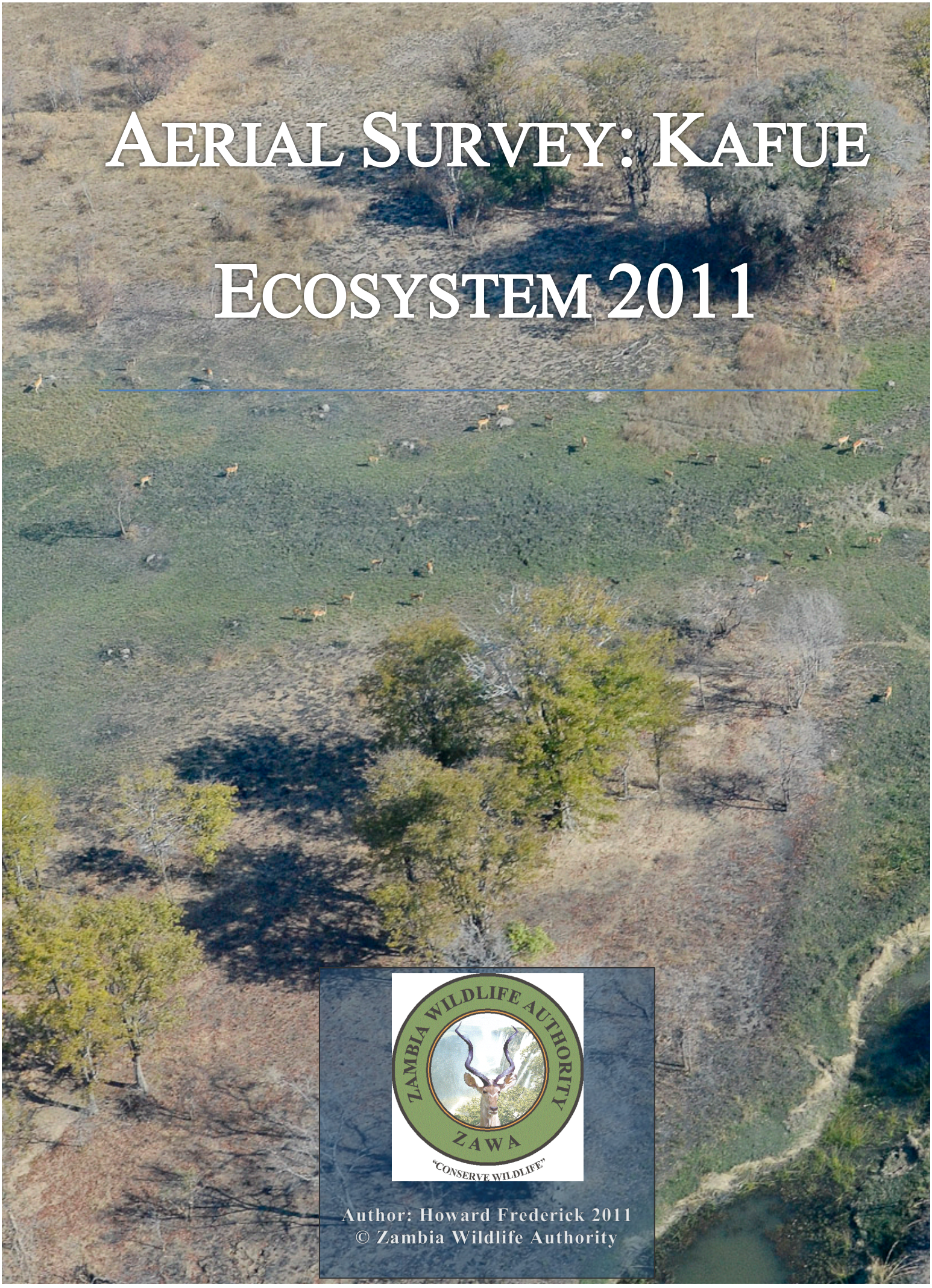
Aerial Survey: Kafue Ecosystem 2011



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Special thanks also to the Zambian Air Force for supporting the survey of the P4 area.

Aerial Survey: Kafue Ecosystem 2011

Final Report

This report should be referenced as:

Frederick H (2011) "Aerial Survey: Kafue Ecosystem 2011". Zambia Wildlife Authority, Chilanga.

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Executive Summary

Overview

This report is the result of an independently coordinated aerial survey of Kafue Ecosystem, commissioned by the Zambia Wildlife Authority.

- In August and September2011 a sample count of the Kafue National Park (KNP) and surrounding Game Management Areas (GMAs) was carried out, with the aim of assessing wildlife populations in the Kafue Ecosystem;
- The entire Park and most of the surrounding Game Management Areas were surveyed at between 3% and 12% sample coverage.
- Distribution data and estimates were produced for all large herbivore species, including the key species in the General Management Plan.
- A partial total count of the buffalo population was carried out to attempt to determine more accurately the population of buffalo in the ecosystem; sample counts have proved to be highly variable in the past.

Main findings

- Most species are stable or showing increasing trends from 2008; in many cases these trends are statistically significant over the longer term (from 2002 and 2006).
- Elephant numbers are stable for the ecosystem (3,715 ± 781se); however, more carcasses were found in the ecosystem and the carcass ratio is more than double the previous estimate (3.1% vs. 1.3% in 2008). Mulobezi GMA had several recent carcasses and elephant are no longer using most of the GMA, only found immediately along the border of the Park.
- Puku show a strong increasing trend from 2002 and 2006, and are stable from 2008 (estimate 11,751 ± 1,828se).

- The population of buffalo (population estimate 4,566 ± 687se) was assessed and, if at least partial total counts are used in the future, should be a good baseline for future surveys.
- Red lechwe show a weakly significant increase from 2006 and 2008 (estimate 9,262 +/- 2,037se) and a strong increase from 2002.
- Human encroachment is prevalent in many parts of the ecosystem, and probably represents a significant threat to the health of Kafue:
    - Bike trails and footpaths are widespread in GMAs and the Park;
    - Several poacher's camps were seen in the Park and the GMAs.
    - Livestock, settlements and cultivation are present and widespread in many GMAs.

Recommendations:

- Lechwe surveys can be done relatively cheaply and quickly (2 days / 8 flight hours) and should be done on a yearly basis.
- The general survey of the ecosystem can be done on a continuing 2-year cycle, and a survey strategy should be developed by the Project to capitalise on the better spatial data gathered by this survey (for faster and cheaper surveys without loss of accuracy).

1 Introduction

An aerial wildlife survey was carried out in August and September 2011 of the Kafue National Park and its surrounding GMAs, with the aim of assessing wildlife populations. The aim was to assess the population status of large mammals as accurately as possible, to examine trends in wildlife numbers, and to map the distribution of wildlife and human activities in the survey area.

The Kafue National Park Project, supported by Norway and the World Bank (under the Support for Economic Expansion and Diversification (SEED) Programme) secures critical habitat and species in the Park and adjacent GMAs. As indicated in the TOR for this study (Appendix 1), previous surveys in 2002, 2004, 2006 had mixed results showing significant (doubling/halving) fluctuations in many animal estimates; this led to concern about possible dramatic declines in some wildlife species between 2004 and 2006, though anecdotal evidence from ZAWA staff and tourist operators indicated more stable or increasing populations.

This survey was coordinated by an independent consultant at the request of the Zambia Wildlife Authority (ZAWA). Norway and World Bank provided support under the "Programme for the Development of Kafue National park as a Model for Sustainable Economic Use and Biodiversity Conservation in a Management Extensive Environment (2005-2009)".

1.1 Survey History

Previous surveys in the Kafue Ecosystem include:

- The previous survey by this consultant (Frederick 2008);
- ZAWA surveys in 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2002, 2004, 2004, and 2006 (Simpamba, pers. comm. 2008, ZAWA 2006);
- Petri Viljoen's 2007 survey of the Busanga Plains (1,748 km^2) (Viljoen, 2007);
- Specific elephant surveys in 2001 and 2004 (Guldemond, Lehman, Ferreira, & van Aaarde, 2005);
- A lechwe population study (Grimsdell & Bell, 1972).

Survey methods have been poorly documented – many of the surveys (1994-2004) exist only as estimate tables without spatial data or methodological information. As a result it is difficult to interpret the population variations indicated above as either ecological or methodological variations.

The 2008 survey did not receive permission to fly the P4 prohibited area and thus omitted about 25% of the Park and the entirety of Lunga-Luswishi.

2 Methods

The aim of the survey was to develop accurate and precise estimates of wildlife populations in the Kafue ecosystem (National Park and surrounding GMAs), with a special focus on the indicator species for the Kafue National Park Project Document (ZAWA 2004): elephant, buffalo, puku and red lechwe. Thirty days of fieldwork were allocated for the survey, including training.

Transect (sample) counts were carried out using Systematic Reconnaissance Flight (SRF) methods based on Norton-Griffiths (1978), covering the entire survey area. The Busanga Plains red lechwe population was sample-counted twice – first in the general survey of the whole ecosystem, and then re-surveyed at a higher intensity for the specific distribution of the lechwe.

A total count was initially proposed to be carried out of the core buffalo and elephant areas. However, the elephant distribution was far more dispersed and accessible in open habitat than the distribution encountered in 2008, especially in the area of the Ngoma forest, which was a problem area in the 2008 survey; this is most likely due to the timing of the survey, as anecdotal observations during the course of the survey indicated that elephant were concentrating in the Ngoma forest after the first ten days of the survey. A partial total count of the Ngoma and Chunga (riverine) areas was carried out for buffalo only.

2.1 Study area

The study area was defined by the TOR as "Kafue National Park and surrounding GMAs". A survey plan was drawn up for the study area with the exception of the Bilili GMA, which was found to be entirely depleted of wildlife in 2008. A buffer of approximately 5km was covered outside of

Kafue NP into the Bilili area. Table 1 shows the coverage of the survey by protected area; Figure 1 shows the Park and surrounding GMAs.

Table 1: Protected area official areas and surveyed area, 2011.

Zone	Status	Area (km^2) *	Surveyed (km^2) **
Kafue	National Park	22,400	22,424
Sichifulo	GMA	3,600	2,900
Nkala	GMA	194	211
Namwala	GMA	3,600	3,161
Mumbwa	GMA	3,370	3,181
Mulobezi	GMA	3,420	3,600
Bilili	GMA	3,080	581
Lunga-Luswishi	GMA	13,340	13,462
Kasonso-Busanga	GMA	7,780	6,874
Mufunta	GMA	3,417	6,356
Outside	n/a		7,708
	Total		70,458

* The area indicated is the official area based on the original surveyed area by the Zambian Ministry of Lands (Survey Department). The GIS data used by ZAWA shows major differences in some cases (see the Appendices).

** Note that surveyed area is an estimate based on the transect width and whether the centre of the transect fell within the given protected area; as a result the calculated area may differ

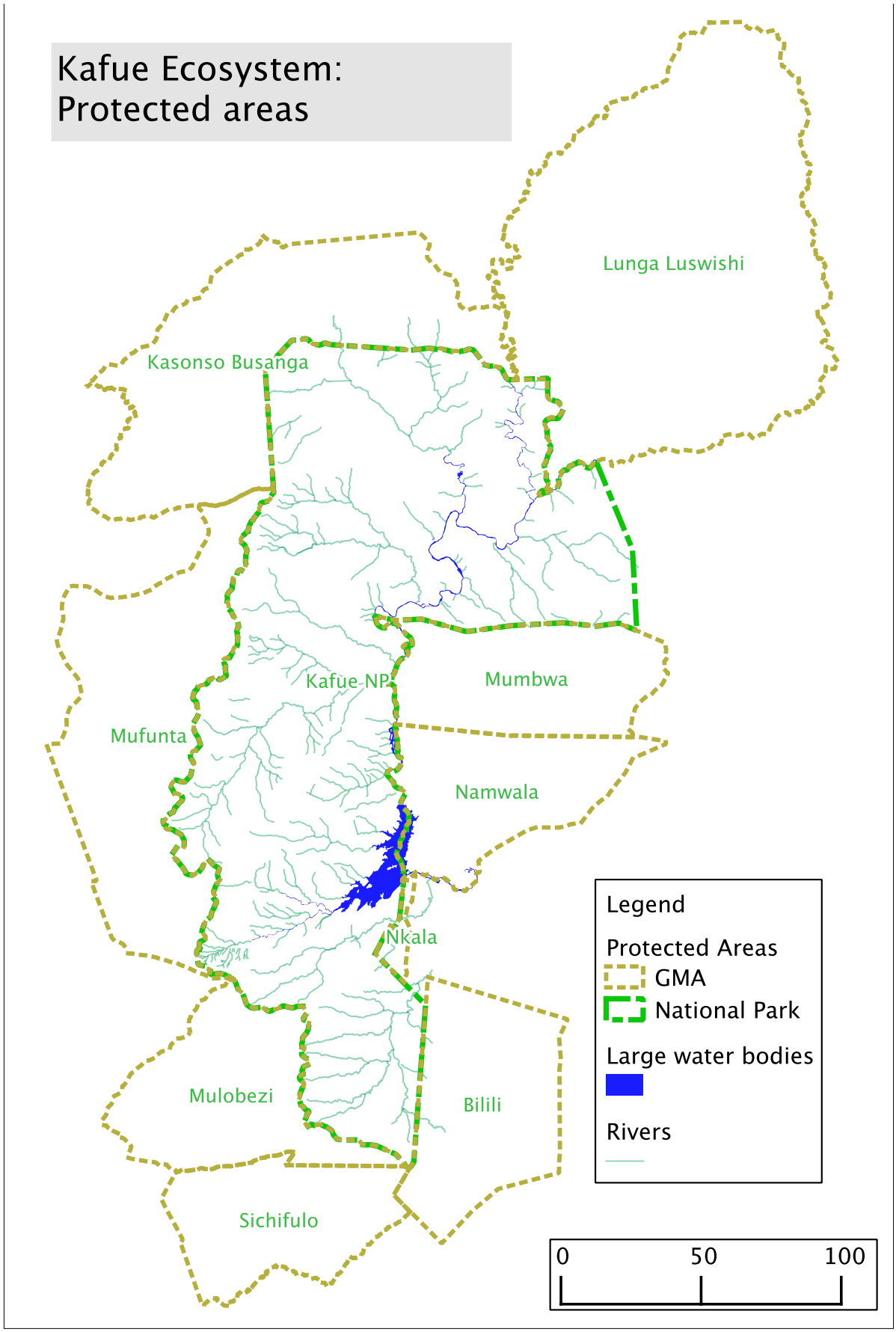

Figure 1: Protected areas, Kafue ecosystem.

2.2 Stratification & Transects

The survey area was divided into sample blocks based on the wildlife distributions mapped in the 2008 survey and sightings from patrol data. Survey intensity (space between transects) was determined by the likely density of wildlife – high density areas (including the majority of Kafue National Park) were surveyed with 2.5 km spacing (approximately 12% coverage), and most GMAs at 5km spacing except for Lunga-Luswishi and Mufunta which were surveyed at 10km spacing due to the expected extremely low density of wildlife.

Note that surveys prior to 2008 did not fully indicate flight paths or the nature and determination of the strata used; for the 2006 survey, strata were determined by physical and environmental features presumably for ease of navigation in the field. The relatively accurate distribution data from 2008 and this report may be used to further target survey effort in the future, making surveys cheaper and more efficient.

Most transects were flown east-west, except for Kasonso-Busanga East (north-south) and the second survey of Busanga, which was flown SW-NE perpendicular to the main distribution of lechwe (Figure 2). Transects were determined prior to all flights and transect endpoints programmed into GPS units; transects were subdivided into 2.5 km subunits also determined by GPS points.

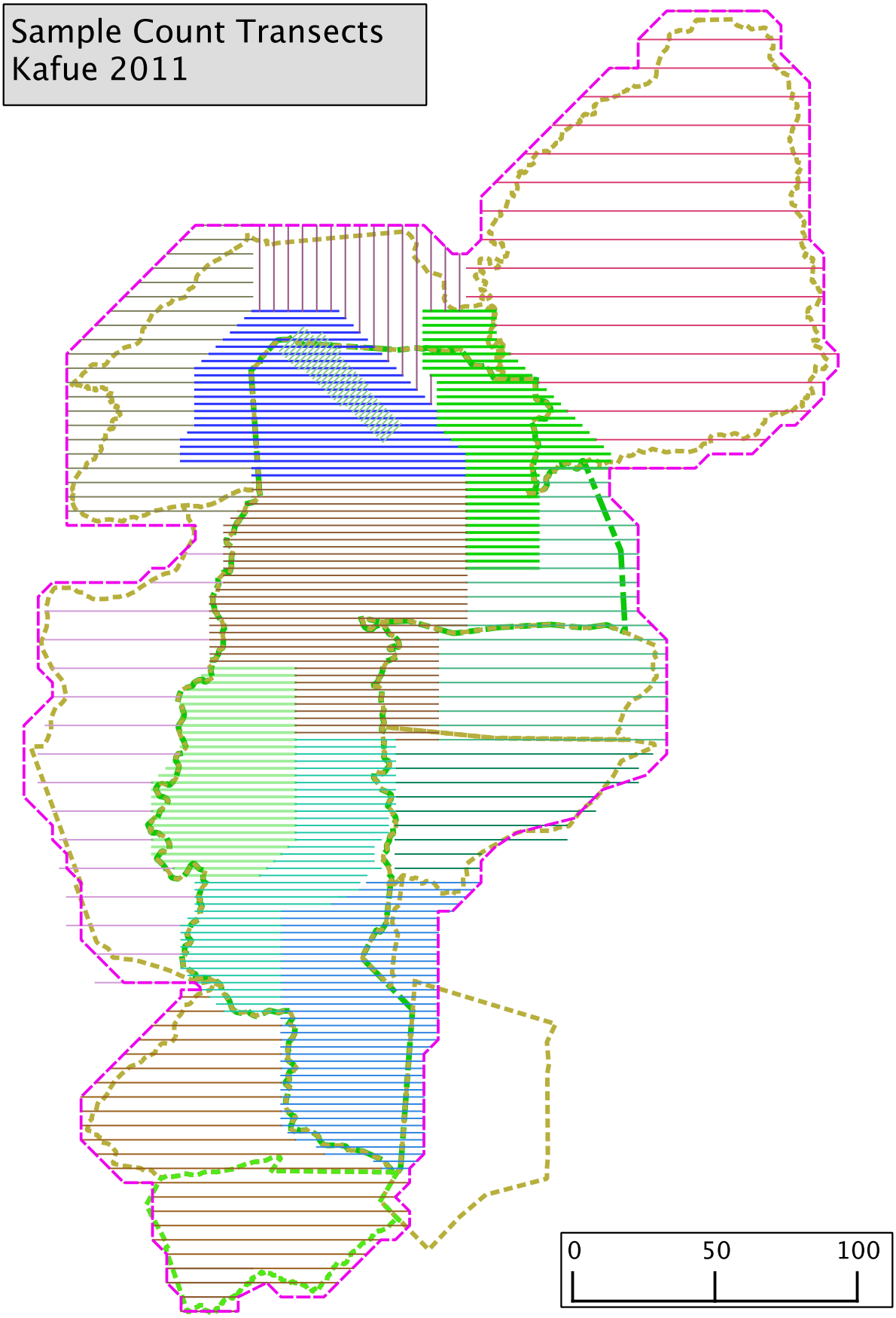

Figure 2: Transect spacing and layout.

2.2.1 Buffalo Partial Total Count

Time and budget constraints limited the team from doing a full total count of buffalo in the survey area. Buffalo numbers have been extremely variable in previous surveys, ranging from <1,000 to >14,000 in the past seventeen years. This is typical of sample counts of highly aggregated species such as buffalo, which tend to occur in large herds; the sample count may count only a few groups, and those very large – removing or adding a single group by chance can change the estimate by more than half or double, respectively.

The buffalo population of the Park is mostly contained in a few large herds, such as the Ngoma and Chunga herds which were known to be likely between several hundred and over a thousand individuals.

A modified total count method (Norton-Griffiths 1978) was flown to attempt to improve the estimate:

A. When large buffalo herds (>100) were sighted during transect flights the current subunit was finished and then the aircraft returned to photograph the entire herd.
B. Where those herds were also seen in the transect that observation was removed from the sample calculation.
C. On the 21st of September a search pattern was flown along both sides of the river from Hippo Camp to Itezhitezhi Dam, with two observers and the pilot searching for buffalo herds.
    a. Flying height was between 500 and 700 feet.
    b. Herds spotted were circled and photographed (three herds).
D. Photographs were counted, groups mapped, and checked against observations during transect flights.
    a. One likely double-count group was removed: a herd of estimated 330 animals was seen in Mushingashi on the 18th, and a herd of estimated 326 on the 21st 30km away, and assumed to be the same group.

b. One group on the western side of Chunga block was not photographed well during the sample count and the portion of the group (69 individuals) that was in the transect was retained for the sample count analysis.

This 'mixed' method is likely to give a truer representation of the total number of buffalo than has been achieved to date (M. Norton-Griffiths, pers. comm.).

2.3 Fieldwork

Systematic Reconnaissance Flight methodology (Norton-Griffiths 1978) was followed for the aerial survey and for data analysis.

The survey took place from the 29th August to the 21stSeptember2011.

Aircraft were chartered by ZAWA from Sky Trails Ltd. Both aircraft (Cessna 182 & Cessna 337) were fitted with analogue radar altimeters and programmable Garmin GPS units (GPS296 and GPS495). Three pilots rotated duties between aircraft during the survey; each pilot was trained in survey methodology by the survey consultant (height control, wing-level flying, transect and block navigation). Pilots were responsible for safety, navigation to and along daily transect assignments, and reporting to the survey coordinator.

Front seat observers (FSOs) in the co-pilot's seat were responsible for recording radar altimeter readings to the nearest 10 feet at the beginning of each subunit. FSOs recorded geo-referenced information on data sheets and announced the beginning of each subunit. For each subunit, FSOs recorded the presence or absence of human activities and surface water at any point along the transect, together with a rough indication of quantity:

- Any habitation (houses, as long as not clearly abandoned);
- Cultivation;
- Metal roofing sheets on any structure (an economic indicator);
- Livestock;
- Rivers; and

- Water holes.

Quantities were indicated within the subunit for each activity: 1 or more (1+), 10 or more (10+), and 100 or more (100+).

Rear seat observers (RSOs) recorded on personal tape recorders all observations of large mammals and birds observed within defined counting strips on the left and right sides of the aircraft, and recorded subunit and transect numbers as announced by the FSO. All animal groups >10 were required to be photographed, but observers were encouraged to photograph any observation. Recorded observations were transcribed onto data sheets after each flight.

Calibrated counting strips on each side of the aircraft were defined by rods affixed to each wing strut. The width of counting strips was determined per subunit on the basis of height above ground, as recorded on the radar altimeter. Rear seat observer strip-widths were regressed against radar altimeter heights by flying across the Ngoma airstrip over markers of known distance (Table 13, Appendices).

Cameras for the RSOs were placed on suction mounts in the window at the same level and close to the observer's point of view, but without obstructing view of the strip. During calibration the cameras were positioned to have the same strip field of view using the same ground marks as the observers.

The ground coordinator received all data sheets from front and rear seat observers immediately following each flight, downloaded GPS data from FSO and pilot, and copied any photographs from the digital cameras.

2.4 Data Validation& Standards

Data were checked and logged during and following the survey to confirm observer performance, flight performance, and geographic accuracy:

A. GPS data were recorded and downloaded for every session to confirm transect start / end positions and times.

B. Ground speed was checked:

a. Average speed over transects was calculated; two transects were re-flown following poor conditions (speeds > 190 km/h) in high winds (Itezhi West block).

b. Graphs of speeds during sessions were examined to confirm that no long (> 5 minute) sections of any transect was too fast (see Appendices).

C. Observer fatigue was minimised during survey design:

a. Counting sessions lasted a maximum of 3.5 hours, typically 2.5.

b. Transects were limited to 35 minutes maximum, typically 20.

D. Flying height performance was reviewed regularly with pilots and FSOs and confirmed to be within bounds (average height (351 feet) and standard deviation (+/- 20 to 60 feet depending on aircraft).

E. Observer side comparisons were made to check the number of observations and the number of individuals seen per day; e.g. the Busanga second count for lechwe showed 830 left and 807 right lechwe, 132 and 129 wildebeest, though the numbers of observations were different (25 and 59 respectively for lechwe, reflecting the way in which observers tallied groups in this high-density area). Observer side comparisons were consistent.

F. Group size estimation errors were minimised with photographs of groups (approximately 50% of larger groups had adequate photographs), and a correction factor applied to un-photographed groups.

2.5 Lab work

Census data were analysed using a script (Frederick 2011) written in the R statistical language (R Core Development Team 2011). Population estimates were calculated using Jolly's Method 2 for Unequal Sized Units (Jolly 1969). *d* tests (Cochran 1954; Norton-Griffiths 1978) were used to test for population changes. Distribution maps were created using ArcGIS 9.3.1 (ESRI 2009).

Rear seat observer observations were corrected by reference to photographs taken of groups larger than 20 animals. Photographs were viewed in Adobe Photoshop (Adobe Systems 2009), colour corrected and the count tool used to place coloured dots on each animal and tally the total numbers.

Observations of groups >30 without photographs (i.e. that could not be photographically verified) were corrected for observer counting bias. A regression was performed on photographed (checked) vs. estimated numbers, and two correction factors were determined:

- Groups >30 but <50: multiplied by 0.95;
- Groups >50: multiplied by 0.86.

3 Results

3.1 Estimates

The estimates tables presented in the following pages all use the following format:

- Obs – the total number actually observed within the transect;
- Est – the estimated number based on the sample area and total area;
- SE – the standard error of the estimate.

Note:

- Sample counts are especially unreliable for small, secretive species (duiker, grysbok) or for carnivores (which have cryptic coloration and habits).
- Sample counts are also unreliable for species in low densities. Where fewer than 20 individuals were seen, the estimate is not presented (greyed out).
- d-tests for change over time are presented in tables showing historical data. d-tests area a t-test, with critical value 1.96 at an alpha value of 0.05. Figures are shown in bold where the d value is above the critical threshold.

3.1.1 Overall Wildlife / Administrative blocks

Overall wildlife numbers, by administrative area, are indicated in Table 2; Figure 3 shows a density map of all wildlife species combined.

Table 2: Estimates by administrative area.

	Kafue			Bilili			Kasonso-Busanga			Lunga-Luswishi			Mufunta		
Species	Obs	**Est**	SE	Obs	**Est**	SE	Obs	**Est**	SE	Obs	**Est**	SE	Obs	**Est**	SE
Buffalo	175	**1,446**	697	-			-			-			-		
Elephant	269	**2,280**	493	-			3			-			-		
EL Carcass 2	3			-			-			-			-		
EL Carcass 3	-			-			-			-			-		
EL Carcass 4	2			-			-			-			-		
Puku	1,403	**11,751**	1,865	-			25	**194**	143	223	**2,240**	1,127	-		
Red lechwe	1,030	**8,465**	3,700	-			-			-			-		
Hartebeest	458	**3,937**	660	-	-	-	40	**345**	219	6	48	45	21	**499**	363
Impala	1,547	**12,884**	1,654	15	126	91	13	172	132	128	**1,885**	790	2	17	16
Kudu	111	**913**	165	3	25	24	6	64	43	25	**310**	128	3	90	88
Roan	233	**1,916**	580	-	-	-	1	8	7	-	-	-	17	509	500
Sable	821	**7,208**	1,017	-	-	-	39	**382**	167	49	**1,172**	800	15	449	411
Waterbuck	481	**4,135**	667	4	34	31	1	8	7	9	72	35	-	-	-
Warthog	1,055	**9,111**	701	11	92	59	76	**598**	180	105	**1,159**	317	21	**177**	94
Bushbuck	17	140	109	-	-	-	3	23	16	5	109	51	-	-	-
Baboon	128	**1,057**	332	-	-	-	126	**###**	431	192	**5,908**	3,832	4	120	118
Bushpig	27	**222**	107	-	-	-	1	8	7	3	24	23	-	-	-
Common duiker	2	16	11	-	-	-	-	-	-	-	-	-	-	-	-
Duiker	26	**222**	45	-	-	-	21	**180**	41	31	**798**	174	18	453	155
Eland	113	**938**	572	-	-	-	-	-	-	-	-	-	-	-	-
Ground Hornbill	171	**1,474**	208	2	17	16	19	236	100	36	**1,022**	383	20	**491**	212
Hippo	145	**1,192**	313	-	-	-	-	-	-	8	64	60	-	-	-
Oribi	17	140	40	-	-	-	5	65	49	2	16	15	-	-	-
Reedbuck	111	**964**	159	-	-	-	6	46	30	6	186	108	4	120	118
Sitatunga	2	16	15	-	-	-	-	-	-	-	-	-	-	-	-
Vervet monkey	150	**1,306**	337	-	-	-	-	-	-	9	118	69	-	-	-
Wattled crane	55	**452**	163	-	-	-	8	62	33	-	-	-	-	-	-
Wildebeest	150	**1,230**	765	-	-	-	1	8	7	-	-	-	-	-	-
Zebra	118	**970**	278	-	-	-	-	-	-	5	155	152	-	-	-
Poacher's camp	4	33	24	-	-	-	-	-	-	-	-	-	-	-	-
Poacher's camp (old)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	Mulobezi			Mumbwa			Namwala			Nkala			Sichifulo			Outside			Ecosystem		
Species	Obs	**Est**	SE	Obs	**Est**	SE	Obs	**Est**	SE	Obs	**Est**	SE	Obs	**Est**	SE	Obs	**Est**	SE	Obs	**Est**	SE
Buffalo	-			-			-			-			-			-			175	**1,446**	697
Elephant	63	**824**	524	33	**422**	292	-			11			-			4			383	**3,715**	781
EL Carcass 2	1			-			-			-			-			-			4	**42**	21
EL Carcass 3	1			1			-			-			-			-			2	**25**	18
EL Carcass 4	1			1			-			-			-			-			4	**50**	26
Puku	-			122	**1,028**	457	-			-			-			29	**300**	175	1,802	**15,513**	2,238
Red lechwe	-			-			-			-			-			-			1,030	**8,465**	3,700
Hartebeest	29	**489**	294	54	**853**	339	5	84	82	8	61	57	-	-	-	-	-	-	621	**6,317**	910
Impala	23	**387**	221	146	**1,231**	371	8	67	62	29	**219**	204	-	-	-	6	100	97	1,917	**17,087**	1,904
Kudu	21	**354**	210	2	34	33	7	118	77	-	-	-	4	67	65	3	79	63	185	**2,053**	337
Roan	-	-	-	-	-	-	-	-	-	1	8	7	-	-	-	-	-	-	252	**2,440**	766
Sable	70	**1,162**	541	51	**676**	487	19	312	277	-	-	-	22	**367**	290	3	93	67	1,088	**11,822**	1,602
Waterbuck	-	-	-	12	169	135	-	-	-	25	**192**	179	-	-	-	6	48	32	538	**4,657**	706
Warthog	27	**455**	190	51	**633**	241	17	252	215	-	-	-	31	**518**	193	10	146	79	1,404	**13,142**	905
Bushbuck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25	**272**	121
Baboon	-	-	-	-	-	-	2	34	33	-	-	-	-	-	-	3	93	92	454	**8,228**	3,874
Bushpig	-	-	-	4	68	66	-	-	-	-	-	-	-	-	-	-	-	-	35	**321**	128
Common duiker	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	**16**	11
Duiker	11	185	47	1	8	8	2	34	33	-	-	-	5	84	56	8	211	94	123	**2,176**	271
Eland	12	202	196	-	-	-	-	-	-	-	-	-	-	-	-	18	143	133	143	**1,283**	619
Ground Hornbill	6	101	71	7	118	77	10	169	77	-	-	-	7	117	70	24	**515**	255	302	**4,261**	576
Hippo	-	-	-	13	110	79	-	-	-	-	-	-	-	-	-	-	-	-	166	**1,366**	329
Oribi	6	101	52	2	34	33	4	33	24	-	-	-	2	33	32	1	8	7	39	**431**	99
Reedbuck	1	17	16	6	76	42	7	75	51	-	-	-	3	50	49	22	**382**	225	166	**1,916**	330
Sitatunga	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	31	31	3	**47**	34
Vervet monkey	39	**657**	285	-	-	-	3	51	49	-	-	-	-	-	-	2	62	61	203	**2,194**	453
Wattled crane	-	-	-	2	17	16	-	-	-	-	-	-	-	-	-	-	-	-	65	**531**	167
Wildebeest	-	-	-	-	-	-	-	-	-	9	69	64	-	-	-	16	127	119	176	**1,434**	777
Zebra	-	-	-	2	25	18	-	-	-	-	-	-	-	-	-	11	96	76	136	**1,246**	327
Poacher's camp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	**33**	24
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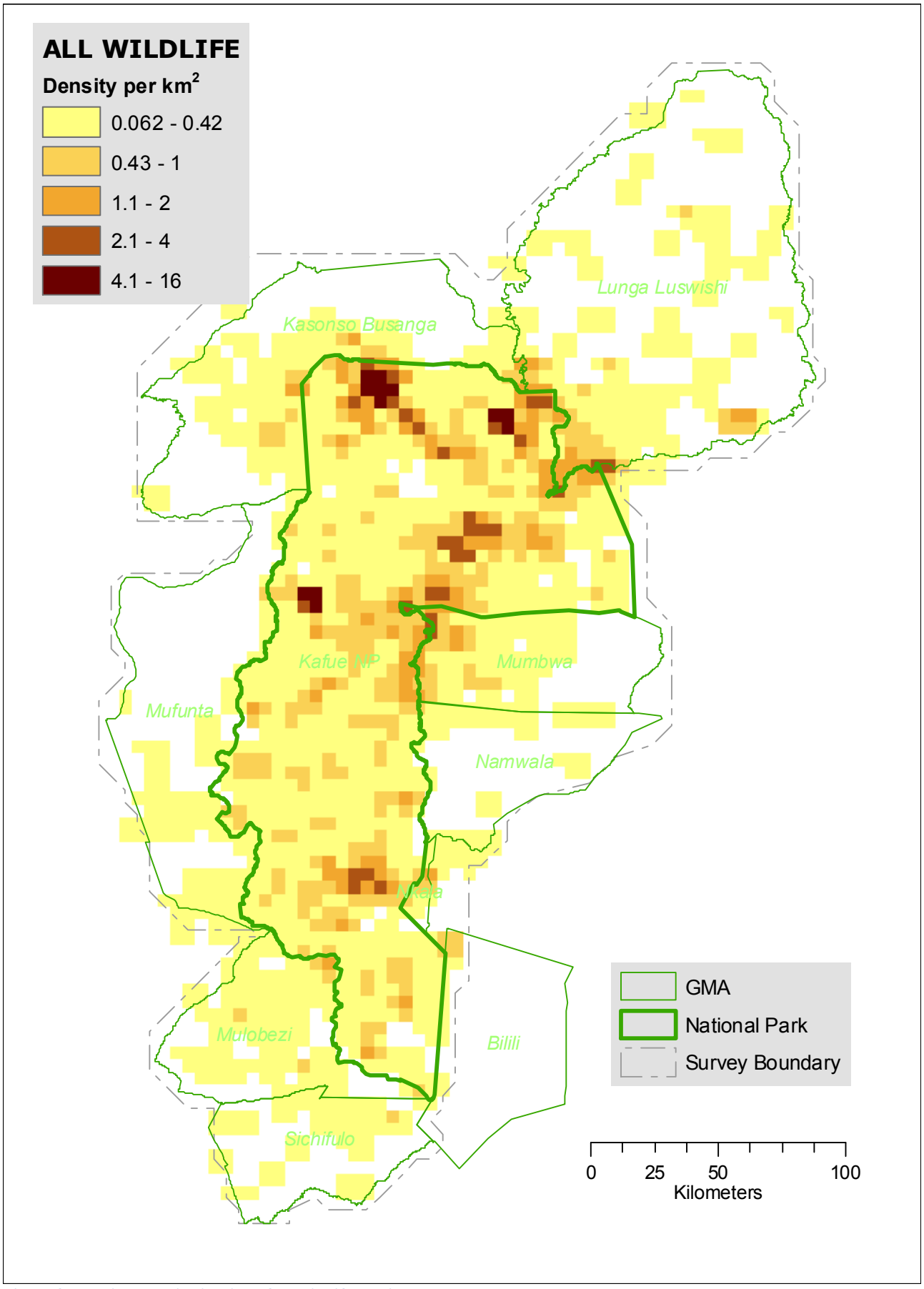

Figure 3: Density and distribution of all wildlife species.

3.1.2 Red lechwe counts

The distribution of lechwe was limited to Kafue National Park, with no lechwe seen in Kasonso-Busanga. While the second estimate of red lechwe was 1,256 animals higher, the difference is not statistically significant (d = 0.26, p > 0.05) and the results may be merged (weighted by variance) (Table 3).

Table 3: Red lechwe estimates 1 and 2

	Observed	Estimate	SE	C.V.
Busanga 1	1030	**8,465**	3,700	43.7%
Busanga 2	1476	**9,608**	2,441	25.4%
d value		0.26	p > 0.05	*No difference*
Merged estimate		**9,262**	2,037	21.0%

3.1.3 Buffalo counts

The estimate of buffalo in the park excluding all large herds that were counted separately is 1,446 +/- 697se. Five herds were counted separately and removed from the sample count, where they had been observed during transect flights. This total number was added to the sample estimate to give a final population estimate of 4,566 +/- 697se (Table 4).

This final estimate for buffalo includes statistical error (true value +/- 697) but does not take into account possible total count errors – e.g. undercounting bias due to hidden animals (which was certainly an issue as three herds were photographed in dense cover). Double-count errors are very unlikely given the distribution of the herds and their unique composition; one likely double-counted herd was removed (see Methods).

Table 4: Buffalo combined estimate.

Source	Estimate	SE
Sample Count	1,446	697
Total count		
Busanga	670	
Chunga 1	1189	
Chunga 2	580	
Mushingashi	326	
Ngoma	355	
Total	4,566	697

3.1.4 Comparison with 2008 results – all species

The P4 prohibited area was unable to be flown in 2008 – as a result a large part of Kafue and the entirety of Lunga-Luswishi was not flown and estimates for the Park are incomplete. Extrapolation was attempted for elephant, assuming similar distribution in the un-surveyed area, but was expected to be only a guess. The data from 2011 have been re-analysed with a subset of the data using the same coverage as the 2008 survey, to allow comparison. Data for the national park, excluding the P4 area, are shown below.

Note that the only mammal species showing significant change ($p<0.05$) are Ground hornbill and Wattled crane, which may reflect better briefing and training of observers in 2011 rather than an increase.

Table 5: Subset (non-P4 prohibited area) of 2011 data for comparison to 2008.

	2008			2011 Subset			
Species	Obs	**Est**	SE	Obs	**Est**	SE	d-value
Buffalo	1,276	**6,314**	2,549	155	**4,240**	693	-0.81
Elephant	528	**2,521**	359	231	**1,904**	467	-1.05
Puku	1,146	**5,700**	851	904	**7,452**	1,488	1.02
Red lechwe	1,018	**5,494**	1,153		**9,262**	2,037	1.61
Hartebeest	788	**4,048**	466	374	**3,129**	547	*-1.28*
Impala	1,471	**7,208**	1,161	905	**7,454**	1,385	0.14
Kudu	138	**695**	123	78	**643**	129	-0.29
Roan	199	**1,193**	287	182	**1,500**	538	0.50
Sable	1,378	**7,753**	932	727	**5,987**	831	*-1.41*
Waterbuck	573	**2,715**	347	386	**3,181**	581	0.69
Warthog	1,185	**6,328**	483	835	**6,881**	592	0.72
Bushbuck	9	43	26	15	124	108	0.73
Baboon	83	**469**	150	49	**404**	167	-0.29
Bushpig	12	75	43	19	157	83	0.87
Common duiker	33	**184**	36	24	**197**	41	0.23
Eland	1	5	4	112	**923**	573	1.60
Ground Hornbill	69	**335**	64	128	**1,055**	167	**4.03**
Hippo	312	**1,481**	490	102	**841**	272	-1.14
Oribi	21	**113**	26	12	99	36	-0.32
Reedbuck	42	**202**	49	89	**733**	133	**3.75**
Sitatunga			-	2	16	15	1.07
Vervet monkey	67	**402**	137	124	**1,018**	318	1.78
Wattled crane	18	97	70	55	**453**	163	**2.00**
Wildebeest	524	**2,690**	858	150	**1,233**	766	*-1.27*
Zebra	272	**1,396**	250	110	**907**	274	*-1.32*
Poacher's camp			-	4	33	24	1.35

The d-test for differences is significant at 1.96 or greater (or less than -1.96) (d.f. > 30), and significant results are shown in bold (ground hornbill and Wattled crane).

3.1.5 Comparison with 2002 & 2006

Table 6 illustrates longer term trends from 2002 and 2006, for the entire park (2008 and 2004 data are not comparable). This table is limited to species which are normally reliably assessed in aerial survey – i.e. excluding primates, predators and small or secretive species.

Of note:

- Nine of these species are increasing from 2006, and none show significant decreases.
- Several show increases or are close to significantly increasing (d>1.6 but less than critical 1.96, e.g.) from 2002.

Table 6: Kafue National Park trends 2002/2006 to 2011

Year	2002			2006			2011		d-test	
Species	**Est**	**95%CL**	**Obs**	**Est**	**95%CL**	**Obs**	**Est**	**95%CL**	**2002**	**2006**
Buffalo			**374**	**3,719**	37	175	3,896	1,365		1.74
Duiker	**282**	124	**10**	**115**	50	26	222	88	(0.77)	**2.87**
Eland	**-**	-			-	113	938	1,121	1.64	1.64
Elephant	**2,197**	1,295	**251**	**2,506**	1,212	269	2,280	966	0.10	1.48
Ground Hornbill	**1,086**	475			-	171	1,474	407	1.22	
Hartebeest	**3,552**	4,340	**192**	**2,097**	898	458	3,937	1,294	0.17	**2.98**
Impala	**14,791**	5,618	**492**	**5,318**	1,483	1,547	12,884	3,241	(0.58)	**3.90**
Kudu	**555**	294	**18**			111	913	323	1.60	**4.65**
Oribi	**49**	87	**26**	**259**	116	17	140	79	1.51	0.82
Puku	**7,113**	2,834	**255**	**3,095**	890	1,403	11,751	3,656	**1.97**	**4.70**
Reedbuck	**519**	307	**22**	**286**	177	111	964	311	**2.00**	**4.37**
Red Lechwe	**1,623**	3,229	**414**	**5,817**	3,365	1,030	8,465	7,252	1.69	1.70
Roan	**2,392**	2,017	**107**	**1,088**	1,560	233	1,916	1,136	(0.40)	**2.25**
Sable	**9,245**	7,274	**345**	**3,389**	1,250	821	7,208	1,994	(0.53)	**3.42**
Waterbuck	**1,749**	1,307	**221**	**3,798**	2,114	481	4,135	1,307	**2.53**	1.91
Warthog	**6,539**	2,079	**615**	**6,395**	1,153	1,055	9,111	1,373	**2.02**	**2.55**
Wildebeest	**1,426**	1,984	**82**	**808**	1,076	150	1,230	1,499	(0.15)	1.32
Zebra	**1,094**	1,344	**140**	**2,583**	1,204	118	970	546	(0.17)	0.62

The d-test for differences is significant at 1.96 or greater (or less than -1.96) (d.f. > 30), and significant results are shown in bold.
Buffalo estimates for 2002 were not considered reliable and have been removed (estimate > 30,000 and impossible confidence limit).

3.2 Key species accounts & maps

3.2.1 Elephant

The elephant population in the Kafue ecosystem is probably stable (Table 7). The Park shows a declining trend but this is non-significant (d= -1.13, p >0.05). The estimated numbers of elephant in the entire ecosystem are slightly higher but also non-significant (d= 0.56, p > 0.05). These discrepancies probably reflect the highly mobile nature of elephant populations, moving in and out of the park area.

In 2008 an extrapolated value was used for the missing P4 section of the Park, using the missing area to add 32% to the initial estimate. This year, the proportion of elephant that was found in the whole park including P4 area was shown to be 20% higher than the area excluding P4, and this 20% extrapolation has been used for the charts and tables following.

Table 7: Elephant trend data with corrected extrapolation for 2008.

Year	2002		2004		2006			2008			2011			d-test to 2011:			
Elephant	**Est**	**95%CL**	**Est**	**95%CL**	**Obs**	**Est**	**95%CL**	**Obs**	**Est**	**95%CL**	**Obs**	**Est**	**95%CL**	**2002**	**2004**	**2006**	**2008**
Kafue NP total	**2,197**	1,295	**1,555**	876	**251**	**2,506**	1,212	*528*	***2,521***	*703*	269	**2,280**	986	0.10	1.08	(0.28)	(1.13)
Kafue NP extrap.									**3,025**	843							
Ecosystem			**1,961**	649		**4,273**	877		**3,455**	463		3,715	781	9.32	3.39	(0.93)	0.56

d-test (student's t-test) are shown comparing previous surveys to the 2008 results. Values shaded and in bold are significantly different at an alpha value of 0.05 (critical d-value 1.96, >30 d.f.). Negative values (decreases) are in parentheses.

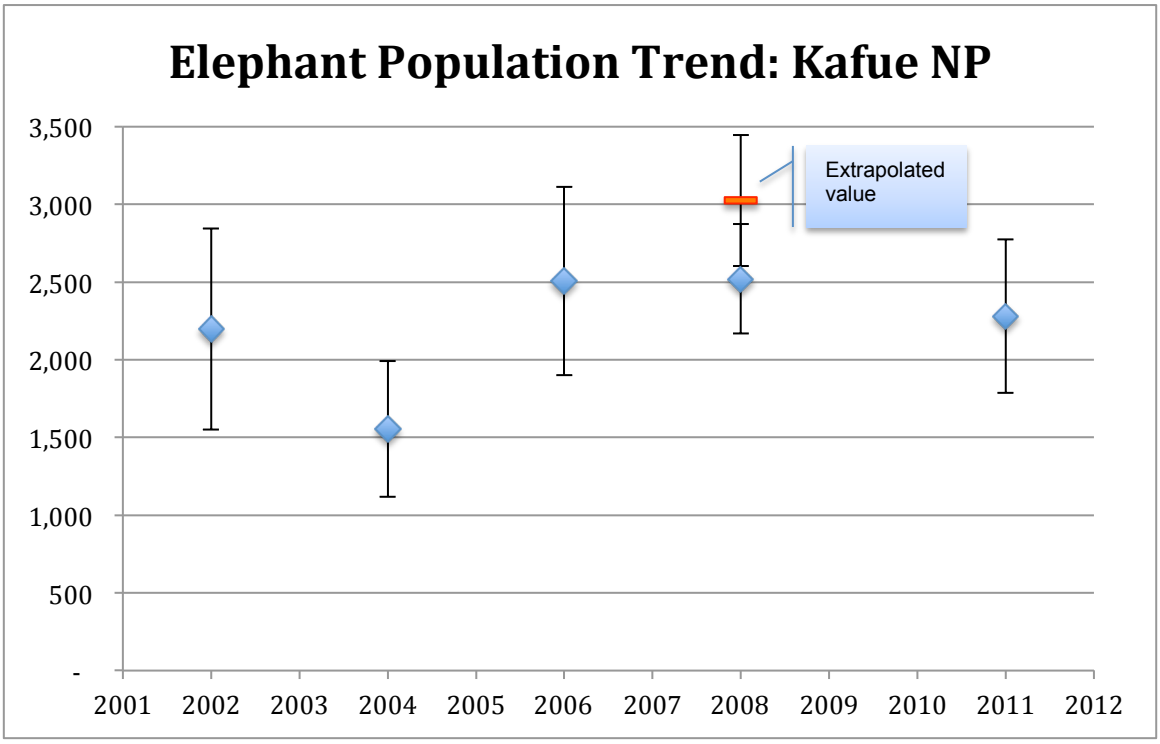

Figure 4: Elephant population trend Kafue NP 2002-2011, with arrow indicating extrapolated value.

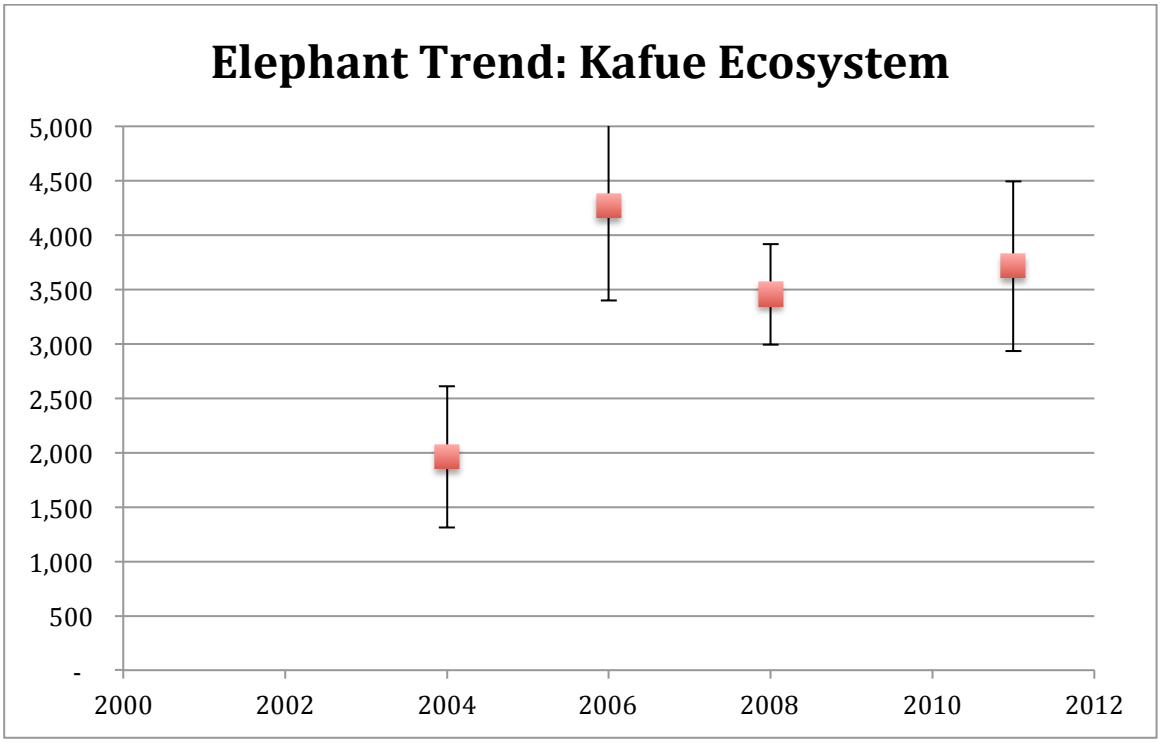

Figure 5: Elephant population trend Kafue ecosystem 2004-2011.

3.2.2 Elephant Carcass Data

Fifteen elephant carcasses were seen during the sample count (Table 8 & Figure 6). The map and table following indicate all the carcasses seen, while Table 2 shows the estimated values for carcasses seen in sample strips.

More carcasses were seen than in 2008, and five were "recent" (<1 year) according to MIKE standards, indicating a higher level of mortality than previously.

Of concern is the presence of five carcasses in SW Mulobezi, and the contraction in elephant range from that area. Elephant in Mulobezi were found in the SW portion of the GMA in 2008, but found only directly on the border with the Park in 2011 (though more total were found than previously).

Elephant carcasses are difficult to spot from the air, and usually represent an undercount. The carcass ratio is 3.1%, more than double the value of 2008 (1.3%).

Table 8: Elephant carcasses sighted, whole ecosystem.

MIKE Class	Number
Category 1	0
Category 2	5
Category 3	4
Category 4	6

Table 9: Elephant population data from GMAs.

	1997		2004		2006		2008		2011	
Admin	Est	SE	Est	SE	Est	SE	Est	SE	Est	SE
Kasonso			**401**	27			**5**	5	**23**	22
Mufunta							**17**	16	**0**	0
Mulobezi			**55**	7	**385**	562	**252**	178	**824**	524
Mumbwa	**124**	117	**181**	23	**1,228**	500	**66**	57	**422**	292
Namwala			**127**	7					**0**	0
Nkala			**210**	20	**114**	98	**90**	37	**84**	58
Sichifulo	**374**	350			**40**	34			**0**	0

Table 10: Estimated elephant carcass data from GMAs.

	1997		2004		2006		2011	
Admin	**Est**	**SE**	**Est**	**SE**	**Est**	**SE**	**Est**	**SE**
Bilili	**12**	12						
Kasonso	**12**	12						
Mulobezi	**60**	39	**69**	19	**11**	22	51	48
Nkala			**31**	2				
Sichifulo	**24**	13	**164**	22				
Mumbwa							25	24

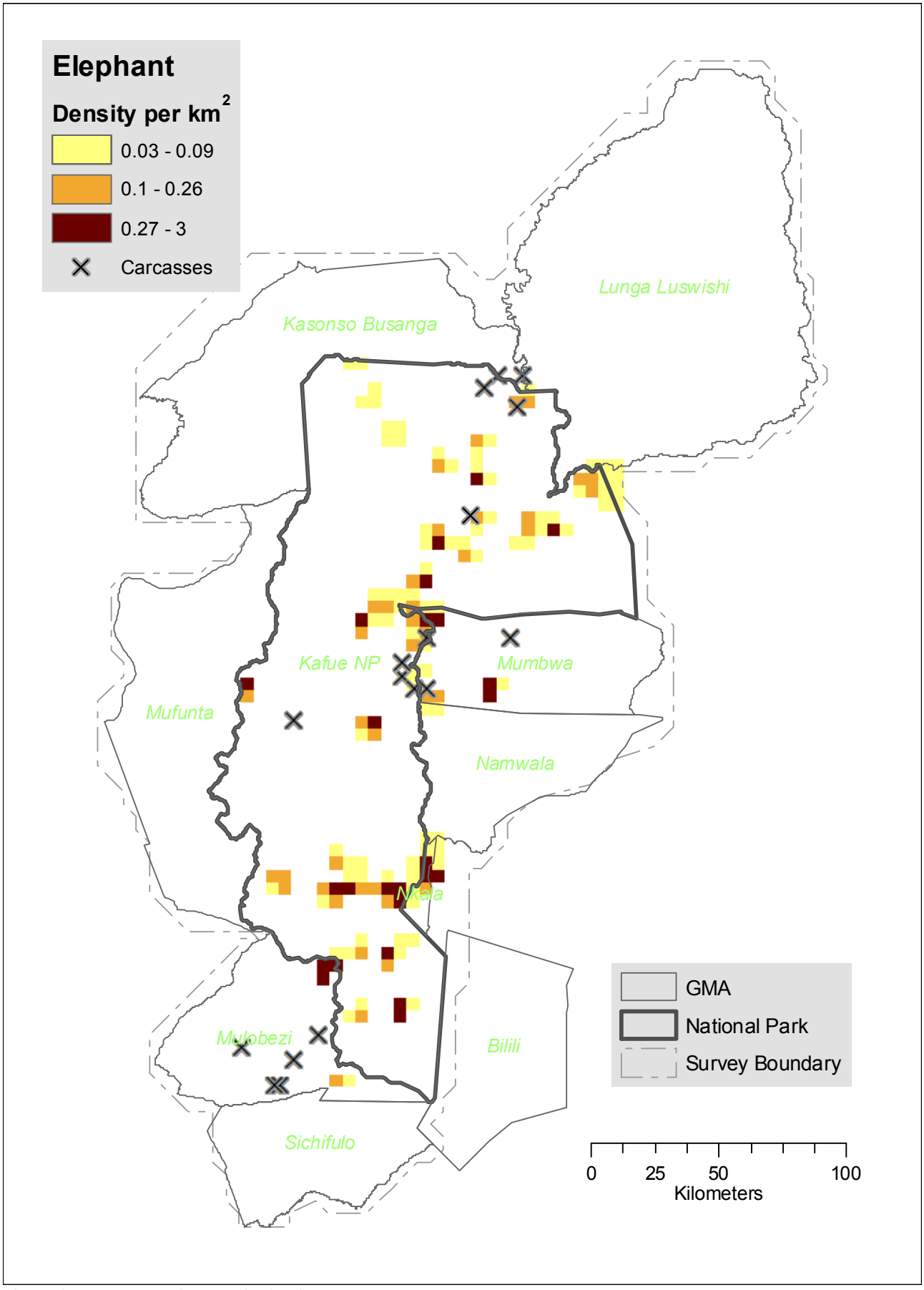

Figure 6: Elephant density and distribution.

Elephant distribution within the NP is very similar to that found previously. Mulobezi shows a contraction in range, and five carcasses were spotted (and no elephant) in an area that had elephant in 2008.

3.2.3 Buffalo

The buffalo population was estimated at 4,566 +/- 697se. Almost all buffalo were seen inside the Park, though one group of 13 was seen in Lunga-Luswishi outside of the transect (Figure 7).

Trends in the ecosystem are difficult to comment on due to the absence of previous total counts and the lack of spatial data.

Future surveys in Kafue that use narrow transect spacing (3km or less, as here) should continue to use this method of returning and counting herds, coupled with a focussed count of known concentrations.

	1997		2004		2006		2008		2011	
Admin	**Est**	**SE**	**Est**	**SE**	**Est**	**SE**	**Est**	**SE**	**Est**	**SE**
Bilili							99	84	0	0
Lunga-Luswishi			15	8					0	0
Nkala			807	868			2,102	1,880	0	0
Sichifulo					1,268	1,022			0	0
Kafue NP	2,484	1,095	14,434	6,228	3,719	72	6,314	2,549	4,566	697

Table 11: Buffalo population in Kafue ecosystem, 1997-2011.

Note that 2011 used a combination of total and sample counts and probably represents an undercount of buffalo; previous surveys used sample counts only and are likely to be highly inaccurate.

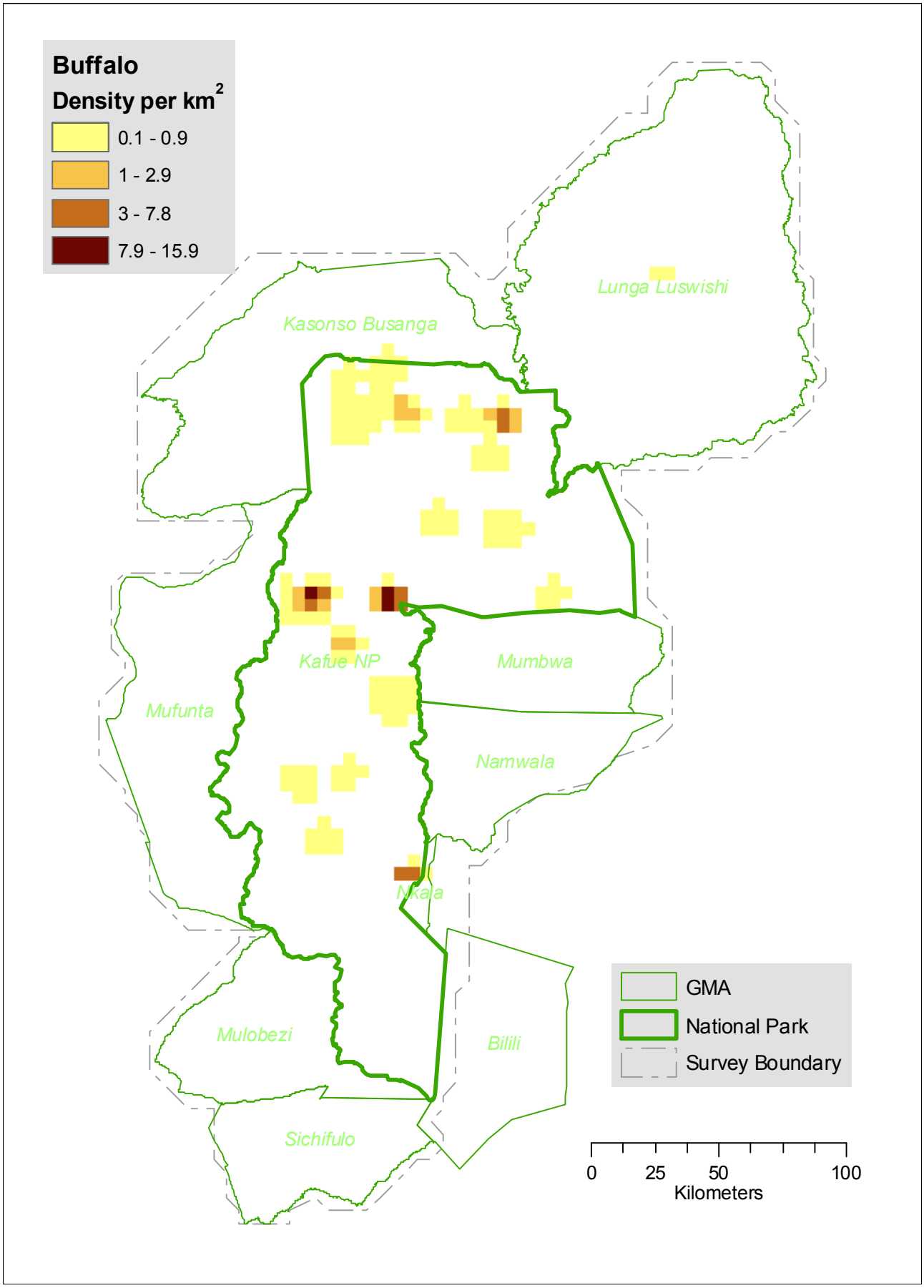

Figure 7: Buffalo density and distribution (all sightings).

Figure 7 is based on total count (direct counts of groups) plus estimates (density calculated from strip width).

3.2.4 Puku

The puku population is probably stable from 2008 (Table 5). While direct comparisons cannot be made to the 2008 data (missing P4), the puku population seems to be returning to levels last seen in the 1990s.

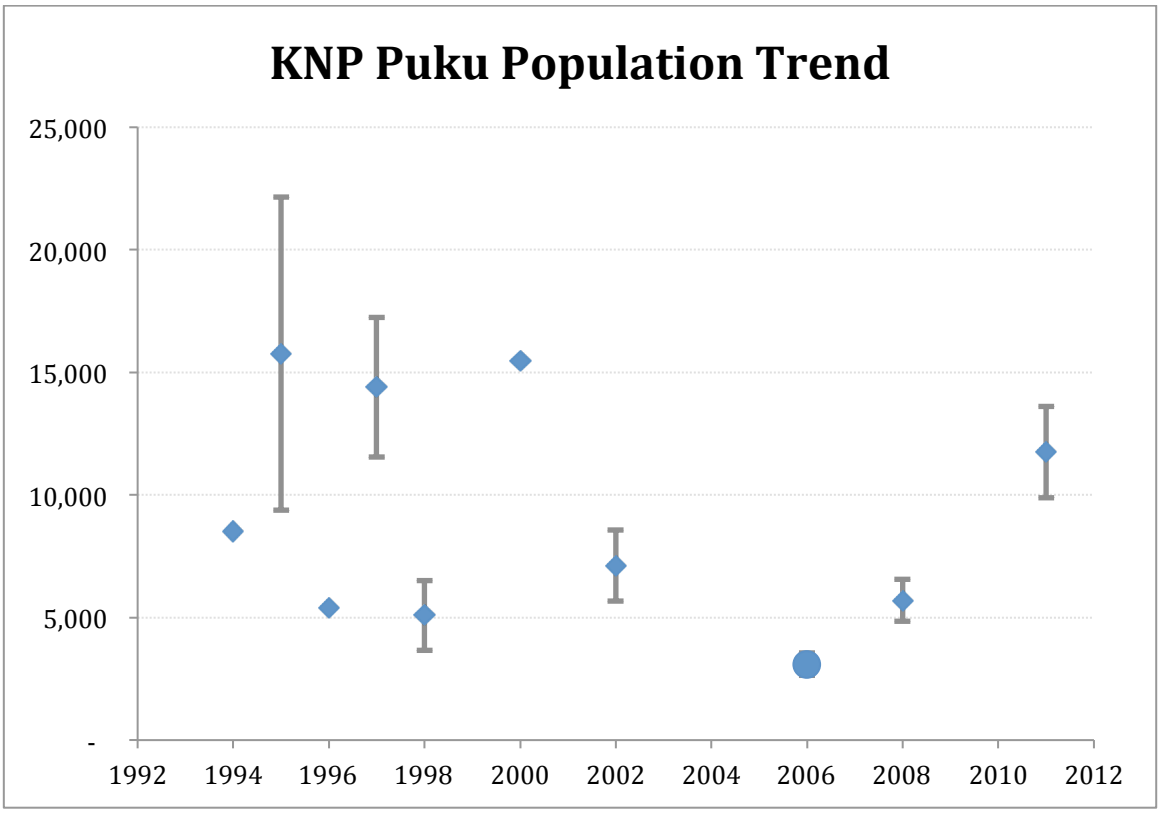

Figure 8: Puku population trend 1994-2011

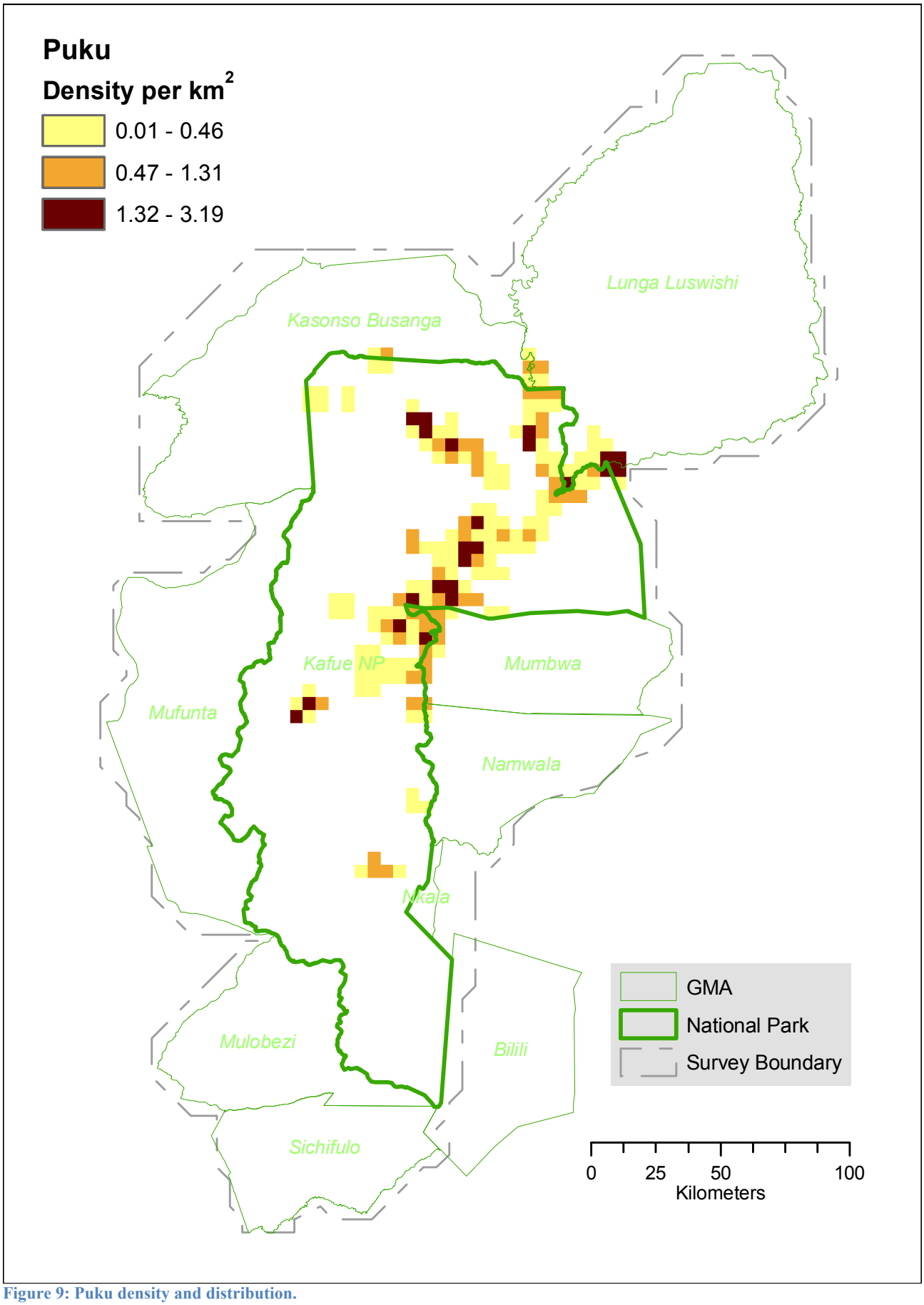

Figure 9: Puku density and distribution.

3.2.5 Red Lechwe

Red lechwe show a weakly significant increase (d=1.69, p <0.10) from 2008. Standard errors were higher (coefficient of variation 22.0% vs. 16.7% in 2008) reducing the power to detect change; however, it is likely that the population is increasing at around 19% per annum.

The second count, at 1.5 km spacing instead of 2.5km, and perpendicular to the distribution of lechwe, gave 33 transects (samples) vs. the first count with only 14 – the coefficient of variation for the second sample counts was thus almost half the first count.

It should be possible to do regular monitoring of the lechwe population on a yearly basis as a sample count can be done in a single morning's session, targeting only the immediate distribution of the lechwe as in the second count here. A team could calibrate an aircraft on one day, then fly one or more sample counts on the following days, for a minimal cost (3 flight hours training / calibration, 4 flight hours per count). Given the highly variable nature of the lechwe population yearly double sample counts are strongly advised.

Table 12: Red lechwe population trend 1997-2011

	Kafue NP		Kasonso-Busanga	
Year	Est	SE	Est	SE
1997	**6,325**	3,442	**151**	121
2004	**8,880**	5,633		
2006	**5,817**	6,595	**41**	27
2007	**2,098**	279	-	
2008	**5,494**	916	-	
2011	**9,262**	2,037	-	

Note that 2008 and 2011 data are merged estimates from double sample counts.

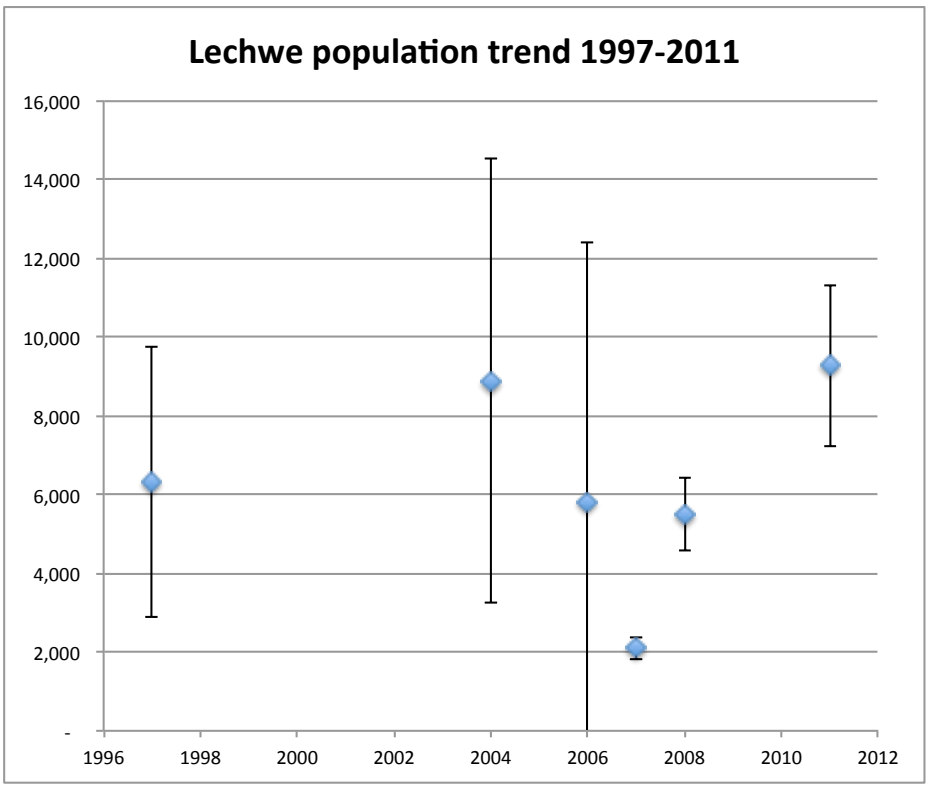

Figure 10: Puku population trend 1997-2011.

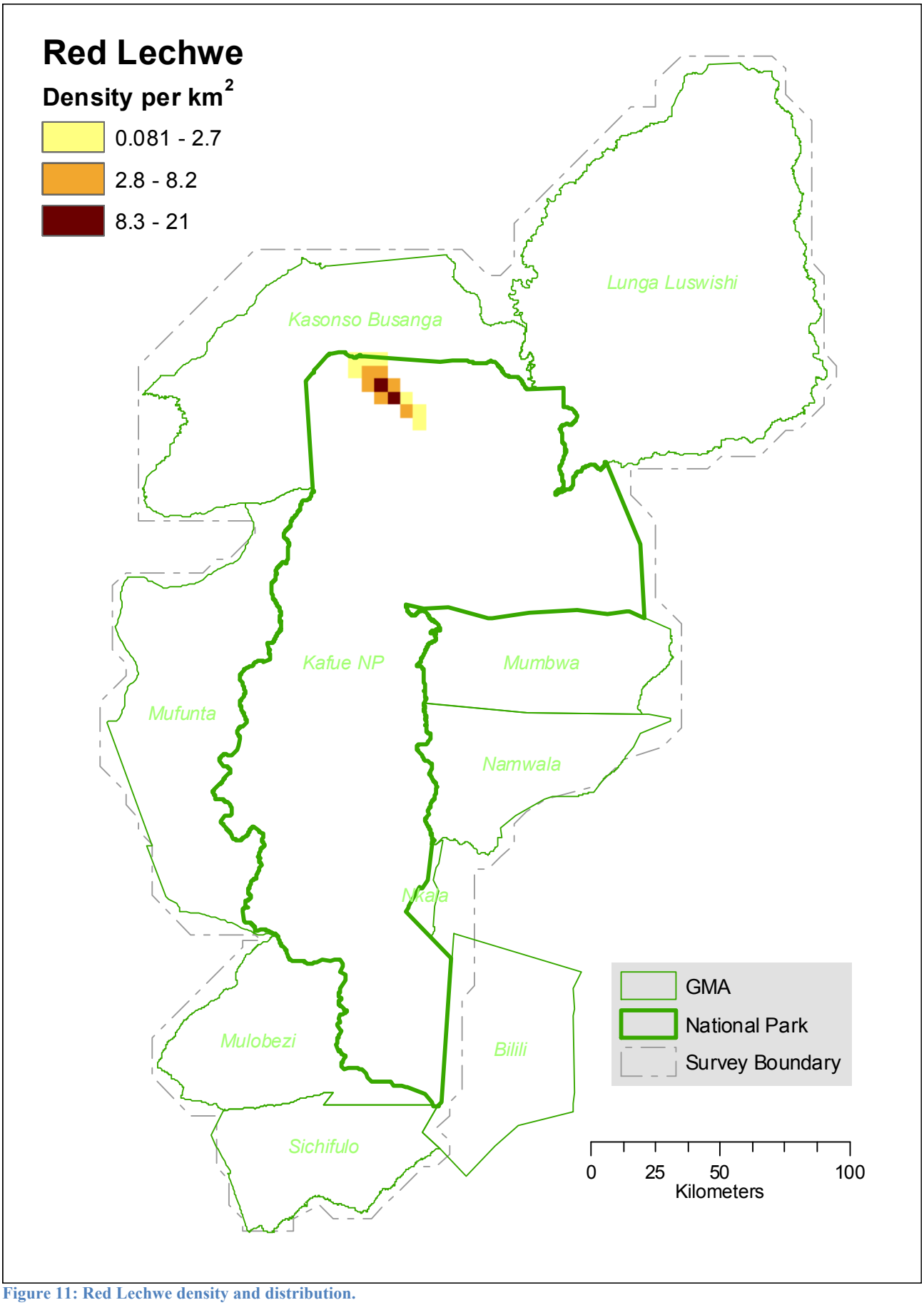

Figure 11: Red Lechwe density and distribution.

3.3 Distribution Maps: Other species

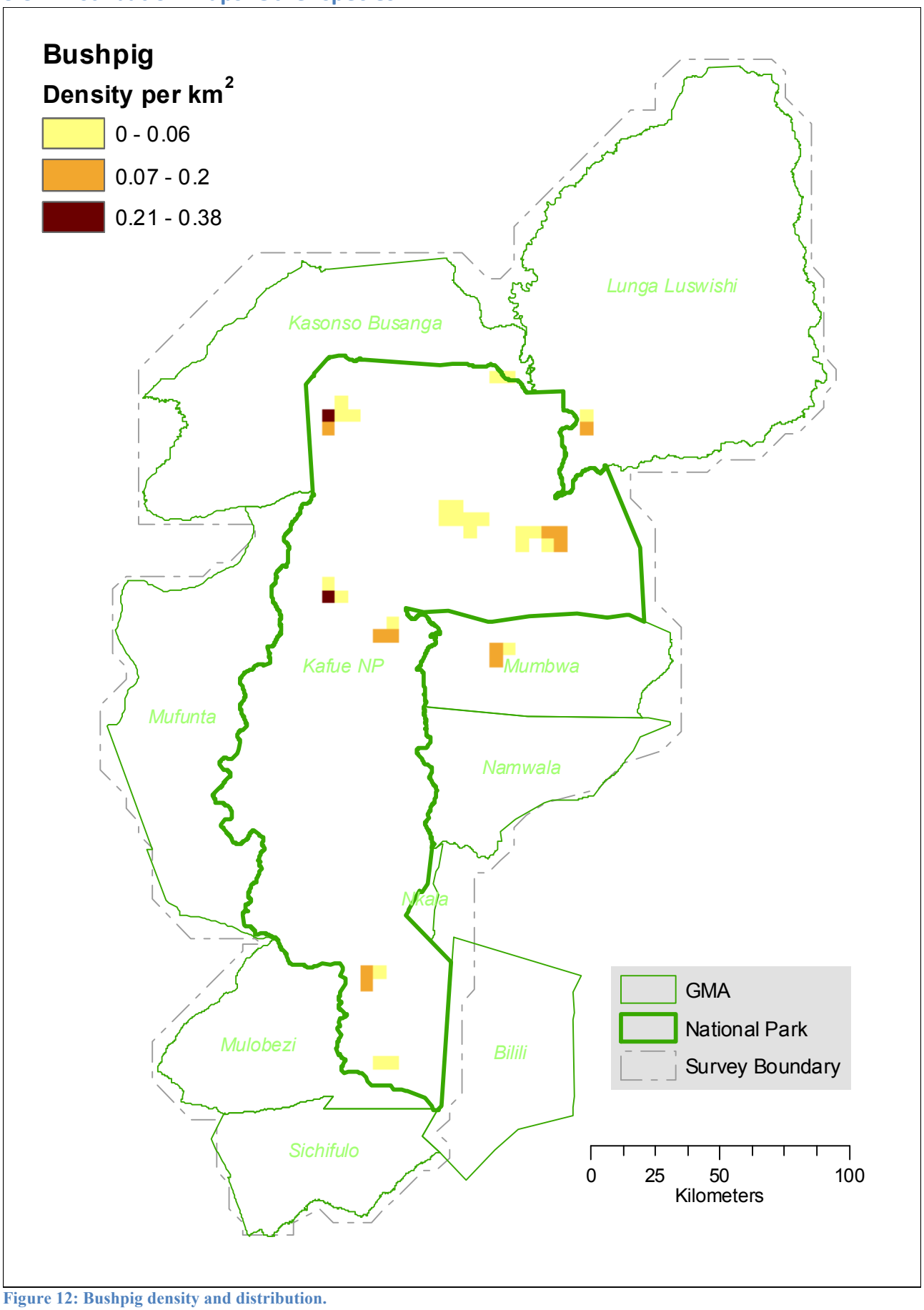

Figure 12: Bushpig density and distribution.

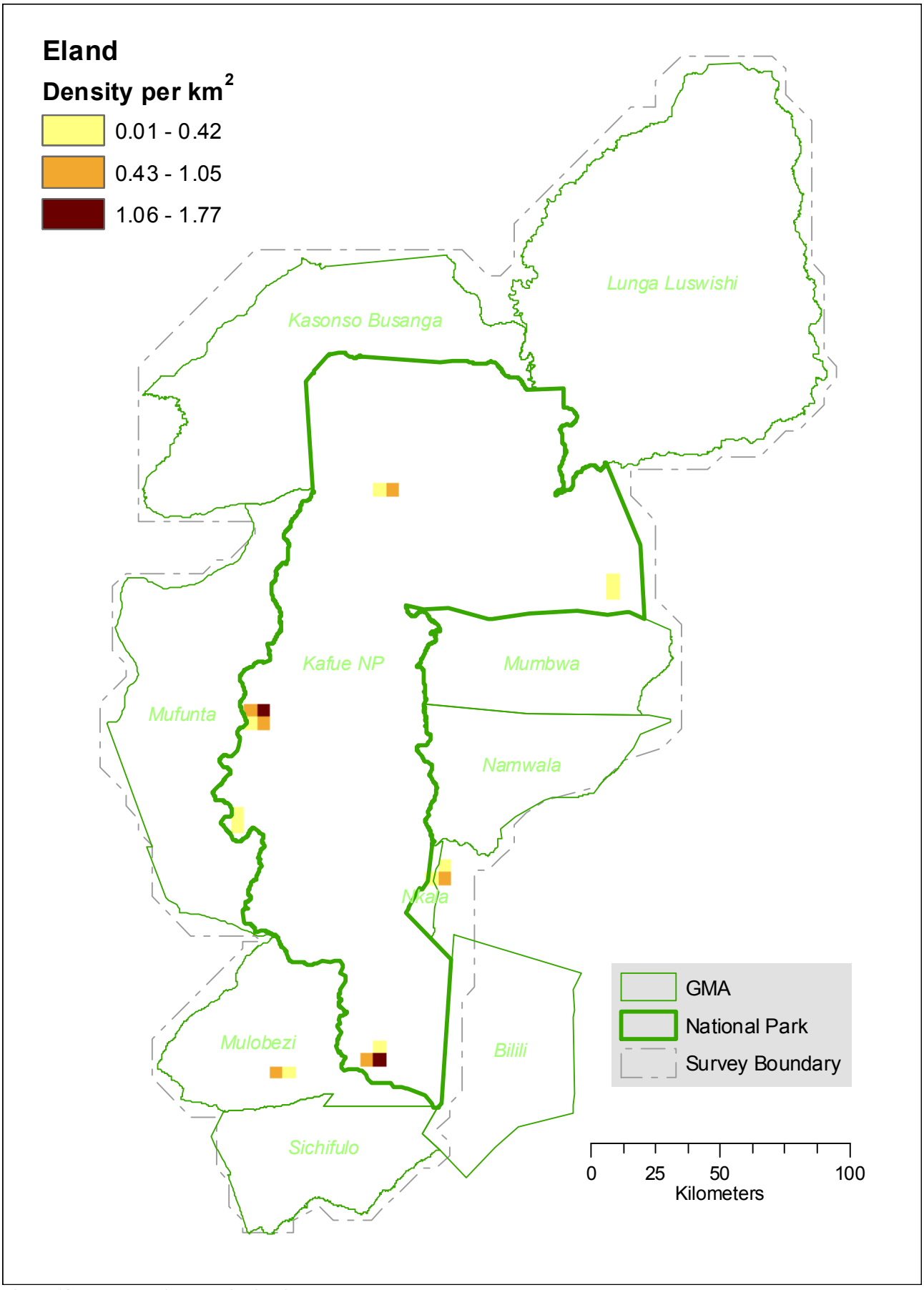

Figure 13: Eland density and distribution.

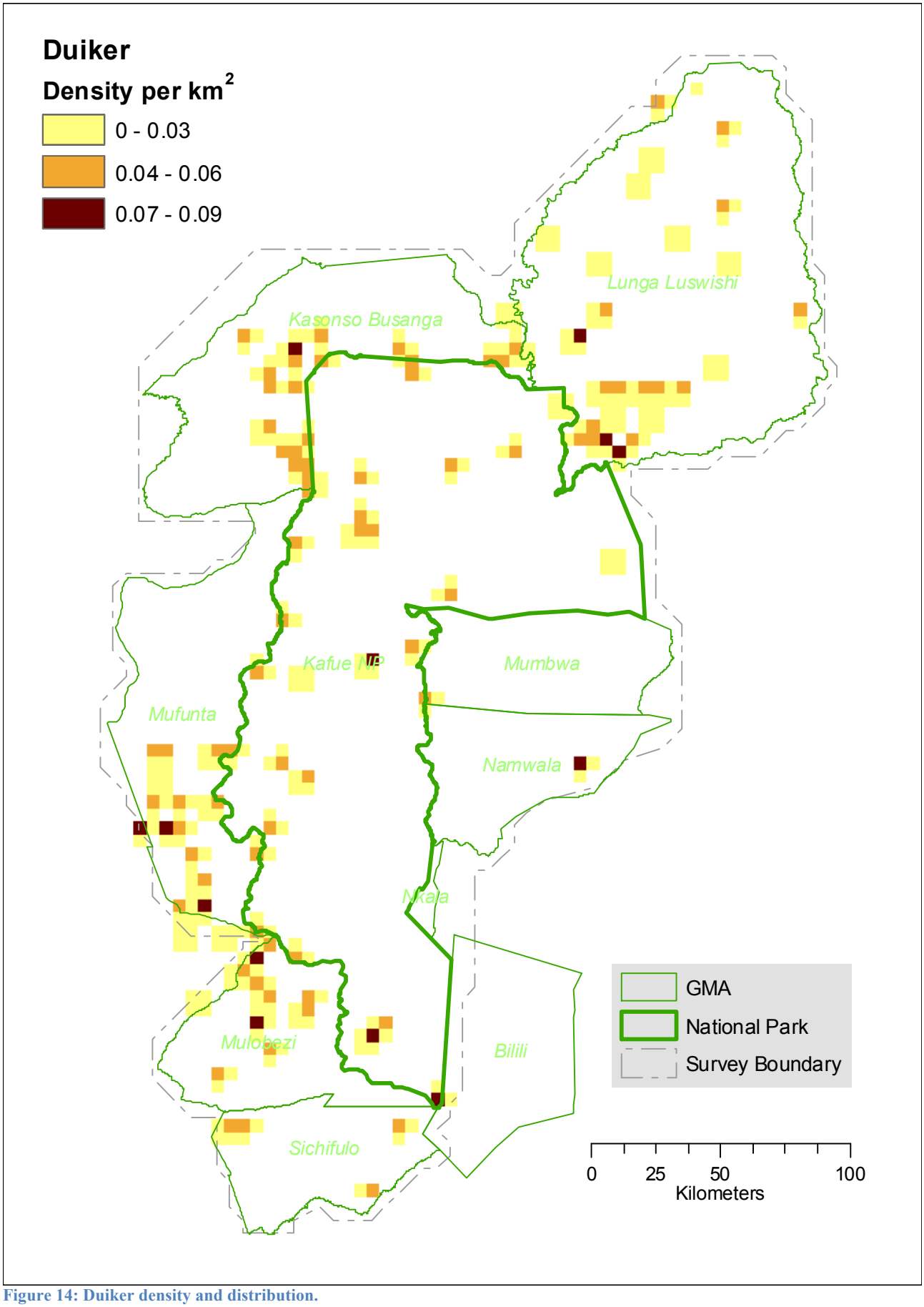

Figure 14: Duiker density and distribution.

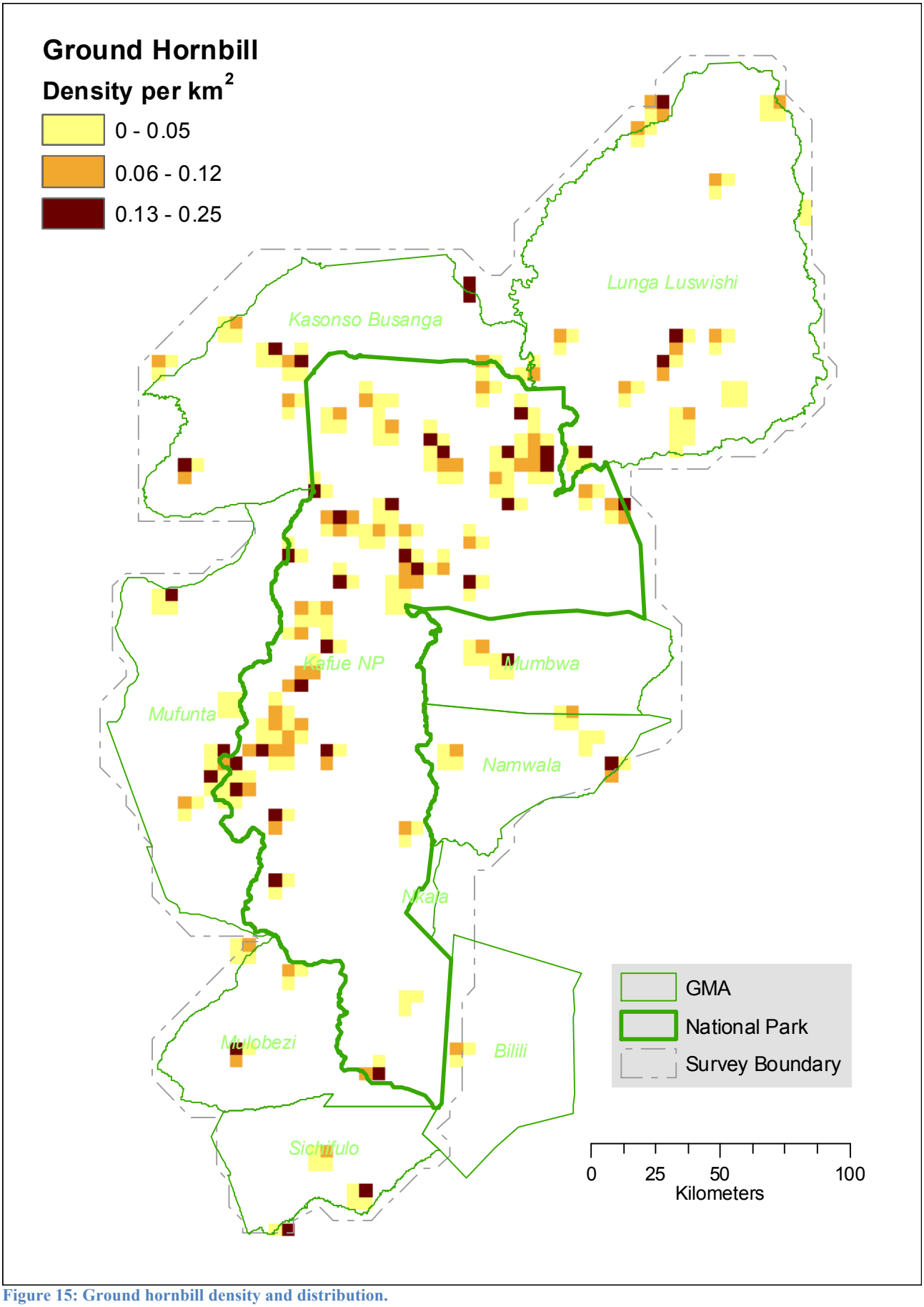

Figure 15: Ground hornbill density and distribution.

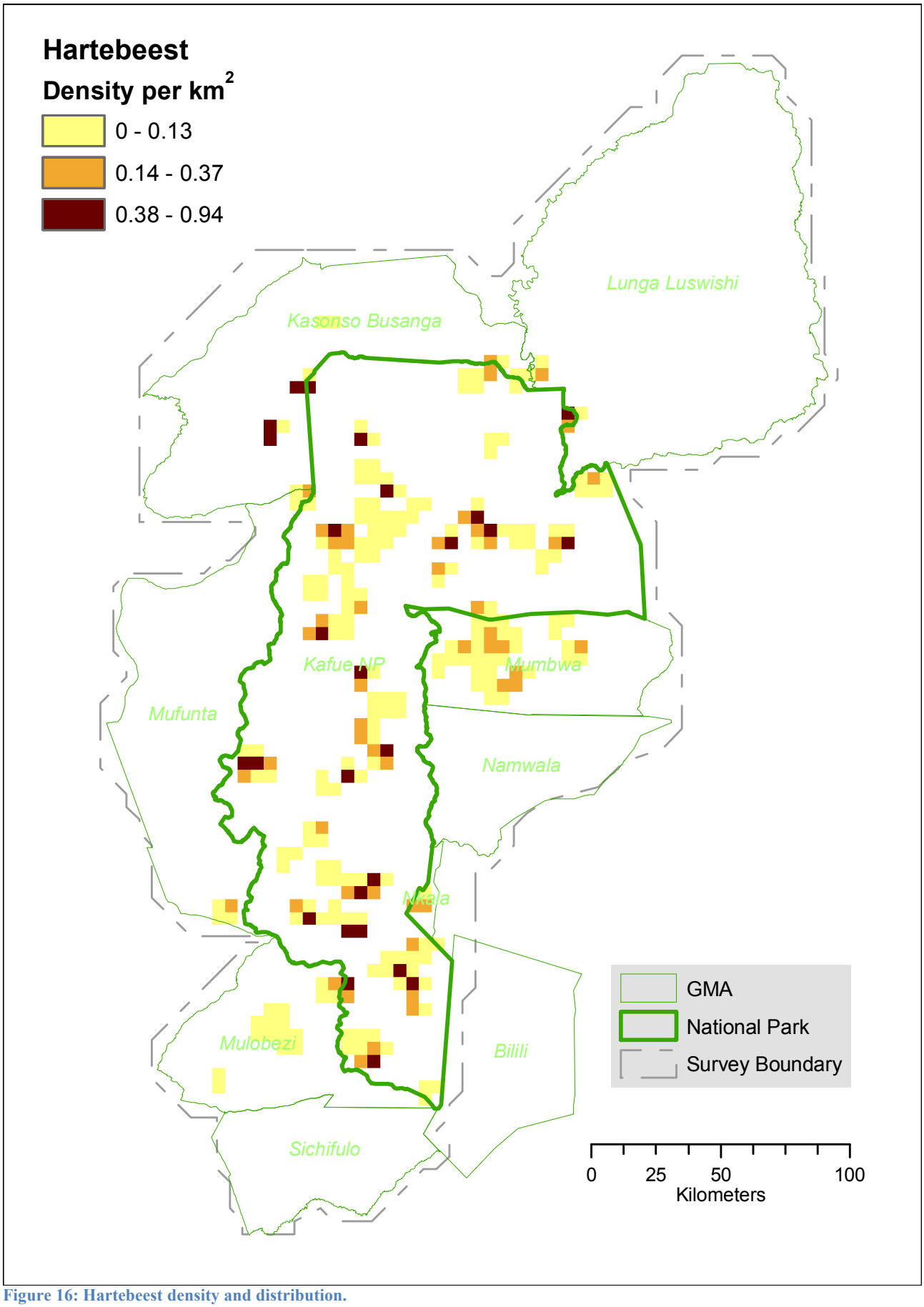

Figure 16: Hartebeest density and distribution.

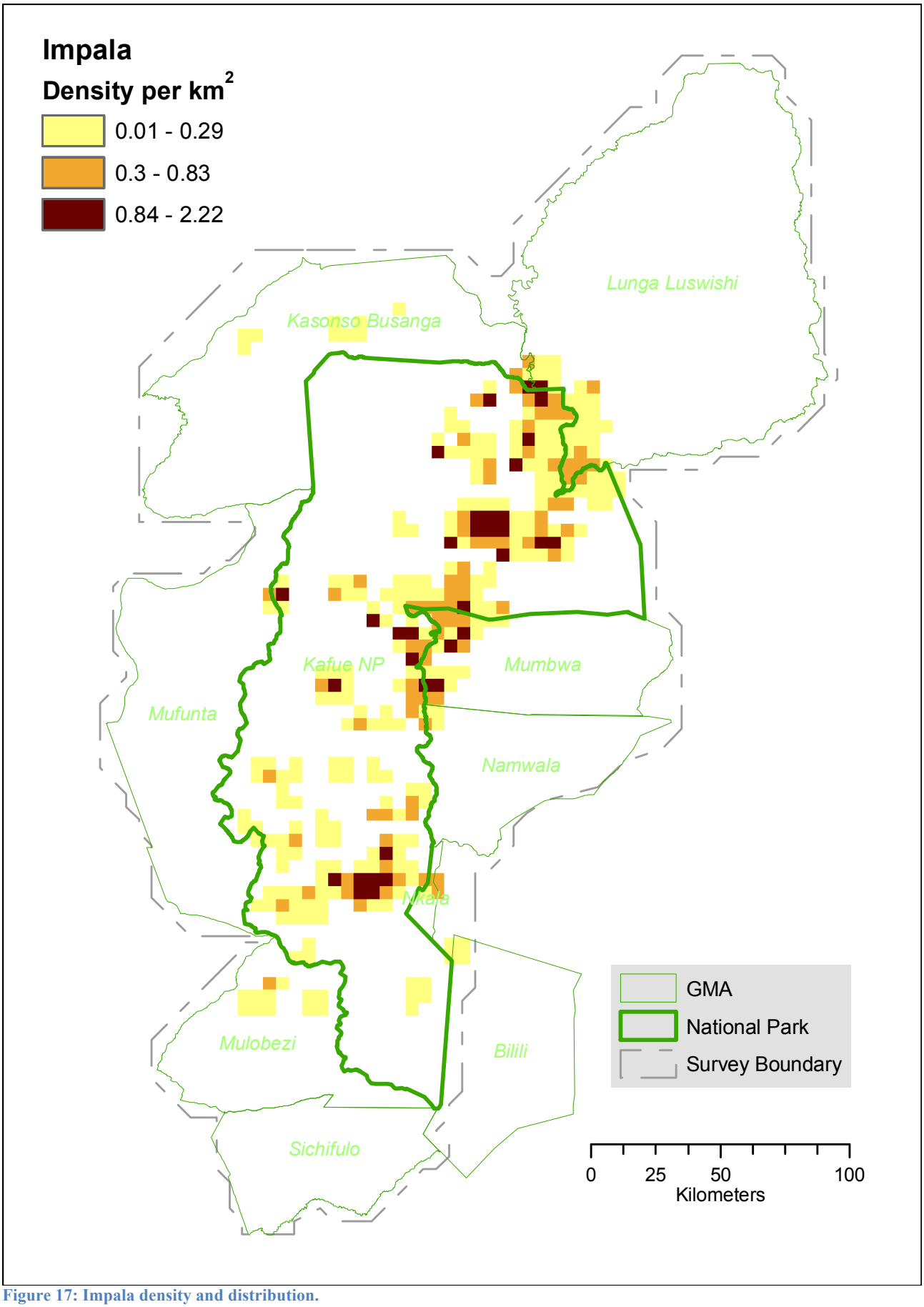

Figure 17: Impala density and distribution.

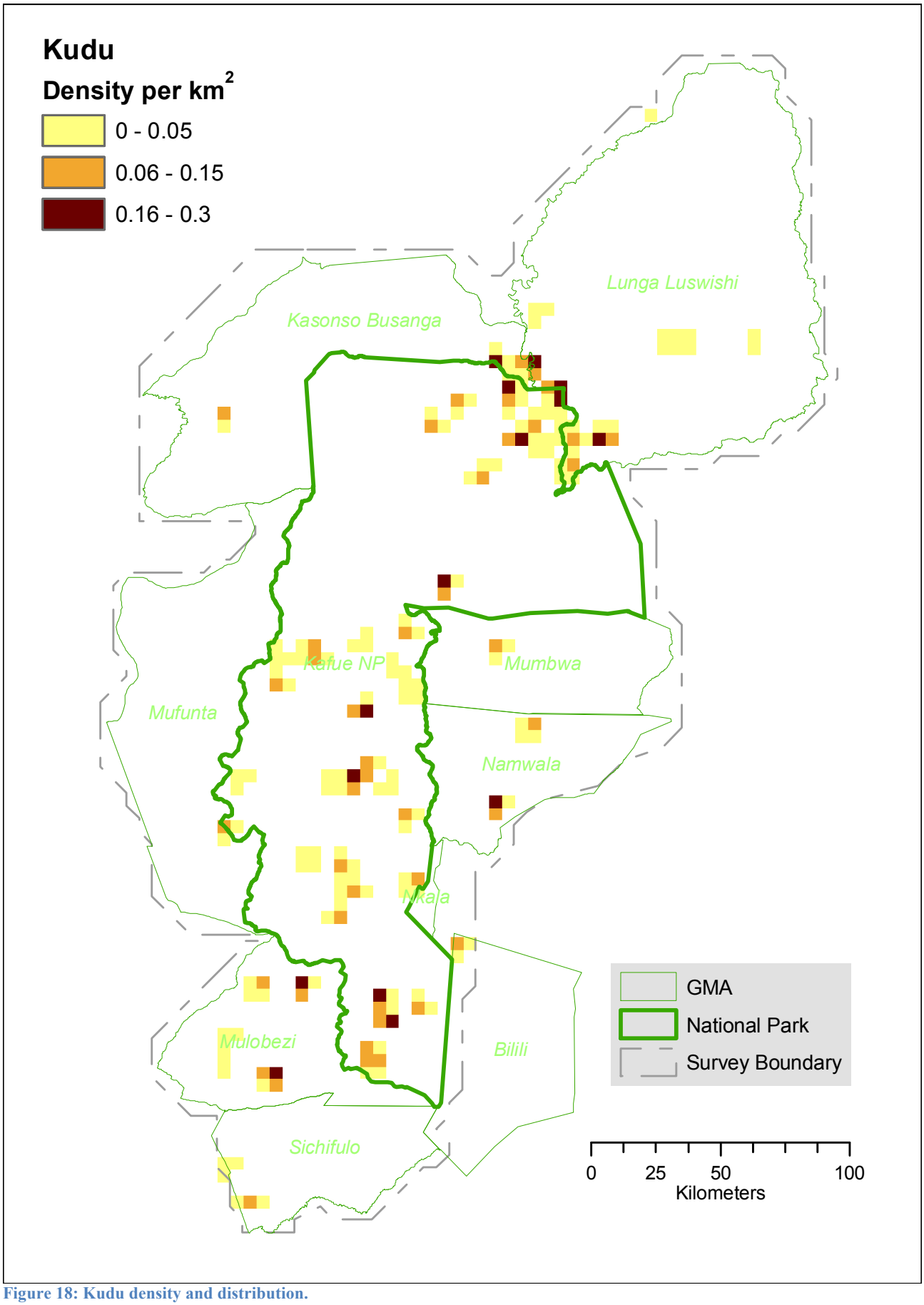

Figure 18: Kudu density and distribution.

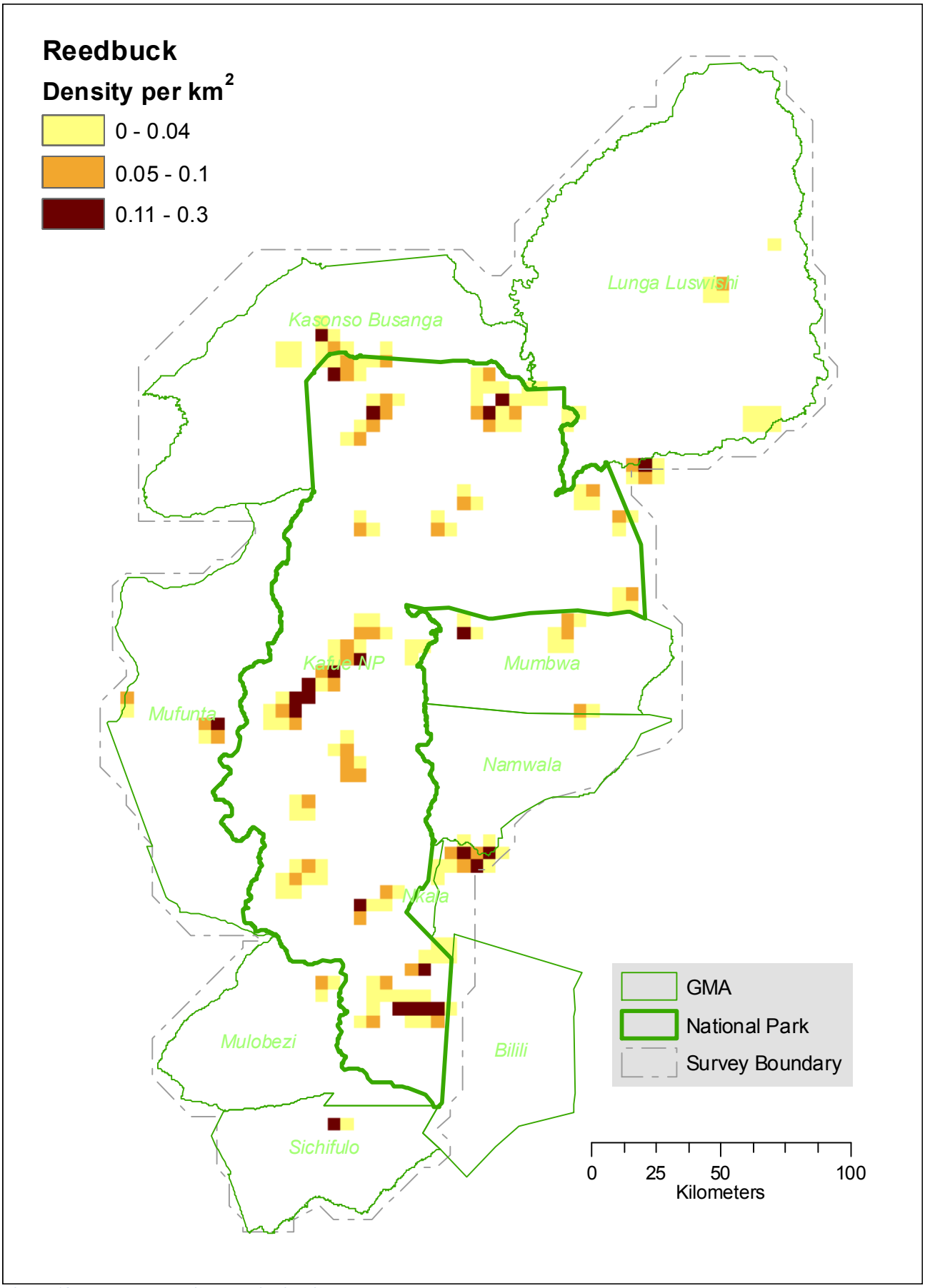

Figure 19: Reedbuck density and distribution.

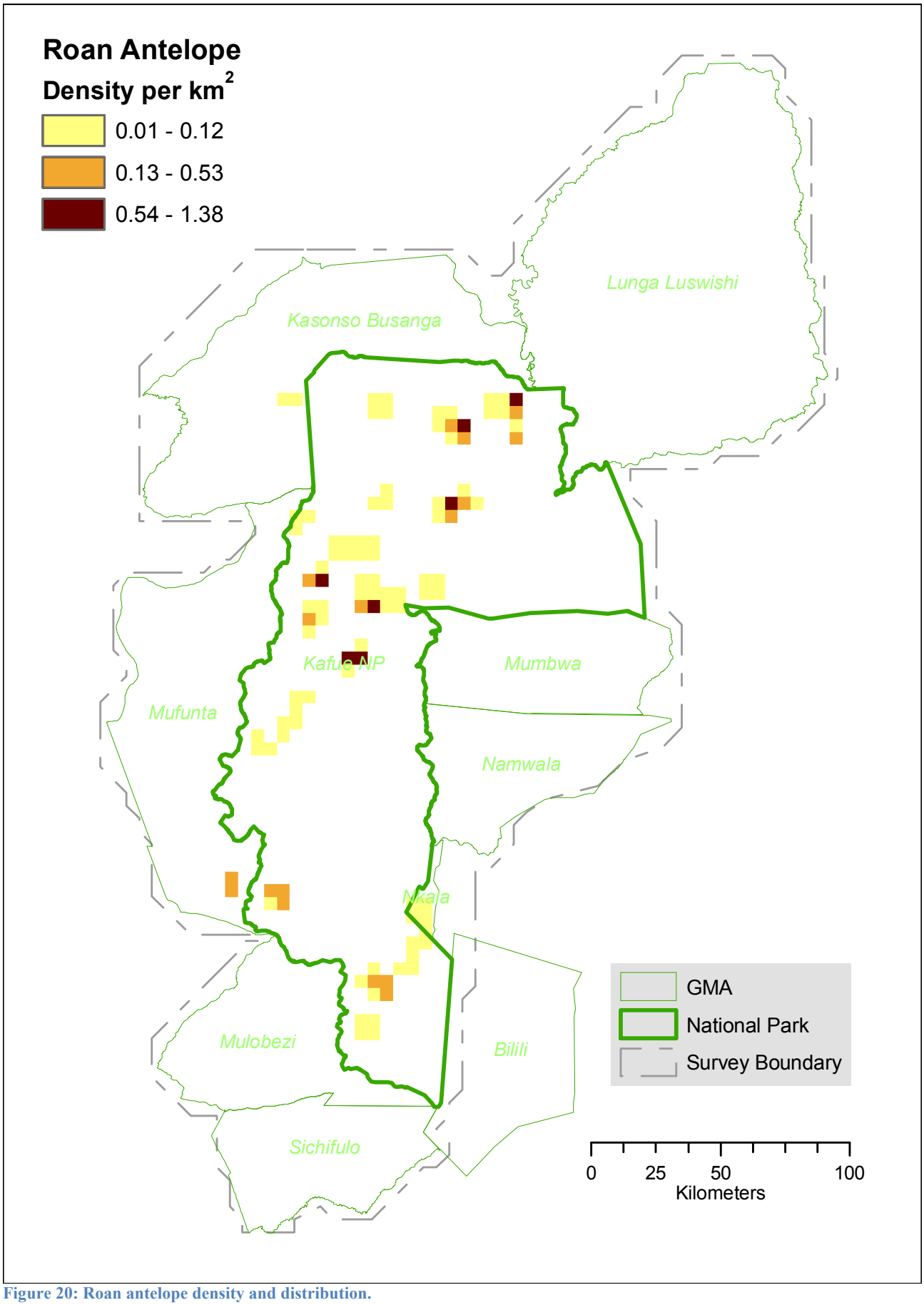

Figure 20: Roan antelope density and distribution.

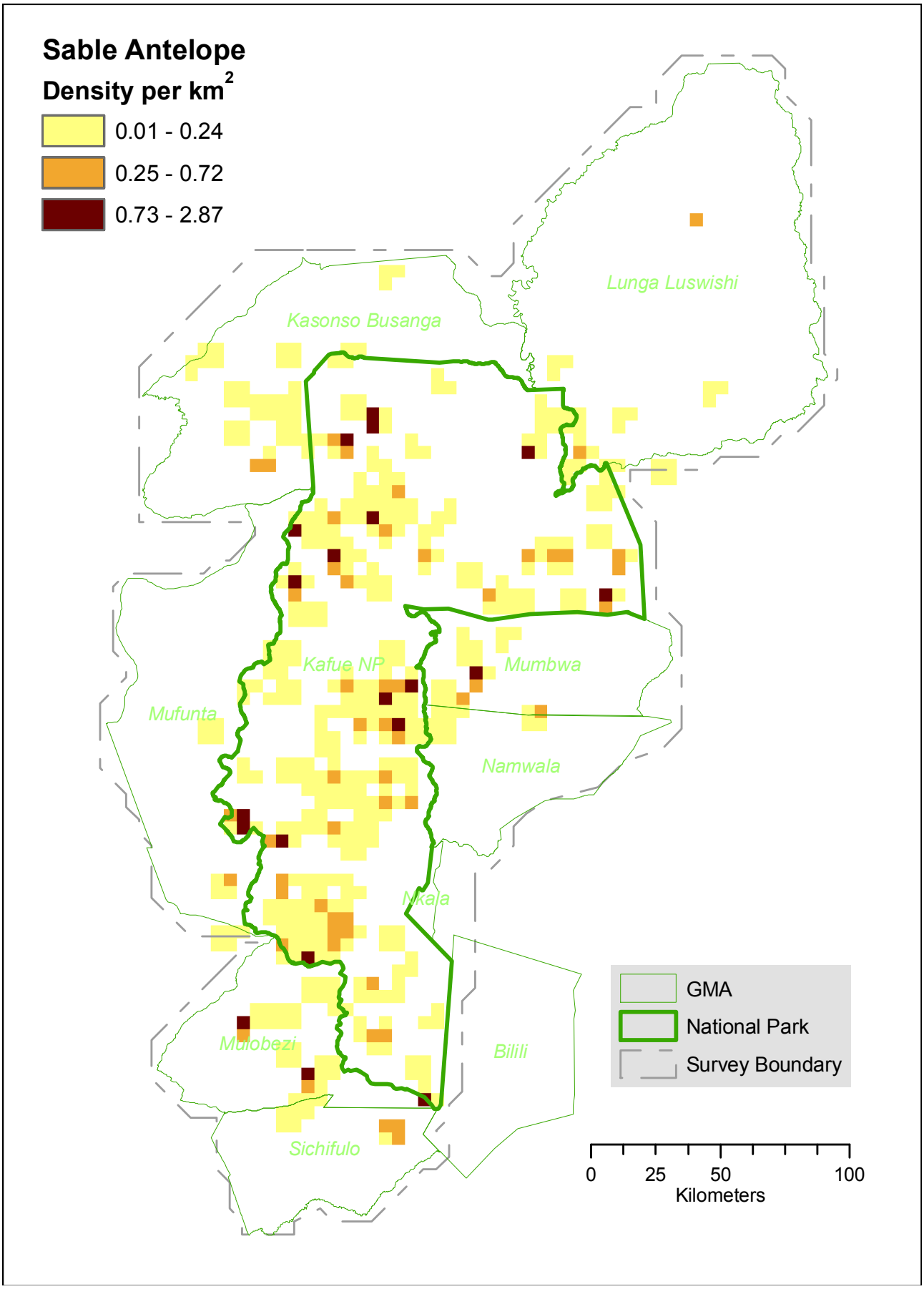

Figure 21: Sable antelope density and distribution.

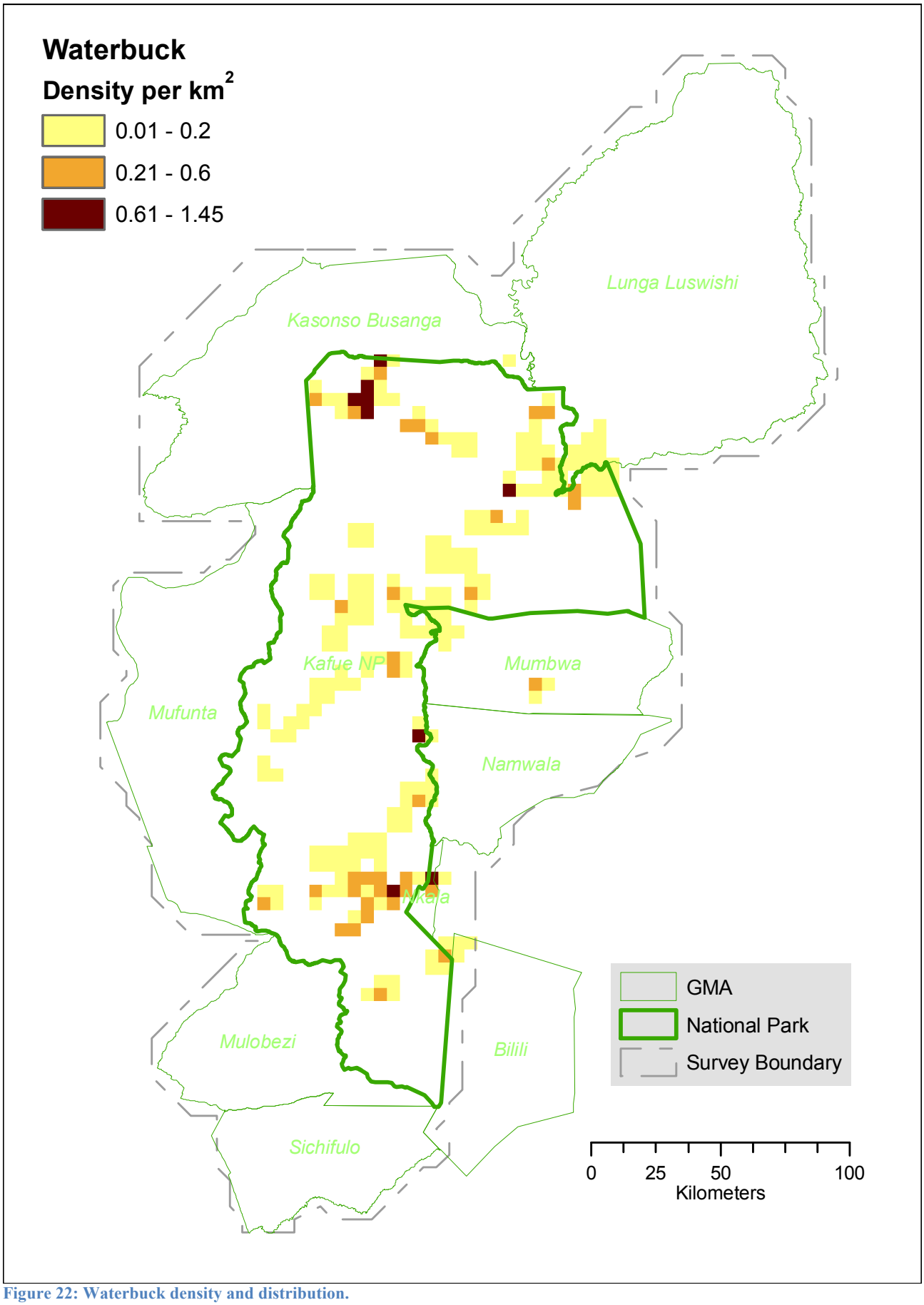

Figure 22: Waterbuck density and distribution.

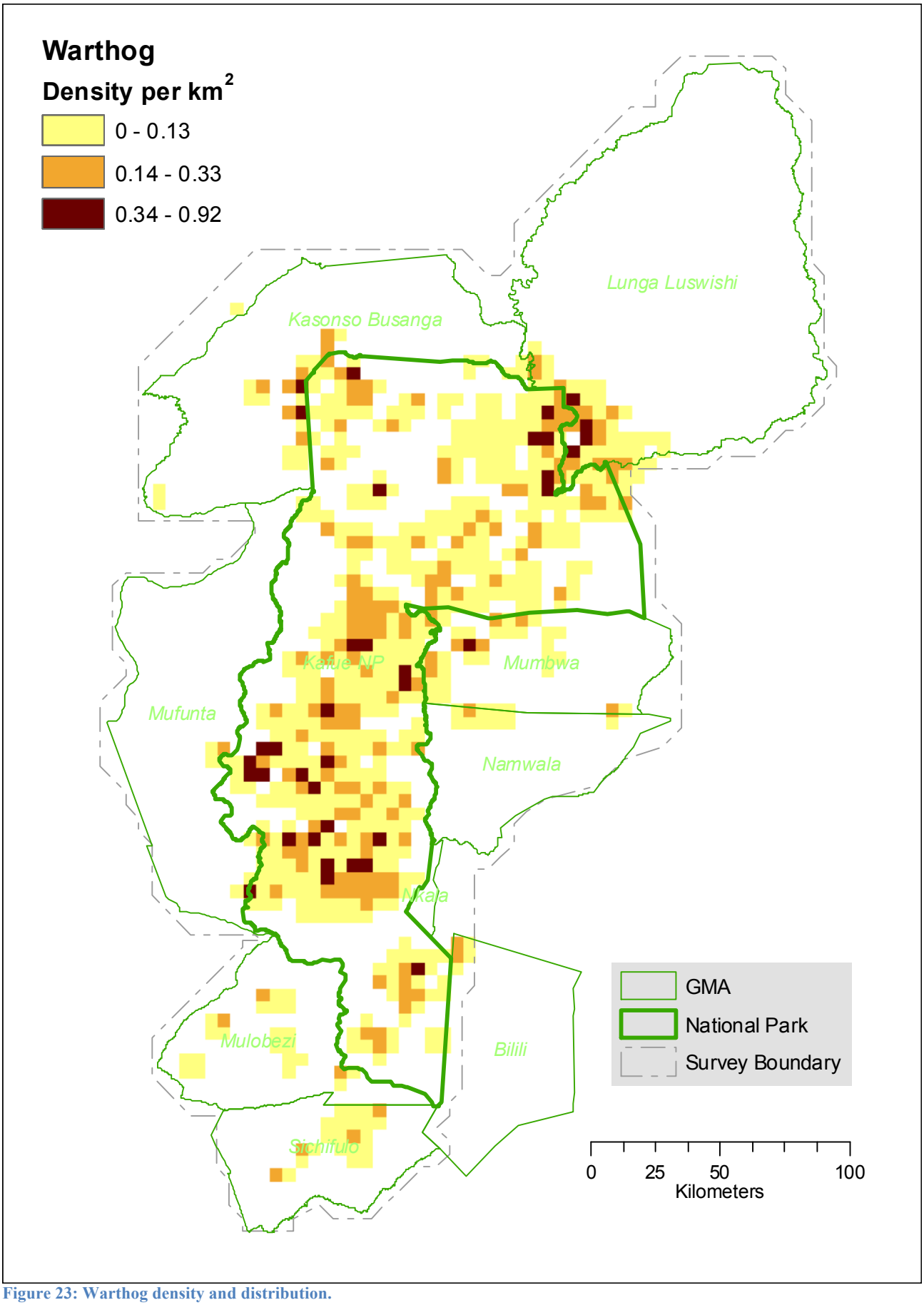

Figure 23: Warthog density and distribution.

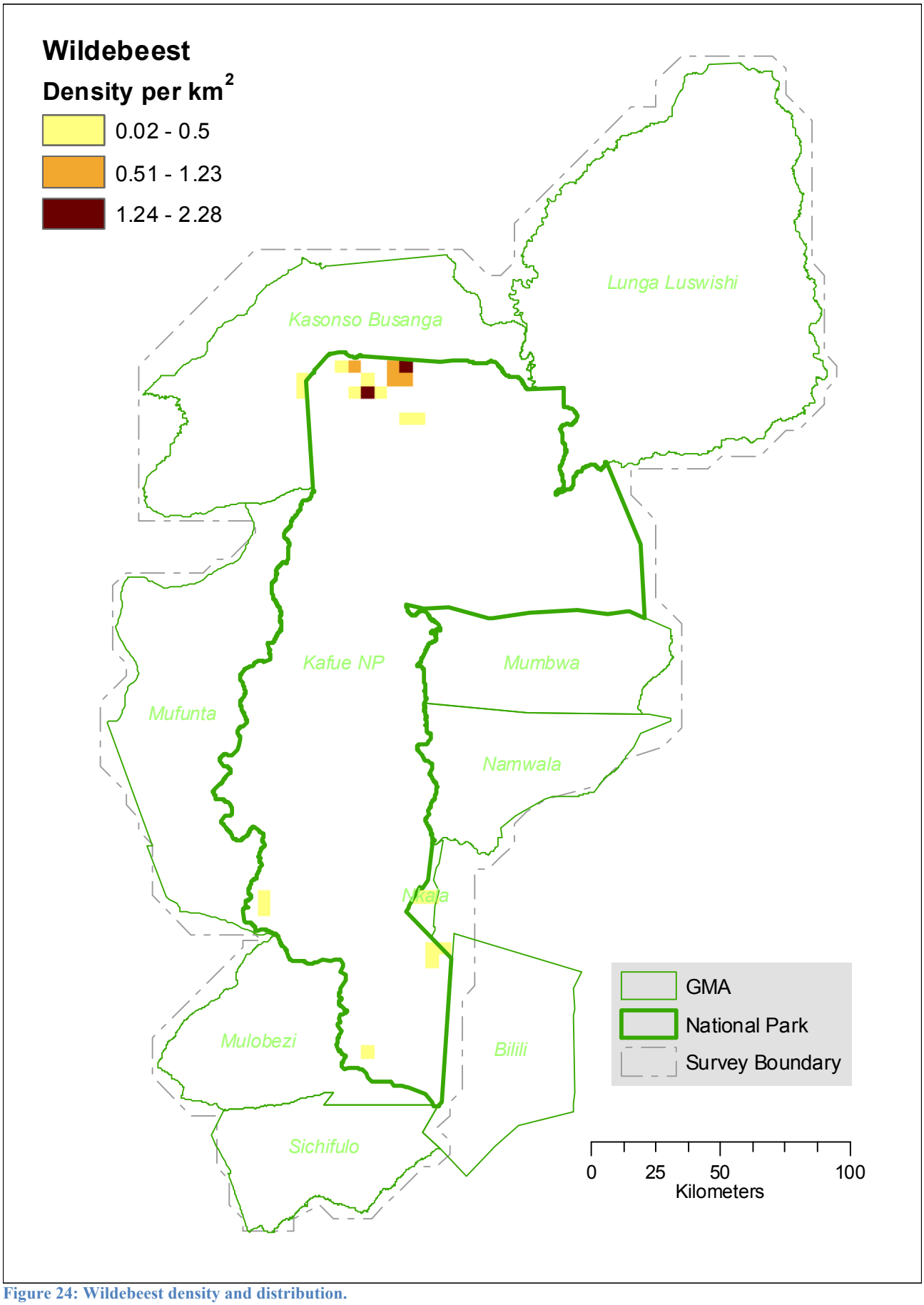

Figure 24: Wildebeest density and distribution.

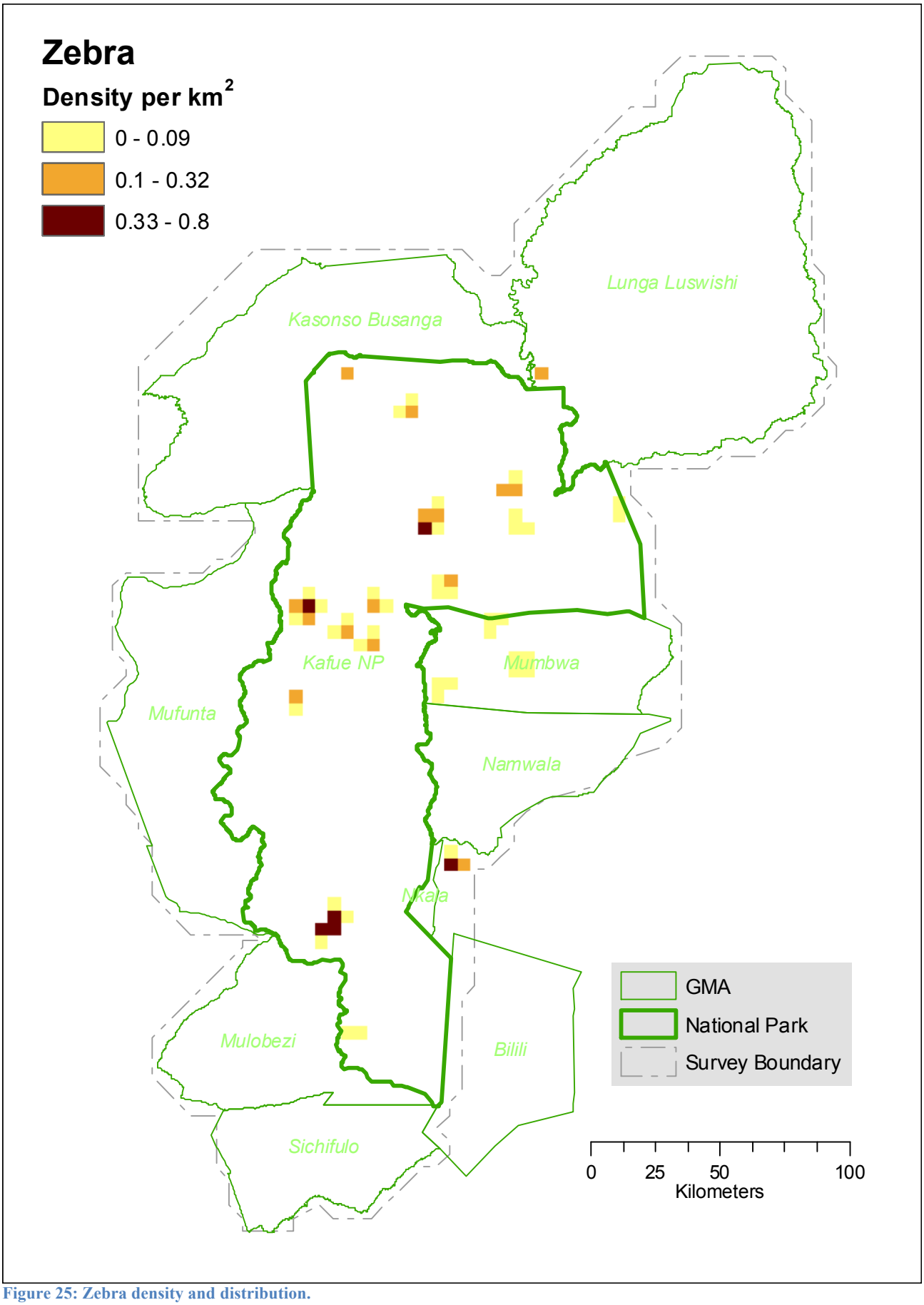

Figure 25: Zebra density and distribution.

3.4 Human Activities

Maps of human activities recorded by FSO and RSOs during flights are presented following.

- Huts, cultivated fields and metal sheeting are shown as approximate intensities per subunit.
- Following recommendations from the 2008 survey, livestock was counted by RSOs and a density map is presented in the same manner as for wildlife density.
- A map was produced showing poacher's camps, bike trails and footpaths. Parts of the Park are heavily used by people, and the bike paths are particularly indicative of trade in either meat or forest products.
- Livestock and cultivation are generally present in all GMAs. Huts and metal sheeting are not always present in as high numbers as livestock and cultivation, which suggests that encroachment is developing in the GMAs.

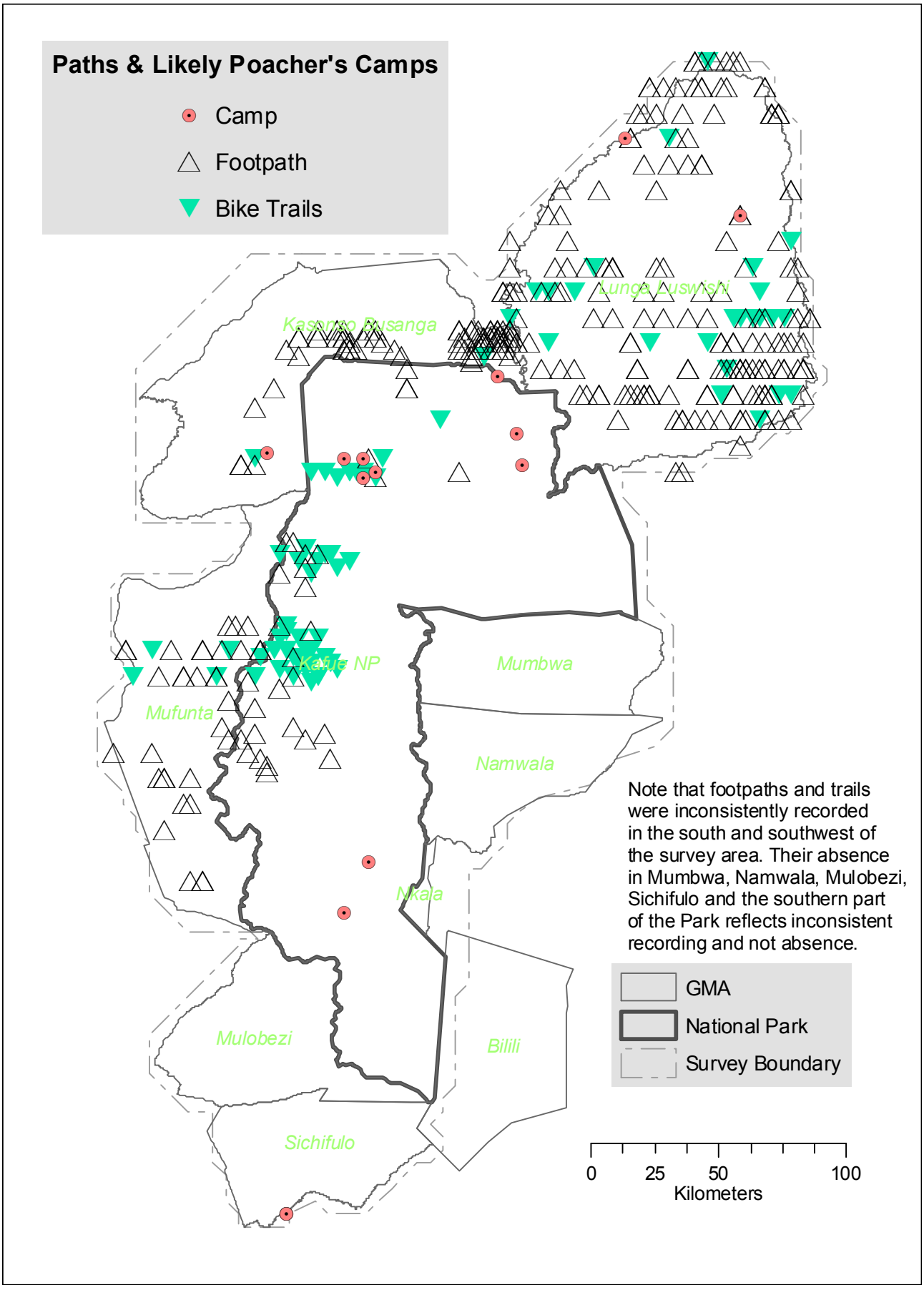

Figure 26: Distribution of foot and bike paths and poacher's camps in the ecosystem.

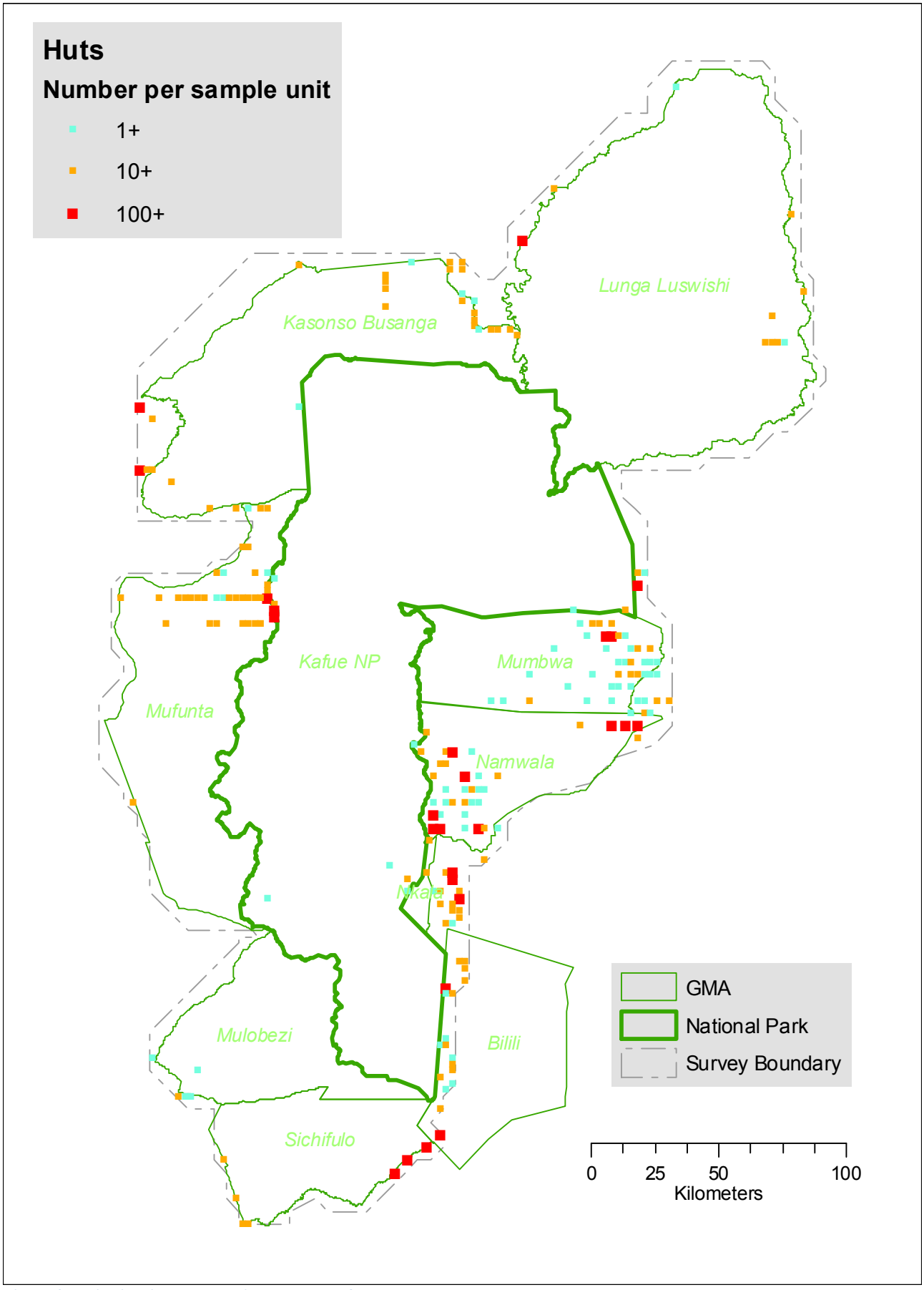

Figure 27: Distribution and relative numbers of houses.

Human habitation shows more concentrated 'hotspots' than cultivation or livestock, with large villages clearly showing up (red squares), often with open spaces nearby.

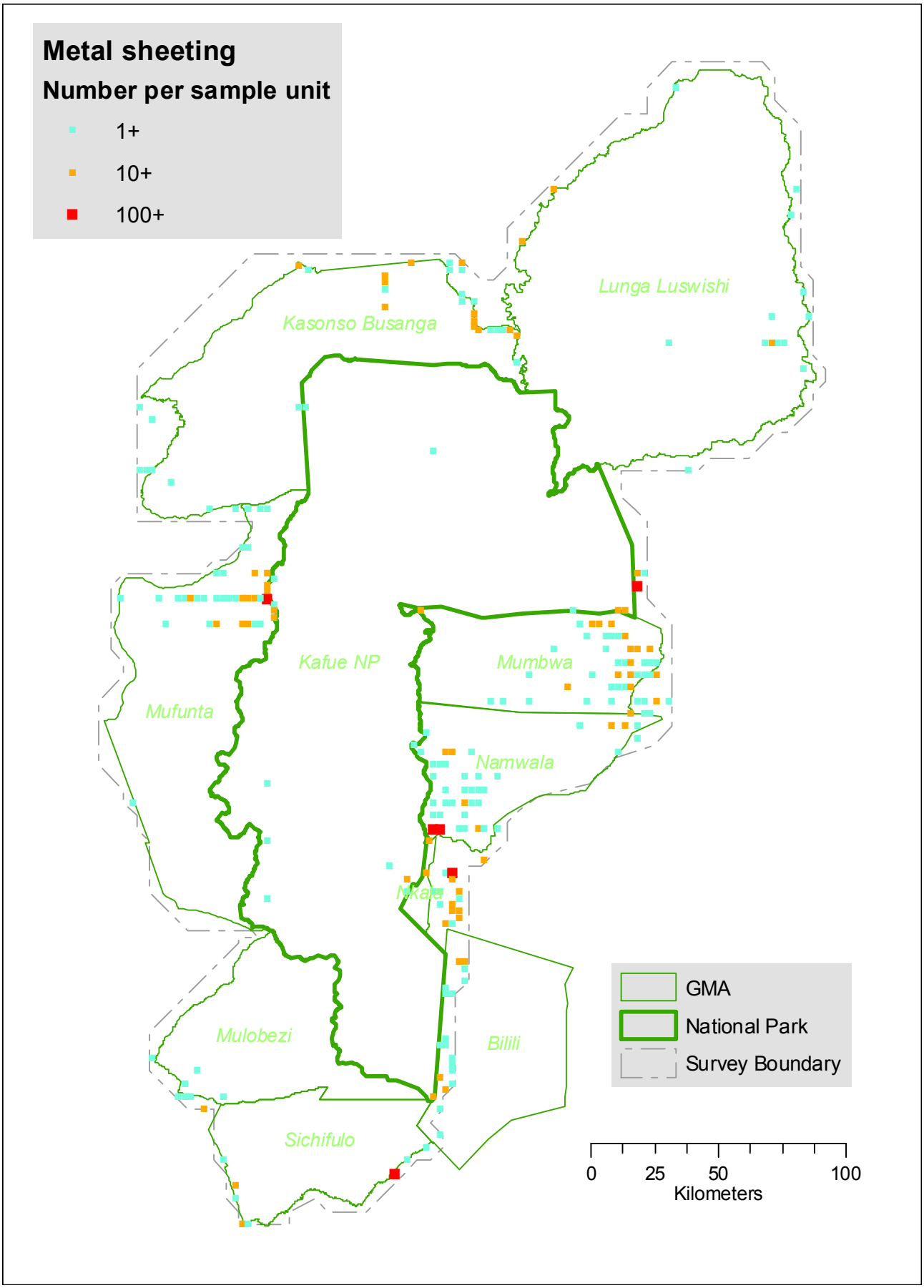

Figure 28: Distribution and intensity of metal sheeting.

Metal sheeting is an excellent indicator of development, showing more established communities; change in metal sheeting can indicate changes in economic status and development over time.

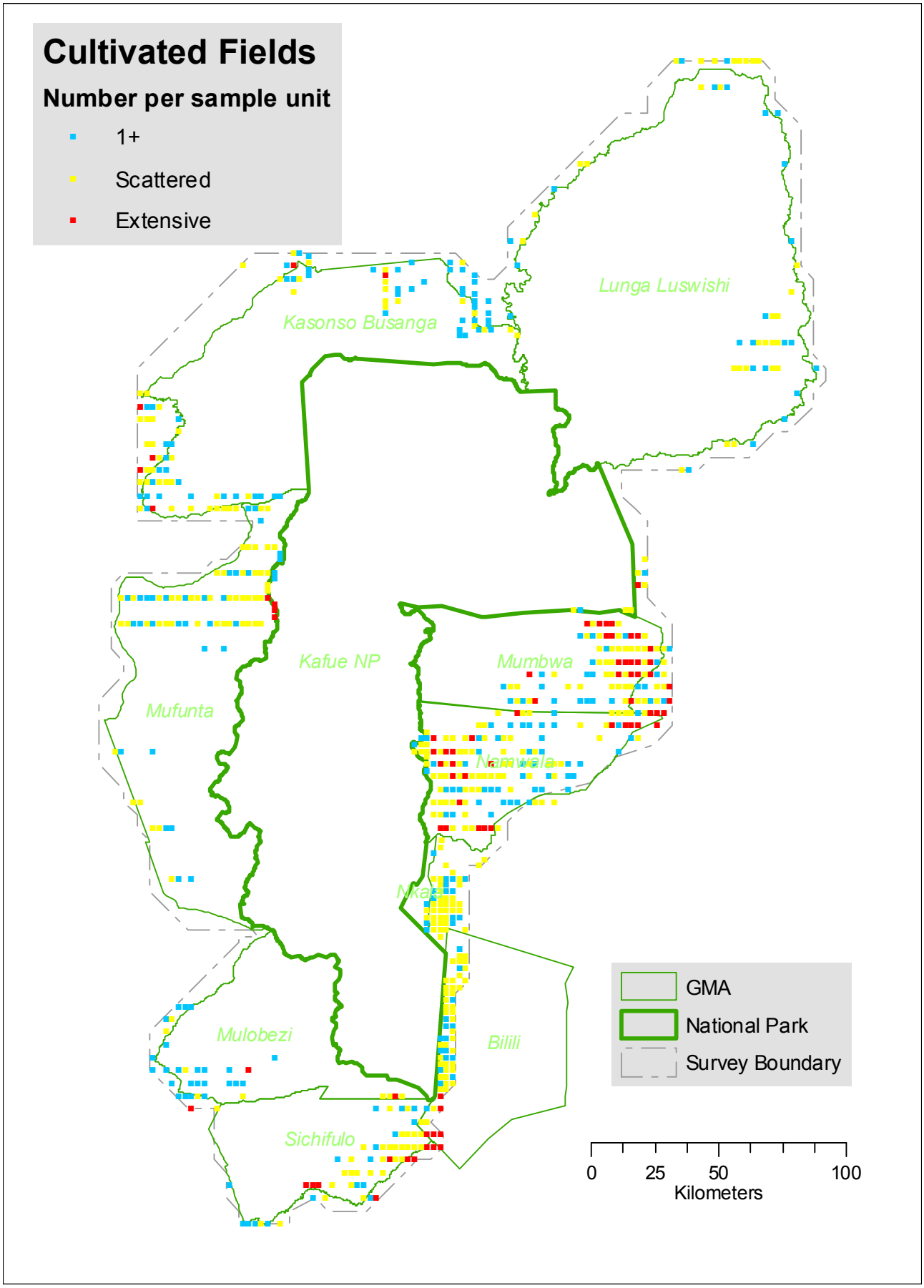

Figure 29: Distribution and intensity of cultivation.

Newer cultivation along the western edge of Bilili and in the NW and north shows up as low intensity (1+ per sample unit). More established agriculture (extensive) is widely distributed in Mumbwa, Sichifulo and Namwala, and one zone of intense agriculture appears in NE Mufunta directly on the border of the Park.

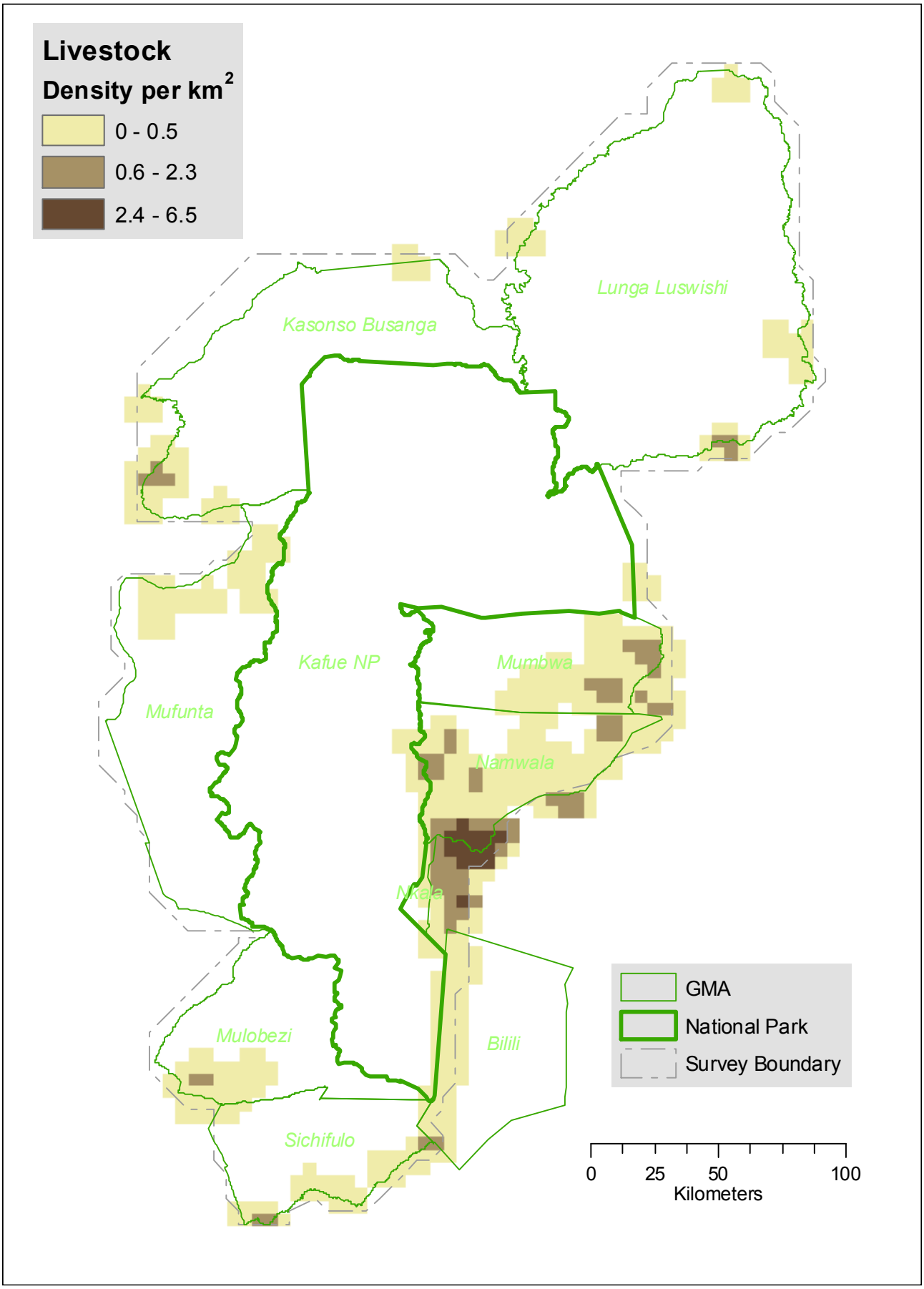

Figure 30: Distribution and intensity of livestock.

Livestock (combined cattle, sheep and goats) shows strikingly similar patterns to agriculture, with the highest intensities in Namwala and Mumbwa.

Discussion

The wildlife populations in the Kafue ecosystem are generally stable or increasing. The indicator species have for the first time been fully assessed with a partial total count of buffalo giving a baseline for comparison in the future; puku, elephant and lechwe populations are apparently stable or increasing.

There is, however, cause for serious concern:

1. The change of elephant distribution in Mulobezi and the presence of more elephant carcasses in this survey is worrying, and is probably part of the wider trend in increased elephant poaching across Africa.
2. There is serious encroachment in the west and northwest of the Park, and in many of the GMAs. Particularly worrying is the amount of bicycle trails seen, which is usually indicative of trade, usually in illegal natural resources (meat, wood, etc.).

Recommendations

The timing of this survey and the use of previous spatial data to target strata has led to an excellent survey strategy, and ZAWA should build on this. Two-yearly surveys should continue for the entire ecosystem, and it is strongly advised to survey the lechwe population on a yearly basis as it could be done with a small yearly budget.

Following from the recommendations in 2008, the previous reports and surveys should be incorporated in a survey database, including spatial data where possible:

- A review of all previous surveys, taking into account changes in survey boundaries, could allow an appropriate trend analysis for some wildlife populations.
- Some surveys could be corrected or at least better documented and summaries of historical data published.

4 References

Frederick H (2008) "Aerial Survey of the Kafue Ecosystem". Zambia Wildlife Authority, Lusaka.

Frederick H (2011) "SRF Calculation Script" version 1.1. URL http://countinganimals.underdiverwaterman.com/tools/

Norton-Griffiths M (1978) "Counting Animals". African Wildlife Foundation, Nairobi.

R Development Core Team (2011). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

ESRI (2009) "ArcGIS 9.3.1". Environmental Systems Research Institute, California.

Grimsdell, J. J. R., and R. H. V. Bell. "Population growth of red lechwe, Kobus leche leche Gray, in the Busanga Plain, Zambia." *East African Wildlife Journal* 10 (1972): 117-122.

Guldemond, Robert AR, Emily R Lehman, Sam M Ferreira, and Rudi J van Aaarde. "Elephant numbers in Kafue National Park, Zambia." *Pachyderm* 39 (2005): 50-56.

Viljoen, Petri. *Busanga Plains Kafue National Park, Zambia, Aerial Wildlife Survey 2007.* South Africa: Wilderness Safaris, 2007.

Zambia Wildlife Authority. *Aerial Survey of Kafue Ecosystem.* Lusaka: ZAWA, 2006.

Appendices

4.1 Crew

Pilots rotated between aircraft depending on hours flown (to conform to civil aviation law), alternating down days:

A. Edmund Farmer (ERJF)
B. Greg Kyle (GK)
C. Jaques Pierrnar (JP)

Aircraft	9J-DOM	9J-MES
FSO	Twakundine Simpamba	Clive Chifunte
RSO Left	Anety Milimo	Benson Kabungo
RSO Right	Chris Kaoma	Neta Simunji

Ground coordinator: Ngawo Namukonde

Survey coordination & training: Howard Frederick

4.2 Calibration

Table 13: Calibration data

	9J-DOM	9J-MES
Left Calibration	0.414	0.469
Left Nominal strip	145	164
Right Calibration	0.430	0.454
Right Nominal strip	151	159

4.3 Aircraft / Flight Parameters

Table 14: Flight parameters, all aircraft.

Parameter	9J-DOM	9J-MES
Survey area (km^2)	39,843	30,618
Flying height (feet AGL)		
Average	352	351
Standard deviation	20	66
No. transects	235	97
Distance (km)	11,702	5,235
Transect speed (km/h avg)	170	176

4.4 Area calculations of protected areas

Official areas were given in the 2008 report ("Official area"). Data from ZAWA's GIS department were used to calculate the areas of the GMAs ("Calculated area"), using QGIS 1.8. Differences in areas are indicated in the table below. They range from fairly insignificant differences (1-5%) to very large differences (e.g. 86.6% for Mufunta).

Table 15: Official & calculated areas of protected areas.

Name	Status	Official area	Calculated area	Difference
Kafue NP	National Park	22,400	22,514	0.5%
Kasonso Busanga	GMA	7,780	6,858	-11.9%
Nkala	GMA	194	203	4.6%
Namwala	GMA	3,600	3,165	-12.1%
Mumbwa	GMA	3,370	3,410.00	1.2%
Bilili	GMA	3,080	3,689	19.8%
Lunga Luswishi	GMA	13,340	13,357	0.1%
Sichifulo	GMA	3,600	3,028	-15.9%
Mulobezi	GMA	3,420	3,585	4.8%
Mufunta	GMA	3,417	6,376	86.6%

4.5 Transect Coverage

Table 16: Survey coverage by administrative area.

Zone	Sample area	Transect area	Transect km.	Intensity
Bilili	62	581	210	10.7%
Kafue	2,574	22,424	8,480	11.5%
Kasonso-Busanga	542	6,875	1,750	7.9%
Lunga-Luswishi	485	13,463	1,510	3.6%
Mufunta	236	6,356	745	3.7%
Mulobezi	232	3,600	783	6.5%
Mumbwa	230	3,181	778	7.2%
Namwala	202	3,162	680	6.4%
Nkala	28	212	85	13.0%
Outside	421	7,708	1,368	5.5%
Sichifulo	173	2,900	580	6.0%
Grand Total	5,192	70,462	16,968	7.4%

4.6 Flight Standards & Tracking

Daily tracking was done of flight standards.

- Ground speed: Examples follow (Figure 31) of the plots of ground speed from GPS data – instantaneous speed measurements (grey) and smoothed average line (red). Speed control was generally excellent in spite of difficult flying conditions (winds often > 20 knots) – the graphs show >190 km/h consistently only at the beginning and end of sessions during transit (cruise).
- Flying height: height above ground was monitored during flight, and periodic review of flight performance was made. The final frequency histogram of radar altimeter heights for the survey is shown in Figure 32.

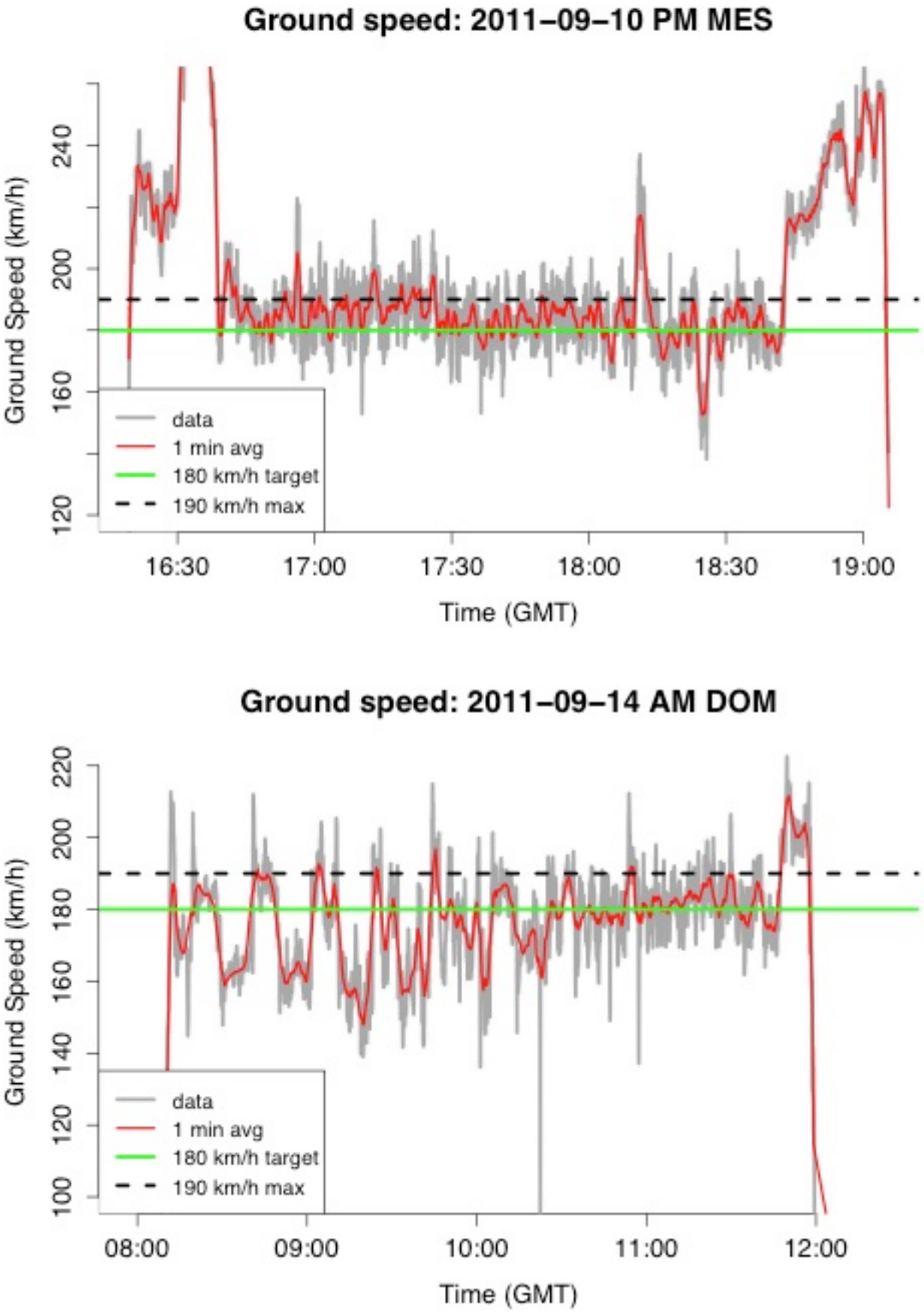

Figure 31: Examples of ground speed monitoring from GPS log.

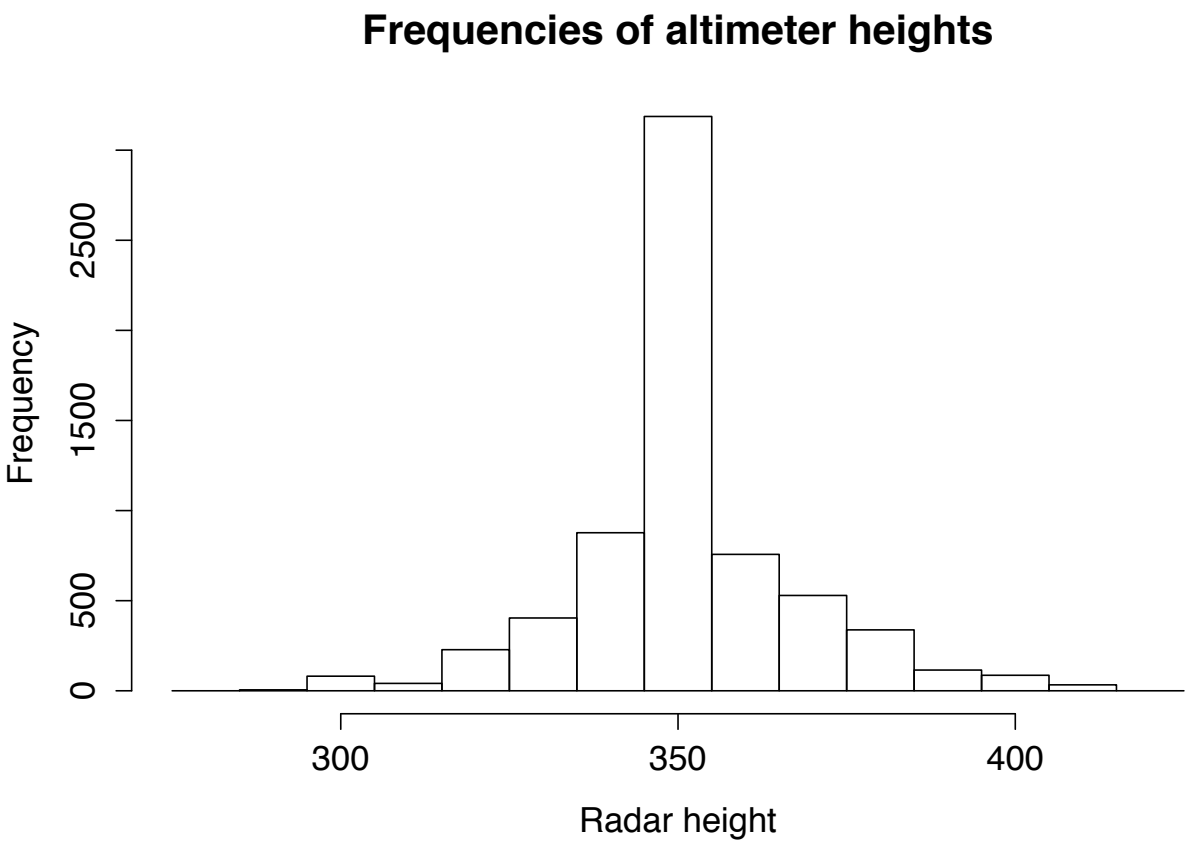

Figure 32: Frequency distribution of radar altimeter heights

4.7 Terms of Reference

Consultancy Services to Undertake an Aerial Survey of Large Mammals in Kafue National Park (KNP) and adjacent Game Management Areas (GMAs) in 2011

1. BACKGROUND

The Zambia Wildlife Authority (ZAWA) has received financial support from Norway and the World Bank under the Support for Economic Expansion and Diversification (SEED) Programme, whose overall objective is to promote and diversify the national economy in order to reduce its dependency on copper. Within the SEED Programme is the Kafue National Park (KNP) Project whose purpose is to secure critical habitat and species in the park and adjacent Game Management Areas (GMAs) through improved management, infrastructure, and tourism development. Part of the financial support for the Kafue Programme is intended for determining the current status of animal populations in the park and adjacent GMAs.

Securing critical species requires data and information on estimates, distribution, trend, etc., so that populations are managed. Population estimates by ZAWA in the past 4 years have been conducted on several occasions, e.g., 2002, 2004, 2006 and 2008 but with mixed results that show tremendous fluctuations in animal numbers. However, the 2006 and 2008 results correlated with anecdotal evidence in the form of breeding herds as provided by from tour operators and ZAWA suggest that wildlife is apparently recovering. This anecdotal evidence is collaborated by field patrol data that indicate a decline in poaching. As a follow up to such positive correlations, ZAWA has decided to hire a specialist in aerial surveys to depict the current status of animal populations in the park.

2 Consultancy Objective

The objective of the consultancy is to provide accurate and credible population estimates, distributions and structure of the large mammals in the Kafue National Park and adjacent GMAs. Such information will be valuable in illustrating that the Kafue Programme is achieving its purpose.

3 Scope of Work

The scope of work includes planning, put in place logistics, execute an aerial survey of large mammals in the Kafue National Park and adjacent GMAs, and prepare a report on population estimates and trend, and spatial distribution of species. While the count will be multi-species, emphasis shall be placed on elephant, buffalo, red lechwe, and puku which have been identified as indicator species.

4.0 Tasks to be Carried Out

To conduct large mammal aerial survey in Kafue National Park and the surrounding GMA's the consultant is expected to undertake the following tasks:

4.1 Survey Plan

The planning for the aerial survey shall comprise the following tasks:

i. Determination of survey boundaries, and sampling intensity (= or 12%) in conformity with the Sub-region.
i. Stratification of the study area;
ii. Orientation of transects, their spacing and length to be determined by sampling intensity;
iii. Identification of transect end and start points using the accepted map datum system in Zambia.
iv. Preparation of two copies of the flight survey plan;
v. Calculation of flight distance for each stratum and total planned flight time; and
vi. Estimation of the required amount of fuel and other materials.
vii. Determine the suitable survey times.

4.2 Logistics

(a) The consultant shall train observers for the survey.
(b) The consultant shall provide an aircraft suitable for aerial survey (fixed wing) and a qualified pilot with experience in conducting aerial surveys.

4.3 Execution

The execution part of the consultancy will involve the following tasks:

i. Calibration of transect width for the pair of observers;
ii. Preparation of instructions for the observers, recorder and pilot;
iii. Allocation of sampling effort between strata within the survey area;
iv. Collection of data, which shall include elephant carcasses; and
v. Putting in place safety measures for the crew members during the aerial survey.

4.4 Data Analysis and Reporting

For purposes data analysis and reporting, the consultant shall use the World Wide Fund for Nature (WWF) software for each stratum and the whole survey area, produce maps for study area showing transect location, spacing and orientation, and densities in each stratum as an input into the survey report.

The aerial survey report should highlight and relate its findings and observations to previous survey data bearing in mind the methodologies employed. It will be advisable to use the MIKE or any other internationally approved method. In addition, the data analysis and reporting should be in comparison to other previous data and results, as far back as ten (10) or more years (e.g. from 1995 aerial survey).

The aerial survey report shall establish and develop a systematic framework of sampling intensity and transects which can be used in future surveys. The reports shall be submitted in soft and hard copies (10).

4.5 Training and data analysis

The consultant shall train the observers (ecologist and other Assistants) in data anaysis

5 Approach

In undertaking these tasks, the consultant shall review existing information on the status and spatial distribution of the large mammals in the park, and interact with relevant ZAWA's technical staff who are knowledgeable or experienced in this field of study.

6 Expected Outputs

The consultant shall produce a consultancy report that shall be in double-spaced, using Times New Roman, Font 12. Ten copies of draft report shall be submitted for review by ZAWA. The review comments will be incorporated by the consultant into the final 20 hard copies and 2 electronic copies. The report format shall be as follows:

1. Contents table of contents;
2. List of tables;
3. List of figures;
4. Executive summary
5. Introduction;
6. Study area;
7. Methods;
8. Results;
9. Discussion;
10. Conclusions;
11. References; and
12. Appendices showing the calibration data, flight information, transect details, crew details, and observations.

7. Qualifications and Experience of the Consultant

Interested consultants must have a post-graduate degree in fields related to wildlife management. At least 10 years experience in aerial surveys in a savannah ecosystem will be necessary.

8 Services to be rendered by ZAWA

ZAWA shall provide support staff in the form of Ecologists and Research Assistants, in addition to field offices in the park (Ngoma and Chunga) and at Chilanga. Additionally, ZAWA shall provide all available documentation, reports, and data.

ZAWA has contracted a firm, World Conservation Society (WCS) to provide aircraft and a pilot to conduct the aerial survey. The firm operates two aeroplanes;

9. Reporting

The consultant shall report to the Director General-ZAWA or the Client designate Director Research, Planning and Information as the Client's Coordinator. He/she shall submit an inception report two weeks after commissioning of the study. An interim report shall be submitted within 70 days of the study. ZAWA shall review and provide comments within two weeks of receiving the inception and interim reports. Final report after taking into account comments from stakeholders