

Final Evaluation Report

Your Details	
Full Name	Evelyn Piña Covarrubias
Project Title	Acoustic monitoring of illegal hunting in tropical forests of Belize
Application ID	28726-2
Date of this Report	15/08/2022

1. Indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
Workshop in Tapir Mountain Nature Reserve (TMNR) to members of the conservation communities of Belize				We successfully conducted our workshop on 24 th August 2021.
Full deployment of 40 AudioMoth acoustic sensors for detection of hunting				The Covid-19 pandemic caused a lack of rangers on the ground, which had a significant negative impact on the full placement of our acoustic sensors in TMNR.
Field tests on localisation of hunting with AudioMoth acoustic sensors coupled to GPS modules				Covid-19 disrupted the supply of electrical components, which made impossible to build a new set of AudioMoth acoustic sensors coupled to GPS modules.
Data analysis				Still to be done, following delays to the deployment of devices.

2. Describe the three most important outcomes of your project.

a). I organised and ran an in-person workshop 'Soundscape ecology, acoustic sensing and use of AudioMoths for monitoring biodiversity and forest threats' (Fig. 1), covering basic concepts on acoustic theory, conservation technology, and configuration, use and deployment of AudioMoth acoustic loggers in the field, and on acoustic data analysis. The workshop was given to 10 people in the conservation community of Belize, which included undergraduate and PhD students, NGO staff, forest rangers, and academics, from the University of Belize, The Belize Zoo, Panthera Belize, Belize Karst Habitat Conservation, and Pook's Hill Lodge. The Belize Forest Department, and main local NGOs (Friends for Conservation and Development, Belize Audubon Society), were not present in the workshop due to schedule clashes, however they all showed interest in obtaining training by us in the future. The workshop was very well received, and attendees showed interest in using AudioMoths to monitor local birds, frogs, and for the PhD thesis of an attendee studying bat ecology and conservation in the area. One AudioMoth acoustic logger was donated to each attendee, to encourage and facilitate the adoption of acoustic technology within the conservation community of Belize for monitoring their local biodiversity. At the end of the workshop, attendees were invited to answer a short questionnaire about on-the-ground knowledge of general hunting habits in relation to habitat and topography. Results will inform our full deployment of acoustic loggers in the area, to prioritise likely hunting hotspots.



Figure 1. Setting up the participatory session of the workshop given on acoustic monitoring to the conservation community of Belize.

b). The data we retrieved from my Stage-1 of fieldwork in 2020, on testing AudioMoth acoustic sensors coupled with GPS modules, directly contributed to the development of the AudioMoth GPS + GLONASS Bundle by the Open Acoustic Devices team. This AudioMoth GPS board records sound with millisecond precision, ideal for locating gunshots using methods that we developed on my first Rufford grant (Piña-Covarrubias et al. 2019).

c). All three of our fieldwork seasons were extremely helpful for my team and me to create valuable links with local associations and institutions (i.e., KARST and the Belize Forest Department) that oversee the management of TMNR. Likewise, I substantially improved on existing knowledge of the current state of TMNR, and its access points and trails, which will help me in future fieldwork. I have shared this valuable information with the management authorities of TMNR, who have a very limited knowledge of the state of their reserve and its access points and trail network.

3. Explain any unforeseen difficulties that arose during the project and how these were tackled.

Two major and unforeseen difficulties arose during the project. Firstly, Stage 1 of fieldwork in early-March 2020 was disrupted by the unfolding Covid-19 pandemic, and the beginning of restrictions on movement. While I was conducting my fieldwork (with the collaboration of Dr Jake Snaddon) the Belizean borders started to close, requiring us to evacuate the site before we could finish our activities. We were not subsequently allowed to return for 1 year. This resulted in the loss of 40 6v batteries by humidity, which had already been purchased and shipped to our field site in Belize,

and which were going to be used to power the set of 40 AudioMoth acoustic sensors in the full deployment of devices (originally planned for that field season). By Stage 3 of fieldwork in late-June and early-July 2022, Dr Jake Snaddon was able to donate 80 off-the-shelf AudioMoth acoustic devices (Fig. 2 (left)) that will eventually serve to conduct the full deployment in TMNR. On this fieldwork season, Dr Jake Snaddon and I managed to deploy 42 devices in 21 sites (Fig. 2 (right)). We did not have the support of local rangers because there were no available people on-the-ground (an ongoing consequence of the Covid-19 pandemic). Although the smaller batteries of these off-the-shelf devices will not last for a full year, and we could only deploy half the available devices, we made substantial progress at reaching areas that had previously been completely unexplored, and at identifying hunters' trails and camps, all of which will provide extremely valuable information for analysis and future fieldwork. Dr Jake Snaddon has agreed to come back later in the year to collect the data recorded by the 42 deployed devices.



Figure 2. AudioMoth acoustic sensors donated by Dr Jake Snaddon (left), and devices deployed in one site of TMNR (right).

Secondly, while I was conducting field tests on the AudioMoth acoustic sensors coupled with GPS modules (Fig. 3) during Stage 1 of my fieldwork, the devices began to malfunction in the high ambient humidity. My plan to build a replacement set of devices for Stage 2 of fieldwork was rendered impossible by the Covid-19 pandemic severely disrupting the production and shipping of micro-components (mostly from China). Nonetheless, on Stage 1 of fieldwork I collected valuable data that was shared with team member Alex Rogers of Open Acoustic Devices, and which contributed to the development of the AudioMoth GPS + GLONASS Bundle.



Figure 3. AudioMoth acoustic loggers coupled with GPS modules, here testing satellite signal capture.

4. Describe the involvement of local communities and how they have benefited from the project.

My in-person workshop 'Soundscape ecology, acoustic sensing and use of AudioMoths for monitoring biodiversity and forest threats' was targeted to rangers from nearby communities. I have also worked with the managers of TMNR and have exchanged knowledge of exploitation by hunters with them. Both managers and rangers benefit from learning how acoustic sensors can inform their work, and to identify hunting (gunshot) frequencies in the reserve. I work closely with Aaron Juan from TMNR co-manager Belize Karst Habitat Conservation, and two rangers from Pook's Hill Lodge, who are learning how to deploy, use and manage acoustic sensors.

5. Are there any plans to continue this work?

Later this year, I will seek funding to finish our full deployment of the second set of 40 AudioMoth acoustic loggers in the top section of TMNR. With the results obtained from the full survey of TMNR, or even the partial survey to date, we will build a heatmap of hunting within the reserve, which we will share it with the Belize Forest Department authorities so they can maximise on-the-ground patrolling efforts of forest rangers. Secondly, I will seek funding to purchase, and deploy, a set of 10

AudioMoth GPS + GLONASS Bundle in TMNR to field test localisation of hunting (originally planned for this 2nd Rufford Small grant). I also will seek funding to monitor the hunting in Calakmul Biosphere Reserve in Mexico, with the collaboration of Cristina Argudín-Violante of the University of Southampton, who is currently working in this area with local communities and hunting. Lastly, I will seek funding to run a second workshop on the use of acoustic sensors directed to a larger number of rangers.

6. How do you plan to share the results of your work with others?

After we collect data from our full deployment of AudioMoth acoustic sensors, we will publish a peer-reviewed research paper on first measurements of hunting frequency in Belize including a heat map of hunting in TMNR, to complement previous questionnaire surveys of local communities. I am currently leading on writing two data papers for peer-reviewed journals to make publicly available the database of our acoustic monitoring, and the database of our experimental gunshots and their metadata, for use by other research groups. I expect to submit these by October 2022.

7. Looking ahead, what do you feel are the important next steps?

I will pursue the completion of our full deployment of 40 AudioMoth acoustic sensors, to ground-truth the efficacy of AudioMoth acoustic sensors coupled with GPS modules for their future use in TMNR, for the location of gunshots in this protected area.

Our team has now perfected the development of machine-learning algorithms to sift and analyse acoustic data for gunshots (Katsis, Hill, Piña-Covarrubias et al. 2022a, 2022b), which had previously presented a substantial hurdle to the utility of acoustic data for monitoring exploitation anywhere in the world. We will use this technique to analyse the data from the current and future deployment.

I want to expand the deployment of AudioMoth acoustic sensors to rural communities of the Calakmul Biosphere Reserve in Mexico, which suffer from significant illegal hunting. I will expand on the social science work currently being done by Cristina Argudín-Violante with hunters, who have agreed to wear GPS trackers on hunting excursions. AudioMoth deployments will then map the distribution of gunshots, providing objective population-level metrics against which to evaluate data from individual hunters.

8. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the Foundation receive any publicity during the course of your work?

I used The Rufford Foundation logo on my workshop given to the conservation community of Belize (Fig. 4(top & bottom left)), as well as publicly acknowledging The Rufford Foundation on twits showcasing my field activities (Fig. 4 (bottom right)).

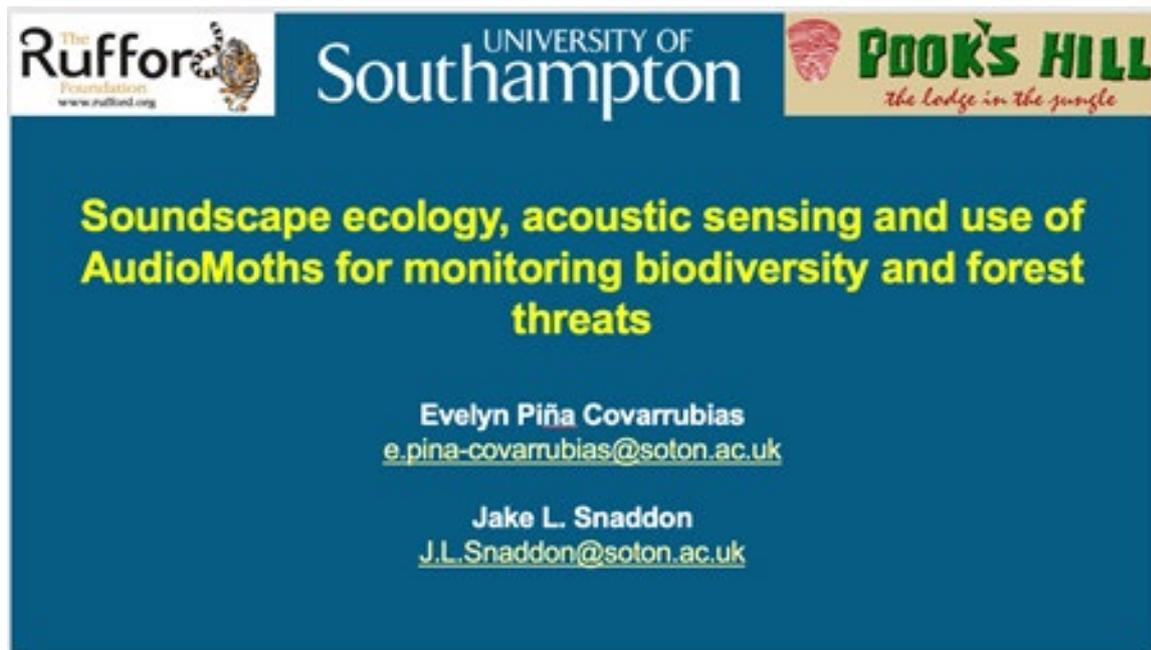


Figure 4. Use of The Rufford Foundation logo in my workshop presentation, and in social media.

9. Provide a full list of all the members of your team and their role in the project.

Dr Jake Snaddon provided fieldwork assistance and facilitated on-site engagement with local organisations; **Professor C Patrick Doncaster** providing support with planning and additional budget costs; **Professor Alex Rogers** provided assistance at building five AudioMoth acoustic sensors coupled with GPS, which were used in my Stage 1 of fieldwork, lending of three more devices on Stage 2, and general remote assistance with the functioning of devices during Stage 1 and 2 of fieldwork. TMNR co-manager **Aaron Juan** from Belize Karst Habitat Conservation facilitated our access to TMNR.

10. Any other comments?

I wish to thank The Rufford Foundation for their continuous support and patience with the extended timeframe of my project. I wish also to express my gratitude to Pook's Hill Lodge for their generosity in waiving infrastructure costs, which kept my project within budget in the face of Covid-enforced overspend on travel. The community of all those who work in and around TMNR made me feel welcome in Belize and made very demanding fieldwork a pleasure.