

Final Evaluation Report

Your Details	
Full Name	Stephen Holden Jones
Project Title	Amphibian Conservation on Cacao Plantations
Application ID	37380-1
Date of this Report	12/13/23

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
Complete sampling effort for Proyecto Cacao Ranas				Support from The Rufford Foundation allowed us to hire an additional field assistant and double our total sampling effort. The fieldwork for this project was completed in March 2023.
Better understand factors influencing the diversity of amphibians in the agricultural landscape of the Ecuadorian Chocó				Although our original plan was to sample for amphibian diversity across two sites in the Ecuadorian Chocó, this was logistically impossible. We had enthusiastic support from the Fundación para la Conservación de los Andes Tropicales (FCAT) and elected to double our sampling effort to span the dry and wet seasons instead. Preliminary results suggest that shade cacao plantations do not adequately replace even small patches of remnant forest as habitat for amphibians, although we will begin formal data analysis in January 2024. We expect to submit a manuscript for publication at the end of 2024.
Build capacity for local researchers and communicate findings to local community				We trained both field assistants in general field methodology, data curation, and scientific communication in addition to specific amphibian identification and sampling techniques. The project's primary field assistant, Darwin Zambrano, began the project as a monthly contracted employee but now works full-time for FCAT on a range of projects in addition to his work with amphibians. Darwin and Julio Loor (the project's second field assistant) presented preliminary results from this project during a workshop for local farmers hosted at FCAT in June 2023. Additional dissemination will follow in 2024 post data analysis.

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

- a) We have collected a massive dataset on amphibian diversity and distribution in a fragmented agricultural landscape in the Ecuadorian Chocó, one of the most diverse ecosystems on earth. In addition to abundance and diversity, we have collected genetic data and sampled for chytrid presence from nearly 2,000 amphibians across a variety of land-use gradients in both the rainy and dry season. We have collected data on the landscape and local context of each of our 32 sampling sites. Our sampling sites cover four distinct land-use types; remnant forest, abandoned cacao plantation, active shade-grown cacao plantation, and active sun-grown cacao plantation.
- b) Although we have only performed preliminary data analysis thus far, these results show that the habitat quality of remnant forests cannot be replaced by even shade-grown cacao. This is exemplified by our discovery of a few populations of *Leucostethus bilsa* and other forest-dependent amphibians in small remnant forest fragments near and within the FCAT Reserve. *L. bilsa* is a critically endangered dart frog (Dendrobatidae) formally described in 2020. It was previously known from a 6 km² patch of forest from the Bilsa Forest Reserve. This range expansion exemplifies the importance of small-scale conservation work in the region by organisations like FCAT. Following the discovery and identification of *L. bilsa* in one of our sites we began a search effort which successfully identified additional populations in forested habitats within the FCAT Reserve. Despite intensive sampling in the surrounding agricultural landscape, this species is clearly forest dependent. This information will help inform conservation efforts for FCAT and other organisations.
- c) A primary goal of the project is to better understand aspects of cacao plantations that promote amphibian diversity. Although data analysis will begin in January 2024, our robust dataset will allow us to distinguish the relative importance of landscape context (such as surrounding forest cover, access to water), and local management (such as canopy cover, leaf litter, pesticide application frequency) on amphibian diversity patterns.

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

We encountered many unforeseen difficulties over the duration of our project. During the beginning of my time in Ecuador (June 2023), the country experienced an intense nationwide strike. This restricted movement and delayed the site establishment phase of our project. This and other logistical issues caused us to focus our sampling efforts on the landscape surrounding FCAT. Instead of sampling at 15 sites each at FCAT and an additional partner organisation, we sampled 32 sites at FCAT. We believe this will lead to a more robust understanding of the factors influencing amphibian diversity, which will still be generalisable across other areas in the Chocó and beyond.

Landowners of active cacao plantations were concerned with our plan to install pitfall traps as they presented a safety hazard. For this reason, we did not install any pitfall traps, and sought to sample for rare species by increasing our sampling effort to six survey nights at each of 32 sites. The complicated topography of the landscape surrounding FCAT also made water-based pesticide sampling impossible. Some plantations had no nearby streams, and the cost of this sampling method would have restricted us to collecting a mere snapshot of pesticide application shortly before sampling occurred. We instead partnered with FCAT's undergraduate research programme to perform a survey of landowners to understand the frequency and type of pesticide being applied on each of our sites. Carlos Sanchez, a student at the University of South Carolina performed surveys in the summer of 2023 which will form part of his undergraduate thesis.

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

We have collaborated closely with local communities during all phases of this project. Darwin Zambrano and I toured every site and spoke to every potential landowner (30 in total) asking for permission to establish transects on their land and perform sampling six times over the course of 7 months. Darwin is a well respected member of the local community and advocated for any landowner concerns such as the use of pitfall traps, and the timing of sampling efforts. Both Darwin and Julio were encouraged to take ownership and leadership of the project and made many invaluable contributions to improve sampling efficiency, suggest future extensions, and identify challenging specimens. In addition, Darwin and Julio performed all of the sampling in the wet season independently.

Both Darwin and Julio are employed through FCAT, a local organisation that has 20 years of experience running conservation and management projects in the area. FCAT employs approximately 30 local community members to run their station and support a diverse range of research and conservation projects. By collaborating with FCAT, we supported these efforts to provide economic alternatives in a region with high unemployment. We worked with FCAT to develop a presentation during a community engagement workshop in June 2023. Darwin and Julio spoke with local cacao farmers about preliminary findings from the project and their experience monitoring amphibians in the surrounding landscape.

5. Are there any plans to continue this work?

Although we exceeded our original sampling goal in cacao plantations in the region, our findings have encouraged us to continue studying mechanisms to promote amphibian conservation. FCAT began an ambitious forest restoration project on degraded pastureland in 2022. This presents an exciting opportunity to understand how forest restoration influences biodiversity patterns of amphibians. No published studies have investigated the rate or degree of recolonisation by amphibians following forest restoration. Given their sensitivity to land-use changes as demonstrated by this study, amphibians are an ideal indicator group to monitor over the course of forest restoration.

We took advantage of this opportunity by establishing a series of transects in each of the two existing forest restoration sites. Darwin and Julio performed a month of amphibian monitoring in the rainy and dry seasons in the 1st year following forest restoration to acquire a baseline dataset of initial community assemblage. We will apply for additional funding from The Rufford Foundation to support the next round of monitoring and expand monitoring efforts to other sites in landscape. The data we collect in this project will inform the degree to which forest restoration can restore habitat for forest-dependent species such as *L. bilsa*, helping to inform restoration prioritisation in the Ecuadorian Chocó and across the tropics.

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

We will share the results of our work via a series of peer-reviewed publications. I will be leading the preparation of a short manuscript detailing the discovery of a new population of *L. bilsa* with anticipated submission in June 2024. I will also lead the analysis and preparation for a manuscript exploring the diversity patterns of amphibians in the agricultural landscape surrounding FCAT. Once I have completed data analysis, I will prepare a more robust presentation for the local community around FCAT which I plan to give in 2024 or 2025.

It is likely that further studies on landscape connectivity and landscape genetics will emerge from tissues collected during this sampling effort. When genetic tissues are sequenced by collaborators at Universidad San Francisco de Quito it is possible that we will find species previously unknown to western science. These findings would also be detailed in peer-reviewed publications. Pending additional funding support, we plan to eventually publish the results of our recently started forest restoration monitoring project. We expect that results will be ready for publication in 5-10 years, depending on the rate of recolonisation by amphibians.

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

The most immediate steps are to analyse previously collected data. I will lead this effort beginning in January 2024. Collaborators from Texas State University and the Universidad San Francisco de Quito will perform the laboratory work to assess chytrid prevalence in a subset of approximately 600 amphibian swabs collected during the project. This data will be included to understand the disease dynamics of amphibians in the agricultural landscape, which is especially interesting given our understanding of pesticide application on our study sites.

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?

Yes, I gave presentations with the preliminary results from this project to the FCAT community in November 2022 and June 2023, the Charles Darwin Foundation's scientific community in March 2023, and the University of Hawaii's graduate research symposium in April 2023. I included the Rufford Foundation's logo and thanked the foundation for their support in all talks. I periodically updated fieldwork progress of the project on my personal Twitter and Instagram pages where I thanked The

Rufford Foundation and other funding organizations for their support. The Rufford Foundation will be mentioned in future talks and publications.

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

S. Holden Jones – Fulbright Ecuador, University of Hawai'i at Mānoa - project lead, experimental design, site establishment, fieldwork, data analysis, manuscript preparation, communication, funding

Darwin Zambrano – FCAT – fieldwork, experimental design, site establishment, identification, reforestation monitoring, communication

Julio Loor – FCAT – fieldwork, identification, reforestation monitoring, communication

Dr. Juan Manuel Guayasamin – Universidad San Francisco de Quito – experimental design, identification, genetic analysis, laboratory support, manuscript preparation, funding.

Daniela Franco – Universidad San Francisco de Quito – fieldwork, identification, genetic analysis, laboratory support, manuscript preparation

Dr. Rakan Zahawi – Charles Darwin Foundation, University of Hawai'i at Mānoa – experimental design, manuscript preparation, funding

Dr. David Rodriguez – Texas State University – chytrid prevalence analysis, laboratory support, funding

Dr. Jordan Karubian – FCAT, Tulane University – experimental design, funding

Francisco Velásquez – University of Houston – identification

Carlos Sanchez – University of South Carolina – pesticide application survey

10. Any other comments?

We are really thrilled to have completed a year of sampling for this project. The Rufford Foundation's support has helped us tremendously and allowed us to collect data that we believe will be of high conservation and restoration relevance. As mentioned, we will apply for additional funding rounds to support ongoing research which has evolved as an extension of this project.