ECOLOGY, DENSITY AND POPULATION OF SITATUNGA IN CENTRAL UGANDA

2017 Annual Report

UNIVERSITY OF ALBERTA
QUAECUMQUE VERA

Contributors & Cooperators

Researchers

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Highlights:

Third field season was January – August 2017 along the Mayanja River near Ngoma, Uganda
In early February 2017, the study area experienced drought conditions and partially burned
Camille Warbington presented results of an opportunistic hydrology study and preliminary results of the spatially explicit capture recapture estimate of density at
The Wildlife Society Annual Conference in Albuquerque, New Mexico in September
We recruited undergraduate researchers for assistance in compiling a database of identified sitatunga individuals

Camille Warbington presented preliminary results of the overall study at the
15th African Wildlife Consultative Forum in Arusha, Tanzania in November 2017.

Mark – resight study:

In 2017, we recorded 296 encounters with sitatunga from viewing platforms and trail cameras
Using individuals identified in 2015, we used a Spatially Explicit Capture Recapture (SECR) program to estimate the density of sitatunga along the Mayanja River, ranking competing models according to Akaike Information Criterion (AIC). The best model estimates a density of 4.64 sitatunga (95% confidence interval 2.94 – 7.31) per square kilometer.
We are recruiting an undergraduate researcher for Fall Term 2018 to verify the identification of individual sitatunga

Telemetry Study:

We attempted capture of adult sitatunga for 8 days in July 2017 with the cooperation and supervision of the Uganda Wildlife Authority
We were unsuccessful in capture during 2017, however, we identified methods to aid in capture for 2018 efforts

Other Studies:

We contacted Dr. James Kalema of Makerere University to consult on a study regarding sitatunga feeding site characteristics
We analyzed data regarding sitatunga space use during different hydrologic conditions
Microsatellite DNA extraction and analysis is scheduled to begin in Summer Term 2018

Background:

Trophy hunting is controversial, prompting questions of sustainability, equitable treatment of user groups, and ethics (1,2). For the developing world, however, trophy hunting can provide crucial funds for conservation of wildlife and habitats, especially in places with limited tourism (3 - 5). One reason for skepticism of trophy hunting are sparse data and limited monitoring to form the basis for harvest quotas for target species (1,2,6) Sitatunga (Tragelaphus spekii) is a spiral-horned antelope endemic to sub-Saharan Africa that is a highly valued trophy animal (7, 8). In 2010, the Uganda Wildlife Authority authorized trophy hunting for sitatunga (9). Unfortunately, it has done so without complete data on population size or distribution. This is especially concerning because as recently as 2008, sitatunga was thought to be highly endangered in portions of its Ugandan range (10, 11). Establishing baseline data on the status of the sitatunga populations within hunting areas and expanding existing knowledge about sitatunga ecology must be a main priority to maintain a responsible trophy hunt in Uganda (3,6). Sitatunga have a wide distribution across sub-Saharan Africa, yet there is little scientific information about the species (11).One major reason for the lack of data appears to be the difficulty of working in the wetlands where they live. Sitatunga are adapted for life in dense vegetation in swamps and papyrus marshes, making traditional population survey techniques problematic (12 - 19). Uncertainties about sitatunga are not limited to population density, but extend to basic ecology of the species. For example, there are conflicting reports about the preferred habitats for sitatunga, with some accounts asserting that the species stays in dense wetland vegetation, while other studies report crop-raiding from dry land adjacent to rivers (10, 18). Further, there are inconsistent reports regarding territoriality, movement patterns, and sex ratio (13-19).To ensure sound management of a trophy hunt for sitatunga in Uganda, it is critical to evaluate local information about the species and its population.

Due to the inaccessibility of sitatunga habitats, and the difficulties in distance sampling for population estimation, alternate techniques to monitor and estimate population density are warranted. Camera trapsare emerging as a useful method identifying activity patterns, species presence, and estimating the abundance of antelope (20-22). If animals are individually identifiable, estimating population from camera traps or a mark-resight population design is feasible (21,23). From previous work in Kenya and the Republic of Congo, sitatunga are identifiable based upon coat markings and horn shape in males (17, 19). By incorporating spatial information, a spatially explicit capture - recapture (SECR) study design allows for estimation of density, even if not all animals in the population are equally exposed to "capture" sites or if the effective sampling area is unknown (24). In addition, SECR models estimated using Bayesian statistical methods allow for imperfect identification and sparseness of data (25). Recent research indicates that multiple sources of data improve understanding of populations, especially for cryptic or elusive species (20,26, 27). To ensure responsible and sustainable sitatunga hunting, our research will provide crucial baseline information in three key areas: habitat use, population size, and genetic diversity. Results from our study, which will be undertaken with support from teams based in Uganda and Canada, will provide information to enhance the management of sitatunga in Uganda and has potential to influence wildlife management for other cryptic and elusive species occupying dense habitats.

Objectives and Methods

Objective 1 – Estimate home range and composition of vegetation within the home range of adult sitatunga. We will capture 12 sitatunga and track with GPS radiocollars. We will supplement telemetry relocations with data from a mark-resight study design (21, 26). Observers at machans over open lanes in papyrus will be equipped with still photography cameras and telephoto lenses, and will serve as additional "capture" locations for inclusion in analysis. Trail cameras will be placed in areas used by sitatunga, to serve as "capture" locations and source of temporal activity data (23, 28). Camera data in conjunction with movement data provide a temporal and spatial record of habitat use for individual sitatunga, which will allow for modelling of habitat selection ,and population density similar to those being tracked via GPS telemetry (26, 29-31). Images will be compiled into a library for use as a reference in identification to individual,using coat markings and horn features as identifiers (23). Cameras will be located not only in wetlands but at varying distances from the edge of the wetland into forested habitats to document sitatunga use of dry land. We will identify habitat use by projecting GPS radiocollar relocations onto GIS maps with delineated habitat types (31). We will estimate home range using minimum convex polygons and autocorrelated kernel density estimators (AKDE) (32-34).

Objective 2 – Estimate density of sitatunga in the Mayanja River of Uganda. Building upon movement data from the mark-resight portion of Objective 1, we will use both telemetry and camera data to develop a spatially explicit capture-recapture (SECR) model of population density (26). Home range information from telemetry data will be incorporated into SECR analysis (27). We will use SECR in a Bayesian framework using SPACECAP in program R (25) This program and design has been successfully implemented in Africa for elusive and cryptic species such as leopard (35).

Objective 3 – Document dispersal and large-scale population structure. We will collect genetic material from harvested individuals (males only) and individuals captured as part of the radiotelemetry effort (which includes males and females). We will process sampled material for single nucleotide polymorphisms (SNPs). SNPs are a cost-effective way to record thousands of variable sites in non-model organisms, and is now the preferred marker for population-based diversity studies (36).

Study Area

Our research is taking place in central Uganda, in the marshes of the Mayanja River system, which is part of the Nile watershed in the Nakaseke District of Uganda. Central Uganda lies between 900 and 1100 m above sea level, and contains multiple lakes, rivers, and swamps (37). The Equatorial Ugandan climate is described as generally rainy, with two dry seasons, December to February and June to August, although there is local variation in the length, timing, and duration of the dry seasons (38). Reports from people familiar with the study area indicate that both dry seasons are characterized by a decrease in rain, although the December to February dry season is drier, longer, and more reliable (Anon., E. Enyel , P. Symington, R. Okori, pers.comm).

On average, little of the land is permanently cultivated (38). Other species present include hippopotamus (Hippopotamus amphibius), Nile bushbuck (Tragelaphus scriptusbor), Defassa waterbuck (Kobus ellipsiprymnus), oribi (Ourebia ourebi), bohor reed buck (Redunca redunca), warthog (Phacochoerus africanus), bushpig (Potamochoerus larvatus), and common duiker (Sylvicapra grimmia). As part of this study, we will use GIS to map the extent of papyrus and other suitable habitats. The most recent estimates of the total area of papyrus and other wetlands occurred in 1999. The estimate at that time was 30,000 km^2 (MWE, unpublished data).

Statement of 2017 Study Area Conditions

In 2015 and 2016, research activities occurred during the rainy season of April – August. It is possible that sitatunga behaviour changes during the dry season, which would alter trends noted in data collected for objectives 1 and 2. Thus, in order to understand more aspects of sitatunga ecology, we needed to perform the same research activities during the dry season. In 2017, we began data collection in February to determine any difference in sitatunga detections during the dry season.

On the Mayanja River, early 2017 was dryer and hotter than in recent years (R. Okori and P. Symington, pers. comm.). In late January and early February, a substantial portion of the papyrus (Cyperus papyrus) dominated wetland burned due to the dry conditions and adjacent shoreline charcoal production. The fire events consisted of one large scale fire which burnt wetland from shoreline to shoreline, and several smaller fires that did not traverse the entire width of the wetland. The burnt areas comprised all or part of the cut lanes for three road machans and up to six river machans. Burned areas were reduced to bare ground (if present) and blackened stubble, which we assume is unsuitable for sitatunga. We performed vegetation measurements in the burned areas during the weeks and months following the fire to ascertain recovery of species diversity and vegetative cover.

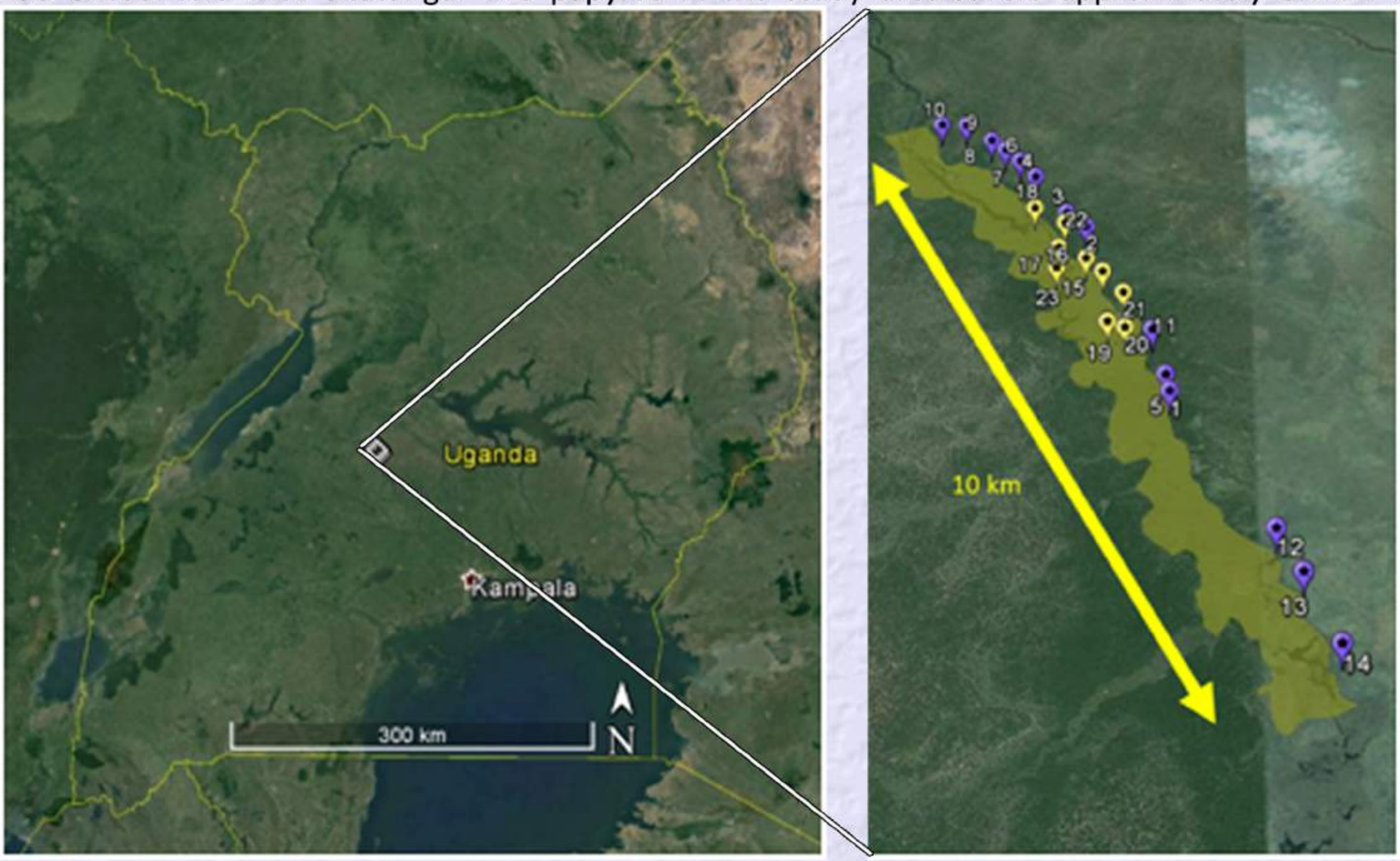
Wetland Recovery from Papyrus Fire 2017

February 14th 2017 **March 2nd 2017** **March 31st 2017**

In addition to the fire, the dry conditions led to a retraction of water within the river channel. Thus, areas used as water access points for livestock in previous years were unsuitable for this purpose in early 2017. In addition, the drought conditions led to dieback of normal foraging areas for cattle. Whereas in previous years we did not observe cattle entering into the lanes cut open for sitatunga, in 2017 we observed cattle actively entering unburnt sitatunga machan lanes to eat papyrus and other plants, and to access water. Previous research into sitatunga habitat and behaviour indicated that sitatunga avoid areas used by cattle, and that sitatunga move to wetland interior during dry seasons. The extreme conditions during early 2017 offered a unique opportunity to test these hypotheses, and underscore the importance of data collection during different conditions.

Results

Field research occurred from 6 February through 18 August in the Mayanja River near Ngoma, Uganda. We used 14 machans and 28 trail cameras across approximately 10 km of river to record 296 encounters with sitatunga. The papyrus in the study area covers approximately 8.1 km^2.



We attempted mark-resight at machans a total of 135 times, 82 times in the morning hours around sunrise (approximately 6:30 AM to 9 AM), and 53 times around sunset (approximately 1630 to 1900). Temperature during data collection ranged from 16 to 34 Celsius, and we recorded 28 rain events during these efforts. We classified an individual as an adult male if horn shape included one full twist.

We classified an individual as an immature male if horns were present but did not meet the shape requirement. Sitatunga were classified as lambs when they displayed very small body size and/or were accompanied by a larger adult female. We classified a sitatunga as unknown sex and/or age if we could not completely see the head to verify presence of horns, or if the body size was intermediate between lamb and adult female size.



We built upon our previous SECR model of density results using sitatunga individuals identified in 2015. We created a candidate set of models to test for differences in detection by sex, location of camera, and a learned response. We did not incorporate habitat covariates in our candidate model set. We ranked the models according to AIC. The top 3 models are listed in Table 1. According to the top ranked model, detection of sitatunga depends upon a site-specific earned response, and there are no differences in density between the sexes. The best model suggests a density of 4.64 (95% confidence interval 2.94 – 7.31) sitatunga per square kilometer. We caution against extrapolation of this estimate to the Mayanja River or outside our study area, because this model was fit using a reduced data set, habitat covariates are not included in this model, and there may be differences in density by year of our study. Further modelling and analysis will clarify these results.

Table 1. Top three SECR models of density for sitatunga in the Mayanja River study area, 2015. Models ranked according to AIC.

Model	Definition	AIC	ΔAIC	Density (Animals/km^2)	95 % Confidence Interval
g0 ~ bk	Detection depends on a site-specific learned response	2545.5	0	4.64	2.94 - 7.31
g0 ~ bk + h2	Detection depends on sex and site-specific learned response	2580.6	-35.15	Males: 4.55, Females: 4.55	Males: 2.80 - 7.40, Females: 2.80 - 7.40
g0 ~ K	Detection based upon the site effectiveness of the preceeding occasion	2783.7	-238.3	2.78	2.84 - 5.46

With the assistance of undergraduate student volunteers, we have created a database of identified individuals to streamline the identification and verification process. We developed a three observer verification process to ensure that identified individuals are confirmed before inclusion in modeling processes. We are following up on SECR programs that can incorporate uncertain identifications in order to increase our sample size for density estimates. These steps will help to improve confidence in any estimate we calculate.

We observed profoundly different water levels during the three years of our study, 2015 – 2017. We considered a possibility that sitatunga detections vary by year, due to water levels and prevailing climate, thus a year effect will be tested in all candidate models of density. We also considered that cattle densities change yearly, and this can also have an effect on sitatunga space use. As a wetland dependant species, sitatunga might not tolerate drought as well as other species of competing wildlife, such as bushbuck or waterbuck, and sitatunga space use may change as a result. Finally, we observed sitatunga using forests in 2015, and were interested in if sitatunga use dry land habitats more or less as the water level changes. The conditions we encountered in 2015-2017 offer a natural experiment to address these questions. We separated the study area into three zones: forest, shoreline, and river. Shoreline and river were wetland zones, characterized by aquatic vegetation and saturated soil (if soil was present). Shoreline wetlands were visible from a 2 m tall platform located on dry land, and River wetlands were not visible from the platform. Forest zones were characterized by lack of aquatic vegetation, presence of woody stems, and a canopy at least 2 m in height. We placed Reconyx Hyperfire trail cameras in all three zones during the three years of our study. We classified 2015 (April – August) as a normal water year, 2016 (April – August) as a flood year, and 2017 (February – April) as a drought year. The number and type of sitatunga sightings we recorded with trail cameras is summarized in Table 2.

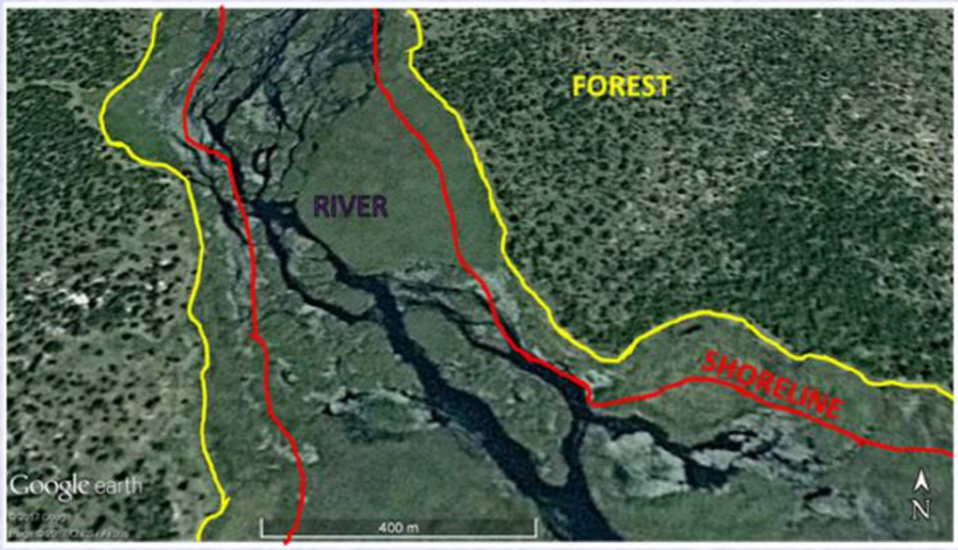


FIGURE 1. *Depiction of the three habitat zones used in the study of sitatunga space use and hydrology, 2015-2017, Mayanja River, Uganda.*

Year	Zone	# Trap nights	# Detections	Proportion
2015 Normal	Forest	318	33	0.104
	Shoreline	98	15	0.153
	River	1357	157	0.116
2016 Flood	Forest	286	4	0.014
	Shoreline	508	25	0.049
	River	587	59	0.101
2017 Drought	Forest	168	0	0
	Shoreline	--	--	--
	River	1012	127	0.125

Table 2. Summary of sitatunga detections by trail cameras in the three habitat zones (Forest, Shoreline, and River) for the three years of the study, 2015-2017, in the Mayanja River area of central Uganda. Proportion is the percentage of days with at least one detection of at least one sitatunga for the given zone and year.

We used a modified chi-squared statistic to test for differences in proportions of sitatunga detections between years for each zone. Results of these tests are summarized in Table 3. For the Forest and Shoreline zones, we found that the proportion of days with a detection of at least one sitatunga was lower in the normal water conditions compared to the flood conditions. Similarly, we found that detections of sitatunga in forests was lower during drought conditions when compared to normal conditions. Finally, we found that proportion of days with sitatunga detections did not differ between years for the river zone.

Table 3.
Chi-squared test for differences in proportions of days with at least one sitatunga detection for the given condition-area combination compared to normal water conditions within the same zones.

Condition	Area	P-value
Flood	Forest	9.66×10^{-6}
	Shoreline	3.59×10^{-4}
	River	0.368
Drought	Forest	4.2×10^{-12}
	River	0.508

Since the proportions of sitatunga did not change between water conditions for the River zone, this area may represent core habitat, or a type of refuge from increased competition from native and domestic herbivores in Shoreline and Forest zones. We performed the same type of test for cattle, and found that the trail cameras only detected cattle in the forest zone, and that the proportion of days with a detection of at least one cow increased every year of the study, regardless of water condition (Table 4). However, we did observe cattle entering Shoreline wetlands to eat papyrus during the drought while collecting data for another part of the study. This may reinforce the importance of the River zone for sustainable sitatunga populations.

Year	Zone	# Trap nights	# Detections	Proportion
2015 Normal	Forest	318	13	0.041
	Shoreline	98	0	0
	River	1357	0	0
2016 Flood	Forest	286	16	0.056
	Shoreline	508	0	0
	River	587	0	0
2017 Drought	Forest	168	27	0.160
	Shoreline	--	--	--
	River	1012	0	0

Table 4.
Summary of cattle detections by trail cameras in the three habitat zones (Forest, Shoreline, and River) for the three years of the study, 2015-2017, in the Mayanja River area of central Uganda. Proportion is the percentage of days with at least one detection of at least one cow for the given zone and year.

In conjunction with the Uganda Wildlife Authority's veterinarian, we attempted capture of adult sitatunga during July 2017. While we were unsuccessful in capture, we did formulate alternative capture strategies to use during capture attempts in 2018. Capture and fitting of GPS radiocollars to adult sitatunga remains a field research priority in 2018.

We collected an additional 8 hide samples from harvested adult male sitatunga. The export mpermit is pending. DNA extraction of the 41 samples from 2015-2016 began in October 2017. Unfortunately, the DNA recovered from the samples is too degraded to allow for SNP analysis; however, microsatellite analysis is still possible. We contacted other safari outfitters in Uganda to collect samples from other populations for comparison of genetic diversity. From attending the AWCF meeting in Tanzania, we also may have access to samples from other parts of sitatunga range to improve analysis and facilitate a genetic library of microsatellites. We hope to collect further samples from the Mayanja River during the 2018 field season. Camille will perform all DNA extraction and analysis. We expect lab work for this project to commence in May 2018.

We completed 18 vegetation surveys, including measurements of vegetation species diversity and height of hiding cover. This includes repeated surveys in burnt areas during their recovery. It also includes six sitatunga feeding areas. We have contacted and begun collaboration with Dr. James Kalema, a botanist at Makerere University, Kampala, Uganda, to assist in identification of wetland plants encountered during vegetation surveys and in preparation of manuscripts regarding the vegetation data.

PhD Candidate Camille Warbington attended The Wildlife Society Annual Conference in Albuquerque, New Mexico, USA in September. Camille presented the results of the hydrology study mentioned above, and a poster on the preliminary SECR density models. Camille also attended the 15th African Wildlife Consultative Forum in Arusha, Tanzania in November, where she presented preliminary results on all aspects of the study.

Timeline

January 2018 – April 2018: field capture of adult sitatunga, record demographic information, take genetic samples, and affix GPS radiocollars; position trail cameras; maintain camera trap grid, including downloading images, troubleshooting malfunctions, and relocating cameras as necessary; photograph sitatunga from machans; obtain genetic materials from harvested sitatunga in Uganda; compile data from GPS collars; import hide samples; measure sitatunga feeding sites; complete verification of individuals identified 2015-2017.

May – December 2018: Obtain satellite imagery of study area and begin assignment of habitat types; complete identification of individuals from images taken in 2018; begin DNA extraction and analysis of genetic diversity via microsatellites; compile population genetic analysis; troubleshoot problems detected in DNA testing methods; begin estimation of home range size; continue identification of individuals from mark-resight and camera-trap data; prepare manuscripts; write thesis.

Significance and Deliverables

In the developing world, trophy hunting offers incentive to landowners to preserve hunted species and their habitats (1,3-6). Even if local communities are supportive of hunting, wildlife managers need data about the hunted species to ensure sustainability (1). To date, there have been few studies of sitatunga, and these studies offer conflicting reports (12-19). Local information about sitatunga ecology and population is therefore imperative to ensure sound management of this species and any harvest. Information about population density,home range, and habitat connectivity will not only improve local management, but also add to the body of knowledge about sitatunga that aid in onservation of the species across its range. After completion of this project, we will have estimates of population size, genetic structure, and habitat use of the sitatunga population in the Mayanja River, Uganda. This project builds upon existing population density estimation techniques for cryptic and elusive species, and capitalizes on multiple data sources to enhance accuracy and precision of estimates (26). In this manner, the results of this research can benefit conservation strategies for other species facing deficient data.

Future Research Priorities

We were able to collect substantial mark-resight data during our field seasons. We have established that sitatunga are individually identifiable based upon coat markings and horn shape, and preliminary analyses verify that our study design is suitable to generate a density estimate. Our analyses will be vastly improved with GPS telemetry data, thus capture of adult sitatunga is a research priority. Assessing differences in genetic diversity between populations of sitatunga can identify obstacles to dispersal or at-risk populations; thus creating a library of microsatllite DNA markers for sitatunga from widely distributed populations is a research priority.

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