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Efficacy of Population Estimates of Large Mammals Obtained through Ground Counts in Lochinvar National Park, Kafue Flats, Zambia

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Abstract

A ground survey of large diurnal mammals was conducted in Lochinvar National Park, to determine population size and presence or absence of species. Strip count method was used which involved walking along transects and counting animals seen, signs such as spoors and pellets. Seven species were sighted during the survey, of which six were observed within 50m from the transect line. Eleven species were identified from animal pellets and footprints. Most sightings (80%) were recorded in the morning between 6:00 - 9:00 hrs. The distribution patterns varied as follows; greater kudu was evenly distributed throughout the woodland vegetation community. Buffalo, bush pig, common duiker, and chacma baboon were concentrated near Sebanze hill and the Fisheries Research station. Common duiker was only found near the southern boundary of the National Park. It was recommended that there should be annual ground surveys to fully understand population status and dynamics of the large mammals.

Keywords:-Diurnal, Large Mammal, Survey, Population Status, Distribution, Woodland

1. Introduction

Most surveys in Lochinvar National Park and the Kafue Flats in general have only covered Kafue lechwe (*Kobus leche kafuensis*) and wattled crane (*Grus carunculatus*) (Chansa & Kampamba, 2005). The population status and distribution patterns, of other species largely remain unknown. This is probably because it is presumably easier to count lechwe and wattled crane because they are mostly found in the open flood plains and can easily be seen and counted from the air. Woodland species have often been ignored to avoid costs, yet it is in the woodlands where disturbance from human activities such as; cattle grazing, bush fire, tree cutting are highest due to the closeness to human settlements. Left unmonitored these human activities destroy the wildlife habitat and species dependent on them.

Population size and distribution of the large mammal species is therefore, crucial information for the park management, as they form a basis for nature tourism for the National Park. Large mammal monitoring is also classified as "high priority" in the Zambia Wildlife Authority Research Policy (Chansa & Kampamba, 2005). While the population **of** Kafue lechwe has been frequently surveyed, other mammals have not been surveyed for more than 15 years. The purpose of this study therefore, was to; i) estimate population size of the large mammals in the woodland, ii) understand distribution patterns of the large mammal in the woodland, and iii) establish a suite of monitoring methods suitable for the woodland sector of Lochinvar National Park.

2. Methods and Materials

2.1 Study Site

The study was carried out in Lochinvar National Park, which is located on the south banks of the Kafue River almost directly opposite the Blue Lagoon National Park in the north bank (Figure 1). The area is close to Lusaka the capital of Zambia and therefore a potential area for the development of nature tourism.

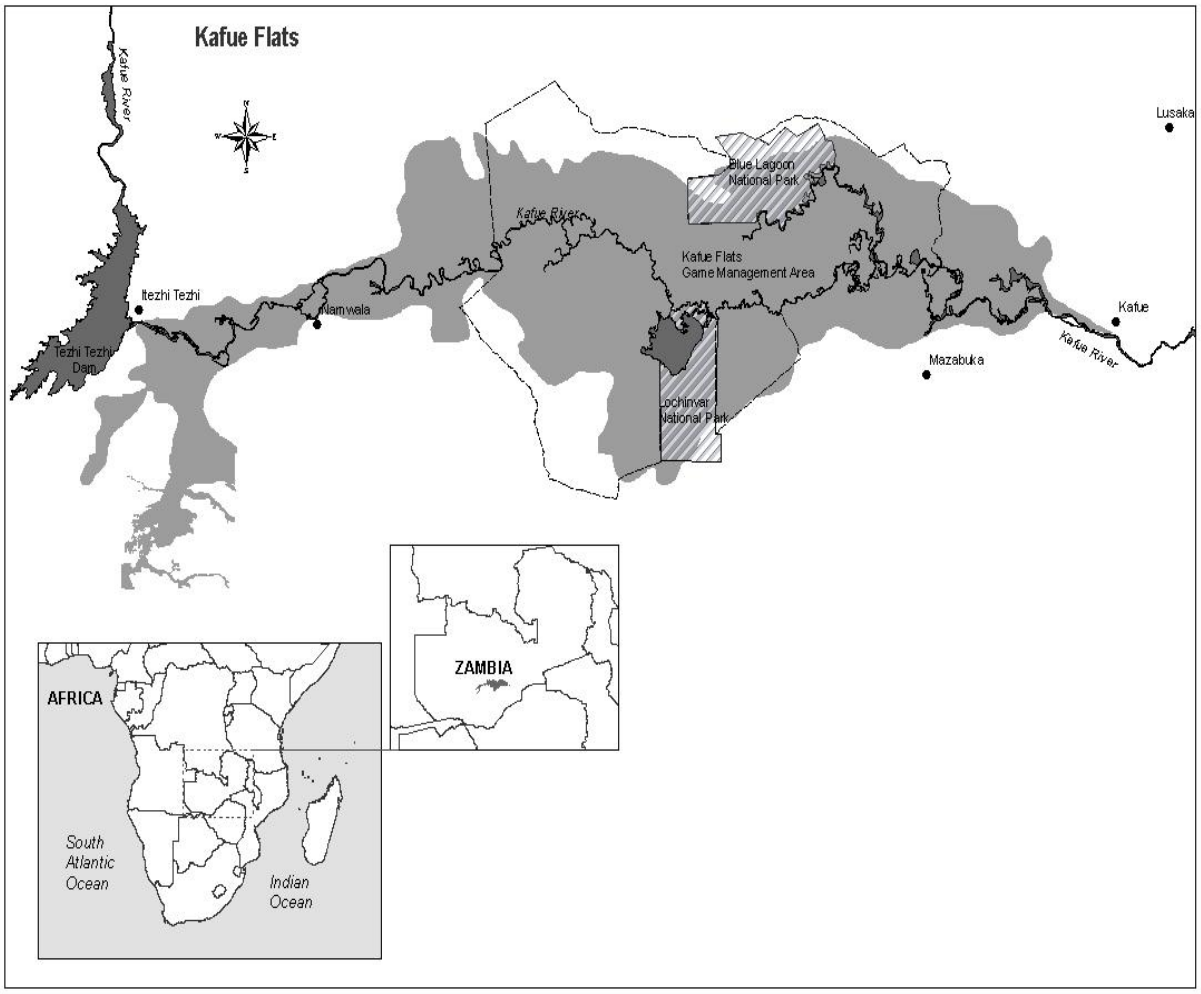

Figure 1 Location of Lochnivar National Park in the Kafue Flats, Zambia.

2.2 Study Design

Strip count method was used. Five transects were placed in the woodland area (Figure 2).Each transect was 7 km in length, but one was subdivided into three parts; 1) west to east (3km), 2) south to north (1km), 3) east to west (3km). Transect D was shorter; west to east (2km) and east to west (2km). This was done to avoid the thick thicket in the area which was impenetrable. Transects were placed 1km apart to prevent double counting. Starting and ending points were set at least one hundred meters apart from the main roads, in order to avoid effects of human activities. Coordinates for the starting and ending points of transects were given by GPS before counting started and are shown in Table 1 below.

2.2.1 Transect Preparation

Wooden pegs were firmly fixed in the ground and painted with lime to mark the beginning and end of each transect to make it easy in locating transects during repeat surveys. The bearing along the transect line was maintained by navigating using a GPS and compass. All animal pellets encountered along transects were identified based on Stuart & Stuart (2000; 2001) and then removed in order to distinguish new pellets from old ones during repeat surveys.

2.2.2 Animal Counts

The survey team walked along transects at speed of approximately 3km/hr) in the morning when it was still cool and when woodland animal species were assumed to be relatively active. All transects were covered twice, once from each end. The survey team consisted two observers and a recorder. When the survey team encountered animals, the following were recorded on the data sheet; i) time, ii) GPS coordinates, iii) species, iv) Sighting distance in metres to the animal from the transect line, and v) size and composition of the group; sex and age class of the animals.

The smallest animals targeted for the survey was common duiker (*Sylvicapra grimmia*), but other smaller animals sighted were also recorded. Pellets and footprints encountered along the transect were identified and recorded based on Stuart & Stuart (2000; 2001). Time of the day, GPS coordinates, and species were filled in the data sheet. Identification of pellets was relatively easy because ungulates produce pellet in clusters, thus the number of pellets was

counted in a cluster as well as the number of clusters. These were then removed from the transect line to prevent double counting during return survey. Spoors were also rubbed off for the same reason. Counts were done in August and September 2011 and 2012 when most of the trees are defoliated and visibility was at its best and fires not yet very hot as to burn pellets completely.

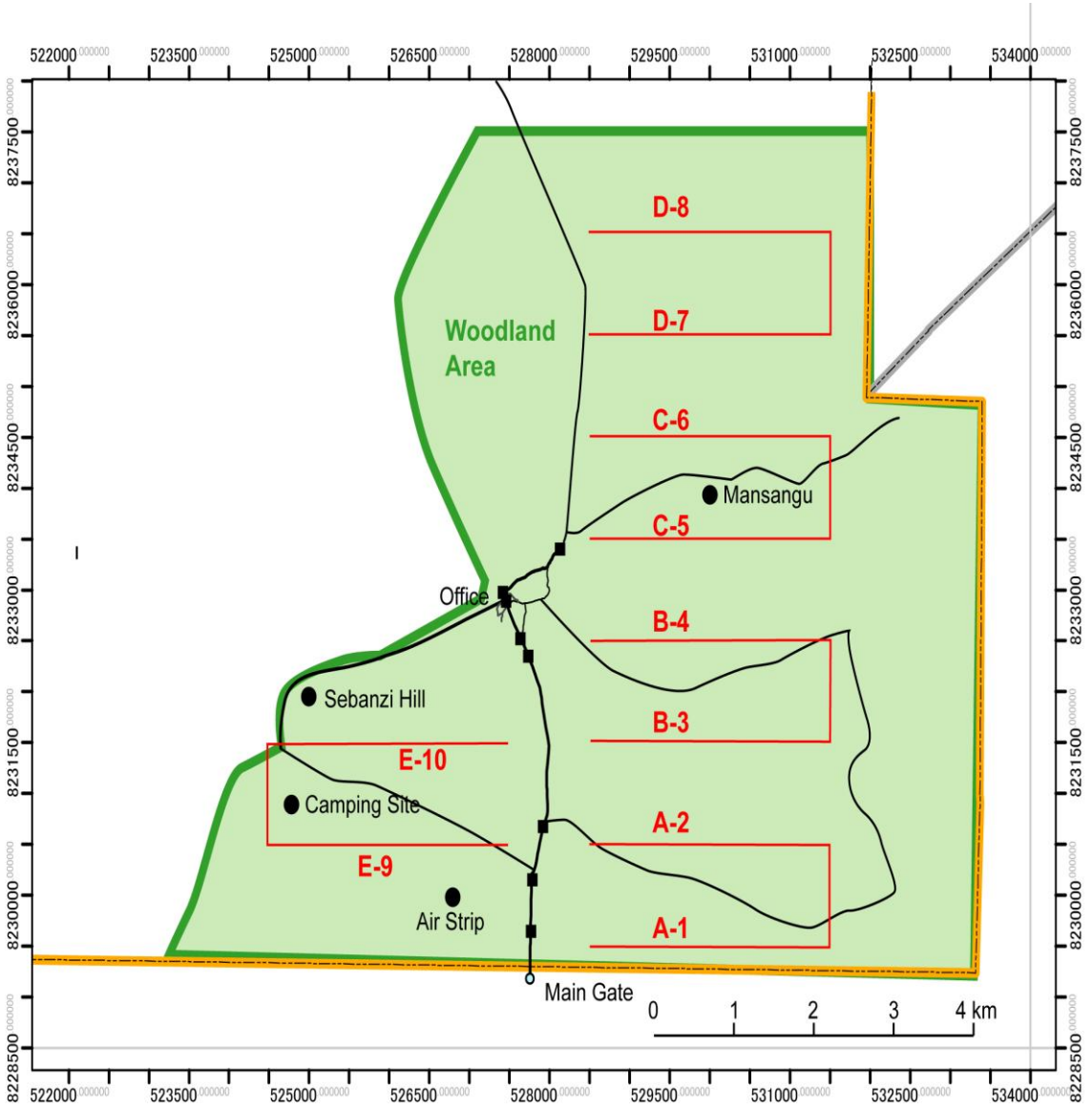

Figure 2 Location of ground transects in the woodland area of Lochinvar National Park, Kafue Flats, Zambia.

Table 1 Coordinates of the Transects, Lochinvar National Park, Zambia

Transect No.		Start		End	
		Easting	Northing	Easting	Northing
A	1	528500	8229500	531500	8229500
	2	528500	8230500	531500	8230500
	a	531500	8229500	531500	8230500
B	3	528500	8231500	531500	8231500
	4	528500	8232500	531500	8232500
	b	531500	8231500	531500	8232500
C	5	528500	8233500	531500	8233500
	6	528500	8234500	531500	8234500
	c	531500	8233500	531500	8234500
D	7	528500	8235500	531500	8235500
	8	528500	8236500	531500	8236500
E	9	527500	8230500	524500	8230500
	10	527500	8231500	524500	8231500
	e	524500	8230500	524500	8231500

Note: All the coordinates are shown on UTM

2.3 Data Analysis

2.3.1 Population Estimation

The estimated population was calculated based on the formula of aerial survey for unequal sampling units (Norton-Griffifths, 1978).

Population total $\hat{Y} = Z \bullet R$ ----------(1)

Population variance $\text{Var}(\hat{Y}) = \frac{N(N+n)}{N} \times (s_y^2 + 2\hat{R}s_{yz} + 2\hat{R}s_z^2)$ (2)

Population standard error $SE(Y) = \sqrt{\text{Var}(Y)}$ -- (3)

95% confidence limits of $Y = \pm\ t \bullet SE(Y)$ -- (4)

where N = the number of sample units in the population

n = the number of sample units in the sample

Z = the area of the census zone

z = the area of any one sample unit

y = the number of animals counted in that unit

$\hat{R}$ = the ratio of animals counted to area searched = $\frac{\sum y}{\sum z}$

t = the value of t-distribution for n-1 degrees of freedom

S_y^2 = the variance between animals counted in all the units

$$= \frac{1}{n-1} \cdot \left\{ \sum y^2 - \frac{(\sum y)^2}{n} \right\}$$

Sz^2 = the variance between the area of all the sample units

$$= \frac{1}{n-1} \cdot \left\{ \sum z^2 - \frac{(\sum z)^2}{n} \right\}$$

S_{zy} = the covariance between the animals counted and the area of each unit

$$= \frac{1}{n-1} \cdot \left\{ \sum z \cdot y - \frac{(\sum y) \cdot (\sum z)}{n} \right\}$$

The total distance travelled multiplied by the fixed strip width (50m) on both sides of the transect (100m) gives the area of sample unit which was computed using Microsoft Excel, 2007 programme.

In this survey the length of transects, was not the same, and for that reason they were treated as follows:

(i) 28 transects: A-1, A-2, A-a, … for the first and second round calculated separately.

(ii) 10 transects: A, B, C, D, E for the first and second round calculated separately.

(iii) 20 transects: A-1, A-2, B-1, B-2, for the first and second round calculated separately, but transects A-a, B-b were not included.

95% confidence level was computed by following formulae:

95% C. L. (%) =1.96[1] x s[2]/$\sqrt{}$(n-1) x a[3]/59.4[4] /Y[5]

1) Value of normal ditribution for p=0.95

2) s : sample standard deviation $s = \sqrt{(\Sigma x^2/n\text{-}x^2)}$

3) a: area of one quadrate

4) Woodland area

5) Y: estimated population

2.3.2 Distribution

Animal species distribution patterns were depicted by mapping the place of sighting and the place where tracks (footprint and pellet) were found using GPS coordinates entered in GIS software Arc View 9.0 for analysis.

3. Results

3.1 Sightings

In total, seven species were sighted during the survey, of which six were observed within 50m from the transect line. Eleven species were identified from pellets and spoors (Table 2).

Sightings were all recorded between 06:00 - 10:30 in the morning (Table3; Figure 3). More than 80% of sightings were recorded between 6:00 - 9:00 hrs, and the number of the observed groups per hour was highest between 6:30 - 7:00hrs. Sighting time also varied between species. For example, kudu and chacma baboons were sighted between early morning to mid morning (till 10:00 hrs or later). Other species were spotted earlier in the morning.

Table 2 Large mammal population counts from transects, Lochinvar National park, Kafue Flats, Zambia

Species	Direct observations				Use of signs	
	Within 50 m of transect line		Beyond 50 m of transect line			
	Number of groups	Number of individuals	Number of groups	Number of individuals	Pellet(s)	Spoor
Aardvark	0	0	0	0	1[1]	0
Blue wildebeest	0	0	0	0	0	1
Buffalo	1	30 - 100[2]	1	1	65[1]	0
Bushbuck	0	0	1	1	3[1]	3
Bush pig	1	2	0	0	18[1]	5
Cattle	1	2	1	1	1[1]	13
Chacma baboon	3	>30	3	10	17	4
Common duiker	2	2	1	1	37	25
Impala	0	0	0	0	1[1]	0
Greater kudu	2	10	2	3	233[1]	58
Spotted hyaena	0	0	0	0	1	2
Unidentified	0	0	1	2	26	0

Notes: 1) Number of pellets in cluster /dung pile; 2) Trees obstructed vision, so counting was less accurate.

Table 3 Species sighting time during the survey, Lochinvar National Park, Kafue Flats, Zambia

Time	Observed groups	Total observation period (min)	Observed groups/ hr
6:00-6:30	3	93	1.94
6:31-7:00	5	128	2.34
7:01-7:30	0	146	0.00
7:31-8:00	1	182	0.33
8:01-8:30	5	229	1.31
8:31-9:00	2	201	0.60
9:01-9:30	0	169	0.00
9:31-10:00	1	120	0.50
10:01-10:30	2	118	1.02
10:31-11:00	0	90	0.00
11:01-11:30	0	58	0.00
11:31-12:00	0	10	0.00
Total	19	1,544	0.74

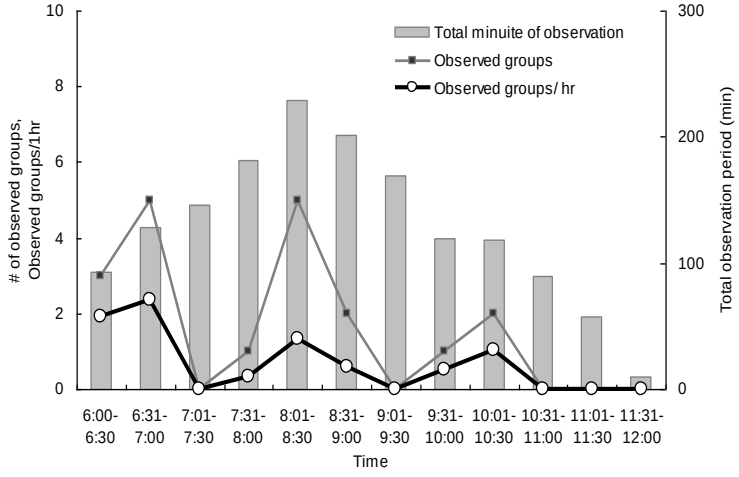

Figure 3 Species sighting time. The thick black line shows number of observed groups/ hr, which is relatively high in early morning.

3.2 Distribution

The distribution patterns varied depending on the species as follows; greater kudu (*Tragelaphus strepsiceros*) was evenly distributed through out the woodland area; buffalo (*Syncerus caffer*) showed a skewed distribution around Sebanze hill, and in the south of Mansangu Fisheries Research Centre; bushpig, (*Potamochoerus larvatus*), chacma baboon (*Papio ursinus*), were also concentrated around Sebanze hill and Mansangu Fisheries Research Centre, while a few were seen along Kudu drive area. Common duiker (*Sylvicapra grimmia*), was found near the southern boundary of the National Park.

3.3 *Population Estimates*

Population estimates of the six species are shown in Table 4, 5 & 6 with wide 95% confidence levels (Figure 4).

Table 4 Population estimates for twenty eight transects (A-1, A-a, A-2…., E-e, E-10), Lochinvar National park, Kafue Flats, Zambia

Species	Number of individuals within 50 m	Density/km^2	Estimated population	95% CL
Buffalo	30-100	10.3	610.80	+/- 328.90
Bush pig	2	0.32	18.80	+/- 36.10
Cattle	2	0.32	18.80	+/- 36.10
Chacma baboon	>30	>4.75	>281.9	
Common duiker	2	0.32	18.80	+/- 36.10
Greater kudu	10	1.58	94.0	+/- 134.7

Notes: Surveyed area 6.32km2; Total woodland area 59.4km^2

Table 5 Population estimates for ten transects (A, B, C, D, E), Lochinvar National Park, Kafue Flats, Zambia.

Species	Number observed within 50 m of transect line	Density /km^2	Estimate	95% CL
Buffalo	30-100	10.3	610.80	+/- 328.90
Bush pig	2	0.32	18.80	+/- 32.3
Cattle	2	0.32	18.80	+/32.3
Chacma baboon	>30	4.75	>281.9	
Common duiker	2	0.32	18.80	+/-32.3
Greater kudu	10	1.58	94.0	+/- 161.5

Table 6 Population estimates for twenty transects (A-1, A-2,.E-10) Lochinvar National Park, Kafue Flats, Zambia

Species	Number of individuals within 50 m	Density / km^2	Population estimate	95% CL
Buffalo	30-100	10.3	610.8	+/-328.90
Bush pig	2	0.36	21.20	+/-41.30
Cattle	2	0.36	21.20	+/- 41.30
Chacma baboon	>30	>5.36	318.2	
Common duiker	2	0.36	21.20	+/- 28.3
Greater kudu	10	1.79	106.1	+/- 153.80

1) Surveyed area 5.60km^2; 2) Total woodland area 59.4km^2

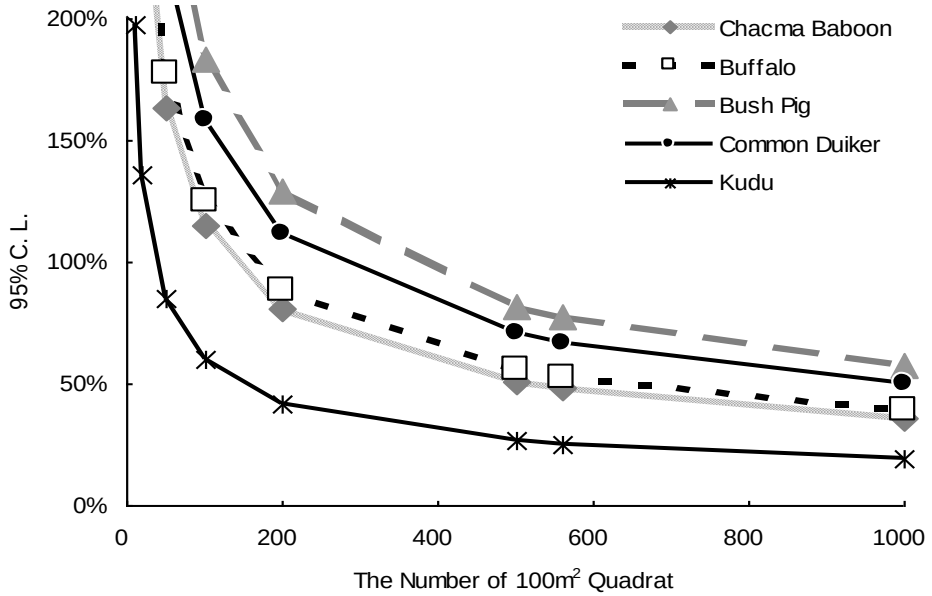

Figure 4 The 95% confidence level in different number of $100m^2$ quadrat with fixed variance. This preliminary calculation employed variance computed for $100m^2$ quadrat.

4. Discussion

4.1 Precision of the Estimated Population

The population status of most mammals, previously reported in earlier surveys (Table 7) have precipitously declined, or some of the species could be extinct. The 95% Confidence intervals obtained in this survey, which in some instances exceeded 100 %, was indicative of unreliable estimates. There were poor sighing frequencies of species and numbers per group was low.

The high value of 95% Confidence Level could also be attributed to minimal sampling effort and this might have led to fewer sightings. However, since even animal pellets and spoors encountered were also low it would be realistic to suggest that animal densities were low. It is critical to consider updating the number of species extinct since the last records were provided by Nefdt in 1992 (Table 7).

Table 7 Species' population account of wild animals of the Kafue Flats, (Modified after; Mwenya & Kaweche, 1982; Nefdt, 1992; Kampamba, 1998)

Species	**Scientific name**	**Population estimate**	**Date lastcounted/ Extinct**	**Source**
Kafue lechwe	*Kobus leche kafuensis*	38,448	2005	Chansa & Kampamba, 2005
Burchell's Zebra	*Equus quagga boehmi*	2,168	1990	Jeffery et al. 1990
Blue wildebeest	*Connochaetes taurinus*	148	1990	Jeffery et al. 1990
Buffalo	*Syncerus caffer*	116	1990	Jeffery et al. 1990
Hippo	*Hippopotamus amphibius*	80	1990	Jeffery et al. 1990
Impala	*Aepyceros melampus*	29-40	1998	Kampamba, 1998
Greater kudu	*Tragelaphus strepsiceros*	30-100	1991	Nefdt, 1992
Oribi	*Ourebia ourebi*	200	1991	Nefdt, 1992
Reedbuck	*Redunca arundinum*	10	1991	Nefdt, 1992
Roan antelope	*Hippotragus equinus*	10 (counted in North bank)	1990	Mwima, 1996
Bush buck	*Tragelaphus scriptus*	Seen no figure provided	1998	Kampamba, 1998
Common duiker	*Sylvicapra grimmia*	Seen no figure provided	1998	Kampamba, 1998
Hyaena	*Crocuta crocuta*	10	1989	Nefdt, 1992
Common waterbuck	*Kobus ellipsiprymnus*	extinct	1950s	Ansell, 1964
Side stripped jackal	*Canis adustus*	seen no figure provided	1998	Kampamba, 1998
Lion	*Panthera leo*	extinct	1960s	Sheppe & Osborne
Leopard	*Panthera pardus*	extinct	1989	Nefdt, 1992
Sitatunga	*Tragelaphus spekei*	Status not known	1972	Mwenya & Kaweche, 1992
Cheetah	*Acinonyx jubatus*	extinct	1989	Nefdt, 1992
Eland	*Taurotragus oryx*	extinct	1973	Bell & Grimsdell, 1973
Wild dog	*Lycaon pictus*	extinct	1967	Sheppe &Osborne, 1971
Puku	*Kobus vardoni*	extinct	1960s	Ansell, 1960
Warthog		Status not reported	1970	Mwenya & Kaweche, 1992
Hartebeest, Lichinsteini	*Alcelaphus lichinsteini*	extinct	1950s	Ansell, 1964
Bush pig	*Potamochoerus larvatus*	Seen number not provided	1998	Kampamba, 1998
Sharpes Grysbok	*Rhapicerus sharpei*	Status not reported	1970s	Mwenya &Kaweche, 1982
Honey badger	*Mellivora capensis*	Seen number not reported	1998	Kampamba, 1998
Aardvark	*Orycteropus afer*	Seen number not reported	1993	Kampamba, 1998

4.2 Factors Influencing Distribution

The current distribution patterns of the animal could be explained by considering the following; i) location of water points. Location of water points affect distribution of the animals in general. The main water points in the late dry season when this survey was done were near Gwisho hot springs and Gypsum mine. For example, both herds of buffalo found near Sebanze hill and Mansangu Fisheries Research Centres were all within a few kilometres from the Gwisho hot spring water point. Earlier on, ZAWA officers observed similar size of herds near the hot springs, suggesting they must have been utilising water from the hot springs. So the location of water points in the dry season seems to influence the distribution of the animals. The reason why greater kudu was widely and almost evenly distributed over the entire woodland area surveyed, could be attributed to its ability to survive without drinking water for some extended periods of time (Kingdon, 2009).

The effect of cattle grazing and human activities could also have contributed to low animal densities and poor distribution. Cattle grazing can disturb wild animals physically, and also decreases the amount of herbage available for wild herbivores. Most animals could be avoiding this area due to increasing human disturbances. The effects of fire cannot be discounted. Late wild fires in particular, often burn off all herbage including leaves on lower tree crowns. This leaves no food for both grazers and browsers. Some shallow water pools also dry up after hot fires when they are directly exposed to the sun which heightens evapouration of water. Such desolate parts of the habitat have no food and water for herbivores and are usually avoided by large mammals.

5. Recommendations

Results obtained in this study suggest a serious decline in both species numbers and population estimates. Repeated surveys would obviously be required to collect more reliable data which management can use to improve management of the National Park. Some of the suggestions that can be used to improve monitoring are given below:

5.1 Research Design

Establishing more transects which would give better picture of the distribution pattern of the animals. For example, the area north of the office, north of Sebanze hill, and south of the airstrip are the possible places for more detailed surveys.

5.2 Decreasing 95% Confidence Limits

Establishing more transects and enlarging sample size may decrease the confidence level. The number of transects may have to be tripled in order to achieve acceptable ranges of 95% confidence level, which is not practical as it may requires large numbers of manpower.

5.3 Increasing the Number of Walks

Increasing the number of walks may decrease the confidence level but this may require to be combined with increase in the number of transects.

5.4 Use of Distance Sampling

Distance sampling or Mean Perpendicular Distance Method is widely used for estimating populations (Jachmann, 2001; Shorrocks, 2007). By introducing Distance sampling, the number of sightings can increase and thus estimation could become more reliable and a narrower 95% Confidence Limits would be obtained.

5.5 Drive Counts or Line Transects along Existing Roads

Drive count is also an option to know population status of the woodland species. Drive count is also common methodology to know population status employed in many parks in Africa. In the woodland in Lochinvar National Park, there are several roads, which could be used for drive counting as shown in Table 8. The total length of the roads is 39.1 km and it is longer than the total length of transects of this survey. The drive count can than save time and energy for the researchers, and preparation work of transects is not necessary. These strong points make it possible to undertake periodic repeated research. On the other hand, fixed-width method is not applicable to estimate the population since; 1) the roads are not straight thus the research area can not be calculated easily, and 2) the roads do not cover woodland area equally, which makes overestimation or underestimation for certain species. Therefore this method can only be used to know the trend.

Table 8 Road network in the woodland area of Lochinvar National Park, which can be used for animal counts

Road	Length in Km	Remarks
Buffalo / Impala drive	3.6	
Gwisho Road 1	3.9	Office to Sebanze hill
Gwisho Road 2	2.5	Sebanze hill – Limpanda WPO Out Post
Kudu drive	12.2	Partly impassable by vehicle, may require rehabilitation
Mansangu Road	3.6	
Mansangu Road – Mpulungu Camp	3.4	Require rehabilitation
Chunga Road	5.0	Woodland area but also probably influenced by human activities
Main Road	3.7	From main gate to National park headquarters
Total	39.1	

5.6 Counting Buffalo

Total count for buffalo could be done, 1) by mapping the location of droppings and footprints, then 2) conducting physical sighting or 2') corresponding with the patrol data sheet recorded by day patrols, the number of groups can easily be assumed by mapping the location of droppings and footprints. In this survey, at least two groups were recognized, one larger concentration was aaround Sebanze hill, and smaller concentration in the south of Mansangu Fisheries Research Centre. These could perhaps be the areas where an intensive survey of buffalo would be carried out in future. Patrol data sheets also can give helpful information, and in fact, the distribution of herds can correspond to the information from the day patrol data sheets. However, the counting by the officers is often not always accurate, so that verification of the data sheet becomes essential. Buffaloes often form large herds, which makes the estimation less precise, thus field staff may require additional training in estimating animals in groups.

5.7 Other Monitoring Methods

For species such as greater kudu, counting pellets as a population index would yield fairly reliable results. Pellet counting is an option that would enable management to understand population trends of greater kudu. It is one of the commonly used indirect methods in many parts of Africa (Jachmann, 2001; Hedge and Lawson 2006, Tsujino & Yumoto, 2004). From the preliminary calculations in this survey it was discovered that pellet count method was reliable as an indicator.

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