SHIFTing from Flora to Fauna: Combining Bioacoustics and Imaging Spectroscopy to Track Seasonal and Spatial Patterns of Riparian Animal Vocal Activity

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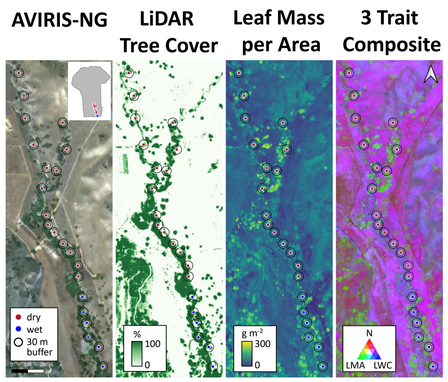
Introduction

Riparian ecosystems are hotspots of diversity and productivity, and harbor many threatened and imperiled species. Recent developments in acoustic monitoring allow tracking wildlife over large areas and long time periods, and upcoming missions like the Surface Biology and Geology Mission (SBG) promise to revolutionize our ability to map habitat.

Here, we test the potential of these tools when used together to study wildlife-habitat relationships in a dryland riparian ecosystem in Southern California, with a focus on spatial scale and temporal variability.

Methods

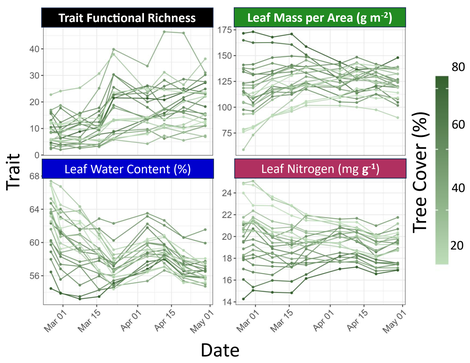
Combining Acoustics, Hyperspectral Time Series, and LiDAR



During the 2022 SHIFT campaign, we collected audio from 21 sites along Figueroa and Lisque Creek, which feature an arroyo willow riparian woodland (*Salix lasiolepis*) and savannah of oak (*Quercus lobata* and *Q. agrifolia*), surrounded by grassland.

The AVIRIS traits leaf mass per area (LMA), leaf water content (LWC), and leaf nitrogen (N) were sampled around each point in variable-scale windows from 5 to 100 m. Points were characterized as 'wet' or 'dry' in streamflow perenniality. Fractional tree cover was mapped with LiDAR.

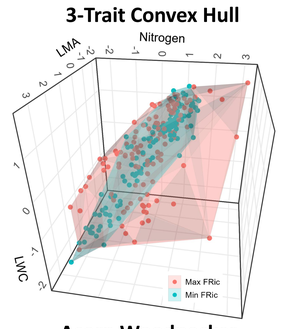
Functional Trait Time Series



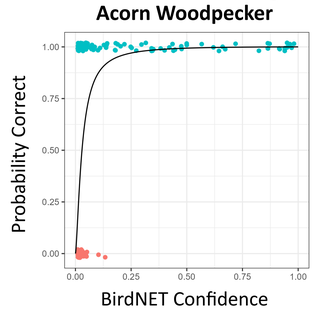
Using LiDAR tree cover, we classified pixels as tree- or grass-dominant. We extracted mean trait values and slopes of variation over time within varying buffer sizes for grass and tree pixels separately, as well as both together.

We extracted wildlife vocalizations with BirdNET and manually validated detections to develop confidence-probability logistic regression models, which we used to compute estimated call rates for 22 species at all sites. We also estimated total species richness using a species accumulation curve approach.

3-Trait Convex Hull

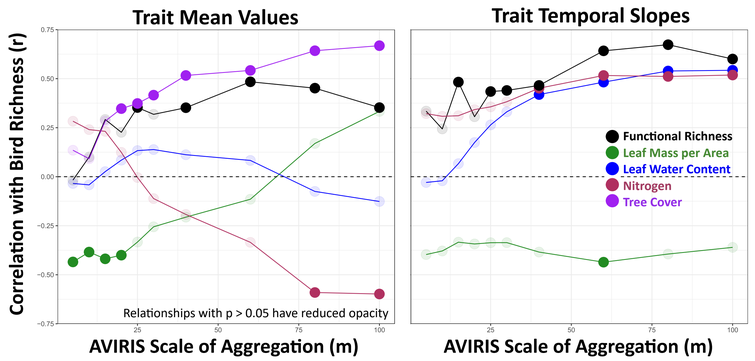


Acorn Woodpecker



Results

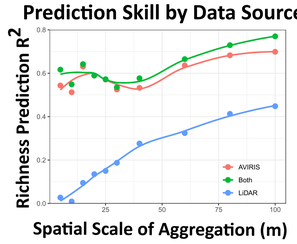
Trait Relationships to Bird Richness Vary with Spatial Scale



Bird richness was positively correlated to plant functional trait richness, tree cover, and the time-slopes of functional trait richness, N, and LWC across most spatial scales ≥ 20 m.

Richness was better and more consistently correlated with the temporal slopes of traits than unitemporal, snapshot trait values. Trait snapshot relationships had inconsistent signs between very fine (5-10 m) vs. coarse (>60 m) scales.

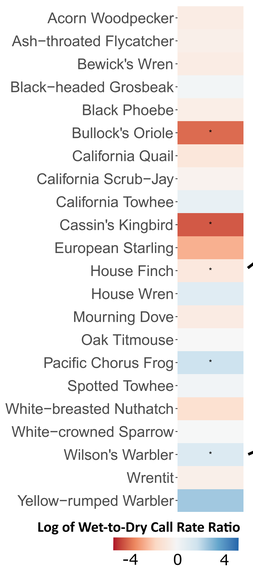
Prediction Skill by Data Source



Simple linear models trained on AVIRIS traits data (including snapshot and time slope values) show skill at predicting bird richness across sites. Addition of LiDAR-derived estimates of tree cover and tree height adds relatively small gains in model fidelity in this ecosystem.

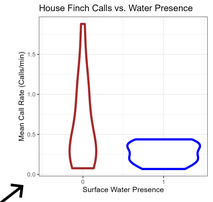
Variable Creek Flow Drives Patterns

Species-Water Relationships



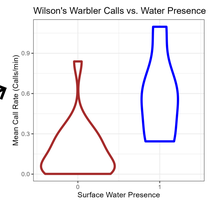
House Finch

Habitat Generalist



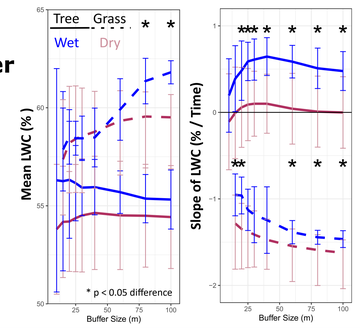
Wilson's Warbler

Riparian Specialist



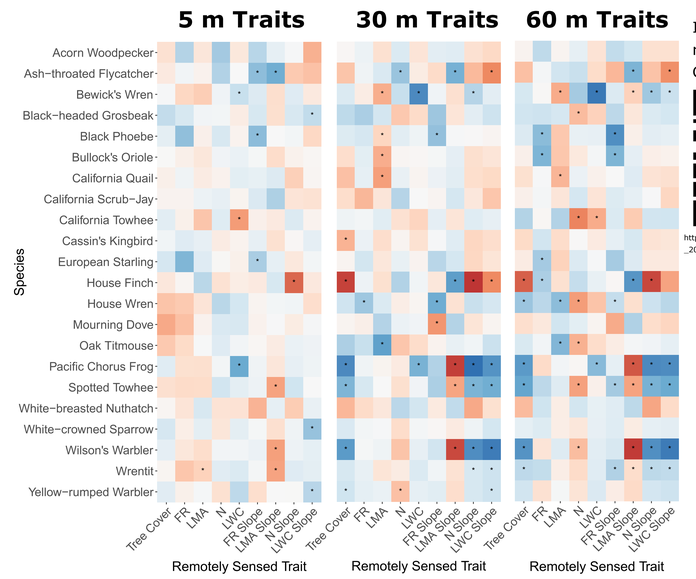
Some species, including riparian-obligate breeders, are more common in perennially flowing than seasonally drying sites.

The time slopes of plant traits differ between wet and dry sites, despite overlap in mean values. Grass-specific values differ less than tree-specific values.



Results

Species Show Diverse Trait Responses



Interested to read more? Check this link:

https://conormcmahon.github.io/agu_2025_bioacoustics_hyperspectral_shift/

* Significant at $p < 0.05$

Discussion

Riparian Ecology

Individual species showed complex and variable relationships to AVIRIS traits and water availability. In contrast to generalists, riparian-associated species like Wilson's Warbler and Pacific Chorus Frog were more common in sites with **more tree cover, higher late-season N and LWC, and perennial water**. These traits are associated with **greater density of willow** and lower density of oak in the riparian woodland. Willow-associated traits were also correlated with greater overall species richness.

Implications for SBG and Future Missions

Wildlife variables and remotely sensed data products were better related at **scales ≥ 30 m**. LiDAR-derived tree cover was correlated to higher overall richness and call rates for some species, but models with all AVIRIS data showed only slight improvement when adding LiDAR. Finally, many relationships were **stronger for time-slopes of trait values than for fixed mean trait values**, highlighting the importance of temporally dense datasets, which will be greatly expanded with upcoming missions like SBG.

Ongoing and Future Work

Continued validation will enable us to model more wildlife species and investigate relationships across guild groupings (e.g. diet, nest type, family). When September traits data become available we will also expand the analysis seasonally and interannually.

Acknowledgements

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