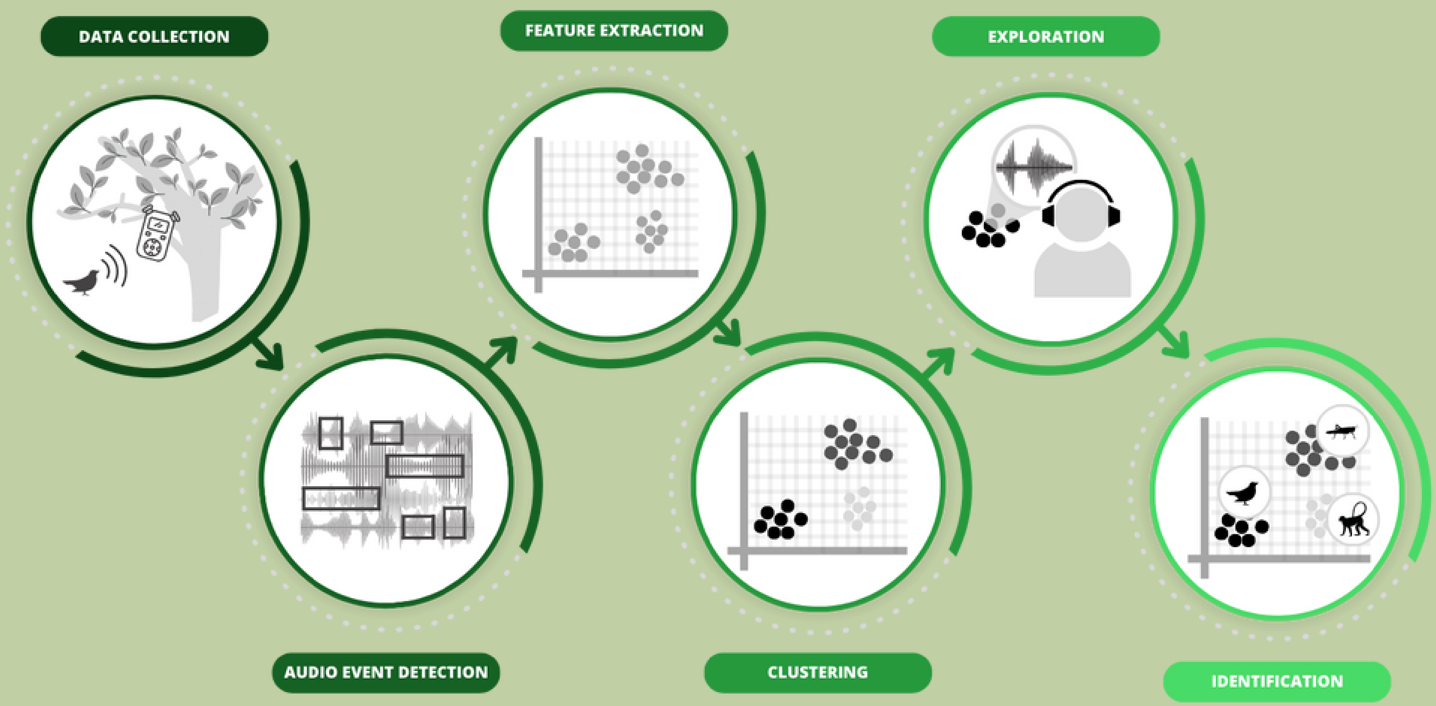
RAINFOREST CONNECTION

ARBIMON CLUSTER ANALYSIS



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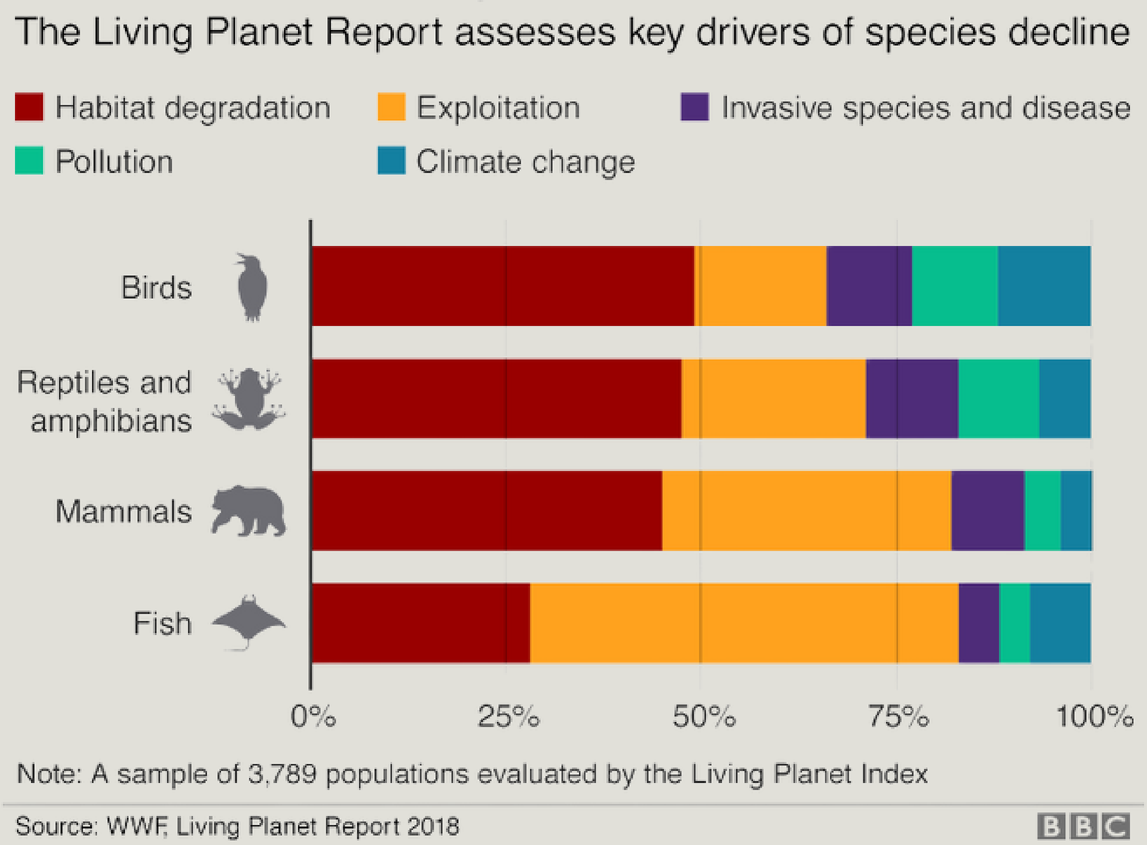
BIODIVERSITY DECLINE CRISIS

The 21st century marks an era in which biodiversity is threatened at a global scale. Monitored populations of vertebrates (mammals, birds, amphibians, reptiles, and fish) have seen a devastating 69% drop on average since 1970, according to World Wildlife Fund's (WWF) Living Planet Report 2022. And even though habitat loss and degradation due to human activities are still the main threats to animal and plant species worldwide, populations of many species are declining even in natural and protected areas, likely due to climate change and infectious diseases. Biodiversity loss can have significant direct human health impacts if ecosystem services are no longer adequate to meet social needs. Indirectly, changes in ecosystem services affect livelihoods, income, and local migration.



HOW TO HALT BIODIVERSITY LOSS?

The first and fundamental step to halt biodiversity loss is to timely detect any population decline and understand its causes. And that is why managers and scientists need to establish successful wildlife monitoring programs that can provide a complete picture of the biodiversity status, trends, and distribution. Sussecful wildlife monitoring programs can thus provide evidence for decision-making and sustainable use of natural resources.

Even though wildlife monitoring programs are essential to halt biodiversity loss, the detection, prediction, and monitoring of biodiversity are still one of our times' most significant conservation management challenges.

Improve wildlife monitoring

Traditional methods to assess species diversity often focus on direct observations of a small range of taxonomic groups and limited spatial and temporal scales. In contrast, passive acoustic monitoring (PAM) can significantly improve our ability to predict species diversity because we can detect the presence of a wide range of animal taxa (e.g., anurans, birds, insects, and mammals).

The ability to deploy multiple acoustic sensors across landscapes quickly enables simultaneous recording, allowing researchers to map species distributions accurately. Furthermore, acoustic data collected over a large spatial scale can be used to answer broader questions regarding the effects of environmental change on species phenology and distribution.

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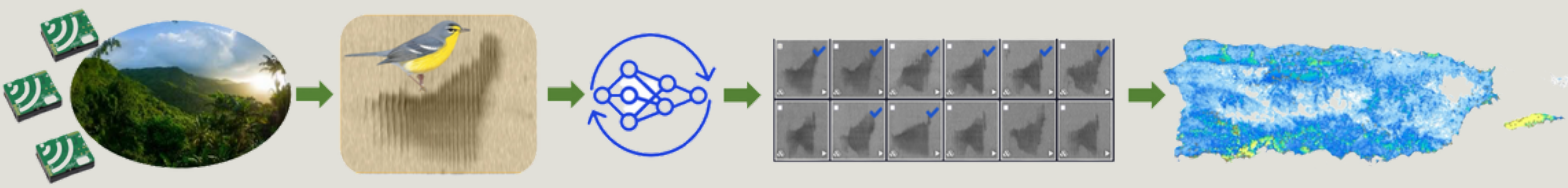
ACOUSTIC MONITORING APPROACHES OFFER AN EASY WAY TO SCALE UP AND STANDARDIZE WILDLIFE DATA COLLECTION AT LARGE SCALES OF TIME AND SPACE.

IMPROVE ACOUSTIC DETECTORS

- Advances in automated signal detection have increased the scope of acoustic monitoring, but extracting meaningful ecological information from raw audio recordings can still be challenging. Supervised deep learning frameworks have been successfully used to predict species' presence in raw recordings. Still, they are trained using large, well-labeled datasets, which can restrict the number of species used in monitoring programs, especially rare and threatened species.

- Alternatively, acoustic indexes have been proposed as a proxy for biodiversity and ecosystem health, but there is still heated debate on their performance and reliability in different ecosystems. We urgently need creative ways to automatically detect species in raw soundscape recordings and improve our wildlife monitoring programs.



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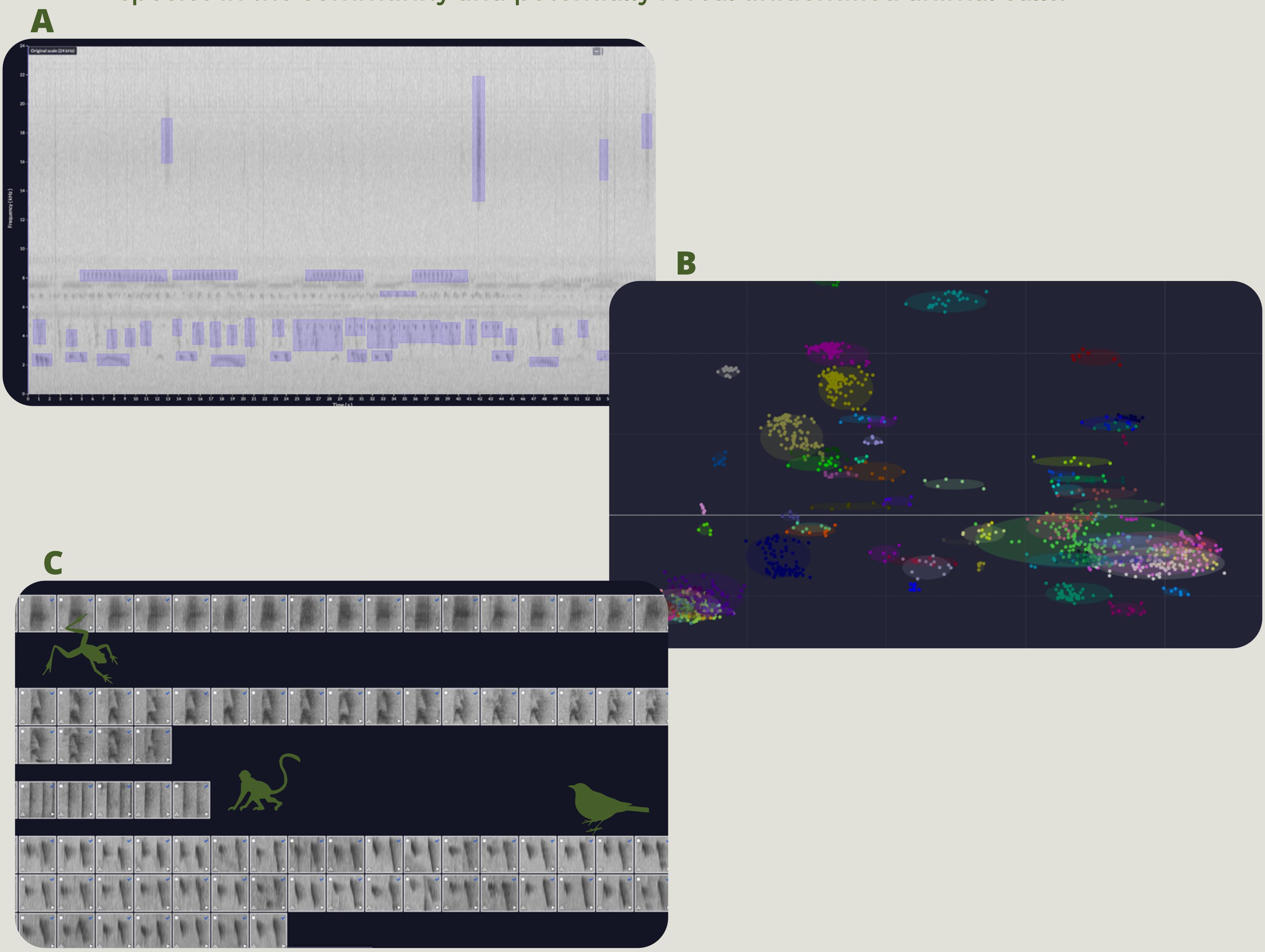
OUR SOLUTION

To improve ecological insights from soundscapes raw recordings, we have added new tools, Audio Event Detection, and Clustering analysis, The new analytical tools allow the automatic detection and categorization of sounds in large audio datasets, with an intuitive UI to explore the results. Applying these tools to ecosystem soundscapes can enable quick identification of vocalizing species in the community and potentially reveal unidentified animal calls.



ARBIMON UI for audio event detection (AED) and clustering. A - Visualizing the detected audio events in the recordings, B - Exploring the two-dimensional map and colored clusters, C - Exploring clusters using a grid view

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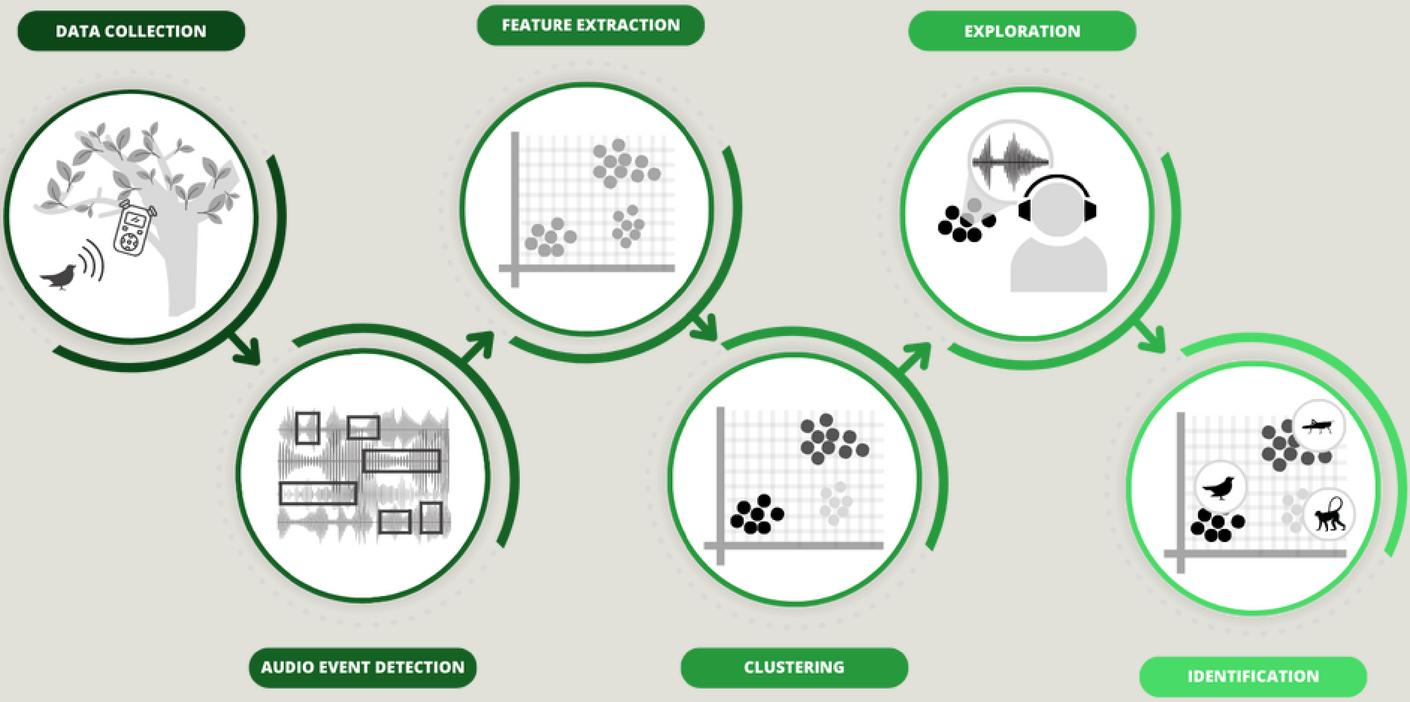
OUR PIPELINE



The pipeline consists of two six steps:

- 1) data collection with passive acoustic sensors,
- 2) automatically detects relevant sounds in raw field recordings,
- 3) extract acoustic features from the detected acoustic events,
- 4) cluster these sounds based on acoustic feature similarities,
- 5) Explore clusters using visual inspection and playback
- 6) Identify/validated species in each cluster.

This new analytical tool will improve the speed, scope, and scale of the current biodiversity programs around the world

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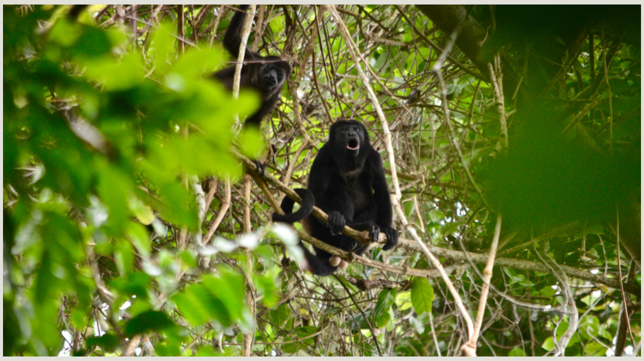
Potential uses

The potential uses of our pipeline include:

1) Quickly identifying communities of species,
2) Estimating species richness and composition,
3) Discovering unknown sound categories,
4) Quickly searching for examples of a desired signal/call without the need for any existing examples,
5) Collecting training data for supervised audio recognition models,
6) Pattern Matching can be used after AED & Clustering to detect more examples of the desired sound category efficiently.





TESTING AND RESULTS

We evaluated the results of the Audio Event Detection and Clustering tools using a dataset of ~18 hours of soundscape from Barro Colorado Island, Panama (BCI), containing species annotations (Table 1). We ran clustering 4 times with different parameters on the same set of detected events. For each Clustering result, two experts categorized each audio event with a max frequency 6 kHz, where species calls within their expertise occur. Known species were labeled with their scientific name, and unknown sounds were sorted into numbered categories. We found that in all cases, the resulting clusters had a reasonably strong agreement with the expert labels, following expected trade-offs in performance based on the parameters. For example, the number of discovered categories depends on how strict the clustering criteria are. Smaller Distance Thresholds and larger Min. Points values will lead to fewer, more homogenous clusters. Across all trials the V-measure score between the cluster IDs and expert labels was at least ~0.80.

Trial	1	2	3	4
Distance Threshold	0.05	0.1	0.05	0.1
Min. Points	5	5	10	10
No. Clustered Points	657	2852	324	2054
No. Clusters	52	161	10	54
No. Validated Categories	20	104	5	37
Homogeneity	0.98	0.84	0.94	0.82
Completeness	0.74	0.77	0.92	0.77
V-measure	0.85	0.80	0.93	0.79

Table 01: Results of four trials of unsupervised sound event detection and clustering applied to an audio dataset of ~18 hours from several sites in BCI. Sound events with a max frequency 6 kHz were labeled by experts, and their clustering labels were evaluated for homogeneity and completeness.

Follow our tutorials and start exploring this new analytical tool.

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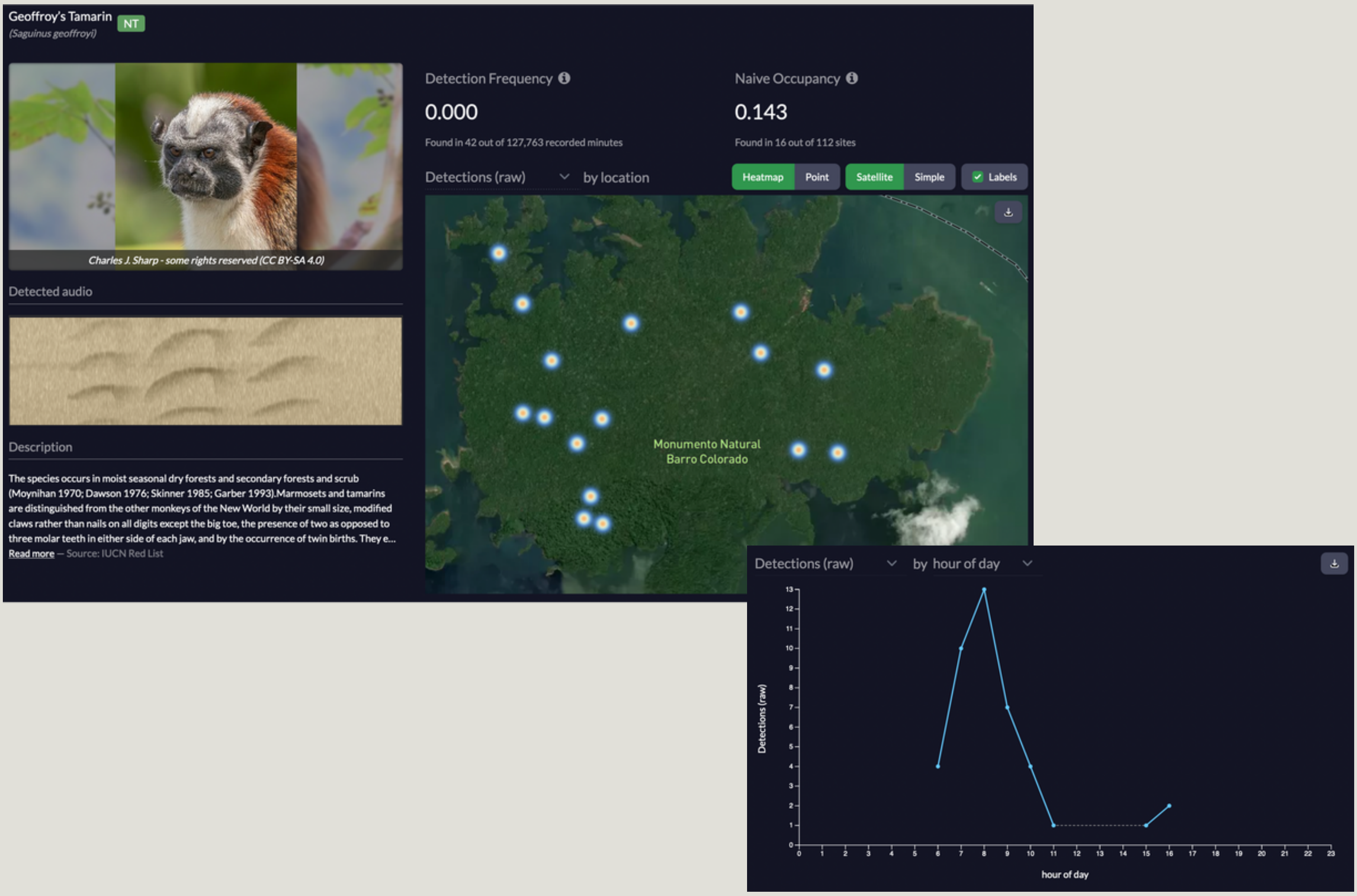
Biodiversity insights

Results from validated clusters can be further visualized and explored through Arbimon Insights. This user-friendly interface summarizes and displays the main results in maps and plot formats and includes information on the vocalizations, distribution, and ecology of species detected.



FUNDING

NATIONAL GEOGRAPHIC SOCIETY

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