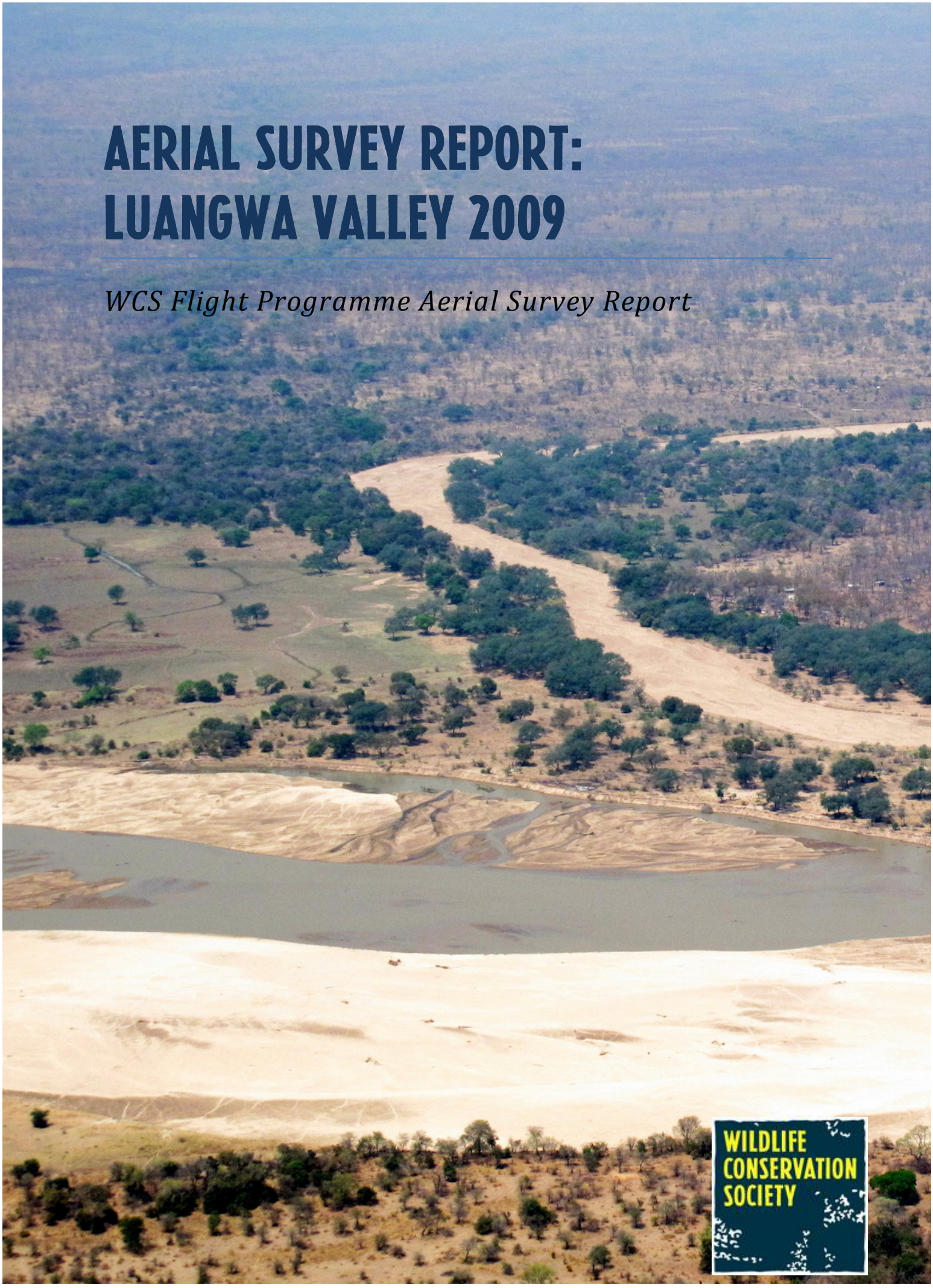
AERIAL SURVEY REPORT: LUANGWA VALLEY 2009

WCS Flight Programme Aerial Survey Report



WILDLIFE CONSERVATION SOCIETY

AERIAL SURVEY REPORT: LUANGWA VALLEY 2009

WCS Flight Programme Aerial Survey Report

This report should be referenced as:

WCS Flight Programme (2009) "Aerial Survey Report: Luangwa Valley 2009". Wildlife Conservation Society, New York.

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Introduction

This report describes the results of the 2009 sample count of a large part of the Luangwa Valley in eastern Zambia. This survey was part of an ongoing research programme in the COMACO areas and controls which aims to monitor changes in the distribution and abundance of wildlife species. The same methods (Systematic Reconnaissance Flights with consistent observer and pilot training) are used from year to year to allow valid comparison between surveys.

In 2009 the Wildlife Conservation Society organised this valley-wide sample count, extending beyond the areas normally sampled in the yearly programme. This is the first time a Luangwa Valley count has been carried out since 1973 (Caughley & Goddard 1975). Previous surveys in the ecosystem were done by the WCS Flight Programme in 2006, 2007 & 2008, and by the ZAWA in 1999 & 2002 (WCS 2007, 2008, 2009 and ZAWA 1999, 2002).

WCS normally does a yearly count of the COMACO chiefdoms in the Game Management Areas outside the national park system, and the Zambia Wildlife Authority (ZAWA) and the Frankfurt Zoological Society (FZS) conduct surveys in North and South Luangwa National Parks.

Censuses have been carried out by WCS in Lukusuzi National Park and a part of the Musalangu Game Management Area in 2006, 2007 and 2008. As these areas lie outside the normal COMACO project areas, they should act as 'control' areas for long-term monitoring efforts.

This ecosystem approach to surveys was expected to provide more reliable and valid data on distribution and numbers. Wildlife move freely in much of the Luangwa Valley, and surveys that cover only small parts of the system risk bias due to movements of animals in and out of the survey areas.

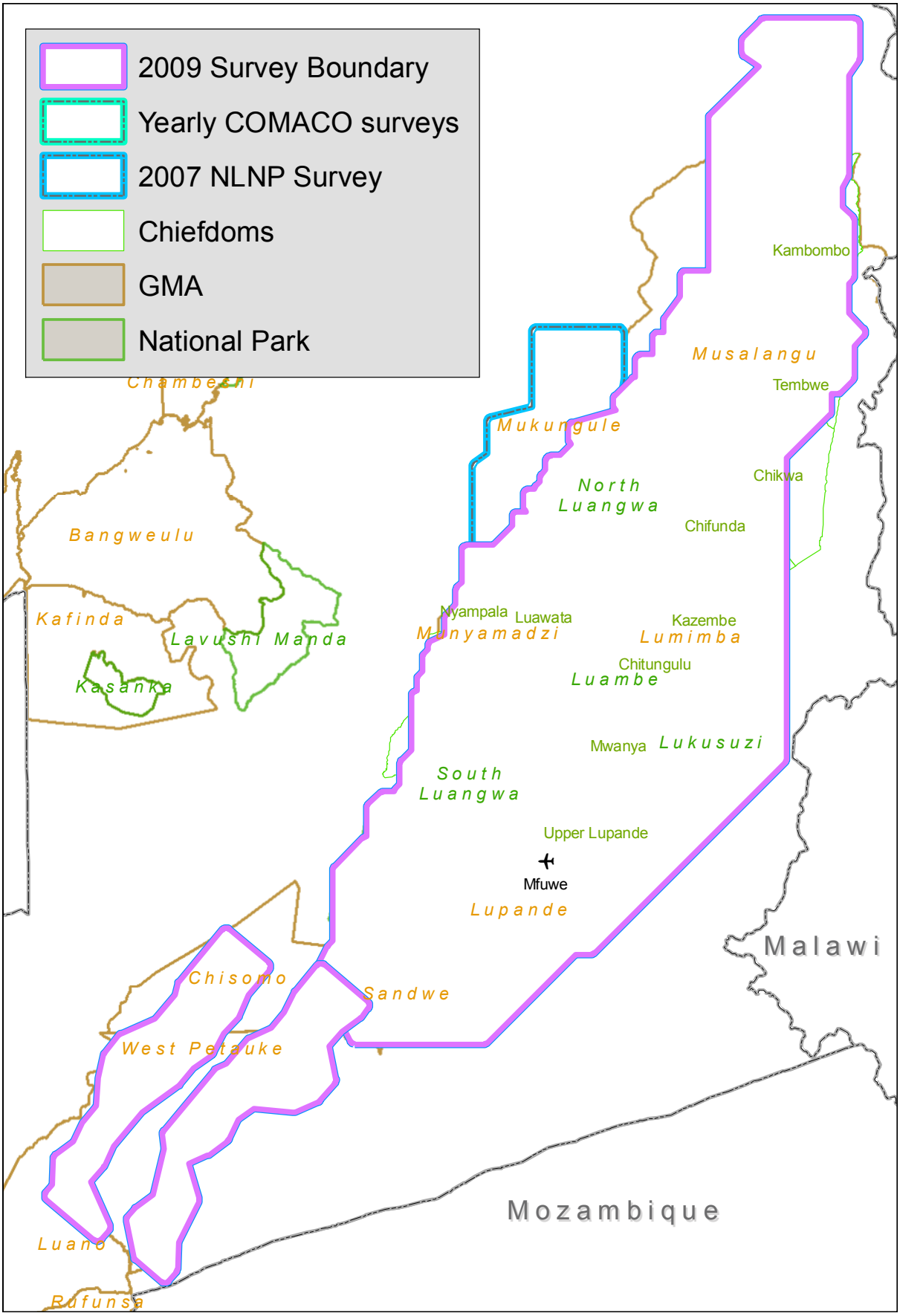

Figure 1: Luangwa Valley survey area.

Methods

Study Area

Figure 1 shows the boundary of the 2009 ecosystem survey, and the boundaries of the previous 2007 surveys. The survey area covered approximately 58,000 km^2.

Transects were flown in east-west directions at the indicated spacing (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.

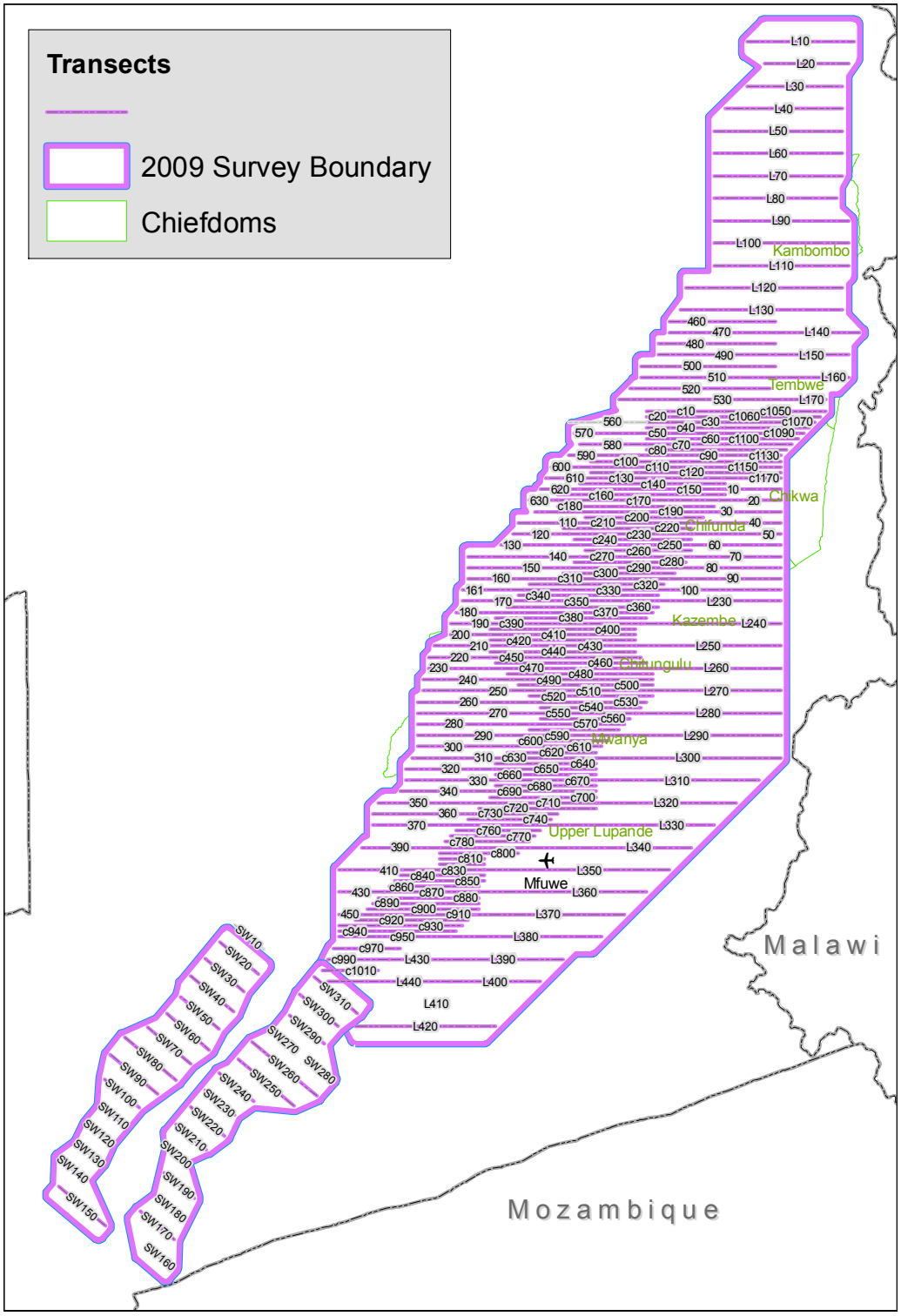

Figure 2: Transect lines, Luangwa Valley 2009.

The survey took place from the 29 September to the 04 October 2008.

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

The survey aircraft (Cessna 182) was fitted with a digital radar altimeter and programmable Garmin GPS unit (GPS296). The survey pilot was responsible for safety, navigation to and along daily transect assignments, and reporting to the survey coordinator.

The front seat observer (FSO) in the co-pilot's seat was responsible for recording radar altimeter readings to the nearest 10 feet at the beginning of each subunit. The FSO recorded geo-reference information on data sheets and announced the beginning of each subunit. For each subunit, FSOs recorded the presence or absence of human activities at any point along the transect:

- Any habitation (houses, as long as not clearly abandoned);
- Villages (somewhat arbitrary, roughly any subunit with >15 houses);
- Cultivation;
- Tin roofing sheets on any structure (an economic indicator).

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. Groups of animals greater than twenty were photographed and the number of frames recorded. 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 Lubonga airfield over markers of known distance.

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. Photographs were counted following each flight and corrected data entered on each sheet.

Lab work

Census data were analysed using a private Excel-based application for SRF survey analysis (Frederick 2008). 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 (ESRI 2008).

Rear seat observer observations were corrected by reference to photographs taken of groups larger than 20 animals. Photographs were viewed in Adobe Photoshop, colour corrected and dots placed on each counted animal within each counting group.

Results

Estimates and distribution maps are presented for wildlife populations and human activities in the census zone.

Tables present some or all of the following data:

- *Actual observed* – the number of individuals observed during SRF for each species.
- *Estimate* – the extrapolated population size for the survey area.
- *Standard error*
- *95% CL – confidence limits at 95% probability value. Population estimates are written in the form "estimate ±95% confidence limit, i.e. elephant = 2,404 ±995.*

Note on census data accuracy:

Estimates for small, secretive or cryptically-coloured species (duikers, carnivores) are likely to be substantial undercounts, and estimates are not normally presented for those species.

Likewise, rarely seen species (e.g. <30 individuals sighted) usually provide highly imprecise estimates; estimates are presented here only for species where more than thirty individuals were actually sighted during the survey.

Estimates & Trends

Estimates are presented in two sections, for comparison to previous survey boundaries. The first is for the entire Valley survey (2009), including all survey areas; the second is for the "Core COMACO areas" included in previous surveys by WCS, which has incomplete overlap with the entire survey area (see figure 1).
For each section, the data are summaries by GMA and National Park boundaries.

- Previous estimates for South Luangwa National Park were not available for this report.
- No consistent surveys are known to have taken place for the GMAs in the Luangwa Valley aside from the COMACO surveys which only cover a part of the GMAs.

Table 1: Estimates for Luangwa Valley parks

	NLNP 4,690 km2			Luambe NP 344 km2			Lukusuzi NP 2,600 km2			SLNP 8,079 km2		
Species	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**
Baboon	22	285	193	10	98	56	-	-	-	92	**906**	325
Buffalo	145	**1,447**	776	-	-	-	-	-	-	1,018	**10,261**	3,176
Bushbuck	-	-	-	-	-	-	-	-	-	4	39	22
Bushpig	-	-	-	-	-	-	-	-	-	5	49	47
Crowned Crane	-	-	-	-	-	-	-	-	-	4	39	37
Duiker	3	39	23	-	-	-	12	497	166	4	89	49
Eland	-	-	-	-	-	-	-	-	-	17	285	228
Elephant	343	**3,749**	525	15	148	97	-	-	-	424	**4,419**	899
Elephant carcass 3	-	-	-	-	-	-	-	-	-	-	-	-
Elephant carcass 4	-	-	-	-	-	-	-	-	-	1	20	19
Giraffe	-	-	-	-	-	-	-	-	-	9	89	50
Ground Hornbill	8	157	88	-	-	-	-	-	-	59	**748**	176
Hartebeest	24	236	106	-	-	-	-	-	-	13	246	152
Hippo	70	**689**	306	96	**945**	507	-	-	-	644	**6,339**	1,471
Impala	442	**4,350**	971	87	**856**	257	-	-	-	957	**9,577**	1,400
Kudu	4	39	22	2	20	18	-	-	-	77	**898**	230
Lion	-	-	-	-	-	-	-	-	-	-	-	-
Puku	126	**1,240**	380	38	**374**	189	-	-	-	384	**3,897**	694
Reedbuck	1	20	20	12	118	104	-	-	-	13	197	139
Roan Antelope	14	177	72	-	-	-	32	**1,325**	363	37	**712**	322
Vervet Monkeys	-	-	-	-	-	-	-	-	-	-	-	-
Warthog	46	**502**	115	5	49	33	3	124	118	97	**1,161**	211
Waterbuck	32	**315**	120	-	-	-	-	-	-	38	**374**	131
Wildebeest	15	148	129	1	10	9	-	-	-	42	**413**	216
Zebra	113	**1,191**	306	21	207	89	3	124	118	261	**2,993**	576
Cattle	-	-	-	-	-	-	3	124	124	-	-	-
Domestic Dog	-	-	-	-	-	-	-	-	-	-	-	-
Mine - active	-	-	-	-	-	-	1	41	40	-	-	-
Mine - old	-	-	-	-	-	-	2	85	78	-	-	-
Pitsawing	-	-	-	-	-	-	-	-	-	-	-	-
Poachers camp	-	-	-	-	-	-	1	41	40	-	-	-
Sheep and Goats	-	-	-	-	-	-	-	-	-	-	-	-

Table 2: GMA blocks, Valley survey area.

	Chifunda			Chikwa			Chisomo			Chitungulu			Kambombo		
	2,018 km2			1,206 km2			1,274 km2			631 km2			3,002 km2		
Species	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**
Baboon	-	-	-	-	-	-	-	-	-	5	49	48	7	290	193
Buffalo	-	-	-	-	-	-	-	-	-	-	-	-	8	331	328
Bushbuck	-	-	-	3	30	20	1	41	42	-	-	-	-	-	-
Bushpig	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crowned Crane	2	20	18	-	-	-	-	-	-	-	-	-	-	-	-
Duiker	2	39	23	-	-	-	1	41	39	-	-	-	2	83	54
Eland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elephant	43	**521**	192	28	276	237	-	-	-	-	-	-	-	-	-
Elephant carcass 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elephant carcass 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Giraffe	-	-		-	-		-	-		-	-		-	-	
Ground Hornbill	6	118	97	-	-	-	-	-	-	-	-		12	497	341
Hartebeest	2	20	19	-	-	-	-	-	-	-	-	-	-	-	-
Hippo	93	**915**	326	-	-	-	3	124	134	15	148	137	-	-	-
Impala	171	**2,007**	571	65	**640**	326	5	207	193	42	**413**	268	7	290	284
Kudu	3	30	28	-	-	-	-	-	-	-	-	-	1	41	41
Lion	-	-		-	-		-	-		-	-		-	-	
Puku	32	**315**	153	5	49	40	-	-	-	12	118	80	-	-	-
Reedbuck	8	157	147	-	-	-	-	-	-	1	41	42	-	-	-
Roan Antelope	15	255	171	10	157	144	1	41	39	-	-	-	-	-	-
Vervet Monkeys	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Warthog	28	403	135	5	49	33	1	41	39	2	20	19	5	207	199
Waterbuck	13	128	75	10	98	96	-	-		-	-		-	-	
Wildebeest	6	59	48	2	20	13	-	-	-	1	10	9	-	-	-
Zebra	8	157	81	9	89	87	-	-	-	2	20	19	-	-	-
Cattle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Domestic Dog	-	-	-	9	89	59	-	-	-	-	-	-	6	227	206
Mine - active	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mine - old	-	-		-	-		-	-		-	-		-	-	
Pitsawing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poachers camp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sheep and Goats	-	-	-	12	118	109	3	124	116	-	-	-	8	246	184

	Kazembe			Luano			Luawata			Lupande			Musalangu		
	1,769 km2			883 km2			1,272 km2			2,618 km2			4,773 km2		
Species	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**
Baboon	-	-	-	1	41	41	3	30	29	8	110	79	6	141	105
Buffalo	-	-	-	-	-	-	56	**551**	279	185	**2,799**	1,473	30	**295**	294
Bushbuck	-	-	-	-	-	-	-	-	-	-	-	-	3	30	29
Bushpig	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crowned Crane	-	-	-	-	-	-	3	30	29	6	59	55	-	-	-
Duiker	3	60	38	-	-	-	2	20	19	3	93	82	10	242	96
Eland	-	-	-	-	-	-	-	-	-	-	-	-	2	20	19
Elephant	-	-	-	-	-	-	119	**1,201**	263	105	**1,128**	270	45	**1,245**	804
Elephant carcass 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elephant carcass 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Giraffe	-	-	-	-	-	-	-	-	-	16	252	112	-	-	-
Ground Hornbill	5	207	209	4	166	154	-	-	-	12	307	138	28	476	271
Hartebeest	-	-	-	-	-	-	4	39	21	6	248	211	7	79	58
Hippo	12	118	109	-	-	-	97	**955**	470	32	**315**	199	-	-	-
Impala	37	**932**	635	6	248	231	152	**1,496**	425	35	**344**	146	31	**305**	144
Kudu	5	100	84	-	-	-	11	108	52	3	61	45	4	49	34
Lion	-	-	-	-	-	-	2	20	19	3	30	26	-	-	-
Puku	8	79	52	-	-	-	37	**364**	119	99	**974**	417	9	89	85
Reedbuck	-	-	-	-	-	-	4	69	51	-	-	-	-	-	-
Roan Antelope	-	-	-	10	414	385	13	136	94	5	207	111	52	**983**	372
Vervet Monkeys	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Warthog	4	166	136	-	-	-	10	98	56	16	378	145	11	158	75
Waterbuck	-	-	-	-	-	-	23	226	119	12	118	115	13	148	81
Wildebeest	-	-	-	-	-	-	9	89	84	-	-	-	10	98	87
Zebra	-	-	-	-	-	-	22	217	113	30	**611**	292	11	230	121
Cattle	-	-	-	-	-	-	-	-	-	34	**1,408**	972	-	-	-
Domestic Dog	-	-	-	-	-	-	-	-	-	2	83	76	1	41	41
Mine - active	3	124	102	-	-	-	-	-	-	-	-	-	-	-	-
Mine - old	10	414	313	-	-	-	-	-	-	-	-	-	-	-	-
Pitsawing	1	41	41	-	-	-	-	-	-	5	207	215	2	83	55
Poachers camp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sheep and Goats	3	60	50	-	-	-	-	-	-	73	**2,486**	1,854	-	-	-

	Mwanya			Nyampala			Sandwe			Tembwe			Upper Lupande		
	1,569 km2			1,163 km2			700 km2			606 km2			1,963 km2		
Species	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**
Baboon	1	10	9	19	187	124	-	-	-	3	124	129	-	-	-
Buffalo	43	**423**	375	34	**335**	179	1	41	25	-	-	-	5	49	46
Bushbuck	1	10	9	-	-	-	-	-	-	-	-	-	1	41	44
Bushpig	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crowned Crane	4	39	39	-	-	-	-	-	-	-	-	-	-	-	-
Duiker	2	20	13	1	10	10	1	41	25	-	-	-	-	-	-
Eland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elephant	51	**565**	307	50	**512**	189	-	-	-	-	-	-	64	**630**	454
Elephant carcass 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elephant carcass 4	1	10	9	-	-	-	-	-	-	-	-	-	2	20	13
Giraffe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ground Hornbill	10	98	77	14	138	87	-	-	-	-	-	-	13	223	135
Hartebeest	-	-	-	-	-	-	1	41	25	-	-	-	-	-	-
Hippo	60	**591**	290	71	**699**	396	1	41	44	-	-	-	11	168	102
Impala	60	**591**	316	162	**1,594**	256	4	166	100	-	-	-	17	167	76
Kudu	1	41	36	11	128	65	-	-	-	1	41	43	5	49	31
Lion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Puku	56	**551**	267	67	**659**	230	-	-	-	-	-	-	17	167	93
Reedbuck	-	-	-	32	**315**	294	-	-	-	-	-	-	-	-	-
Roan Antelope	18	745	633	5	98	72	-	-	-	-	-	-	2	83	71
Vervet Monkeys	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Warthog	13	191	83	7	89	44	2	83	102	-	-	-	3	61	48
Waterbuck	4	39	38	-	-	-	-	-	-	-	-	-	4	39	38
Wildebeest	-	-	-	116	**1,142**	418	-	-	-	-	-	-	-	-	-
Zebra	5	49	47	27	266	88	-	-	-	-	-	-	8	79	66
Cattle	-	-	-	-	-	-	-	-	-	-	-	-	4	39	38
Domestic Dog	7	69	64	-	-	-	-	-	-	-	-	-	-	-	-
Mine - active	1	41	36	-	-	-	-	-	-	-	-	-	-	-	-
Mine - old	1	41	41	-	-	-	-	-	-	-	-	-	-	-	-
Pitsawing	-	-	-	-	-	-	-	-	-	2	83	78	-	-	-
Poachers camp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sheep and Goats	-	-	-	-	-	-	-	-	-	-	-	-	18	303	196

	West Petauke			Out E			Out N			Out S			Out SE			Total		
	1,718 km2			900 km2			2,300 km2			2,100 km2			1,150 km2			49,700 km2		
Species	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**
Baboon	-	-	-	-	-	-	3	124	122	1	41	42	-	-	-	181	**2,437**	503
Buffalo	8	331	327	-	-	-	-	-	-	-	-	-	7	290	275	1,540	**17,155**	3,673
Bushbuck	1	41	40	-	-	-	-	-	-	1	41	42	-	-	-	15	274	94
Bushpig	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	49	47
Crowned Crane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19	187	85
Duiker	1	41	38	-	-	-	-	-	-	4	166	132	4	166	112	55	**1,647**	293
Eland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19	305	229
Elephant	-	-	-	-	-	-	-	-	-	11	455	301	-	-	-	1,298	**14,849**	1,549
Elephant carcass 3	1	41	42	-	-	-	-	-	-	-	-	-	-	-	-	1	41	42
Elephant carcass 4	-	-	-	-	-	-	-	-	-	1	41	44	-	-	-	5	91	50
Giraffe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25	341	123
Ground Hornbill	1	41	40	3	124	114	-	-	-	-	-	-	-	-	-	175	**3,301**	607
Hartebeest	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	57	**910**	289
Hippo	58	**2,402**	1,996	-	-	-	-	-	-	-	-	-	-	-	-	1,263	**14,388**	2,677
Impala	-	-	-	-	-	-	-	-	-	4	166	168	-	-	-	2,284	**24,351**	2,117
Kudu	1	41	42	-	-	-	-	-	-	-	-	-	1	41	38	130	**1,690**	284
Lion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	49	32
Puku	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	890	**8,878**	1,012
Reedbuck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	71	**917**	378
Roan Antelope	29	1,201	970	-	-	-	-	-	-	-	-	-	-	-	-	243	**6,616**	1,397
Vervet Monkeys	6	248	238	-	-	-	-	-	-	-	-	-	-	-	-	6	248	238
Warthog	1	41	40	-	-	-	-	-	-	3	124	126	3	124	118	265	**4,071**	485
Waterbuck	4	166	171	-	-	-	-	-	-	-	-	-	-	-	-	153	**1,652**	335
Wildebeest	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	202	**1,988**	505
Zebra	5	207	146	-	-	-	-	-	-	6	248	250	-	-	-	531	**6,687**	819
Cattle	-	-	-	89	**3,685**	2,921	-	-	-	29	1,201	1,012	23	952	400	182	**7,410**	3,267
Domestic Dog	-	-	-	3	124	78	-	-	-	2	83	70	-	-	-	30	**716**	262
Mine - active	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	207	116
Mine - old	-	-	-	6	248	228	-	-	-	-	-	-	-	-	-	19	787	397
Pitsawing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	414	238
Poachers camp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	41	40
Sheep and Goats	-	-	-	50	**2,070**	481	7	290	264	67	**2,774**	2,030	14	580	400	255	**9,052**	2,849

COMACO Core Area – previous survey zone

Table 3**Error! Reference source not found.** shows the yearly data for the COMACO management units from 1999 to 2009, showing the estimates for the ‘core’ COMACO area surveyed from 1999 to 2008.

Table 3: Trends 1999-2009, COMACO core areas.

Fulaza	1999			2002			2006			2007			2008			2009		
Area of transect		150.82			150.82			91.2			89.2						230	
Total area sampled		760			760			894			874.57			900			819	
SI		19.84%			19.84%			10.20%			10.20%						28.1%	
Species	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE
Buffalo	74	**373**	242	6	**30**	16	21	**206**	175	70	**748**	460	19	**156**	114			
Wildebeest	0	**0**	0	51	**257**	165	33	**324**	226	47	**502**	412	5	**41**	38	10	**98**	90
Waterbuck	8	**40**	27	0	**0**	0	30	**294**	143	5	**53**	39	1	**8**	8	11	**108**	70
Zebra	5	**25**	11	4	**20**	167	10	**98**	86	6	**64**	48	6	**49**	32	1	**10**	9
Elephant	0	**0**	0	3	**15**	14	17	**167**	153	31	**331**	145	29	**238**	95	8	**79**	75
Eland	0	**0**	0	0	**0**	0	2	**20**	18	1	**11**	10	36	**296**	174			
Hartebeest	8	**40**	22	1	**5**	4	2	**20**	17				6	**49**	31	7	**79**	71
Roan	0	**0**	0	5	**25**	21							6	**46**	33	5	**49**	30
Kudu	0	**0**	0	1	**5**	4	4	**39**	27							3	**30**	27
Puku	0	**0**	0	15	**76**	71	11	**108**	48				22	**181**	22	9	**89**	84
Impala				16	**81**	41	65	**637**	417	9	**96**	95	50	**411**	125	16	**167**	91
Warthog				12	**60**	24	3	**29**	18	12	**128**	39	18	**148**	59	6	**59**	42
Bushbuck							1	**10**	9				5	**41**	14			

Chikwa	1999			2002			2006			2007			2008			2009		
Area of transect		49.5			49.5			17.1			16.5						110	
Total area sampled		280			280			168			162			728			699	
SI		17.68%			17.68%			10.20%			10.20%						15.7%	
	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE
Buffalo	0	**0**	0	0	**0**	0							2	**17**	10			
Wildebeest	38	**215**	210	2	**11**	11	16	**157**	127									
Waterbuck	0	**0**	0	3	**17**	13	10	**98**	91	3	**32**	31				10	**98**	94
Zebra	3	**17**	16	1	**6**	5										9	**89**	86
Elephant	25	**141**	126	17	**96**	53	2	**20**	18	2	**21**	19	12	**98**	76	28	**276**	249
Eland	0	**0**	0	9	**51**	39												
Hartebeest	0	**0**	0	0	**0**	0												
Roan	0	**0**	0	0	**0**	0												
Kudu	0	**0**	0	6	**34**	19	4	**39**	30				2	**17**	11	10	**197**	105
Puku	22	**124**	122	16	**91**	55	33	**324**	100	11	**118**	58	25	**208**	145	5	**49**	39
Impala				77	**390**	192	53	**520**	254	8	**85**	65	33	**275**	152	61	**600**	331
Warthog				0	**0**	0	8	**78**	51	8	**85**	53	8	**67**	49	3	**30**	29
Bushbuck													2	**17**	10	1	**10**	10

Chifunda	1999			2002			2006			2007			2008			2009		
Area of transect		239.65			239.65			146.5			146.7						145	
Total area sampled		1436			1436			1436			1438			1454			1,422	
SI		20.80%			20.80%			10.20%			10.20%						10.2%	
	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE
Buffalo	140	**707**	342	31	**154**	126	94	**922**	758	50	**534**	510	113	**934**	633			
Wildebeest	128	**647**	290	12	**60**	52	55	**539**	183	27	**289**	166	86	**711**	349	6	**59**	48
Waterbuck	0	**0**	0	7	**36**	16	4	**39**	36	8	**85**	82						
Zebra	0	**0**	0	7	**36**	32							1	**8**	8	3	**59**	54
Elephant	11	**54**	36	13	**66**	35	35	**343**	147	7	**75**	71	36	**298**	102	43	**521**	177
Eland	0	**0**	0	0	**0**	0				4	**43**	32						
Hartebeest	2	**12**	7	0	**0**	0	10	**98**	75				5	**41**	41	2	**20**	19
Roan	0	**0**	0	1	**6**	5							1	**8**	8	7	**138**	130
Kudu	0	**0**	0	2	**12**	10				4	**43**	27	8	**66**	46	3	**30**	28
Puku	61	**306**	242	70	**353**	105	86	**843**	305	24	**256**	154	57	**471**	147	32	**315**	153
Impala		**0**	0	165	**833**	221	146	**1431**	375	187	**1999**	495	137	**1133**	197	171	**2007**	535
Warthog		**0**	0	14	**72**	53	13	**127**	61	6	**64**	36	12	**99**	39	28	**403**	131
Bushbuck		**0**	0		**0**	0	1	**10**	9									
Hippo		**0**	0		**0**	0	710	**6961**	4526	143	**1528**	420				93	**915**	326
Ground Hornbill		**0**	0		**0**	0	4	**39**	38							6	**118**	88
Poacher's Camp		**0**	0		**0**	0	1	**10**	9				1	**8**	8			

Mwanya	1999			2002			2006			2007			2008			2009		
Area of transect		166.85	km^2		239.65	km^2		113.8	km^2		114.0	km^2			km^2		92	
Total area sampled		1116			1116			1116	km^2		1118	km^2		1111	km^2		1,125	km^2
SI		19.40%			20.80%			10.20%			10.20%						8.2%	
Species	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE			
Buffalo	70	**354**	184	7	**34**	30	9	**88**	59	302	**3234**	2988	7	**57**	46	43	**423**	375
Wildebeest	21	**106**	98	10	**47**	43							8	**65**	63			
Waterbuck	24	**121**	74	0	**0**	0	7	**69**	64	10	**107**	72				4	**39**	38
Zebra	8	**40**	27	14	**67**	45	21	**206**	128	29	**311**	153	25	**203**	80	5	**49**	47
Elephant	44	**221**	67	42	**201**	85	41	**402**	134	3	**32**	30	1	**8**	8	51	**565**	310
Eland	5	**27**	13	0	**0**	0	3	**29**	27									
Hartebeest	5	**27**	14	0	**0**	0							9	**73**	40			
Roan	1	**6**	6	0	**0**	0							6	**49**	38			
Kudu	8	**40**	24	0	**0**	0	3	**29**	20	1	**11**	10						
Puku	86	**435**	250	17	**80**	60	35	**343**	186	12	**128**	92	15	**122**	74	56	**551**	267
Impala		**0**	0	127	**609**	0	80	**784**	281	49	**525**	276	46	**374**	165	60	**591**	316
Warthog		**0**	0	0	**0**	0	11	**108**	55	20	**214**	113	9	**73**	61	13	**191**	86
Bushbuck				0						2	**21**	21						
Poacher's Camp		**0**	0	10	**47**	0	1	**10**	9									
Elephant Bones		**0**	0	0	**0**	0	2	**20**	12							1	**10**	9
Ground Hornbill		**0**	0	0	**0**	0	1	**10**	9							10	**98**	76
Hippo		**0**	0	0	**0**	0	7	**69**	33	95	**1017**	561				60	**591**	289

Chanjuzi	1999			2002			2006			2007			2008			2009		
Area of transect		119			239.65			67.6			69.6						102	
Total area sampled		663			663			663			682.67			655			613	
SI		19.91%			20.80%			10.20%			10.20%						16.6%	
	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE
Buffalo	*24*	**123**	110	*162*	**777**	690	*0*	**0**	0	*2*	**21**	20	*4*	**33**	30			
Wildebeest	*62*	**311**	238	*3*	**17**	14	*13*	**141**	81				*8*	**64**	61	*1*	**10**	9
Waterbuck	*0*	**0**	0	*0*	**0**	0	*0*	**0**	0				*15*	**125**	71			
Zebra	*0*	**0**	0	*7*	**33**	29	*0*	**0**	0							*2*	**20**	20
Elephant	*18*	**88**	63	*3*	**17**	10	*25*	**271**	122	*1*	**11**	10	*15*	**116**	79			
Eland	*0*	**0**	0	*0*	**0**	0	*0*	**0**	0									
Hartebeest	*0*	**0**	0	*0*	**0**	0	*28*	**303**	70									
Roan	*0*	**0**	0	*0*	**0**	0	*0*	**0**	0									
Kudu	*3*	**17**	14	*1*	**6**	5	*0*	**0**	0	*1*	**11**	10	*3*	**24**	9			
Puku	*71*	**355**	129	*21*	**99**	63	*15*	**163**	86	*8*	**85**	79	*20*	**163**	93	*20*	**197**	96
Impala				*76*	**367**	183	*84*	**910**	376	*41*	**438**	266	*9*	**73**	42	*79*	**1345**	315
Warthog				13	**64**	47	1	**11**	0	4	**43**	41	2	**16**	10	4	**103**	20

Nyampala	1999			2002			2006			2007			2008			2009		
Area of transect		65.24			66.24			46.1			45.8							
Total area sampled		451.6			451.6			451.6			449			456			469	
SI		20.22%			14.67%			10.20%			10.20%						0.0%	
	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE			
Buffalo	*436*	**2154**	1944	*472*	**3217**	2054	*12*	**118**	103	*1*	**11**	11	*61*	**498**	435	*34*	**335**	178
Wildebeest	*145*	**716**	404	*59*	**402**	169	*39*	**382**	200	*44*	**470**	260	*145*	**1185**	496	*116*	**1142**	405
Waterbuck		**0**	0	*8*	**55**	35	*20*	**196**	119									
Zebra	*79*	**389**	119	*58*	**395**	258	*85*	**833**	574	*29*	**310**	128	*65*	**531**	359	*22*	**217**	80
Elephant	*62*	**307**	148	*22*	**151**	79	*11*	**108**	80	*54*	**577**	218	*34*	**278**	151	*48*	**472**	186
Eland	*7*	**34**	24	*1*	**7**	6												
Hartebeest	*1*	**7**	6	*0*	**0**	0							*3*	**25**	22			
Roan	*1*	**7**	6	*0*	**0**	0												
Kudu	*3*	**14**	8	*3*	**21**	12	*2*	**20**	18	*6*	**64**	40	*1*	**8**	7	*9*	**89**	53
Puku	*61*	**300**	147	*39*	**265**	112	*33*	**324**	123	*15*	**160**	116	*9*	**74**	42	*61*	**600**	233
Impala		**0**	0	*162*	**1104**	361	*96*	**941**	345	*87*	**930**	340	*123*	**1005**	238	*157*	**1545**	213
Warthog		**0**	0	*2*	**14**	12	*12*	**118**	59				*1*	**8**	8	*5*	**49**	22
Bushbuck		**0**	0		**0**	0				2	**21**	22						
Poacher's camp		**0**	0		**0**	0							*1*	**8**	8			
Reedbuck																32	**315**	297

Luawata	1999			2002			2006			2007			2008			2009		
Area of transect		93.79			66.24			61.3			62.4						126	
Total area sampled		600.7			600.7			600.7			612			602.3			1,618	
SI		20.17%			11.03%			10.20%			10.20%						7.8%	
	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE			
Buffalo	*369*	**1832**	1424	*69*	**621**	485	*20*	**196**	117	*38*	**406**	375	*0*	**0**	0	*45*	**443**	293
Wildebeest	*74*	**366**	236	*18*	**167**	129	*11*	**108**	92				*1*	**9**	9	*9*	**89**	82
Waterbuck	*0*	**0**	0	*4*	**39**	16	*4*	**39**	32							*6*	**59**	42
Zebra	*19*	**96**	67	*2*	**19**	16				*3*	**32**	31	*8*	**66**	59	*3*	**30**	29
Elephant	*137*	**680**	261	*37*	**333**	121	*76*	**745**	163	*66*	**705**	318	*42*	**345**	124	*101*	**994**	209
Eland	*17*	**83**	60	*0*	**0**	0	*2*	**20**	12									
Hartebeest	*8*	**39**	32	*1*	**6**	5										*3*	**30**	21
Roan	*0*	**0**	0	*0*	**0**	0	*14*	**137**	133				*12*	**99**	89			
Kudu	*8*	**39**	38	*0*	**0**	0				*10*	**107**	64	*4*	**33**	24	*9*	**89**	56
Puku	*90*	**448**	359	*1*	**13**	11	*11*	**108**	81	*5*	**53**	51	*7*	**57**	58	*17*	**167**	83
Impala				*54*	**493**	252	*32*	**314**	248	*56*	**598**	247	*24*	**197**	134	*114*	**1222**	339
Warthog				*1*	**13**	13	*7*	**69**	46	*1*	**11**	10	*4*	**33**	21	*9*	**89**	55
Bushbuck																		
Poacher's camp																		
Giraffe										2	**21**	22						

TOTAL	1999			2002			2006			2007			2008			2009		
Area of transect		885	km^2		1,052	km^2		544	km^2		544	km^2			km^2		805	km^2
Total area sampled		5,307			5,307			5,329	km^2		5,336	km^2		5,906	km^2		6,765	km^2
SI		16.67%			19.82%			10.20%			10.20%						#####	
Species	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE	Obs	Total	SE
Buffalo	*1114*	**5542**	2443	*746*	**4833**	2224	*156*	**1529**	776	*463*	**4954**	3055	*206*	**1695**	770	*122*	**1201**	508
Wildebeest	*468*	**2360**	643	*155*	**960**	224	*167*	**1651**	324	*118*	**1261**	309	*253*	**2075**	613	*142*	**1398**	416
Waterbuck	*32*	**161**	74	*22*	**147**	43	*75*	**735**	170	*26*	**278**	113	*16*	**133**	71	*31*	**304**	110
Zebra	*114*	**566**	140	*93*	**578**	266	*116*	**1137**	588	*67*	**717**	202	*105*	**857**	373	*45*	**474**	142
Elephant	*296*	**1490**	341	*137*	**879**	180	*207*	**2055**	296	*164*	**1753**	394	*169*	**1381**	247	*279*	**2907**	517
Eland	*29*	**144**	66	*10*	**58**	40	*7*	**69**	30	*5*	**53**	32	*36*	**296**	13	*0*	**0**	0
Hartebeest	*25*	**125**	36	*2*	**11**	6	*40*	**421**	103	*0*	**0**	0	*23*	**188**	62	*12*	**129**	30
Roan	*3*	**13**	8	*6*	**31**	7	*14*	**137**	133	*0*	**0**	0	*25*	**202**	97	*12*	**187**	130
Kudu	*22*	**109**	48	*14*	**78**	25	*13*	**127**	40	*22*	**235**	82	*18*	**148**	54	*34*	**435**	133
Puku	*391*	**1967**	550	*179*	**979**	185	*224*	**2212**	409	*75*	**802**	241	*155*	**1276**	249	*200*	**1968**	408
Impala	*0*	**0**	0	*678*	**3877**	560	*556*	**5537**	779	*437*	**4671**	757	*422*	**3468**	407	*658*	**7477**	869
Warthog	*0*	**0**	0	*43*	**223**	73	*55*	**540**	122	*51*	**545**	137	*54*	**444**	91	*68*	**924**	171
Bushbuck	0	**0**	0	0	**0**	0	2	**20**	9	4	**43**	31	7	**58**	11	1	**10**	10

Main Findings - Luangwa Valley National Parks

Trends in Lukusuzi and North Luangwa National Parks are shown below. As of writing, no previous estimates were available for South Luangwa National Park to show trends.

Table 4: Estimates and trends, North Luangwa National Park, 2001-2009.

	2009			2007			2003			2001					
Area				4,580 km²						4,653 km²					
Transects		36		*18*			**36?**			*18?*			*d-test 2009 vs.*		
Species	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**Obs**	**Est**	**SE**	**2007**	**2003**	**2001**
Buffalo	145	**1,447**	776	201	**3,851**	1,746	852	**6,471**	2,502	-	**3,031**	930	-1.26	-1.92	-1.31
Elephant	343	**3,749**	525	182	**3,487**	752	426	**3,235**	355	-	**3,750**	538	0.29	0.81	0.00
Hippo	70	**689**	306	37	709	369				-			-0.04		
Impala	442	**4,350**	971	216	**4,138**	1,775	549	**4,170**	110	-	**2,576**	437	0.10	0.18	1.67
Puku	126	**1,240**	380	33	**632**	284	207	**1,572**	352	-	**1,042**	600	1.28	-0.64	0.28
Wildebeest	15	148	129	59	**1,130**	610	85	**646**	295	-	**625**	260	-1.58	-1.55	-1.64
Zebra	113	**1,191**	306	35	**671**	445	202	**1,534**	251	-	**1,231**	243	0.96	-0.87	-0.10
Hartebeest	24						13	99	38						
Bushbuck				2	38	26									
Duiker				1	19	19					57	27			
Kudu	4			9	172	76	23	175	75						
Eland							3	23	11		114	106			
Roan	14			2	38	37	84	638	272						
Warthog	46	502	115	9	172	79	63	478	84						
Sable							1	8	7						
Waterbuck	32	315	120	2	38	38	26	197	65						

Wildlife populations in NLNP are generally stable, for the main large herbivore species with significant populations over time (top half of Table 4); other species such as hartebeest and kudu (bottom half of table) have always been seen at such low numbers that estimates are unreliable.

D-tests comparing 2009 to 2007, 2003 and 2001 data show non-significant differences ($p>0.05$) for these main species.

Table 5: Wildlife observed in Lukusuzi National Park, 2006-2009.

Species	2006	2007	2008	2009
Duiker	**4**	6	2	12
Hartebeest	**2**		**4**	
Kudu	**1**		5	
Roan	**11**	**5**	**1**	**32**
Zebra	**15**	11	20	3
Warthog	**2**	**8**		**3**
Klipspringer	**1**			

Populations in Lukusuzi National Park are very low, and an estimate was possible only for Roan in 2009 (32 observations, population estimate 1,325 +/-323, Table 1). Other species appear and disappear from year to year, and mostly are represented by observations of less than ten individuals.

Main Findings – COMACO core areas

Trends and absolute numbers for all species in the 'core' COMACO areas are indicated in Figures 1-5. Trend analyses (d-tests) are indicated in Figure 4: significantly different values (critical d-value = 1.96, $\alpha=0.05$) are highlighted in bold with gray shading:

- Elephant, kudu, impala and warthog show increasing trends from 2008 (d=2.66, 1.99, 4.18, 2.47 respectively) and from 2002.
- No eland were observed during this survey; eland show a significantly decreasing trend from 2008 (d=-22.44). Few eland have ever been seen in the survey area.

For monitoring purposes, WCS has identified a 'poaching-liable' guild of target species in the COMACO area (waterbuck, eland, roan, hartebeest, kudu). Individual estimates of species in this guild are lumped together (adding estimates and variances) giving a higher power to detect changes in this guild; trends in this guild are shown in Figure 4.

- Chikwa shows a significantly increasing trend in the guild from 2008 (d=1.97).
- Weakly significant trends (α=0.10) were seen in two other COMACO areas:
    - Munyamadzi (d=1.73) shows a weakly significant increasing trend;
    - Chanjuzi (Kazembe / Chitungulu) shows a weakly significant decreasing trend (d=-1.76).
    - All blocks except Chifunda and Chanjuzi show significant increases since either the 2002 or 1999 surveys.

A combined analysis for the two surveys before and after the COMACO project is presented in Table 6. Combining the surveys (variance-weighted average) gives more power to detect change over time.

Table 6: Pre- and post-COMACO analysis

	1999+2002		2008+2009		
Area	**Total**	**SE**	**Total**	**SE**	**d-test**
Chikwa	**98**	29	**44**	11	-1.79
Chifunda	**17**	6	**178**	78	**2.07**
Chanjuzi	**7**	5	**124**	36	**3.21**
Munyamadzi	**147**	47	**357**	93	**2.01**
Mwanya	**44**	36	**61**	34	0.33
Total	**390**	72	**724**	166	1.85

Main findings for COMACO guild and blocks (Figure 4: Overall trends in COMACO core areas, absolute numbers., A combined analysis for the two surveys before and after the COMACO project is presented in Table 6. Combining the surveys (variance-weighted average) gives more power to detect change over time.

Table 6):

- Munyamadzi, Chifunda, & Chanjuzi show significant increases in poaching-liable species (the guild) in the grouped data comparing pre- and post-COMACO data.
- Chikwa and Mwanya still have very low numbers, and show no significant change ($p>0.05$).
- The overall figures (total) show weakly significant increases ($p<0.15$) comparing pre-and post-COMACO periods.

Main findings for overall survey area and all species:

- Wildlife in the survey area show dramatic differences between years and survey blocks (see Figure 3 & Figure 4). This makes comparisons difficult, and highlights the need for continuing ecosystem-wide surveys for longer-term comparison.
- Density of most species is low, and concentrated in riverine areas (see distribution maps) along the borders of the national parks.
- Wildlife populations in the COMACO area are either stable or increasing (Figure 4).
    - The only exception is buffalo, which are extremely difficult to assess due to aggregation.

- Hartebeest show significant increases (d=2.60, p<<0.05) in the grouped data, from an average of 13 to 283 in the survey areas.

Results are presented (Table 2) for the COMACO project area, excluding North and South Luangwa National Parks. Trend data are shown for previous ZAWA and WCS Flight Programme surveys in the survey area.

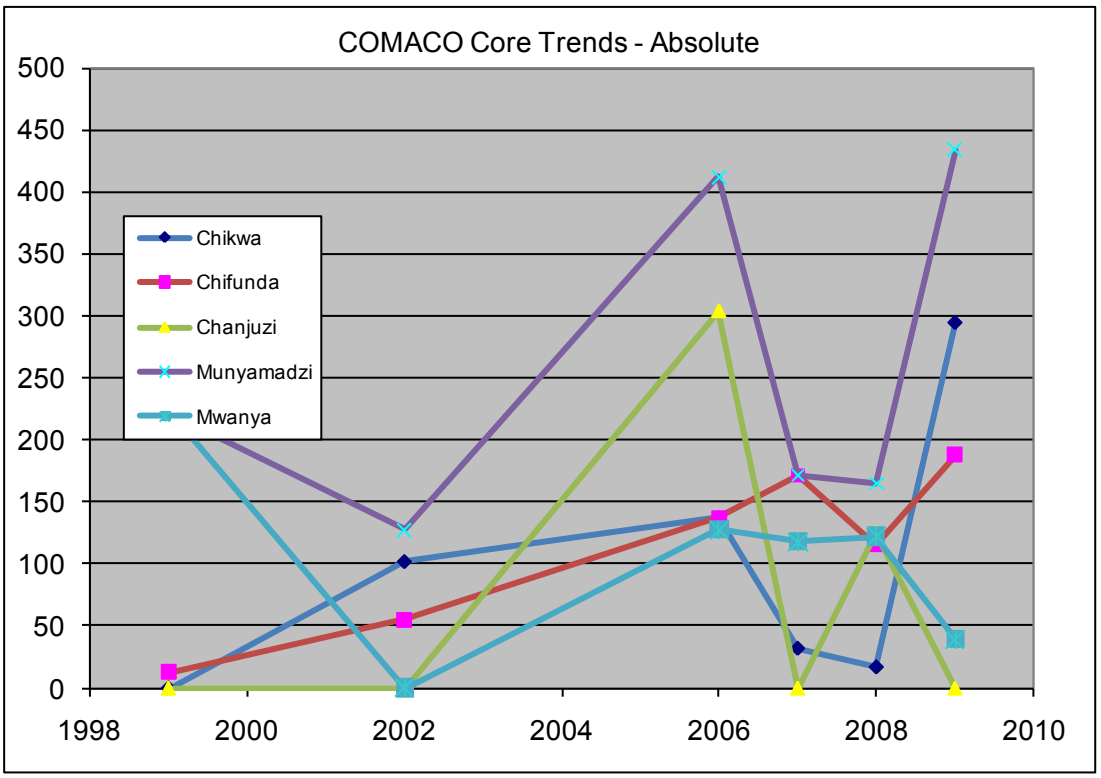

Figure 3: Absolute estimate trends, COMACO core areas.

Figure 4: Overall trends in COMACO core areas, absolute numbers.

TOTAL	1999			2002			2006			2007			2008			2009					
Area of transect		885	km2		1052	km2		544	km2		544	km2		0	km2		805	km2			
Total area sampled		5,307			5,307			5,329	km2		5,336	km2		5,906	km2		6,765	km2			
SI		16.67%			19.82%			10.20%			10.20%			10.20%			11.90%		d-test	d-test	
Species	**Obs**	**Total**	**SE**	**Obs**	**Total**	**SE**	**Obs**	**Total**	**SE**	**Obs**	**Total**	**SE**	**Obs**	**Total**	**SE**	**Obs**	**Total**	**SE**	**2008**	**02**	**99**
Buffalo	*1114*	**5,542**	4,245	*746*	**4,833**	3,401	*156*	**1,529**	1,211	*463*	**4,954**	3,055	*206*	**1,695**	770	*122*	**1,201**	508	**-0.54**	-1.06	-1.02
Wildebeest	*468*	**2,360**	1,476	*155*	**960**	583	*167*	**1,651**	910	*118*	**1,261**	309	*253*	**2,075**	613	*142*	**1,398**	416	**-0.91**	0.61	-0.63
Waterbuck	*32*	**161**	100	*22*	**147**	80	*75*	**735**	483	*26*	**278**	113	*16*	**133**	71	*31*	**304**	110	**1.31**	1.16	0.96
Zebra	*114*	**566**	240	*93*	**578**	551	*116*	**1,137**	788	*67*	**717**	202	*105*	**857**	373	*45*	**474**	142	**-0.96**	-0.18	-0.33
Elephant	*296*	**1,490**	701	*137*	**879**	398	*207*	**2,055**	816	*164*	**1,753**	394	*169*	**1,381**	247	*279*	**2,907**	517	**2.66**	**3.11**	1.63
Eland	*29*	**144**	97	*10*	**58**	45	*7*	**69**	58	*5*	**53**	32	*36*	**296**	13	*0*	**0**	0	**-22.44**	-1.28	-1.48
Hartebeest	*25*	**125**	81	*2*	**11**	10	*40*	**421**	162	*0*	**0**	0	*23*	**188**	62	*12*	**129**	30	**-0.86**	**3.78**	0.04
Roan	*3*	**13**	12	*6*	**31**	26	*14*	**137**	133	*0*	**0**	0	*25*	**202**	97	*12*	**187**	130	**-0.09**	1.17	1.33
Kudu	*22*	**109**	83	*14*	**78**	50	*13*	**127**	94	*22*	**235**	82	*18*	**148**	54	*34*	**435**	133	**1.99**	**2.51**	**2.07**
Puku	*391*	**1,967**	1,248	*179*	**979**	477	*224*	**2,212**	930	*75*	**802**	241	*155*	**1,276**	249	*200*	**1,968**	408	**1.45**	1.58	0.00
Impala				*678*	**3,877**	1,251	*556*	**5,537**	2,296	*437*	**4,671**	757	*422*	**3,468**	407	*658*	**7,477**	869	**4.18**	**2.36**	
Warthog				*43*	**223**	149	*55*	**540**	290	*51*	**545**	137	*54*	**444**	91	*68*	**924**	171	**2.47**	**3.09**	
Guild	*110*	**553**	182	*54*	**325**	108	*149*	**1,490**	538	*53*	**567**	143	*118*	**967**	146	*89*	**1,055**	218	**0.33**	**3.00**	1.77

Poaching-liable guild

	1999			2002			2006			2007			2008			2009					
Area	**Obs**	**Total**	**Se**	**Obs**	**Total**	**Se**	**Obs**	**Total**	**Se**	**Obs**	**Total**	**Se**	**Obs**	**Total**	**Se**	**Obs**	**Total**	**Se**	**09-08**	**02**	**99**
Chikwa	0	**0**	0	18	**102**	46	14	**137**	95	3	**32**	31	2	**17**	11	20	**295**	141	**1.97**	1.30	**2.09**
Chifunda	2	**12**	7	11	**55**	20	14	**137**	83	16	**171**	92	14	**115**	62	12	**188**	134	0.49	0.98	1.30
Chanjuzi	0	**0**	0	0	**0**	0	28	**303**	70	0	**0**	0	15	**125**	71	0	**0**	0	**-1.76**		
Munyamadzi	45	**222**	82	17	**127**	41	42	**412**	182	16	**171**	76	20	**165**	95	44	**434**	123	1.73	**2.37**	1.44
Mwanya	44	**222**	80	0	**0**	0	13	**127**	72	11	**118**	72	15	**122**	55	4	**39**	38	-1.24	1.03	**-2.07**
Total	91	456	115	46	284	64	111	1,117	244	46	492	143	66	544	145	80	956	233	1.50	**2.78**	1.92

Table 7: Wildlife observations in the Upper Control area, 2006-2009

Species	2006	2007	2008	2009
Baboon	30			8
Ground Hornbill	28		2	13
Elephant	24		12	29
Waterbuck		4		
Hartebeest		23	2	
Duiker	13	6	8	11
Zebra	13	11	5	6
Warthog	8		8	8
Impala	6	2		7
Eland	5		39	
Bushbuck	3		1	
Roan	3		3	28
Kudu	1		3	1
Guild	9	27	47	29

Like Lukusuzi National Park, the populations of the 'upper control area' (a subset of the Musalangu GMA) vary widely from year to year, and most species are represented by less than ten individuals.

Distribution Maps

Distribution maps were created in ArcGIS 9.3(ESRI 2008). Individual sightings were summarised by subunit (each 2.5 km long); density for each sighting was calculated on the basis of radar altimeter height for that subunit. Average densities for each species in the COMACO area were then calculated for 10x10 km blocks, which are the grid cells shown on the following maps.

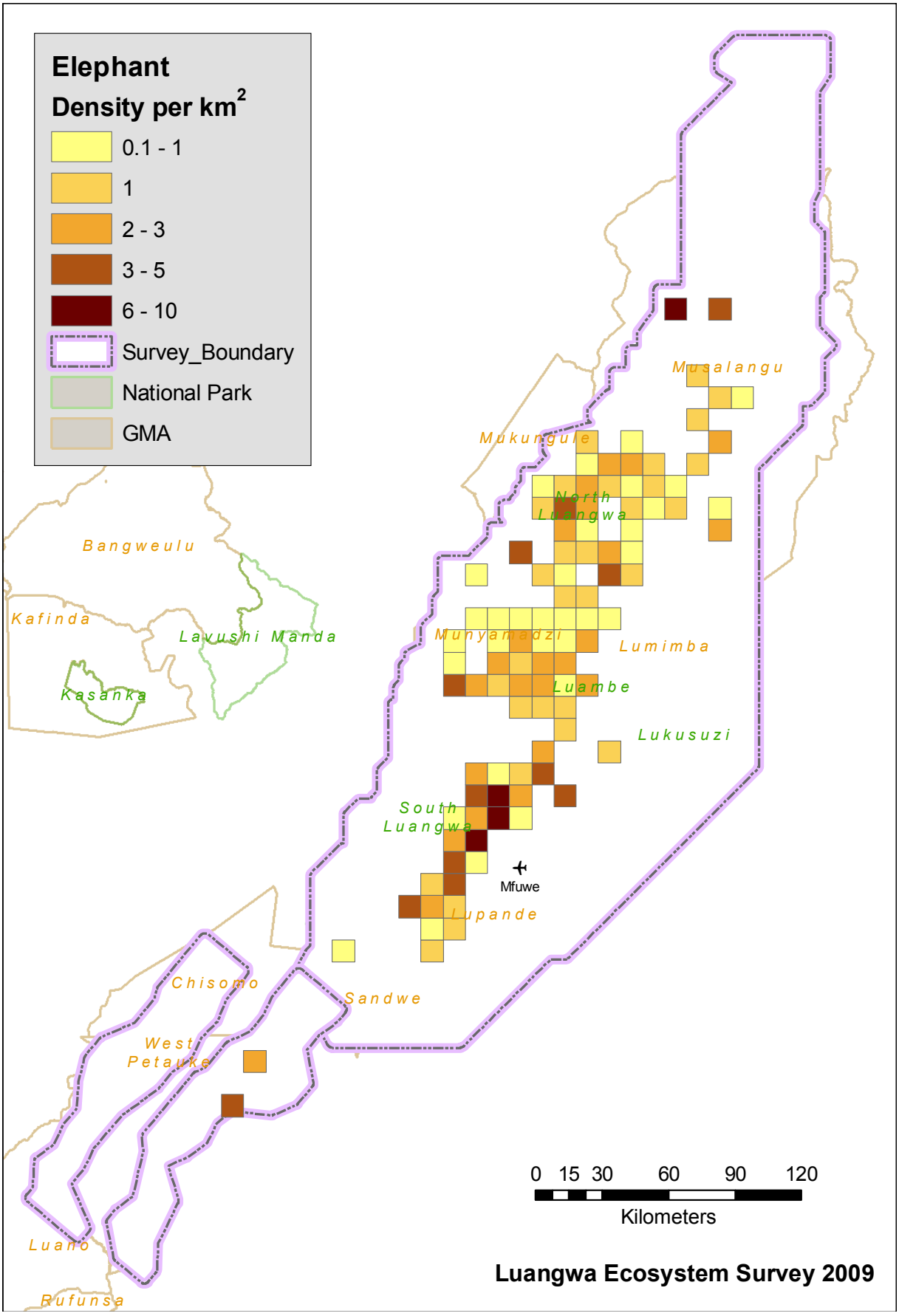

Figure 5: Density and distribution of elephant, Aug-Sept 2009.

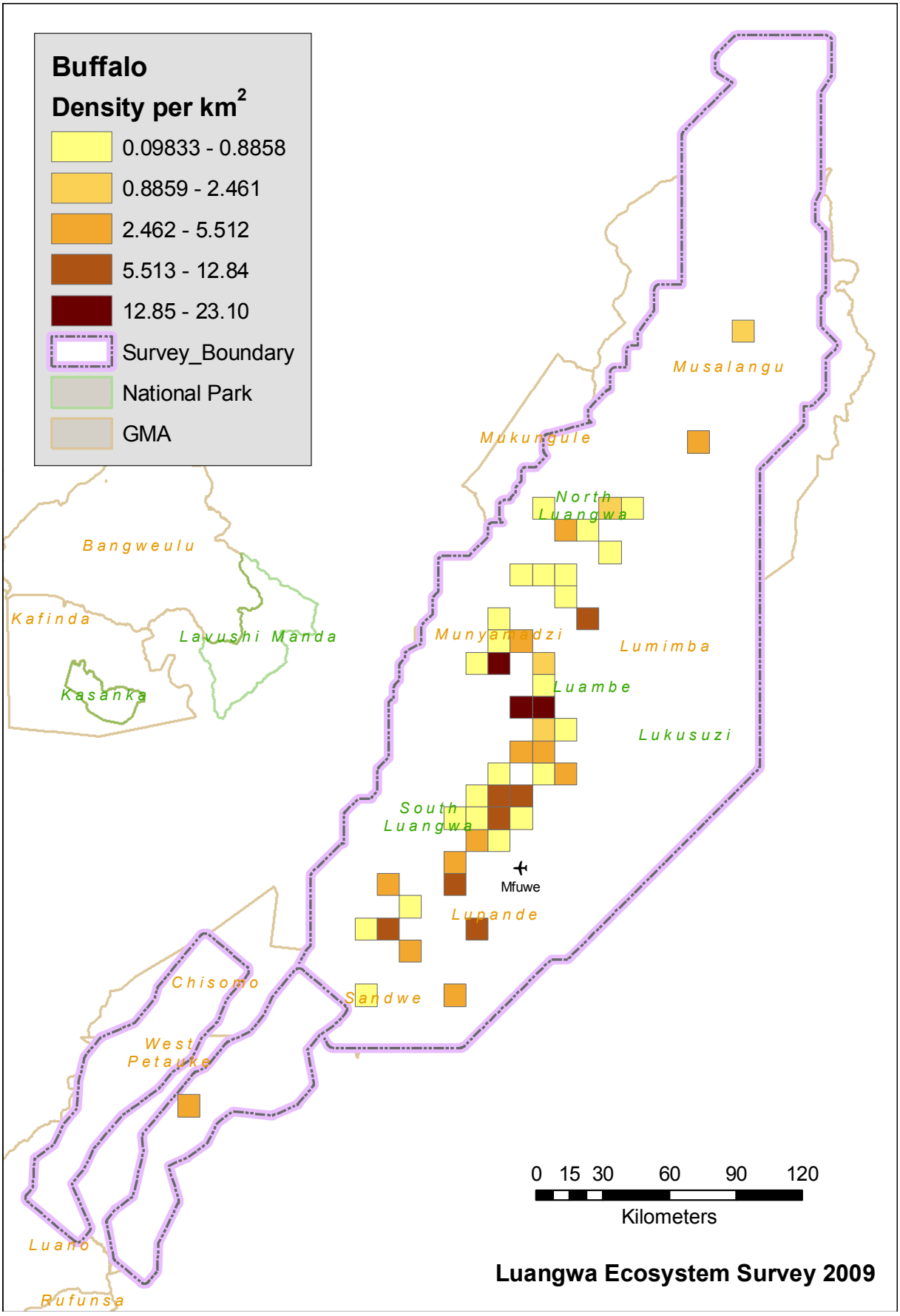

Figure 6: Density and distribution of buffalo, Aug-Sept 2009.

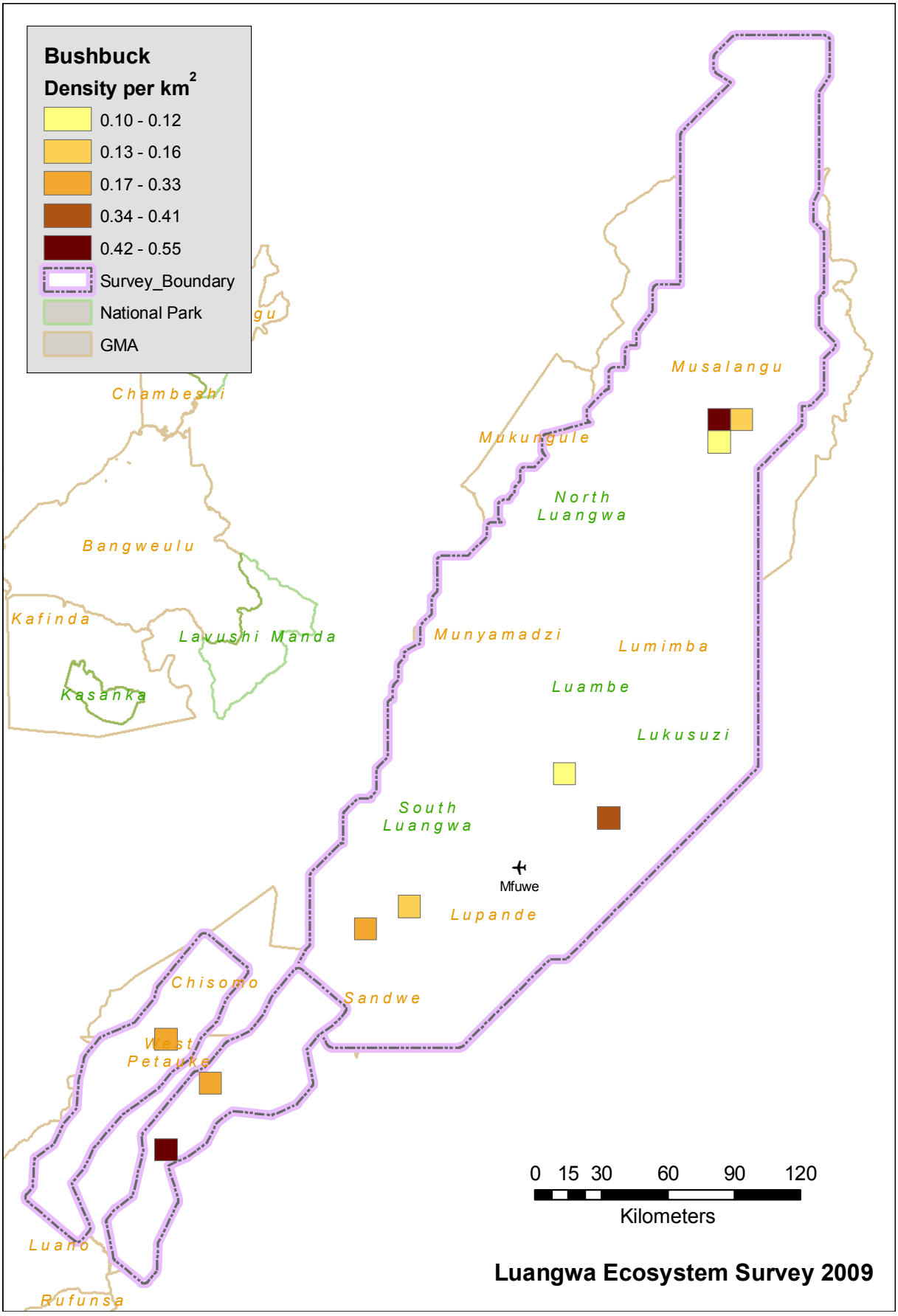

Figure 7: Density and distribution of bushbuck, Aug-Sept 2009.

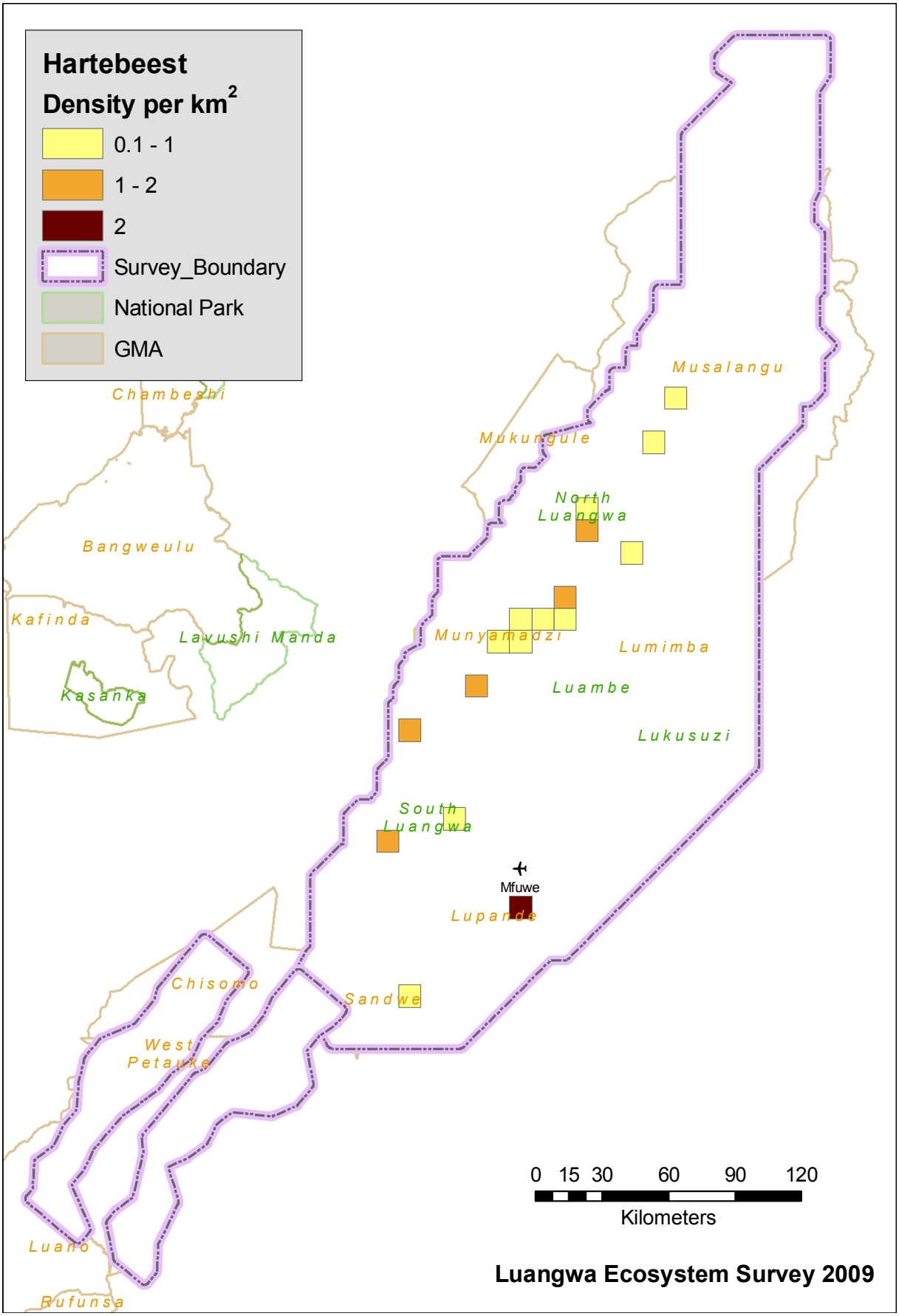

Figure 8: Density and distribution of hartebeest, Aug-Sept 2009.

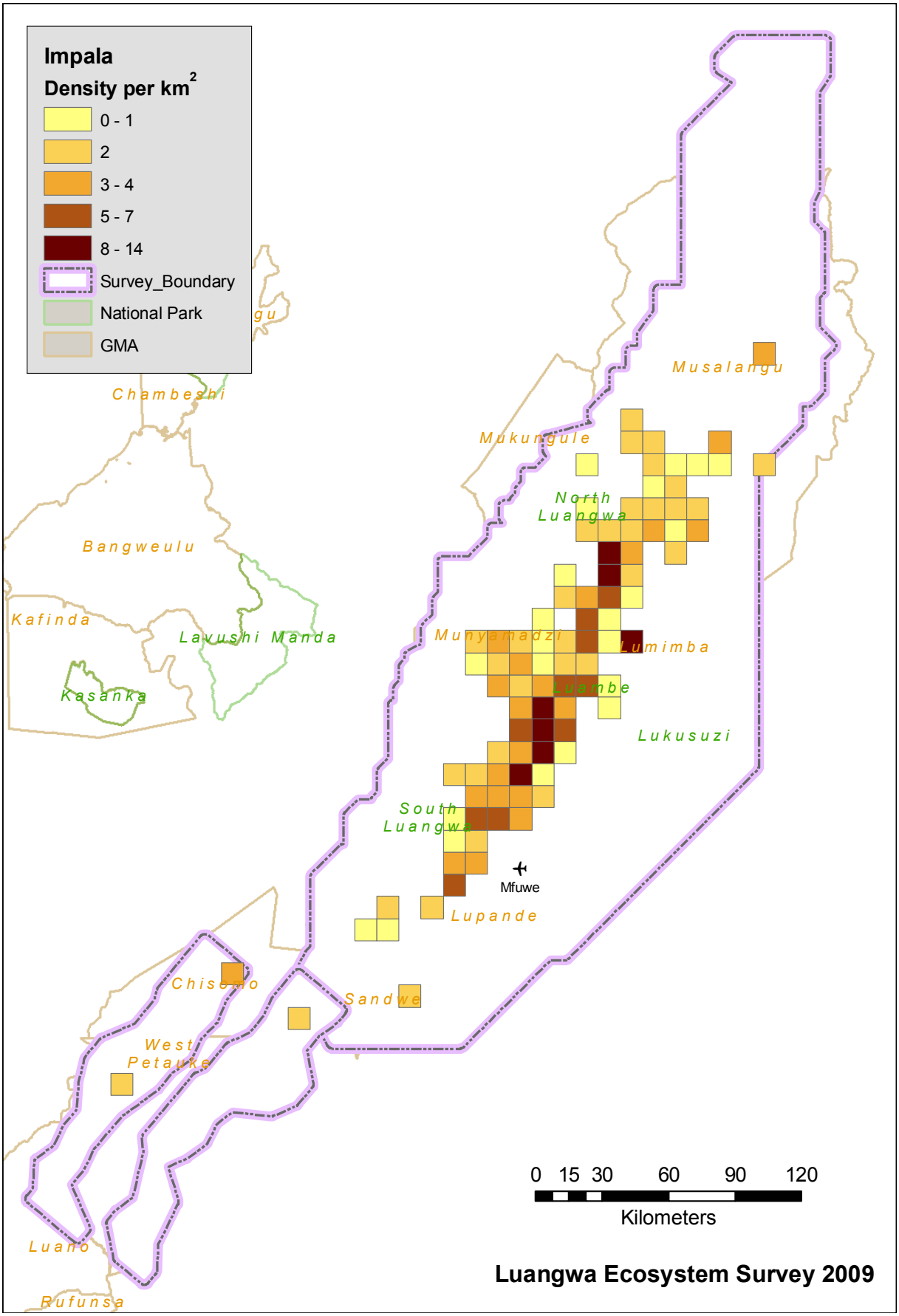

Figure 9: Density and distribution of impala, Aug-Sept 2009.

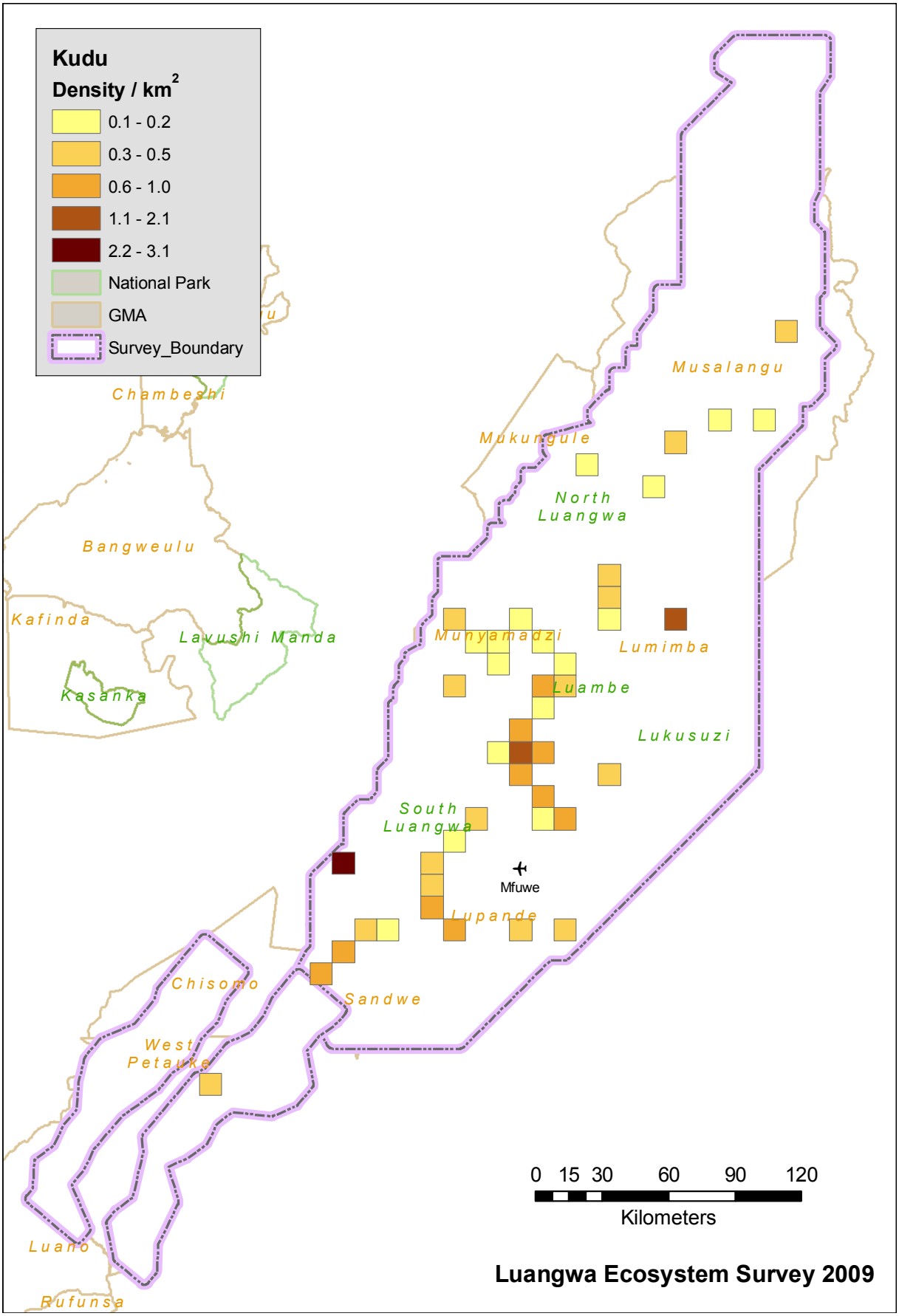

Figure 10: Density and distribution of kudu, Aug-Sept 2009.

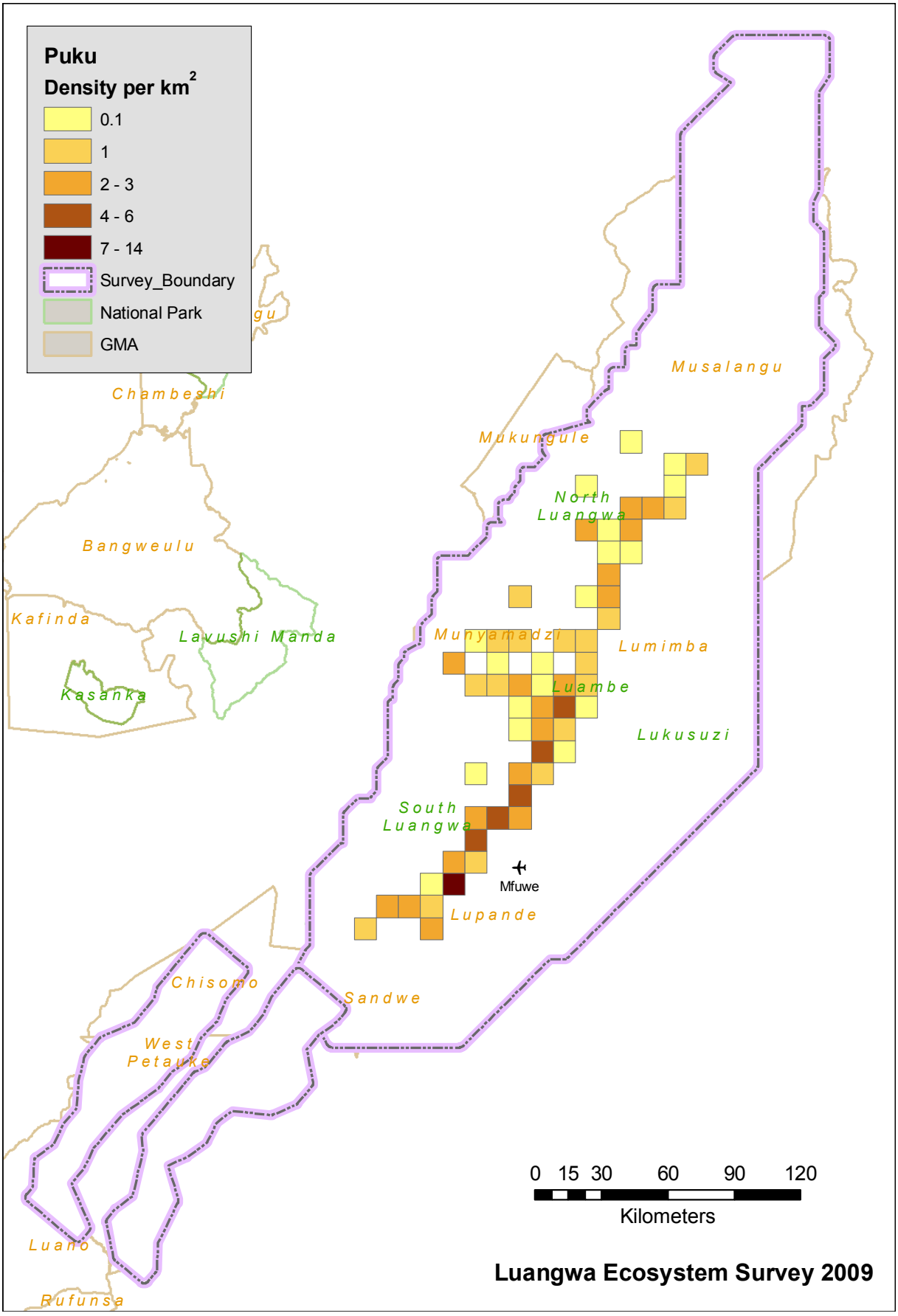

Figure 11: Density and distribution of puku Aug-Sept 2009.

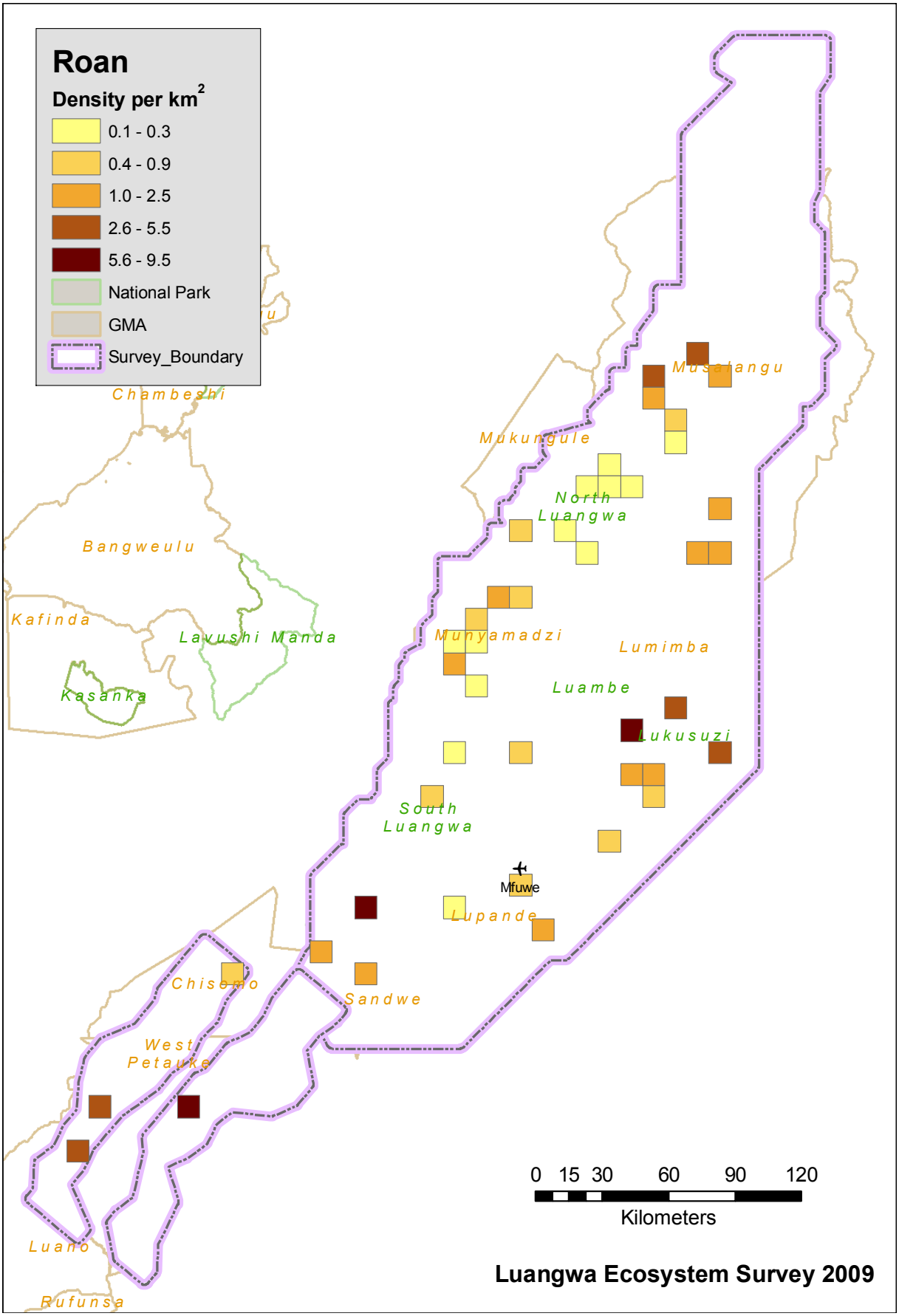

Figure 12: Density and distribution of roan, Aug-Sept 2009.

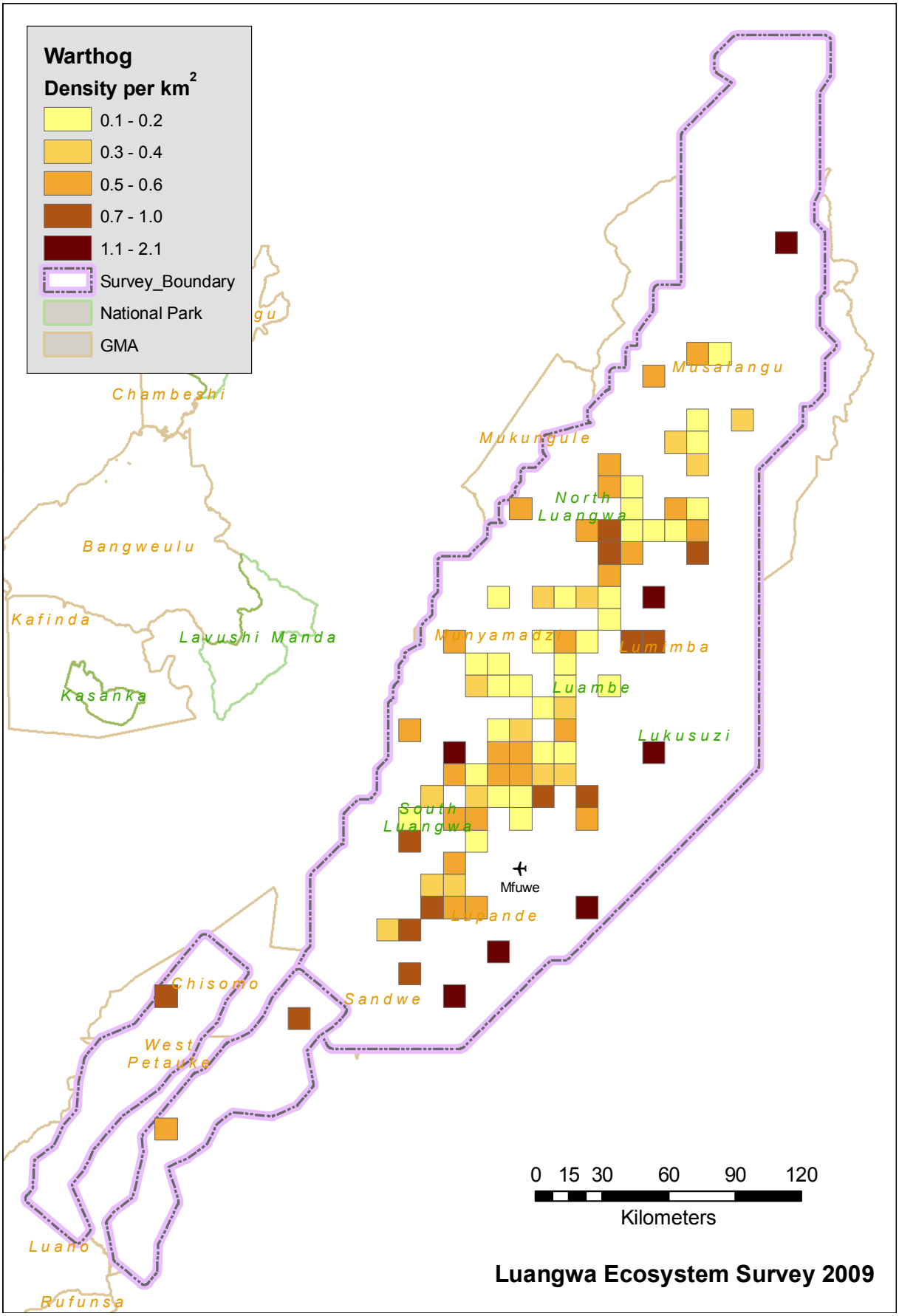

Figure 13: Density and distribution of warthog, Aug-Sept 2009.

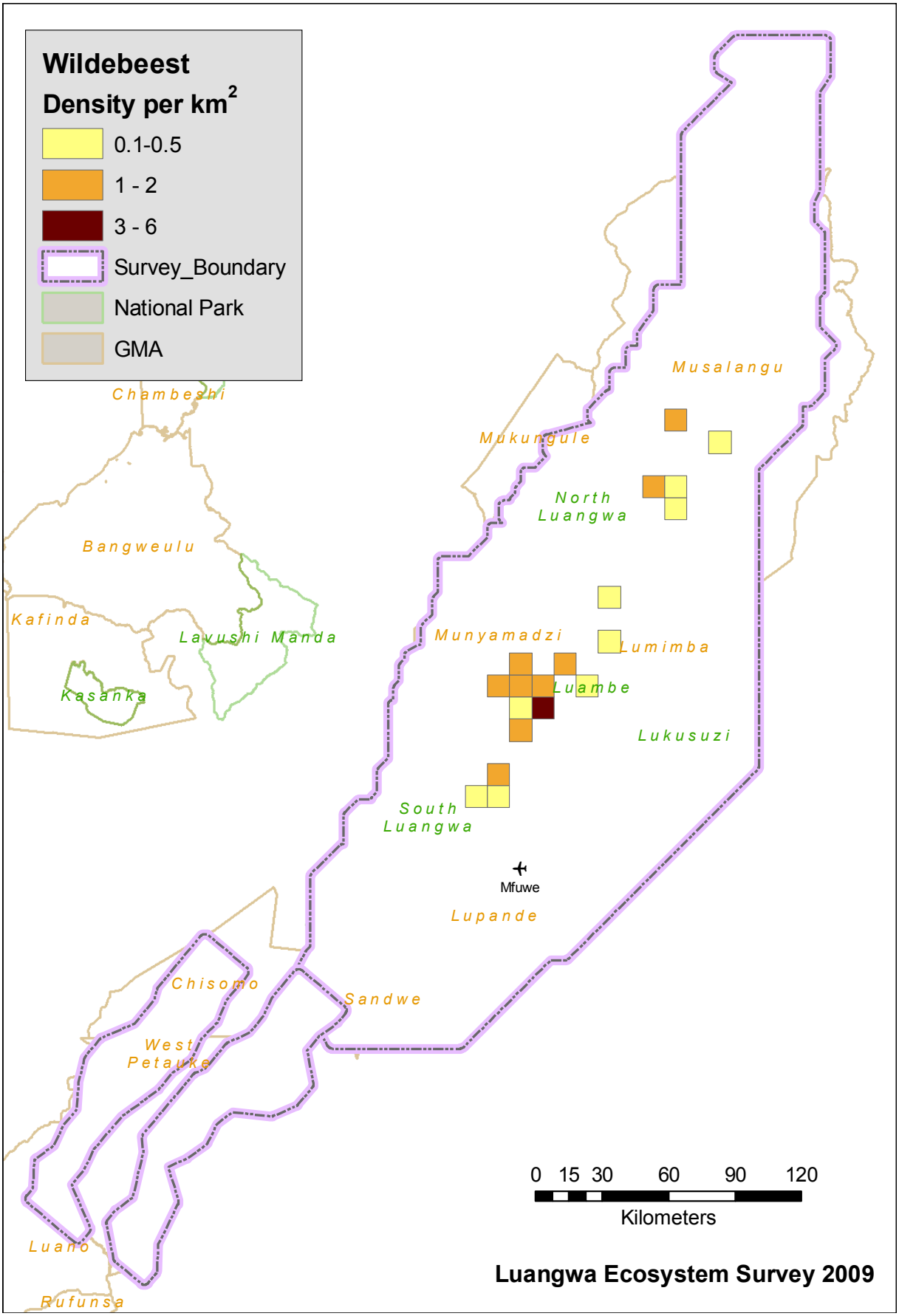

Figure 14: Density and distribution of wildebeest, Aug-Sept 2009.

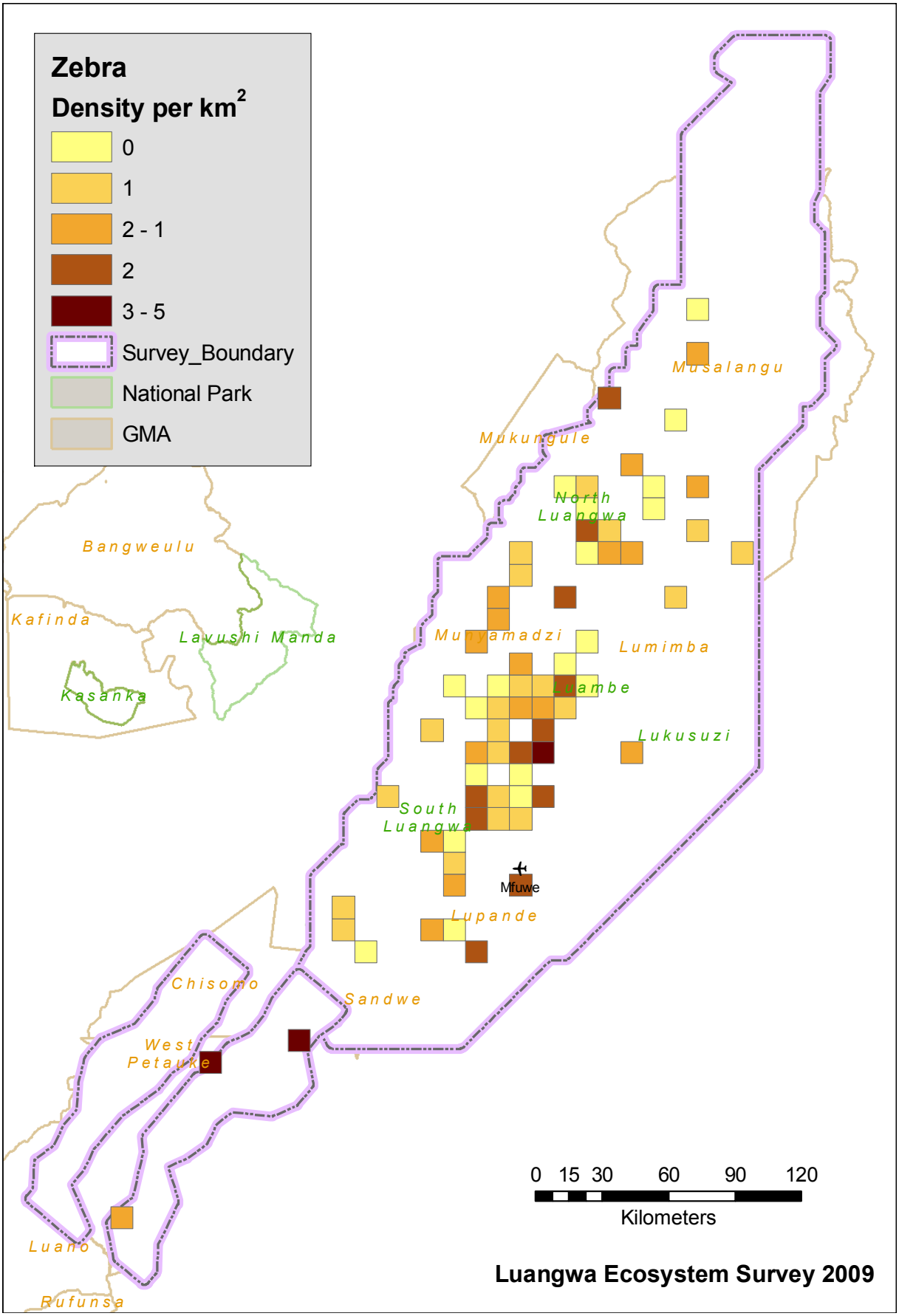

Figure 15: Density and distribution of zebra, Aug-Sept 2009.

Recommendations

This survey has afforded an excellent chance to begin long-term monitoring of areas beyond the individual project boundaries. Monitoring the wider ecosystem will allow management to detect changes in populations that might otherwise have been obscured by movements out of smaller survey areas, between National Parks and Game Management Areas.

- Valley-wide surveys should be carried out 3-yearly, with a more focussed stratification plan based on the 2009 results; this will allow a cheaper and faster survey with the same or better accuracy.
- Park and COMACO surveys, if done independently, should always include a 10 km buffer either side of the main river, to capture the populations that move back and forth across the centre of the system.