Songs of the Spider Monkey: Using Acoustics and Machine Learning to Conserve the Geoffroy's Spider Monkey (*Ateles geoffroyi*)

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1. The Crisis of our Time

- As more land is altered by human activity and more species face extinction, it is essential to understand how to conserve threatened species across human-modified landscapes [1,2].
- Yet we still lack efficient methods to assess how species respond to anthropogenic change across large scales and the knowledge required to protect them [1].
- Passive acoustic monitoring (PAM) is an efficient method for collecting data at large scales; however, the development of automated methods to analyse such large amounts of data is not keeping pace, especially across the tropics [2].

2. Our Endangered Cousins

- 75% of primates are declining due to human disturbance.
- Primates hold significant ecological, economic and cultural benefits.
- The Geoffroy's spider monkey (*Ateles geoffroyi*) is a keystone species, yet they are endangered and face imminent extinction without further protections.

3. Research Aims

- To determine if PAM, combined with a novel machine learning algorithm, can be used to successfully detect the spider monkey across large spatial scales and assess how this species responds to anthropogenic disturbance.
- To develop evidence based conservation strategies to mitigate against this disturbance.

4. Development of Innovative Methods

- A network of 350 audio recorders (Fig. 1) collected acoustic data across a region the size of London, in Costa Rica (Fig. 2).
- We trained a machine learning algorithm to recognise and extract the calls of the spider monkey (Fig. 3).
- Using call locations and satellite data, spatial and statistical modelling techniques were applied to 1. Understand how human activity was affecting the species, 2. Predict suitable habitat, 3. Identify barriers to connectivity and 4. Design a biological corridor.

Fig. 1. AudioMoth acoustic recorder

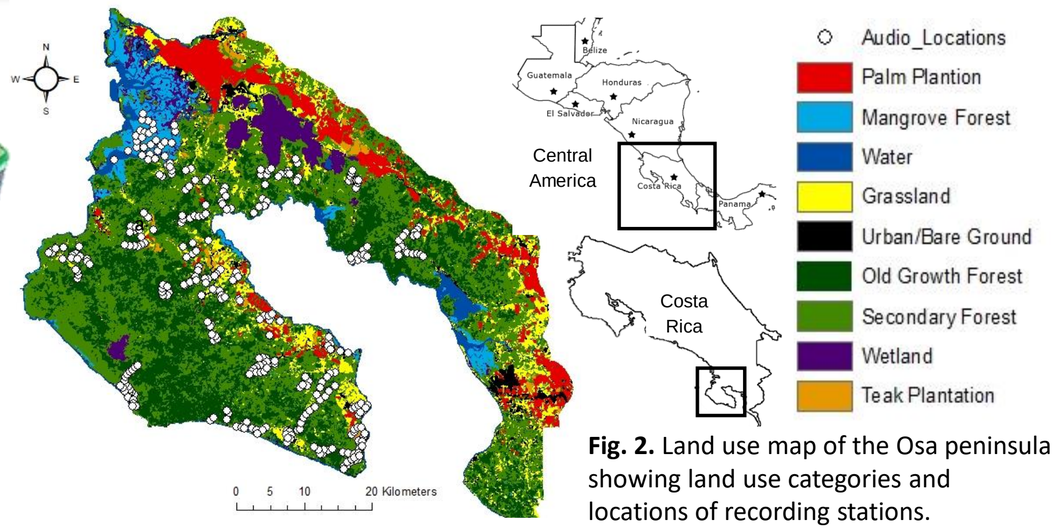

Fig. 2. Land use map of the Osa peninsula showing land use categories and locations of recording stations.

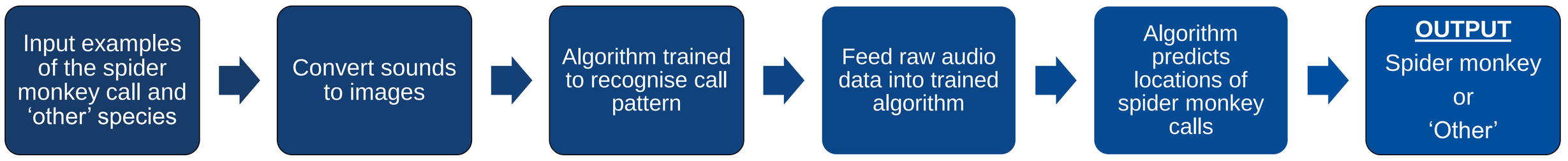

Fig. 3. Workflow highlighting the stages of training a machine learning algorithm to recognise and extract the calls of the spider monkey

5. Results

- The machine learning algorithm analysed 60,000 hours of data in eight weeks vs 20 years of manual listening and found 3000 calls.
- Model accuracy was exceptionally high at 75%
- The Geoffroy's spider monkey was restricted to one area (Fig. 4) and was absent below a threshold of 80% forest cover and within 1 km of paved roads (Fig. 5).
- Habitat suitability maps highlight roads and agricultural land as barriers to movement and the biological corridor demonstrates the most effective way to facilitate this movement (Fig. 5).

6. Impact: Saving Endangered Species

- Creation of an innovative method that is being used by scientists across Latin America to effectively study the response of an endangered species to anthropogenic change at a large spatial scale.
- Threshold values highlight the sensitivity of this species to anthropogenic change and are proving valuable in setting targets and developing conservation strategies.
- Results have been used to prevent the development of paved roads through critical regions and create a biological corridor to facilitate movement.

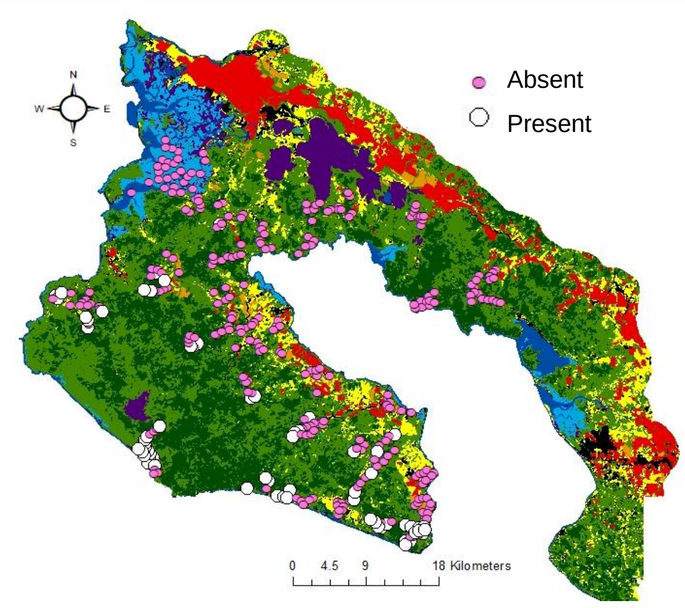

Fig. 4. Map of land use and recording stations, showing presence (white) and absence(pink) points for the spider monkey

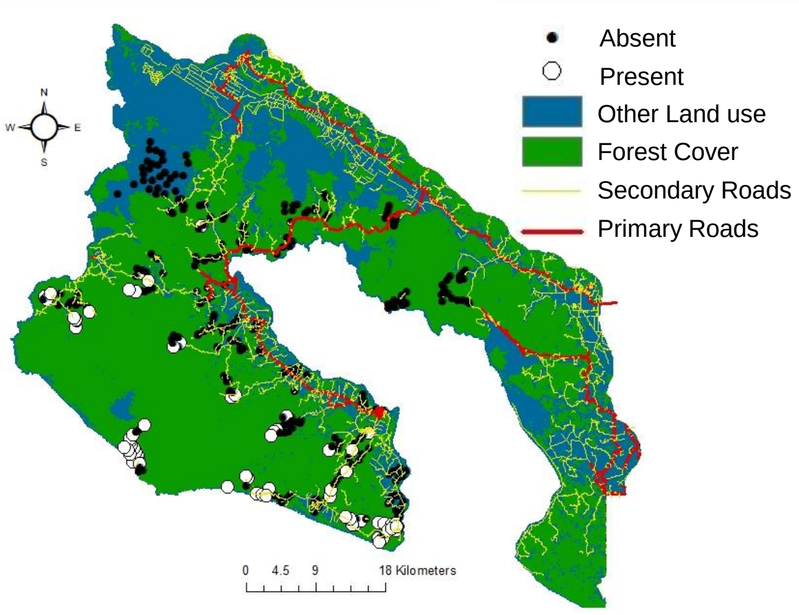

Fig. 5. Map of forest cover, roads network and recording stations showing presence (white) and absence (black) of the spider monkey

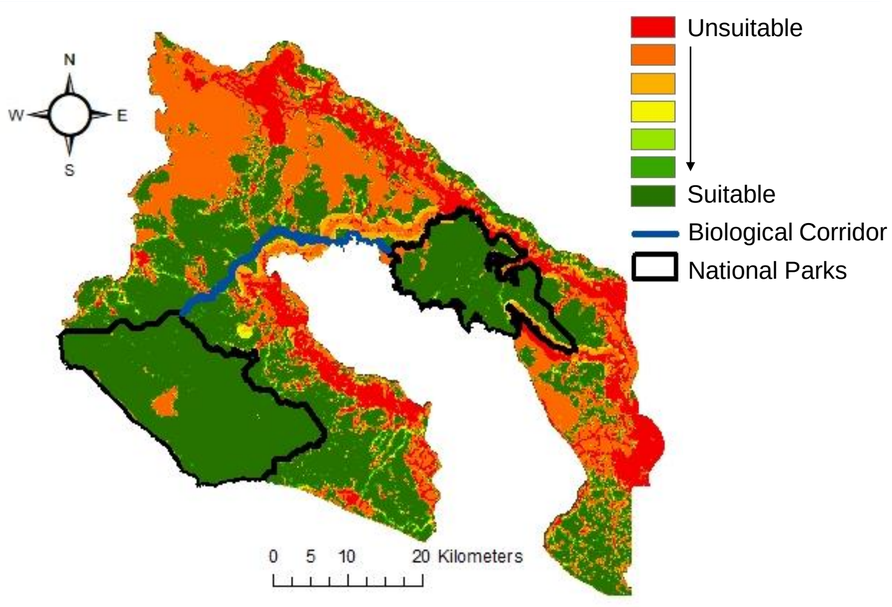

Fig. 6. Habitat suitability map and least resistance path for the biological corridor (blue) between national parks (black)

References

[1] Junker, J. *et al.* (2020) 'A Severe Lack of Evidence Limits Effective Conservation of the World's Primates', *BioScience*. Oxford University Press, 70(9), pp. 794–803. doi: 10.1093/biosci/biaa082.

[2] Browning, E. *et al.* (2017) 'Passive acoustic monitoring in ecology and conservation', *WWF Conservation Technology Series*, 1(2), pp. 1–75. Available at: https://www.wwf.org.uk/conservationtechnology/documents/Acousticmonitoring-WWF-guidelines.pdf.