The Rufford Foundation
Final Report

Congratulations on the completion of your project that was supported by The Rufford Foundation.

We ask all grant recipients to complete a Final Report Form that helps us to gauge the success of our grant giving. The Final Report must be sent in **word format** and not PDF format or any other format. We understand that projects often do not follow the predicted course but knowledge of your experiences is valuable to us and others who may be undertaking similar work. Please be as honest as you can in answering the questions – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Please complete the form in English and be as clear and concise as you can. Please note that the information may be edited for clarity. We will ask for further information if required. If you have any other materials produced by the project, particularly a few relevant photographs, please send these to us separately.

Please submit your final report to jane@rufford.org.

Thank you for your help.

Josh Cole, Grants Director

Grant Recipient Details	
Your name	Evelyn Piña Covarrubias
Project title	Acoustic monitoring of human exploitation and wildlife in tropical forests of the Yucatán Peninsula, Mexico
RSG reference	17047-1
Reporting period	June 2015 – June 2016
Amount of grant	£4703
Your email address	epc1g14@soton.ac.uk
Date of this report	13/06/2016

1. Please 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
Record high-fidelity soundscapes of humans, jaguars, pumas and their prey in tropical forests of the Yucatán Peninsula, Mexico, in order to develop a methodology to effectively categorise sounds emitted by human-agents of threat in relation to local wildlife activity.		✓		During the first field season in 2015, I recorded high-fidelity soundscapes of four human agents of disturbance (chainsaws, gunshots/rifles, car engines and human voices), within three locations in the Yucatán Peninsula (two in Mexico and one in Belize). This work was done with the assistance of team member Prof C. P. Doncaster, using three high fidelity SM3 acoustic loggers purchased on the Rufford grant. Detectability of sounds varied greatly with weather. Chainsaws and shotguns were detected at ca. 1 km with no wind or rain, but when rainy/windy conditions were present, detectability was difficult at even distances of 250 m. Insects flying near the detector, thunder and airplanes passing overhead shaded sound detectability. Human voices travelled more easily through the forest canopy than the understory. The shotgun was detected at greater distance than the rifle. Gunshots triggered towards acoustic loggers were detected at farther distances than the ones triggered away from them. No gunshots were detected beyond 1 km. Sounds emitted by a small chainsaw were harder to detect than from a large chainsaw. The incomplete part of the objective, to record sounds of large felids and their prey, was addressed in the second objective, below.
Pilot the development of dollar-sized disposable acoustic			✓	A prototype for the small, low-cost acoustic logger, developed by team member Prof Alex Rogers and engineering PhD student Andrew Hill,

Objective	Not achieved	Partially achieved	Fully achieved	Comments
loggers that monitor human agents of disturbance in natural areas.				was tested during the second field season by me with assistance of team member Prof C Patrick Doncaster. The pilot study was designed to record sounds of 1) human disturbances (chainsaws and gunshots) inside a natural forest area in Belize; and 2) roars and calls from captive jaguars inside The Belize Zoo.

2. Please explain any unforeseen difficulties that arose during the project and how these were tackled (if relevant).

At the start of this project, I proposed to make experimental recordings of the sounds of forest exploitation in tropical rainforests inside Cockscomb Basin Wildlife Sanctuary (CBWS) in Belize. However, the required permits to use a gunshot and a chainsaw in this protected area took too long to come through. I therefore switched field site Pook's Hill on the edge of Tapir Mountain Nature Reserve in Belize, close to CBWS. This forest had sufficient natural rainforest to trial acoustic loggers in replicated triangular deployments with up to 1-km edges. I was granted use of a shotgun and chainsaw to make experimental recordings of sounds of forest exploitation.

Initially, I was interested in recording dog barks as a sign of human exploitation. However, I decided not to do this because it became clear from our discussions with local hunters that they rarely use dogs on hunting trips.

I originally proposed to record free-range and captive animal sounds in the area. However, it proved very problematic to find and record animal sounds in the field, due to the low abundance of animals even in nature reserves, and the low frequency of their calls. The high-fidelity devices did not detect these rare events in the first stage of fieldwork in 2015.

In the second stage of fieldwork, in 2016, I was granted a permit to record sounds of captive jaguar inside the jaguar recovery area of The Belize Zoo. I recorded jaguars here with prototype low-cost acoustic loggers. Roars and calls from several individuals have now provided the necessary baseline for including jaguar calls in the information that these devices will eventually be enabled to relay from the field to a base station.

In further stages of his project, I hope to expand the soundscapes with other captive felids and prey animals from The Belize Zoo, and to test the acoustic loggers in the

field, at their next stage of development with capability for relaying relevant information to a base station.

3. Briefly describe the three most important outcomes of your project.

1. Collation of a soundscape of human agents of disturbance.

The summation of all results from the soundscape of human agents of disturbance suggests that a network of the prototype low-cost acoustic loggers placed at least at 500-m apart could record important sounds of human exploitation. Gunshots and chainsaws could frequently be picked up at minimum distances of ca. 500 m by both prototype and high fidelity SM3 loggers (Fig. 1-2). A triangular grid of loggers on the scale that we trialled (Fig. 2) could cover 20 km^2 with ca. 100 devices deployed every 500 m.

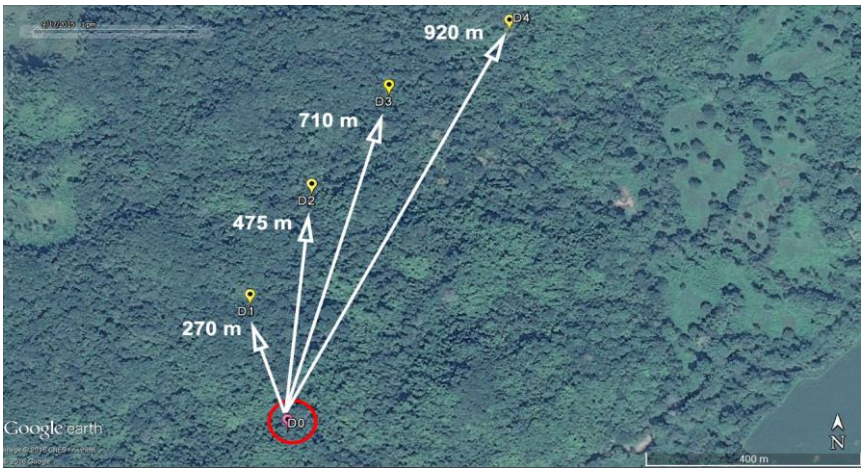


Figure 1. An example of the sound attenuation experiment. The high fidelity and prototype loggers inside the red ring could pick up the shotgun at all of the yellow dots and the chainsaw at 270 and 475 m. Red ring = position of acoustic logger; yellow dots = gunshot/chainsaw; white arrows = detectable distances.

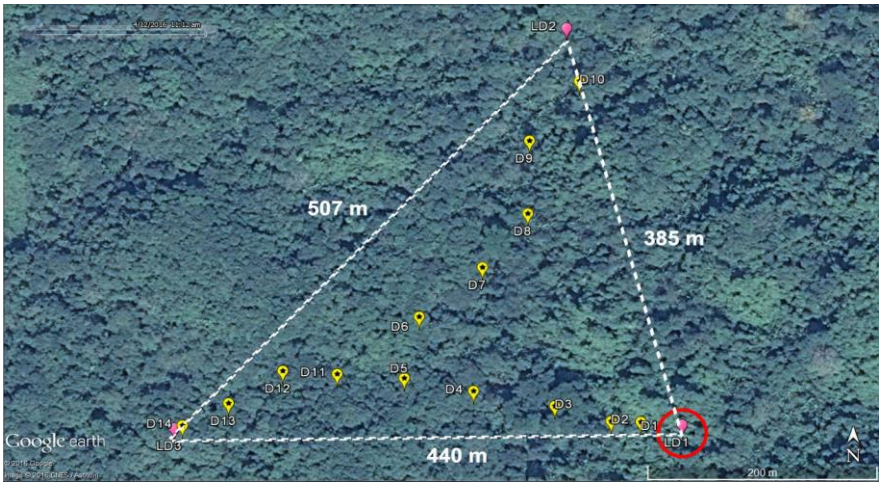
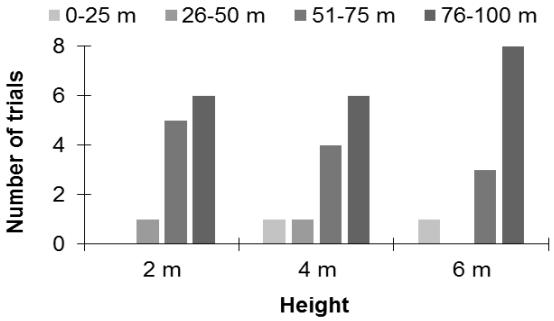
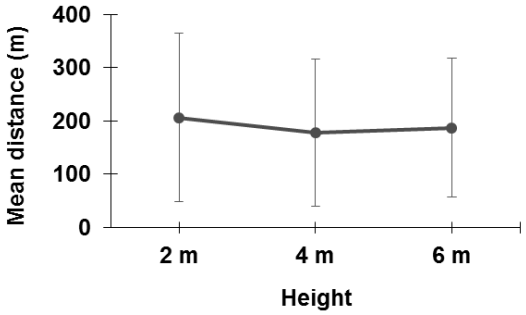


Figure 2. An example of a prototype network of devices. The high fidelity and pilot loggers inside the red ring could pick up the shotgun at all of the yellow dots. These three devices cover 0.08 km^2; 4 would cover 0.16 km^2; 6 would cover 0.32 km^2. Pink dots = position of acoustic loggers; yellow dots = gunshot/chainsaw.

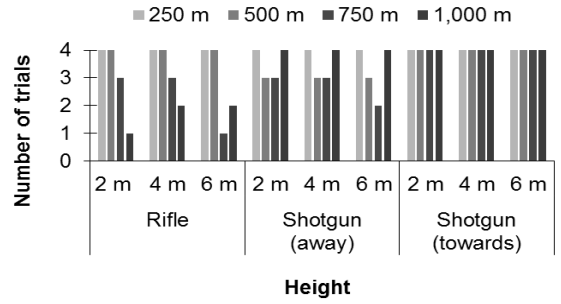
The soundscape of human agents of disturbance collated with the high fidelity SM3 acoustic loggers showed interesting differences in detectability between the four tested categories of human exploitation. Human voice was generally detected from farther away with acoustic loggers placed higher up in the forest (6 m vs 4 m or 2 m; Fig. 3A). Therefore, it travelled more easily through the forest canopy than the understory. In contrast, detectability of the truck engine showed no substantial change with height (Fig. 3B). A shotgun (towards acoustic loggers and away from them) was detected at greater distance than a rifle. Furthermore, gunshots triggered towards the acoustic loggers were detected at farther distances than others triggered away from them. No gunshots were detected beyond 1 km in any trial (Fig. 3C). A small chainsaw could not be detected by any of the acoustic loggers at any of the distances tested. However, large chainsaws were more easily detected, but in general, sound could travel only for short distances (250 m; Fig. 3D). Detectability of sounds varied greatly with weather. Chainsaws and shotguns were detected at ca. 1 km with no wind or rain, but when rainy/windy conditions were present, detectability was difficult at even distances of 250 m. Insects flying near the microphone, thunder and airplanes passing overhead shaded sound detectability.



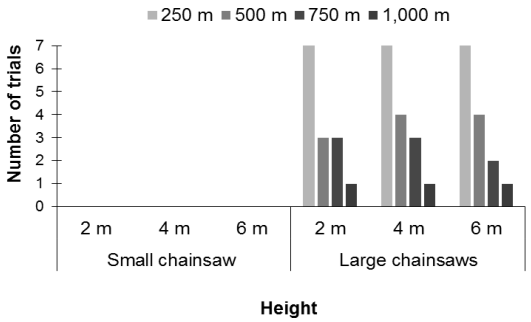
A. Human voice.



B. Truck engine ($\dot{x}$ ± SD). Minimum and maximum distances: 53 – 569 m; 56 – 497 m; 69 – 497 m, respectively.



C. Rifle/shotgun.



D. Chainsaws.

Figure 3. Maximum distances at which human voice, truck engine, rifle/shotgun and chainsaws can be detected audibly with high-fidelity SM3 loggers at heights above ground of 2, 4 and 6 m.

This information is useful for considerations about where to deploy acoustic loggers. Small devices could potentially be deployed into the forest canopy, where they may pick up a greater diversity of sounds but are also more susceptible to wind noise. With good sensitivity, devices could be placed several hundred meters apart, and still expect to pick up many sounds of forest exploitation. This compares to other current options of devices five times more expensive, 10 times larger, and needing to be placed 50-m apart.

2. Trials of the first-stage development of a novel method for acoustic monitoring of human exploitation in protected forests.

Team member Prof Alex Rogers and engineering PhD student Andrew Hill designed and developed a prototype (Fig. 4) for the small, low-cost acoustic logger. Team member Prof C Patrick Doncaster and I tested these loggers during the second field season in 2016, experimenting with records of gunshots and chainsaws in tropical rainforests in Pook's Hill, Belize, and roars of captive jaguars inside The Belize Zoo.

Figure 4. Prototype low-cost acoustic logger, measuring 5x4x1 cm, and weighing 32 g. Projected cost £10. This compares with SM3, measuring 32x21x6 cm, weighing 3,200 g and costing £800.

The sound attenuation and sound location experiments showed differences between the prototype low-cost and high fidelity SM3 acoustic loggers. The prototype recorded a clearer spectrogram signal of gunshots than the SM3. Moreover, the prototype showed a clearer frequency response and less background noise when recording the chainsaws compared with the high fidelity SM3 acoustic loggers. The reason for these differences is that the prototype was less sensitive to background noises that otherwise tend to flood the focal signals. We therefore conclude that the prototypes have capability that is fit for purpose.

3. Involvement from local communities in the project.

During the two stages of fieldwork, I conducted meetings with local rural communities in the Northern Yucatán Peninsula, to introduce them to the potential uses of low-cost acoustic loggers. I discussed the benefits that such devices could bring to them and their communities, as an affordable and accessible way for monitoring their forests and their natural resources. Some communities in the area receive monetary aid from a government-run program that makes payment for ecosystem services. This program requires them to protect the wildlife resources on their lands, and the acoustic loggers present a viable option for improved monitoring by the communities themselves. I was pleased to find that they expressed enthusiasm for testing the acoustic loggers in their lands when they become available.

4. Briefly describe the involvement of local communities and how they have benefitted from the project (if relevant).

I conducted two meetings with about 50 residents of local communities of Santa María, Nuevo Tesoco and San Pedro, in the Northern Yucatán Peninsula, to explain the purpose of this project. They expressed eagerness to use the acoustic loggers on their lands when they become available. Three local residents contributed with the fieldwork in Mexico during 2015.

5. Are there any plans to continue this work?

I intend to test the next stage of development of the acoustic loggers at the same field sites. With my electronics colleagues, I want to: 1) find the optimum balance of quality and quantity of acoustic information that can be stored in the loggers; 2) optimise battery performance; 3) effectively distinguish between 'noise' and useful information about human exploitation and wildlife; 4) explore different ways to place acoustic loggers in tree canopies using drones; and 5) develop and test a method that will relay real-time alerts from the acoustic loggers to a central hub. My long-term goal is to validate the utility of these acoustic loggers in the field, in experimental and real-world situations, to train local people from the Yucatán Peninsula and Belize on their use, and to obtain feedback from them to improve this method.

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

I will show my work at international meetings including the Annual Meeting of The British Ecological Society in Liverpool (December 2016). In addition, I will publish my results in peer-reviewed journals to share them with a wide scientific audience.

7. Timescale: Over what period was The Rufford Foundation grant used? How does this compare to the anticipated or actual length of the project?

I spent the money obtained with my Rufford Small Grant between May 2015 and April 2016. I started my fieldwork activities at a later stage than originally anticipated, due to a delay in the awarding of the grant and to fit in with fieldwork schedules. Instead of conducting only one visit to the field, I conducted two (2015 and 2016). The first fieldtrip focused on the collation of the high-fidelity soundscape of human exploitation in Mexico and Belize. The second fieldtrip focused on experimenting with the prototype low-cost acoustic loggers in Belize, recording chainsaws and gunshots from a small network of the devices, and also roars of captive jaguars in the Belize Zoo. Team members developed the prototype for the low-cost acoustic logger on time, which allowed me to get ahead of my proposed activities for this grant, to conduct this second field season in 2016.

8. Budget: Please provide a breakdown of budgeted versus actual expenditure and the reasons for any differences. All figures should be in £ sterling, indicating the local exchange rate used.

Item	Budgeted Amount	Actual Amount	Difference	Comments
SM3 high-fidelity acoustic devices (incl. VAT) @ US$2,823.68 + Import tax @ Mx$9093.55	2400	2227	173	Instead of buying the SM3 in the UK, I bought them in USA.
SD card 128 GB (Kingston) @ £53x6	317	0	317	Instead of buying six 128 GB SD cards I bought three 32 GB SD cards.
SD card 32 GB (Kingston) @ Mx$498 x3	0	68	68	
Cord for deploying SM3 @ Mx$207	0	9	9	
Duracell rechargeable D batteries (pack of 16)	71	0	71	Instead of buying rechargeable batteries, I bought Alkaline batteries.
Charger for D batteries	20	0	20	
Duracell Alkaline D batteries @ Mx$233 x 3 packs of 4	0	32	32	
App iPhone @Mx$379	0	17	17	I made use of a sound app to calibrate acoustic loggers in the field.
Flight London-Mexico City (British Airways)	975	1071	96	
Flight Mexico City-Cancún in 2015 (Interjet) @ Mx$3230.86	141	148	7	
Flight Cancún - Belize City (Tropic Air) @US$552	354	0	354	Due to the high price of the available flights, I decided to go to Belize by coach.
ADO coach ticket from Cancun to Belize City in 2015 @ Mx$616	0	28	28	
ADO coach ticket from Belize City to Cancun in 2015 @ Mx$494 + BZ$19	0	29	29	

Item	Budgeted Amount	Actual Amount	Difference	Comments
PACT tax in Belize in 2015 @ BZ$37.5	0	12	12	
Subsistence in Belize in 2015 @ BZ$470	125	151	26	
Accommodation in Belize in 2015	300	0	300	
Bullets bought in Belize in 2015 @ BZ$90.9	0	29	29	
ADO coach ticket from Cancun to Belize City (C Patrick Doncaster and Evelyn Pina) in 2016 @ Mx$1344	0	62	62	Instead of only one field season, I conducted two. In 2016 C Patrick Doncaster and I went to Belize to test the prototype low-cost acoustic logger, experimenting with chainsaws and shotguns, and to record sounds of captive jaguars in The Belize Zoo.
Food and other expenses in Belize (C Patrick Doncaster and Evelyn Piña) in 2016 @ BZ$1200	0	385	385	
Accommodation in Belize (C Patrick Doncaster and Evelyn Piña) in 2016 @ BZ$243	0	78	78	
ADO coach ticket from Belize City to Cancun (C Patrick Doncaster and Evelyn Piña) in 2016 @ BZ$38 + Mx$988	0	57	57	
PACT tax in Belize (C Patrick Doncaster and Evelyn Piña) in 2016 @ BZ$75	0	24	24	
Flight ticket from Cancún to Mexico City (C Patrick Doncaster and Evelyn Piña) in 2016 @ Mx$6416	0	294	294	
Total £	**4703**	**4721**	**18**	

Assumed exchange rate: Mx$21.83 Mexican pesos = £1 UK sterling, US$1.56 = BZ$3.12 = £1 UK sterling.

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

It is a priority to take the development and piloting of acoustic loggers through to deployment by communities. This will require new developments in the electronic components of the loggers, to allow them to relay information between devices, to be done in collaboration with team member Alex Rogers and PhD students Andrew Hill and Peter Prince. It will require field tests by me in tropical forests from the Yucatán Peninsula, in areas with high hunting and logging pressure. It will be essential to include and obtain feedback from local people when testing the acoustic loggers in the field.

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

I used the logo to give two talks at the Centre for Biological Sciences at the University of Southampton (Conservation Club and Environmental Biosciences Seminar) in March and November 2015 and to present a poster at the University of Southampton Biological Sciences Postgraduate Symposium (July 2016).

11. Any other comments?

I would like to thank The Rufford Foundation for granting me with this Rufford Small Grant. This project would have not been possible without your support.