Murchison Falls National Park Lions: population structure, ranging and key threats to their survival

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June 2014

WILDLIFE CONSERVATION SOCIETY

WILD PROGRAMME

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Acknowledgements

The study was made possible with support from USAID through the WILD program of Wildlife Conservation Society Uganda. We are grateful to the Uganda Wildlife Authority Murchison Falls National Park management for their support to this research and we thank the entire team involved for their assistance during the implementation.

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INTRODUCTION

Globally, large carnivores are facing a population decline as the ever growing human population reduces habitable landscapes in which they can live. Large carnivores are presumed to be a primary source of human-wildlife conflict (HWC) in regions where they occur, due to the predation of livestock and competition for wild game with humans (Mcdonald & Sillero-Zubiri, 2002). Increasing human and livestock populations, and land use changes are anthropogenic factors that can directly aggravate this conflict, while climatic factors, abundance and distribution of wild prey, and stochastic events influence it indirectly (Distefano, 2005) . HWC is often detrimental to the survival of carnivores leading to local and global extinctions (Cardillo et al., 2004). In the developing world - including Africa, the effects of this pressure on carnivores are more pronounced as the relative cost of coexistence with carnivores for low income communities is higher than in developed areas, leading to low public tolerance and frequent lethal control of problem animals (O'Connell-Rodwell et al., 2000).

The African lion *Panthera leo* can play an important role in income generation for countries in Africa. Income generated from National Parks and Wildlife Reserves with this iconic species often finances the protection of other species. In Uganda Lions come second to mountain gorillas as the most sought after species from results of a Wildlife Conservation Society (WCS) study of attitudes of tourists in Queen Elizabeth National Park (QENP) (Plumptre and Roberts, 2006). Tourists are willing to pay more and stay longer in the country if their chances of encountering a lion on their trip is good, resulting in more money spent in the country.

The Wildlife Conservation Society (WCS) in partnership with Uganda Wildlife Authority (UWA) conducted a national census of lions and hyenas in Uganda in the three largest savannah parks; QENP, Kidepo Valley National Park (KVNP) and Murchison Falls National Park (MFNP) between November 2008 and November 2009 (Mudumba, Okot et al. 2009). These are the parks with the largest lion populations in the country. The results of the survey showed that the lion population in Uganda had declined by at least 30% in less than 10 years with the largest decrease of 40% registered in MFNP (from 324 in 2002 to 132 individuals in 2009). At the same time, after the discovery of commercially viable quantities of oil inside the park; preparations for seismic surveys and oil extraction was starting in MFNP.

HWC is especially pronounced around MFNP as people have moved into areas near the park boundary over the past 10 years (Driciru, 2005). The area was less developed than other parts of the country due to firstly the existence of a hunting reserve to the north of the park before the 1980s civil war, and secondly the 1988-2007 insurgency in northern Uganda led by the Lords Resistance Army which required the local population to live within internally displaced people's camps away from the park boundary. The absence of direct human pressure on the park's resources during that time led to an increase in wildlife and reduced incidences of predation and persecution of wildlife (Rwetsiba & Nuwamanya, 2010). It also probably led to animals migrating out of the park to the historical hunting reserve. With the return of relative peace to the area in 2008, people started rebuilding and resettling in areas often close to the park, making themselves and their livestock vulnerable to attacks from predators

and crop raiding from grazing animals. This trend has been further exacerbated by an overall increase in human population in Uganda (Mugisha, 2002).

These increased human pressures were probably leading to a decline in lion numbers in MFNP, but there was little information available on lion ecology or which threats were the key ones leading to losses of this carnivore. The last study on lions in MFNP was over a decade ago, when Driciru (2005) looked at home range patterns of lion prides on the north and southern bank of the park. However her study area was limited to portions of the park that were secure at the time. Driciru (2005) conducted the study at a time before the recently observed influx of people as a result of the return of peace, when there were fewer livestock available at the periphery of the park, lower pressures on lion prey from hunting or livestock grazing, and before the oil explorations inside the park. No animals were radio-collared during that study and lion locations were recorded opportunistically to give an estimate of the ranging patterns of the monitored groups for about a year.

In order to better understand the ecology of lions and threats to their survival in MFNP, USAID funded a study through the WILD program of WCS Uganda which partnered with UWA to establish a research station in the park. This report summarises the findings of this research on lions in MFNP to date. The objectives of this study were to:

(1) Describe the ecology of lions in MFNP
(2) To find out the number of lions and their area of occurrence
(3) Determine the factors affecting lion population decline and key threats
(4) Establish the level of Human wildlife conflict in and around MFNP

This report mainly discusses the findings from the lions of the northern bank where we had daily radio telemetry of collared lions. We only give ranges on 2 lions from the southern bank where we put satellite collars and received daily locations of lions wearing the collars as they were too remote to visit regularly to obtain other data.

MATERIALS AND METHODS

Study site

Murchison Falls National Park (MFNP) is located in the north western part of Uganda (02°15'N 31°48'E), and as with all other national parks in the country, is managed by the Uganda Wildlife Authority (UWA) figure 1. Established in 1952, the 3,840 km^2 park was a popular tourist destination in the 1960s, having the highest number of visitors per year in Eastern and Central Africa (Rwetsiba and Nuwamanya 2010). The Nile River runs from east to west, and is channeled through a narrow (7 m wide), chasm to drop 43 m, the Murchison falls after which the park is named (Figure 1). Two wildlife reserves are contiguous to MFNP: Karuma Wildlife Reserve (KWR) to the southeast and Bugungu Wildlife Reserve (BWR) to the southwest. Together, the three protected areas contain 5,308 km^2 of natural woodland and grassland

habitat and are collectively referred to as the Murchison Falls Conservation Area (MFCA). The study area was on the northern bank as well as southern bank of MFNP totaling an area of about 1,500 km^2.

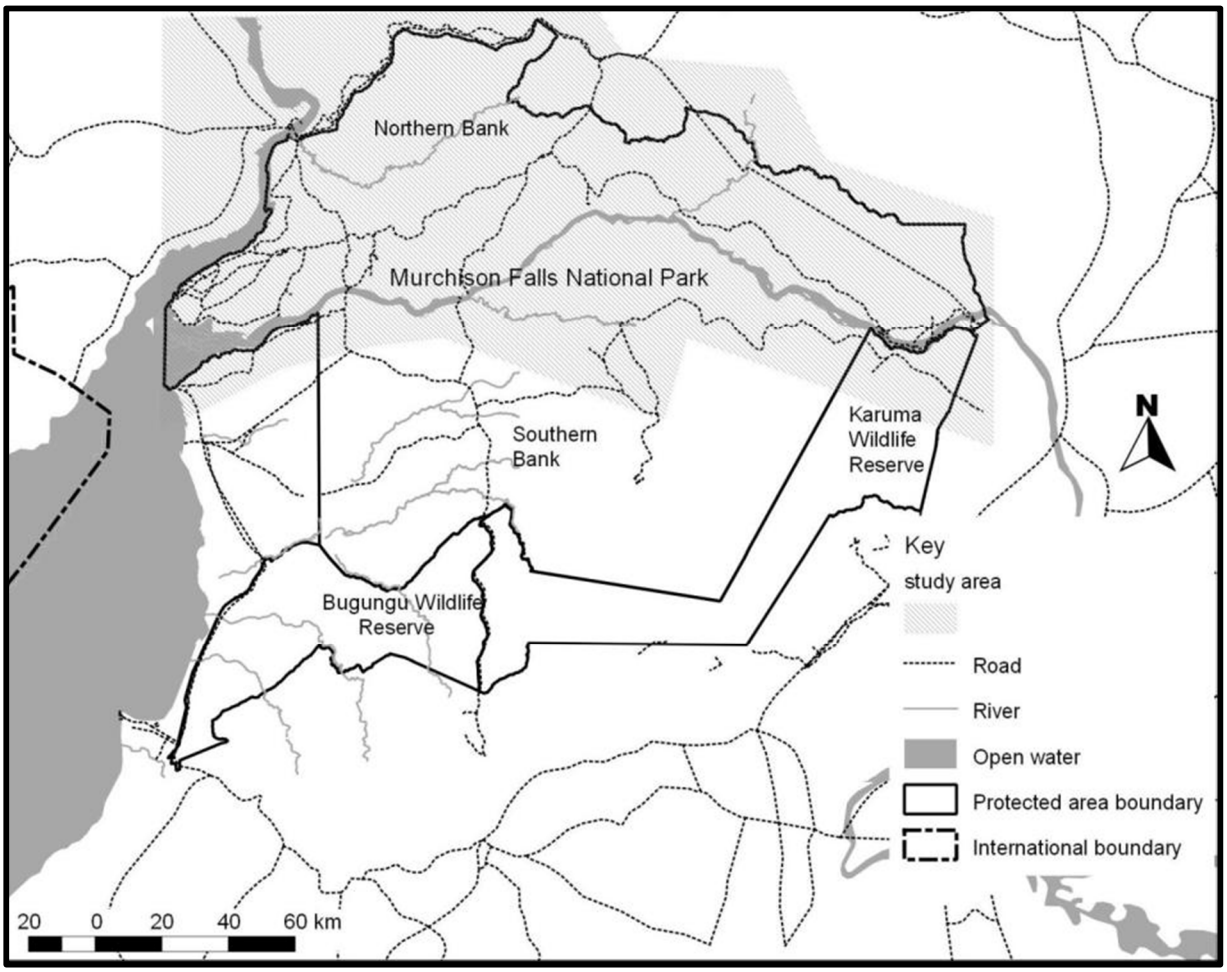


Figure 1: Murchison Falls National Park showing study area

Historically, MFNP had a rich and large carnivore community consisting of lions, leopards *Panthera pardus*, spotted hyenas *Crocuta crocuta*, and Africa wild dogs *Lycaon pictus*, as well as smaller carnivores such as jackals, smaller cats and mongooses. There has been no confirmed sighting of African wild dogs in the last three decades (Driciru 2005; Mudumba, Okot et al. 2009).

The main carnivore prey species available in the park include the Uganda kob *Kobus kob thomasi*, warthog *Phacochoerus africanus*, hartebeest *Alcelaphus buselaphus lelwel*, Cape buffalo *Syncerus caffer caffer*, waterbuck *Kobus ellipsiprymnus*, giraffe *Giraffa camelopardalis rothschildi*, oribi *Ourebia ourebi*, and reedbuck *Redunca redunca*. Aerial surveys of large mammals in the park between 1996 and 2010 have shown an increase in the population of ungulate species over this time (Rwetsiba and Nuwamanya 2010).

There are two wet seasons in the region; the main wet season from April to June and a minor one from September to October. Mean annual precipitation is 1,000-1,250 mm. The main dry season runs from mid-December to mid-February with temperatures reaching up to 40 ^{o}C and averaging about 31 ^{o}C. The Albert Nile borders the entire western side of the study area. The Park's topography is mostly undulating grassland interspersed with whistling acacia *Acacia drepanolobium* and Borassus palm *Borassus aethiopum* on the northern bank, and dense woodland intergrading with closed-canopy moist forest dominated by Cynometra *Cynometra alexandri* in the south. The vegetation of the park is becoming more woody when compared to 1958 (Nangendo et al, 2005). The reasons quoted for the changing vegetation cover of the park have been a result of a sharp decline in the population of elephants in the 1970s and 1980s and poor fire management regimes (Nangendo, 2005). The mean elevation of MFNP is 800 m. Nangendo et al (2005) provides a detailed description of the vegetation of MFNP.

Data collection on lions

Radio telemetry

One healthy adult lion and lioness was selected from each pride and temporarily immobilized using standard lion capture techniques (Jacquier et al., 2006). Seven lions were fitted with a VECTRONICS Aerospace GmbH ® collar 5 fitted with a 3D GPS PLUS 2010 VHF/GPS and 2 with AWT satellite / VHF wildlife collar, and 4 lions fitted with Ultimate V5C 373 wildlife collars.

The total weight of each collar was less than 3% of the body weight of the animal it was attached to. The process of fitting collars followed best practice as previously described (Driciru, 2005). Lions were darted on the rump or shoulder with immobilizing agents at recommended distances away (15-25 m) in the safety of a vehicle. Antibiotics were administered to counter any opportunistic infections that could have resulted from human handling (Driciru, 2005). All captured lions were weighed and measured according to De Waal et al. (2004).

The satellite collars were programmed to record and send locations which were at times used to narrow the search area when tracking lions. Each collar had a unique frequency which we received on a receiver unit connected to a Yagi-Uda antenna (Sir Track). Radio collared individuals were tracked by vehicle once every day and their geographic location reading taken using a handheld GPS unit (Garmin 60Cx) at the time of their encounter. The GPS/satellite/VHF and GPS/GSM/VHF collars were programmed to record six positions in 24 hours and to transmit their coordinates via a satellite or GSM station to a data base each time that four positions had been registered.

Home range analysis

The transmitted locations of lions wearing satellite collars were downloaded using GPS PLUS software version 3.9.3 and entered into spreadsheet software, after removing rows for scheduled locations which were missed (GPS failed to record a location, probably because of thick vegetated over-

story). The locations were then imported in a Geographic Information System (Quantum GIS, v. 1.6.0 with a GRASS GIS 6.1 plugin).

We used the incremental area analysis to evaluate the number of fixes necessary to adequately describe home ranges and calculated home ranges using the fixed kernel analyses (Harris et al. 1990). Kernel analyses were made in RANGES $8_{v2.9}$ of the radio locations assessing each 5% interval using a smoothing multiplier of 0.7 which appeared to give ranges that were not over smoothed but also were continuous and not separated into islands. Analyses were also made for lions which were not collared but had been observed sufficiently frequently to have at least 600 location points during the study period.

Use of indicators for presence of lions

When searching for the lions we made observations of other animals looking for signs of forward vigilance, whistling or ground pronging to find lions. Congregations of vultures in flight, in trees or landing were also used to find lions on a kill. We also used lion spoor to track lions.

The tracking of lions at times relied on UWA ranger guides and patrol teams who alerted the monitoring team of sightings which we investigated and confirmed before inclusion in the tracking data bank. UWA ranger guides taking visitors on safari collected information on encountered lions on standard data sheets that included: Location, age, gender, location, activity and body condition. This information was cross-checked and once verified used in the analysis.

Pride structure and composition

When we encountered lions, information on location, body condition score, group size, prey animals within vicinity, vegetation type, proximity to oil exploration site, activity, number of safari cars, and field remarks were recorded.

Whenever possible, first time sightings were photographed using a NIKON D40 or Canon EOS X6i camera to show whisker spots for identification and a movie clip recorded using a NIKON CoolPix P100. From the photographs as well as sightings, we used individual recognition using whisker spots, scars and natural ear tears from sightings to collect data on; demography, movement and distribution.

For each pride the number of members was determined through frequent visits and individual recognition. Lions of less than a year old were grouped as cubs, more than a year but less than 2 years as juveniles, between 2 and 3 years as sub adults and all lions at least 4 years old as adults.

Habitat selection

A map of the habitats in MFNP was obtained from National Forest Authority (NFA) biomass maps (2005) - compositional analysis was carried out following Aebischer et al (1993) with first the relative significance of each vegetation type tested using Wilks lambda (λ) and then a ranking matrix calculated to show whether the habitat preferences under the study time frames were significantly more or less than amongst the options. Habitat selection was analysed at two levels: within the study area; second-order habitat selection (i.e. comparing proportional vegetation use within 95% kernel home range with

proportions of total available vegetation types in the study area), and home ranges; third-order habitat selection (i.e. comparing the proportions of GPS locations for each pride in each vegetation type with the proportion of each vegetation type within the pride's 95% kernel home range) (Johnson, 1980). Statistical tests, unless otherwise described, were two-tailed with the level of significance set at 0.05.

Human-wildlife conflict assessment

Information on the locals' perceptions and attitudes towards carnivores, livestock losses to predators, and demographic and socio-economic status of households was collected using a survey questionnaire. The survey was conducted during January and February 2011 by five trained research assistants familiar with the research area and fluent in the local dialects. Each questionnaire consisted of 49 closed and 11 open-ended questions. Only one person per household was surveyed, and households were randomly selected using a fixed interval (every fifth house) from a landmark point in the community (e.g. the village clinic, school or a main junction. A minimum of 15 households at each community were surveyed. Participation was voluntary and the aim, likely output, and anonymous nature of the survey was clearly explained to all involved, in order to avoid data biases due to wrong expectations among the participants of rewards or compensations which could exaggerate the reported losses to carnivores (Romanach et al., 2007).

The questionnaire consisted of sections focusing on: demographics of the household, socio-economic status, perceived problem animals, livestock and husbandry practices, resources collected from the park, land tenure systems, relationship between household and park management, large carnivore sightings, and predation incidences and proposed solutions. Also, a section proposing an insurance scheme was included. Prior to administering it in the study area, the questionnaire was tested with a team of WCS researchers' familiar with human-wildlife conflict in the region, and edited for clarity and simplicity (Annex).

Data analysis

From lion locations collected before, during and after drilling for oil, we calculated distances and plotted locations of lions from an oil drilling site in a Geographic information system software (Quantum GIS 1.7.0). A summary of distances between the oil drill site and lions from an equal number of locations collected before, during and after drilling was done in statistical analysis software R (version 2.12). We did ANOVA of mean distances between drill site and lions for the period before, during and after drilling and a post hoc Tukey's HSD test significance between periods.

Responses from all questionnaires were digitally collated into a spreadsheet and eventually into the statistical analysis software R (version 2.12). General linear models were used to examine relationships between attitude and welfare, benefits from park, carnivore sightings, participants' ethnicity, gender, and occupation, resource use and husbandry practices, and carnivore attacks on

wildlife and people; other parameters included: distance to nearest police and ranger stations, distance to park boundary and health centre. Geographic information system software (Quantum GIS 1.7.0) was used to extract geographic parameters: distance to the park boundary, distance to the nearest police or ranger station, and distance to the nearest health centre.

The cultural beliefs in the area regarding large carnivores were also recorded and divided in two groups; those that promoted conservation and those that did not. Using the responses from a specific subset of questions, a welfare and attitude index was developed for each participant (Appendix 1).

Statistical tests, unless otherwise described, were two-tailed with the level of significance set at 0.05.

RESULTS

Demography

Ten lions on the northern bank (from 4 prides) and 2 lions (from 1 pride) on the southern bank were collared for this study. For a three year period up to June 2014, average pride size was 17.75 ± 2.17 with maximum pride size of 24 found in the Delta area and minimum pride size of 14 lions found in Wangkwar area (Table 1).

Table 1: Pride structures of the northern bank study area in each year of study

		Pride				
Month & year	Age group	Delta	Oil	Borassus	Wangkwar	Total
Oct-2011	Cub	9	6	6	2	23
	Juvenile	4	4	0	0	8
	Sub adult	0	1	1	0	2
	Adult	7	7	8	7	29
	sub-total	**20**	**18**	**15**	**9**	**62**
Oct-2012	Cub	2	8	9	4	23
	Juvenile	5	0	5	0	10
	Sub adult	4	4	4	0	12
	Adult	7	7	5	7	26
	sub-total	**18**	**19**	**23**	**11**	**71**
Oct-2013	Cub	7	1	3	7	18
	Juvenile	2	5	5	1	13
	Sub adult	5	0	3	4	12
	Adult	10	11	9	2	32
	sub-total	**24**	**17**	**20**	**14**	**75**
Jun-2014	Cub	5	3	0	0	8
	Juvenile	3	1	3	1	8

Sub adult	1	5	5	4	15
Adult	15	11	12	7	45
sub-total	**24**	**20**	**20**	**12**	**76**

The current population of lions on the northern bank as of June 2014 from total counts was 76 (59.2% adults) with 8 cubs, 8 juveniles and 15 sub adults. The Wangkwar pride has 1 juvenile lion while the Delta and Borassus region prides have 3 juveniles.

Delta pride has had 24 members for the last 2 years while the borassus pride has had 20 individuals. The Oil region pride and the Wangkwar pride average 18.5 and 12.3 lions respectively over the study period. This is despite continued monitoring of the areas for new individuals. It is therefore likely that we have recorded all the pride members of these 2 prides. However it is likely that Wangkwar pride individuals are not yet fully identified (Figure 2). However, the numbers of recognized lions has increased from 62 to 76 over the nearly four years of study and probably reflects an increase in the lion population during this time.

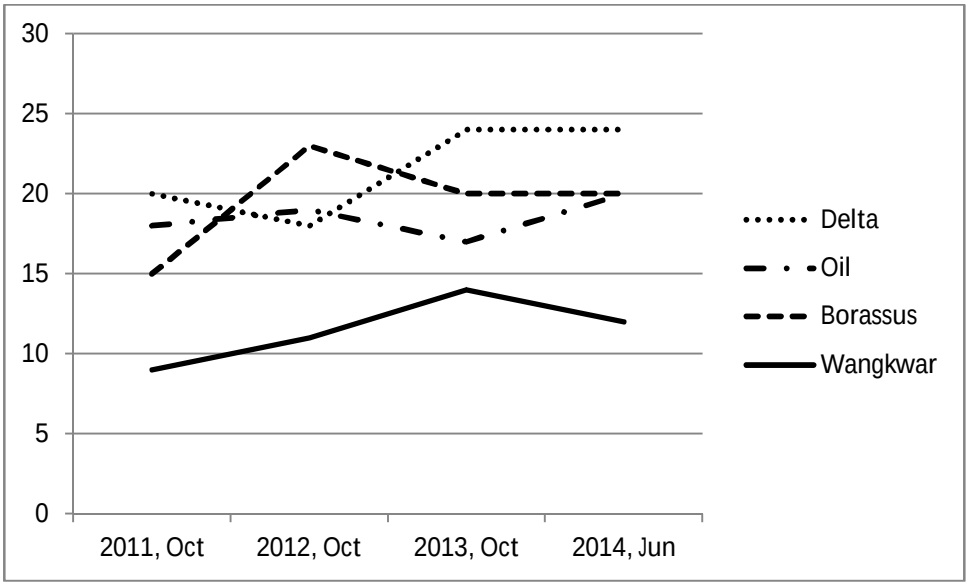


Figure 2: Number of lions from 4 prides on northern bank of MFNP; Oct 2010 to June 2014

Fecundity and Sex ratios

A total of 18 females were of reproductive age with 88.8% (n=16) seen with cubs during the study period. Excluding Wangkwar pride, because we found only 2 adult females despite many visits, the average number of reproductive females per pride has been 6.1 ± 0.78 (n=16). Delta pride has had the highest number of reproductive females (Table 2).

Table 2: Number of reproductive females per pride between Oct. 2011 and Jun. 2014

Pride	Month & year			
	Jun-2014	Oct-2013	Oct-2012	Oct-2011
Delta	7	5	4	4
Oil	10	10	6	6
Borassus	9	7	7	6
Wangkwar	2	2	2	2

A total of 59 cubs were born during the study period. The average number of cubs born per female per year from the study is 2.65 ± 0.39 in 26 litters. Eight lionesses had 1 litter, 4 lionesses had 2 litters and 4 lionesses had 3 litters. Most (n= 14) of the litters were first seen before the age of 1 month and 11 litters were first seen aged at least one month old. Most (61.5%, n=16) of the litters seen consisted of 2 cubs; 19.2% (n=5) had 3 cubs; 15.4% (n=4) had only 1 cub; and 3.8% (n=1) consisted of 4 cubs. Uniquely, one litter of a collared lioness Faib (DFO_002) was observed from birth. We were able to collect accurate information about this littler from time of birth including number of cubs born. This is not usually the case and what is usually recorded in the wild is number of cubs seen with the lioness after about 3 weeks. This potentially misses out cubs that do not survive for that long from birth. The sex ratio is slightly skewed at birth 1 female for 1.3 males (n= 25 for females and 34 for males) and 1:1 for litters older than a month (n= 23 for females and 21 for males). There were more females amongst adults at 1 male for every 1.7 females (n=29).

Mortality

Twenty seven lions died during the study period just over half being males (52%). Among the age classes, 81.8% (n= 18) were cubs, 4.5% (n= 1) juveniles and 13.1% (n= 3) adults. The cause of death for forty percent could not be ascertained; of the remaining sixty percent, 45% (n= 6) died of natural causes and 55% (n= 9) died from human related incidences.

Figure 3: Rescue of male trapped in wire snare

The human related incidences were: a) strangling by illegal wire snare trap for a juvenile and a pride male (Bernie, OMS_007), and b) suspected poisoning for adult female Bridget (OFS_021) who died pregnant with 3 cubs at an oil well site (Buffalo East 1). Three cubs were killed by uncontrolled fire suspected to have been started as part of early burning in the Borassus region.

Among those that died due to natural causes was pride male Bright (DMO_012) killed by another adult male lion coalition, Butcherman (DMO_011) and Bernie (OMS_007) in a pride take-over fight in the delta region. Fatuma (DFO_003) was trampled by 2 buffalos while giving birth and killed with 3 cubs. The others were a Juvenile Leticia (DFB_049) who was gored by a warthog during a fatal hunt. On 12th July, 2014 Banura's (DFB_073) 2 cubs (1 female, DFB_080 and 1 male, DFB_081) were trampled by buffaloes killing them instantly. In April 2014, Wako's (BMR_069) VHF collar was found near Pakuba airstrip (02 20 06N, 31 28 12E) and Wako has not been seen and is likely dead. The oil region pride registered the most number of dead lions (Table 3). In addition, seven lions have been seriously injured (3 by wheel traps & 4 by wire snares) and required veterinary interventions (3 lost their limbs).

Table 3: Dead lions by pride, sex and age class

Pride	Adult		Juvenile	Cub		Total
	Female	Male	Male	Female	Male	
Borassus			1	1	2	4
Delta	2	1		3	5	11
Oil	1			2	6	9
Wangkwar				1	1	2
Grand Total	**3**	**1**	**1**	**7**	**14**	**26**

Ten lions have not been seen for at least a year. The females are most likely dead and the males could have possibly dispersed from their natal prides or lost prides (Table 4).

Table 4: List of known missing lions

Name	Unique code	Sex	Age Group	Date last seen	Comment
Opido	DMO_001	Male	Adult	Mar-11	Last seen by WCS lion team near Tangi gate
Freda	DFB_024	Female	Adult	May-11	Last seen by WCS lion team in delta area
Peace	BFR_045	Female	Adult	Jun-11	Last seen by WCS lion team in Wangkwar area
Mathew	WMR_026	Male	Adult	Jul-11	Last seen by UWA chief warden along wangkwar road
Male 2	BMR_037	Male	Adult	Jul-11	Last seen by UWA ranger at Tangi gate, could have move eastwards out of our coverage
Male 1	WMR_038	Male	Adult	Jul-11	Last seen by UWA Vet. Problem animal in Purongo
Mpagi	WMR_039	Male	Adult	Aug-11	Last seen by UWA guide on wangkwar road to top of falls
Akum	BFR_041	Female	Juvenile	Sep-11	Last seen by UWA ranger at Tangi gate
Acayo	BFR_042	Female	Juvenile	Sep-11	Last seen by UWA ranger at Tangi gate
Faib	DFO_002	Female	Adult	Feb-14	Last seen by WCS lion team near Pakuba airstrip

Home range

Incremental area analyses were made for each lion's locations and it was found that the 95% kernel contour area for all collared lions reached an asymptote between 300-600 locations (Appendix II). We only analysed those lions that had enough locations to reasonably assess home range size. We examined change in area of ranges by 5% intervals and found no inflexion point (Appendix II). Therefore, we assessed home range size of 95%, 75%, 50% and 25% fixed kernel contours (Table 5 and figure 4).

The largest representative home range from 95% fixed kernel home range size estimate is 70 km^2 for a male lion in the oil region and smallest is 35.9 km^2 for a lioness in the borassus group (Table 5 and figure 4).

Table 5: Summary of individual home range size

		Fixed kernel home range (km^2)			
ID (sex)	**Pride**	**95%**	**75%**	**50%**	**25%**
DMO_001 (Male)*	Delta	206.8	119.0	69.1	11.4
DFO_002 (Female)	Delta	65.1	29.6	14.6	6.7
DMB_052 (Male)	Delta	70.7	38.5	16.9	4.9
Average		**67.9**	**34.1**	**15.8**	**5.8**
DFB_073 (Female)	Oil	43.5	20.0	8.7	3.0
DMO_011 (Male)	Oil	88.6	31.4	16.8	5.6
DMB_075 (Male)	Oil	36.5	17.0	10.0	4.7
Average		**56.2**	**22.8**	**11.8**	**4.4**
OMS_005 (Male)	Borassus	70.0	34.4	16.0	6.1
BFR_013 (Female)	Borassus	35.9	17.1	7.3	2.7
Average		**53.0**	**25.8**	**11.7**	**4.4**
WFR_006 (Female)	Wangkwar	40.7	24.9	9.6	1.7
SbFK_001 (Female)	South bank	9.7	3.3	1.2	0.2
SbMK_002 (Male)	South bank	18.5	11.8	6.4	2.5
Average South bank		**14.1**	**7.6**	**3.8**	**1.4**

* Male dispersed from pride range after take-over by coalition of 2 males giving it abnormally wide ranges. DMO_001 has not been included in the calculation of average range size of the Delta pride.

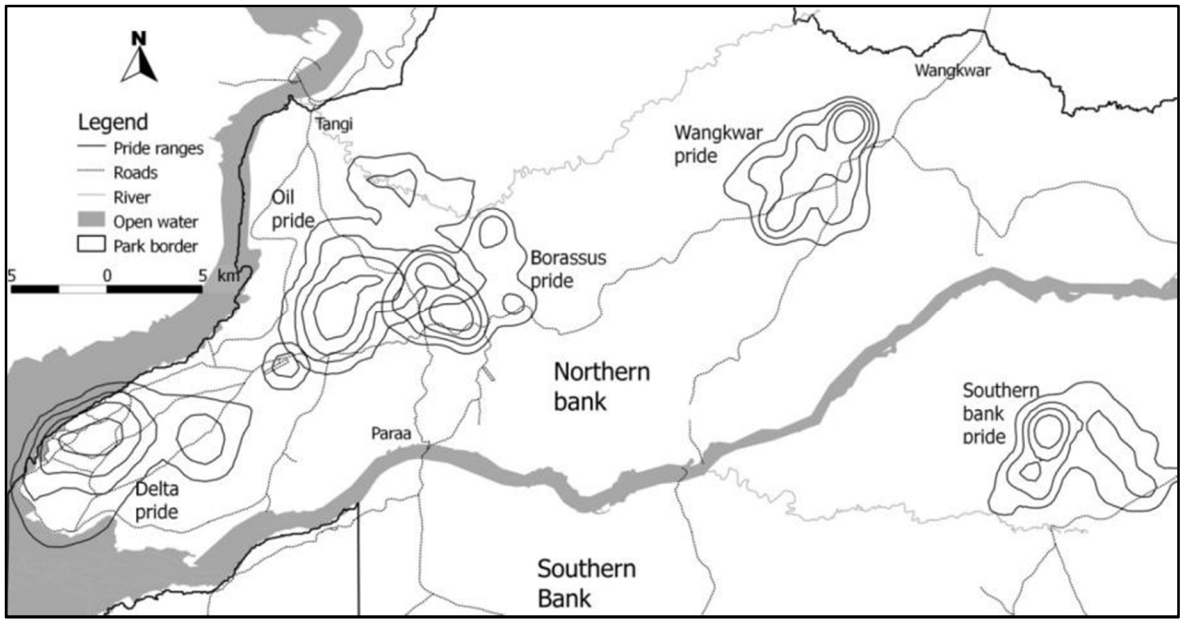


Figure 4: Lion pride ranges during the study period

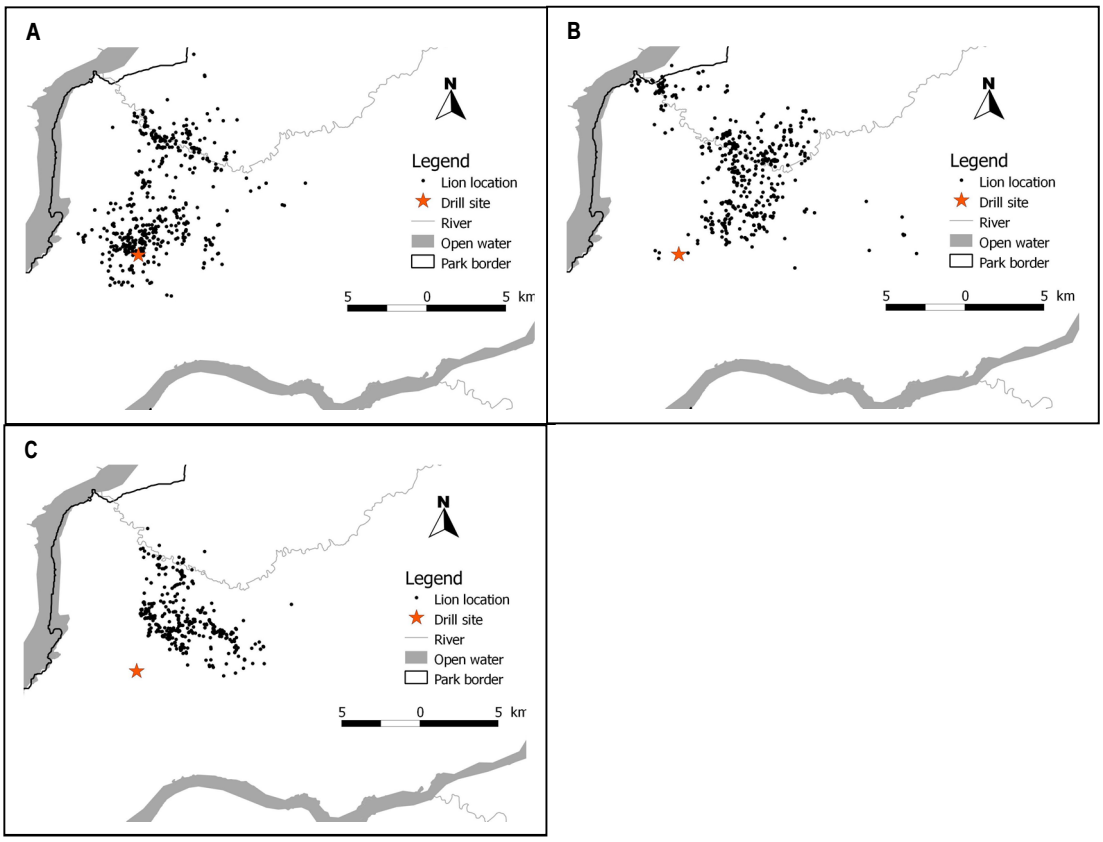
We collected locations of three lions (2 male and 1 female) that lived near the Buffalo East-1 (BE-1) oil pad in the oil region for a month before, a month during and a month after drilling. One male and the female satellite collars failed towards the end of drilling at the BE-1 and so we only calculated their distances for the period before and during drilling at BE-1. We calculated the distances between OMS_005 and BE-1 before and during drilling as well as the distance between OMS_005 and BE-1 before and after drilling (Table 6). The results for DMO_001 should be interpreted carefully because it was the time this male had just lost its pride and was wandering through the region from the Delta. DMO_001 had the largest displacement with a change in mean distance between the period before and during drilling at BE-1 of 44.4 km. OMS_005 had a change in mean distance of 33.1 km during drilling and 11 km after drilling at BE-1 from the mean distance before. The female BFR_013 had the smallest displacement with a mean distance of 8.8 km further away from BE-1 during drilling than it was before drilling. An analysis of variance (ANOVA) of mean displacement yielded significant variation among periods before, during and after drilling, $F = 281.75$, $p < .001$. A post hoc Tukey test showed that the mean displacements differed significantly amongst the periods at $p < .01$.

Table 6: Distances of lions from Buffalo East-1 site for the period before, during and after drilling. The P-Value of the mean distance before and during drilling for DMO_001 & BFR_013, and P-Value of mean distance before and during drilling, and before and after drilling for OMS_005 is given.

		Distance to the drill site (Km)					
Individual	**Period**	**Min.**	**1st Qu.**	**Median**	**Mean**	**3rd Qu.**	**Max.**
Opido (DMO_001) Male	Before	26.0	43.8	71.2	63.0	76.8	99.9
	During	77.5	104.2	108.0	107.4	112.7	147.7
P Value (mean of distance before and during drilling)					**P<0.0001**		
Pam (BFR_013) Female	Before	41.7	47.0	62.6	66.1	82.4	114.8
	During	31.0	51.7	59.7	74.9	81.9	150.4
P Value (mean of distance before and during drilling)					**P<0.0250**		
Silverback (OMS_005) Male	Before	0.9	12.5	22.6	35.6	69.8	131.6
	During	5.9	54.1	72.5	68.7	83.3	121.4
P Value (mean of distance before and during drilling)					**P<0.0001**		
	After	23.8	32.7	44.1	46.6	58.4	107.7
P Value (mean of distance before and after drilling)					**P<0.0001**		

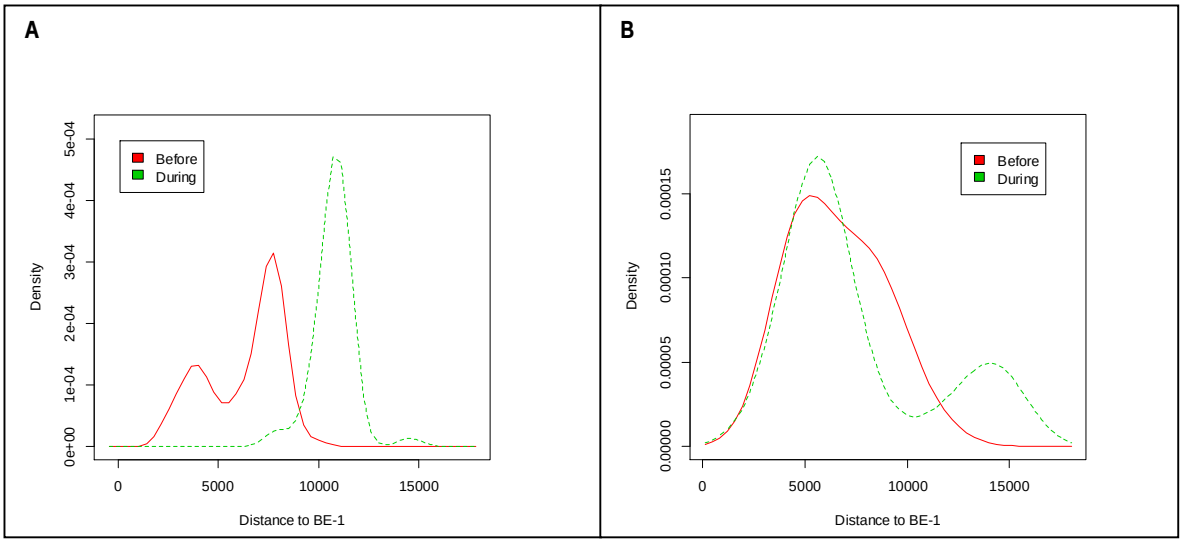
Before drilling work started at BE-1, the lions were located close to the drill site as shown in **A** - Figure 5. During drilling at BE-1, all the three individuals analysed were displaced north east wards of the drill site with some locations falling outside the park boundary. For the male whose collar lasted the entire experiment - for the same period as the drilling phase, its locations were out of the drill area for the 91 days analysed after drilling at BE-1 had stopped.

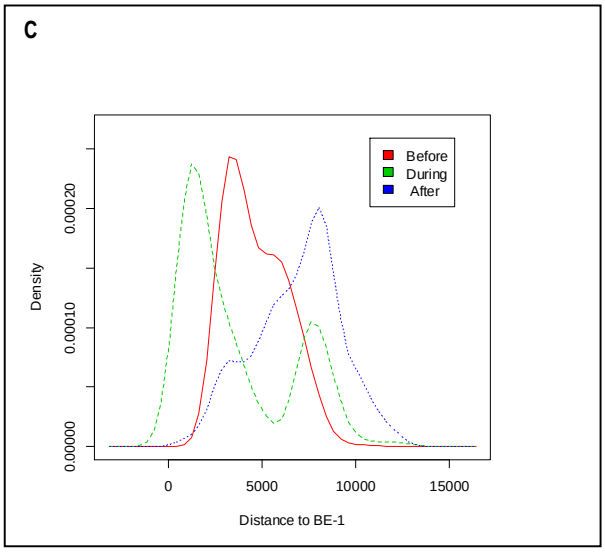
Figure 5: Locations of lions before (A), during (B) and after (C) drilling at Buffalo East-1.



We carried out kernel density analysis of the distances from BE-1 of three lions whose locations were near the oil pad (BE-1) before, during and after drilling. Kernel density plots are effective at viewing distributions as they are not much affected by the number of bins used. All lions show increases in mean distance between the periods before and during drilling at BE-1 except OMS 005 (Figure 6).

Figure 6: Kernel density of distances between lions and BE-1 for the period before, during and after drilling. A, B and C are for DMO_001, BFR_013 and OMS_005 respectfully.





Habitat Selection

Most of the study area was covered by thickets (53%), but all prides including the solitary male preferred open savannah (Figure 7). The level II (i.e. comparing proportional vegetation use within 95% kernel home range with proportions of total available vegetation types in the study area) habitat selection analysis for the GPS collared lions showed that there was a statistically significant difference between the proportions of available landscape vegetation types and utilised habitat by the lions (X^2 = 35.3, df = 4 , $p < 0.01$). The overall comparison of vegetation use from the 95% kernel ranges compared to habitat availability in the study area suggest that prides selected home range non-randomly ($\lambda < 0.05$; $p < 0.01$). The preference rank of available habitats, from most to least preferred, was bare areas > open savannah > forest..

Bare area occurred in the 95% kernel home range of only one pride and was therefore excluded from the third-order habitat selection analysis (i.e. comparison of the proportions of GPS locations within each vegetation type to the proportion of habitats within the 95% kernel home ranges). Third order habitat selection showed again a non-random habitat selection (weighted mean $\lambda < 0.05$, $p < 0.01$). The vegetation types in order of preference were: open savannah > thicketed savannah > forest (Table 7). In terms of habitat selection before and after the start oil exploration activities, the lions use of habitat did not change significantly (although they used proportionally less forest and more open savannah vegetation before the commencement of drilling at the well pad) (X^2 = 2.3, df = 2, p = 0.3).

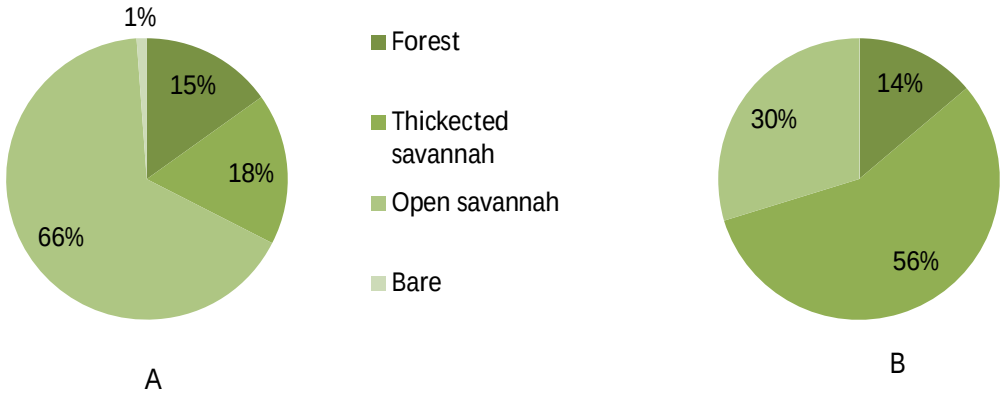


Figure 7: Proportional availability of vegetation types within the study area (A) and mean relative representation of these habitats within the lions' home ranges over the study period.

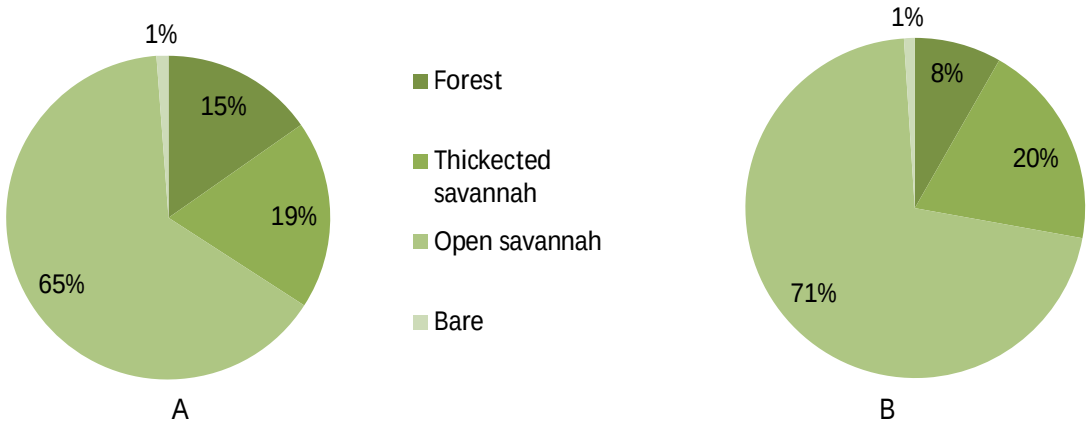


Figure 8: Habitat use before (A) and after (B) drilling activity in the study. There was an increase in percentage use of thicketed savannah from 16% to 19% during the oil activities.

Table 7: Simplified ranking matrices for lion prides based on (a) comparing proportional vegetation use within 95% kernel home range with proportions of total available vegetation types in the study area, and (b) comparing the proportions of GPS locations for each pride in each vegetation type with the proportion of each vegetation type within the pride's 95% kernel home range. The signs signify preference (+ selected, - avoided) of "row" habitat to "column" habitat.

a) 95% kernel home range vs. Total study area

	Vegetation type				
Vegetation type	Bare areas	Open savannah	Thicketed savannah	Forest	Rank
Bare areas		"+++"	"+++"	"+++"	3
Open savannah	"---"		"+++"	"+++"	2
Thicketed savannah	"---"	"---"		"+++"	1

Forest	"---"	"---"	"---"	0

b) GPS locations vs. 95% kernel home range

	Vegetation type			
Vegetation type	Open savannah	Thicketed savannah	Forest	Rank
Open savannah		"+"	"+++"	2
Thicketed savannah	"-"		"+"	1
Forest	"---"	"-"		0

Three habitat types occurred in the 95% kernel home ranges estimated using locations of collared lions collected for 40 days before and 40 days after the commencement of drilling for oil in the park. Comparison of vegetation use of 40 days of data collection before drilling activity with available 95% kernel home range in the pride range gave a $\lambda = 0.93$, $p = 0.5$, i.e., lions prides used their "available" pre-disturbance habitat at random. The most preferred vegetation type was open savannah and least preferred forest (Table 8).

However, when looking at 95% kernel home range areas for data collected for 40 days after the onset drilling activity and compared to 95% kernel home range of the prides, the vegetation preference rank is thicketed savannah > forest > open savannah. The test for random vegetation use was $\lambda = 2.14$, $p = 1$.

Table 8: Simplified ranking matrices of habitat preference for lion prides based on (a) comparing proportional vegetation use within 95% kernel home ranges 40 days before drilling activity with proportions of total available vegetation types in the 95% kernel home range for each pride, and (b) comparing proportional vegetation use within 95% kernel home ranges 40 days after drilling activity with proportions of total available vegetation types in the 95% kernel home range for each pride. The signs signify preference (+ selected, - avoided) of "row" habitat to "column" habitat.

a) 95% kernel home range 40 days before oil well activity vs. 95% kernel home range

	Vegetation type			
Vegetation type	Open savannah	Forest	Thicketed savannah	Rank
Open savannah		"+"	"+"	2
Forest	"-"		"+"	1
Thicketed savannah	"-"	"-"		0

b) 95% kernel home range 40 days during and after oil well activity vs. 95% kernel home range

	Vegetation type			
Vegetation type	Open savannah	Forest	Thicketed savannah	Rank
Open savannah		"-"	"-"	0
Forest	"+"		"-"	1
Thicketed savannah	"+"	"+"		2

Prey items

Sixty six percent of the carcasses found during the study period were identified as killed by lions and one buffalo was killed when it got stuck in a mud-pit (Table 9). There was no significant difference between the proportions of large (buffalo, waterbuck & hartebeest 22.9% of diet), medium (kob 60.0% of diet) and small (oribi & warthog 17.1% of diet) prey eaten by lions in the wet and dry seasons (X-squared = 5.4119, df = 2, p-value = 0.07. From the carcasses found, there is no apparent selection for either sex, however lions ate more female warthogs (89%, n= 14) than males and more male buffalos than females.

Carcasses with signs that they had been killed by poachers were found mostly (62%, n=16) in the wet season with hippopotamus as the most commonly poached species (31.2% of poached carcasses found). Other species poached were; buffalo, elephant, kob, oribi and warthog.

Table 9: Count of carcasses for various causes of death

	Cause of Death					
Species	**Natural**	**Poached**	**Predators**	**Road kill**	**Unknown**	**Study period**
Buffalo	1	3	3		3	10
Hartebeest			12			12
kob		3	64	2	14	83
Oribi		1	10	1	1	13
Warthog		1	14			15
waterbuck			2			2
Total number of carcasses	**1**	**8**	**105**	**3**	**18**	**135**

When we only assessed kills with lions present, the main prey was kob (61%, n=135). Waterbuck are consumed least (2% of diet) and only in the wet season (Table 10 and figure 9).

Table 10: Count of carcasses killed by lions in each season

Species	**Dry (%) n=60**	**Wet (%) n=75**	**Study period (%) n=135**
kob	70	55	61
Warthog	5	16	11
Oribi	7	12	10
Hartebeest	15	4	9
Buffalo	3	11	7
waterbuck	0	3	2

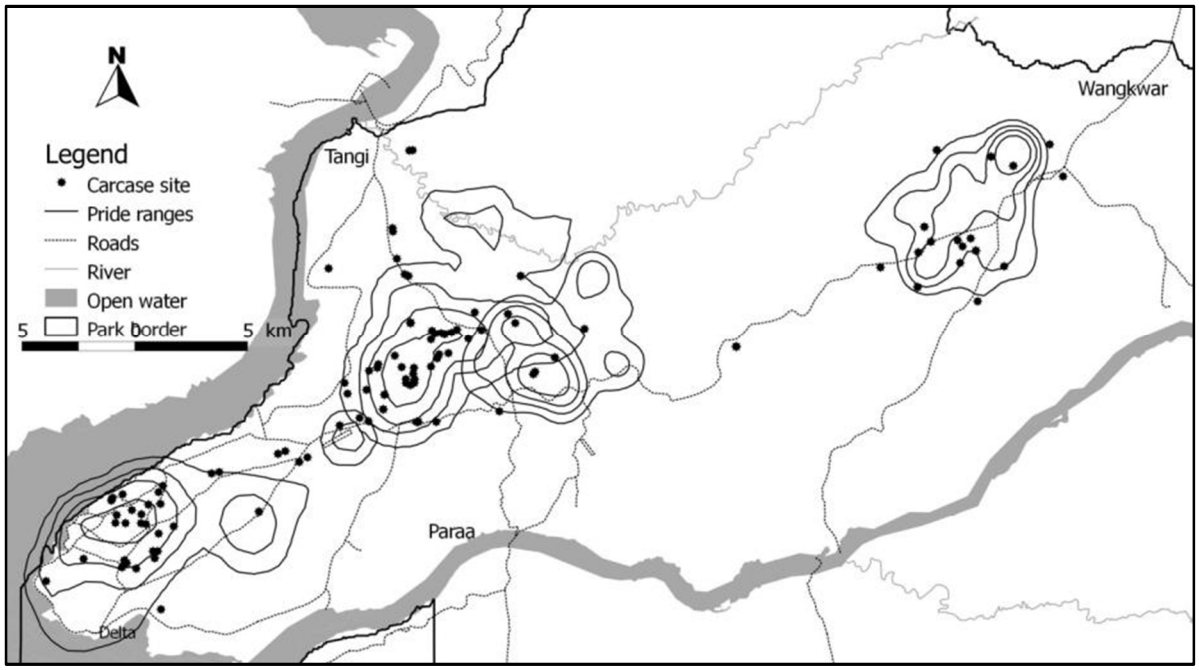


Figure 9: Locations of all carcases found during the study period with lion ranges from the northern bank MFNP

If we analysed differences in what prides consumed, the Wangkwar pride consumes mostly kob (70%, n= 17) and no oribi or waterbuck carcasses were found in their range or for the oil region pride range (Table 11).

Table 11: Distribution of carcasses within each prides range

Species	Pride (%)			
	Borassus n=43	**Delta n=61**	**Oil n=14**	**Wangkwar n=17**
Buffalo	4.7	8.2	7.1	11.8
Hartebeest	7	9.8	14.3	5.9
kob	48.8	67.2	64.3	70.6
Oribi	16.3	9.8	0	0
Warthog	20.9	3.3	14.3	11.8
Waterbuck	2.3	1.6	0	0

We analysed number of carcases found in 0-25%, 0-50%, 0-75% and 0-95% kernels from which we calculated a density of prey per kernel. The average density of prey kills was found to increase towards the core of areas of the ranges (Table 12).

Table 12: Density of prey kills per area for 0-25%, 0-50%, 0-75% and 0-95% kernels. This was calculated from prey kills found in the prides ranges.

	Kernels			
Pride	**0-25%**	**0-50%**	**0-75%**	**0-95%**
Delta	1.55	2.03	1.09	0.60
Borassus	0.91	0.59	0.79	0.43
Oil	4.32	3.73	2.41	1.14
Wangkwar	1.18	0.73	0.68	0.64
Average	**1.99**	**1.77**	**1.24**	**0.70**

From the study, we compared if lions preferred large, medium or small prey. A chi-square test of independence was performed to examine the relation between lion kills and their availability from 2012 UWA census for small, medium and large prey. The relationship between what lions kill and what is available was significant, $X^2 = 637.4, P < .01.$ The results suggest that lions prefer small prey (kob and warthog) when compared to medium (hartebeest and waterbuck) or large (buffalo).

Vultures and other scavengers

All vultures and storks found on carcases were identified and counted. On most carcases we encountered White-backed vultures (85%). Others were Marabou storks (12.6%), hooded vultures (1.2%), Palm nut vultures (0.3%) and Ruppell's griffon vulture (0.9%). Ruppell's griffon vultures were only seen in the dry season while the Palm nut vultures were seen in the wet season.

Socio economic information of participants

A total of 160 participants were interviewed, mostly male (80%) and mostly from the Acholi (39%) and Alur (36%) ethnic groups (Table 14). Most interviewees moved into the area after the 2007 probably with the signing of the peace treaty that brought an end to the long civil war (*mean 3.7 ± 1.1 SD years ago*).

Table 13: Ethnicity of people interviewed in household

Gender	Acholi	Alur	Other*	Total
Female	11	13	8	32
Male	52	45	31	128
Total	63	58	39	160

*Other contains participants of the Amachole (1), Jonam (7), Langi (7), Mudama (1) and Mugungu (22) ethnic groups.

Two thirds (66.9%) of the interviewees were subsistence farmers (Figure 10). The remaining participants were fishermen (16.9%), salaried employees (5%), business owners (5%), students (3.1%), wage labourers (2.5%), and a pastor. There was no significant difference between annual household incomes measured from estimates given by the respondents engaged in the main economic activities of the area: charcoal burning, farming, fishing and skilled labourer ($X^2 = 5.09$, $df = 6$, $P = 0.52$).

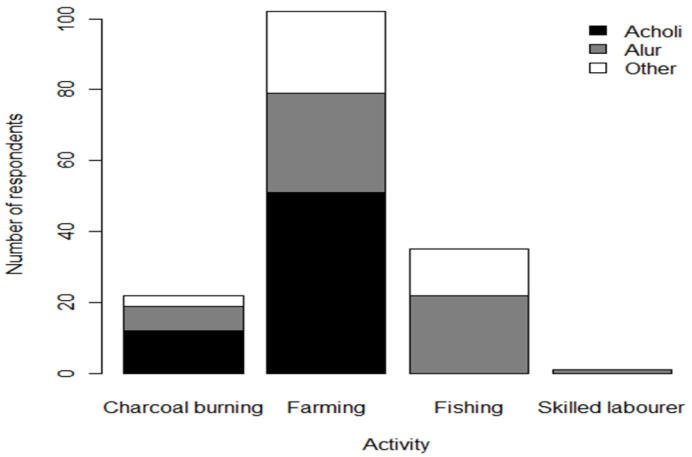


Figure 10: Main income generating activities of the interviewed house-holds around Murchison Falls National park.

Although the study area has many rivers and an open water body, more than half (55%) of the interviewees said that they considered their drinking water to be contaminated. Moreover, 8.7% did not own the land they lived on. The majority of landowners (30.6%) owned land less than 5 acres in size. Most (59.4%) of the interviewees valued their land at less than one million shillings, 17.5% between one to five million shillings, and 23.1% at more than five million shillings. There was no significant difference between ethnic groups' estimated value of land ($X^2 = 3.26$, df = 4, P = 0.51). Twenty nine percent of the interviewees owned a woodlot (n=114). Most (55.9%) owned a bicycle and/or television and 3 households owned a motorcycle (Table 15).

Table 14: Assets owned by the house-holds interviewed

Asset	Number of interviewees
Generator and/or car	4
Bicycle and/or television	90
Motorcycle	3
Radio	32
None	32

When we asked the interviewees their sources of income and how much it was, 75% of all salaried earners got at least 250,000/= per annum while just 50% of students, business owners and a pastor had a median income of 250,000/= per annum (Figure 11).

Housing of interviewees was grouped into three categories; most interviewees (82%) lived in mud and thatch houses, 7% in pole and thatch and 11 % in brick and corrugated iron roofed houses. Sixty five percent of the respondents owned fowl (i.e. chicken, ducks and turkeys), in contrast to only 1% who owned cattle. One percent of the interviewees were employed by the park with no significant difference in ethnicity ($X^2 = 3.12$, $df = 2$, $P = 0.20$) (Figure 12).

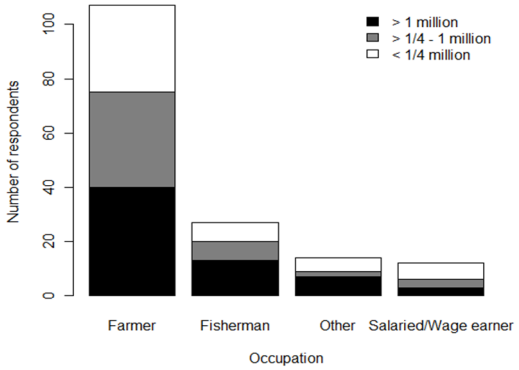


Figure 11: Annual incomes of house-holds from their occupations.
*Other: Student, Pastor and businessman

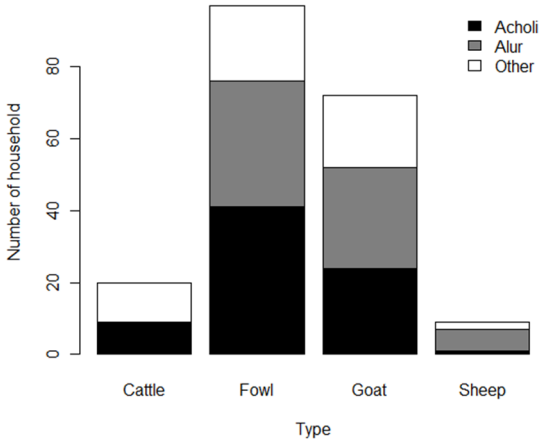


Figure 12: Domesticated animals owned by households per ethnic group.

Human-carnivore conflict levels

A total of 51 people (reported by 26% of interviewees) were reported as having been killed by predators in the area between 2010 and 2011. Predator attacks on people were mostly (3.7%; Table 16) among people who were farmers.

Table 15: Number of predator attacks per occupation, number in parentheses shows the percentage of the total occupation.

Occupation	Number attacked (%)
Farmer	6 (3.7)
Fisherman	3 (1.9)
Salaried/Wage earner	1 (0.6)
Other	1 (0.6)

Most respondents (64) stated that their dogs were used for guarding livestock (72.3%), while the rest kept them for cultural reasons. None of the respondents admitted using their dog for hunting wildlife. There was no significant difference between dog ownership among the different ethnic groups ($X^2 = 2.21$, $df = 2$, $P = 0.33$).

About one in three (n=52) of the interviewees reported having lost livestock to predators in the last year. Most (56%) of the losses were reported by households that kraaled their livestock for the night, 36% by those who neither kraaled nor guarded them, and by 8% of who guarded their livestock with dogs. All households (n=5) who used fire around livestock sheds at night did not lose any to predators. There was no significant difference in numbers of livestock lost to carnivores between herds kept communally and those managed privately ($X^2 = 1.84$, $df = 1$, $P = 0.17$).

Thirty (48%) interviewees who answered the question about poaching were aware of wildlife poaching taking place in the region, with no significant difference in awareness (or admittance of awareness) among ethnic groups ($X^2 = 1.74$, $df = 2$, $P = 0.41$). Nineteen percent of the respondents said that they try to trap problem animals which they defined as animals that cross from the park to the community land.

All the tribes of the region use wildife parts and/or products. Predator skins were reported to be valued as symbols of royalty, while elephant faeces? is locally used in the preparation of the house floor (Table 17). Twenty six percent of the interviewees were aware of a fellow villager who had been killed by carnivores (9%) or other wildlife (17%). When asked how they responded to predator attacks to humans and to livestock, the respondents varied significantly on whether to kill, do nothing or report to authorities ($X^2 = 5.05$, $df = 1$, $P = 0.02$).The respondents also varied on whether they reported to UWA, local police, local leader or killed the animal with the majority usually reporting to authorities ($X^2 = 55.22$, $df = 4$, $P < 0.05$) (Figure 13).

Table 16: Uses of wild animals and their parts per ethnic group

Animal part used	Function	Acholi	Alur	Other
Leopard skin	Symbol of royalty	Yes	Yes	Yes
Hyena liver	Poison	No	Yes	No
Hyena nose	Fetish	Yes	No	Yes
Lion skin	Symbol of royalty	Yes	Yes	Yes
Lion oil	Medicine	No	Yes	No

Elephant waste	Building material	Yes	Yes	Yes

When asked to rank the animals from most problematic to least, the interviewees ranked lions and leopards highly as dangerous problematic animals. The hippopotamus (*Hippopotamus amphibius*) was mentioned as the most problematic by respondents (33%), followed by the elephant (*Loxodonta africana*) (22.4%). There was a significant difference among ethnic groups in which animal were deemed problematic (X^2 = 118.82, df = 36, P < 0.05). However, elephants were mentioned most times by the respondents as problematic animal (Figure 14).

About what they did with the problem animal, most (54.4%) respondents said they eat the problem animal if caught. This was common in all ethnic groups. Killing of predators in retaliation for predation on humans (7%) livestock (12%) was reported by 19% of the respondents.

There was a question about the willingness of the interviewee to contribute to the establishment of an insurance scheme for losses to predators. Most (70%) of the respondents said they would contribute to such a scheme (Table 18), with no significant difference among occupations (X^2 = *3.05, df = 3, P = 0.38)* and ethnicity *(X^2 = 2.93, df = 2, P = 0.23*).

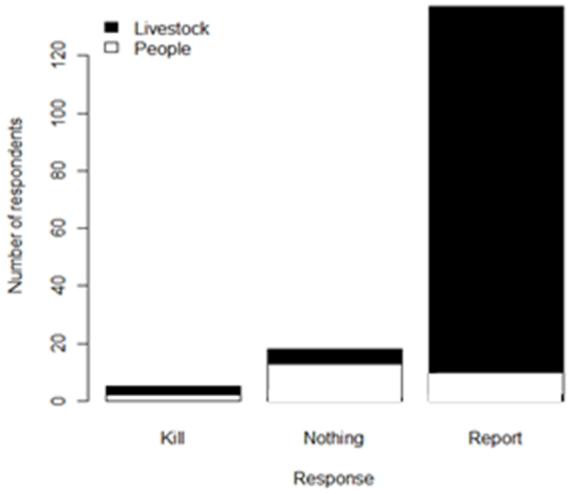


Figure 13: Response of households to predator attacks.

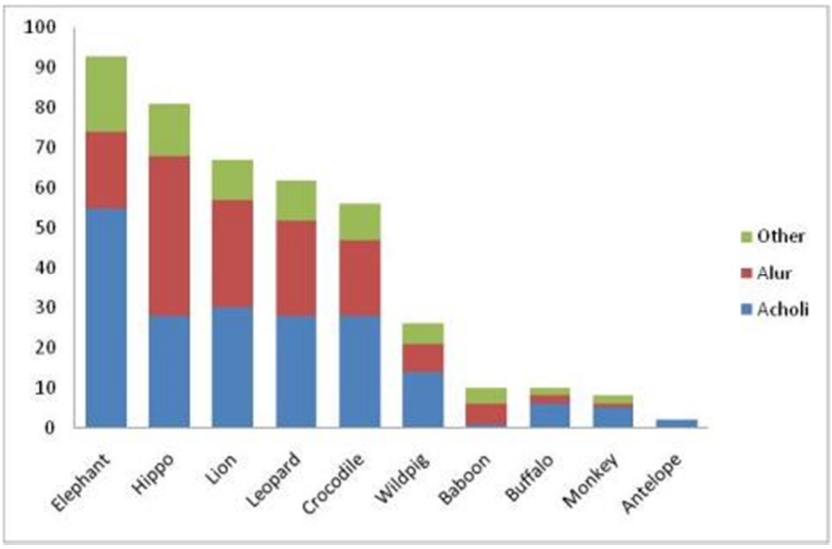


Figure 14: Cumulative problem animal list per ethnicity for the house-holds interviewed around Murchison Falls National Park. This list was generating by adding the number of times the animal was mentioned and not from the rank of most to least dangerous as explained in the text.

Table 17: Support of an insurance scheme among the occupations of the respondents, parentheses show the percentage within occupation

Occupation	Agree (%)
Farmer	76(48)
Fisherman	18(11)
Salaried/Wage earner	11(7)
Other	9(6)

Perceptions of conflict with carnivores and attitudes towards conservation

The locals' relationship with the park authorities differed significantly among respondents (Figure 15; X^2 = *138.75, df = 3, P <0.05*), with 44.3% (n=71) reporting as having a bad relationship with the park staff.

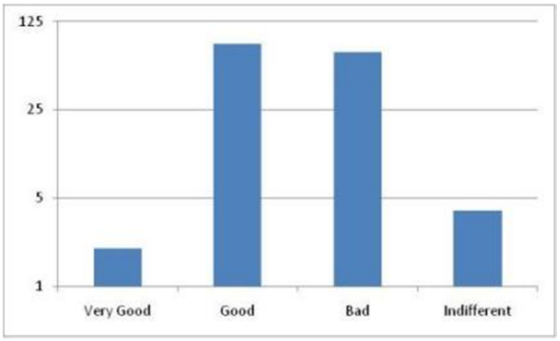


Figure 15: Relationship of interviewed house-holds with MFNP management.

The interviewees proposed seven solutions to the human wildlife conflict (Table 19). Increase in ranger patrolling was the most frequent proposal (39.6%), with a few (2.4%) people proposing lethal control.

Table 18: Interviewee proposed solutions to predation by large carnivores.

Solution to predation by carnivore	Number (%)
Deploy more ranger patrols	17 (39.6)
Fence the park	15 (34.9)
Kill the predators	1 (2.4)
Translocate the predators	1 (2.4)
Dig wildlife trench around park	6 (14.3)
People should stop using the park	1 (2.4)
Train local people to manage problem animals	1 (2.4)

The vast majority (80%) of the respondents felt that predators should be conserved in the park with no difference among ethnic groups ($X^2 = 0.47$, $df = 2$, $P = 0.79$).

When asked if they would agree to fencing off the park as a way of reducing problem animals, most of the study subjects agreed to this as solution to predation (Figure 16). Twenty five percent of all other ethnic groups, 31.6% and 34.2% Alur and Acholi respectively agreed to fencing the park. There was no significant difference in ethnicity or occupation ($X^2 = 5.44$, $df = 2$, $P = 0.06$ and $X^2 = 0.83$, $df = 3$, $P = 0.84$ respectively).

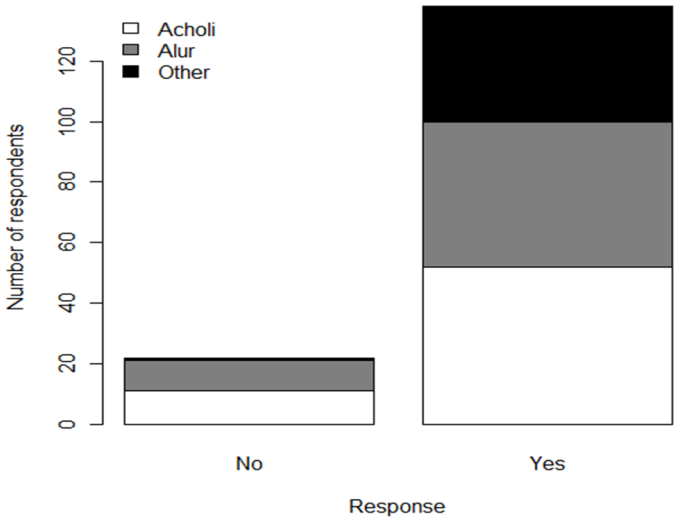


Figure 16: Response of respondents to proposal to fence the park as remedy for predation by large carnivores.

Exploring causes/relationships of current attitudes

The attitude of respondents towards wildlife was determined using responses from a specific subset of questions from which an index was developed for each participant based on (Moser & Kalton, 1971) (Appendix I). The mean attitude score of respondents towards carnivore conflict and other wildlife was 9.9 ± *2.14 SD* and there was no significant difference between attitudes towards carnivores and conservation per ethnic group (*mean 9.86±4.28 SD, df = 3, P = 0.09*) or occupation *(mean = 12.62±5.18 SD, df = 3, P = 0.06, Figure 15*).

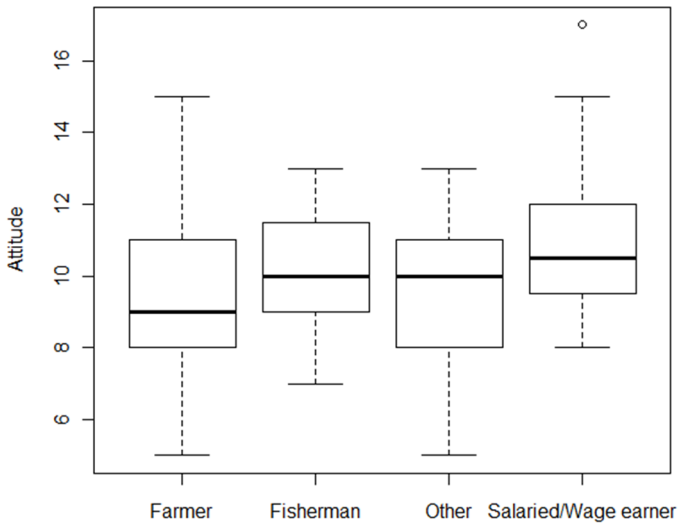


Figure 17: Mean attitude score of the interviewees per occupation calculated from subset of questions and indexed for each participant (Appendix I).

Some of the parameters were tested for contribution to the attitude score: whether the respondent had received incentives from the park management, if the respondent had reported predator attacks on livestock, if carnivores had killed a village member in last year, and whether they had made a sighting of lion and/or leopard in last year had a significant difference in the mean attitude score of people with different responses (Table 20).

Respondents whose livestock had not been attacked by predators in the last year generally had a more positive attitude towards conservation of carnivores.

Table 19: Mean attitude scores of respondents for the variables with significant differences in means. The degrees of freedom = 1. The response is to the question under parameter.

Parameter	Response	Mean	SD	Estimate	SE	P
House hold received incentives	No	9.5	2	0.77	0.33	<0.02
	Yes	10.3	2.2			
Village member killed by carnivores	No	10.3	1.9	-1.60	0.36	<0.00
	Yes	8.7	2.3			
Carnivores attacked livestock	No	10.2	1.9	-0.89	0.34	<0.01
	Yes	9.4	2.5			

Respondent seen lions in last year	No	10.7	2.1	-1.20	0.33	<0.00
	Yes	9.4	2			
Respondent seen leopard in last year	No	10.3	2.2	-0.77	0.33	<0.02
	Yes	9.5	2			

A respondent's history of seeing lions or leopards and having received incentives from the park directly were correlated. A hierarchical multi-variant method (Dass et al., 2012) was used and correlated parameters were entered as first ANOVA factors to minimise their effect. Interviewees who reported death of a village member contributed most (28.6%) to the explained variation in attitude scores of respondents in the model (Table 21).

Table 20: A multi-variant linear model output of the attributes that predict attitude of respondents towards carnivore conservation around Murchison Falls National Park

Parameter	Df	Sum Sq	Mean Sq	F value	P
Incentives	1	23.74	23.74	6.05	0.015
Seen Leopard	1	18.52	18.52	4.72	0.031
Seen lion	1	32.66	32.66	8.33	0.004
Livestock attack	1	15.41	15.41	3.93	0.049
Village death	1	36.13	36.12	9.21	0.003
Residuals	154	603.93	3.922		

We took all the questions related to wealth of the interviewee and scored them to make a welfare score as a measure of how rich or poor a respondent is (Appendix 1). Each respondent was then scored to calculate their poverty index. However, poverty index was not a predictor of the interviewee's attitude towards carnivore conservation. The same applies to respondents: gender, tribe, house-hold size, occupation, duration of stay in the village, husbandry practice and livestock owned, whether they harvested resources from the park; and distance to: park to boundary, police or ranger station, and health centre.

DISCUSSION

Population demography and home ranges

The population of lions throughout their remaining range in the world has been declining (Bauer and Van Der Merwe, 2004). The latest estimate for Uganda is typical of this trend and MFNP represents the worst decline in lion population for Uganda whose estimated 400 individuals only survive in 3 savannah parks (Okot et al, 2013). The lions of MFNP occur at low densities estimated at about 12 individuals per 100 km^2. This lion population density is strikingly similar to that of an earlier study (Driciru, 2005). The lion population density estimate of MFNP lies below the established 35 to 45 individuals per 100 km^2 for the prey rich and large East Africa savannahs but above 1.5 to 2.0 lions in the drier regions in southern Africa like Kalahari (Sunquist and Sunquist, 2002). The lions of MFNP are also forming smaller group sizes (18.5 ± 2.5) only observed in lions that dwell in woodlands with the more open savannah parks like Serengeti having larger lion assemblies at 35 individuals (Sunquist and Sunquist, 2002).

Although the percentage of cubs from this study is comparable to that a decade ago (this study, 44.6% and Driciru 2005, 43.8%), the number of juveniles has declined over the same period. The reduction in number of juveniles may signify that the area has lost most cubs in the past 2 years. This is despite the large litter sizes (2.2) and high percentage of breeding females (65%).

The lions of MFNP were found to live in small ranges (36 km^2 – 70 km^2) about half of the area recorded for home ranges elsewhere in East Africa (Sunquist and Sunquist, 2002) but typical of Uganda's lions as observed in QENP (Van Orsdol, 19282 and Ziwa and Plumptre 2009). Such small ranges have been observed in prey rich open savannahs. This is not surprising because large mammal census in MFNP showed all the lion prey population to be on the increase from previous estimates (Rwetsiba and Nuwamanya 2010). Therefore, it is reasonable to assume as observed elsewhere that prey presence is one of the major factors influencing habitat choice and size.

From this study, it is apparent that human related and illegal activities are the main threats to lion survival in MFNP. Most mortality (71%, n=7) in adult lions is a result of human related incidences mainly wire snares and other illegal traps. To date, four critically injured lions are being observed periodically as they recover from snare injuries but will remain maimed for life. WCS Uganda efforts to curb this threat are ongoing. Using GIS and UWA ranger patrol data, snare prone areas on the northern bank have been identified and zoned according to type of traps. This has been followed by snare removal exercises in part of the 550 km^2 wire snare prone area. So far over 2500 wires, 34 spears, and 2 elephant traps have been collected, and 6 animals rescued from wire snares. WCS has also paid for the cutting into pieces of all wire snares that were collected during the snare removal exercise and those kept in MFNP stores to avoid reuse in case they are stolen. Together with UWA community conservation department, WCS facilitates willing ex-poachers to retrieve wheel-traps at homes and in park. It is necessary to continue these joint exercises because they directly reduce lion mortality.

Habitat selection

There was a clear avoidance by lions of the predominately available thicketed savannah vegetation type, and a strong preference for open savannah. This preference has been reported before for lions in Kenya and Tanzania (Sunquist & Sunquist, 2002). Forest habitat was least utilized as expected but contrary to what has been recorded in Gir forest, India, where prides use mostly deciduous forest (Jhala et al., 2010), or south and west Africa where moist forest is preferred (Bauer et al., 2003; Funston et al., 2003). In MFNP, lion prey is mainly encountered in the open savannah (Rwetsiba & Nuwamanya, 2010). Inclusion of a vegetation type within the home range of a lion pride however does not necessarily imply living in it, but rather securing access to the prey species living on it.

Third order habitat selection analysis showed preference for open savannah overall. This finding further strengthens the observed preference for open landscape as opposed to thickets by the MFNP lions – as shown by the 2nd level habitat selection analysis. However, for the period during and after drilling of oil wells in the park, the lions showered some preference for thicketed savannah. This could be a reaction of lions to encroachment as was observed in Zimbabwe lion sport hunted areas (Davidson et al., 2011). It remains to be seen if similar changes to habitat preference will be observed following future anthropogenic disturbances in the area. More efforts are therefore required to minimize or if possible avoid artificial activities in the known core lion ranges, especially if future radio-telemetry data show these core areas to be relatively stable and therefore realistic to plan activities around them.

Although lions like the rest of the large carnivores show adaptive plasticity (Jhala et al., 2010), the implications of the shift in habitat preference could lead to lower chances of lion sightings on game drives. Lions are an important attraction for Uganda's tourism business and the reason tourists stay longer. Therefore, maintaining a high enough encounter rate of lions is important for tourism in the area, but it is going to be problematic to achieve this if lions are frequenting densely vegetated areas.

Lion experiential tourism is a new product being developed by WCS Uganda and UWA where by visitors, for an extra fee, will be given exclusive access to lion groups out of the tourist circuits. This study suggests that the ideal group to consider for search a program is the Borassus pride. The Borassus pride is large and well-studied with over three years of information on individuals. The group is a short drive (under 7 km) from the main tourist lodges on the northern bank yet still no visitor tracks cross this region limiting the possibility of other tourists mobbing lions. The pride range also offers unrivalled views of MFNP ungulate populations and visitors do not have to go through the main tourist circuits after the experiential lion trip.

Oil exploration in the park

Commercially viable quantities of oil have been discovered under MFNP and the process of further exploration and production will ramp up significantly over the next coming years. This has enormous potential to cause further disturbance to wildlife as has already been observed (Ayebare, 2011). From our preliminary analysis of distances between lions and a drill site during the study, most of the lions tested

moved further away from BE-1 during drilling than they had before in the same time period. The male whose collar lasted the entire experiment previously had his range overlaying BE-1 site but after drilling completely avoided the area. DMO_001 had just lost its pride and so some other factors - like avoidance of stronger male in the area near BE-1, could be responsible for its observed movement pattern. Although it is too early to make conclusions, it is apparent from movements of the lions that they are being directly affected by drilling exercises in the park and could be shifting ranges.

Lions typically settle in areas that offer maximum fitness and so unnatural factors like drilling that cause a shift in range however indirect have an impact on the fitness of the individual displaced and eventually on the population. In Tanzania, reduction of prey availability due to habitat conversion forced lions to rely on livestock outside protected areas causing conflict with pastoralist community (Packer et al., 2011). Since lions probably respond differently to different types and levels of disturbance (Ogutu et al., 2005) and are very resilient to environmental stochasticity (Whitman et al., 2007), we cannot easily guess what the long term impact of the planned oil drilling activities will have on the park's lions and their relationship with communities living near their ranges. However, the petroleum industry has the capacity to fund conservation and so mitigation plans and policies should be put in place to ensure the continued conservation of lions and other wildlife in the park.

Local attitudes to wildlife

The study sheds light on local public perceptions and attitudes towards wildlife and carnivores in particular. Although there are multiple tribes in the area - in almost all cases there was no difference in attitudes/perceptions between tribes, suggesting that a universal-landscape level conservation strategy would work.

Poverty level was not a good predictor of local people's attitude towards carnivores and other wildlife. It was found that attitude was affected by past experiences with respondents having a negative or positive attitude depending on their previous interaction with carnivores. Respondents for instance who had received incentives directly from the park authorities had a more positive attitude when compared to those who had not.

Although communities neighbouring the park are experiencing losses to carnivores and other problem animals, most (80%) of the respondents still want them conserved in the park. The majority prefer to report incidences of problem animals to the park management, local leaders or nearest police rather than kill them. This could be due to the relatively high reported losses of livestock to carnivores in the area, compared to other areas in Uganda like Queen Elizabeth National Park which have a considerably lower figures per annum (Moghari, 2009). This is promising for conservation, which suggests that the ability of these authorities to address the reported problem should be strengthened, in order to ensure that this non-lethal/better report trend is maintained.

Large animals, such as the hippopotamus and the elephant feature - not surprisingly - high in the local people's list of problem/dangerous animals for their size but also due to their ability to destroy comparatively larger crop fields even in single raids (Hoare, 2000; Weladji & Tchamba, 2003). The two

largest carnivores, the lion and the leopard, in the area also rank high (3rd and 4th respectively), which shows that human-carnivore conflict is an existing or perceived problem. There is therefore need to address it before it gets worse – as human population expands in the area.

It is encouraging to see that only a small percentage of people proposed lethal control of predators as the best solution to problem animals regardless of occupation or ethnicity. However, it should be taken into account that people may have not been straight forward with their response – fearing to admit that they would support a currently illegal management scheme. Also, it contradicts with the much higher percentage (19%) who said that they trap problem animals. In Ngorongoro Conservation Area in Tanzania, the Masai were found to kill lions in retaliation to predation of their livestock due to absence of structures for dealing with the problem animals (Kissui, 2008). The study method did not include quantitative measures of conflict which would show just how much harvesting of carnivores and other wildlife is going on. A further investigation is necessary in order to be able to clearly explain the level of tolerance to large carnivores in the area.

In order for the conservation efforts in the area to work, a positive attitude towards local wildlife is not sufficient in itself. The management of the park must be viewed positively by the locals, in order for any campaign/strategy that necessitates the involvement of local communities to succeed and be positively received (Naughton-Treves, 1999). "A disliked doctor cannot be trusted to give a good medicine". Currently, half of the people have a negative or indifferent attitude towards the park and this may be because they do not benefit from the park? UWA currently runs community conservation clinics in the villages neighbouring the park, emphasis should be put on ensuring not only teaching the locals about wildlife conservation but the role of UWA staff so as to encourage collaboration. Recruitment of locals in park management staff has been shown to encourage local participation in conservation initiatives and ultimately increased tolerance of carnivores (Mcdonald & Sillero-Zubiri, 2002).

It is suggested from the study that all the locally extant large carnivores are part of the culture and beliefs of the ethnic groups. There are small differences between ethnic groups and it is important to explore more closely to find any potentially positive taboos than can be used to increase local respect for the carnivores. Although the study did not explore whether any of these traditional uses are actually sources of conflict, carnivores were admittedly being killed for parts and it is also worth following further. The area has experienced the sharpest national decline in lion numbers in a decade potentially illegally harvested as parts. However, lion and leopard parts take significant roles as symbols of royalty and are also used as medicine among the Acholi and Alur. Harnessing these attributes for conservation purposes is beneficial to local conservation of species. This can be achieved through identifying locally revered species, linking them to carnivores and presenting them to locals as flagship species and hence complement existing conservation efforts (Williams et al., 2000). However, steps should be made to ensure that only credible locals are recruited. This is because reports have emerged of rangers recruited and working in national parks of their origin collaborating with locals to conduct illegal activities especially poaching.

From the data collected, the model did not identify important parameters influencing local people's attitude towards carnivore and therefore, no conclusive arguments can be made with the

available evidence. A study quantifying conflict would perhaps account for more variability in attitude and be able to qualify the conclusions. However, the strong significance of predicators in explaining attitudes has led to the following: death of individuals due to wildlife especially to a community which receives very little direct benefit from the park is an important aspect influencing attitude. Deaths of people from predators has been demonstrated to influence levels of tolerance among communities living in areas of abundant predators elsewhere (Bauer & Van Der Merwe, 2004; Romanach et al., 2007).

The attitude of the local communities towards conservation was affected by whether they had sighted carnivores. It was a general trend for individuals who had seen lions or leopards in the last year to have a comparatively more negative attitude to those who had not. Since sighting carnivores correlates with attacks on livestock, the data suggests that local people often see carnivores in conflict situations and develop a negative attitude towards them; this highlights the need to expose locals to less dangerous encounters with carnivores, and more crucially, reduce the extent of conflict to levels that do not affect local tolerance to carnivores. This cannot wholly be divorced from the weaknesses of husbandry techniques employed in the area. Poorly made kraals or unattended livestock provide easy prey for carnivores and lure predators to human settlements (Woodroffe et al., 2007).

Carnivore conservation recommendations

Based on the findings of this study, the following recommendations are proposed to guide stakeholders to address threats and ensure conservation of lions and other wildlife in MFNP.

- Improve livestock management among the communities vulnerable to depredation
- Consider compensation and an insurance scheme for victims of carnivore and other wildlife depredation or crop raiding
- Start incentive programs to offset costs of depredation by carnivores
- Run environmental education and community involvement in carnivore conservation programs
- Establish carnivore management teams to respond to individual conflicts resulting from local attacks
- Register and mark fishing canoes on Albert Nile and initiate periodic snare removal exercises

Use of predator proof kraals and good livestock husbandry for vulnerable communities has been found to greatly reduce incidences of depredation (Lagendijk & Gusset, 2008). This study showed that predation of livestock occurred mainly in households that had kraals (56%) and also in those that let their livestock roam without any form of protection (36%). The kraals therefore are not offering the desired protection and need to be improved upon to minimise breach by predators. The reduction of attacks from predators has been shown to increase local acceptance of carnivores there by reducing incidences of retaliatory killing (Goodrich, 2010). Also, although predator proof Kraals are relatively expensive to build, use of locally sourced materials keeps the costs low and the associated reduction in depredation ensures a good return on investment. WCS Uganda is piloting the use of solar lights along enclaves in QENP to deter carnivores as well as provide security for people. Already incidences of depredation have sharply declined

in places with lighting at night (WCS Uganda, unpublished data). This is proving to be successful and probably should be replicated in communities that keep livestock near MFNP boundary.

Compensation of losses to carnivores and other wildlife although difficult to manage increases tolerance of carnivore and benefits their conservation and is often practiced together with an insurance scheme with contribution from locals or funded by resource manager with assistance from conservation organisations (Mcdonald & Sillero-Zubiri, 2002; Karanth et al., 2005). From the study, the majority of respondents (70%) are willing to contribute towards an insurance scheme to compensate for losses to wildlife; this was irrespective of ethnicity, occupation or level of income. The pitfalls of compensation schemes have been: government corruption, high levels of depredation which cannot be sustainably paid off, poor regulation with no proper verification system due to hard to reach areas, and the ethical issue of putting a price on human life (Boitani et al., 2010; Goodrich, 2010). However, MFNP's surrounding communities are easy to reach given that a proper communication system is in place and it should be relatively easy to verify attacks by predators. This is particularly relevant to attacks on humans that are easy to verify and known to greatly improve local tolerance of predators (Maclennan et al., 2009; Goodrich, 2010). In addition, revenue from lion experiential tourism may contribute to funding of such a scheme. This would make lion experiential tourism more attractive. People are willing to pay extra if they know the money will go into reducing conflict between human and wildlife as will be the case with the compensation scheme.

Incentives to local community's from this study had a positive correlation with attitude towards conservation of carnivores and other wildlife. The policy in Uganda currently sees 20% of gate collections given to the districts in which the park entrance is located. This money often does not reach the most affected members of community who bear the cost of depredation as they live furthest away from the administrative headquarters, and also, it is never explicitly clear to the people that the service or benefit is a result of conservation of wildlife in their areas (Hazzah et al., 2009). Local communities show benefit from conservation through direct employment, sale of services to tourism industry or payment for tolerating carnivores in order to encourage conservation in the areas where humans live with predators.

Environmental education and community involvement in conservation programs enables local communities to more ably and willingly contribute to conservation of locally extant species as they feel they own wildlife in the area (Naughton-Treves, 1999; Mugisha, 2002). Feeling ownership of species in their areas is pro-conservation because it lowers the cost of monitoring wildlife by the wildlife managers and also reduces illegal harvesting of species due to community policing (Distefano, 2005). MFNP is serviced by many radio stations on which environmental programs can be aired and given that most of the populace has got radio sets, it is a relatively cheap and efficient way of sensitizing the locals.

Problem animal management and response teams should perhaps be synonymous with areas with wildlife and people. Carnivores even in intensively managed areas with well-maintained fences such as southern Africa still predate (Lagendijk & Gusset, 2008; Hunter et al., 2009), and as such, a team composed of local leaders and park authority should always be in place to respond and evaluate cases of suspected problem animals. This will necessitate training of locals in post-mortem of livestock with specific emphasis on predator kills which can be arranged as workshops to involve carnivore experts.

WCS lion monitoring team has been collecting and mapping the distribution of snares since the start of the project in 2010. UWA rangers on routine patrol regularly remove snares and have an idea of the areas that snares and wheel traps are typically set. All this information should be used to zone the protected area and enable prioritizing of blocks to be hauled for illegal activities and items. This data could also be imported into SMART - that is in advanced stages of development, to help plan more efficient ranger patrols. Snares can easily be seen and files of people moving in the designated area can make it safe quickly (T. Mudumba, Field observation during snare removal in Delta of MFNP). Such snare removal efforts can be arranged to coincide with festivities in-order to draw attention and funding. Snares and other traps collected can be used to make crafts as is the case in South Africa and the returns from sale of the crafts used to fund conservation. We also observed during the study period that most illegal access to the north western part of MFNP is from the Albert Nile. All poachers arrested in the Delta come on boats posing as fishermen from the 7 Beach Management Units (BMU) bordering the park. We noticed that these boats are not marked and are very difficult to police give the high logistics involved. Therefore, investing in color-coding and registering all water vessels especially the canoes permitted to fish in the water near the park would help identify rogue fishermen. This would make it easier for UWA marine unit to make a follow up of boats that help poachers escape.

Overall, this study highlights the need for the park management to involve the local community more in conservation of carnivores around MFNP. It emphasizes the potential negative effect of depredation of livestock and people that reduces local tolerance for wildlife leading to revenge killings of carnivores, and also hampers conservation efforts in general. Drilling as an oil activity is also affecting lion distribution and oil companies should share data on other activities to enable more analysis. It is recommended that a study to quantify conflict is done in the future so as to better gauge local peoples' attitude towards carnivores and its drivers, and that measures to reduce conflict as suggested in this study are taken by local management.

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APPENDIX 1

The cultural beliefs in the area regarding large carnivores recorded from the survey were divided in two groups; those that promoted conservation and those that did not. Using the responses from a specific subset of questions, a welfare and attitude index was developed for each participant with respondents scoring higher for better living conditions in the welfare scale and those with positive answers that are to the park or conservation receiving a higher mark for the attitude scale.

Welfare scale

Question number	Parameter	Response alternatives	Score	Total
3	Nature of housing	Plastic or mad wall + thatch or plastic roof	0	2
		Poles wall + thatch or plastic roof	1	
		brick wall + iron roof	2	
12	Annual income	<100,000 - 250,000 UShs	0	2
		>250,000 - 1000,000 UShs	1	
		>100,000 UShs	2	
13	Household items	None of the items listed	0	4
		Radio	1	
		Bicycle & television	2	
		Motorcycle	3	
		Generator & car	4	
14	Livestock owned	None of the items listed	0	3
		Only fowl	1	
		<10, sheep, goats or pigs	2	
		At least 1 cow or >10; sheep, goats or pigs	3	
23	Land size	No land owned	0	3
		<5 acres	1	
		5 - 9 acres	2	
		>10 acres	3	
24 (a)	Land tenure	Do not own land	0	1
		Own or rent	1	
24 (b)	Land valuation (cost per acre)	< 1000,000 UShs	0	3
		>1000,000 - 5000,000 UShs	1	
		>5000,000 - 10,000,000 UShs	2	
		>10,000,000 UShs	3	
25	Fuel availability	Do not own a woodlot	0	1
		Own a woodlot	1	
37	Quality of drinking water	Contaminated	0	1
		Safe	1	
		Total		20

Attitude scale

7	Poaching	Trap animals	0	1
		Do not trap animal	1	

10	Employment benefit from park	Not employed in tourism sector	0	1
		Employed in tourism sector	1	
42	Cultural beliefs related with conservation	Mentions anti-conservation belief	0	1
		Mentions pro-conservation belief	1	
43	Utilisation of carnivore parts	Does not use parts	1	3
		Mentions at least 1 traditional use	2	
		Mentions > 1 traditional use	3	
45	Carnivore attacks	Attacked in last year	0	1
		Not attacked in last year	1	
47	Carnivore deaths	Village member killed in last year	0	2
		No village member killed in last year by predators	1	
48	Response to carnivore attacks to people	Kill	0	2
		nothing	1	
		report to authorities	2	
49	Response to carnivore attacks to livestock	Kill	0	2
		nothing	1	
		report to authorities	2	
53	Retaliatory killing of wildlife	Participates	0	1
		Does not participate	1	
54	Relationship with park management	Bad	0	3
		Indifferent	1	
		Good	2	
		Very good	3	
56	Solution to predation	Solution entails removal or fencing wildlife area	0	1
		Solution does not involve removal of wildlife	1	
57	Conservation of large predator	Do not support conservation	0	1
		Support conservation	1	
59	Fencing of the park	Supports fencing	0	1
		Do not support fencing	1	
		Total		20

APPENDIX II

Figure 18: Incremental area analysis of lion locations

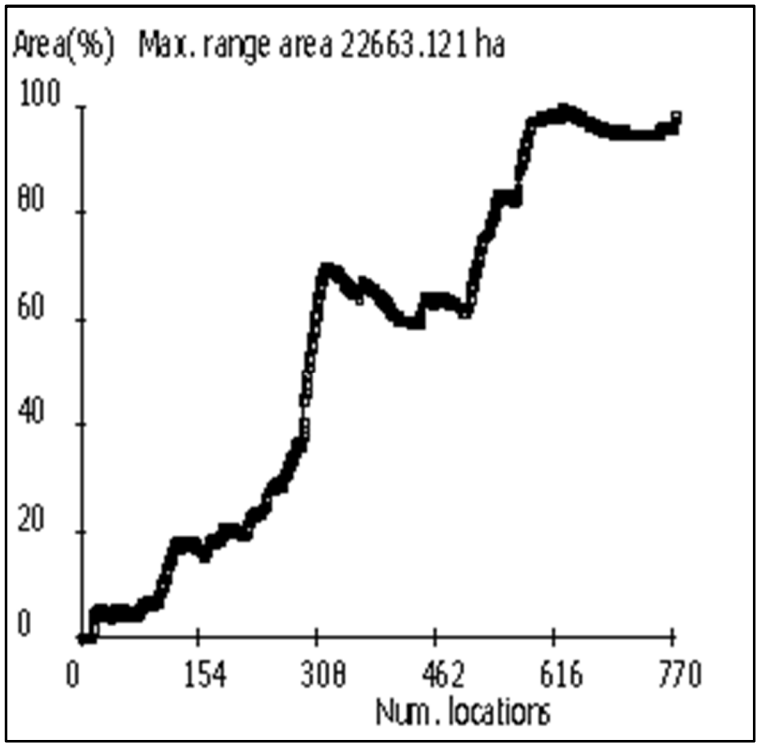
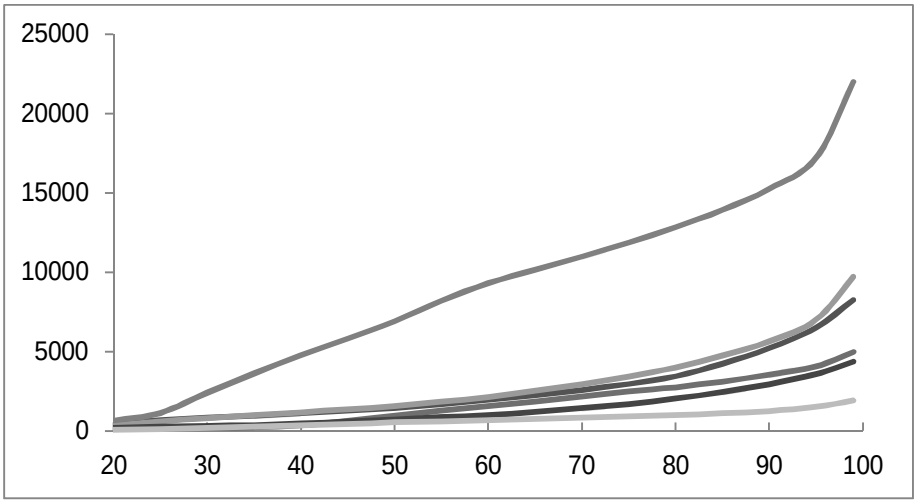


Figure 19: Test for inflexion of lion home range in MFNP. Y-axis is the home range size



ANNEX

Carnivore status and conflict assessment survey; 2011

WILDLIFE CONSERVATION SOCIETY

WILDLIFE CONSERVATION SOCIETY,
PLOT 802, KIWAFU RD, KANSANGA
PO BOX 7487, KAMPALA
www.wcs.org

WILD PROGRAMME

Sheet No. ..012.......

Distance from park: ...05........km

Introduction and explanation of Survey

Wildlife Conservation Society Uganda (WCS) under its WILD program (Activity 1.2.2) large carnivores: lions, hyenas, wild dogs and cheetah) carried out a national census of lions and hyenas in the three largest carnivore habitats; Queen Elizabeth National Park, Kidepo Valley National Park and Murchison Falls National Park between November 2008 and November 2009. The results of the survey show that the population of lions in Uganda has declined by at least 30% in less than 10 years with the largest decrease of 40% registered in Murchison Falls National Park (MFNP).

This study seeks to explore further the status of carnivores in Murchison falls national park and the human-wildlife conflict that may exist with communities living around the park. We explicitly want to emphasize that this study is significant, and we want to contribute to the mitigation of conflict by generating ideas, highlighting and proposing recommendations to the policy and decision makers at the local and national levels; Environment Officers and other stakeholders for improved conservation and management of these vital animals.

Your answers will be kept strictly confidential and used only for proposing policy actions for the lions and other large predators and your well-being. Unauthorised official or government institutions will not gain access to the data. The data will only be accessed by WCS officials; all based in Uganda who are actively involved in managing and implementing nature conservation programmes including lion monitoring in 2 national parks of Uganda and other conservation activities. The data will also be stored anonymously, so there will not be any reference to your household data.

Date of interview...19/10/2011.....Interviewer.........Sophia..........GPS Point..A21 0316135..../..0213947
Village..Kaligonzi......Parish......Kivuje..............Sex of respondent..M. Tribe .....Alur..........................
Please Cross (X) on the alternative that best represents your view or write clearly in the space provided

1. How many people are in the household?

Status	Description	Age	Sex	Education level	Occupation
Head of Household	1	54	m	Primary 7	1
Spouse	2		F	P 2	
Member 1			F	0	
Member 2					
Member 3	17 Children		8 m		
Member 4			9 F		
Member 5				Highest level primary 7.	
Member 6					

Description – 1)husband, 2)Wife, 3)Child 4)Relative 5)Orphan 6) Visiting worker 7)Dependent 8) Female head
Education Level – 0) no formal education, 2) Primary, 3) Secondary 4) College/University education
Occupation – 0) no work 1) Farming-including subsistence 2) student 3) Own business 4) wage labour 6) Salaried employee 7) Infant 8) Fisherman 9) Other – specify

Carnivore status and conflict assessment survey; 2011

2. How many years has your family been in this village or location.....?
   1) Less than 1 year 2) 1-5 years 3)5-10years (4)10years or more

3. House Materials for Main Dwelling (try to make discreet observations on approach)
   Walls;
   (1) Timber/poles 2) Brick (3) Mud 4) Iron 5) Plastic Sheeting

   Roof;
   (1) Thatch 2) Tiles 3) Iron Sheets 4) Plastic Sheeting

4. Do you have any problems with crop raiding animals from the park? (1) Yes 2)No

5. Which Species?
   1)Buffalo 2)Antelopes 3)Lion 4)Monkeys 5)Baboons 6)Elephants 7)Wild pigs 8. Hippos (9) Crocodiles
   8) Other (Specify).....Hippos.....

6. Which species is most problematic?
   Hippos
7. Do you ever trap some of these problem animals? 1) Yes (2) No

8. Do you eat them? (1) Yes 2) No
   Hippos

9. Does your community receive any income or benefit from the park (*contributions from UWA/concessionaires to any local development*)? (1) Yes 2) No
   Constructed primary school. Roads to local people.

10. Do you get any form of employment or income from tourists (services or sales)? 1) Yes (2) No

11. What is the main source of income for the house-holds? (*Tick only one option*)
    1. Fishing ( ) 2. Charcoal burning ( ) 3. Cultivation (x) 4. Selling firewood ( )
    Other.....

12. How much money does your household earn per year (after taxes)? (*Once again I would like to remind you that this a confidential survey only to be used for research purposes; no one will gain access to the data*)
    Annual household income .....720,000.....UG.Shs

13. Do you own any of the other things below?
    (1) Radio 2) Television 3) Bicycle 4) Motorcycle
    5) Pickup truck or car 6) Generator

14. Do you have any animals amongst your household assets?

Livestock Item	Number
Goats/ x	7
Sheep	
Pigs x	10
Chickens /ducks/ pigeons	
Rabbits	
Cows x	2
Dogs	

15. Why do you keep livestock?

Economic benefits (specify)	
Cultural value	x
Prestige	
Draught power/animal traction	
Meat	x
Milk	x
Other	

Carnivore status and conflict assessment survey; 2011

16. In the last month how many days did you graze your animals on;
    a) Your own land? x
    b) Neighbours land? .....
    c) Communal land? .....
    d) Park land? .....
    e) Other *specify*: .....

17. Where do you keep the livestock at night?

Privately	
Communally	

on verander

18. What is the nature/ structure of livestock housing?

1. Housed (specify)	
2. Fenced	
3. Tied with rope outside	
Combination (*choose any two or all*)	

not tied.

19. How do you herd your livestock?

Herder	x
Rope at home	
Rope in the bush	
Free to roam (free ranging)	
Housed / zero grazing	
Combination of above	

20. What are the methods/ systems you use to protect your livestock against wildlife?

Method	Day	Night	Effectiveness
Herders/ guarding	x		
Dogs			
Fire			
Enclosure (specify)			
Nothing		x	0

Effectiveness scale: 0- not effective 1-slightly effective; 2-Effective 3-very effective

21. How could the safety of your livestock be improved?
    construction of shed.

22. Why don't you improve on the safety of your livestock?
    Poverty.

23. Land Resources - How much land do you have? What do you use it for?

Land Type	Area (Local Unit)	Land ownership e.g. leasehold, freehold, customary, others---------- -----
x 5	2.3 ha	

Land Type *– 1) Natural forest/woodland, 2) Woodlot, 3) Arable, 4)Wetland, 5) Grassland Pasture 6)Woodland/forest pasture 7)Cash crop plantation*

Carnivore status and conflict assessment survey; 2011

24. Land ownership/land tenure?
(1) – Own 2) rent/Hire 3) Do not own land
If at all you are to sell your land, how much would it cost? UShs/ha....23 millions

25. Do you own a woodlot? 1) Yes (2) No
If woodlot is owned:

Species of tree	Area (Ha)	Purpose

26. Do people use the park? (1) Yes 2) No
How long does it take to walk there.....?

27. Which months of the year do you use the park most?

Month	Reason

28. Which months is food scarce or expensive?

Month	Reason
Jun - July	Drought.

29. Which fuels do you use each week and how much?

Source	Use	Volume (unit)	Share of fuels provided by park
Wood	Cooking	1 bag per day.	
Charcoal	Cooking	1 basin per day	
Grass			
Paraffin	Light	a week	
Gas			
Electricity			
Other?			

Use- 1) Cooking 2) Lighting 3) Heating
***Share** – 1) None 2) A quarter 3) Half 4) Three quarters 5) All*

30. How far on average do you travel each day to collect firewood? Time...7 hrs..... Distance....3 kms
Is it from the park? 1) Yes 2) No

31. How has this changed in the last 5 years? 1) No change (go to 35) (2) travel further 3) travel shorter

32. What is the reason for the change (if any)?
.....
.....population increase.....
.....
.....
.....

Carnivore status and conflict assessment survey; 2011

33. What is the source of water for domestic use and for watering animals, and where is it located?

Source	Location (In approximate Kms from homestead or kraal)	
	Domestic	Livestock
River/stream	X 2km	
Bore hole	X	
Protected spring		
Shallow well	X 1km	
Dam		
Other *Specify*		

Record distance of one way trip

34. Does your water come from the park? (1) Yes 2) No

35. How many 20ltr jerry cans do you use each day for domestic purposes?
7 Jerry Cans.

36. What type of treatment do you use to purify water for drinking?

Nothing	X
Boiling	
Boiling and Filtering	
Chemicals	

37. What is the quality of your drinking water?
1. Excellent (2) Good 3.Fair 4.Poor

38. Do you collect medicinal plants from the park? 1) Yes (2) No

39. What is the main reason you collect medicinal plants?
1) Own Consumption 2) Sale

40. Do you harvest or sell anything from the park? 1) Yes 2) No

Item	Local Unit	Own harvested units Sold Annually	Own Harvested Units Consumed Weekly	Price Per unit
Yams	Heap			
Mushrooms	Basket			
Wild honey	Litre			
Others.....				
Small wild animals:				
Rats	Piece			
Rabbits	Piece			
Duiker	Piece			
Porcupine	Piece			
Guinea fowl	Piece	N/A		
Francolin	Piece			
Other				
Large wild animals:				
Big Antelope	Piece			
Giraffe				
Large predators	Piece			
Buffalo	Piece			
Other products:				
Building Poles from forest	Piece			
Timber from forest				
Grass for thatching	Bundle			
Rattan	Bundle			

Carnivore status and conflict assessment survey; 2011

Sand	Heap			
Clay	Heap			
Stones				
Handicrafts/panniers	Item			
Firewood	Bundle			
Charcoal	Sac			
Mineral.....	Gram			

41. How often do you see these animals? *Please put a cross(×) appropriately*

	Never	Rarely	Few times	Most of the time
Lions	×			
Leopards	×			
Hyaenas	×			
Jackals	×			
Other.....				

42. What cultural beliefs are associated with lions, leopards, hyaenas or jackals in your community? *Please specify the animal and then write its use*

.....
.....Nothing.....
.....

43. What lion or other large predator parts do you use in your culture or community and what are they used for?

.....
.....Nothing.....
.....

44. Have you seen a lion, leopard, hyaena or jackal in the last one year?
Yes ( ) What was it?..... How many?..... Where did you see it?.....
No (×) .....
45. Have you ever been attacked by lions or other predator?
Yes ( ) Activity when attacked.....Time of day.....
No ( )

46. Has anyone in your village ever been attacked by lions other large predator? Hippo
Yes ( ) Activity when attacked.....Time of day.....
No ( ) .....
47. How many people in your village have been killed by lions and other large predators in the last one year?
.....Hippo killed one one Nothing (2 People).....
.....
48. What do you do when lions and other large predators attack people? Hippo
Nothing (×) Go to park authorities ( ) Go to police ( ) Local leaders ( ) Kill the animal ( )
Other.....

49. What do you do when lions and other large predators attack livestock?
Nothing ( ) Go to park authorities ( ) Go to police ( ) Local leaders ( ) Kill the animal ( )
Other.....
50. What tools/methods are used for hunting animals in the area? *Please tick all those that you know*
1.Wire snare (×) 2.Spear (×) 3.Nets (×) 4.Wheel trap (×) 5.Guns ( )
Others.....

51. Have you lost livestock in the last one year to Lions and other large predators, or disease?

Livestock	Number	When	Disease	Wild animal
Cattle				
Goats				
Sheep		None		
Other (s)				

Carnivore status and conflict assessment survey; 2011

52. Where did you lose the livestock and at what time of the day? (tick appropriately)

Activity	Day	Night
While grazing on communal land		
While grazing in the park		
At home		

53. Do animals in the park get killed in retaliation for livestock/crop losses in your village?
1) Yes (x); 2) No ( )
a) If Yes how?
hipos eat at night.

If No, why?

54. How are your relations with the park authorities?
1) Very good ( ), 2) Good (x), 3) Bad ( ) 4) indifferent ( )

If bad, what kind of actions will help to improve it?

55. What should be done for livestock, killed by lions and other large predators from the park in your opinion?
compensation
chase the animals from community land

56. What do you think could be done to stop lions and other large predators from attacking livestock?
- fencing.

57. Do you think lions and other large predators should be conserved in parks? Yes (x) No ( )
Why? - for future generation to see
- Bring income.

58. How can people with livestock live along side lions and other large predators more easily?
there is no way people can leave along side predators.

59. Would you like the park to be fenced against lions and other large predators leaving the park?
Yes (x) No ( )
If No – why not

Would you contribute to the maintenance of a fence or other barrier? Yes (x) No (x)

60. Would you be interested in contributing to some form of insurance scheme where you contribute reasonably each year and if an animal was killed you would be compensated from the scheme?
Yes (x) What kind of contribution and how much?
No ( ) If No why not?

Thank you very much