Final Evaluation Report

We ask all grant recipients to complete a project evaluation that helps us to gauge the success of your project. This must be sent in **MS Word and not PDF 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 – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Please DO NOT fill in and submit this form until the project has been completed.

Complete the form in English. Note that the information may be edited before posting on our website.

Please email this report to jane@rufford.org.

Your Details	
Full Name	Lucas Ferreira Colares
Project Title	Unravelling How Will Arthropods Respond to Habitat Loss and Fragmentation in the Brazilian Amazon
Application ID	35553-1
Date of this Report	03/12/2025

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
Unravel the effects of forest loss and fragmentation on insect diversity			X	We were able to identify the thresholds of forest loss that drive decreases in insect diversity and abundance in the Amazon. These are currently published in British Ecological Society's Journal of Animal Ecology or under preparation for publication. We successfully installed 1,320 sticky traps distributed across 36 islands, 3 areas of continuous forest, and the vast water matrix of the Balbina archipelago, culminating in more than 200,000 insect individuals collected.
Raise awareness on the importance of insect conservation through educational interventions			X	During the development of this work, we visited two local high schools in the village near the study region in the Amazon. These are described in previous reports. Additionally, we presented our results to senior and future researchers at four conferences across the UK and Brazil, at Universities of Liverpool and Birmingham (UK), and the Federal Universities of Bahia and Santa Maria (Brazil), reaching approximately 450 students across our initiatives. Across social media, we shared our results on the official Instagram page from post-graduate program that the project was associated in the

				Brazilian university and across X. We did not conduct any quantitative measures of awareness.
Identify and report which species are currently more vulnerable to extinction driven by habitat loss		X		Although we were unable to identify individuals to species-level due to the number of insects collected (that is, more than 200,000 individuals from 14 taxonomic orders), we report the major groups most sensible to forest loss in the Amazon, that is cicadas, bees, and wasps. These results are currently published in Journal of Animal Ecology or under preparation.
Provide baselines and tools for insect research and conservation in the Amazon			X	We reported the organization of insect communities across preserved ecosystems (i.e., strict conservation units), providing the baseline for insect abundance in Central Amazonia. Furthermore, we developed an Artificial Intelligence model for fast surveys on insect diversity and abundance, which is freely available to support further conservation research (see the published paper; further details will be described in a paper under preparation).

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

a). The identification of shifts in insect communities after forest loss and fragmentation. Our project revealed that forest loss triggers markedly divergent responses in Amazonian insect communities depending on their life history. Using more than 200,000 identified individuals, we evidenced that terrestrial insects decline sharply in areas with low forest cover, while aquatic insects, especially mosquitoes and mayflies, become ecological "winners" in deforested landscapes.

b). The inspiration that our project induced on the youth and to future researchers. Beyond its scientific contribution, the project fostered meaningful community engagement in the Balbina region. Local students and residents participated in field activities, interacted with the research team, and were exposed to accessible presentations about biodiversity, conservation, and AI-powered science. This direct involvement of Amazonian youth, many of whom rarely have opportunities to engage with cutting-edge ecological research, helped demystify scientific careers and encouraged new generations of researchers from the region.

c). The development of AI-driven tools to accelerate insect surveys in the Amazon. We developed one of the first large-scale deep-learning pipelines for automated insect detection and body-size estimation in Amazonian ecosystems. By training AI models capable of processing more than 20,000 specimens in a few hours and achieving a mean accuracy of 79%, the project demonstrated that AI could reduce bottlenecks in insect monitoring. All datasets, models, and images with verification by entomologists were made publicly available, enabling replication and adoption by other researchers. This technological outcome opens the door to rapid, low-cost, high-resolution insect surveys across vast tropical landscapes and can help overcome shortfalls that limits conservation action in the region.

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

The main challenges faced during the project can be divided into five categories. (1) The sampling design used during the first field expedition in the Balbina Reservoir did not reflect real-world conditions. To address this, we redesigned our sampling strategy after the first expedition, which resulted in a robust setup of more than 1,400 traps distributed across an area twice the size of London. We initially planned to sample arthropods using a combination of sticky traps and pitfall traps. However, we abandoned the pitfall traps due to the small team size, limited resources, and the large spatial extent of the study area. In addition, the pitfall trap sampling design was not compatible with the timeline of the sticky trap sampling. Therefore, we chose to reallocate the resources originally intended for pitfall traps to expand the spatial coverage of the sticky trap sampling design. (2) Personnel issues with administrators at the high school where we presented our research, as well as with the heads of the conservation units, caused delays due to bureaucracy. Unfortunately, there was little we could do other than wait for the pace of Brazilian institutions. (3) We faced funding shortages during the expeditions because the study area turned out to be far larger than anticipated and accessible only by boat, requiring a team of at least two people. Fortunately, co-funding from the National Geographic Society arrived during this period and enabled us to complete the fieldwork. (4) The overwhelming number of insects captured in the traps became a major bottleneck, preventing fine-scale species-level analyses – identifying and measuring more than 200,000 individuals would have taken years. To overcome this, we trained an AI model to automatically measure and identify specimens to the order level, allowing us to infer community responses using this higher-level taxonomy. (5) Finally, one of the most significant challenges was the extensive field campaign itself, which lasted four consecutive months in one of the most remote regions of the Amazon rainforest. We met this challenge with good humour and the support of an excellent team of local villagers, without whom the work would not have been possible.

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

Residents of Balbina village played an essential role in the field campaigns. Their knowledge of the reservoir's waterways, forest islands, and seasonal conditions was indispensable for safely navigating one of the most remote regions of the central Amazon. Local boat operators, guides, and field assistants were formally hired, providing direct economic benefits and strengthening the partnership between researchers and the community. Our project also included outreach activities at the local high school, where we presented our findings and the broader importance of insect biodiversity for ecosystem health. These sessions exposed students to modern ecological research, artificial intelligence tools, and real-world conservation challenges in their own region. This encouraged local participation in environmental stewardship and fostered enthusiasm for conservation and technology among Amazonian youth. The presence of an Amazon-born researcher leading this project reinforced the message that leading high-impact scientific research is accessible to people from the region. This resonance was particularly important for students and young residents who rarely see themselves reflected in academic leadership.

5. Are there any plans to continue this work?

Yes. The work initiated in this project is continuing along multiple fronts. The research group led by Prof. Carlos Peres is expanding the study to additional biological groups within the Balbina archipelago, enabling a broader understanding of how forest loss affects different components of Amazonian biodiversity. In parallel, I am applying the same methodological framework developed here to other areas across the Amazon rainforest, including the large-scale sampling design, rapid-inventory approaches, and AI-driven insect identification tools. These new applications will allow us to test the generality of our findings across different landscapes. Together, these efforts will help establish a scalable, low-cost monitoring strategy for Amazonian insects and contribute to long-term conservation planning in the region.

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

We are committed to ensuring that our results reach a wide audience, from scientists and conservation practitioners to local communities in the Amazon. The main findings have already been published in an open-access scientific article, and all datasets and AI models have been deposited in public repositories so that other researchers can easily access, reuse, and expand upon our work. We will continue to present the results at international conferences and academic seminars, highlighting both the ecological insights and the technological innovations developed throughout the project. Furthermore, at least three other papers are planned for publication in the next 3 years from this same project. At the community level, our team if recurrently returning to Balbina village to share other research in an accessible way with residents and schools, helping to strengthen scientific literacy and increase awareness of how the surrounding landscape is changing. These outreach activities are an important part of our long-term engagement with the people who live in and rely on the region. In addition, we are continuously offering workshops and training sessions for students and early-career researchers in Amazonian universities, focusing especially on deep-learning techniques for biodiversity monitoring and on large-scale sampling approaches. By doing so, we hope to disseminate the practical tools created in this project and enable others to apply them across the rainforest.

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

Looking ahead, the most next steps involve expanding insect monitoring across the Amazon using the tools, insights, and methodological framework developed in this project. The Balbina study demonstrated that large-scale, AI-assisted insect surveys are both feasible and highly informative, and now we plan to apply the same approach across diverse Amazonian landscapes. This expansion is essential for understanding how forest loss, climate change and land-use transitions are reshaping insect communities at the biome scale. An especially exciting next step is the launch of the IARAA Project, which brings AI-driven insect monitoring into Indigenous territories. This initiative is being co-developed with Indigenous communities, integrating their ecological knowledge with modern computational tools to create a low-cost, long-term biodiversity monitoring network. By empowering Indigenous peoples with access to automated identification tools and training opportunities, our team aims to strengthen local stewardship and generate unprecedented data on insect diversity in some of the most intact regions of the Amazon. Together, these next steps can transform how we monitor and understand insect biodiversity, enabling rapid, inclusive, and spatially extensive assessments that are crucial for conservation planning and the long-term resilience of Amazonian ecosystems, all thanks to the kick-off grant provided by Rufford Foundation.

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. All presentations, outreach materials, and scientific publications produced during the project included The Rufford Foundation logo in their Acknowledgements or Funding sections. This ensured that the Foundation's support was clearly recognized in every instance where we shared the results or described the trajectory of the project. In addition, the Foundation received visibility during seminars, community presentations, and academic events in which the project was featured. To facilitate transparency and access, we have compiled all materials containing the Rufford logo into a Google Drive folder.

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

The project was made possible through the contribution of a diverse and dedicated team. The core research team included *Lucas Ferreira Colares*, who served as the team leader during his PhD, coordinating all stages of the project; *Cristian de Sales Dambros*, the lead supervisor; and *Carlos Augusto Peres*, co-supervisor, who provided scientific guidance throughout the study. Field operations and insect work were supported by *Renato Azevedo*, who served both as a field assistant and insect taxonomist, as well as *Sâmia Letícia* and *Ricardo Ruaro*, who assisted in the intensive field campaigns. We also collaborated with several experienced local partners whose contributions were essential for navigating the Balbina archipelago and ensuring the success of our field expeditions. *Antônio Silva dos Santos, Benedito Ferreira da Silva, Edson Silva do Nascimento*, and *Felipe de Souza Macêdo* all worked as local boat drivers and field assistants, providing invaluable knowledge of the region and logistical support. Administrative coordination within the conservation area was facilitated by *Ketlen Macêdo*, local administrator of the Uatumã Sustainable Development Reserve, and *Gilmar Klein*, lead administrator of the Uatumã conservation unit. Their support with permits, communication, and logistics was fundamental to the successful execution of our project.

10. Any other comments?

I would like to use this space to express my sincere gratitude to the Rufford Foundation for supporting our project. The grant played a crucial role in making this research possible, enabling extensive fieldwork in one of the most remote regions of the Amazon and supporting the development of tools that can transform how we monitor insect biodiversity. Beyond the scientific outcomes, the Rufford Foundation's support helped foster local engagement, promote conservation awareness, and empower communities to better understand the ecological changes occurring around them. This investment in early-career researchers and conservation initiatives has a tangible impact on both the scientific community and the future of Amazonian ecosystems, and I am deeply thankful for the opportunity it provided.

ANNEX – Financial Report

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