Progress Report

"Listening to Owls and People in the Fragmented Atlantic Forest: Detecting and Addressing Threats Through Passive Acoustic Recording and Community Engagement" (ID 38408-1)

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Our project aims to utilise non-invasive autonomous recording units (ARUs), alongside interviews and workshops, to evaluate changes in the richness and composition of the owl assemblage in the Atlantic Forest landscape. We focus on identifying key threats and collaborating with rural communities and timber companies to preserve one of the world's most diverse owl communities.

In 2022, we deployed ARUs (Autonomous Recording Unit, Audio Moth 1.2.0) to record spontaneous owl vocalisations at 140 of the originally selected 210 sites, distributed across three habitat types: protected forest, small farms, and pine plantations (Figure 1).

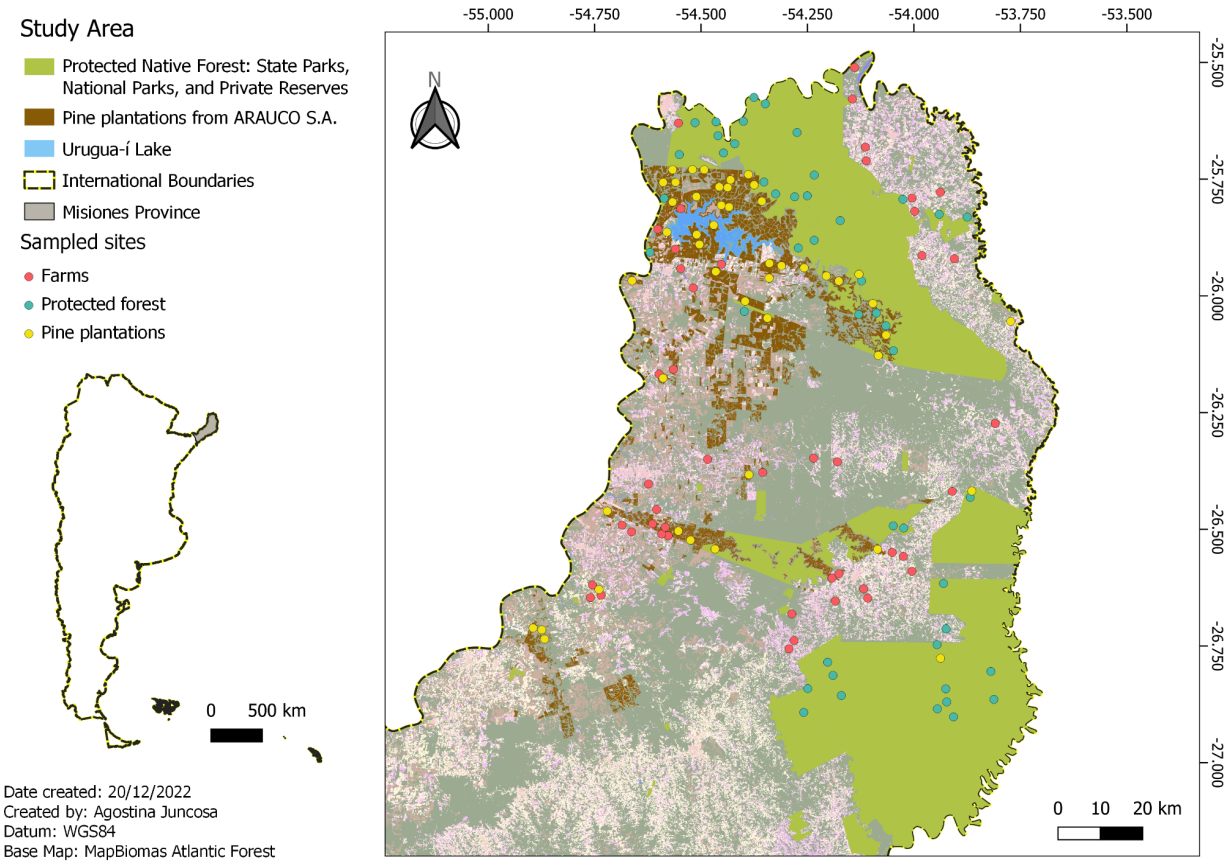


Figure 1. Study area and sampling sites across three habitat types in the Atlantic Forest of Misiones.

Each site was carefully chosen to ensure a minimum distance of 1.5 km for independence. We aimed to minimise temporal biases in owl vocalisations by surveying during the season of peak vocal activity, as advised by expert A. Bodrati. At the centre of each site, we installed an ARU on a small-diameter tree at 1.5 – 2 m height to prevent sound masking from the tree trunk. The ARUs were set to record in cycles of 2-minutes-on/8-minutes-off, totalling 12 minutes per hour, over 24 hours for at least 14 consecutive nights. With 40 ARUs available simultaneously, our team worked progressively, covering seven stages of sampling between June and October. To address changes in night hours throughout the fieldwork period, we recorded continuously over 24 hours. This approach allowed us to separate day and night recordings using sunset and sunrise times from https://www.timeanddate.com/. We then categorised these recordings automatically using a Python script. We collected 6,542 hours of nocturnal data, covering approximately 18,000 km² (Figure 1). Additionally, at each of the 140 sites, we conducted vegetation measurements using the point-centred quarter method. This involved two orthogonal transects of 50 m at each site, where we measured various vegetation attributes, such as the diameter at breast height (DBH), tree height, health status, and species identification, totalling measurements for 2800 trees. We also registered the number of snags, measured litter depth, and assessed the volume of woody debris at each site, among other attributes.

The fieldwork posed unique challenges and particularities in different environments. Particularly in farms, our visits entailed extensive interaction with local people, where we spent considerable time discussing their lives, beliefs, and practices. These interactions provided valuable insights and strengthened community relations.

In 2023, we embarked on processing the substantial volume of acoustic data collected. Our initial focus was on a subset of recordings to assess owl detection frequency, the most commonly found species, and to understand the variety and levels of background noise in the recordings. Specifically, we scrutinised the first five nights from 15 sites across three habitat types, analysing a total of 166 hours of recordings. This analysis revealed four owl species, including the Near Threatened *Strix hylophila*, endemic to the Atlantic Forest. We identified 97 audio files containing owl vocalisations, with 205 vocalisations labelled. Recognising the labour-intensive nature of manual labelling, we turned our focus to developing a machine-learning detector for Atlantic Forest Owls. This involved re-training a convolutional neural network, particularly BirdNET, with field recordings and noise-modified data. Initially, I focused on re-training BirdNET for two specific owl species, *Tyto alba* and *Megascops choliba*. Using audio files from XenoCanto, I manually extracted individual calls and overlaid them with varying noise intensities from our field recordings. The re-trained BirdNET achieved a precision of 0.92 over 100 epochs. We compared the performance of the original and re-trained BirdNET models using an evaluation dataset created with some of my labelled field recordings, assessing their effectiveness in detecting owl species. The

re-training significantly enhanced BirdNET's predictive capacity for *T. alba* and *M. choliba* from my field recordings, as demonstrated by improved F-Scores in Figure 2.

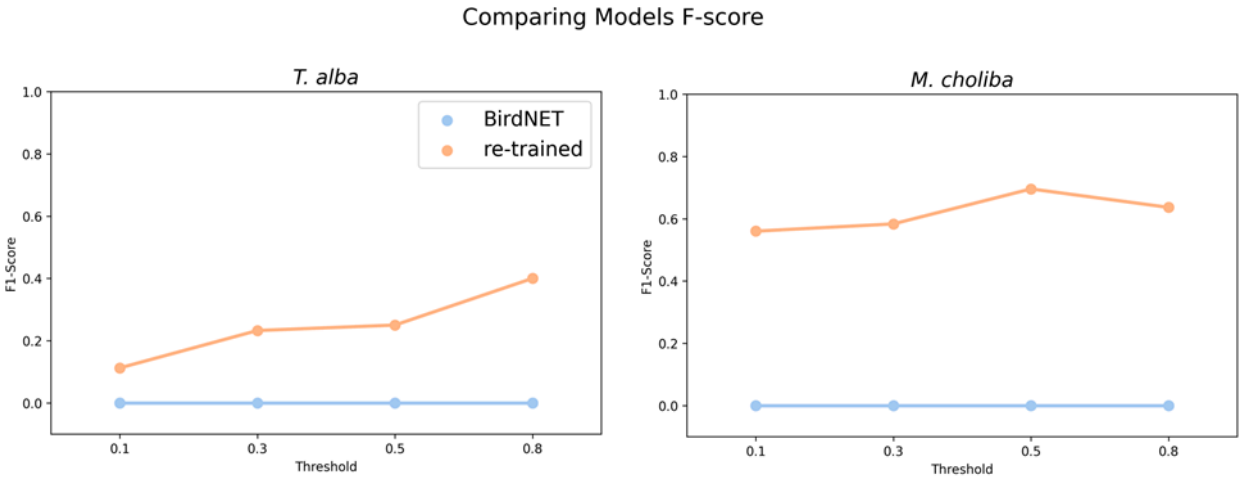


Figure 2. F-Score comparison for BirdNET (light blue) and re-trained BirdNET (orange) at different threshold values. The graph shows the performance for predicting *Tyto alba* (left) and *Megascops choliba* (right).

My ongoing work involves expanding the training of BirdNET to cover more than thirteen classes, including various owl call types and other nocturnal birds. Owing to the scarcity of region-specific labelled data from soundscape recordings, I have adopted an active learning approach. This process starts with re-training BirdNET using noise-modified data from Xeno-Canto and selected labelled data from other sources. Through iterative cycles, we run the model on unlabelled field recordings, manually verifying and incorporating selected predictions into the training set. This continuous refinement and expansion of the dataset will progressively mitigate the domain shift problem, significantly enhancing the model's accuracy in detecting species in our recordings, as detailed in Appendix 1.

In terms of conservation outreach, during 2023, our team participated in two significant scientific dissemination events. The first was a dynamic public engagement event held in the main square of Iguazú, Misiones, Argentina. This event attracted a diverse audience, including visitors from various parts of Argentina and foreign tourists, as well as local residents and school groups. At our stand, we organised two interactive sections. The first section focused on the biodiversity of the Atlantic Forest of Misiones, emphasising bird diversity. Here, we engaged visitors through hands-on activities like bird observation using binoculars and a parabolic microphone for listening to bird sounds. We also included a participatory game where attendees matched bird sounds to corresponding photos, which was particularly enjoyable for children. The second section was dedicated exclusively to owls. We displayed photos of the 13 owl species found in the Atlantic Forest of Misiones and discussed their unique adaptations for nocturnal hunting, such as enhanced vision and silent

flight. We also showcased a video depicting the silent flight of owls and shared informative materials, including owl feathers and pellets. Furthermore, I shared insights from my research, demonstrated the autonomous recorders used for acoustic data collection, and played owl vocalisations alongside their spectrograms. To foster a deeper connection with the subject, we distributed brochures featuring appealing illustrations of the thirteen owl species of Misiones, emphasising the importance of their conservation. For children, we provided colouring pages and stickers of owls, showcasing their habitats. These printed materials, created in collaboration with an artist, successfully conveyed the significance of owl conservation in an engaging and accessible manner. The event was well-received, with our stand remaining busy throughout its four-hour duration. The second event, "Happy Hour Científico," hosted by the environmental NGO CeIBA, aimed to bring science closer to the public. More than 30 adults attended the event, including professionals from scientific institutes, park rangers, tourist guides, teachers, and many other interested citizens. It featured a relaxed interview format, followed by a Q&A session, offering a platform for serious discussions about our project and the broader importance of science-based conservation actions. For further insights and to view photographs of these events and the materials distributed, please refer to Appendix 2.

Looking ahead to 2024, we plan to revisit farms to distribute educational materials and conduct perception surveys. We also aim to integrate owl conservation activities into the existing school programmes of Proyecto de Selva de Pino Paraná. Our goal is to complete the analysis of our acoustic data by June, enabling us to model owl occupancy and co-occupancy across the Atlantic Forest of Misiones. This will be crucial in identifying key habitat attributes and human impacts on owl populations.

We are profoundly grateful to The Rufford Foundation for their trust and support, which have been pivotal for the successful progress of our project.

Appendix 1

Retraining a CNN to automatically detect nocturnal birds vocalizations (Strigiformes & Caprimulgiformes) in the Argentinean Atlantic Forest, an active learning approach

INITIAL MODEL TRAINING

Create the training set and re-train the model (BirdNET transfer learning)

I'm going to start with 100 clips for each class.

Download and manually label all local recordings available in Xeno Canto for each class.

Overlay noise from my field recordings over Xeno Canto data to make them more alike to what the model will encounter analyzing my recordings.

Gather and label all ARU recordings available for each class and include them in the training data set.

INITIAL MODEL EVALUATION

Evaluate the model on evaluation data set. Obtain metrics such as F1 Score and Accuracy.
Run the model on the unlabeled dataset, analyze true and false positives.

Evaluation data set built from labeled recordings from my field deployment plus others from WA and AM ARUs. Ideally, there will be examples for all classes.

Run the model on the evaluation data set

The importance of the evaluation data set is to obtain metrics that consider true and false negatives.
This will give us a measure of our model's ability to detect each class in the field recordings. :)

Run the model on the set of the unlabelled field recordings.

Data set of the first night of every site= 140 nights.
Considering approx. 11 night hours per day, 10 minutes of recording/hour = 15400 min.
Considering that an audio file lasts 2 minutes --> 7700 audio files to analyze per iteration.

FINAL MODEL EVALUATION

Evaluate the final model.
Model ready to predict on the entire data set without the need for validation.
Choose metric to use as a detectability covariate for each species.

ITERATIVE MODEL IMPROVEMENT

ACTIVE LEARNING

Every iteration involves three main steps

Continue at this stage for several iterations until the validation metrics stabilize at their highest value

Verification and labelling

Select segments for human verification based on model predictions.

Verify and correctly label these segments..

. CRITERIA
- Detections with high probability for each species (20 examples).
- Detections with low probability (10 examples).
- Random selection of detections (10 examples).

Re-training

Incorporate verified and correctly labeled segments into the training data set.

Re-train the model with the new training data set.

Re-evaluation

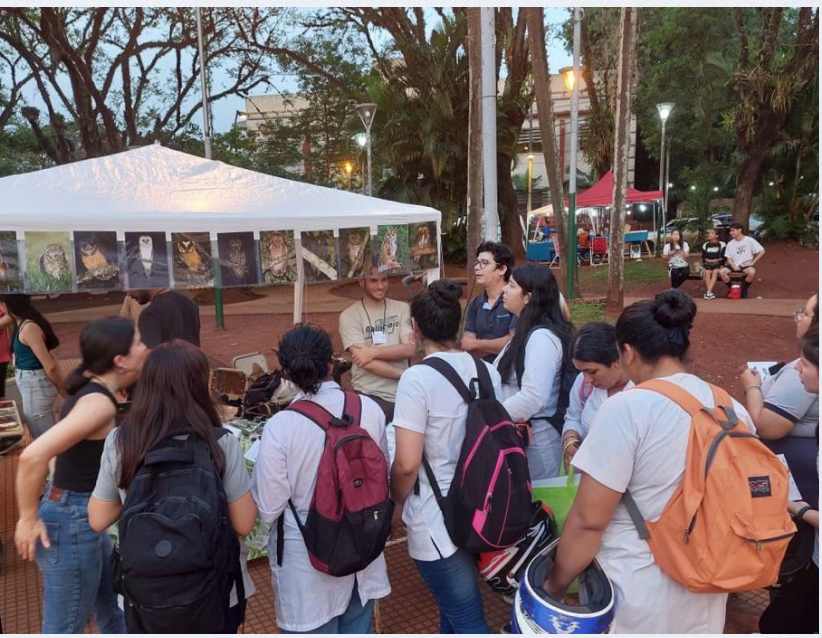
Run the new model on the evaluation data set.

Using the same metrics, evaluate improvements concerning the previous iteration.

Run the model on the unlabeled field dataset to obtain new detections to verify.

Appendix 2

Scientific outreach event at Iguazú main square



10/06/23

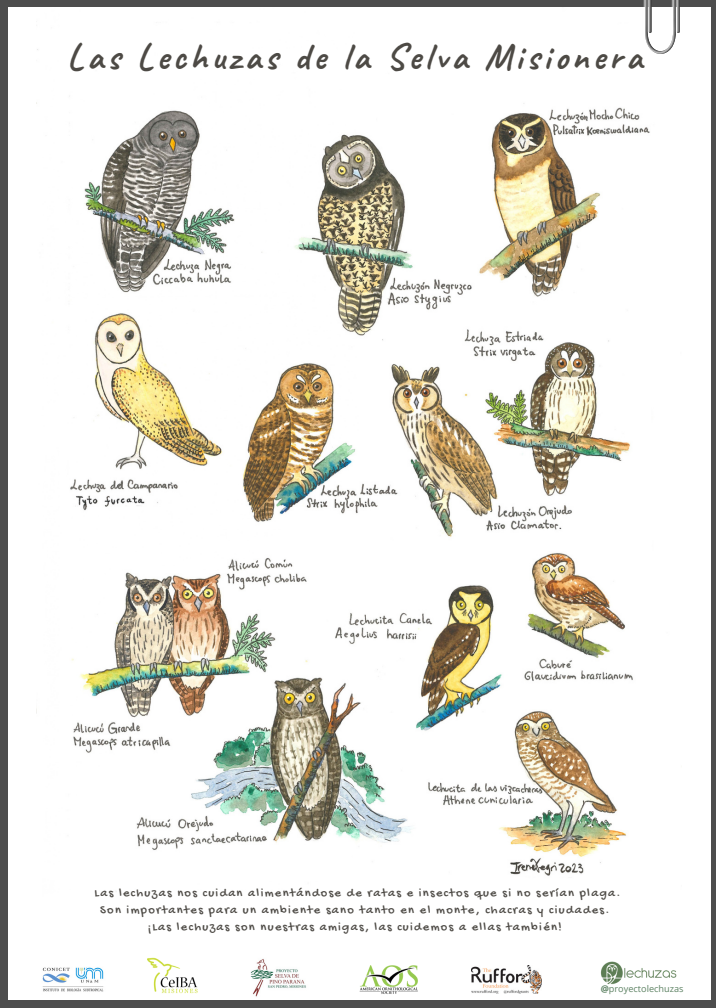
Appendix 2

Scientific Happy Hour

11/17/23

Educational outreach materials

Stickers



Colouring pages