

Final Evaluation Report

Your Details	
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Project Title	Listening to owls and people in the fragmented Atlantic Forest: detecting and addressing threats through passive acoustic recording and community engagement
Application ID	38408-1
Date of this Report	11 th July 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
Perform Passive Acoustic Monitoring and train an automatic detector to recognize Atlantic Forest owls and other nocturnal species				Between July and December 2022, we performed passive acoustic monitoring by deploying 141 autonomous recording units (AudioMoth v1.2.0) across three habitat types in the Argentine Atlantic Forest (>1.5 km apart), covering an area of 18,000 km². Only 5 units (3.5%) failed, resulting in 136 sites with usable data. We recorded continuously over 24-hour periods, collecting ~14,000 hours of audio, including ~7,000 hours of nocturnal recordings. In 2023, we manually annotated 166 hours of recordings from 15 sites (5 nights per site), identifying 97 audio files (~2% of 4,980 two-minute clips) with at least one owl vocalisation, from four species, including the endemic <i>Strix hylophila</i>. This confirmed owl presence but also highlighted the labour-intensive nature of manual review. We then trained and fine-tuned an automatic recogniser based on BirdNET to detect owl and other nocturnal bird vocalisations from our recordings. With this improved model, we analysed the full ~7,000 hours of nocturnal data and detected 9 of the 13 regional owl species, as well as five species of nightjars and potoos, and three crepuscular birds. This fulfilled the objective of both performing PAM and developing an effective automated detection method.
Study species-specific habitat associations and the probability of occupancy of each species according to habitat structure, % of forest in the landscape, human footprint, and other factors.				I have validated the top-scoring detection per site and surveyed night for several owl species and completed detection histories for four species so far. These detection histories span 136 sites across three habitat types, with 5 to 35 surveyed nights per site (sampling occasions) sufficient for occupancy modelling. I expect to finalise detection histories for at least 6–7 species within the next month. Although we have detected 0 species, some are extremely rare in the dataset, likely precluding occupancy analysis for them using our data alone. We also finished collecting and processing vegetation structure data at the local scale using the point-centred quarter method. This required

			between 1–3 hours per site, depending on accessibility and vegetation. We measured over 2,000 trees across all sites, adapting the method to work across various habitat types (e.g., minimum 10 cm DBH, maximum 17 m search radius). We computed 18 local variables including bamboo cover, understory height and density, leaf litter depth and coverage, density of woody debris, presence of snags and large trees, among others. At the landscape level, I assessed habitat composition at four spatial scales (0.5, 1, 5 and 10 km² buffers) using MapBiomas Atlantic Forest land cover data and R packages such as landscapemetrics and terra. We calculated percentages of native forest, agriculture, and pine plantations, forest patch shape, habitat diversity, and distance to continuous forest. Additional environmental variables included distance to the nearest permanent watercourse, slope, and canopy height (10 m resolution). These variables are ready for use in occupancy models once the detection histories are completed. Although this objective is not yet fully achieved, all necessary spatial and field data have been gathered and curated, and model development is underway.
Identify patterns of owl species co-occurrence (avoidance or aggregation) and determine how species traits and anthropogenic habitat modifications influence those patterns.			This objective builds directly on the outputs of the single-species occupancy models described in Objective 2. The necessary detection histories and environmental covariates are already being compiled and processed. Once the single-species models are completed, I will apply two-species occupancy models to assess patterns of co-occurrence (e.g. segregation or aggregation) between species pairs. Based on the current dataset, I expect to model co-occurrence for at least six owl species pairs. The environmental and habitat variables already compiled (e.g. vegetation structure, landscape composition, human footprint) will be used to evaluate how species traits and anthropogenic factors influence these co-occurrence patterns. While modelling has not yet begun, all necessary data are in place, and analysis is expected to proceed once species-level occupancy models are finalised.
Determine how changing land use influences			As with the previous objectives, this analysis depends on the same dataset of detection histories and environmental variables. At this stage, we

community composition, taxonomic and functional richness of owls. This information will be useful to plan conservation actions and management practices to plan habitat configuration that aims to maximize owl taxonomic and functional diversity.			consider the objective partially achieved. Although we detected 9 owl species, some were recorded only occasionally, which may limit our ability to robustly assess patterns of taxonomic and functional diversity using our data alone. However, the single-species and two-species occupancy models will allow us to evaluate species-specific habitat use and co-occurrence patterns in relation to land-use change and habitat structure. These results will inform conservation recommendations regarding habitat composition and configuration to support multiple owl species. In addition, although this objective was initially focused on owls, our dataset also includes sufficient detections of other nocturnal and crepuscular birds, such as nightjars, nighthawks, and potoos. This opens the possibility to expand diversity and community-level analyses to these groups, providing further insights into how land-use changes affect nocturnal bird communities.
Understanding local people's perception of owls			We conducted 45 semi-structured interviews with local residents to explore their knowledge, perceptions, and beliefs about owls, and to identify potential threats to owl conservation. Most of the people interviewed were individuals I had met during previous stages of the project when placing the recorders on their farms, which meant I had visited them at least three times. Others were contacts of project collaborator Bianca Bonaparte, who had previously worked in rural areas during her thesis. In both cases, people already knew us, which helped build familiarity and ensured that we were not seen as park rangers or enforcement personnel which is a common concern among landowners that can limit openness. This allowed for more honest and relaxed conversations. All interviews took place in people's homes, on their farms. We used a semi-structured format that encouraged open dialogue and allowed the conversation to flow naturally, often guided by the participants' own interests and experiences. Interviews lasted on average 1.5 hours, and up to three hours in some cases. We did not record the conversations to help participants feel more comfortable. Bianca led the questioning, while I took detailed notes, occasionally asking follow-up questions. The interview included general knowledge

			questions (e.g., which owls they knew and what they eat), reactions to owl vocalisations (assessed through immediate verbal and non-verbal responses, later scored using a Likert scale), and image-based prompts to elicit aesthetic or emotional responses. We also collected stories, memories, and beliefs related to owls, many of which emerged spontaneously during the sound playback section. In total, we reached 50 people, with 45 agreeing to participate in the interview. Responses varied from individual interviews to group settings with family members joining in. Both qualitative and quantitative analyses were performed and are included in the project outcomes (see Section 2b).
We will implement an education programme and workshops together with Proyecto Selva de Pino Paraná (pinoparana.org), consisting of workshops in ten rural schools of Misiones, Argentina, each year.			This objective was fully achieved and even surpassed. Over the course of two and a half years, the team visited an average of 22 rural schools per year, reaching approximately 800 students annually. Since 2023, I have become an active member of the educational team of Proyecto Selva de Pino Paraná, participating regularly in planning meetings held every three weeks and some extra meetings to co-design the activities and structure of each year's programme. The programme is designed for primary school students, from 1st to 7th grade, typically aged between 6 and 12 years old. Results from our ecological and cultural research have been incorporated into the educational programme. For example, local names for owls and specific cultural beliefs documented during interviews are now used in classroom activities. One activity features an Atlantic Forest endemic owl, and others use owl sounds and images to explore emotions and empathy, particularly with younger children. Themes such as habitat loss, fragmentation, and ecosystem connectivity, all key to owl conservation, are covered extensively. In some activities they cover the role of dead standing trees, the ecological link between woodpeckers and owls (especially in farms), and the importance of biodiversity for maintaining healthy ecosystems that benefit both wildlife and local people. Activities are designed to promote

			coexistence by recognising rural communities as part of nature, encouraging a positive and empowered relationship with the environment. Each annual programme runs from August to the following August and is built around a specific theme, often developed following teacher and student interests and needs. From mid-2023 to mid-2024, the theme was “Recognising native species, their habitats, and ecological relationships.” From mid-2024 to mid-2025, the theme shifted to “Conservation and connectivity of the Atlantic Forest of Misiones and its relationship with the people who live in it.” Owls were present in both programmes, indirectly in the first, through activities about habitat and associated species, and more directly in the second, with specific owl-focused content. Workshops were delivered across a range of rural schools, including isolated “satellite classrooms” that serve students from multiple grades in remote areas. These schools are often overlooked by traditional outreach, yet their students live in close relationship with the forest and have strong potential to influence local conservation through their families and communities. The continued integration of our project’s findings into this dynamic educational effort ensures a lasting impact.
We will organise three talks/workshops to discuss the ecological importance of owls, the diversity of Atlantic Forest owls, and the cultural role of some species with workers of the principal timber company in Misiones, and private and public protected areas.			Although we did not carry out the three formal talks or workshops as originally planned, I and other collaborators participated in several outreach and engagement events focused on the ecological and cultural importance of Atlantic Forest owls. In 2022, I delivered a one-hour talk to over 100 certified tourist guides from Iguazú National Park, and I plan to return next year with updated results. I also took part in a public science event (“Scientific Happy Hour”) where I presented on owls, passive acoustic monitoring, and automatic detection methods for rare and threatened species in complex tropical environments, reaching an audience of more than 30 people. In addition, I participated in a major outreach event in the main square of Puerto Iguazú, where we interacted with the public, including many teachers and students, at a stand dedicated to bird, and specifically owl, biodiversity and conservation.

			The stand remained open for five hours and included field equipment used in owl studies, photographs of all Atlantic Forest owls, and games with prizes for both children and adults. The educational team of Selva de Pino Paraná also participated in four similar outreach stands held in San Pedro and Piñalito (Misiones), where owl diversity was one of the main themes. Beyond these public events, I engaged directly with 45 families during farm visits while conducting interviews on owl perception, using the opportunity to further discuss owl ecology and conservation in informal yet meaningful ways. Finally, I submitted the partial project report to the Iguazú National Park Administration and will send the final report to them as well as to the Ministry of Ecology and ARAUCO, the largest timber company in Misiones, where acoustic recorders were deployed in pine plantations. These communications ensure that key stakeholders will receive and benefit from the project's findings.
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2. Describe the three most important outcomes of your project.

a). Development of a tailored recogniser for nocturnal birds and large-scale acoustic analysis

One of the main achievements of this project was the development and application of a tailored machine learning model for detecting owls and other nocturnal bird species from passive acoustic monitoring (PAM) recordings in the Atlantic Forest.

We deployed 141 autonomous recording units (AudioMoth v1.2.0) across three habitat types (native forest, pine plantations, and small-medium farms), covering over 18,000 km². We successfully collected approximately 14,000 hours of audio recordings, of which around 8,000 hours were nocturnal.

Initially, we manually annotated a subset of 166 hours of recordings to understand vocal activity and background noise patterns. This manual effort confirmed the presence of four owl species, including *Strix hylophila*, an Atlantic Forest endemic.

Recognising the limitations of manual labelling, we then fine-tuned BirdNET, the most widely used open-source model for bird sound recognition, to improve its performance on our low-quality field recordings. The original model was trained on high-quality focal recordings and performed poorly in our acoustic domain. To address this, we:

- Created a custom training dataset using recordings from Xeno-Canto overlaid with field noise,
- Fine-tuned the model's classification layer using BirdNET's training interface,
- Applied an Active Learning strategy to iteratively add real field detections into the training set,
- Collaborated with PhD candidate Tessa Rhinehart (University of Pittsburgh), who guided the machine learning process.

After nine rounds of iterative training and validation, the final model achieved a macro mean Average Precision (mAP) of 0.50 for 19 owl classes which is a substantial improvement over the original BirdNET performance (mAP = 0.12).

Using this model, we processed all ~7,000 hours of nocturnal recordings and confirmed the

presence of 9 owl species (out of 13 expected), along with five caprimulgids (nightjars and potoos) and three crepuscular bird species. These results are being used to construct detection histories for occupancy modelling, and preliminary analyses suggest differences in naïve site occupancy across habitat types (Figure 1).

This work demonstrates that passive acoustic monitoring, combined with machine learning and iterative model improvement, can be an effective and scalable approach to monitor elusive nocturnal species in complex Neotropical soundscapes. The process and findings are being prepared for publication to support broader application in conservation and biodiversity monitoring.

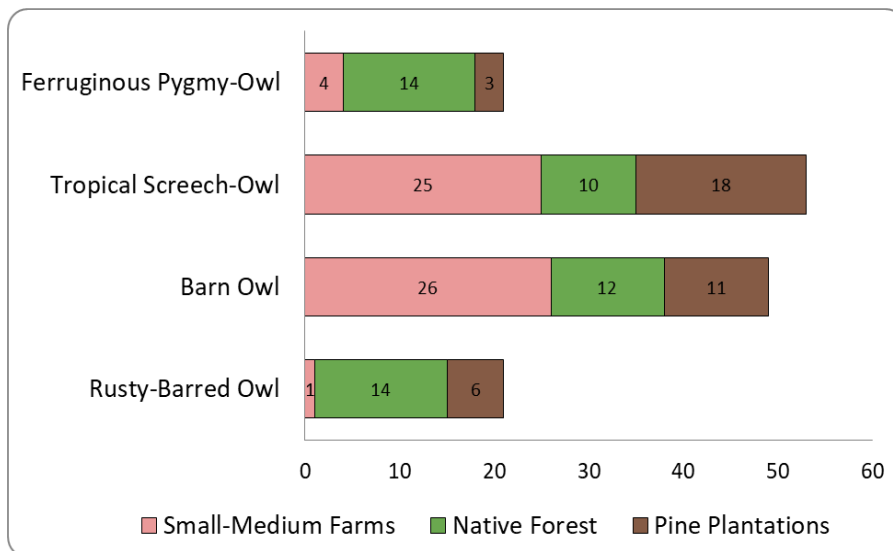


Figure 1. Number of sites with owl detections, partitioned by habitat type (n = 136 sites).

b). Insights into local knowledge, perception, and beliefs about owls

We conducted 45 semi-structured interviews with local people to explore their knowledge, perceptions, and beliefs about owls. While 50 individuals were approached, five declined to participate. Most participants were people we had previously engaged with during fieldwork, especially where acoustic recorders had been installed. Others were contacted through project collaborator Bianca Bonaparte, who had prior experience working in rural areas. In all cases, participants already knew us, which helped ensure that we were not perceived as representatives of enforcement authorities. This contributed to more honest and open conversations, particularly within the flexible structure of the interviews, which were conducted in people's homes on their farms.

Knowledge and species recognition

When asked to name owl species, 80% of participants did not use formal names but described owls based on physical traits or behaviours. Only 13% mentioned one correct name, and 6.7% mentioned two. The most common names were "Suindá" (for *Tyto furcata*) and "Caburé" or "Cabure-i" (for *Glaucidium brasilianum*). Notably, one participant used a name we had not previously recorded, referring to *Athene cunicularia*, and shared detailed observations of its behavior, reflecting a meaningful interest in owls.

Using traits such as colour, size, habitat, or behaviour, 44% of participants distinguished two owl types, 20% recognised three, 17% identified one, 13% recognised four, and 4.4% differentiated up to six. When asked what owls eat, rodents were the most frequently mentioned item (Smith's Salience

Index = 0.5), followed by insects. Less frequent responses included fruits, birds, snakes, chickens, pigs, bats, chicks, and even cats.

Emotional and cultural responses to owl sounds and images

Participants were generally more expressive in response to owl vocalisations than to images. We played the calls of four species and recorded their immediate reactions (first words, facial expressions, posture), followed by an internal Likert scale score (1 = most positive, 5 = most negative). These results are visualised in Figure 2 (wordclouds) and Figure 3 (violin plots).

Screech-type calls (2–4 kHz, harsh tonal quality) from *Tyto furcata* and *Strix hylophila* generated significantly more negative reactions than the control calls (harmonic and frog-like, <1 kHz) from *Glaucidium brasilianum* and *Megascops choliba* (mean difference = 2.79 points, SD = 0.12, $p < 0.0001$).

Only the vocalisations of *T. furcata* and *M. choliba*, both common in farmland, were frequently recognised, although many participants did not associate them with owls. In several cases, the screeching call of *T. furcata* was attributed to a supernatural spirit. Interestingly, the story was often linked to the sound itself, rather than the owl as a visible animal.

Beliefs and local knowledge

The American Barn Owl (*Tyto furcata*), locally known as “Suindá”, or “Suindaira” was commonly associated with a widespread belief that its flight call foretells death. In some versions of the myth, the owl announces a future death; in others, it causes it. One particularly vivid version describes the owl “cutting the pall” for the deceased, a metaphor derived from the harsh sound it makes, which some likened to tearing cloth. Reactions varied: some people feared the owl, others tried to scare it away, and some reported that children used slingshots to chase it off.

Glaucidium brasilianum (“Caburé” or “Cabure-í”) was linked to a Guaraní belief that its feather, or a special “fly” hidden under its wing, could be used by men as a charm to attract women. Two variations of this belief were recorded. One involves collecting feathers, which are sometimes sold (or faked using feathers from *Athene cunicularia*, a common farmland species). The other claims that the charm is a magical “fly” beneath the owl’s wing that must be extracted while the bird is alive, leading to its eventual death. Although the story is well known, the species itself was rarely recognised by photo or sound, likely because it is more associated with forest environments and less visible in farmland areas. This highlights a potential disconnection between cultural narratives and actual ecological distribution. A common joke mentioned was that someone was tricked into using a chicken feather instead of a Caburé feather and ended up with bad luck in love.

Reflections and implications

Overall, most people knew at least one or two owl species and recognised their ecological role, particularly in pest control, citing that they eat rodents and snakes. However, we also noticed signs of cognitive dissonance. Although not formally tested, one participant offered a powerful anecdote, she explained that she knows owls are beneficial, as her mother taught her they eat snakes and rats, and that it’s good to have them around. Yet, she admitted to being deeply afraid of owls, of their sounds, of the night, and of darkness. This insight showed us that knowledge alone may not be enough to foster appreciation or coexistence.

This reflection emphasises the need for conservation strategies that go beyond information-based outreach. Building positive emotional experiences and alternative associations with owls may be key to promoting coexistence. These findings will inform both our scientific publication in preparation and our ongoing educational work with schools.



Figure 2. Wordclouds showing the first words expressed after hearing each owl call. Colours represent Likert values: green = positive (1), red = negative (5).

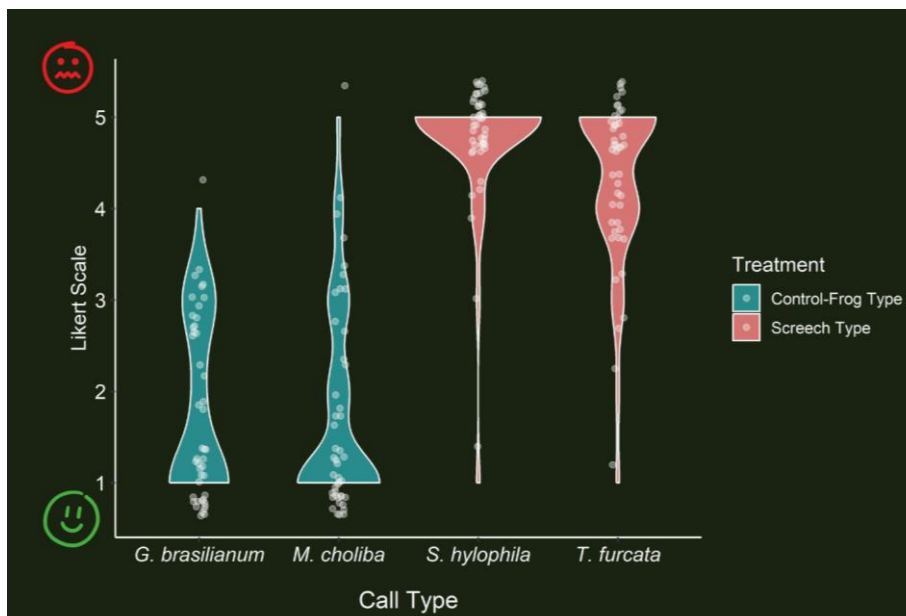


Figure 3. Violin plot of Likert scores by owl species and call type (screech vs. control). Screech-type calls received significantly more negative evaluations (mean difference = 2.79, SD = 0.12, $p < 0.0001$).

c). Education for conservation: engaging rural children with native species, habitats, and coexistence

To evaluate the impact of the 2023–2024 school visits under the theme “*Recognising native species, their habitats and ecological relationships*”, we used a before-and-after drawing activity. Children were asked: “*Imagine someone gives you a farm as a gift—what would you like it to have?*” and instructed to draw their ideal farm, including all the elements they considered important.

After the educational activities, 50% of the children incorporated at least one habitat feature linked to native species discussed during the sessions. The proportion of drawings that included water bodies as key elements for people and wildlife increased from 50% to 70%. Students also added more specific food items for fauna, such as native fruit trees, insects, fish, and other local animals. The number of students who included native forest patches rose from only 8 (4%) before the activities to 33 (15%) afterwards. Streams were frequently depicted, reflecting the emphasis placed during activities on water management and its ecological importance.

In September 2024, we began the new education programme under the theme “*Conservation and connectivity of the Atlantic Forest of Misiones and its relationship with the people who live in it*”, which will run until July 2025. The activities aimed to help children recognise themselves as part of the forest, understand the relationships between living beings (including humans) and ecosystems, and reflect on how their actions influence the environment and quality of life.

Among the activities, one for younger children focused on emotions and empathy. Children listened to recordings of native animal sounds, including owls, and were asked to describe how these made them feel. Responses to the sound of the Burrowing Owl (*Athene cunicularia*), a species common on farms, were mixed, some children associated it with fear or horror, while others expressed positive feelings. Many misidentified the sound as belonging to parrots or raptors, though upon seeing a photo, all recognised it as an owl, most had seen it on their farms.

Other activities centred on protecting and restoring habitat. Children learned about the value of regenerating forest patches for native fauna and discussed how these areas can become healthy forests over time. Another activity challenged students to find solutions for coexistence between small-scale farming and wildlife and their habitat. In this role-play, children acted as forest animals, while facilitators played farmers. Together, they explored how food production could be balanced with minimal impact on native species. Through this activity, students engaged with concepts such as habitat loss, fragmentation, and connectivity.

For older students (~11–12 years), we introduced a group activity based on species-specific ecology. Students were divided into small groups and assigned a “focus animal”: a howler monkey, a frog, or the Tawny-browed Owl (*Pulsatrix koeniswaldiana*), a large, forest-specialist species endemic to the Atlantic Forest. Each group had to “become” the animal, learning about its biology, needs, and threats, and then use that knowledge to design an ideal landscape where the species could thrive alongside humans (Figure 4: plates 1, 3, and 4).

To evaluate this activity, we used a visual mapping method. Students were shown a landscape image with forest edges and given a set of elements (e.g., animals, plants, fruits, wood, water). They were asked to cut and paste elements they felt should be part of that forest, then draw links between them and explain those connections. The activity was repeated in a second visit to compare changes in selected elements and types of ecological links (Figure 4, plate 2). Although we have not yet analysed the full results, this evaluation is expected to be completed by the end of 2025.

At the end of the activities, we distributed educational materials to the children, including illustrated cards featuring owls of the Atlantic Forest, as well as posters and materials on woodpeckers, species that provide nesting cavities used by small owls, especially in farmland settings (see Annex 2).



Figure 4. Students learning and reflecting on owls, their characteristics, and their ecological roles. 1) Students from School N°972 (Colonia Liso) learning about owl characteristics and ecological importance. 2) Student from School N°644 (Colonia Fortaleza) participating in the evaluation activity during the second visit. 3) & 4) Students from 7th grade working with the Tawny-browed Owl (*Pulsatrix koeniswaldiana*) to find solutions for human–owl coexistence, balancing sustainable farming with habitat preservation. Red arrows indicate owls in the materials.

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

One of the main challenges was the difficulty in detecting many of the target owl species. While we expected some species to be rare, several factors reduced our overall detection success. Many owls have low vocal activity, and our recorders struggled to capture low-frequency sounds, which are also difficult for BirdNET to detect, even after re-training. Additionally, vegetation significantly attenuates sound. Preliminary tests on effective detection radius across habitat types ([Londoño-Oikawa et al. 2023](#)) showed that, in forested areas, detectability drops to zero at one-third the distance compared to open areas. The effective detection range of our custom AudioMoth enclosures was approximately 100 metres in forest and up to 300 metres in open areas. In contrast, professional SM4 recorders, which have stereo microphones, offer a detection range of up to 800 metres, significantly increasing survey coverage. However, AudioMoths are around ten times less

expensive and allowed us to deploy many more units across a broader area. The combination of species rarity, limited vocal output, acoustic masking, and short detection ranges made it particularly difficult to detect owls, especially in forested areas.

To address this, we dedicated considerable effort to retraining BirdNET with the aim of building a model capable of efficiently scanning our recordings. We tested several approaches and ultimately adopted a targeted search strategy, validating top-scoring detections per night and site manually to avoid introducing false positives in occupancy modelling. We detected 9 of the 13 owl species known to inhabit the Atlantic Forest. Of the four not detected: Stygian Owl (*Asio stygius*), commonly found in urban parks and open lawns with large trees, was likely absent from our surveyed sites; Black-banded Owl (*Strix huhula*) is the rarest in the region and likely restricted to old-growth forest, with only one known site under heavy playback disturbance; Long-tufted Screech Owl (*Megascops sanctaecatarinae*) likely inhabits riparian areas, and its vocalisation resembles that of *Rhinella* frogs, making detection difficult due to masking and misclassification; and Tawny-browed Owl (*Pulsatrix koeniswaldiana*) produces a very low-frequency call (below 200 Hz), often masked by ambient noise. BirdNET performed poorly with our field recordings, although it detected the species in higher-quality SM4 recordings.

Overall, we consider the detection of 9 out of 13 species a strong outcome, especially considering that at least two were likely absent from our sites and two were acoustically elusive. Importantly, we detected two of the four Atlantic Forest endemic owl species. In retrospect, we may have benefited from increasing acoustic survey coverage, particularly in forests, rather than investing as much effort in local-scale vegetation surveys. These were time-consuming and may have limited relevance for understanding owl distribution. Fine-resolution remote sensing data may offer a more efficient alternative for modelling habitat associations.

Another major challenge was our initial lack of experience with machine learning and Python programming. This represented a steep learning curve, especially when working with limited computing resources on a personal laptop. However, I was able to acquire essential skills and overcome this barrier, and I now feel well prepared to apply this knowledge to other species and adapt BirdNET and similar pre-trained convolutional neural networks for passive acoustic monitoring.

Additional difficulties included rough terrain, extreme weather, and vehicle limitations. As institute vehicles were permanently out of service, I had to use my personal 4x4 SUV, which was not ideal for accessing the interior of the Atlantic Forest. We became stuck in the mud several times, including once when a bridge over a stream partially collapsed beneath the vehicle. Moisture damage to recorders was another issue. Some custom enclosures failed during heavy rainfall. Although we managed to recover most units and lost only a small portion of data (3.5%), we lost several expensive rechargeable batteries. This required purchasing replacements and revising the enclosure design to improve water resistance.

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

This project directly involved local communities in Misiones by creating training and job opportunities and fostering lasting engagement with people living in rural areas. Local field technicians were hired and played a key role, contributing valuable knowledge while gaining experience with new research methods such as vegetation surveys and passive acoustic monitoring. The project also involved numerous volunteers, most of them students of biology, park ranger training programmes, or related fields. Many came from small towns in Argentina and neighbouring countries. For some, this was their first experience in a conservation research project, giving them the opportunity to develop practical skills and contribute meaningfully.

One particularly rewarding example was the case of Alia Arce, a biologist from a rural village in Paraguay. She spoke Spanish, Portuguese, and Guaraní, and had extensive knowledge of Atlantic Forest tree species. Her presence in the field significantly improved our communication with local families, helping to create a warm and respectful environment. Alia learned how to study birds, design ecological fieldwork, and use passive acoustic monitoring tools. Her experience in the project helped her later secure paid jobs working with birds. Another volunteer, Loreley Cuadrado, went on to obtain a permanent paid position as a field technician at CONICET. All volunteers, regardless of their prior training, contributed significantly to the project and benefitted from their involvement, receiving our ongoing support for future job applications.

The project also enabled close collaboration with Arauco Argentina S.A., the largest timber company in the region and one of the largest in the country. Arauco holds FSC certification and showed genuine interest in our research. They granted us access to their lands, where we placed acoustic recorders. We will provide them with the final results and management recommendations to help improve or maintain suitable habitats for nocturnal raptors within their plantations.

Another key partnership was with Proyecto Selva de Pino Paraná, an organisation with a long-standing bird research and environmental education programme active for over 20 years. Working with this team significantly extended our reach and impact, allowing us to include evidence-based information about owls and their conservation in educational activities delivered to primary school students, including those in remote and isolated areas.

Local rural residents also played a vital role in the project. Many allowed us to install recorders on their private land and took part in our interviews. Each family was visited at least four times, often for up to three hours per visit. These interactions frequently led to conversations that extended beyond owls, touching on broader conservation issues such as poaching, pollution, and habitat loss. People felt comfortable engaging with us, and many expressed interest in continuing to collaborate on future projects. All of them have my personal WhatsApp contact and know they can reach out at any time with questions about owls, birds, or other wildlife.

In addition to in-person activities, we also established a social media presence through the Instagram page [@proyectolechuzas](https://www.instagram.com/proyectolechuzas), which now has over 600 followers, including many local residents, students, and teachers who took part in the project. Although we had limited time to maintain regular content creation, the page became a valuable tool for outreach, receiving messages, questions, and expressions of interest, especially from people we met during fieldwork.

5. Are there any plans to continue this work?

This project addressed the complex challenge of studying rare and elusive nocturnal raptors across a gradient of habitat types in the Argentine Atlantic Forest, a region that holds the largest remaining continuous patch of this biome and is home to 13 resident owl species, including four endemics. While the ecological component formed the core of my PhD thesis, the work supported by this Rufford Grant extended beyond its academic scope by incorporating a strong social dimension. Engaging with local communities provided insights into human–owl relationships, revealing how owls function not only as ecological indicators but also as culturally meaningful species. These results offer a valuable foundation for future research and conservation planning.

I am committed to continuing this line of work through a research career focused on the ecology and conservation of nocturnal raptors and other night-active birds. Working with these species presents unique challenges, particularly in dense and acoustically complex environments, but also offers exciting opportunities. Because our connection with these animals is primarily through sound, passive acoustic monitoring remains a key tool, both for studying them scientifically and for understanding how people perceive and relate to them.

Looking ahead, I plan to build on this research through a postdoctoral position and by mentoring undergraduate students. Priorities include repeating acoustic surveys over multiple years to infer

population trends using dynamic occupancy models, which are essential to assess the long-term effects of land-use change on owl populations. I also aim to investigate owl vocal repertoires in greater detail, linking specific vocalisations to behaviours and life stages. These efforts will help bridge acoustic data with ecological interpretation, potentially allowing us to infer breeding status or territorial interactions through sound. Furthermore, integrating vocal data with movement ecology will provide new insights into habitat use and resource selection, leading to better-informed conservation strategies and land management recommendations in productive landscapes.

I have recently been awarded a Fulbright scholarship to undertake an internship at the Cornell Lab of Ornithology. This opportunity will allow me to expand my technical and analytical skills, strengthen international collaborations, and further integrate bioacoustics, ecological theory, and conservation practice. There remains much to uncover about these ecosystems, especially in understanding how biodiversity patterns respond to land use, and I am fully committed to continuing this work and scaling its impact.

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

Results from this project have already been partially shared with local collaborators. During the second phase of fieldwork, I revisited nearly all participants who had allowed us to install recorders on their private lands. In these visits, beyond conducting interviews, I presented preliminary findings, including which owl species were detected on their properties. I showed images and played vocalisations of the owls, and distributed educational materials we had developed. When children were present, we also shared colouring pages and stickers. These visits became informal outreach sessions, often lasting over an hour, where we exchanged knowledge and discussed owl ecology, behaviour, and their role in the ecosystem.

At a broader local level, in 2022 I gave a talk to over 100 certified tourist guides as part of their annual training programme. These guides play a crucial role in conservation outreach, particularly in Iguazú National Park, which receives up to 10,000 visitors a day. I plan to deliver another updated talk next year, sharing final results and conservation recommendations.

I have submitted a partial report to the Iguazú National Park administration covering data collected with acoustic recorders in their jurisdiction. I will also provide final reports to the Ministry of Ecology of Misiones Province and to Arauco Argentina S.A., the region's largest timber company, including habitat and land-use recommendations aimed at promoting owl conservation in protected and productive landscapes.

Through our local NGO, CeIBA (Asociación civil Centro de Investigaciones del Bosque Atlántico; <https://ceiba.org.ar/proyectos/proyecto-lechuzas/>), we will disseminate findings more broadly. CeIBA regularly produces a newsletter, *Conservación en Práctica*, on specific conservation topics, and one edition will be dedicated to this project. The organisation, along with the regional CONICET office, also coordinates a series of public talks, interviews, and media outreach. Research conducted through our institute is frequently featured in institutional news, which is then picked up by local media for radio, newspaper, or TV coverage, as happened previously when I launched a volunteer recruitment campaign (Annex 2).

I have also written a section on Atlantic Forest owls for the website of Proyecto Selva de Pino Paraná (<https://www.pinoparana.org/las-lechuzas-de-la-selva-misionera>), and I plan to update it with our final results and materials.

In academic contexts, the ecological portion of the project will be included in my doctoral thesis, which is expected to be completed by June 2027. I have already presented parts of the work at the "V Congreso de Ingeniería y Ciencias Aplicadas de las Tres Fronteras" and the "XX Reunión Argentina de Ornitología", focusing on the retraining of BirdNET for improved detection of nocturnal birds and the active learning methodology we developed. I plan to present further findings at the upcoming

“XXII Reunión Argentina de Ornitología” and at an international conference. I also intend to publish at least three scientific papers based on the data and methodologies developed through this project.

In terms of digital outreach, we created social media pages on Instagram and Facebook ([@proyectolechuzas](#)) and used these platforms to share project news and connect with participants. Although time constraints limited our ability to maintain a consistent publishing schedule, we aim to strengthen these platforms as a key next step and would like to allocate more time and resources in the future to keep them active, share project results, and broaden engagement with a wider public.

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

The immediate next steps include finalising the validation of the recogniser’s predictions to complete the detection histories for all owl species. This will allow me to begin occupancy modelling to assess the probability of habitat use by different species in relation to both local and landscape-level habitat characteristics. I also plan to model species co-occurrence patterns using two-species occupancy models to explore potential interactions among owl species, such as spatial aggregation or avoidance, and how these may be shaped by environmental conditions. These analyses will provide valuable baseline information and inform land management strategies that aim to enhance owl habitat use and promote coexistence.

Beyond the current project objectives, I aim to deepen our understanding of owl detection probabilities under different environmental conditions. I plan to analyse detection in relation to habitat type, time of night, and moon phase, which could help refine future passive acoustic monitoring protocols by targeting periods of peak detectability. Since the recogniser was trained to distinguish different vocalisation types for certain species, we will also investigate which call types are most frequently recorded. This could contribute to developing call-type-specific monitoring strategies, particularly when using automated detection tools.

On the social side, future steps involve applying our findings within the educational programme of Proyecto Selva de Pino Paraná. For instance, *Megascops choliba*, commonly detected in farms and associated with positive feelings, could be used as a flagship species to foster emotional connections with owls. Conversely, species like *Tyto furcata*, often linked to superstitions and fear, may benefit from educational efforts that highlight its ecological value, particularly its role in rodent control. Interestingly, our interviews revealed a widespread disconnection between the sounds and visual identification of owls. Many people did not realise that the 'white owl' producing a feared vocalization was the same bird they had seen in their environment. This opens up valuable opportunities for school activities that connect sounds with visual identification, encouraging familiarity and fostering more positive relationships between people and owls.

I will continue contributing to the planning and design of educational activities as part of the Proyecto Selva de Pino Paraná team, particularly in rural schools. In the future, I hope to expand these efforts to additional regions in northern Misiones and further integrate our ecological findings into engaging educational content for children and their communities.

We also see great potential in strengthening our presence on social media to extend the project's reach beyond local, in-person interactions. While we established Instagram and Facebook pages and began sharing content, our limited time and capacity constrained what we could produce. In future phases, we hope to dedicate more time, and potentially a small stipend, to generating consistent, engaging science communication content tailored for social media. This would allow us to share project results, increase public awareness about owls, and foster long-term engagement with broader and more diverse audiences.

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 used The Rufford Foundation logo in all relevant outreach, academic, and educational materials related to the project. It appeared in two presentations delivered at conferences in September 2024: the [V Congreso de Ingenierías y Ciencias Aplicadas de las Tres Fronteras](#) (Congress of Engineering and Applied Sciences of the Three Borders) in Foz do Iguaçu, Paraná, Brazil, and the [XX Reunión Argentina de Ornitología](#) (20th Argentine Meeting of Ornithology) in Córdoba Province, Argentina.

The logo was also included in internal seminars at my research institute, in postgraduate course presentations, in a seminar at UNILA (Federal University for Latin American Integration) in Foz do Iguaçu, and during the *Scientific Happy Hour*, a public outreach event organised by CelBA (<https://ceiba.org.ar/proyectos/happy-hour-cientifico/>; see appendix).

Additionally, the Rufford logo featured on all printed educational materials distributed in rural schools and to the families interviewed on their farms (see photos below). It is also visible on the project section of the CelBA website and on the project's Instagram page.

I will continue to include the logo and acknowledge The Rufford Foundation's support in all future outputs, including scientific publications, presentations at national and international conferences, and social media communications.

Finally, The Rufford Foundation logo is also displayed on our Instagram page ([@proyectolechuzas](#)), where we list the supporting institutions of the project.

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

Agostina S. Juncosa Polzella – Project leader. PhD student at the Instituto de Biología Subtropical (IBS) – CONICET, Argentina.

Facundo Di Sallo – PhD, Postdoctoral Fellow at IBS. Supported the manual annotation of recordings and contributed to the ecological aspects of the project.

Bianca Bonaparte – PhD, Postdoctoral Fellow at the Federal University for Latin American Integration (UNILA), Brazil. Member of the Educational Programme of Proyecto Selva de Pino Paraná. Contributed to the design and implementation of interviews and educational activities.

Tessa Rhinehart – PhD candidate, University of Pittsburgh, USA. Collaborated on retraining BirdNET to improve its performance in recognising nocturnal birds from low-quality recordings.

Hana Londoño-Oikawa – MSc. Conducted preliminary analyses of the effective detection range of AudioMoth recorders across different environments.

Fernando Foletto – Field technician. Assisted with fieldwork and interviews. Grew up on a farm in Misiones and has deep knowledge of local history, fauna, and local languages (Portuguese and Guaraní).

Carlos Ariel Ferreyra – Field technician. Park ranger and member of Proyecto Selva de Pino Paraná.

Milka Raquel Gómez – Field technician. Park ranger and member of Proyecto Selva de Pino Paraná.

Irene Negri – Volunteer field assistant. Biology student. Created all the owl illustrations used in the educational materials.

Germán Gil – Volunteer field assistant. Park ranger.

Loreley Cuadrado – Volunteer field assistant. Graduate in Environmental Diagnosis and Management.

Alia Arce – Volunteer field assistant. Biologist.

Luciano Colli – Volunteer field assistant. Biologist.

Giovanina Domínguez – Volunteer field assistant. Park ranger student.

Cecilia Anahí Lighuen Orozco – Member of the Educational Programme of Proyecto Selva de Pino Paraná. Helped plan and deliver school activities. Park ranger and specialist in Conservation Biology.

Marcos Hugo Sosa – Member of the Educational Programme of Proyecto Selva de Pino Paraná. Helped plan and implement educational activities in schools.

Anabella Belén Fariña – Member of the Educational Programme of Proyecto Selva de Pino Paraná. Helped plan and deliver educational activities in schools. Park ranger.

Clara Fernández – Member of the Educational Programme of Proyecto Selva de Pino Paraná. Helped design educational activities and develop materials for schools, teachers, and social media. Agroecology Technician.

Emilse Mérida – Member of the Educational Programme of Proyecto Selva de Pino Paraná. Contributed to the planning of school activities and the development of educational materials. Teacher.

Brisa del Alba Ramírez – Volunteer with the Educational Programme of Proyecto Selva de Pino Paraná. Helped plan and deliver educational activities. Park ranger student.

Carla Beatriz Hirt – Volunteer with the Educational Programme of Proyecto Selva de Pino Paraná. Helped plan and deliver educational activities. Park ranger student.

Kristina Cockle – Researcher at IBS-CONICET and member of CeIBA. Advisor for Agustina S. Juncosa Polzella's doctoral thesis. Supervised all ecological aspects of the project and contributed to the design of interviews.

Mario S. Di Bitetti – Researcher at IBS-CONICET, member of CeIBA, and Associate Professor at the University of Misiones. Co-advisor for Agustina S. Juncosa Polzella's PhD thesis. Supervised the theoretical framework of the ecological study, particularly study design and analysis.

10. Any other comments?

I am deeply grateful to The Rufford Foundation for supporting this project and contributing to the understanding and conservation of these rare and elusive birds, which play a vital role in ecosystem balance and hold significant cultural value. This grant has been a major boost in my early career. It allowed me to gain experience in writing proposals, managing and coordinating a multidisciplinary team, and reflecting more deeply on how to align project goals with local needs and perspectives.

I remain committed to continuing this line of work and to contributing to conservation efforts that are evidence-based and locally grounded. In a context where Argentina is facing a severe economic crisis, where science, education, and environmental protection are being systematically defunded, the support of organisations like The Rufford Foundation is invaluable. Such support helps keep conservation work alive and gives hope to those of us who believe in building a more just and sustainable world for all living beings.

ANNEX 1 – Financial Report

[Intentionally deleted]