2021 Acoustic Monitoring Report

December 15, 2021

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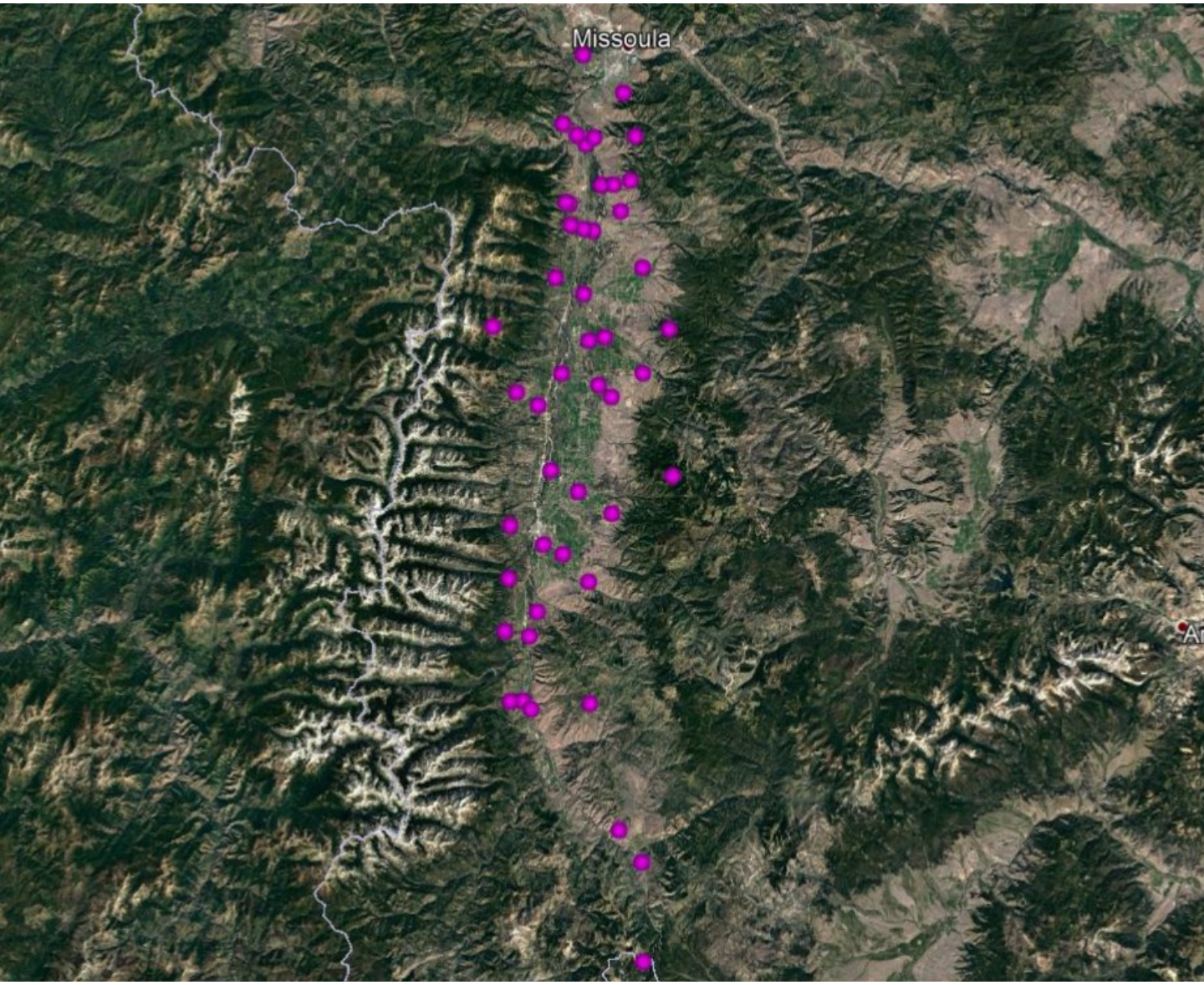
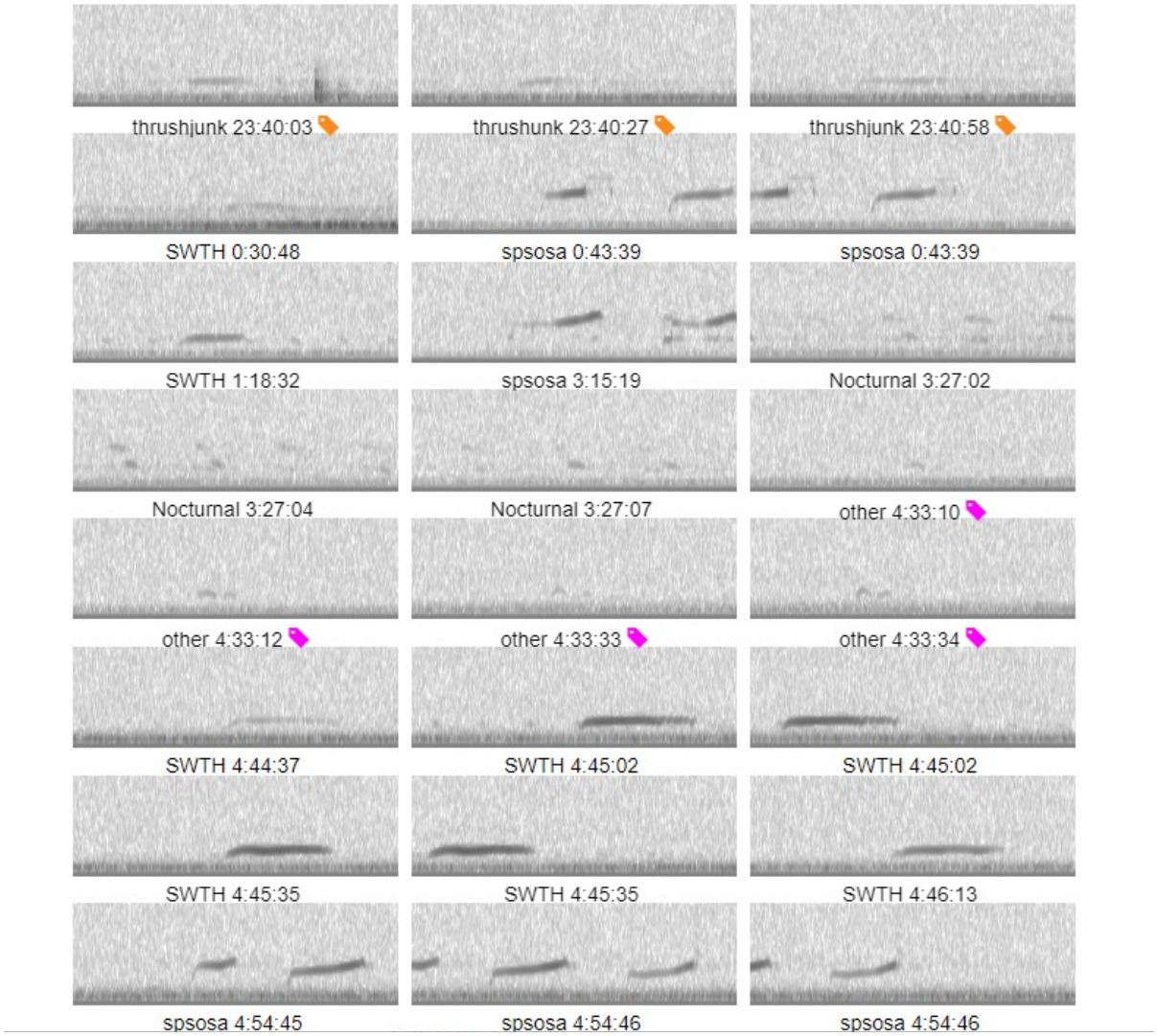


The purple dots show where we installed microphones, in the Bitterroot Valley, during fall migration of 2018 and 2019.

Summary

We operated the Bitterroot array of microphones to study passerine migration by recording and analyzing nocturnal flight calls (NFCs). While we pioneered this array, the largest ever built for NFC monitoring, we also simultaneously developed software, called Vesper, that allows us and others to make sense of terabytes of audio files. Due to the lack of historical and current NFC monitoring in the Intermountain West, we face challenges identifying calls, but the absence of information also offers a chance for discoveries.

This report outlines the status of Vesper development, the challenges of data processing, a few discoveries, updates on publications and research collaborations using our data, and work planned for the next few months.



The screenshot, above, shows spectrograms, or audio clips, we reviewed by sight and sound using the Vesper interface. Vesper runs detectors to extract sounds of interest. Once extracted, we sort millions of clips to specific species or other categories, like the ones above.

Vesper Software Development

Substantial Vesper Improvements

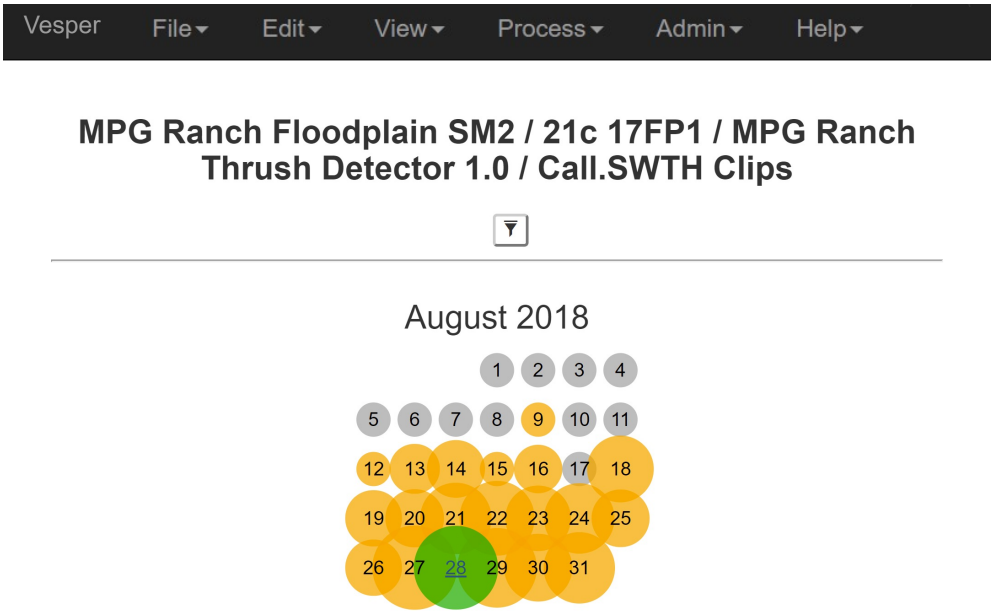
Over the last several years, enhancements to the Vesper platform (Vesper link) made the way we process, review, and analyze the data more efficient and accurate. Improved detectors reduced the number of false positives and increased the number of NFCs pulled from the recordings. Vesper's developer, Harold Mills, continues to optimize the software for our workflow, making it easier to label, relabel, and retrieve vocalizations of interest. Our ability to export different types of data for use in analyses also became easier.

More Vesper Users

Word about the usefulness of Vesper continues to spread to citizen scientists and other organizations. At least a dozen computer savvy NFC enthusiasts use Vesper to process the recordings they collect in their back yards. Jeff Wells, from the National Audubon Society (Wells bio), is currently using Vesper to process and analyze NFC recordings he made years ago in the boreal forests of the Northwest Territories.

Beyond MPG and NFC Research

Any software engineer can build a detector and plug it into the Vesper platform. Vesper currently runs NFC detectors developed by different organizations including MPG Ranch, the non-profit Old Bird (OldBird), and the BirdVox project (BirdVox). Vesper's use is not limited to NFC recordings. The USDA's Pacific Southwest Research Station is currently exploring the use of Vesper, with a customized detector, to identify a specific type of Northern Goshawk call from hundreds of microphones in the Sierra Nevada ecoregion.



A screenshot of Vesper's main page, above, shows the layout of the user interface. The menu, at the top of the screen, contains many of the new functions developed in the last several years. The calendar depicts the number of Swainson's Thrush calls we identified. Larger orange circles indicate more calls than the smaller orange circles, and gray circles indicate no calls.

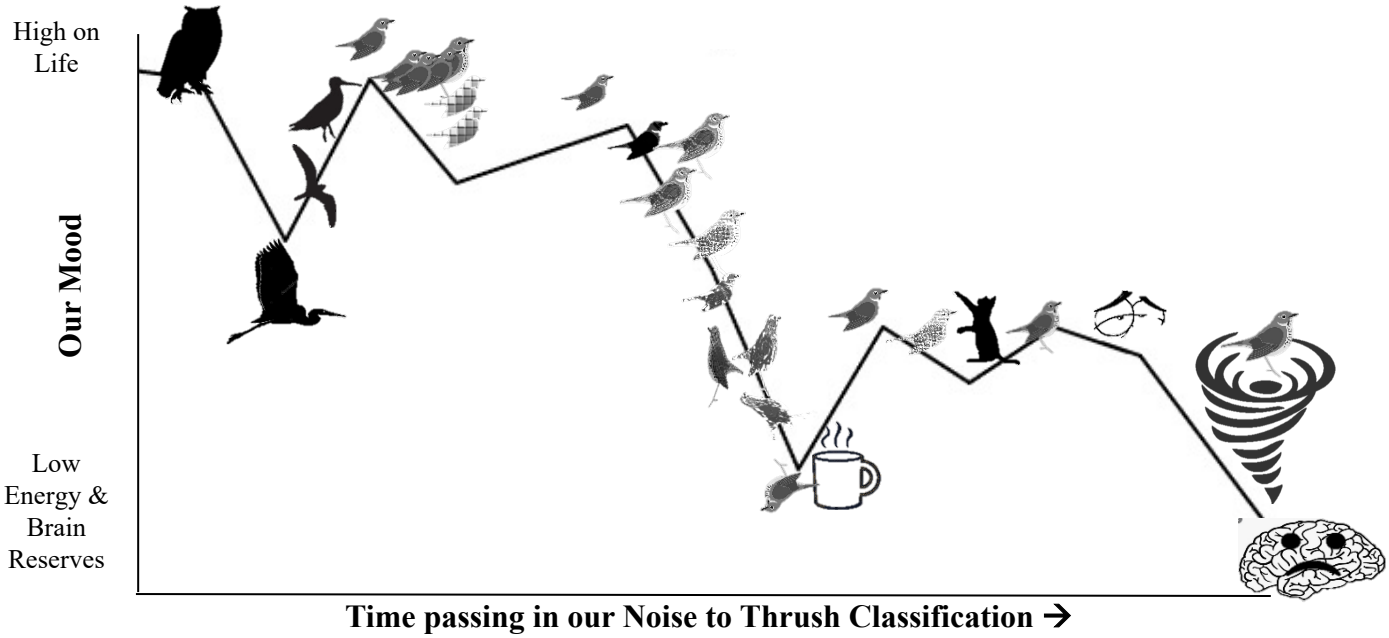
Status of Data Review

Data Review Procedure

For the Bitterroot Array, we focused on processing thrush detections in the past year. Vesper extracts sounds of a specific "thrush-like" frequency and duration. Other sounds also fit these acoustic characteristics, and we must manually review the output to separate the vocalizations of interest from noise. We also categorize some non-NFCs to help train exclusion algorithms and identify other sounds or phenomena of interest. Though it may still seem like a lot of human effort, we have significantly reduced the manual reviews. This approach will ultimately result in a higher quality dataset to train more accurate detectors.

Challenges

Our workflow for processing data comes with many highs and lows. We usually start with high energy as we learn the nocturnal soundscape of a monitoring site. As we move deeper into the review, we face the challenge of filtering through layers of noise like Great Horned Owl begging calls that look and sound like the thrush calls of interest. A reviewer can get lost in the land of noise until one hears a species of interest, like the Common Nighthawk, or calls from unusual shorebird species. As the classification transitions from noise to thrush-like calls, we clutch our NFC reference manuals, with confidence, and prepare to dig into species identification. We see and hear the "classic" thrush NFCs, but also start to accumulate a handful and then a pile of thrush-like vocalizations that match nothing in the reference materials. After hours of this process, and as eye strain and brain fatigue increase, we recognize the need to sometimes go back and review completed work. It also helps to find the right balance of caffeine and time with a pet to recharge. This is pioneer life on the NFC frontier.

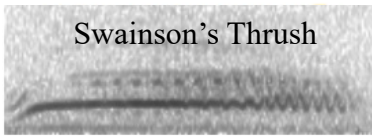


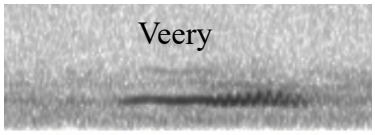
The Thrush Conundrum

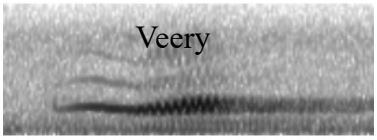
One of our biggest challenges is identifying thrush NFCs from the genus Catharus. Approximately 80% of the Catharus calls belong to Swainson's Thrushes. Hermit Thrushes and Veeries make up less than 3% and 2%, respectively. The remaining 15% are unknown thrush calls.

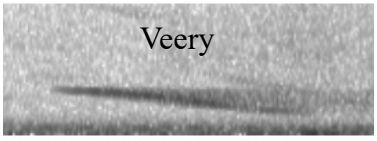
All three of these thrush species have typical and atypical NFCs. Atypical calls of Swainson's Thrush versus Veery, and Veery versus Hermit Thrush may overlap with one another. We reached out to other NFC experts about these confusing calls, and they shared that they also face similar challenges with these confusing calls.

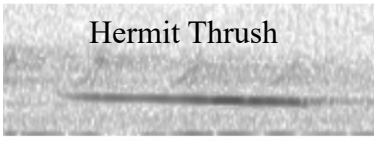
Typical Flight Calls







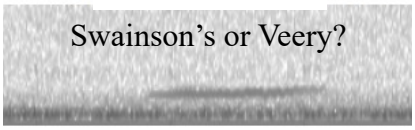


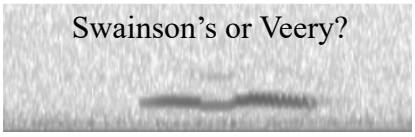


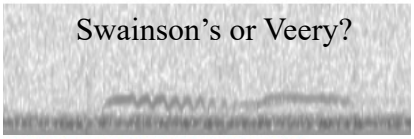
The typical calls, on the left, are from birds that someone recorded and visually verified during the day. We obtained these recordings from either xeno-canto or a CD of reference flight calls. The atypical calls, on the right, came from the Bitterroot Array recordings.

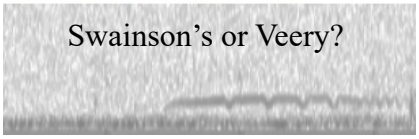
A Swainson's Thrush flight call rises in pitch slightly and sounds bell-like. If present, a burry quality is stronger at the end of the call. A Veery flight call varies, but usually sounds burry and typically drops in tone. The flight call of the Hermit Thrush also descends in tone and may sound burry. Atypical calls of these species, on the right, are not easy to identify to species. They either do not match the typical samples or overlap with another species.

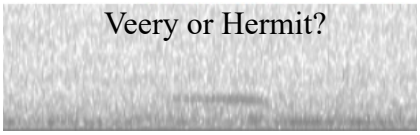
Atypical NFCs









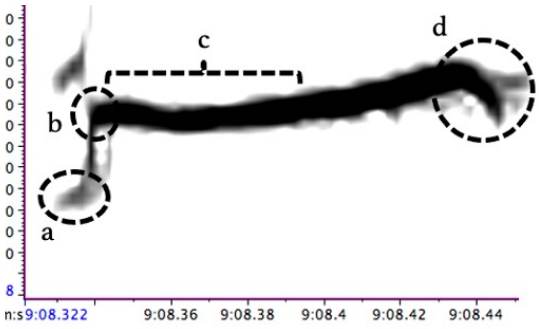


We do not know the reason for the variability in our Catharus thrush NFCs. but we have several hypotheses. Are calls from subspecies dissimilar? We wonder if calls from Hermit Thrushes in the West are not the same as those in the East. Two subspecies of Swainson's Thrushes hybridize in the Pacific Northwest. Could their flight calls sound different? Is it possible that calls from males versus females, or younger versus older birds are not alike? More research is required to answer these questions, and currently no easy way exists to conduct it. Microphone backpacks do exist to record flight calls during migration. At this time though, the packs remain too large to mount on passerines.

When NFCs are not Species Specific

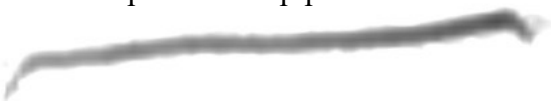
As already discussed, some birds elicit distinct NFCs, making identification easy. Other calls are so similar we struggle to identify the species. We collaborated with Cedar Mathers-Winn to identify methods for telling some of our commonly encountered and difficult-to-distinguish species apart. We focused on Chestnut-collared and Lapland Longspurs, Brewer's and Clay-colored Sparrows, Myrtle and Audubon's subspecies of Yellow-rumped Warblers, and Solitary versus Spotted Sandpipers. We used our own NFC data from the Bitterroot Array and from calls recorded in our Portable Recording Station to study these species (Research Update). We also solicited calls from other researchers, citizen scientists, and mined calls with verified visual identifications from the online resource xeno-canto and Cornell's Macaulay Library. Cedar used Raven Pro software to measure various metrics on the resulting spectrograms, and then used a quadratic discriminant function analysis to test the identification accuracy to species or subspecies. He also assessed visual spectrogram features that an average person could use to avoid complicated and software-dependent measurements. We completed most of the writing for this analysis and will soon submit the manuscript to Western Birds.

Cedar's analysis separates Solitary and Spotted Sandpiper calls; they are one of our most common shorebird detections. Cedar identified four regions of their calls (right)- the foot (a), knee (b), dip (c), and tail (d)- that help identify the species. Solitary Sandpipers usually show all four features (below, left), while Spotted Sandpipers typically lack all but the tail (below, right). Cedar saw enough variability in calls that half could not be classified using these characteristics, and we will likely encounter a similar trend in the Bitterroot Array data. However, we consider any refinement of identification a triumph, and many NFC enthusiasts await the publication of these analyses.



Solitary Sandpiper

Spotted Sandpiper



A Spotted Sandpiper occupies its favored habitat along the river.

Surprising Discoveries:
Migrating Shorebirds

The Bitterroot Valley is not known as a significant migration corridor for shorebirds. The valley has limited stopover habitat for shorebirds, and the number of on-ground observations is low. Shorebirds also tend to fly non-stop and at higher altitudes making them harder to detect. Yet, our recordings helped us discover a potential and unexpected migration route for Upland Sandpipers over the Bitterroot Valley.

Other shorebirds we recorded include Greater and Lesser Yellowlegs, and Baird's and Solitary Sandpipers who breed in Canada and Alaska. Though calls from these migrants account for less than 2% of our total NFCs, they can help us track when and where shorebird species migrate over the Bitterroot Valley.

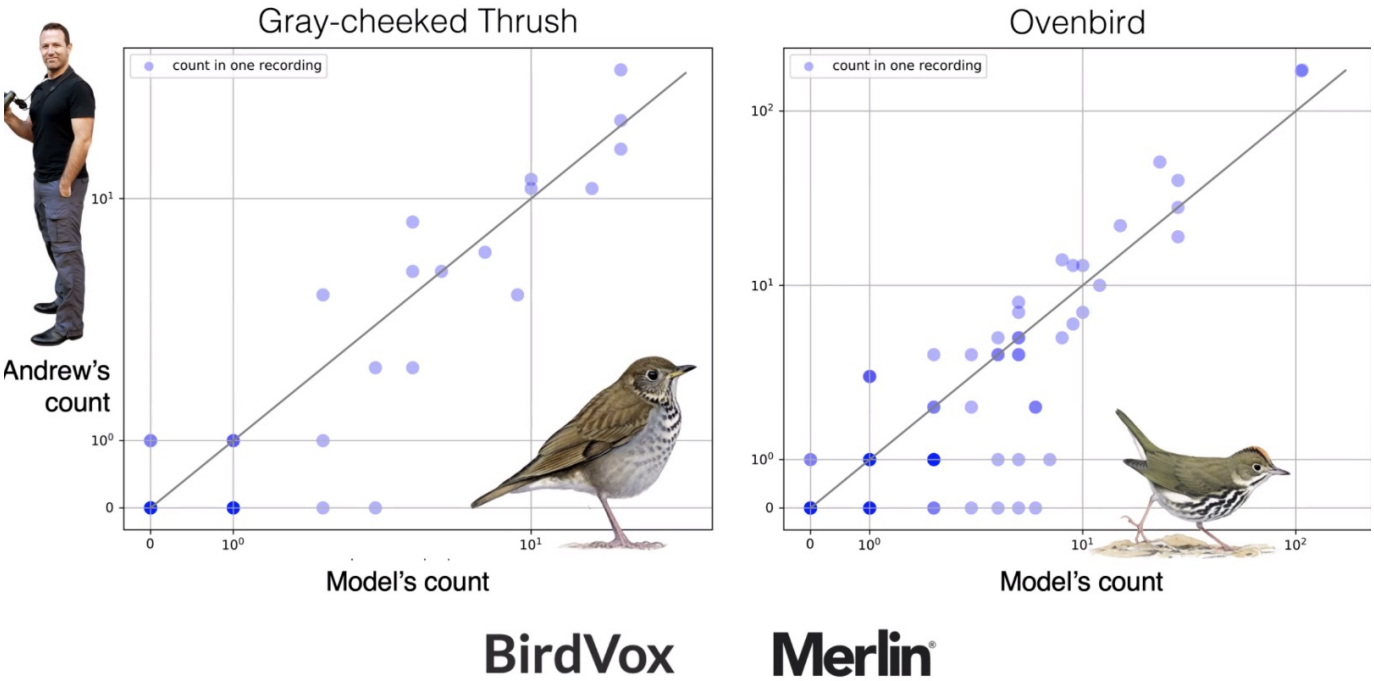
When we detected migrant shorebirds, they occurred up, down, and across the valley. This observation suggests the type of habitat, the amount of development, topography, and elevation did not factor into where we detected their calls. We also found many of the birds travelled in August and early September rather than later in the migration season. With shorebird numbers declining, baseline information like this could prove helpful for longer-term monitoring.

We recorded several species of migrating shorebirds above a rugged upland monitoring site, in the foothills of the Sapphire Mountain range. This habitat is not commonly associated with shorebirds.

A Potential Collaboration

Two scientists at the Cornell Lab of Ornithology, Andrew Farnsworth and Benjamin Van Doren, contacted us about sharing NFC data. Andrew is one of the NFC experts in the US, and Benjamin is a post-doc working with Andrew. They will use our data to further train BirdVox, an artificial intelligence system like the one in Vesper software. They would use our audio clips, that we hand classified to a species, and train a model to automatically classify NFCs to species. Eventually, the work from BirdVox would merge with Cornell's Merlin Sound ID app (Merlin app). Merging BirdVox with Merlin would allow users to identify NFCs in real-time.

Benjamin shared examples of their preliminary data on two passerines, below. The scatterplots compare the number of NFCs Andrew identified by hand to those detected by the software. Overall, their models perform with reasonable accuracy.



Our shared goals for using the MPG data include:

- The MGP dataset will train an NFC model, or detector/classifier, that works to extract and identify the calls we previously classified to a species or some other category.
- The training results will guide papers related to the identification of NFCs using artificial intelligence.
- All the final models and datasets will reside in a location open to the public and shared with the NFC community.
- We will work to include the models in Vesper so that other researchers and citizen scientists can use them on their NFC recordings.

Future Directions

Our plans over the next several months include:

- Between 2018 and 2019, we collected over 1,000,000 thrush-like NFCs to process. We completed the review of almost half of these and expect to finish the rest this winter. The remaining will go more quickly now that we have a system to classify unknown calls and other sounds.
- After the thrush calls are complete, we will move on to the tseep calls that include sparrows, warblers, and other higher pitched noises. Like the thrush, tseep NFCs overlap between some species, and we will refine how to categorize those. Other species, like Wilson's Warbler and Savannah Sparrow, are distinct and easy to identify.
- We will finalize the manuscript for the work Cedar Mathers-Winn completed and submit it to the journal, Western Birds.
- Our preliminary discussions for a collaboration with researchers at Cornell looks promising. We will finalize the details of a data sharing agreement and prepare the required datasets for them.
- This fall we installed microphones and recorded at our three long-term monitoring sites on MPG. The recordings still need processing, and then we will review and proof the data.

Acknowledgements

We wish to thank everyone who helped us process our recordings:
Eric Rasmussen, Carrie Voss, Lesley Rolls, and Garrett MacDonald.
We also acknowledge Kate's cat, Walnut, who keeps us entertained during long data processing days.