Improving capacity to monitor wildlife and design and evaluate anti-poaching strategies in Central African protected areas

Final Report

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Project Officer Name: Derek Litchfield
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2. **Narrative**

a. *One-paragraph executive summary stating project purpose, results and achievements.*

Conservation efforts, including the establishment of protected areas, in the African tropical forest zone have largely been unable to curtail commercial bushmeat hunting. Although anti-poaching patrols are one of the main strategies used to control illegal hunting, protected area managers have had no systematic, unbiased way to design patrol deployments and assess their effectiveness. From April 2013 to March 2016, we used acoustic monitoring to record gunshots occurring in a circumscribed area of Cameroon's Korup National Park (KNP). Funded by the UK-based Darwin Initiative and in collaboration with the Programme for the Sustainable Management of Natural Resources in South West Cameroon (PSMNR), the project's goal was to assist the park in developing an evidence-based decision-support system to design, assess, and implement effective anti-poaching patrols and wildlife monitoring schemes. In February 2014, as part of the Darwin Initiative project, we deployed 2 acoustic sensors in the Rumpi Hills Forest Reserve (RHFR; 443 km^2), located a few km to the southeast of KNP, as a comparative site to KNP. The Rumpi Hills forest has received little to no conservation attention despite the fact that it provides critical habitat for some of the region's most threatened mammal species, including the forest elephant, the Nigerian-Cameroon chimpanzee (*Pan troglodytes ellioti*), the drill (*Mandrillus leucophaeus*), and the poorly studied Preuss's guenon (*Allochrocebus preussi*). The purpose of the USFW grant was to demonstrate how the wildlife and gun hunting acoustic monitoring protocol can be "exported" to other protected areas. We (J. Linder with co-PIs Christos Astaras and Peter Wrege) installed 8 additional acoustic sensors in the RHFR in November 2014, to monitor 45 km^2 of rainforest. Between Nov. 2014 and Oct. 2015, we recorded 79,551 hours of sound data and estimate that over 750 shots were fired by hunters annually in our study area. Extrapolating our results to the whole of the RHFR, we estimate that hunters shoot over 7,300 times in the reserve annually. The mean number of gunshots/day/sensor was 0.21 (range = 0.05 – 0.37). Gunshots were somewhat evenly distributed throughout the week with a slight increase in gun hunting from Monday to Friday and a decline from Friday to Sunday. Seventy-five percent of the gunshots occurred at night and 25% occurred during daylight hours. We also successfully located the long calls of the endangered Preuss's guenon in our sound data, confirming its presence in the RHFR. We are currently developing a detection algorithm for this species to assess its spatial distribution in the RHFR and for potential use in other forests suspected to harbor this species. Our projects in Korup NP and RHFR have shown that passive acoustic monitoring can revolutionize how protected areas are monitored and managed. Based on our research we suggest that tropical forest protected areas adopt acoustic technology as a monitoring and assessment tool and, where relevant, integrate the acoustic data with the SMART conservation software.

b. *Longitude and latitude coordinates of the main location of project work.*

Rumpi Hills Forest Reserve: 9.18^o E, 4.92^o N

c. *Descriptions of activities undertaken to achieve each objective in the project proposal.*

Objective 1: Characterize the temporal and spatial patterns of gun hunting activity in submontane and lowland forest areas of RHFR and evaluate large mammal diversity in light of these patterns.

- Activity 1.1: Conduct a rapid survey of RHFR, mapping existing inter-village trails crossing the reserve and permanent, communal bush-huts within and in the periphery of the reserve
- Activity 1.2: Deploy and maintain a grid of ten (10) acoustic sensors in RHFR
- Activity 1.3: Analyze the acoustic data from RHFR for the period Aug. 2014-July 2015 and report on the gun hunting intensity and wildlife activity in the reserve.

In August 2014, we ordered six acoustic sensors and related accessories (i.e. batteries, microphones, cables) from Wildlife Acoustics, which were then modified by Peter Wrege at Cornell University for use

in our project. These supplies were subsequently sent to our field site (Mundemba, Cameroon). In October 2014, we met with the Meka Ngolo community, which is located adjacent to the RHFR and from which we would conduct our research, to develop a collaborative working relationship. We had previously worked with this village to install two acoustic sensors in the RHFR in February 2014 (funded by the UK-based Darwin Initiative). We did not conduct a rapid survey of the RHFR to map existing trails, as originally proposed in our project proposal (Activity 1.1), because of time constraints and because our field staff from Meka Ngolo were extremely knowledgeable about the forest. Essentially, such a survey proved unnecessary. In November 2014, as part of the USFW-funded project, we deployed an additional eight acoustic sensors (six purchased using USFW funds) in the RHFR (see Figs. 1a and 1b), for a total of 10 sensors (Activity 1.2). We placed one sensor (RH05) just outside RHFR in an area known to have hunting activity (based on earlier exploratory surveys in the region by Christos Astaras in 2007) to compare hunting levels between forest in and out of the reserve. The 10 sensors were located at altitudes ranging from 240m – 788m above sea level. Approximately, every three months, we revisited all 10 sensors to replace batteries and swap out SD memory cards. Thus, for example, the November 2014 "deployment" includes all sound data from November 2014 through mid-February 2015. There was a total of 4 such deployments covered by the granting period (Nov. 2014, Feb. 2015, May 2015, Sept. 2015). The results presented in this final report cover the one-year period from Nov. 2014 through Oct. 2015. The sound data on the memory cards were uploaded to project computers in Cameroon and then the cards were mailed to Peter Wrege to backup sound files and for analysis. Using the audio software program *Raven*, Wrege ran algorithms on the RHFR sound data to detect gunshots in the sound files (gunshot detection algorithms were designed during the Darwin Initiative project and other projects on which Wrege was associated). Each flagged putative gunshot was then manually screened by project PIs and/or expert field staff and scored based on its probability of being an actual gunshot (as opposed to, for example, a branch breaking or distant thunder). We selected only the most conservative scores when identifying actual gunshots, which were then used to assess hunting activity. Results of our gunshot analysis are presented in section 2f of this report (Activity 1.3).

Objective 2: Incorporate acoustic monitoring as both a wildlife monitoring and an anti-poaching evaluation/design mechanism in the management plan of RHFR

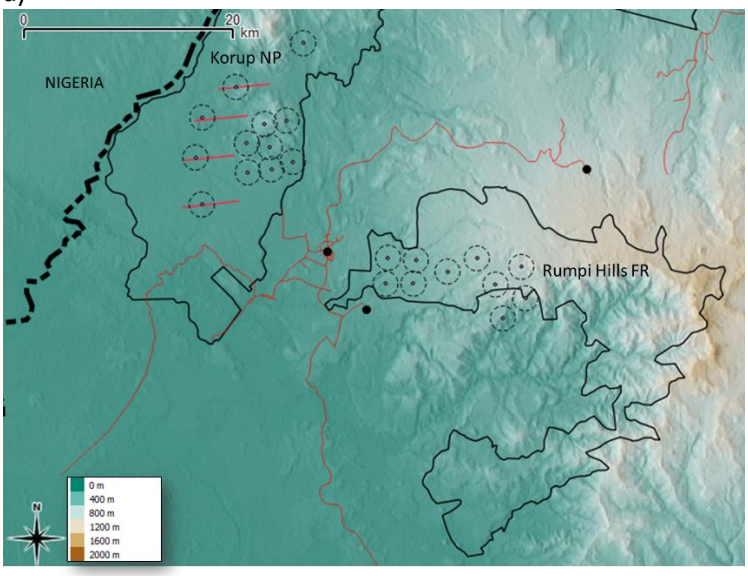
- Activity 2.1: Train local Ministry of Forest and Wildlife (MINFOF) and local partner organization staff in deploying and maintaining an acoustic grid and in analyzing the ensuing acoustic data
- Activity 2.2: Develop a detailed monitoring and anti-poaching patrol protocol for RHFR
- Activity 2.3: Organize a workshop to draft the section that will formally incorporate the acoustic monitoring protocol in the RHFR management plan

In conjunction with our DI project, which ran simultaneously with our RHFR project, we trained five members of the local NGO Korup Rainforest Conservation Society, 4 members of the Cameroon ministry of wildlife (MINFOF), and two people from the village Meka Ngolo to deploy and maintain the acoustic sensors in the RHFR. The KRCS and MINFOF members were also trained in data analysis using the computer program *Raven*. One of the KRCS members (Mr. Orume Robinson) has recently been hired by the PSMNR to oversee all acoustic monitoring deployments and analysis in southwestern Cameroon. In December 2015, we organized a workshop in Buea, Cameroon that brought together the Regional Delegate of MINFOF and representatives from PSMNR and nine protected areas in Cameroon and Nigeria, including the RHFR (represented by Ms. Delphine Erem, the Divisional Delegate of MINFOF for Ndian Division). In this workshop we introduced our acoustic monitoring program, explained its usefulness in managing a protected area, presented results from two years of data collected in Korup NP, and trained five Cameroonians in more advanced techniques for analyzing data from acoustic sensors.

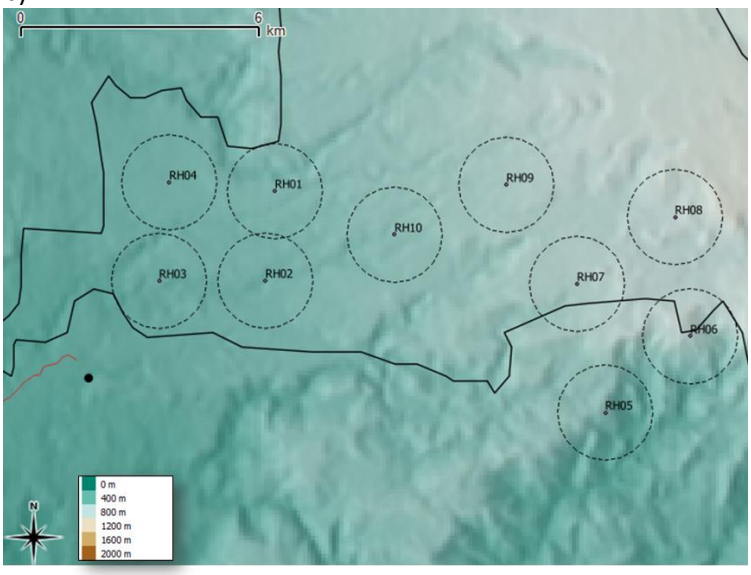
Our results will be incorporated into a report that will be submitted to the PSMNR and MINFOF/Ms. Delphine Erem. The report will (a) detail the utility of acoustic monitoring for protected area management, (b) provide results, the first time ever, on the intensity and spatiotemporal patterns of gun hunting pressure under the current conservation status quo in RHFR, as well as hard evidence on the presence of threatened species (i.e., Preuss's guenon) in the reserve, and (c) describe recommendations for the development of a wildlife and human activity monitoring program in support of upgrading the reserve to a wildlife sanctuary.

Figure 1 a) Location of acoustic sensors in the Rumpi Hills Forest Reserve, Cameroon, relative to acoustic sensor locations in Korup National Park, with 1.2 km buffers marking the approximate effective detection area for gunshots and b) Close-up of sensors in RHFR with sensor identification numbers and 1.2 km buffers

a)



b)



d. *Explanation of the problems encountered for any objectives not met.*

Towards the end of the project's time period (Sept – Dec. 2015), we encountered technical problems with sensors 7, 8, 9, and 10. Some of these sensors simply did not record any sounds during these months while some recorded on some but not all days of those months. This has actually helped us to understand the limits of our current training of acoustic teams. In hindsight, the team needed to have better guidelines of how to look at random files to assess continued good monitoring, and training on what to do about it when problems arise. We also should have at the ready a few spare sensors to trade into the field when problems arise, and more clearly designed protocols for trying to troubleshoot failures in components of the system. This is an important finding as acoustic sensors are deployed in other landscapes in Africa, Europe, and Asia. Despite these technical problems we were still able to quantify the spatial and temporal patterns of gun hunting in the reserve and fulfill our objectives.

We are still in the process of designing an effective detection algorithm for Preuss's guenon (Activity 1.3).

We have not yet developed a detailed monitoring and anti-poaching patrol protocol for RHFR (Activity 2.2) nor have we drafted the section in the RHFR management plan that will formally incorporate the acoustic monitoring protocol (Activity 2.3)

e. *If the goals and objectives were not met, the reasons why*.

We did not, yet, develop a detailed monitoring and anti-poaching patrol protocol for RHFR nor draft the section in the RHFR management plan that will formally incorporate the acoustic monitoring protocol for a number of reasons. First, we decided to focus our attention on convincing the management of Korup NP to adopt the acoustic monitoring protocol as part of a broader wildlife and human activities monitoring program. We successfully lobbied the PSMNR and Cameroon government and acoustic monitoring is now officially one of the many ways Korup NP monitors gun hunting activities and the effectiveness of its conservation strategies. We also wanted to wait to discuss with MINFOF the utility of using acoustic monitoring in the RHFR until we submitted our RHFR report to them. That has been delayed because our data analyses have taken longer than expected. Following this, we will stay in contact with MINFOF concerning the upgrade of RHFR to a wildlife sanctuary. If and when that process gains traction we will lobby MINFOF to include in a management plan acoustic monitoring as one of the strategies to monitor gun hunting patterns.

We initially had difficulty locating sample calls of Preuss's guenon, critical to designing an effective detection algorithm. Although tapes of primate recordings collected by Thomas Struhsaker in Cameroon in the 1960s had been deposited in the Macaulay Library of Cornell University, these proved difficult to use. Because the original tapes were in poor condition, none had been digitized for outside access. One tape had annotations of Preuss's guenon calls and most of this tape was eventually successfully digitized. Using the one sample call as a template, we then had to hand browse a subset of our RHFR sound data when this species is most likely to vocalize (between 17:00-18:30). Six months of sounds were hand-browsed (Feb. – Mar. 2015) and an additional six calls were located. Peter Wrege is in the process of developing a detection algorithm to locate all calls of Preuss's guenon in our RHFR sound files. I am encouraged by our progress on this and anticipate an effective detector developed within the next two months.

f. *Assessment of the project's impact including measurable and verifiable outcomes such as quantities of the target species, land area, or people affected by your project's work*. *Other outcomes to report (based on your specific project) may include workshops, publications, number of trainees instructed, hours on patrol, number of snares removed, etc.*

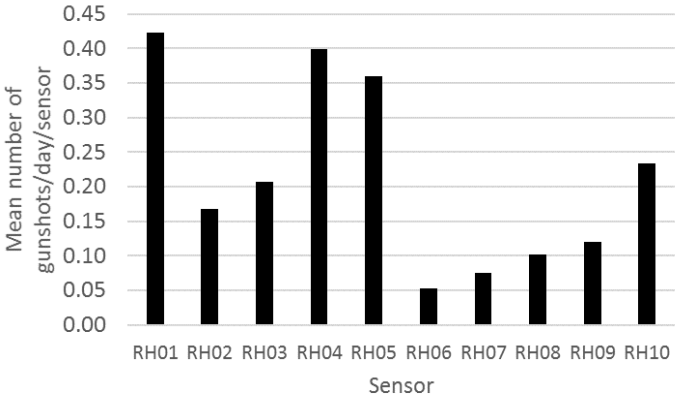
In this section, we report results of gun hunting activities (Activity 1.3) between Nov. 2014 and Oct. 2015 for Rumpi Hills Forest Reserve and, to put it into context, we compare our results to those from Korup National Park for the same one-year period.

Fig. 2 shows the distribution of extrapolated gunshots across all 10 sensors. The sensors recorded a total of 725 gunshots but some sensors failed to record every day of every month. To make comparisons across sensors more accurate we, therefore, took the sensors that failed to record every day each month and extrapolated from the actual number of gunshots recorded to calculate the expected number of gunshots/day/sensor. The extrapolated total number of gunshots across the 45 km^2 study area from Nov. 2014 – Oct. 2015 was 754. The mean number of gunshots/day/sensor was 0.21 (SD = 0.08). Extrapolating to the whole reserve (441 km^2), we estimate that there are 7,389 shots fired by hunters in the RHFR each year.

In comparison, we recorded 2086 gunshots in a 54 km^2 area in Korup National park during the same time period (Nov. 2014 – Oct. 2015) and the mean number of gunshots/day/sensor of 0.48 (SD = 0.13). Thus, a national park which maintains anti-poaching patrols and other conservation strategies aimed at reducing hunting had over twice the gun hunting pressure than an unprotected reserve with no anti-poaching activities.

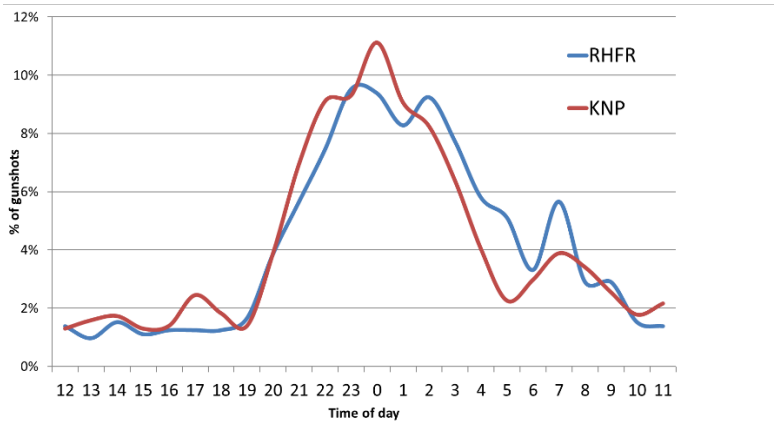
We found that gun hunting intensity varied extensively across the 45 km^2 RHFR study site, with sensors 1, 4, and 5 (the sensor outside the RHFR) accounting for over 57% of all gunshots (Fig. 2).

Figure 2. Mean number of gunshots/day/sensor in RHFR



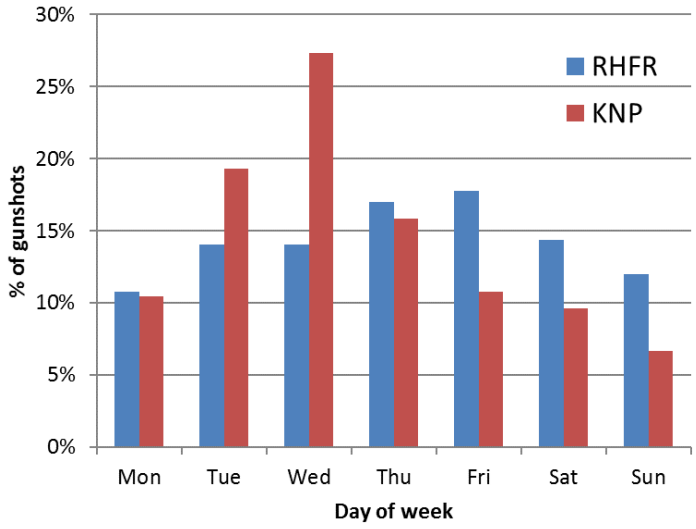
In the RHFR, 75% of the gun hunting took place at night (18:00 – 05:59) and 25% took place during the day (0600 – 17:59) (Fig. 3). This followed the same pattern as found in Korup NP for the same time period.

Figure 3. Proportion of gunshots recorded by time of day in RHFR and Korup NP.



In the RHFR, gun hunting intensity was more evenly distributed across the days of the week than compared to Korup NP (Fig. 4). Korup NP showed a more pronounced peak of hunting intensity on Tuesdays and Wednesdays. Both sites, however, showed a gradual decrease in hunting intensity from midweek to Sunday. On Saturdays, major markets opened in towns and villages in Cameroon and Nigeria and on Sundays most people attended church in the mornings. The less pronounced daily patterns of gun hunting in RHFR were surprising and may suggest that hunters in and around the RHFR may be influenced by different factors and, possibly, are less driven by market forces. This should be explored further.

Figure 4. Proportion of gunshots recorded by day of week in RHFR and Korup NP.



Other notable outcomes resulting from this project include:

- Workshop held in Buea, Cameroon in Dec. 2015 bringing together representatives from MINFOF and nine protected areas in Cameroon and Nigeria.
- Training in deploying/maintaining acoustic sensors and analyzing data of 11 people from MINFOF, the local NGO KRCS, and the village Meka Ngolo.
- Manuscript accepted to the high impact journal *Frontiers in Ecology and the Environment* on the utility of acoustic monitoring for protected area management based on the results from Korup NP.
- Contacted by other researchers for guidance on adopting of acoustic sensors to monitor human activities in other areas of Cameroon and the Gulf of Guinea including the Dja Biosphere Reserve, Takamanda NP, Banyang Mbo Wildlife Sanctuary, and Bioko Island. Researchers working in Bangladesh, Indonesia, and Greece also contacted us about deploying acoustic sensors.

In 2017, we also anticipate the following additional outcomes:

- Submission of a manuscript for publication in a leading conservation journal detailing our RHFR results in relation to those from Korup NP and our first experience deploying a network of acoustic sensors outside of Korup NP.
- Submission to MINFOF of a report detailing our results from monitoring the RHFR, describing the utility of acoustic monitoring in protected area management, and recommending a monitoring protocol. Our hope is that our results will generate renewed interest in improving the protection of this unique ecosystem.
- Finalizing the detection algorithm for Preuss's guenon, analyzing the spatial distribution of Preuss's guenon in the RHFR, and sharing the detection algorithm with our colleagues in North West Cameroon who are studying that species to improve its conservation status.

g. *Description of any cooperation or collaboration among local organizations that was directly associated with this project*.
The success of our project has only been possible through the collaboration with the Mundemba-based Korup Rainforest Conservation Society (KRCS), the only Cameroonian NGO working towards biodiversity conservation of the Korup landscape and the socioeconomic development of local communities. All field staff are members of KRCS. We also collaborated with the people of Meka Ngolo, as they live adjacent to the reserve and use the forest for non-timber forest products. Finally, we work closely with the Cameroon Ministry of Forest and Wildlife (MINFOF) and the Programme for the Sustainable Management of Natural Resources in South West Cameroon (PSMNR; a German-Cameroon cooperation aimed at sustainably managing natural resources). MINFOF is responsible for the maintenance of the RHFR, including the establishment of wildlife and hunting monitoring programs. The MINFOF member responsible for management of the RHFR was present in a workshop we held in Dec. 2015 related to acoustic monitoring.

2h. *The cost and purchase date of any equipment purchased under this Award*.
n/a