Final Evaluation Report

Your Details	
Full Name	Vijay Ramesh
Project Title	Conservation Through Sounds: Using Acoustics to Evaluate the Effectiveness of Forest Restoration
Application ID	28916-1
Grant Amount	£5099
Email Address	vr2352@columbia.edu
Date of this Report	15/02/2022

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
To understand how vocalizing biodiversity varies along a gradient of forest regeneration efforts in the Anamalai hills (methodology involved acoustic data collection and statistical analysis of acoustic data)			✓	The Covid-19 pandemic and the national lockdown were major factors in affecting field work. However, despite these obstacles, we managed to collect sufficient data to answer the initial objectives proposed. We detected a total of 116 bird species across ~69 hours of manual inspection of audio recordings. This included a total of 74 rainforest bird species (64%) and 42 open country bird species (36%). Analysis of bird community composition across the gradient (benchmark sites (BM), naturally regenerating sites (NR) and actively restored sites (AR)) of forest regeneration revealed that AR sites occupied an intermediate position between BM and NR sites, indicating a direction of change in bird community composition toward BM sites (an encouraging result). Further analysis of the data as well as research outcomes are presented in sections below.
To engage local communities and a broader audience with the results of this study.			✓	Multiple outreach activities have been carried out with respect to reaching a broader audience: In July 2020, I co-wrote a popular science article in Mongabay India on the use of bioacoustics for conservation, and highlighted the work being carried out in the Valparai plateau. Link: https://india.mongabay.com/2020/07/listen-closely-using-bioacoustics-in-wildlife-conservation/ In August 2020, I was invited by the Kalinga Centre for Rainforest Ecology (a local NGO that aims to connect a broad audience with nature) to give a lecture on bioacoustics to a general audience. I proceeded to talk about the field work I had carried out so far, along with talking to

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In November 2020, I was invited by the Linnean Society of London to deliver a virtual lunchtime lecture. Here, I discussed the Rufford funded project and preliminary analysis of data, along with talking about a collaborative initiative titled - 'Project Dhvani' - that aims to monitor biodiversity using sounds across human-modified landscapes of India. Event link: https://www.eventbrite.co.uk/e/sounds-of-the-wild-tickets-126839128247;Video: https://www.youtube.com/watch?v=wv_DSYh2O2o

In March 2021, as part of World Forests Day, I was invited to be a part of an online panel discussion (for a broad audience) titled 'Soundscapes: A language of nature' alongside Eric Leonardson, President of the World Listening Project and Claudia Isonde, a sensorial artist and musician. Here I presented a few preliminary results from the Rufford funded project. The video can be viewed here: https://www.youtube.com/watch?v=NQW9ySyfdVE

In April 2021, further outreach was carried out as part of an online lecture series organised by the International Centre for Theoretical Sciences. I was invited to talk about the Rufford funded project as part of a virtual exhibition titled 'Cosmic Zoom'. My talk can be viewed here: https://www.youtube.com/watch?v=-lxXAtGQ6Ok

In June 2021, our interactive website was launched. This website can be viewed here: http://www.projectdhvani.org/ (This site was developed to host project updates as well as engage a broad audience with the field of bioacoustics).

I am currently preparing our final reports for the state forest department of Tamil Nadu.

				A copy of this report will be provided to The Rufford Foundation. In June 2021, I began working with an illustrator (Chayant Gonsalves) to design an interactive panel showcasing soundscapes from restored, naturally regenerating and benchmark (protected area) sites. The idea is to convey the differences in overall biodiversity across these sites, using a novel technology - acoustics. These panels will be displayed on multiple social media portals and exhibited at the EcoQuest Nature Discovery Centre in Valparai.

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

In March 2020, as a result of the Covid-19 pandemic, a national lockdown was imposed across India, resulting in stoppage of field work. Many of our audio recorders could not be retrieved from remote field sites across the Valparai plateau. Between March and April 2020, limited movement was possible across the plateau due to Covid-19 restrictions. In May 2020, I carried out field work for 3 weeks to make up for lost time in April and March. In the end, we managed to collect sufficient data to answer the questions/objectives proposed for this Rufford funded project.

As a result of the pandemic, many of the in-person outreach events planned as part of the project could no longer be carried out. Instead, we switched to carrying out numerous outreach activities virtually.

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

The outcomes of the project have been divided into research and outreach outcomes:

A)   Research Outcomes
Our study shows that bird species composition has shown a partial recovery across actively restored sites, highlighting the value of carrying out active restoration of degraded forest fragments in a human-modified landscape like the Western Ghats. The results also highlight the importance of protecting existing forest fragments as recovery has only been partial, even after two decades of intensive restoration efforts. Acoustic data can be used to evaluate the effectiveness of conservation intervention approaches such as restoration and shows potential, when used appropriately. In an era of ongoing environmental changes, our study advocates the need to consider multiple taxonomic groups for assessing and evaluating conservation intervention approaches.

We detected a total of 116 bird species across ~69 hours of manual inspection of audio recordings. This included a total of 74 rainforest bird species (64%) and 42

open-country bird species (36%). Across our dataset, the white-cheeked barbet *Psilopogon viridis*, followed by the red-whiskered bulbul *Pycnonotus jocosus* and the crimson-backed sunbird *Leptocoma minima* had the greatest number of detections. Five species were detected just once in our dataset.
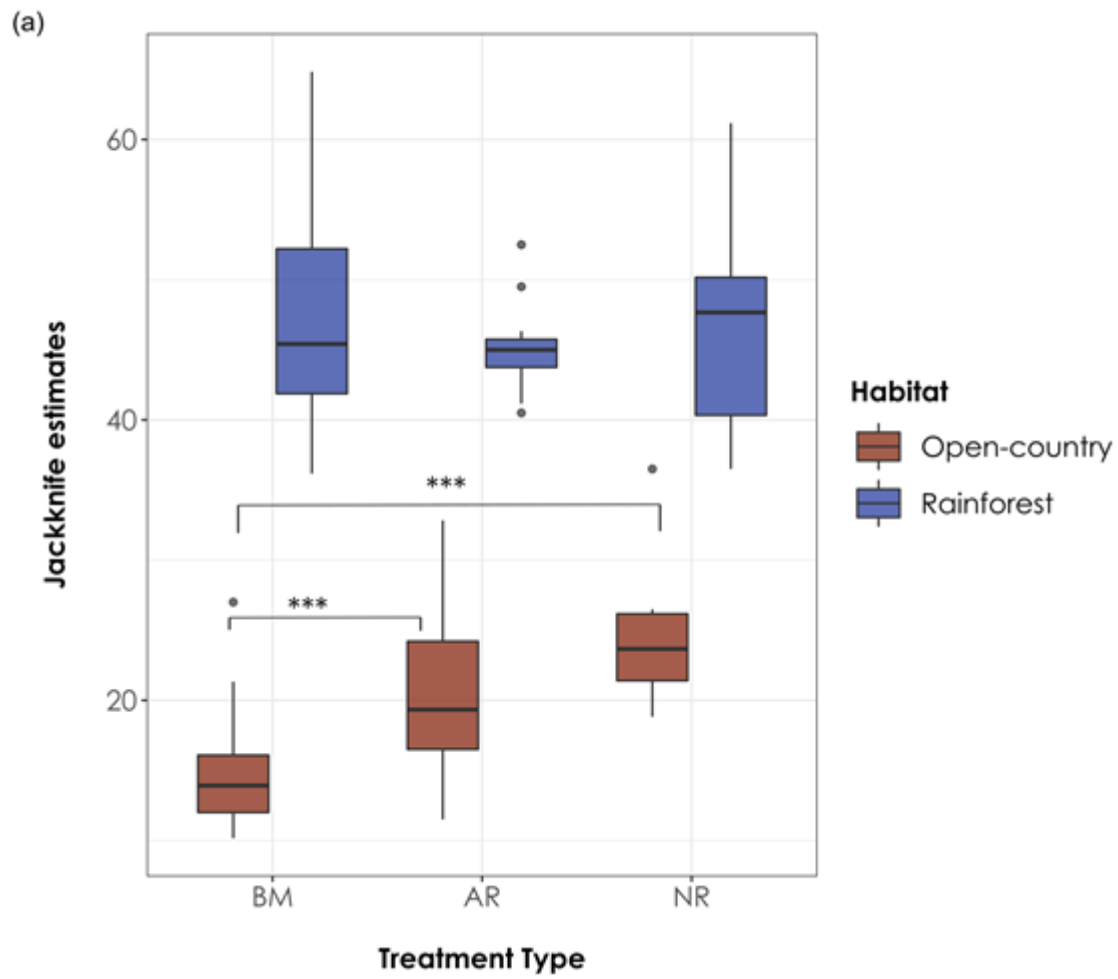

Fig. 1. Jack-knife estimates of bird species richness

(a) We observed no significant difference in the first-order jack-knife scores across the three treatment types when we considered rainforest bird species. The jack-knife estimate of open-country bird species varied significantly between BM-AR sites and BM-NR sites (Tukey HSD test, $P < 0.05$), with NR sites having the highest estimate (mean ± SD: 24 ± 5), followed by AR sites (mean ± SD: 20 ± 6) and BM sites (mean ± SD: 15 ± 4). In the above figure, BM = undisturbed benchmark rainforest sites, AR = Actively restored forest sites and NR = Naturally regenerating forest sites.
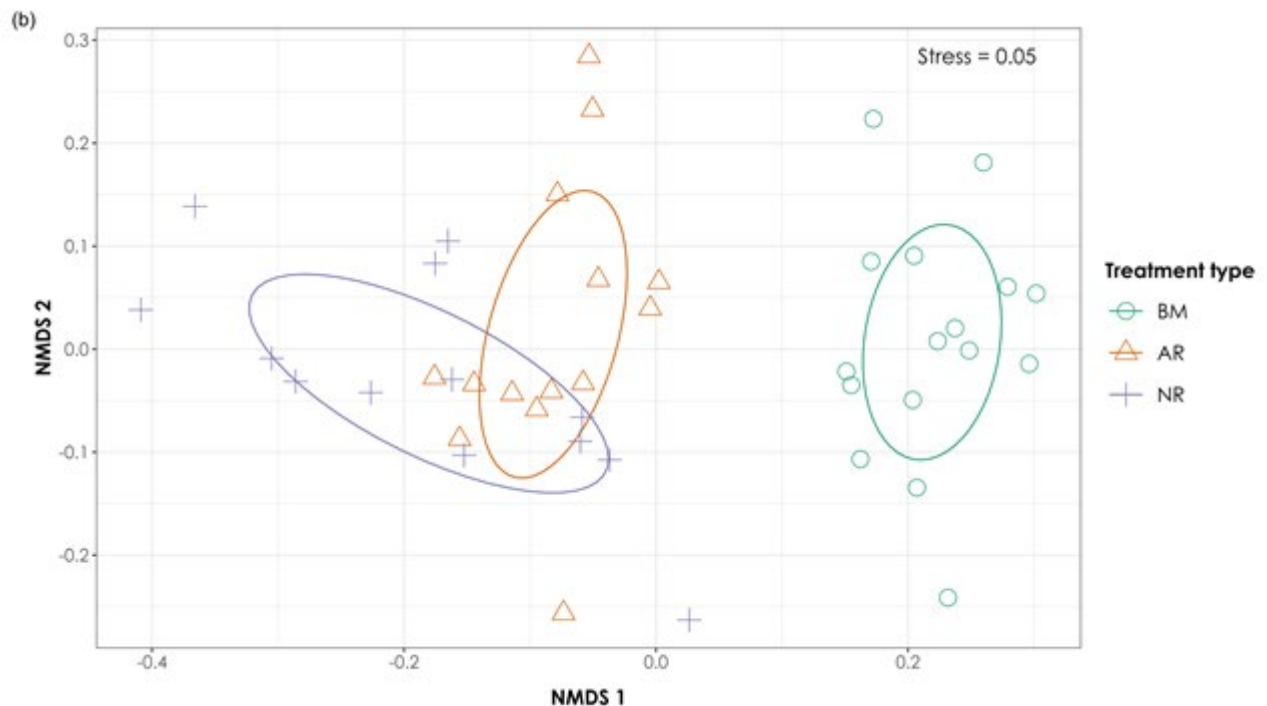
Fig. 2. NMDS ordination results of bird species detections.

(b) The ordination analysis of bird detections data (stress = 0.05) revealed distinct clusters of BM sites, but relatively loose clusters for AR and NR sites. However, AR sites occupied an intermediate position between BM and NR sites, indicating a direction of change in bird community composition toward BM sites. In the above figure, BM = undisturbed benchmark rainforest sites, AR = Actively restored forest sites and NR = Naturally regenerating forest sites. This result is encouraging as it suggests that active restoration has resulted in recovery of bird community composition.

One of the biggest advantages in using acoustic data is in analysing the overall acoustic environment at a given site. We derived a metric called acoustic space use (ASU), which is defined as the proportion of frequency space that is 'used' for a given time period (where 'used' refers to the frequency space that is occupied by vocalisations/sounds above a threshold amplitude). In other words, we could visually and quantitatively examine how the frequency space of benchmark, naturally regenerating and actively restored sites vary. By carrying out such an analysis, we can interpret how actively restored fragments are being used by vocalising biodiversity.

The aforementioned analysis and all pertaining research have been made open access so that a broad scientific community can reproduce our methods. Please see the following GitHub repository: https://github.com/vjjan91/acoustics-westernGhats.

At present, the research carried out as part of the Rufford funded project is being submitted to a peer-reviewed journal. Please reach out to me at vr2352@columbia.edu if you would like more information.

B)   Outreach outcomes

The outreach outcomes achieved include a combination of: 1) Popular science articles, 2) talks and invited presentations, 3) display of sounds on an interactive website and 4) illustrations of the research for a non-scientific audience. A majority of the outreach activities that have been carried out so far can be found in the table above (response to question 1). Below you will find illustrations of birds recorded in different treatment types – naturally regenerating sites, actively restored sites, and benchmark sites. These illustrations will be displayed at the EcoQuest Nature Discovery Centre in Valparai and are not to be reproduced without permission.

Birds recorded in a naturally regenerating site (Artist: Chayant Gonsalves).

Birds recorded in an actively restored site (Artist: Chayant Gonsalves).

Birds recorded in a benchmark site (Artist: Chayant Gonsalves).

4. What do you consider to be the most significant achievement of this work?

5. Briefly describe the involvement of local communities and how they have benefitted from the project.

This entire project was possible as a result of my collaboration with a local non-governmental organisation, Nature Conservation Foundation (NCF), and relying on their existing relationships with members of the Kadar community at Valparai (180 families in six villages). The Kadar are a traditional hunter–gatherer community and have supported wildlife research and conservation initiatives in this landscape for the last three decades. Specifically, I collaborated with two members of the Kadar community (Vijay Kumar and Krishna Kumar), who were instrumental in the success of this project. Throughout the field season, I worked with Vijay Kumar and Krishna Kumar by hiring them as field collaborators. In addition, they were trained in standardised ecological survey techniques, including the use of audio recorders for ecological research.

6. Are there any plans to continue this work?

Only through continuous long-term monitoring can we learn about the effectiveness of conservation intervention approaches such as active restoration. With this first RSG project, I have now established a reproducible protocol to use bioacoustics to monitor bird diversity across naturally regenerating, actively restored and benchmark sites. We plan to continue this work to expand to other taxonomic and functional groups and revisiting our sites after a period of 3 years (2023).

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

Apart from outreach that has been carried out as part of the project so far, I will share the results of my work in the following ways:

- I will publish one peer-reviewed scientific publication by December 2022. Publication of this peer-reviewed article will provide a sense of the robustness of my study design and analysis. Sharing these results with the wider conservation community will encourage collaboration and advancement of research.

- I will publish two popular science articles by December 2022. These articles will also be featured on the online portal designed for interactive visualisations (www.projectdhvani.org) and my personal website, thereby reiterating and emphasising the results of my study.

- I will submit a report to the Tamil Nadu Forest Department and local research partners along with presenting the same findings. This report will outline likely recommendations that would emerge from this study, highlighting the effectiveness of restoration efforts. By also making an in-person presentation, I will gauge an understanding of the results of this study by forest department officials and local research partners.

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

The Rufford funded project funds were used from December 2019 to June 2021. A majority of the tasks were completed by June 2021 (as outlined in the initial grant proposal). Few outreach and research outputs are expected to continue until December 2022.

9. Budget: 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. It is important that you retain the management accounts and all paid invoices relating to the project for at least 2 years as these may be required for inspection at our discretion.

Item	Budgeted Amount	Actual Amount	Difference	Comments
35 AudioMoth acoustic recorders	1471	1519	+48	Costs of shipping and tax were not considered.
35 microSD memory cards (32GB each)	520	520		
2 external hard drives (2TB each)	99	105	+6	Costs of shipping and tax were not considered.
120 AA Batteries	81	50	-31	Difference in currency rate led to costs being lower.
35 Custom-made protective cases for recorders	41	40	-1	Custom cases were made in India.
2 Memory card holders		7	+7	Purchased to allow ease of access to memory cards while in the field (for switching memory cards between recorders).
Thick strings to fasten protective boxes	12	11	-1	
Bus travel (Bangalore to Valparai)	26	20	-6	Overnight bus travel was purchased in advance resulting in cheaper fares.
Salaries for 2 field collaborators	1189	1188	-1	
Food at field station	428	401	-27	Cooking at the field station and eating out lesser resulted in lower costs.
Lodging at field station	285	300	+15	
Fuel costs	347	301	-46	Lower costs incurred when travel was reduced in March 2020 and April 2020 as a

				result of the covid-19 pandemic.
Outreach	300	384	+84	Money paid to an illustrator for the creation of interactive visualizations of bird species recorded.
Miscellaneous	300	240	-60	Expenses towards vehicle maintenance and minor injuries in the field.
TOTAL	**5099**	**5084**	**-15**	

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

Long-term monitoring of active restoration is of utmost importance to not only monitor biodiversity, but also assess the trajectory of conservation intervention activities. Immediately, we are planning on publishing our research outputs for a wide scientific audience in an open access peer-reviewed journal. Second, we are planning on continuing our acoustic monitoring across the gradient of restoration with a focus on certain taxonomic/indicator groups like mixed-species flocks of birds and insects for example in a forthcoming/collaborative Rufford small grant.

11. 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?

Yes, the Rufford Foundation logo was used in all presentations and talks. We have also included this logo in our outreach material and interactive illustrations (made into a video to describe the work carried out). Please see the links to the talks for more information.

12. Please provide a full list of all the members of your team and briefly what was their role in the project.

First and foremost, this project would not have been possible without the help of Kadar community members (Krishna Kumar and Vijay Kumar) who were instrumental in the completion of field work. Secondly, I would like to thank the Nature Conservation Foundation for their tireless efforts to restore forest fragments for the last two decades. In addition, plantation companies and managers allowed me to work in their plantations for which I am very grateful. Below is a list of team members and their role:

Field work
Vijay Kumar (Field collaborator)
Krishna Kumar (Field collaborator)
Moorthy (Field collaborator)
Sathish (Field collaborator)
Vani Das (Field collaborator)
Manickraj (Field collaborator)

K Srinivasan (Project coordinator, Nature Conservation Foundation)
Kshama V Bhat (Project assistant, Nature Conservation Foundation)

Project Dhvani Team
Akshay V Anand (Project assistant)
Pavithra Sundar (Online outreach intern)
Pratiti Majumdar (Online outreach intern)
Pooja Choksi (Scientist)
Sarika Khanwilkar (Scientist)

Mentoring and support from Columbia University
Ruth S DeFries (Department of Ecology, Evolution and Environmental Biology, Columbia University)
VV Robin (Department of Biology, Indian Institute of Science Education and Research, Tirupati)

Nature Conservation Foundation
Divya Mudappa (Scientist, Nature Conservation Foundation)
T R Shankar Raman (Scientist, Nature Conservation Foundation)
Anand Osuri (Scientist, Nature Conservation Foundation)

Thanks to
Priyanka Hari Haran (PhD student, University of Florida)
Ganesh Raghunathan (Research affiliate, Nature Conservation Foundation)
Chayant Gonsalves (Educator and illustrator)

13. Any other comments?

I am very grateful to The Rufford Foundation for supporting this work. I would like to especially thank Jane Raymond for all administrative help on this project.