Technical Report

Aerial surveys of Murchison Falls Protected Area

F. Wanyama, P. Elkan, F. Grossmann, S. Mendiguetti, F. Kisame, G. Mwedde,

R. Kato, D. Okiring, S. Loware, and A.J.Plumptre

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Executive Summary

This report summarises the findings of a Systematic Reconnaissance Flight (SRF) survey over the Murchison Falls National Park (MFNP) and the Bugungu and Karuma Wildlife Reserves, together called the Murchison Falls Protecetd Area (MFPA). MFPA is located in north western Uganda where the Nile River flows into Lake Albert. A systematic reconnaissance flight (SRF) was made using a 2.5 km grid across MFPA, using a design that has been used previously so that the same grid cells are surveyed each time.

The findings of the survey were that many species were stable or increasing. Elephant numbers were estimated at 1,330 slightly down from the 2012 survey but not significantly different given the standard errors of the survey. Jacksons Hartebeest, Uganda Kob, Waterbuck and Buffalo appear to have increased in number, while oribi, warthog and giraffe populations appear to be stable compared with surveys made in 2010 and 2012. Only one old elephant carcass was observed in these surveys indicating that poaching pressure is low.

We make several recommendations to improve the protection of elephants in particular but also to conserve the other large mammal species. In particular we believe that the move to Oil production in the park that is planned for the coming years should be monitored very closely. Elephants should be tracked using radiocollars as well as regular aerial surveys to monitor the movements of individuals as well as the general distribution of the species. Elephant numbers on the southern bank of the Nile are increasing and there is a need to increase law enforcement presence in this area to ensure these elephants are protected.

Table of Contents

Introduction

Murchison Falls Protected Area (MFPA) consists of the Murchison Falls National Park (MFNP) and two adjacent Wildlife Reserves; Bugungu and Karuma. These protected areas are located in the north west of Uganda and conserve the largest contiguous set of protected areas in Uganda. MFNP contains the largest population of Rothschild giraffe in the World and is critical for the conservation of this endangered subspecies (Brown *et al.* 2007; Fennesey & Brenneman 2010). Large mammal species such as Jackson's Hartebeest (possibly Lelwel Hartebeest if the taxonomy proposed by Groves and Grubb 2011 is accepted), buffalo, oribi, waterbuck, Uganda Kob and Reedbuck occur here together with elephants.

MFNP was established in 1952 from the Bunyoro-Gulu Game Reserve which was established when people left the area following an outbreak of sleeping sickness in 1912 (Olupot *et al.* 2010). When the explorer Samuel Baker first visited this area he described the banks of the Nile as being heavily populated and cultivated in 1866 but rinderpest and then sleeping sickness caused people to move away from the area. The Karuma and Bugungu Game Reserves were established in the 1960s from controlled hunting areas and then established as Wildlife Reserves in 2003. In the 1940s and 1950s the region around MFPA was well known as a good region for hunting elephant with some of the largest 'Tuskers" in east Africa to be found in the Aswa-Lolim Hunting Reserve to the north of MFNP.

Regular aerial surveys were made in the 1960s and early 1970s of the elephant and buffalo populations using sample counts in quadrats (Laws *et al.* 1975). Within MFPA and Aswa-Lolim, the elephant population increased from some 10,000 elephants in the early 1960s (approximately 60% south bank, 12% north bank, 28% Aswa-Lolim), to some 21,000 by the early 1970s (approximately 47% south bank, 8% north bank, 45% Aswa-Lolim – Lamprey *et al.* 2003). Between 1965 and 1967, 2,000 elephants were culled in an effort to protect the park's vegetation (Laws et al 1975). The Aswa Lolim Game Reserve was degazetted by Idi Amin in the 1970s and land allocated without titles by him to his friends as ranches. The overthrow of his regime led to massive poaching of elephants in the region and numbers dropped to only 1418 in MFNP in 1980 (Douglas-Hamilton *et al.* 1980) and numbers continued to decline with insecurity in the region, as a result of fighting with the Lords Resistance Army, to 269 in 1996 (Lamprey *et al.* 2003).

This report summarises the results of aerial surveys of both the MFNP and the two contiguous wildlife reserves, Bugungu and Karuma, to the south of the park. The surveys were made as part of the Pan-African Arial Survey of Elephants (PAASE), a series of surveys of all of Africa's savanna elephants, in response to the increasing poaching of elephants for ivory across the continent. These surveys were financed by the Paul Allen Foundation.

Methods

PAASE developed a strict protocol of methods for the aerial surveys that would ensure they were standardized across the continent. These methods are detailed in the PAASE Aerial Survey Standards and Guidelines (PAASE 2014) and summarized here.

Sampling methods

In order to ensure comparability between surveys in previous years the same design was flown where possible. In this survey we made an SRF survey with transect lines at 2.5km intervals (as used

in the 2012 survey of the park – previous surveys between 1996-2010 had used 5km intervals). Adaptive sampling was not used in any of the surveys in Uganda because of the need to survey all large mammal species and the fact that stratifying the protected areas could not be achieved for all species simultaneously. Transects were flown north-south as recommended by the PAASE (2014) and data were separated for analysis north and south of the Nile.

Equipment

Two aircraft were used in these surveys a Cessna 182 (N22044) and a Cessna 206 (N242TC). Both were fitted with a Laser and Radar Altimeters (although one radar altimeter developed a fault for part of the survey) and readings were collected from both altimeters to allow comparison and checking.

Canon EOS 7D cameras with 20 mm wide-angle lenses were mounted on suction mounts to the rear windows of each plane one for each Rear seat observer mounted behind their heads with a cable release. The cameras were oriented to capture the view of the observer as closely as possible. Cameras were fixed on manual focus and taped at infinity and settings made to ensure fast shutter speeds to ensure that all images were sharp. Photographs were taken for any groups larger than 10 individuals for all ungulates and photographs were taken for all groups of elephants observed (including single individuals).

Voice recorders were used by the RSO's to capture information including the transect line number, subunit number along the line, species observed and number seen. These were transcribed onto datasheets immediately following the survey (either morning or evening) and then photos were checked to obtain the accurate numbers of animals in groups. A continuous recording of all people in the aircraft was also made starting from when the aircraft left the ground to when it returned. This allowed us to put a time-stamp on the recordings to help correct issues where it wasn't clear what had been said into the voice recorder.

Flight lines were uploaded to the pilots GPS unit and the lines and subunits were uploaded to the FSO's GPS unit to enable the FSO to call out both the line numbers and subunits along the line as well as record Radar altimeter readings about every 20 seconds.

Calibration

Calibration flights for the SRF were made for each of the two aircraft and their survey teams in MFPA. The planes flew between 250-500 feet above the ground over white boards placed at 20 metre intervals along the runway. Observers both counted the number of white squares they could see and also took photographs which were checked later for the number of white boards between the streamers. Calibrations were entered in a computer by the FSO while in flight to check progress while the calibrations were being calculated and to ensure that flights with unexpected numbers were re-flown at the same height to check ground distances. Using this method we were able to ensure that the R^2 value exceeded 0.89 for each calibration and that the intercept was between +/-20m.

A test transect (2 hour flight) comparing laser altimeter and radar altimeter readings over various types of habitat and topography was undertaken. The results are presented in a separate report but showed that on the whole the two methods were comparable except when flying over dense canopy

in forested areas. In these areas the lazer altimeter measured to the top of the tree canopy while the radar altimeter measured to the ground.

Survey flights

The flights were flown early in the morning about one hour after dawn (7.30-8am) and ended by 11am. On some days flights were also made in the late afternoon between 3.30-6.30pm (dusk is around 7pm). The SRF surveys were made on 20th and 21st May 2014. Each aircraft interleaved transects it flew so that they flew every second transect allowing us to compare results between planes and also between observers within the planes. Training was carried out for two days before the surveys commenced as this was the first of three surveys to be made in Uganda and one of the RSOs was new to this work. Observers entered the data on datasheets and in the computer immediately after the flight and where time permitted they also checked their counts of groups of animals from the photographs. For some flights the photo checking continued to a subsequent day and on some days no flights were made to allow observers to catch up with the backlog of images.

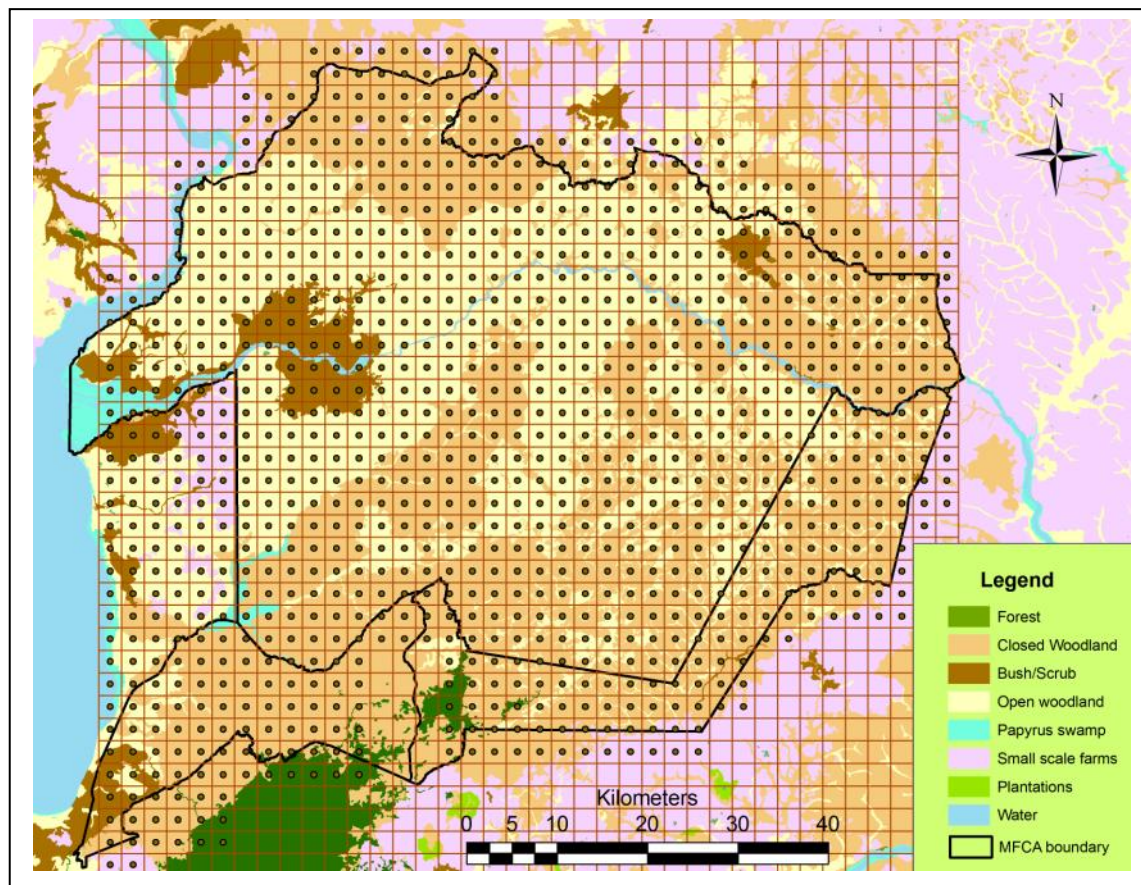The survey design for the MFPA is shown in figure 1.

Figure 1. Survey design for SRF survey of MFPA

Elephant Carcasses

All elephant carcasses were recorded and classified according to the MIKE aerial standards: 1. Fresh; 2. Recent; 3. Old; 4. Very Old.
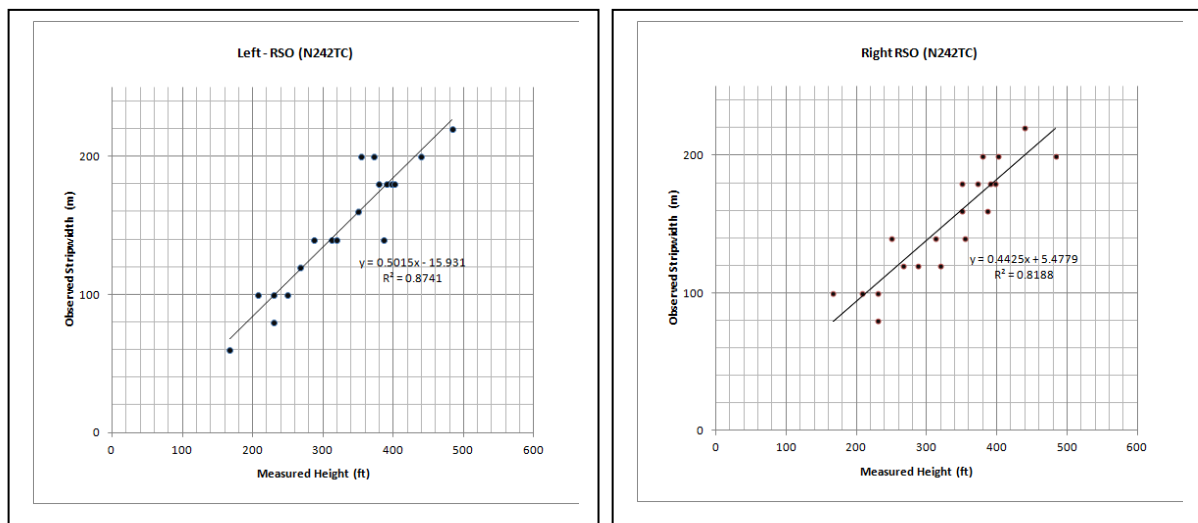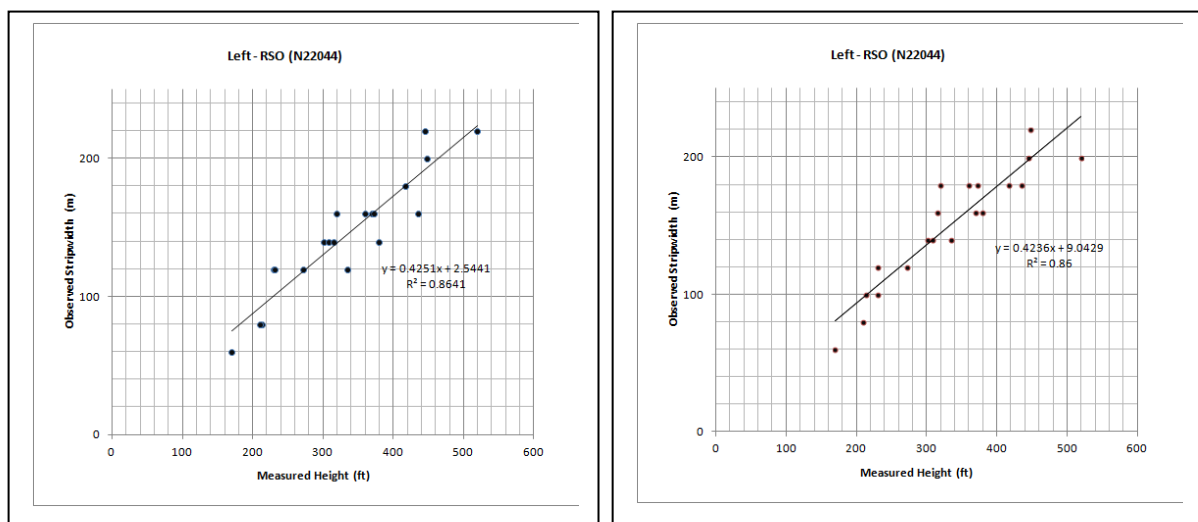
Results

Systematic Reconnaissance Flight (SRF)

Calibration figures

The calibration lines for both left and right observers are given in figure 2 for each aircraft used in the survey. These show that calibrations had R^2 values of between 0.81-0.87 and intercept were between +/- 20m as per the PAASE guidelines (PAASE 2014). The calibrations were made several times to try to reach an R^2 value of 0.9 or above but failed and we present the full data here that were used rather than omit points to make the lines look better.
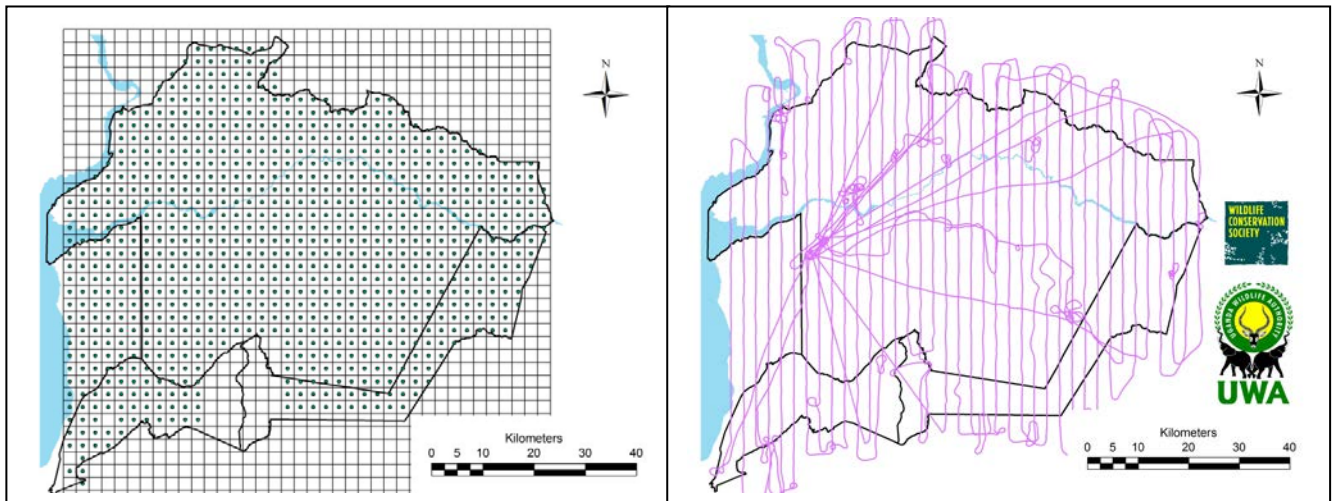
Aircraft N242TC

Aircraft N22044

Figure 2. Calibration regression lines relating height of plane above ground to strip width on the left and right sides of each aircraft.

Subunits surveyed in 2014
Figure 3 shows the subunits that were surveyed in 2014. The planes did fly over other subunits to the south of the MFPA but did not record data as the canopy was too dense to be able to observe animals. To the north the planes stopped where there was cultivation.

Figure 3. Map of the subunits surveyed in the SRF(left) and flight lines of the planes (right)

The average height of the plane was 306 feet above the ground giving an average strip width searched of 275 metres.
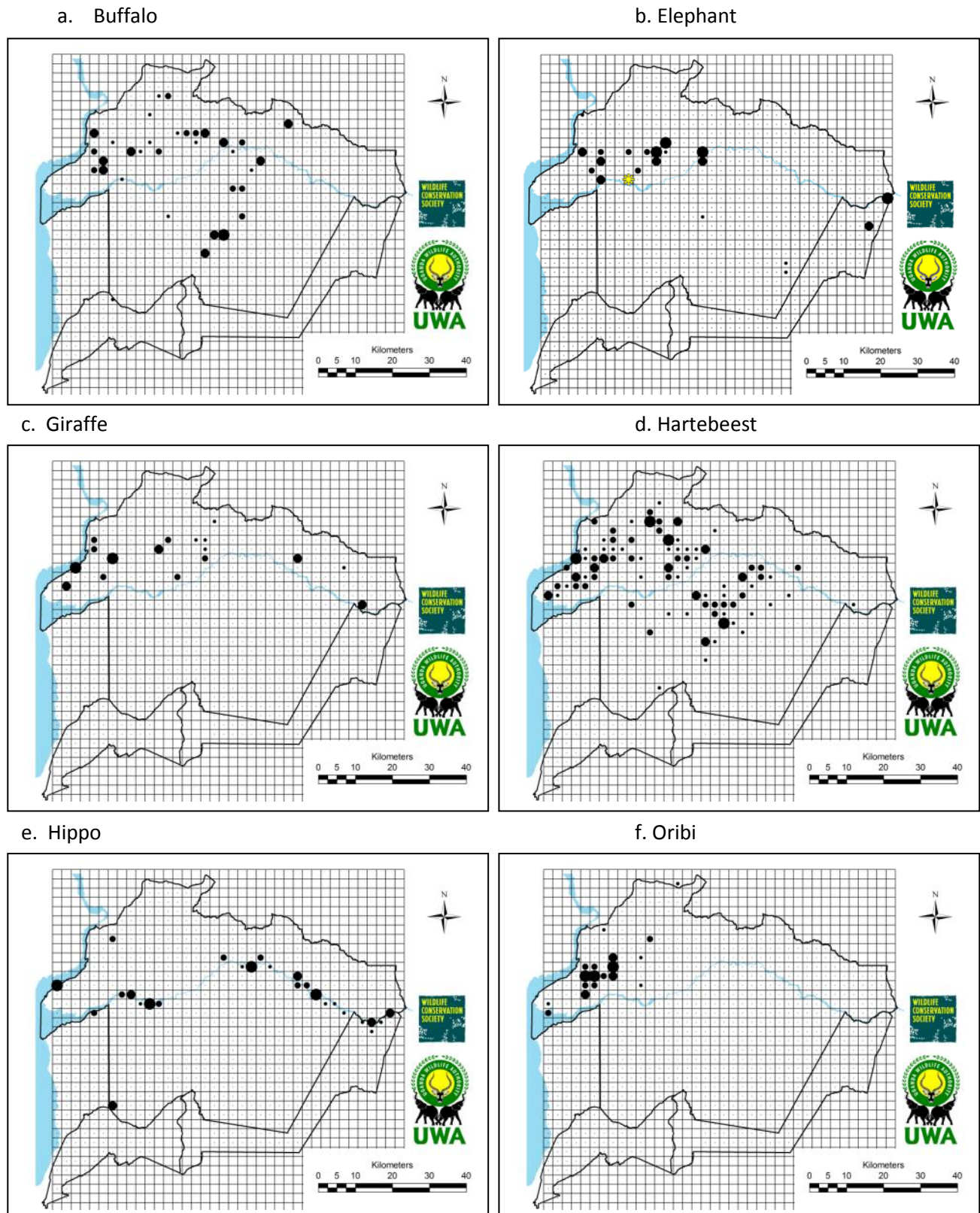
Estimated numbers of animals from SRF
The results of the estimate for each species is given in Table 1 for both the north and south bank of the MFPA as well as for the area as a whole. Each species density is mapped for each 2.5 x 2.5 km grid cell in figure 4.

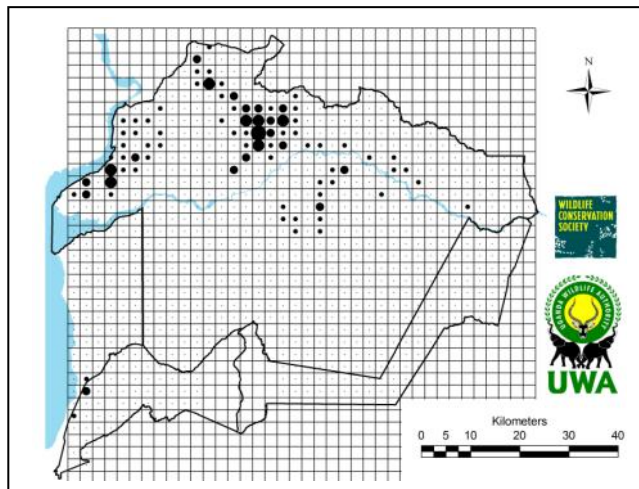**Table 1.** Estimated species abundance in MFPA north and south of the Nile river and for the whole area.

Species	North Bank			South Bank			MFPA Total		
	Est	SE	95% +/-	Est	SE	95% +/-	Est	SE	95% +/-
Elephant	977	349	767	375	214	471	1,330	441	970
Buffalo	7,376	2,174	4,783	5,589	2,336	5,139	12,841	3,411	7,505
Giraffe	884	241	531				860	235	517
Hartebeest	5,385	966	2,125	2,830	758	1,668	8,108	1,149	2,527
Hippo	809	289	636	884	237	522	1,683	325	714
Oribi	558	241	530				543	234	515
Uganda Kob	50,653	9,966	21,925	8,910	2,550	5,611	58,313	10,432	22,951
Warthog	3,330	616	1,355	1,723	295	650	4,986	844	1,857
Waterbuck	3,627	637	1,401	1,687	434	954	5,240	790	1,737
Cattle				5,768	2,209	4,861	7,076	2,473	5,440
Shoats				259	171	375	262	175	385

a. Buffalo

b. Elephant

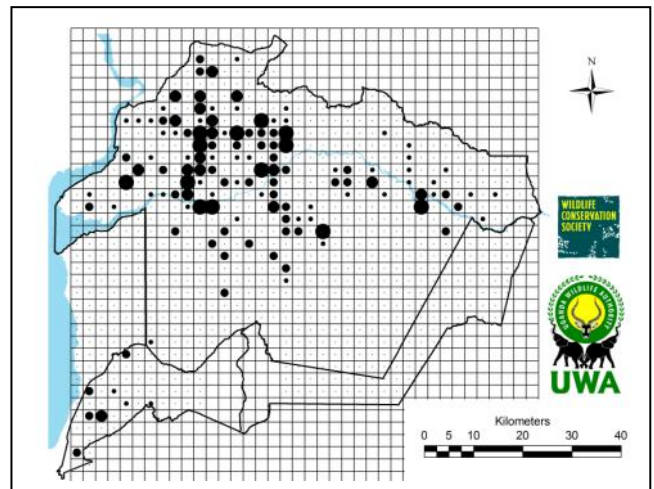c. Giraffe

d. Hartebeest

e. Hippo

f. Oribi

Figure 4 (part 1). The relative densities of buffalo, elephant, giraffe, hartebeest, hippo and oribi in each 2.5 x 2.5 km cell mapped for the MFPA. The yello star in he elephant map indicates the only carcass observed of elephants.
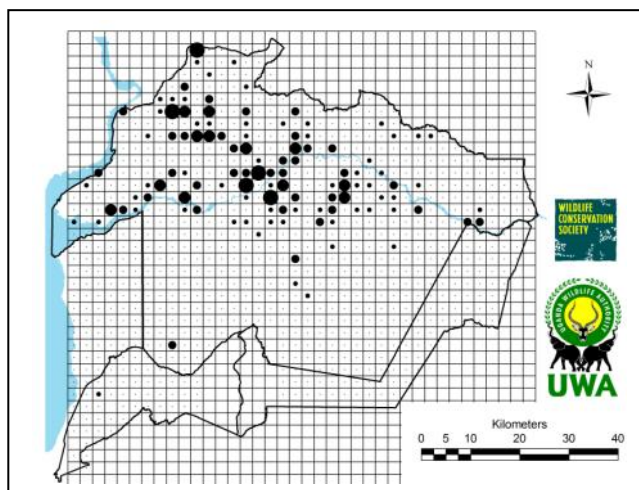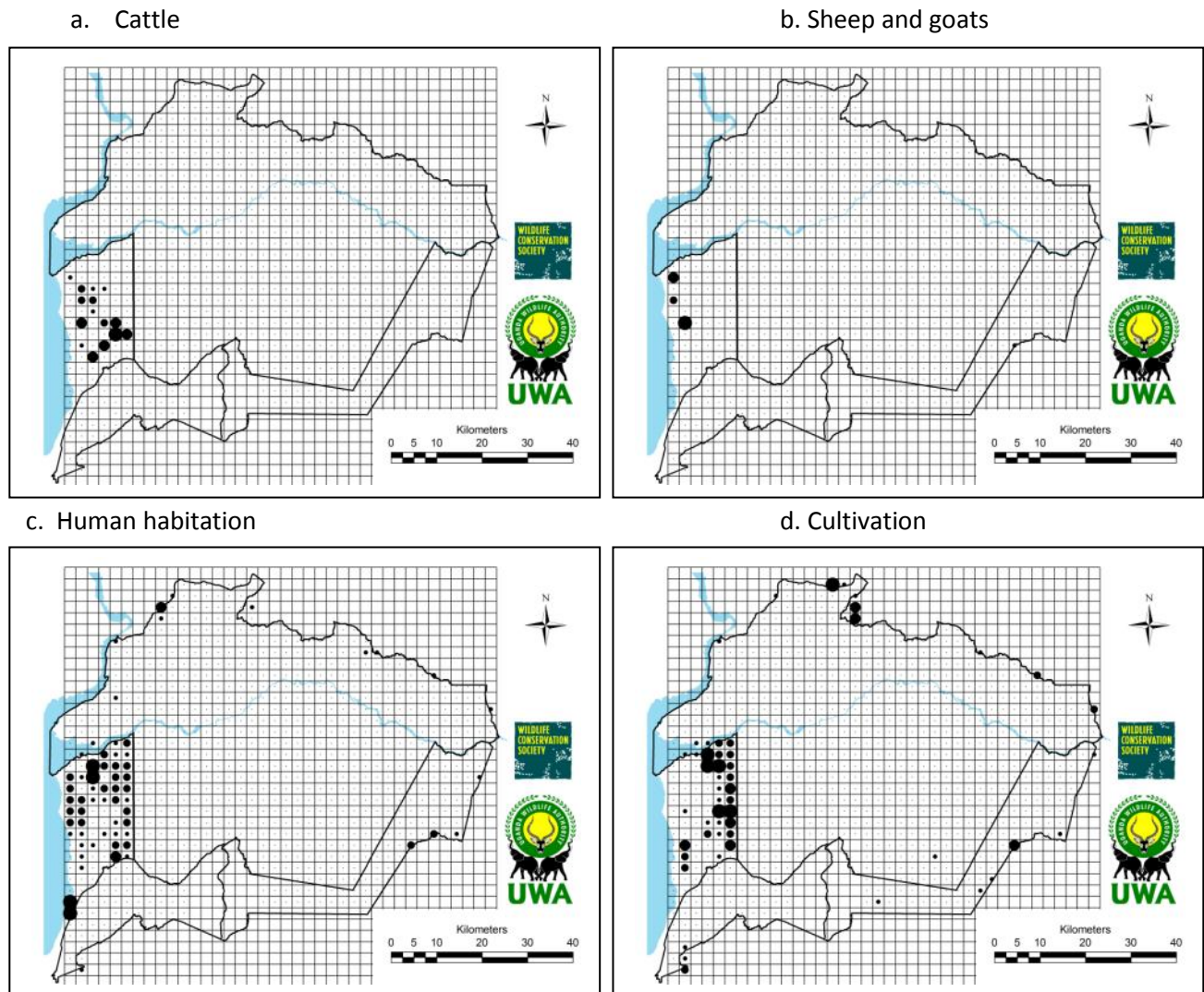
g. Uganda kob

h. Warthog

i. Waterbuck

Figure 4 (part 2). The relative densities of Uganda kob, warthog and waterbuck in each 2.5 x 2.5 km cell mapped for the MFPA.

A comparison of the average number of sightings per transect by the rear seat observers (appendix 2) indicates that the two rear seat observers for N242TC had similar numbers of sightings of large mammals (T=1.595, df=25.63, P=0.12) but that the observes in N22044 had significantly different numbers (T=2.24, df=29.19, P=0.032). Sam Loware only saw about 55% of the numbers of animals that David Okiring saw in N22044. This could mean that the numbers of some species were underestimated in this survey. A comparison of average group size of animals seen from the plane also showed significant differences between the RSOs in both planes (N242TC: T=3.548 ,df=1116.46 , P<0.001 ; N22044: T=4.274 ,df=439.14 , P<0.001) with Samuel Loware and Kato Robinson observing larger groups of animals than Fred Kisame and David Okiring.

In the past 20 years most of the large mammals have been concentrated in the north west of MFPA. Figure 4 shows that this is beginning to change now and that animal numbers are starting to increase in the east of the north bank and also in the centre of the park south of the Nile river. Oribi are the only species confined to the north west of the park, the Buligi area where much of the oil production will be taking place. Giraffe are also confined to the northern bank of the park also but the other species occur on both banks, although few elephant were observed on the southern bank still.

Measures of human presence are mapped in figure 5. These show that the bulk of the habitation and livestock are outside the MFPA boundary to the west of the southern bank of the park in the Wanseko area. There was some cultivation spotted within the Karuma Reserve to the south east of the MFPA (figure 5d).

a. Cattle

b. Sheep and goats

c. Human habitation

d. Cultivation

Figure 5. The relative abundance of signs of human presence in each 2.5 x 2.5 km cell mapped for the MFPA.

The chief anti-poaching warden of Murchison conducted a one day overflight with the WCS survey aircraft and other UWA colleagues evaluate threats, and take action to follow up with investigations and protection measures. Only one old carcass was detected during the survey though UWA MIKE data document four elephants having been killed in the Park over the past year.

Discussion

Trends in elephant and other large mammals

WCS has compiled aerial survey data from MFPA from as many records we have been able to find by trawling the published literature and working through old records in the library at QENP (table 3). From the beginning of aerial surveys in MFPA counts were made flying strips but it is unclear whether observers were using streamers to restrict their search area initially and accuracy may have varied with different weather conditions (Buss 1990). Numbers of elephants fluctuated between years in the 1960s (figure 6) which may have been partly a result of the method and partly because at this time elephants migrated out of MFPA in the dry seasons (Buss, 1990). Figure 6 shows that elephant numbers still have a long way to go to recover to their 1960-1970s population levels (when they were at their peak numbers).

Figure 6. Plot of numbers of elephants for each year since 1957 in MFPA.

Table 3. Counts from aerial surveys in MFPA since the early 1960s. Numbers for all surveys that WCS have been able to compile information from published and unpublished records are given.

Year	Elephant	Buffalo	Giraffe	Hartebeest	Oribi	Uganda Kob	Waterbuck	Warthog
1957	5,268							
1958	8,710							
1959	7,438							
1963	5,868							
1964	7,634							
1966	7,779							
1967	8,313	14,291						
1969	9,364			4,644		2,581	3,969	1,171
1971	3,551							
1973	9,971	30,000	175			10,000	4,000	
1974	4,072							
1975	1,061						4,000	1,000
1976	1,422							
1980	1,418	18,731	5	14,000		30,700	6,037	5,500
1981		15,269						
1991	308	1,610	78				1,600	
1995	269	2,477	126	2,749		6,355	634	566
1999	778	3,889	347	2,903		7,458	1,639	792
2002	692	8,200	229					
2005	516	10,043	245	4,101	285	9,315	2,298	1,441
2010	904	9,192	930	3,589	904	36,640	1,962	6,430
2012	1,617	7,506	757	6,263	23	36,234	2,508	6,648
2014	1,330	12,841	860	8,108	543	58,313	4,986	5,240

Giraffe estimate remained consistent with previous years which is a positive sign for this endangered species. Warthog estimates were also similar. Buffalo, hartebeest, Uganda kob, and waterbuck numbers also indicated population increases. The Uganda kob estimate is much higher than previous estimates.

Elephant status and conservation

The SRF results for MFCA reveal a continued steady increase in elephant numbers following the general pattern indicated by surveys in 2005, 2010, and 2014. The 2014 estimate is lower (by 300) than the 2012 estimate however in consideration of 95% confidence intervals there is no significant difference. While a total count was not conducted, the lack of elephant carcasses (n=1 old) viewed from the SRF survey lines and in recce flying before and after survey support UWA's MIKE data which indicate that poaching has decreased in the Park over the past year.

Human elephant conflict has been and is a major concern for communities around MFCA, and two "crop raiding" groups were observed near the eastern border of the Park.

While UWA efforts to secure the elephants of MFCA seem to be bearing fruit, the expansion of the oil production activities in the northern sector of the Park present a major period of risk for the recovering elephant populations as well as giraffe.

The following conservation actions are recommended:

- As elephant conservation is more successful and elephants feel secure they will range further into the southern sector of the Park. Continued support to the Anti-poaching and LEM efforts of UWA and deployment of UWA staff to the south will be important for protection efforts throughout the entire area of the Park.
- Increased frequency of aerial monitoring visits by UWA aircraft to support Park monitoring of threats, particularly in the south and east which are logistically more difficult to access.
- Collaring and monitoring with GPS/satellite collars the "crop raiding" groups and orientation of efforts to reduce their activities and HEC.
- Training of UWA staff in relation to preparing them for working with Total Oil E&P Uganda to minimize negative impacts of the exploration operations in the Park
- Continued monitoring of the movements and distribution of elephants and other species in the oil exploration areas as they start to move into production
- Within the broader Murchison Falls Conservation Area it is recommended to extend effective elephant protection efforts to the area of Uganda immediately adjacent to Nimule Park in South Sudan. Several incidents of poaching of this elephant population when they cross to the Uganda side have been be registered over the past years. UWA should mobilize and continue with transboundary cooperation with the Nimule Park South Sudanese counterparts.

Acknowledgements

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Appendices

Appendix 1. Survey teams

The composition of the survey teams are given by plane and survey here:

Observer	QEPA – N242TC	QEPA – N22044
FSO	Frederick Wanyama	Falk Grossman
RSO left	Fred Kisame	Samuel Loware
RSO Right	Kato Robinson	David Okiring
Pilot	Paul Elkan	Soqui Mendiguetti

Appendix 2. Comparison of observers

The number of animals seen for each species are given for each plane and rear seat observer together with the average number of sightings per transect flown and average group size of observations:

MFCA

Species	Plane N242TC		Plane N22044	
	Fred Kisame Eria	Kato Robinson	Okiring David	Samuel Loware
Buffalo	80	380	598	361
Elephant	29	58	31	29
Giraffe	16	21	51	7
Hartebeest	226	377	147	146
Hippo	13	37	118	18
Oribi		34	8	18
Uganda Kob	1,539	2,490	1,650	765
Waterbuck	120	122	203	134
Warthog	85	184	186	96
Cattle	126	372	141	187
Shoats		4	25	
Grand Total	**2,238**	**4,103**	**3,231**	**1,772**
Mean number per transect	121.9	223.7	188.4	103.9
Mean group size seen	3.4	5.2	2.7	4.8

Appendix 3 – SRF population estimates from each plane separately

We here present the results of the estimated numbers for MFPA analyzing the two planes independently. This effectively assumes they were flying transects of 5 km width with blocks of 2.5 x 5 km being sampled.

	N242TC			N22044		
	Population	**SE**	**95%**	**Population**	**SE**	**95%**
Buffalo	**8,184**	3,008	6,617	**17,651**	6,360	13,993
Elephant	**1,548**	703	1,547	**1,104**	591	1,300
Giraffe	**658**	231	508	**1,068**	435	957
Hartebeest	**10,728**	1,931	4,248	**5,393**	916	2,015
Hippo	**890**	268	591	**2,503**	577	1,269
Oribi	**605**	380	837	**479**	302	665
Uganda Kob	**71,681**	19,254	42,359	**44,450**	8,034	17,674
Waterbuck	**4,305**	908	1,998	**6,203**	1,358	2,988
Warthog	**4,786**	1,188	2,613	**5,190**	1,307	2,876
Cattle	**8,077**	3,653	8,036	**6,037**	3,623	7,971
Shoats	**71**	69	151	**460**	361	795

The results show a large difference in estimates between the two planes, particularly for buffalo, Jackson's hartebeest and Uganda Kob. Whether these differences are due to observer differences or simply due to the clumped nature of the animals leading to large differences is unclear. Testing the difference between these population estimates using Z-test shows that only the estimates for hartebeest and hippos are significantly different between the planes.