Progress Report for the Jana Robeyst Trust Fund

Project Title: African forest elephant distribution using passive acoustic monitoring and occupancy modelling

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Summary
Over the past decade, African forest elephants (Loxodonta cyclotis) have experienced drastic decline in abundance and habitat loss due to increased poaching and resource extraction throughout West and Central Africa. Since forest elephants live in dense, remote forest habitats, it is not possible to conduct systematic visual surveys. Transect counts of elephant dung are the favored method to estimate forest elephant populations, but these are expensive and covering large landscapes is time-consuming. Passive acoustic monitoring provides a non-invasive, potentially more cost-effective method of detecting elephant presence across large spatial and temporal scales. Combined with occupancy modeling, acoustic surveys can reveal elephant distribution across a vast range, which can help scientists and regulators improve conservation efforts and monitor spatiotemporal changes in distribution.

This research will serve as a proof-of-concept for the application of occupancy modeling with long-term acoustic presence data to infer African forest elephant temporal and spatial distribution during a time of intense poaching and habitat loss. The outcome from this study aims to incorporate the occupancy model in future acoustic monitoring projects across West and Central Africa in order to monitor on-going, long-term trends of forest elephant distribution across a large spatial and temporal scale. This study is a first step towards filling in current data gaps in forest elephant distribution in order to evaluate and track forest elephant conservation status in dynamic areas where poaching effort increase and landscape development is rapidly growing.

Background
African forest elephants (*Loxodonta cyclotis*) were recently identified as a genetically distinct species from the African savanna elephant (*Loxodonta africana*), warranting a need for separate population monitoring and conservation status (Ishida et al 2011). In contrast to the open habitat of the savanna elephant, forest elephants inhabit dense rainforests throughout

Central and West Africa and have, therefore, not been as extensively studied (Breuer et al 2016).

The Congo Basin has provided optimal habitat for forest elephants over thousands of years, however, in recent years it has attracted lucrative industrial prospects (e.g.; logging, oil extraction, mining), which have consequently changed the landscape over the past few decades. Within the last 10 years, elephant habitat has reduced by 30% (Maisels et al. 2013) and is increasingly fragmented. Industrial activities lead to the development of roadways in remote regions of the Congo Basin for more efficient and reliable transportation of equipment and resources. Those new roads also became a convenient route to transport illegal bushmeat and ivory from the dense, remote elephant habitats (Blake et al. 2008), therefore poaching has increased with accessibility to elephants. Consequently, the population is estimated to have declined by 60% (Maisels et al. 2013) over the last decade.

To improve conservation efforts, a better understanding forest elephant distribution in relation to anthropogenic activities is crucial. Since forest elephants inhabit dense, remote forests, visual monitoring and dung transect surveys are challenging. Passive acoustic monitoring has proven to be a successful, non-invasive and cost-efficient method of collecting continuous, long-term presence data of elephants in forested environments (Wrege 2010, 2012). An occupancy model can then use the acoustic presence data to infer elephant distribution across the study area. Occupancy modeling (the probability that a target species occurs at a surveyed site using presence/non-presence data) has been increasingly implemented to infer species' distribution over space and time using presence data (Hines et al 2010, Bailey et al 2014), while requiring less rigorous data collection than abundance and density estimation, and allowing for missing data and imperfect detection. The application of occupancy models to passive acoustic data is a relatively new concept, however, scientists often use motion-activated camera surveys to construct occupancy models (Shannon et al 2014, Fuller et al 2016).

Objectives

- Determine acoustic presence of African forest elephants at 20 sites in Kakum National Park, Ghana, using passive acoustic recording devices
- Determine visual presence of African forest elephants at 20 sites in Kakum National Park, Ghana, using motion-activated camera traps
- Obtain occurrence data of African forest elephants in Kakum National Park, which was collected one year prior to this research (June 2017).
- Compare the distribution of African forest elephants between the three methods using an occupancy modeling framework
- Determine the efficacy of passive acoustic monitoring to determine African forest elephant distribution
- Combine the three methods to better model the distribution of African forest elephant in Kakum National Park in relation to environmental and anthropogenic factors

- Estimate the detection range of African forest elephants in the Kakum National Park forest habitat

Completed Work

In June 2018, after obtaining the remaining funds to provide the necessary equipment and support field efforts, I travelled to Kakum National Park, Ghana and worked with the Rangers of the Ghana Forestry Commission to deploy the Swifts and camera traps at each of the 20 study sites (Figure 1). Given the dense vegetation in the forest, and the challenges that the rainy season presented (e.g., impassable rivers), it was clear that the time to deploy equipment at all 20 sites throughout the park would take more than anticipated, exceeding a month of time. The survey design required simultaneous recording at each site, and with a recording gap of one month or greater, I was concerned that the temporal gap would result in unusable data for the objectives.

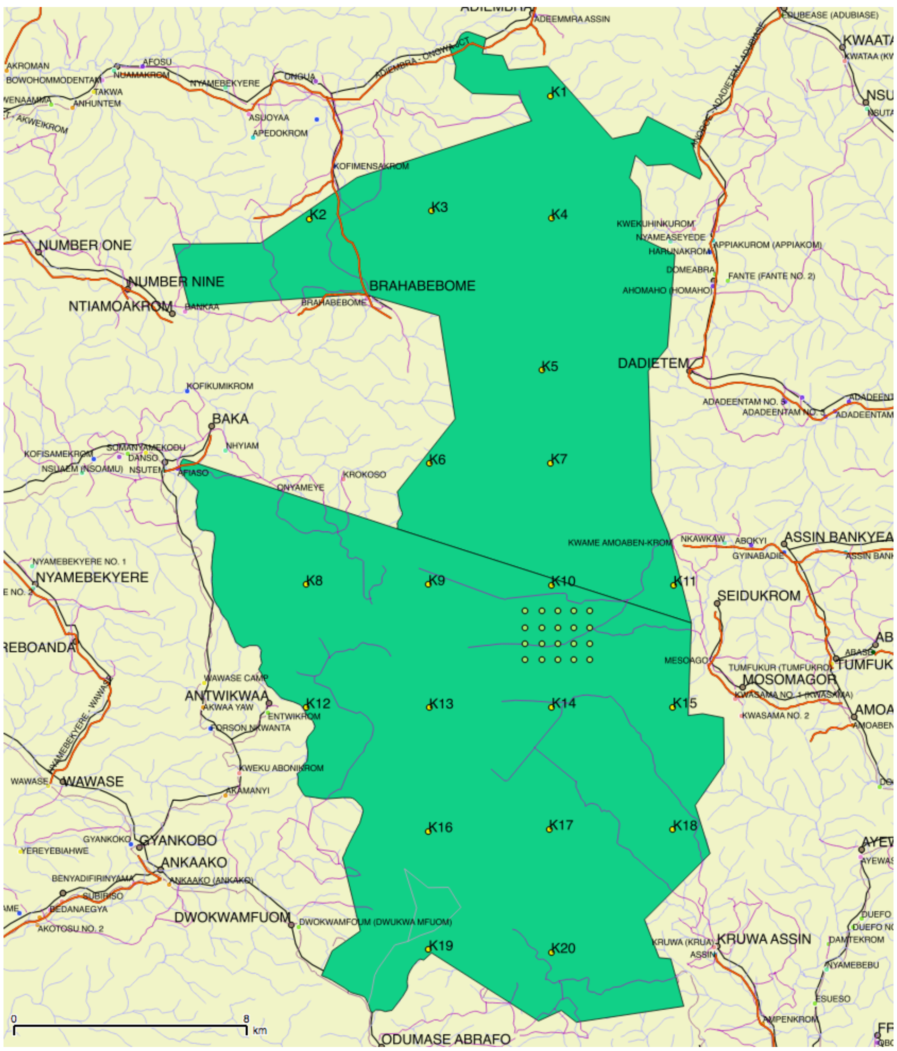

Figure 1. Configuration of the 20 sites (yellow dots) where camera traps and Swifts were deployed between June and September 2018. The green region delineates Kakum National Park from the surrounding area. The cluster of yellow dots in the middle of the park represents the configuration of the Swifts during the detections range survey in September 2018.

Working with the lead Park Ranger (Mr. Samuel Annan Riverson), we recruited several men from surrounding villages to assist in deploying and retrieving the equipment. Each individual was selected based on his previous work experience in patrolling the forest, and his reputable reliability and responsibility. I worked with the men for several days in training them to program the devices, proper deployment techniques, and identification of the appropriate site. They were very interested in the research on elephant distribution and were eager to participate in field efforts. The men were compensated for their time and efforts.

With 5 teams designated to specific sites across the Park, we successfully deployed acoustic recording devices and camera traps at 20 sites between 20 June and 10 July, 2018. The devices remained in place until September/October. In November, I extracted the data from the media cards on all devices and began analysing the data.

Challenges

After reviewing the camera trap photos, only two elephants were captured by the cameras. This is not unexpected, as my hypothesis is that the west and central African rainforests are too dense to allow for accurate detection of forest elephants, however, I would like to test the cameras in another forest to confirm that the lack of elephants captured by these cameras is not unique the Kakum habitat. That effort will be conducted at a later time. The lack of elephant photos precludes any occupancy model comparison to acoustic models using those data. However, it does illustrate that camera traps are not useful to estimate distribution of forest elephant in Ghana.

There were two sites in which the acoustic recording device (Swift) malfunctioned, resulting in partial or complete loss of data. These malfunctions were likely caused by water intrusion during the rainy season, despite significant efforts to make the housing of the Swift water proof. Those sites affected are K14 and K19 (see Figure 1).

To make the analysis of the acoustic data time-efficient, I ran a detector algorithm on the sound files to detect elephant rumbles. The detector yielded many false positive events, comprising vehicle noise from the roads surrounding the park. The number of detector events was too large to review, so I decided to manually review the sound data, in search of elephant rumbles. I began with the sites in the northern section of the park and, after a couple months of analysis, did not find many elephant signals. This is not unexpected, as forest elephant distribution from the dung count surveys suggests that elephants spend more time in the southern portion of the park. I then decided to prioritize analysis for the sites in the southern portion of the park, and am currently reviewing those sites.

Ongoing Work

I am currently analysing the sound data in search of forest elephant rumbles. Once I have looks at a representative portion of all 20 sites, I will then use those data to run occupancy models in order to estimate the distribution of forest elephants. I will then compare that distribution estimate to that of the dung count survey from 2017.

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