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To: The Rufford Foundation
Re: Progress Report for Lindsey Rich

Project: Developing a large scale, standardized monitoring program for carnivores in Botswana
Location: Ngamiland District and Moremi Game Reserve, Botswana
Primary Investigator: Lindsey N. Rich
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Project Goals and Objectives:

Northern Botswana has one of the most diverse carnivore guilds in Africa and is considered a stronghold for many carnivore populations. These carnivore species are under threat, however, as Botswana recently reported declining wildlife populations, increasing pressures from illegal hunting, and large scale changes in land management policies. To address concerns raised by these reports, information on wildlife species' densities, distributions, and ecology is needed. Working in collaboration with the Botswana Predator Conservation Trust, I aim to address this knowledge gap by identifying and implementing a sustainable method for monitoring carnivore communities across northern Botswana. To achieve this overall goal, I have three research objectives:

1) Estimate the densities of sympatric meso- and large carnivores using camera trap surveys in combination with advanced statistical models
2) Estimate overall carnivore richness and determine what influences the distribution of carnivores across the multi-use landscape
3) Evaluate the efficacy of spoor surveys, as compared to camera trap surveys, for monitoring the distribution and population trends of large carnivores

In addition to my research objectives, I have also identified two outreach objectives:

1) Build local capacity in regards to monitoring wildlife populations through field workshops, presentations, and individual training.
2) Develop a conservation program for children from local communities

Progress Summary:

I completed my pilot study in May - August 2013. Upon arriving in Botswana, I worked with researchers from the Botswana Predator Conservation Trust, my local collaborator, to identify three focal study sites. The study sites represent different levels and types of human impact, ranging from the livestock grazing areas of Shorobe (i.e., high impact) to Wildlife Management Areas NG33/34 to Moremi Game Reserve (i.e., low impact), and fall along a gradient of resource availability and quality (e.g., distance to permanent water). This range of conditions will allow a natural, spatially and temporally replicated experiment of how carnivore species and carnivore communities are influenced by human land use practices, access to water, and habitat quality. During my pilot study, I trialed my field methods in two, 100km^2 study sites within Wildlife Management Areas NG33/34.

Camera trap surveys

I deployed 25 camera stations in each study site for ~5 weeks. In the first study site, I designed my sampling using a 4-km^2 fixed grid which resulted in camera stations being spaced at intervals of ~2km. In the second study site, I tested an alternate sampling design known as the cluster design. Each cluster included 3-4 camera stations spaced ~500m apart and clusters were separated by 3-4 km. I trialed this design because the spatial models I am using to estimate density require individuals to be photographed at multiple camera stations (i.e., recaptures). I hypothesized that the cluster design would improve my likelihood of recapturing both meso and large carnivores. Specifically, I hypothesized I would recapture mesocarnivores (e.g., caracal and serval) within clusters and large carnivores (e.g., leopard and cheetah) among clusters.

I collected >500,000 photographs over 74 days of sampling (one of the remote sensing camera models had extremely high sensitivity and took an abundance of photos of nothing—changing shadows, moving vegetation, etc.). On the positive side, the cameras photographed all meso- and large carnivores indigenous to this region (Table 1).

Table 1. Meso- and large carnivores photographed during the 2013 pilot season where *n* = the number of independent detections.

Species	**Scientific Name**	***n***
Aardwolf	*Proteles cristatus*	28
African wild dog	*Lycaon pictus*	17
Bat-eared fox	*Otocyon megalotis*	11
Black-backed jackal	*Canis mesomelas*	72
Caracal	*Caracal caracal*	16
Cheetah	*Acinonyx jubatus*	9
African civet	*Civetticitis civetta*	85
Honey badger	*Mellivora capensis*	50
Leopard	*Panthera pardus*	64
Lion	*Panthera leo*	29
Serval	*Leptailurus serval*	28
Spotted hyena	*Crocuta crocuta*	237
Wildcat	*Felis silvestris*	47

Currently, I am employing newly developed statistical analyses to estimate the density and occupancy of these carnivore species. In addition to these carnivores, I photographed forty other wildlife species (Table 2).

Table 2. List of wildlife species photographed during the 2013 pilot season (in addition to the species listed in Table 1).

Wildlife Species			
Aardvark	Dwarf mongoose	Humans	Slender mongoose
African buffalo	African elephant	Impala	Bush Squirrel
African porcupine	Francolin spp.	Kori bustard	Springhare
Baboon	Small spotted genet	Lilac breasted roller	Starling spp.
Banded mongoose	Giraffe	Magpie shrike	Steenbok
Cape hare	Greater kudu	Mouse spp.	Vervet monkey
Common duiker	Ground hornbill	Oxpecker	Warthog
Common tsessebe	Guinea fowl	Pangolin	Blue Wildebeest
Crimson-breasted shrike	Red-billed hornbill	Pied babbler	Burchell's Zebra
Dove spp.	Yellow-billed hornbill	Roan antelope	Zorilla

Spoor surveys

A wildlife guide from Sankuyo and I carried out 8 spoor surveys within each study site over the same time period that camera traps were deployed. We surveyed for large carnivore (i.e., lion, leopard, cheetah, wild dog, and spotted hyena) spoor. We covered >200 km of transect and detected the spoor of all large carnivores; hyena spoor was detected most often while cheetah spoor was detected least often. I am in the process of preparing the data for analysis using spatial autocorrelation occupancy models.

Ecological covariates

I conducted 8 distance sampling surveys for prey species with the help of volunteer research assistants. We recorded the GPS coordinates of the sighting, angle to the animal, distance to the animal (using a rangefinder), species, cluster size, and habitat type. The prey species recorded with the greatest frequency was impala (*Aepyceros melampus*). We also recorded the Greater Kudu (*Tragelaphus strepsiceros*), Burchell's zebra (*Equus burchellii*), African elephant (*Loxodonta africana*), warthog (*Phacochoerus africanus*), giraffe (*Giraffa camelopardalis*), blue wildebeest (*Connochaetes taurinus*), and steenbok (*Raphicerus campestris*). I am preparing this data for analysis in Program DISTANCE. Following the analysis, I will compare prey density estimates from DISTANCE to camera trapping rates of prey. If they are strongly and positively correlated, this would suggest that camera trapping rates of prey could be used as an index of prey densities.

We also collected data on the microhabitat features surrounding each camera station. Specifically, we collected data that will allow me to estimate canopy cover, tree density, and the dominant tree species. In addition to the 1,250m^2 area encircling the camera station, we collected this data at areas located 50m down the road from the camera station and 50m up the road. I hypothesize that these microhabitat features may influence a carnivore's probability of

detection. Lastly, I collected several GIS layers that will allow me to estimate vegetative cover, road density, and distance to a permanent water sources.

Outreach efforts

To implement a long-term, sustainable monitoring program it is imperative to involve and train individuals from local organizations. Thus, I met with several members of the Sankuyo Community Trust to discuss my research. Sankuyo is a village in my study area and has user rights of the wildlife management areas (NG33/34) I worked in. Two wildlife guides from Sankuyo also received intensive, hands-on training on how to implement my field techniques. When I return to Botswana, I plan to have several field workshops for the Sankuyo Trust, Okavango Research Institute and the Department of Wildlife and National Parks to build capacity in regards to monitoring wildlife populations.

Lastly, to instill a conservation ethic in Botswana's future generations and in turn, increase the likelihood of wildlife persisting in and outside of protected areas, a wildlife guide from Sankuyo and I have developed Wild Joys (Figure 2). Wild Joys is a conservation outreach program for children from rural communities in Botswana. We take kids into nearby protected areas to provide them with positive wildlife encounters and expose them to natural history, animal behavior, and field techniques (e.g., camera trapping, track surveys, and radiotelemetry). In August 2013 we took 42 children from Sankuyo village into the field over the course of 6 days. This was the first time the majority of children had ever seen lions, wild dogs, and leopards. To see a fundraising video we created, please visit www.lindseyrichresearch.com/wild-joys-outreach.

Funding & Timeline

My pilot season was funded by The Rufford Foundation, Temenos Foundation, and Wilderness Wildlife Trust. I applied for multiple grants to support my 2014 field season (e.g., Fulbright Research/Study Grant, National Geographic Conservation Trust, Cleveland Zoo, and Columbus Zoo). I recently secured funds from the Cleveland Zoo and was notified that I am a Fulbright finalist. I am waiting to hear back regarding the remaining grants so I can start planning my 2014 field season. I plan to return to Botswana for six-month field seasons in 2014 and in 2015. The anticipated completion date of this project is August 2016.