



AMPlifying Bat Monitoring Across North America

AN ONLINE PORTAL SHARES ACOUSTIC DATA TO ADVANCE BAT CONSERVATION ACROSS THE CONTINENT

By Theodore J. Weller and Brendan C. Ward



Credit: Jose Martinez-Fonseca

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▲ A fringed myotis (*Myotis thysanodes*) performs echolocation in flight.

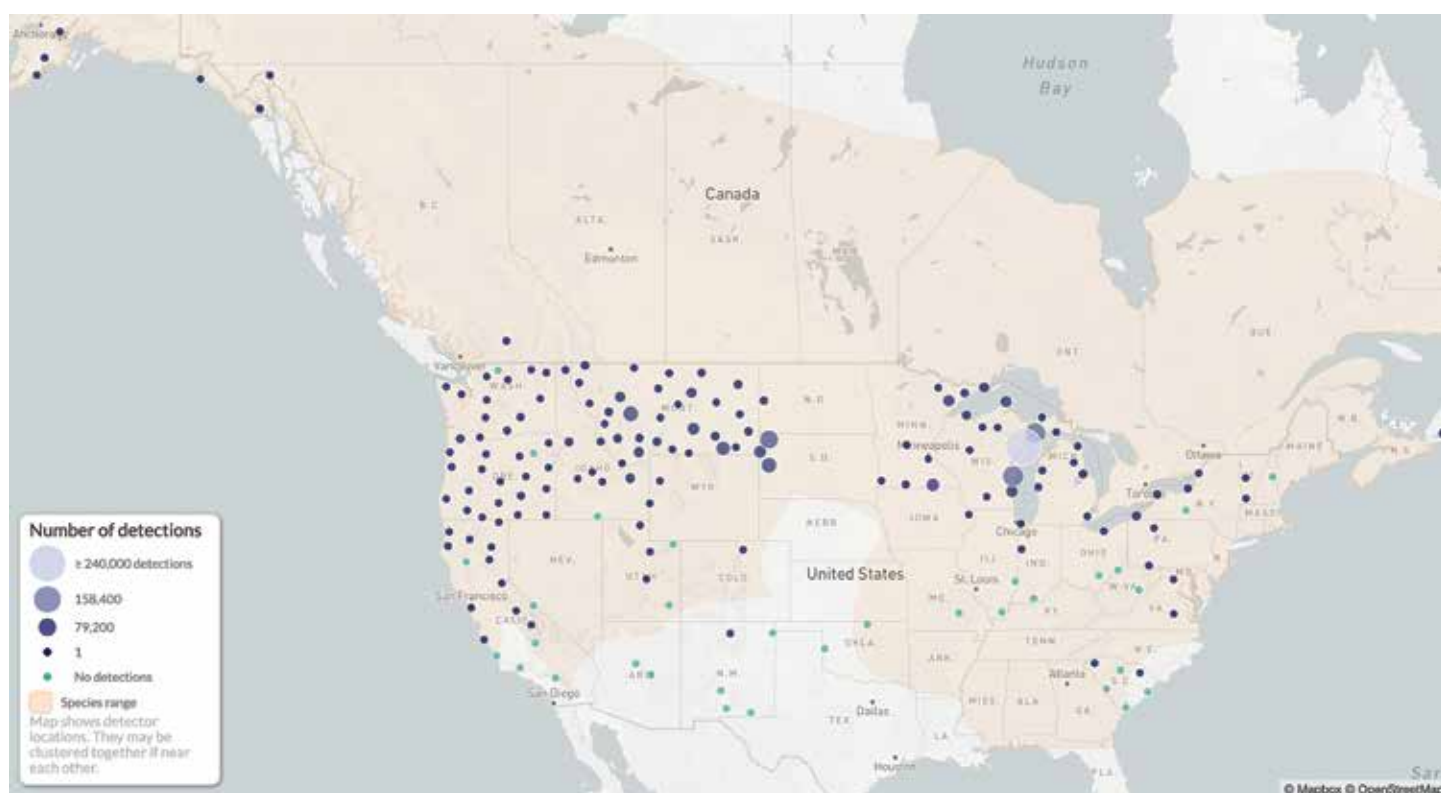
One summer afternoon on the Mendocino National Forest in Northern California, a biologist was on the lookout for bats. Well, not the bats themselves, actually. Afternoons aren't an ideal time to find these nocturnal species. The researcher was looking for evidence of which species had been flying around a bat detector deployed at the edge of a forest stand four days earlier.

Once the domain of only the most tech-savvy biologists, these bat detectors are now affordable and easy to use. Across the U.S. and Canada, more and more people — from research scientists studying the intricacies of echolocation behavior to amateur

naturalists curious about bats in their local parks — are setting up these devices to try to determine what species are in the area and how many times they pass by.

A single bat detector can yield interesting results for one area. But what if we could compile the results from bat detectors across the continent? The results would allow researchers to track — almost in real time — when and where bats occur on the landscape and how that may be changing.

The Bat Acoustic Monitoring Portal — BatAMP — is making that vision a reality.



Credit: BatAMP

Filling in the gaps

Bats occur in nearly every type of ecosystem on the continent, from high-elevation forests to deserts to neighborhoods in our largest cities. As the primary consumers of nocturnal insects, bats are critical to ecosystem function and agricultural production, providing millions of dollars in pest control services annually (Boyles et al. 2011).

Over the last 15 years, two novel threats — white-nose syndrome and wind energy development — have impacted bat populations across North America. These new stressors occur against the backdrop of broader concerns about loss of habitats and climate change that impact all wildlife.

At the same time, our understanding of bats lags behind that of other wildlife. Often, biologists don't even have a complete list of species that occur in an area. To fill these information gaps, they are increasingly turning to technologies such as bat detectors to monitor species presence and activity levels.

Bat detectors use a microphone to record the echolocation calls of bats passing nearby. The devices can

be handheld, attached to a car or installed at specific locations to monitor bat activity for a few hours or a few years. Biologists then visualize and analyze the recorded calls with specialized software, identifying them to a species using a combination of automated identification programs and expert knowledge.

AMPing up

Each year, biologists deploy these bat detectors in thousands of places across the continent, helping them develop a better understanding of bat activity at each individual site. Researchers can home in on species of interest or compare activity and species presence between local areas or experimental treatments.

What these specific studies can't tell us much about, though, is what is happening at regional or continental scales. They also don't allow us to compare among broad land cover types, such as agricultural areas, forests, prairies and urban areas.

To develop a better understanding of bat ecology at these broad scales, the bat monitoring community needed an easy way to share data collected across many different monitoring efforts. That's

▲ Survey effort and number of detections of little brown bats are presented against a backdrop of the species' distributional range within the Bat Acoustic Monitoring Portal's visualization tool. Users can filter records by month and year and view the identity and number of species detected at each location.



why we launched the Bat Acoustic Monitoring Portal (batamp.databasin.org) in 2013, through a partnership between the USDA Forest Service Pacific Southwest Research Station and the Conservation Biology Institute. Our primary goal was to make it easy for people to contribute their monitoring results — regardless of the original reasons they collected them — by creating a centralized place to share data. The result is one of the first continental-scale repositories of bat acoustic monitoring data. As of February 2020, BatAMP contained over 6 million detections of 34 different species from 44 states and provinces collected between 2006 and 2019.

Biologists conduct acoustic monitoring for a wide variety of reasons. While they may use different hardware and software applications, their data collection protocols are relatively similar, and most biologists summarize their results in the same way. We designed BatAMP to accept the results of any acoustic monitoring hardware, software and species analysis procedure. This allows contributors

to share data collected to meet their projects' goals while contributing to improved understanding of bats at larger spatial scales.

To contribute data to BatAMP, contributors upload nightly summaries of bat species presence or activity levels recorded at each detector using a simple spreadsheet format. They also provide information on the type of detector used, the method for identifying species and other details useful for evaluating the summary results.

A continental perspective

To make it easier to explore trends in this growing collection, we developed the BatAMP Visualization Tool (visualize.batamp.databasin.org). Because it was specifically developed for bat acoustic monitoring data, it provides users an unprecedented ability to explore and discover patterns in bat occurrence across the landscape. It is easy to see where bat detectors have been deployed across the U.S. and Canada. Users can readily identify which species have been observed in an area, identify

► April Damanti deploys a bat detector on the Mendocino National Forest for multi-night monitoring of echolocation calls following protocols for the North American Bat Monitoring Program.



Credit: Arielle Falcone



hotspots of species richness and locate areas that need more monitoring.

To better understand where a species has been detected, users visualize acoustic monitoring results against the backdrop of IUCN range maps for individual species. For poorly known species, BatAMP provides a unique resource for determining where species have been detected recently. This can help the bat monitoring community identify areas for more intensive sampling or suggest new areas to survey.

One of the most powerful features of the visualization tool is the ability to filter detections by month or year, offering insights into how patterns of bat presence and activity change over time and space. Aggregated over an increasing number of detectors operated for increasingly long monitoring periods, these data can help biologists develop season-specific range maps and better understand continental-scale bat migration patterns.

Seasonal migration is an important — and threatened — ecological phenomenon (Wilcove and Wikelski 2008). In the U.S. and Canada, most bat species migrate between summer and winter habitats, traversing latitude, longitude and elevation (McGuire and Boyle 2013). While hibernating species such as little brown bats (*Myotis lucifugus*), may migrate tens or hundreds of kilometers (Norquay et al. 2013), long-distance migrants such as hoary bats (*Lasiurus cinereus*) and Mexican free-tailed bats (*Tadarida brasiliensis*) migrate thousands of kilometers. These basics are well known, but we do not know many specific details. When do bats depart one location? When do they arrive at the next? What routes do they follow? Are they predictable year to year?

Compiling and visualizing the cumulative results of acoustic monitoring efforts — regardless of why they were performed — can help expand and refine our understanding of how bats move seasonally across the landscape. BatAMP leverages ongoing monitoring efforts across the U.S. and Canada to gain this continental perspective. Because the visualization tool allows results to be viewed month by month, biologists can develop testable hypotheses about how and when bats move seasonally. These data patterns can then be evaluated using more intensive methods, such as tracking individual

You can contribute

Anyone who has collected echolocation monitoring data since 2006 can contribute results to BatAMP. Instructions for contributing and a dataset template are available at BatAMP (batamp.databasin.org). Doing so helps amplify the use of your data, expanding insights into conditions at your own study area, for your purposes, and contributing to a broader understanding of when and where bats are active across the U.S. and Canada.

For those participating in the NABat program, we expect to include those results within the BatAMP visualization tool over the coming year. Simply upload to the NABat site (nabatmonitoring.org) to have data included in both systems.

animals or expanding acoustic monitoring efforts, creating a positive feedback loop that increases BatAMP's effectiveness over time.

Leveraging data from wind energy development

These broad-scale data can also help us better mitigate the impacts of wind energy on bat populations. Hundreds of thousands of bats are killed every year at wind energy facilities across the U.S. and Canada (Arnett and Baerwald 2013). Fatalities are highest during autumn when North American bats are both mating and undertaking seasonal movements. Learning more about when, where and how bats move across the landscape can help minimize these conflicts.

Prior to construction, wind energy facilities use acoustic surveys to determine which bat species are present and when bat activity is highest. These surveys can help fill important data gaps in the seasonal distribution of several species. Bat biologists have conventionally focused on places and times in which bat activity was thought to be highest — particularly, forest and riparian areas in the summer. Wind energy facilities, however, are often located in windy, open areas that are not normally surveyed. Since they are often conducted in the fall, these pre-construction surveys can also provide important seasonal context.

Comparing echolocation results among proposed facilities has been used to assess relative risk to bats. By contributing data to BatAMP, wind energy facilities can place their echolocation monitoring



results in a broader context, including the ability to compare results to areas where bats are monitored for other reasons. Comparing bat activity between open, windswept landscapes and forests and riparian areas could provide valuable insights to both the wind industry and bat ecologists.

It may also help facilities better anticipate and avoid potential negative impacts to bat populations. Likewise, by sharing monitoring results, wind energy facilities can help contribute to our understanding of the seasonal movements of bats, which in turn, may be useful for siting future facilities.

Understanding white-nose syndrome

Aggregating data can also help researchers better understand the effects of white-nose syndrome, a fungal disease that has killed millions of bats across North America during winter hibernation (Frick et al. 2017).

Winter activity by hibernating bats outside their winter roosts was one the earliest observed symptoms of WNS. Many forward-thinking biologists exploited this by placing echolocation detectors near hibernacula to measure rates of echolocation activity as a non-invasive, early-warning system for detecting WNS.

They soon discovered, however, that they lacked a reliable baseline of winter activity to compare with activity at sites where WNS was suspected. With few exceptions (Lausen and Barclay 2006), acoustic monitoring had not been used during winter in areas where temperatures were below freezing. Now, however, it is increasingly understood that some bat species are occasionally active during winter, even in areas not impacted by WNS. As a result, winter acoustic monitoring has become more common. Results compiled within BatAMP allow an understanding of rates of winter bat activity, how these may vary within and between regions and how they may be changing over time in response to disease or climate change.

Biologists have also used summertime monitoring to infer changes in bat populations before and after WNS (Brooks 2011). If populations are changing due to WNS, biologists expect to observe changes in the proportion of sites where species are acoustically detected. This is the foundation of the acoustic monitoring portion of the North American Bat Monitoring Program, or NABat (Loeb et al. 2015), which defines a statistically robust site

selection process and an acoustic detector deployment protocol to monitor the population status of most bat species across the continent. In addition to providing the necessary statistical framework for broad-scale monitoring, NABat provides a framework for archiving acoustic monitoring data at a fine level of detail, including individual recordings.

Integration with NABat

NABat (nabatmonitoring.org) provides a data portal where several types of bat monitoring data can be uploaded and archived. These data can be invaluable for helping understand bats' seasonal activity, especially when combined with data from other seasons and data not collected according to NABat protocol.

BatAMP is working with NABat to share data and integrate NABat data into the visualization tool to leverage monitoring resources and improve insights from growing aggregated datasets.

The goal of these efforts is to ensure that users find it easy to contribute acoustic monitoring data by aligning upload processes so that they sync with the original goals of data collection. Eliminating duplication of effort and minimizing the need to reformat data will encourage users to contribute data toward these larger goals.

We are working together to build a combined technology platform that advances the state of the art in aggregating bat acoustic monitoring data. We hope this work can accelerate our understanding of bat populations and ecology at the continental scale. A single detector can tell us a lot about bats in one particular place. Bringing together data from across the continent can tell us so much more. ■



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