| Hbst | Lichtenstein's Hartebeest |
| Imp | Impala |
| Kudu | Kudu |
| PCmp | Poachers' camp |
| Puku | Puku |
| Rbk | Reedbuck |
| Roan | Roan antelope |
| Shoa | Sheep and/or goats |
| Wbck | Waterbuck |
| Wbst | Cookson's Wildebeest |
| Whog | Warthog |
| UnCa | Unidentified carcass |
| Zeb | Zebra |

Other abbreviations

| Abbreviation | Meaning |
|---------------------|---|
| n | number of transects sampled |
| N | possible number of transects in stratum |
| t | Student's <i>t</i> value, $P = 0.05$ |
| T # | transect number |
| - | no animals seen in strips |

Date of Survey : 13/08/02
 Stratum Locality : South Luangwa NP
 Stratum Area : 556 km²
 N : 133 n : 12
 Pilot : J. Cadd
 Map overlay file : None

Stratum Name : Chifungwe
 Base Line Length : 43 km
 Calibrated Strip Width at 300ft : 318 m
 t : 2.201
 Observer : P Zyambo, W Moonga

Transect summary table :

| T # | EleM | EleF | Zeb | Wbck | Imp | Kudu | Wbst | Bbk | Ghb | Whog | Hbst | Puku | Rbk | UnCa |
|-----|------|------|-----|------|-----|------|------|-----|-----|------|------|------|-----|------|
| 1 | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - |
| 2 | - | 6 | - | - | 50 | - | - | - | - | 7 | - | - | - | - |
| 3 | - | 17 | 12 | 6 | 25 | - | - | 1 | 4 | 5 | - | - | - | - |
| 4 | 2 | 42 | 2 | 2 | 12 | - | - | - | - | - | - | 8 | 2 | - |
| 5 | - | - | - | - | - | - | - | - | - | - | - | - | 4 | - |
| 6 | - | 4 | 4 | - | 35 | 10 | - | - | - | 2 | 6 | - | - | - |
| 7 | - | - | 3 | - | - | - | - | - | - | - | - | - | 2 | 1 |
| 8 | - | - | - | - | - | - | - | - | - | 9 | - | - | - | - |
| 9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 10 | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - |
| 11 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 12 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

Sighting Totals

| | EleM | EleF | Zeb | Wbck | Imp | Kudu | Wbst | Bbk | Ghb | Whog | Hbst | Puku | Rbk | UnCa |
|--|------|------|-----|------|-----|------|------|-----|-----|------|------|------|-----|------|
| | 2 | 69 | 21 | 8 | 122 | 10 | 1 | 1 | 4 | 25 | 6 | 8 | 8 | 1 |

Date of Survey : 13/08/02
 Stratum Locality : South Luangwa NP
 Stratum Area : 1222 km²
 N : 169 n : 11
 Pilot : J. Cadd
 Map overlay file : None

Stratum Name : Nosbara
 Base Line Length : 54.2 km
 Calibrated Strip Width at 300ft : 318 m
 t : 2.228
 Observer : P Zyambo, W Moonga

Transect summary table :

| T # | Zeb | Kudu | Whog | Rbk | Bbk | Ghb |
|-----|-----|------|------|-----|-----|-----|
| 1 | 5 | 5 | 2 | - | - | - |
| 2 | - | - | - | - | - | - |
| 3 | - | - | - | - | - | - |
| 4 | - | - | - | - | - | - |
| 5 | 4 | - | - | - | - | - |
| 6 | - | - | - | 2 | - | - |
| 7 | - | - | - | - | - | - |
| 8 | - | - | - | - | 1 | 3 |
| 9 | - | - | - | - | - | - |
| 10 | - | - | - | - | - | - |
| 11 | - | - | - | - | - | - |

Sighting Totals

| | Zeb | Kudu | Whog | Rbk | Bbk | Ghb |
|--|-----|------|------|-----|-----|-----|
| | 9 | 5 | 2 | 2 | 1 | 3 |

Date of Survey : 14/08/02
 Stratum Locality : South Luangwa NP
 Stratum Area : 1961 km²
 N : 204 n : 27
 Pilot : J. Cadd
 Map overlay file : None

Stratum Name : Lubi
 Base Line Length : 66.9 km
 Calibrated Strip Width at 300ft : 318 m
 t : 2.056
 Observer : P Zyambo, W Moonga

Transect summary table :

| T # | EleM | EleF | Buff | Zeb | Wbck | Imp | Kudu | UnCa | Rbk | Whog | Eld | Puku | Ghb | Grf | PCmp | Roan | Hbst | Bbk |
|-----|------|------|------|-----|------|-----|------|------|-----|------|-----|------|-----|-----|------|------|------|-----|
| 1 | - | - | - | 4 | - | 44 | - | - | 1 | 6 | 2 | 2 | 3 | - | - | - | - | - |
| 2 | - | - | 5 | - | - | 3 | - | - | - | - | - | 8 | - | - | - | - | - | - |
| 3 | - | - | 9 | 8 | - | 43 | - | - | - | 8 | - | - | - | - | - | - | - | - |
| 4 | - | - | - | 8 | - | 30 | - | - | 2 | 1 | - | 1 | - | - | - | - | - | - |
| 5 | - | - | - | 12 | - | 99 | - | - | 2 | - | - | - | - | - | - | - | - | - |
| 6 | - | - | - | 11 | 5 | 7 | 6 | - | - | 4 | - | - | - | - | - | - | - | - |
| 7 | - | - | 50 | 21 | 4 | 39 | - | - | - | - | - | 6 | - | - | - | - | - | - |
| 8 | - | - | 4 | - | - | 11 | - | - | 1 | - | - | 11 | - | - | - | - | - | - |
| 9 | - | 6 | 31 | 7 | - | 24 | - | - | - | - | - | 26 | - | - | - | - | - | 2 |
| 10 | - | 6 | - | 53 | 11 | 4 | 3 | - | - | - | - | 14 | - | 1 | 2 | - | - | - |
| 11 | - | - | - | 9 | - | 28 | 3 | - | - | - | 1 | 17 | 3 | - | - | - | - | - |
| 12 | 1 | 18 | - | 24 | - | 4 | - | - | - | - | - | 10 | - | - | - | 9 | - | - |
| 13 | - | - | - | 6 | - | 13 | - | - | - | 2 | - | - | 3 | - | - | - | - | - |
| 14 | - | 5 | 34 | 22 | 1 | 57 | - | - | 6 | 2 | 10 | 24 | - | - | - | - | 2 | - |
| 15 | - | - | 98 | 7 | - | 11 | - | - | - | - | - | 23 | 6 | - | - | - | - | - |
| 16 | - | 4 | - | 3 | 2 | 53 | - | - | - | 4 | - | 26 | - | - | - | - | - | - |
| 17 | - | - | 2 | 13 | - | 18 | - | - | - | 4 | 2 | 11 | - | - | - | - | - | - |
| 18 | - | 35 | - | 4 | 4 | 62 | - | - | - | - | - | 10 | - | - | 1 | - | - | - |
| 19 | 2 | 57 | - | 2 | - | 8 | - | - | - | - | - | - | - | 5 | - | 1 | - | - |
| 20 | 3 | 46 | 561 | 22 | 1 | 35 | - | 1 | 2 | 5 | 5 | 20 | - | - | - | - | 3 | - |
| 21 | - | 18 | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | 5 | - |
| 22 | 1 | 7 | - | 10 | - | 25 | - | - | - | 1 | - | 8 | - | - | - | - | - | - |
| 23 | - | 9 | - | 11 | 4 | 22 | - | - | - | - | - | 7 | - | 4 | - | - | - | - |
| 24 | - | - | - | 18 | 1 | 61 | - | - | - | 3 | - | - | - | - | - | - | - | - |
| 25 | - | - | - | 3 | 4 | 5 | - | - | - | - | - | 4 | - | - | - | - | - | - |
| 26 | - | 3 | - | - | 4 | 24 | - | - | - | - | - | 41 | - | 3 | - | - | - | - |
| 27 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

Sighting Totals

| | EleM | EleF | Buff | Zeb | Wbck | Imp | Kudu | UnCa | Rbk | Whog | Eld | Puku | Ghb | Grf | PCmp | Roan | Hbst | Bbk |
|--|------|------|------|-----|------|-----|------|------|-----|------|-----|------|-----|-----|------|------|------|-----|
| | 7 | 214 | 794 | 280 | 41 | 730 | 12 | 1 | 14 | 40 | 20 | 269 | 15 | 13 | 3 | 10 | 10 | 2 |

Date of Survey : 15/08/02

Stratum Locality : South Luangwa NP

Stratum Area : 1128 km²

N : 156 n : 21

Pilot : J. Cadd

Map overlay file : None

Stratum Name : Stratum 4

Base Line Length : 51 km

Calibrated Strip Width at 300ft : 318 m

t : 2.086

Observer : W Moonga, P Zyambo

Transect summary table :

| T # | EleM | EleF | Buff | Zeb | Wbck | Imp | UnCa | Hbst | Whog | Puku | Roan | Grf | PCmp |
|-----|------|------|------|-----|------|-----|------|------|------|------|------|-----|------|
| 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2 | - | - | - | 4 | - | 9 | - | 4 | 1 | - | - | - | - |
| 3 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| 4 | - | 24 | - | - | - | - | - | - | - | - | - | - | - |
| 5 | 2 | 3 | - | 2 | - | - | - | - | - | - | - | - | - |
| 6 | - | - | - | 1 | - | 4 | - | - | - | - | - | - | - |
| 7 | - | 13 | - | - | - | 15 | - | - | - | 7 | - | - | - |
| 8 | - | 7 | - | 2 | - | - | - | - | - | - | 2 | - | - |
| 9 | - | - | - | - | - | 40 | - | - | 4 | 15 | 1 | 2 | 1 |
| 10 | - | 14 | 41 | - | 1 | 32 | - | - | 3 | 8 | - | - | - |
| 11 | - | 16 | - | - | - | 3 | - | - | - | 4 | - | - | - |
| 12 | - | 3 | - | - | - | - | - | - | - | - | 2 | - | 1 |
| 13 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 14 | - | 4 | - | - | - | 4 | - | - | - | - | - | - | - |
| 15 | 1 | 2 | 35 | - | - | - | - | - | - | - | - | - | - |
| 16 | 1 | 9 | - | - | - | 6 | - | - | 5 | - | - | - | - |
| 17 | - | 2 | - | - | - | - | 1 | - | - | - | - | - | - |
| 18 | - | 3 | - | - | - | - | - | - | 7 | 3 | - | - | - |
| 19 | - | 3 | - | - | 1 | - | - | - | - | - | - | - | - |
| 20 | - | - | - | - | - | - | - | - | - | 5 | - | - | - |
| 21 | - | - | - | - | - | - | - | - | - | - | - | - | - |

Sighting Totals

| | EleM | EleF | Buff | Zeb | Wbck | Imp | UnCa | Hbst | Whog | Puku | Roan | Grf | PCmp |
|--|------|------|------|-----|------|-----|------|------|------|------|------|-----|------|
| | 4 | 107 | 76 | 9 | 2 | 113 | 1 | 4 | 20 | 42 | 5 | 2 | 2 |

Date of Survey : 17/08/02

Stratum Name : Stratum 5

Stratum Locality : South Luangwa NP

Base Line Length : 65.4 km

Stratum Area : 1127 km²

Calibrated Strip Width at 300ft : 318 m

N : 203 n : 19

t : 2.101

Pilot : J. Cadd

Observer : P Zyambo, W Moonga

Map overlay file : None

Transect summary table :

| T # | EleM | EleF | Buff | Zeb | Wbck | Imp | Kudu | Whog | Ghb | Roan | PCmp | Puku |
|-----|------|------|------|-----|------|-----|------|------|-----|------|------|------|
| 1 | - | - | 2 | - | - | - | - | - | - | - | - | - |
| 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| 3 | - | - | 3 | - | - | - | - | 1 | - | - | - | - |
| 4 | - | - | - | - | - | - | - | - | 3 | - | - | - |
| 5 | - | - | 35 | - | - | - | - | 1 | - | - | - | - |
| 6 | - | - | - | - | - | - | - | - | - | 1 | - | - |
| 7 | - | - | - | - | - | - | - | - | - | - | - | - |
| 8 | - | - | - | - | - | - | - | - | - | 7 | - | - |
| 9 | - | - | - | - | - | - | - | - | - | - | - | - |
| 10 | - | - | - | - | - | - | - | - | - | - | - | - |
| 11 | - | - | - | - | - | - | - | - | - | - | - | - |
| 12 | - | - | - | 5 | 3 | - | - | - | - | - | - | - |
| 13 | - | 11 | - | - | - | - | 6 | - | - | - | - | - |
| 14 | - | 11 | - | - | - | - | - | 1 | 1 | - | 1 | - |
| 15 | 3 | 3 | - | - | - | - | - | - | - | - | - | - |
| 16 | - | 9 | - | - | - | 15 | - | - | - | - | 1 | 10 |
| 17 | - | 12 | - | - | - | 10 | - | - | - | - | - | - |
| 18 | - | - | - | - | - | - | - | 3 | - | - | - | 2 |
| 19 | - | - | - | - | - | 6 | - | - | - | - | - | 8 |

Sighting Totals

| | EleM | EleF | Buff | Zeb | Wbck | Imp | Kudu | Whog | Ghb | Roan | PCmp | Puku |
|--|------|------|------|-----|------|-----|------|------|-----|------|------|------|
| | 3 | 46 | 40 | 5 | 3 | 31 | 6 | 6 | 4 | 8 | 2 | 20 |

Date of Survey : 19/08/02

Stratum Locality : South Luangwa NP

Stratum Area : 1224 km²

N : 269 n : 17

Pilot : J. Cadd

Map overlay file : None

Stratum Name : Lusiwasi

Base Line Length : 87.9 km

Calibrated Strip Width at 300ft : 318 m

t : 2.12

Observer : P Zyambo, W Moonga

Transect summary table :

| T # | Buff | Zeb | Wbck | Imp | Ghb | Whog | Roan | Dkr | Bbk |
|-----|------|-----|------|-----|-----|------|------|-----|-----|
| 1 | - | - | - | - | - | - | - | - | - |
| 2 | - | - | - | - | - | - | - | - | - |
| 3 | - | - | - | - | - | - | - | - | - |
| 4 | - | - | - | - | - | - | - | - | - |
| 5 | - | - | - | - | 3 | - | - | - | 1 |
| 6 | - | - | - | - | - | - | - | - | 3 |
| 7 | 6 | 6 | - | - | - | 2 | - | - | - |
| 8 | - | 3 | 4 | 9 | - | - | - | - | - |
| 9 | - | - | - | - | - | - | - | - | - |
| 10 | - | - | - | - | - | - | - | - | - |
| 11 | - | - | - | 2 | - | - | - | - | - |
| 12 | - | - | - | - | - | - | 1 | 1 | - |
| 13 | - | - | - | - | - | - | - | - | - |
| 14 | - | 2 | - | - | - | - | - | - | - |
| 15 | - | - | - | - | - | - | - | - | - |
| 16 | - | 4 | - | - | - | 2 | - | - | - |
| 17 | - | - | - | - | - | - | - | - | - |

Sighting Totals

| | Buff | Zeb | Wbck | Imp | Ghb | Whog | Roan | Dkr | Bbk |
|--|------|-----|------|-----|-----|------|------|-----|-----|
| | 6 | 15 | 4 | 11 | 3 | 4 | 1 | 1 | 4 |

Date of Survey : 18/08/02
 Stratum Name : Chilongozi
 Stratum Locality : South Luangwa NP
 Base Line Length : 38.3 km
 Stratum Area : 1004 km²
 Calibrated Strip Width at 300ft : 318 m
 N : 116 n : 11
 t : 2.228
 Pilot : J. Cadd Observer : P Zyambo, W Moonga
 Map overlay file : None

Transect summary table :

| T # | EleM | EleF | Buff | Zeb | Imp | Kudu | EIC3 | Whog | Puku | Ghb | Grf |
|-----|------|------|------|-----|-----|------|------|------|------|-----|-----|
| 1 | - | - | - | - | 55 | - | - | - | - | - | - |
| 2 | 3 | 17 | - | - | 8 | - | - | 5 | - | - | - |
| 3 | - | - | 50 | - | 11 | - | 1 | - | 4 | 2 | - |
| 4 | 1 | 6 | - | - | - | - | - | 2 | - | - | - |
| 5 | - | 3 | - | - | - | - | - | - | - | - | - |
| 6 | - | 7 | - | - | - | - | - | - | - | - | - |
| 7 | - | - | - | 5 | - | - | - | - | - | - | 1 |
| 8 | - | - | - | 4 | - | - | - | - | 2 | - | 2 |
| 9 | - | - | 8 | - | - | 2 | - | - | 1 | - | 1 |
| 10 | - | - | - | - | - | - | - | - | - | - | - |
| 11 | - | - | - | - | - | - | - | - | - | - | - |

Sighting Totals

| | EleM | EleF | Buff | Zeb | Imp | Kudu | EIC3 | Whog | Puku | Ghb | Grf |
|--|------|------|------|-----|-----|------|------|------|------|-----|-----|
| | 4 | 33 | 58 | 9 | 74 | 2 | 1 | 7 | 7 | 2 | 4 |

Date of Survey : 18/08/02
 Stratum Name : Nsefu
 Stratum Locality : South Luangwa NP
 Base Line Length : 16.3 km
 Stratum Area : 226 km²
 Calibrated Strip Width at 300ft : 318 m
 N : 51 n : 5
 t : 2.776
 Pilot : J. Cadd Observer : P Zyambo, W Moonga
 Map overlay file : None

Transect summary table :

| T # | EleM | EleF | Buff | Zeb | Wbck | Imp | Kudu | EIC3 | UnCa | Puku | Whog | Ghb | Grf |
|-----|------|------|------|-----|------|-----|------|------|------|------|------|-----|-----|
| 1 | - | 3 | - | - | - | 43 | - | - | - | 3 | - | - | - |
| 2 | - | 10 | 3 | - | 1 | 4 | 1 | - | 1 | 10 | 4 | - | - |
| 3 | - | - | 50 | 1 | - | 31 | - | 1 | - | 63 | 7 | 1 | - |
| 4 | - | 5 | 2 | - | - | 7 | - | - | - | 81 | - | - | 2 |
| 5 | 1 | 3 | - | - | - | 34 | - | - | - | 41 | 3 | - | 1 |

Sighting Totals

| | EleM | EleF | Buff | Zeb | Wbck | Imp | Kudu | EIC3 | UnCa | Puku | Whog | Ghb | Grf |
|--|------|------|------|-----|------|-----|------|------|------|------|------|-----|-----|
| | 1 | 21 | 55 | 1 | 1 | 119 | 1 | 1 | 1 | 198 | 14 | 1 | 3 |

Date of Survey : 13/08/02
 Stratum Locality : Lupande GMA
 Stratum Area : 816 km²
 N : 196 n : 10
 Pilot : J. Cadd
 Map overlay file : None

Stratum Name : East Lower Lupande
 Base Line Length : 63.3 km
 Calibrated Strip Width at 300ft : 318 m
 t : 2.262
 Observer : P Zyambo, W Moonga

Transect summary table :

| T # | EleM | EleF | Wbck | Imp | EIC3 | Pig | Puku | Bbk | Shoa |
|-----|------|------|------|-----|------|-----|------|-----|------|
| 1 | - | - | - | - | - | - | - | - | - |
| 2 | - | - | - | - | - | - | - | 1 | 15 |
| 3 | 2 | - | - | - | - | - | - | - | - |
| 4 | - | - | - | - | - | - | - | - | - |
| 5 | - | - | - | - | - | - | - | - | - |
| 6 | - | - | - | 3 | - | - | - | - | - |
| 7 | - | - | - | - | - | - | - | - | - |
| 8 | - | - | - | - | - | 1 | - | - | - |
| 9 | - | - | - | - | - | - | - | - | - |
| 10 | - | 10 | 2 | 6 | 2 | - | 6 | - | - |

Sighting Totals

| | EleM | EleF | Wbck | Imp | EIC3 | Pig | Puku | Bbk | Shoa |
|--|------|------|------|-----|------|-----|------|-----|------|
| | 2 | 10 | 2 | 9 | 2 | 1 | 6 | 1 | 15 |

Date of Survey : 17/08/02
 Stratum Locality : Lupande GMA
 Stratum Area : 295 km²
 N : 68 n : 4
 Pilot : J. Cadd
 Map overlay file : None

Stratum Name : Machinje
 Base Line Length : 22.2 km
 Calibrated Strip Width at 300ft : 318 m
 t : 3.182
 Observer : P Zyambo, W Moonga

Transect summary table :

| T # | Roan | Hbst |
|-----|------|------|
| 1 | - | - |
| 2 | - | - |
| 3 | 6 | 4 |
| 4 | - | 2 |

Sighting Totals

| | Roan | Hbst |
|--|------|------|
| | 6 | 6 |

Date of Survey : 12/08/02
 Stratum Locality : Lupande GMA
 Stratum Area : 1797 km²
 N : 178 n : 6
 Pilot : J. Cadd
 Map overlay file : None

Stratum Name : East Lupande
 Base Line Length : 58.1 km
 Calibrated Strip Width at 300ft : 318 m
 t : 2.571
 Observer : P Zyambo, W Moonga

Transect summary table :

| T # | Buff | Shoa | Ghb | Roan |
|-----|------|------|-----|------|
| 1 | - | - | - | - |
| 2 | - | - | 2 | - |
| 3 | - | - | 2 | - |
| 4 | - | 10 | - | - |
| 5 | 10 | 12 | - | 8 |
| 6 | - | - | - | - |

Sighting Totals

| | Buff | Shoa | Ghb | Roan |
|--|------|------|-----|------|
| | 10 | 22 | 4 | 8 |

Date of Survey : 18/08/02
 Stratum Locality : Lupande Hills
 Stratum Area : 1012 km²
 N : 104 n : 7
 Pilot : J. Cadd
 Map overlay file : None

Stratum Name : Lupande Hills
 Base Line Length : 36.9 km
 Calibrated Strip Width at 300ft : 318 m
 t : 2.447
 Observer : P Zyambo, W Moonga

Transect summary table :

| T # | EleF | Zeb | Imp | Kudu | Shoa | Roan |
|-----|------|-----|-----|------|------|------|
| 1 | - | - | - | - | - | - |
| 2 | - | - | 2 | - | 15 | - |
| 3 | - | - | - | 2 | - | 4 |
| 4 | 5 | 1 | - | - | - | - |
| 5 | - | - | - | - | - | - |
| 6 | - | - | - | - | - | - |
| 7 | - | - | - | - | - | - |

Sighting Totals

| | EleF | Zeb | Imp | Kudu | Shoa | Roan |
|--|------|-----|-----|------|------|------|
| | 5 | 1 | 2 | 2 | 15 | 4 |

Appendix 5. Position data for sightings in Lupande GMA.

| Longitude °E | Latitude °S | Species | Group Size |
|---------------------|--------------------|-----------------|-------------------|
| 31.10733 | 13.13122 | buffalo | 1 |
| 31.82300 | 13.09522 | buffalo | 1 |
| 31.82300 | 13.09522 | buffalo | 5 |
| 32.06100 | 13.20641 | buffalo | 10 |
| 31.14167 | 13.13122 | buffalo | 45 |
| 31.90867 | 13.57412 | bushbuck | 1 |
| 31.97000 | 13.02322 | eland | 4 |
| 31.65817 | 13.25473 | elephant bulls | 1 |
| 31.89400 | 13.02322 | elephant bulls | 2 |
| 31.81850 | 13.52012 | elephant bulls | 2 |
| 31.55400 | 13.41673 | elephant cows | 1 |
| 31.55400 | 13.41673 | elephant cows | 2 |
| 31.72307 | 13.25883 | elephant cows | 2 |
| 31.57283 | 13.38973 | elephant cows | 3 |
| 31.65167 | 13.25473 | elephant cows | 3 |
| 31.68933 | 13.22773 | elephant cows | 3 |
| 31.75767 | 13.14212 | elephant cows | 3 |
| 31.72307 | 13.24533 | elephant cows | 3 |
| 31.57283 | 13.38973 | elephant cows | 4 |
| 31.61917 | 13.41673 | elephant cows | 5 |
| 32.21117 | 13.02322 | elephant cows | 6 |
| 31.57550 | 13.44373 | elephant cows | 7 |
| 31.58233 | 13.41673 | elephant cows | 7 |
| 31.75100 | 13.14212 | elephant cows | 7 |
| 31.56667 | 13.47074 | elephant cows | 8 |
| 31.57350 | 13.38973 | elephant cows | 16 |
| 31.72500 | 13.17373 | giraffe | 1 |
| 31.62400 | 13.36273 | giraffe | 4 |
| 31.62400 | 13.44373 | ground hornbill | 1 |
| 31.99283 | 13.47641 | ground hornbill | 2 |
| 32.02967 | 13.38641 | ground hornbill | 2 |
| 32.29495 | 13.08417 | hartebeest | 2 |
| 32.34113 | 13.04350 | hartebeest | 4 |
| 32.01700 | 13.02322 | impala | 1 |
| 31.67583 | 13.22773 | impala | 1 |
| 32.00167 | 13.02322 | impala | 2 |
| 31.81550 | 13.67500 | impala | 2 |
| 31.85567 | 13.35812 | impala | 3 |
| 32.01700 | 13.02322 | impala | 4 |
| 32.04200 | 13.02322 | impala | 4 |
| 31.75767 | 13.14212 | impala | 6 |
| 31.95850 | 13.02322 | impala | 7 |
| 31.97000 | 13.02322 | impala | 8 |
| 31.72500 | 13.17373 | impala | 8 |
| 31.92383 | 13.02322 | impala | 14 |
| 31.64950 | 13.33573 | impala | 22 |
| 31.91933 | 13.02322 | impala | 23 |
| 31.66800 | 13.28173 | impala | 25 |
| 32.20917 | 13.09522 | kudu | 1 |
| 31.76929 | 13.72967 | kudu | 2 |

| Longitude °E | Latitude °S | Species | Group Size |
|---------------------|--------------------|-----------------------|-------------------|
| 32.16750 | 13.02322 | kudu | 7 |
| 32.05500 | 13.05922 | elephant carcass, old | 1 |
| 31.75100 | 13.14212 | elephant carcass, old | 1 |
| 31.75767 | 13.14212 | elephant carcass, old | 1 |
| 31.91700 | 13.25012 | pig, domestic | 1 |
| 31.91933 | 13.02322 | puku | 1 |
| 31.65917 | 13.28173 | puku | 3 |
| 31.65817 | 13.25473 | puku | 3 |
| 31.67583 | 13.22773 | puku | 4 |
| 31.91933 | 13.02322 | puku | 5 |
| 31.78300 | 13.14212 | puku | 6 |
| 31.62400 | 13.36273 | puku | 9 |
| 31.62400 | 13.36273 | puku | 12 |
| 31.89400 | 13.02322 | puku | 18 |
| 31.71683 | 13.17373 | puku | 18 |
| 31.76929 | 13.37633 | roan | 4 |
| 32.34113 | 13.14100 | roan | 6 |
| 32.16583 | 13.20641 | roan | 8 |
| 31.93033 | 13.20641 | sheep &/or goats | 4 |
| 31.93567 | 13.20641 | sheep &/or goats | 8 |
| 32.05417 | 13.29641 | sheep &/or goats | 10 |
| 31.90867 | 13.57412 | sheep &/or goats | 15 |
| 31.81550 | 13.67500 | sheep &/or goats | 15 |
| 32.08867 | 13.02322 | warthog | 1 |
| 31.63717 | 13.33573 | warthog | 1 |
| 31.56817 | 13.41673 | waterbuck | 1 |
| 31.68933 | 13.22773 | waterbuck | 1 |
| 31.75767 | 13.14212 | waterbuck | 2 |
| 31.97000 | 13.02322 | wildebeest | 40 |
| 31.72307 | 13.43300 | zebra | 1 |
| 31.64617 | 13.47074 | zebra | 2 |
| 31.67717 | 13.25473 | zebra | 3 |
| 32.13717 | 13.09522 | zebra | 18 |