What questions can be answered with mobile acoustic survey data?

Habitat Analyses

- It is possible to use mobile acoustic survey data to analyze the associations of bat species with different types of habitats. This can help inform local management efforts, such as evaluating population trend responses to restoration programs.
- Because a time series is not needed for analysis, habitat analysis can be run immediately.
- When conducting mobile surveys, it is important to concurrently collect accurate GPS tracks. This allows every bat call to be tied to a specific location, which can then be compared with surrounding habitat characteristics.
- A simple habitat analysis compares the distance from a bat call to the nearest patches of different habitat types with those distances for a random set of points taken along the survey route. By comparing these distances, one can determine if a bat species is associated with particular habitat types.

A Local Example

- These data are from the Yurok Tribe Wildlife Department's (YTWD) mobile surveys in Northern California.
- In Figure 1, the purple triangles represent the points where bat calls were recorded, and the green triangles are a selection of random points along the transect.

Figure 1. Map of the mobile route with random points (green triangles) and locations of recorded bat calls (purple triangles).

- Figure 2 shows the distances of available perennial graminoid grassland for the random points along the survey route in red on the left and the distances of calls for different bat species or species groups.

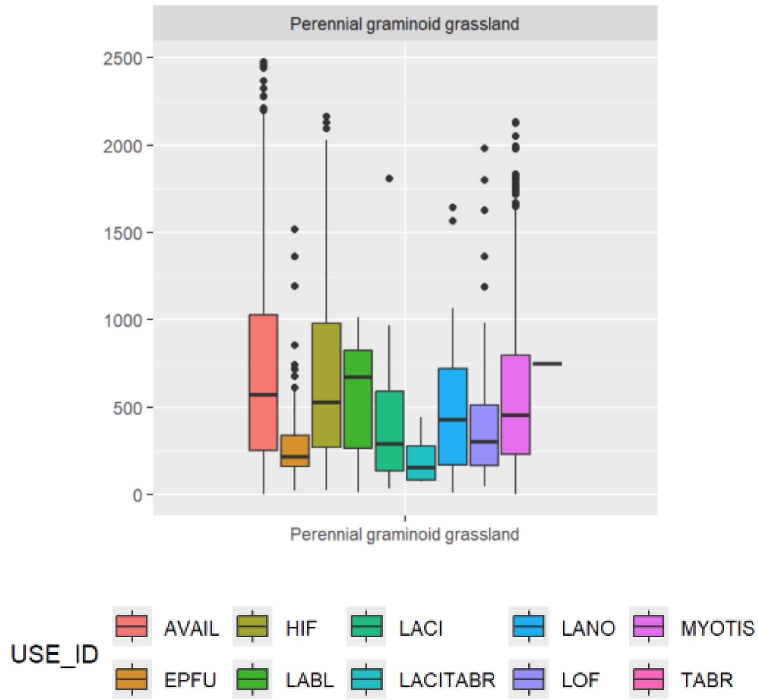


Figure 2. A plot of the distance of available perennial graminoid grassland along the mobile survey route (red box plot) with the distances of recorded bat calls for each species or species group.

- One can see that EPFU (*Eptesicus fuscus*, big brown bats) are more likely to be recorded closer to the perennial graminoid grassland habitat type.
- Figure 3 shows that there is a trend of a greater likelihood of recording big brown bats (EPFU) at a closer distance to perennial graminoid grasslands.

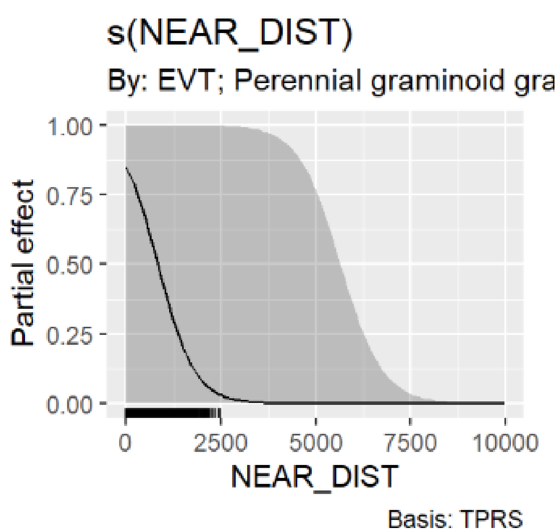


Figure 3. The likelihood of recording a big brown bat (EPFU) along this particular transect is greater when on is closer (has a shorter distance from) the perennial graminoid grassland habitat.

Population Trend Analysis

- With the mobile survey methodology, one can loosely assume that each call sequence represents a single bat, which provides a metric of relative abundance.
    - This assumption is not necessary, however, as long as there is a consistent relationship between the number of call sequences recorded and the absolute abundance among sampling years, which allows for some flexibility in the data collection protocol.
- With this metric of relative abundance, population trends can be assessed.

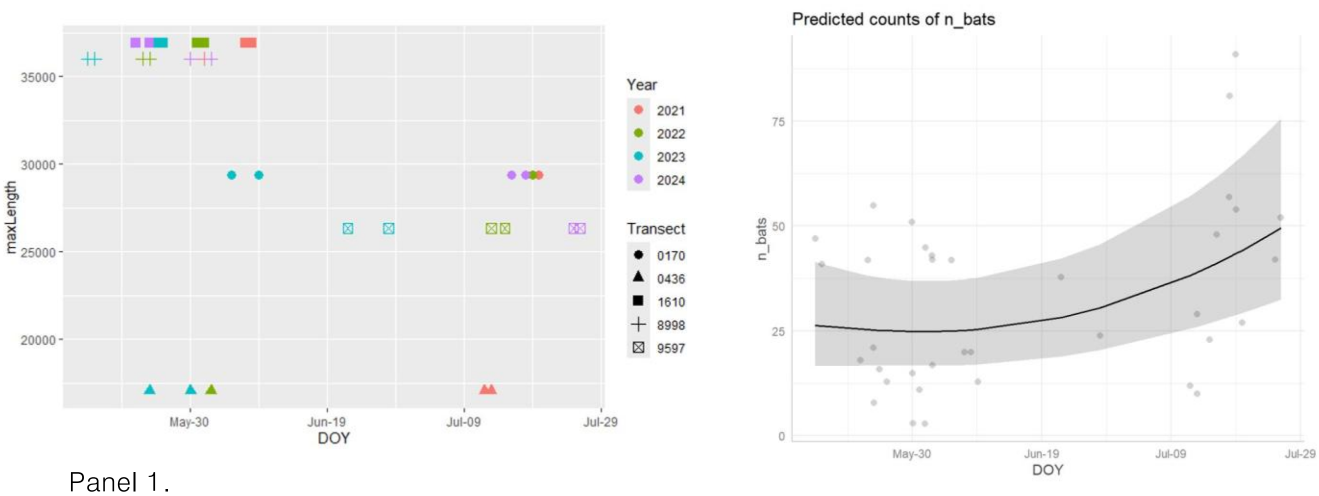
A Local Example

- These data are from the Yurok Tribe Wildlife Department's mobile surveys in Northern California.
- Table 1 shows the different components of the model. Some of these are parameters of interest and others are sources of variation that we want to minimize as much as possible through the survey design. This is how **key elements** of the protocol (p. 4), which should be followed as closely as possible, are identified.

Table 1. An outline of the basic model components for assessing population trends. Variation in the data can be limited through consistent data collection methods ("Design" aspects), which improves the ability to identify trends of interest ("Parameters of Interest").

	Predictor	Reason
Design	**Unique Transect ID** (Can be GRTS cell)	Identify sampling unit with repeated measures
Design	**Transect Length**	Account for sampling effort -should be recorded each time the transect is conducted to help account for any wrong turns
Design	**Day of Year**	Account for interannual variation in sampling timeframe -not needed if run the same time every year
Design	**Detector, Software, microphone, etc**	Other things that effect sampling variation -Changing methods (e.g., detectors types) should overlap old method so that variation can be calculated
Parameters of Interest	**Year**	Annual Trend
Parameters of Interest	**Perturbation**	Management or Threat Can be incorporated with Year (time since), as a factor (event), or as a continuous measurement
Parameters of Interest	**Habitat**	Can be used, especially for extrapolation to landscapes, but not necessary for trend analysis

- In Panel 1, the graph on the left plots the survey length by the time of year for all surveys. Here, you can see that some routes were surveyed at slightly different times of year. The graph on the right shows the modeled effects of day of year on bat abundance. Here, one can see a trend of increasing abundance later in the year as young bats become volant.
    - By surveying a route consistently at the same time of year, one can limit this variation and make it easier to identify trends of interest.



Panel 1.

- Figure 4 shows the modeled trends for the number of all bats (n_bats) for each survey over time.
- Simply put, the trends for each survey are combined in a hierarchical analysis to give an overall picture of trends in the number of bats for the area.
- Note that factors like time of year can influence these trends (please see below), which is why it is important to minimize sources of variation whenever possible, like consistently sampling at the same time of year.

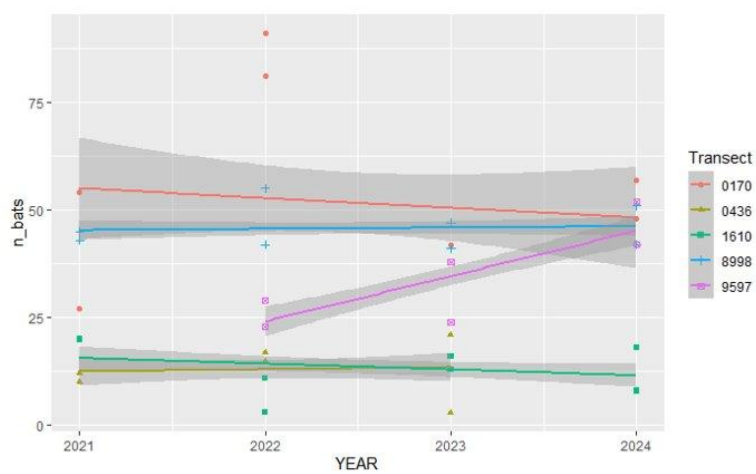


Figure 4. Modeled trends of bat abundance over time for the Yurok Tribe Wildlife Department's five mobile survey routes.

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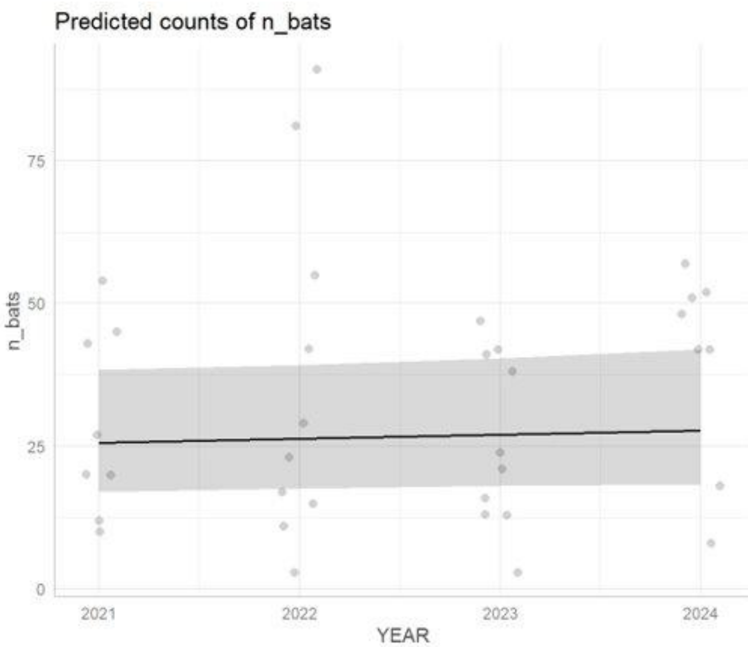
- Panel 2 shows the predicted count of bats for all YTWD mobile surveys over time and illustrates a non-significant trend of counts over time. The model shows a statistically non-significant effect of year on the predicted count, which indicates that the relative abundance has not changed over the sampling period.
- Note that this plot does not account for factors like the day of year.
- The table shows the average modeled count (mean expected number) of calls across all YTWD transects for each year. The confidence interval is for the mean, so the mean of all transects falls within this range.



Year	Bats/Transect (32km)	95% CI
2021	25.53	17.01-38.32
2022	26.23	17.56-39.18
2023	26.94	17.99-40.36
2024	27.68	18.29-41.89

```
## Conditional model:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -61.62375   57.40852  -1.073    0.283
## YEAR          0.02696    0.02837   0.950    0.342
## ns(DOY, 2)1   0.20720    0.31534   0.657    0.511
## ns(DOY, 2)2   0.68981    0.14021   4.920 8.67e-07 ***
## ---
```

Panel 2. A plot of the predicted count of bats over time and the model output show a non-significant effect of year on the modeled count of bat calls. The table shows the average modeled count of calls across all YTWD transects for each year,

- In 2024, four dams were removed along the Klamath River. The mobile survey data collected from 2021 to 2024 provide valuable baseline information about the relative abundance of bats in the watershed prior to this restoration project. Data that are collected moving forward will allow YTWD biologists to investigate questions abound the response of bat population to the dam removal.

Landscape Scale Examples

- A species status analysis for Tri-colored bats aggregated data across a large geographic scope and over a long timeframe.

- Figure 5 shows a map of the geographic scope of the aggregated survey data overlaid with USFWS management regions.
- Table 2 shows the number of routes, individual surveys, and participating states by year.

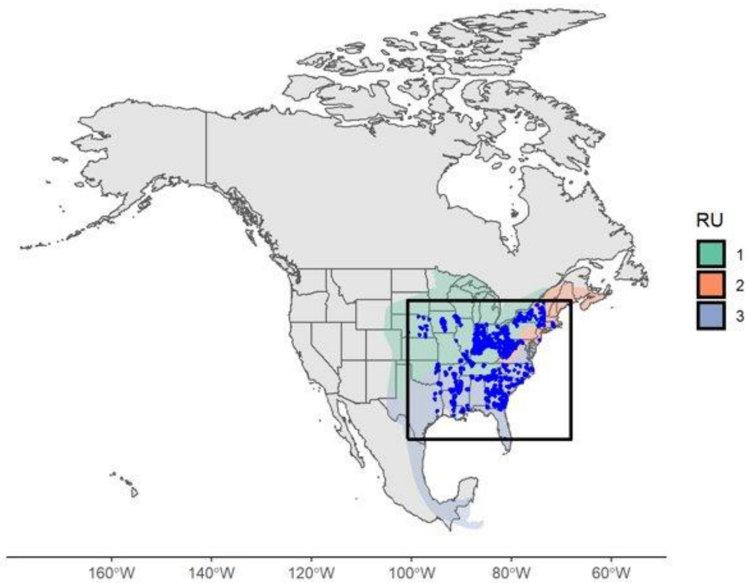


Figure 5. A map of survey locations used in the analysis overlaid with USFWS management regions.

Year	Routes	Surveys	States
2009	87	145	3
2010	132	338	6
2011	224	501	8
2012	526	1388	16
2013	580	1648	17
2014	464	962	19
2015	348	666	17
2016	430	841	20
2017	380	720	18
2018	378	744	23
2019	375	760	22
2020	57	130	6

Table 2. Number of routes, individual surveys, and participating states for all years of data.

- The left panel of Figure 6 shows the median number of calls for all surveys run for each year. The data show that the distribution of the call rates declined by 50% from about 12 to 6 calls from 2009 to 2020

- In the panel on the right, lambda is a standard growth rate (rate of change from year to year). The white box plots show the annual rate of change and the red box plots are the sum of changes up to that point (e.g., the 2015 plot shows the changes from 2009 to 2014). A 50% decline in the cumulative growth rate is evident.

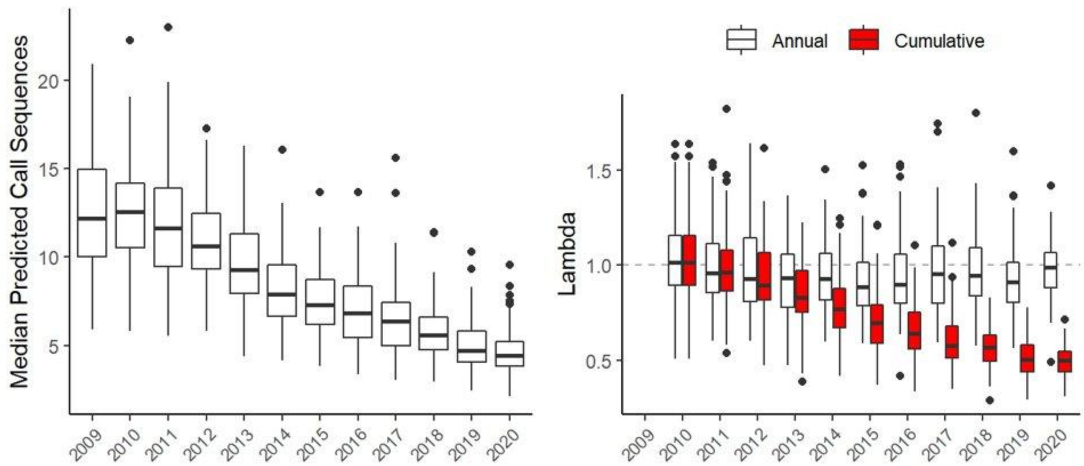


Figure 6.

- Figure 7 shows an 83% decline in northern long-eared bat activity from 2009 to 2020. With a median call sequence of 0.53 in 2009 and 0.09 in 2020, it is clear that surveys with low numbers of calls can be extremely valuable for understanding changes in relative abundance when aggregated over time and space.
- The right panel shows that the annual growth rate was below 1 in 2020, indicating that while the cumulative decline has begun to stabilize, the population is still declining.

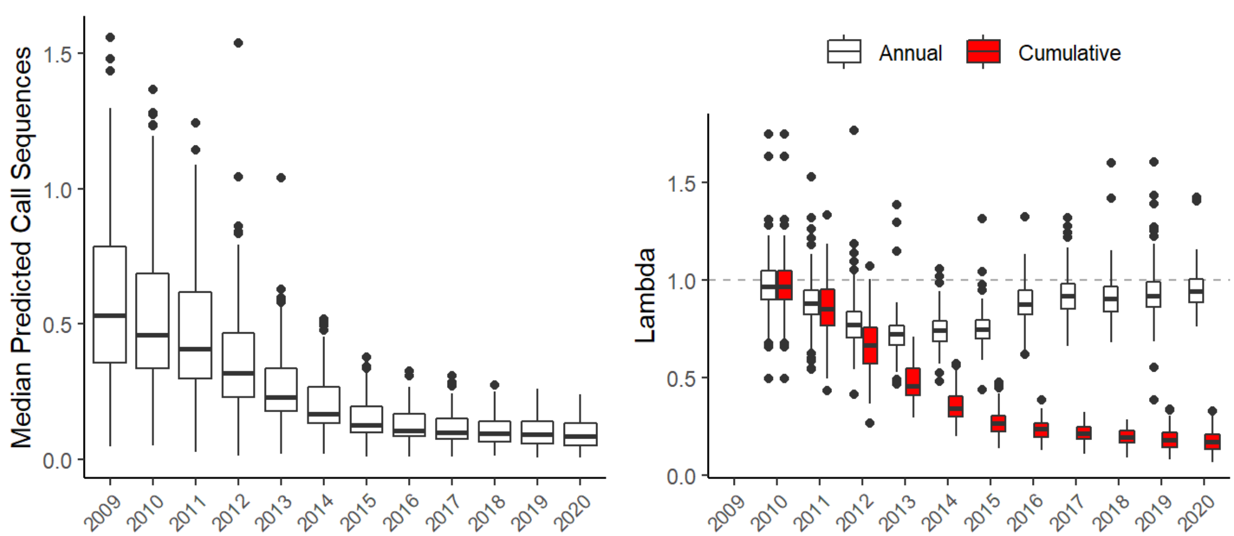


Figure 7.

- Figure 8 shows the number of tri-colored bat calls since the detection of Pd (*Pseudogymnoascus destructans*, the fungal pathogen that causes white-nose syndrome). Studies show that the impacts of white-nose syndrome on bat populations begin about two years after the detection of Pd and begin to stabilize four years after detection. Here, the model was allowed to identify break points (they were not manually entered), and we see the same response in tri-colored bats.
- In Figure 9, call sequences are plotted by a wind energy risk index, illustrating a continuous decline over time.

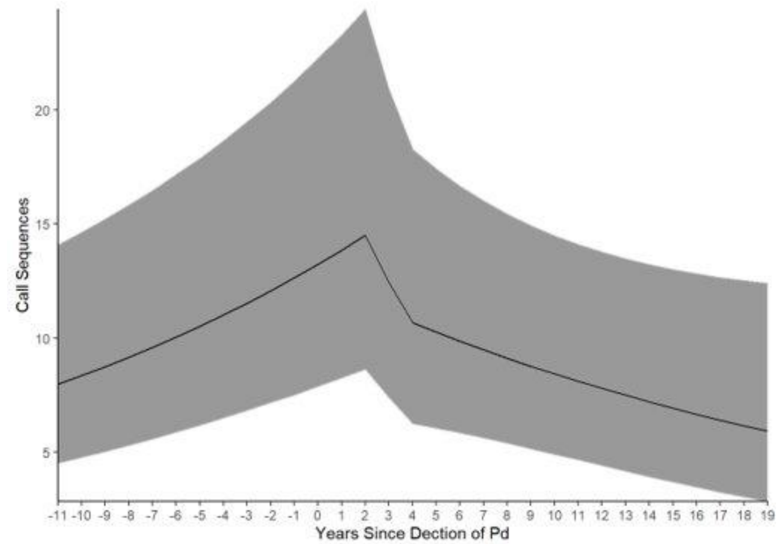


Figure 8.

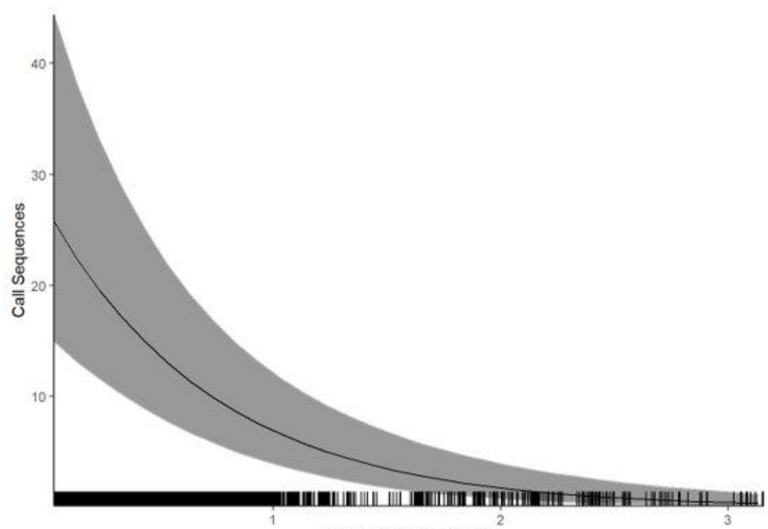


Figure 9.

- The North American Bat Monitoring Program uses mobile acoustic survey data to estimate bat abundances and population trends at the continent-wide scale. https://esajournals.onlinelibrary.wiley.com/doi/10.1002/ecm.1617