BioSoundSCape

Connecting acoustics and remote sensing to study habitat-animal diversity across environmental gradients

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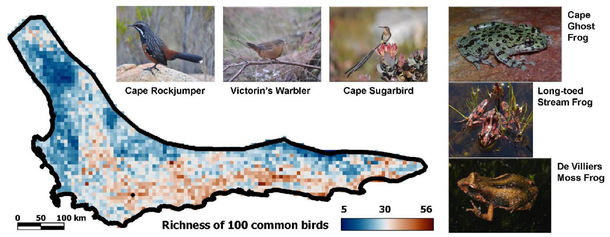
BioSCape (https://www.bioscape.io)

- Where: the Greater Cape Floristic Province, South Africa.
- Goal: to improve understanding of spatial variability in ecosystem function and species abundance.
- How: using NASA's advanced airborne instruments at relatively high spatial resolution (< 20 m), combined with observations on the ground.

BioSoundSCape

- Measure ground-based animal diversity using low-cost autonomous recording units (ARUs) across the Cape Region, South Africa.
- Scale these measurements using remotely-sensed indicators of habitat variation.



Motivation

Very limited ability to measure/monitor biodiversity, particularly over highly biodiverse biomes, species ID costly.

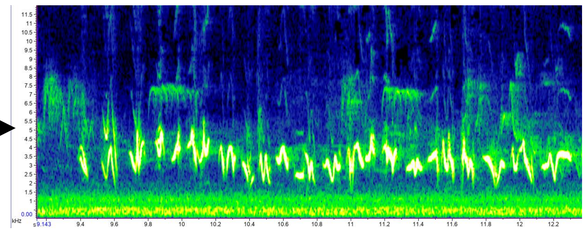
Hard logistics | Limited expertise | Scaling challenges | Urgency of need

Methodology

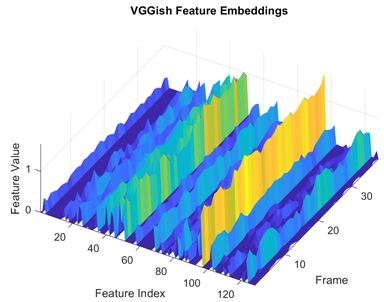
Low-cost, automated recorders capture bird calls and songs

AudioMoth

Sounds represented as images, called spectrograms



EXTRACT



Sound features from vector of weights of the VGGish AI model

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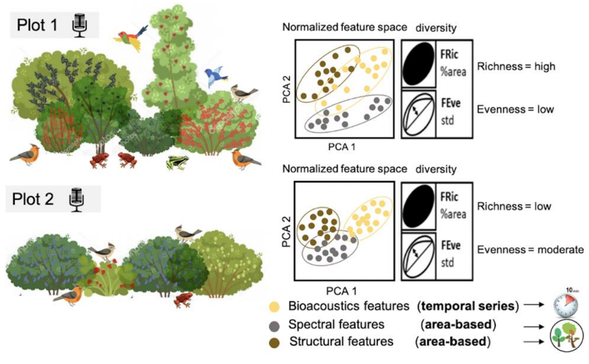
Index	Definition
Acoustic Entropy (H)	Evenness/species richness of acoustic space
Acoustic Richness (AR)	Species richness of acoustic space
Acoustic Dissimilarity Index (D)	Dissimilarity between two communities
Acoustic Complexity Index (ACI)	Degree of complexity

adapted from Lindseth & Lobel, 2028

Indices describing the acoustic energy in the spectrograms

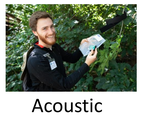
Analyses

- Unsupervised and species agnostic approach to monitor biodiversity with sounds
- Does not require species identification -- uses metrics from the soundscape
- Data-driven, transferable and scalable in space and time
- Integrates remote sensing to monitor the animal-habitat diversity relationship
- Multi-dimensional analysis correlating soundscape features to biodiversity metrics

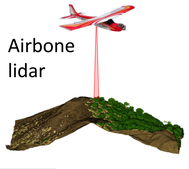


- Covariate measurements (acoustic, lidar, imaging spectroscopy) embedded into a unified measurement framework
- Diversity (acoustic, structural, spectral) estimated using Hutchinson's n–dimensional hypervolume approach (richness, evenness, and divergence)

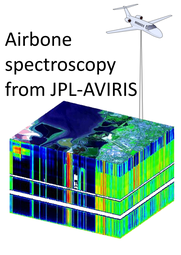
Datasets



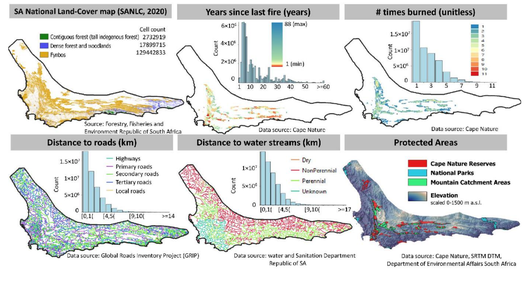
Acoustic surveys



Airbone lidar



Airbone spectroscopy from JPL-AVIRIS



Research Questions

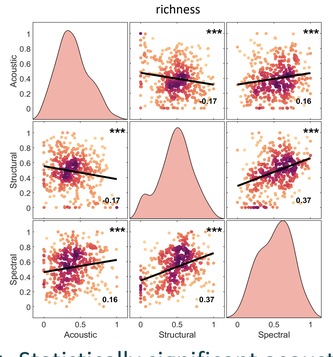
Q1. How is acoustic diversity related to animal diversity (birds and amphibians)?

Q2. What are the relationships among measures of acoustic, spectral and structural diversity and how do they change across spatial scales and vegetation types?

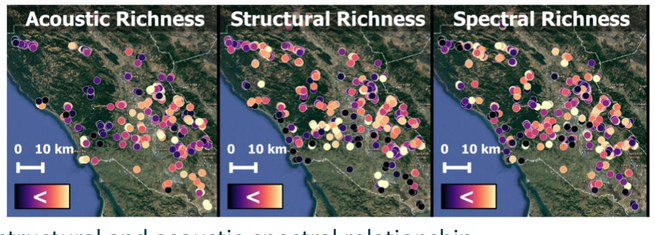
Q3. How do anthropogenic and natural disturbance affect acoustic diversity and habitat quality?

The Sonoma County Prototype

(Using the Soundscapes to Landscapes dataset -- https://soundscapes2landscapes.org/)



- Acoustic diversity: Used the first 5 PCA from acoustic indices
- Structural diversity: Canopy Height, Plant Area Index, Foliage height diversity, RH 25
- Spectral diversity: Used the first 5 PCA from reflectance bands



- Statistically significant acoustic-structural and acoustic-spectral relationship.
- Acoustic diversity negatively (structural) or positively (spectral) correlated with habitat diversity.
  - Dense old-growth conifer forests (structurally rich) less acoustically rich.
  - Oak woodlands and shrublands richer in acoustic and spectral diversity.