A-BiRD: An Automated Bird Recognition Device For Acoustic Monitoring And Conservation

Figure 12. Ayello, F. (n.d.). Photographer. Pexels. https://www.pexels.com/@francois-ayello-838154943/

Abstract

Traditional bird monitoring relies on daytime, human-presence surveys that miss nocturnal activity and fine-scale spatial interactions. **A-BiRD** is an autonomous acoustic monitoring system that continuously records bird vocalizations and identifies species using machine learning. Using a dual-unit deployment, directional time-delay analysis enables spatial localization of individual callers. Fall migration monitoring recorded **21,131 corroborated vocalizations across 98 species**, revealing structured temporal, spatial, and interspecies patterns not detectable with traditional surveys.

Introduction: Monitoring Gaps

-29%	In North America since 1970 — 2.9 Billion Birds gone
1 in 8	Species Threatened With Extinction
49%	Of Global Bird Species Have Declining Populations

Figure 1 created by finalist using PowerPoint, 2026.

- Daytime surveys miss nocturnal and fine-scale spatial behavior
- Migration and interspecies interactions require continuous coverage
- Scalable, low-disturbance monitoring is needed for full avian activity

Methodology

- Continuous 24-hour acoustic recording during fall migration (Tucson, AZ)
- Species identification using Cornell's BirdNET-Analyzer
- Dual-unit time-delay analysis for spatial localization of callers

Research Question Predictions

Can continuous acoustic monitoring reveal temporal and spatial patterns in bird populations missed by daytime surveys?

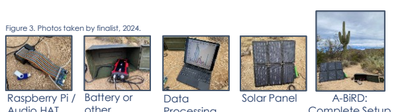
Biological Predictions:

- Seasonal shifts in species composition
- Discrete migration pulses
- Structured day–night activity patterns
- Persistence of resident species

Criteria & Objectives:
- ✓ Operate Without Human Presence
- ✓ Collect and Store Birdsong Audio
- ✓ Identify Species
- ✓ Direction Finding
- ✓ Low Power
- ✓ Common Parts for Lower Cost
- ✓ Autonomous Performance

Figure 2 created by finalist using PowerPoint, 2026.

Figure 3. Photos taken by finalist, 2024.



Autonomous Acoustic Monitoring Pipeline

Figure 4 created by finalist using Canva, 2026.

Figure 4: End-to-end pipeline from field recording to ecological interpretation.

Field Study: Fall Migration

Objectives / Study Design / Limitations

- Deployed A-BiRD units during fall migration in Tucson, Arizona
- Continuous 24-hour monitoring across multiple weeks
- Single site with dual-unit deployment for spatial analysis
- Environmental noise influence detections and vocalization counts reflect calling activity rather than population size

From Acoustic Signals to Ecological Interactions

Continuous 24-hour acoustic monitoring reveals structured temporal and spatial patterns in avian migration.

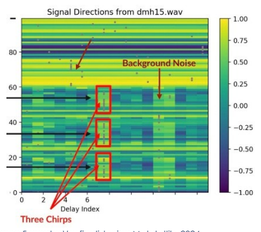
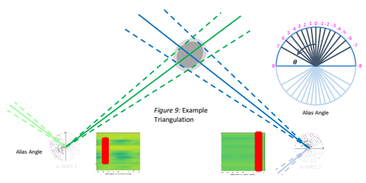


Figure 5 created by finalist using Matplotlib, 2024.



BirdNET-Analyzer cue → time-delay → angle

Figure 6 created by finalist using PowerPoint, 2024.

Figure 7 created by finalist using PowerPoint and Google Earth, 2024.

Figure 5: Detection
Overlapping bird vocalizations resolved within background noise.

Figure 6: Localization
Dual-unit time-delay analysis separates and spatially localizes individual callers.

Figure 7: Interpretation
Spatial patterns in vocal activity reveal fine-scale interspecies interactions.

Findings: Spatial and Temporal Patterns in Bird Vocal Activity

Directional time-delay analysis using a dual-unit A-BiRD deployment enables spatial localization of individual callers, linking acoustic signals to fine-scale ecological interactions.

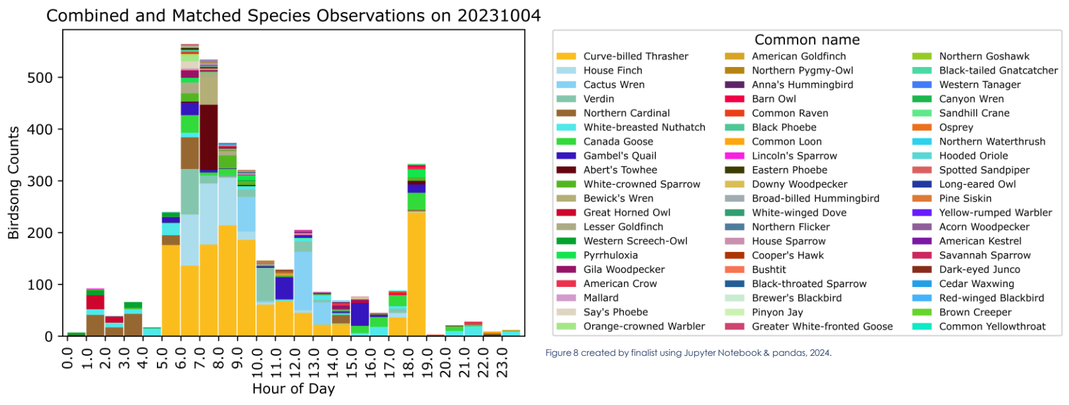


Figure 8 created by finalist using Jupyter Notebook & pandas, 2024.

Figure 8. Diurnal and nocturnal birdsong patterns.
Hourly detections show dawn and dusk choruses, sustained nocturnal owl activity, and intermittent nighttime vocalizations from diurnal species.

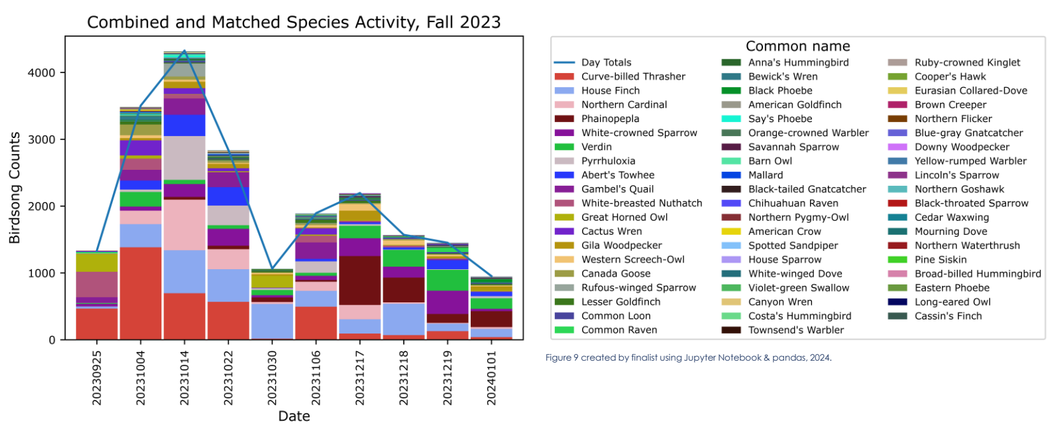


Figure 9 created by finalist using Jupyter Notebook & pandas, 2024.

Figure 9. Seasonal Migration Pulses
Daily detections reveal two distinct migration pulses, with peak diversity (~60 species) and peak activity (~4,300 vocalizations) in early–mid October, followed by late-season decline.

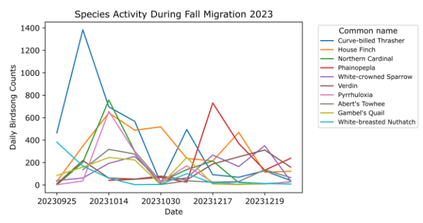


Figure 10 created by finalist using Jupyter Notebook & pandas, 2024.

Figure 10. Seasonal shifts in species dominance
Species-level vocal activity shifts across fall migration reflect migration timing and temporal partitioning.

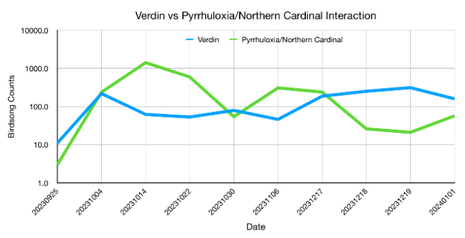


Figure 11 created by finalist using Jupyter Notebook & pandas, 2024.

Figure 11: Evidence of Temporal Separation
Opposing activity patterns suggest potential temporal or habitat-based partitioning; further study is required to confirm mechanism.

Findings: Ranked Species Activity

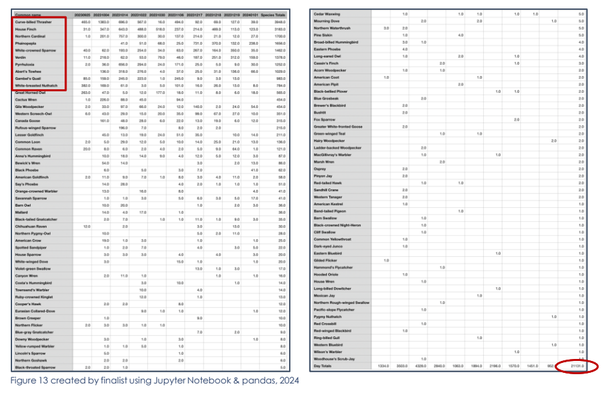


Figure 13 created by finalist using Jupyter Notebook & pandas, 2024

Figure 13: Combined dual-unit A-BiRD detections showing ranked species-level vocal activity during fall migration, totaling **21,131** corroborated birdsong localizations across **98** species.

Conclusions: Objectives & Predictions Met

Biological Insight

Continuous 24-hour acoustic monitoring reveals structured temporal, spatial, and interspecies patterns in avian migration.

What's New

Dual-unit acoustic localization enables spatial inference of individual callers and interactions.

Why It Matters

These patterns are underrepresented in human-presence-dependent surveys.

Forward Look

This framework enables scalable, low-disturbance monitoring for avian ecology and conservation.

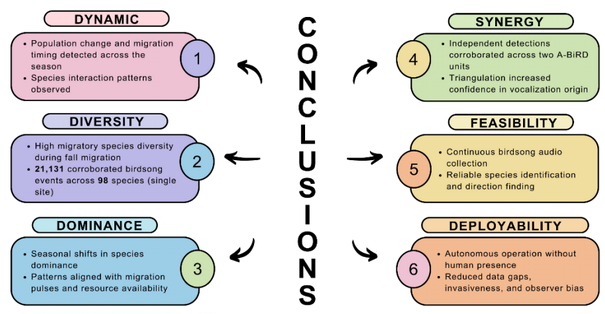


Figure 14 created by finalist using Canva, 2026.

21,131 corroborated vocalizations from **98** species using dual-unit triangulation

Future Directions

- Scaling A-BiRD arrays
- Improving long-term robustness
- Expanding accessibility to enable broader ecological and conservation applications
- Expansion to additional taxa and global biodiversity databases (e.g., eBird).

This study represents the first validated deployment of A-BiRD; ongoing and expanded deployments are in progress.

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