RENEWABLE ENERGY WILDLIFE | RESEARCH FUND

RESULTS SUMMARY
MAY 2025

Reassessing Risk using Acoustic Exposure

A study funded by the Renewable Energy Wildlife Research Fund to assess the relationship between acoustic bat activity and fatality rates on wind farms.

PROJECT OVERVIEW

Wind turbine curtailment is a reliable and widely used method to reduce turbine-related bat mortality. However, the practice also reduces the amount of energy that turbines can generate. Focusing curtailment strategies on periods when risk to bats is greatest can reduce energy losses associated with curtailment, but requires reliable information on when and under what conditions bats are active in the rotor-swept zone of turbines. Data from turbine-mounted acoustic detectors can be used to calculate acoustic exposure — a metric of how many bat passes were detected when turbine rotors were spinning — allowing wind energy facility operators to measure how effectively curtailment strategies prevent turbine operation when bats are active and compare alternative strategies. Such feedback is critical for balancing the simultaneous needs to reduce turbine-related impacts to bats and increasing renewable energy generation. This project explored the relationship between acoustic exposure and fatalities and demonstrated how acoustic exposure can be used to compare curtailment strategies. By assessing how height, season, wind speed influence simulated exposure, we can better understand how these factors influence fatality risk and how to best manage this risk by using curtailment strategically.

STUDY OBJECTIVES

This research project was designed to improve understanding of relationships between acoustic bat activity and fatality rates at commercial wind energy facilities and measure temporal and spatial variation in the distribution of bat activity in the rotor-swept zone of turbines. Study objectives included:

1) Measure seasonal bat activity trends in and near the rotor-swept zone
2) Quantify the relationship between acoustic exposure and fatalities
3) Demonstrate utility of acoustic exposure as a metric to evaluate and modify curtailment strategies

LITTLE BROWN BAT | J.N. STUART, FLICKR

ANALYSIS

We conducted acoustic bat monitoring and standardized carcass counts at a pair of commercial wind energy facilities in southwestern Missouri during summer and fall of 2021 and 2022. Using data from acoustic detectors mounted on turbine nacelles and approximately 20-meters above the ground on turbine monopoles, we explored spatial and temporal trends in bat activity and compared how effectively simulated curtailment strategies reduced risk to bats. To achieve our first objective, we applied generalized-additive models to measure biweekly changes in bat activity by detector height. Bat activity was

consistently higher at monopole-mounted detectors near the ground compared to nacelle detectors. At both detector positions, bat activity peaked during late summer months regardless of study year and wind energy facility.

For our second objective, we used linear models to determine the relationship between bat fatalities and acoustic exposure measured as a function of turbine rotor speed being above 1 rpm (a threshold where turbine-related fatalities may occur). Exposure was significantly correlated to bat fatalities on a biweekly basis regardless of detector height, although this relationship was stronger at nacelle-height. Linear models at both detector heights also correlated acoustic exposure measured by turbine operation and exposure simulated by turbine curtailment parameters. This provided evidence that acoustic exposure simulated as a function of wind speed can be representative of bat exposure to turbine operation for curtailment strategies under consideration.

To assess our third objective, we simulated a range of curtailment strategies with incrementally higher cut-in speeds and qualitatively compared the percent of exposed passes and rate of exposure across the season. The percentage of exposed bats does not vary seasonally, but consistent reductions in the magnitude of exposure, and therefore fatality risk, with increasing cut-in speeds were apparent throughout the season.

KEY PROJECT FINDINGS/TAKEAWAYS

- Acoustic exposure correlates with carcasses but characterizes fatality risk at a finer temporal scale.
- Risk likely varies spatially within the rotor-swept area as detectors sampling near the ground and lower rotor-swept area recorded substantially more bats than those deployed at nacelle height.
- Exposure to turbine operation varies seasonally as a function of wind speed and such variation is consistent between sites, years, and detector positions.
- Acoustic exposure is substantially better than carcass-based fatality estimates at differentiating effectiveness of curtailment strategies with similar parameters.
- Curtailment reduces acoustic exposure by a consistent proportion regardless of season, but the timing of when curtailment is most useful varies seasonally as a function of the amount of acoustic exposure.

NEXT STEPS

- Future studies should represent a wider geographic range to understand if the relationship between acoustic exposure and fatality risk varies among regions.
- Further exploration of species-specific flight patterns could better inform the parameters of curtailment regimes and understand how risk varies in the rotor-swept area.
- Integrating information from thermal imaging cameras could help determine spatial distribution of bats within the rotor-swept zone.

CITATIONS

Peterson, Trevor, Adam Rusk, Caroline Byrne, Seta Aghababian, and Sydney Edwards. 2025. " Acoustic Exposure Reveals Variation in Curtailment Effectiveness at Reducing Bat Fatality at Wind Turbines." *Ecosphere* 16(5): e70277. https://doi.org/10.1002/ecs2.70277

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