Bats and Wind Energy Cooperative
6th Science and All Committees Meeting

February 7, 8, 25; March 4; and September 7
Virtual Meeting

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Executive Summary

Overview

The Bats and Wind Energy Cooperative (BWEC or Cooperative) is an alliance of experts from government agencies, private industry, academic institutions, and non-governmental organizations that cooperate to develop and disseminate solutions to measure and mitigate the impact of wind turbines on bats, while maintaining the ability to develop and operate wind energy facilities in a competitive and cost-effective manner. The BWEC is overseen by the American Clean Power Association (ACP), Association of Fish and Wildlife Agencies, (AFWA), Bat Conservation International (BCI), Energy and Wildlife Action Coalition (EWAC), National Renewable Energy Laboratory (NREL), U.S. Department of Energy (DOE), U.S. Fish and Wildlife Service (FWS), and U.S. Geological Survey (USGS). In 2022, the BWEC's Oversight, Science Advisory, and Technical Advisory Committees met virtually on February 7, 8, 28, March 4, and September 7 for the 6th Science and All Committees Meeting to examine progress of the BWEC toward priorities established at the 2018 meeting, discuss emerging issues, and establish priorities for the Cooperative for the years 2023 to 2026.

During the virtual meetings, the BWEC committee members discussed the following topics:

- Current and future wind industry development
- Offshore wind energy development
- Bat populations
- Fatality estimation
- Bat behavior
- Minimization strategies, including curtailment and deterrent strategies
- BWEC strategic plan 2023–2026
- BWEC business

Research Priorities and Emerging Issues

The BWEC committee members identified research priorities for 2023–2026 in the following categories

- Population estimation, modeling, and data collection.
- Mortality estimation, modeling, and sampling
- Bat behavior at and around wind turbines
- Bat behavior at the landscape scale
- Curtailment
- Deterrence
- Other issues included: improved coordination with existing and potential partners, tracking offshore wind development, exploring policy options for implementation of practicable impact reduction strategies, and BWEC's niche and role for bat and wind energy issues.

Section 6.0 includes tables summarizing specific research priorities and activities by topic. The priorities the BWEC developed do not represent decisions on specific projects, plans, financing, and roles and responsibilities. Furthermore, these priorities are not exclusive to the BWEC or committee members and can be used by anyone interested in bats and wind energy research.

1.0 Introduction

The Bats and Wind Energy Cooperative (BWEC or Cooperative) is an alliance of experts from government agencies, private industry, academic institutions, and non-governmental organizations that cooperates to develop and disseminate solutions to measure and mitigate the impact of wind turbines on bats, while maintaining the ability to develop and operate wind energy facilities in a competitive and cost-effective manner.[1] The BWEC is overseen by the American Clean Power Association (ACP), Association of Fish and Wildlife Agencies, (AFWA), Bat Conservation International (BCI), Energy and Wildlife Action Coalition (EWAC), National Renewable Energy Laboratory (NREL), U.S. Department of Energy (DOE), U.S. Fish and Wildlife Service (FWS), and U.S. Geological Survey (USGS). The BWEC seeks solutions to identified problems and to provide scientifically credible recommendations for standardizing protocols, methodologies, and research designed to reduce risk to bats and support long-term, responsible wind energy development.

To further its work, the BWEC is organized and managed by a Program Coordinator, with oversight and direction from an Oversight Committee consisting of representatives from the above organizations. BWEC's Scientific Advisory Committee is composed of scientists who are leading experts on bat behavior and ecology or in other relevant fields, and who provide scientific guidance to the Program Coordinator and Oversight Committee. BWEC's Technical Advisory Committee is composed of experts and stakeholders from relevant industries, non-governmental organizations, and government agencies with wildlife management responsibilities, who provide insight on the feasibility and implementation of BWEC's objectives.

In 2022, members of all three BWEC Committees met virtually on February 7, 8, 28, March 4, and September 7 for the *BWEC 6th Science and All Committees Meeting*. The meeting purpose was to examine progress of the BWEC toward priorities established at the 2018 meeting, discuss emerging issues, and establish priorities for the Cooperative for the years 2023 to 2026. Several discussions built on pre-recorded webinars related to bat behavior, curtailment, deterrence, and mortality estimator performance (https://rewi.org/news-events/webinars/). BWEC committee members and invited speakers provided presentations to update workshop participants on BWEC progress and new developments. Each set of presentations was followed by a facilitated discussion, in which participants asked questions, made comments, and offered suggestions. High-level ideas were captured on shared Google Docs, and attendees had the opportunity to directly review and add comments during and after the meetings. Discussions also used Mentimeter for informal online polling to help explore potential priorities. Patrick Field and Stephanie Horii, of the Consensus Building Institute, facilitated the meeting.[2]

The lists of prioritized actions and activities that were produced in draft form by the end of the meeting were designed to inform Oversight Committee decision-making; they did not represent decisions on specific projects, plans, financing, and roles and responsibilities. Furthermore, these priorities are intended for stakeholders, and BWEC itself does not and cannot implement all priorities.

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[1] The first two paragraphs of this introduction are taken from the BWEC Charter, as revised in November 2021.

[2] See the Final Participant List, included as Appendix 1.

This document is a summary of the BWEC workshop discussions and priorities identified. It is intended to synthesize comments, questions, ideas, and presentations offered over the course of the BWEC meeting. Accordingly, it is organized by topic, rather than in chronological order, and aims to group together thematically similar discussion items. This document focuses primarily on the first four workshops related to BWEC priorities with a more succinct, high-level overview of the September 7 BWEC Business meeting.

2.0 Wind Industry Update

2.1 Overview of Current and Future Wind Development Related to Bats

2.1.1 Wind Industry Update

Stu Webster, American Clean Power Association (ACP), described the current and future state of the energy industry. Wind energy is the largest source of clean power in the country. Texas, California, and other Midwest states hold the main producers for wind energy; other states like Wyoming are expected to make larger contributions as long-distance transmission infrastructure develops. Offshore wind is expected to have considerable growth-continuing to expand in the Atlantic and establishing new projects in the Pacific and Gulf of Mexico. Substantially more resources will be needed for annual installations and transmission infrastructure, to meet the nation's clean energy goals.

Industry continues to be interested in bat research that aims to address population uncertainties, bat behavioral interactions with turbines, minimization measures, and other research priorities to achieve conservation objectives in lieu of allocating the continued high capital toward fatality monitoring. The presentation from the ACP suggested several areas of focus for the BWEC and/or other collaboratives. For the BWEC, suggested focal issues include decreased investment into fatality monitoring, greater interest in conservation research, addressing key data gaps such as time of fatality, and continued R&D and deployment of other minimization measures.

2.1.2 BWEC Committee Discussion

- Industry Trends and Progress
  - Two other types of renewable energy, hydropower and nuclear power, will likely have less significant impacts on the renewable energy portfolio in the coming years.
  - Advancements in transmission are expected to make substantial progress, which has been one of the major limitations for broader integration of renewable energy.
- Challenges
  - Competition occurs among energy sectors (primarily between wind, solar, and natural gas).
  - Projects continue to have unique issues, making it difficult to develop broad strategies for reducing risk costs.
  - Energy companies are dealing with tightening profit margins due to the increasingly competitive market, regulations, etc.
  - Multiple attendees cautioned that increasing climate change damages will likely increase renewable energy demand, which may override wildlife protection and conservation concerns.
  - Regulations and management requirements are often at the state and local level.
  - Stricter regulations may not be in the areas with the highest bat fatalities.
- Opportunities
  - If energy storage complications can be addressed, curtailment can be much more viable.

  - Knowing the time of fatality will help identify the conditions that could be contributing to bat mortality and inform how to fine-tune minimization strategies (e.g., reduce curtailment time). Acoustic monitoring (a relatively lower cost method) can help pinpoint time of exposure.
  - Better understanding of how industry evaluates acceptable energy loss can inform what level of accuracy is needed for curtailment and other minimization strategies. There is a continued need for focused discussions and analyses that identify and explore other market opportunities for reducing industry's costs (e.g., government incentives, distributing costs elsewhere in the supply-chain, etc.).
  - Incentives and regulations should better align with where curtailment is most needed (rather than develop nation-wide incentives and other strategies).

2.2 Offshore Wind and Bats

2.2.1 Update on Offshore Wind and Bats

Cris Hein, National Renewable Energy Laboratory (NREL), shared a high-level update on offshore wind activities relevant to bats. While major data gaps still exist, there have been advances in research and collaborative networks in support of better understanding potential impacts and offer guidance for future studies. Bat activity from shore generally ranges up to 130 km (with some observations much further offshore). Patterns of activity are similar to onshore (July-September; lower wind speeds and warmer temperatures).

Previously, the BWEC had identified a handful of priorities related to offshore wind. The BWEC discussion revisited if/how the Cooperative might want to engage in offshore wind-bats research.

2.2.2 BWEC Committee Discussion

- The BWEC's Potential Role
  - Are there important differences between land vs. offshore wind that warrant a BWEC focus? Overall, the BWEC members acknowledged that offshore wind would continue to be a major issue. They conveyed that the BWEC should remain engaged in offshore wind in some way to help avoid inadvertently missing crucial, big picture information gaps.
  - Many of the land-based challenges, needs, and solutions should have substantial overlap with offshore wind energy issues. Several committee members suggested incorporating offshore wind with the existing priorities as an efficient approach given the BWEC's current limited capacity.
  - Some felt more strongly than others that the BWEC should take on a greater leadership role. Given the anticipated exponential growth in offshore wind development, some committee members felt it is important to get ahead of potential problems.
  - Management agencies (particularly state and local) struggle to keep pace with the rapidly developing offshore wind industry and state of the science and management best practices. Many would likely appreciate more formal and/or supportive role from the BWEC or a similar trusted 3rd-party science-based entity (the BWEC has the benefit of being a long-standing body and may be better suited to take on a leadership role).

    - Consider enhancing engagement with key offshore partners like the Bureau of Ocean Energy Management (BOEM).
- Research Questions
    - How can experimental design and monitoring frameworks, management, and minimization strategies, etc. be modified from land-based strategies for offshore wind energy projects?
    - What are the proportion of impacts on different bat species' populations that can be attributed to offshore wind vs. land-based wind activity? Even a relative order of magnitude estimate could be meaningfully useful.
    - Under what conditions might a bat choose to redirect its path to an offshore wind turbine?

3.0 Bat Populations & Mortality Estimation

3.1 Population Analysis of Bats

3.1.1 Progress toward 2018 Priorities

Cris Hein (NREL) summarized progress related to BWEC's 2018 priorities on population estimation:

2019–2021 Objective	Action	Notes	Activities or Reports focused on Action
Estimate populations & put in context mortality & effectiveness of minimization	1) Refine models & recognize limits 2) Include build out, minimization, etc. 3) Estimates for other species	1) Better precision of existing or new population estimates 2) Build on strengths & limitations of publications related to the population impact of wind energy	• EPRI 2020 • Friedenberg & Frick 2021 • Cornman et al. 2021 • Davy et al. 2021
Collect genetic & demographic data	1) Develop approach for sampling & storage 2) Coordinate among researchers		• Chipps et al. 2020 • Several sites offering 100s-1000s of carcasses • Effort to create data repositories or nodes
Synthesize genetic & population analysis data	1) Summarize approaches & level of effort 2) Summarize data on status & trends	Add gaps in understanding and next steps for research and data collection	• Hale et al. 2022 • NABat status & trends

3.1.2 Bat Populations Overview and Updates

Winifred Frick, Bat Conservation International (BCI), shared the latest information on bat populations and wind energy impacts. Using the hoary bat as an example (one of the non-listed species of greatest concern in North America), Dr. Frick reviewed how studies estimated potential population-level impacts due to wind turbines and calculated fatality minimization targets meaningful to population viability. Dr. Frick explained no universal minimization target exists; targets vary depending on factors such as species biological growth rate, local and large-scale population sizes and growth rates, site-specific environmental factors, etc. Currently studies estimate 50% of the hoary bat population could be lost in the next seven years. Dr. Frick expressed urgency for immediate and enhanced intervention (e.g., rapid and broader adoption of relatively well-studied approaches like curtailment) to effect meaningful change in the rapid decline of hoary bats.

Understanding bat populations requires aggregating many data sources across wide ranges in time, location, etc. Dr. Frick provided an update on the North American Bat (NABat) monitoring program, which helps obtain more precise estimates for underlying data that are critical for understanding the population status and trends for bat species. The first status and trend models are expected in 2022. Current types of accepted data include acoustic data, colony and emergence counts, and capture records. NABat also expects to share an updated NABat master sample grid framework that has been adapted for offshore.

3.1.3 BWEC Committee Discussion

- Remaining Information Gaps
  - NABat can help identify and understand population trends. It cannot accurately estimate total number of bats. The intent is to narrow the variability in our understanding of populations.
  - Committee members also stated that while policy discussions are important for effective management, key data gaps still exist that warrant the BWEC's attention (e.g., bat behavior and population estimation). Other information gaps mentioned included:
    - Minimization strategies are typically applied at times of highest risk, not during the full period in which bats are active and at risk.
    - Exploring all underlying causes that contribute to bat mortality at wind turbines to better predict risk and develop a solution (or package of solutions) to avoid bat fatality risks.
- The BWEC's Potential Role
  - The BWEC has decreased focus on pre-construction monitoring. There was a suggestion to focus more on contributing to NABat to help address large-scale questions, and on post-construction surveys to assess bat exposure.
  - Several committee members conveyed substantial information about bats and minimization strategies exist, insinuating more focus should go toward enhancing implementation. The group was asked what technological or scientific information is needed to inform the policy realm. There was a suggestion to identify a target or goal for minimization (even if the goal is imperfect) - What is a meaningful level of reduction in fatalities? What does it take to reach that target?
- Other Policy-Related Considerations
  - In North America, what needs to be done to implement meaningful changes to adequately address the urgent threats to bat populations? Substantial information and data exist; the major hurdles appear to be related to market, social, and regulatory challenges.

- In the U.S., the strongest regulatory tool is predominantly reactionary by focusing on species near extinction. Are there policy levers that can be more proactive to avoid listing? What action might influence FWS' listing decision?
- Several raised concerns about compliance costs and permitting requirements if hoary bats are listed (e.g., want to avoid project by project HCPs). These hurdles could substantially create a bottleneck and contribute to an overall energy problem. There is a need to bring in the financing community / utilities into the conversation.
- Incentive suggestion: If you are an early adopter of curtailment or other minimization strategies that have a beneficial effect on non-listed species, then you should more easily get some take protection should that species become listed in the future.

Additional information and comments can be found in the BWEC 2023–2026 Priorities Table ***Section 6.1****: Population estimation, modeling, and data collection.*

3.2 Mortality estimation

3.2.1 Progress toward 2018 Priorities

Cris Hein (NREL) summarized progress related to BWEC's 2018 priorities on fatality estimation, modeling, and sampling:

2019-2021 Objective	Action	Notes	Activities or Reports focused on Action
Update GenEst	Develop DWP module		• Dalthorp et al. 2022
Promote use of GenEst	1) Provide training 2) Follow up to assess who is using it, how it is being used & what improvements might be needed	Conduct workshops and webinars to train end users	• Numerous web & in-person trainings conducted
Develop a standardized, sampling method	1) Develop roads & pads search protocol 2) Estimate cost of adoption 3) Assess if suitable for rare events	1) Reduce costs associated with monitoring 2) Standardize monitoring protocols As new methodologies are developed, ensure acceptance	

3.2.2 Overview of Mortality Estimation

Pre-recorded presentation: Performance of the GenEst Statistical Mortality Estimator: https://rewi.org/webinars/performance-of-the-genest-statistical-mortality-estimator/

Cris Hein (NREL) provided an overview of recent advancements and studies related to mortality estimation, modeling, and sampling. Key points included:

- Robust databases like the Renewable Energy Wildlife Institute's AWWIC and Western EcoSystems Technology's RENEW have expanded substantially in recent years, and recent 2020 reports offer mortality estimates by region in the U.S. (AWWIC 2020) and US and Canada

(RENEW 2020). However, while some comparability exists across different databases, they are not fully comparable. This emphasizes the need to be aware of limitations in large datasets and explore how to encourage more standardized methods for database inputs and reporting.
- Bat fatality timing can vary across species at a given location. Therefore, one blanket curtailment strategy customized to one species may not result in similar or meaningful fatality reductions for other species.
- One study explored whether mortality changed when taller/larger turbines were deployed. The study found a weak correlation between fatality rates and turbine size variables, with fatality rates generally peaking at intermediate turbine sizes.
- The Generalized Mortality Estimator (GenEst) performed as well as or better than other similar estimators in modeled simulations.
- Improving mortality monitoring or exploring alternatives continue to be of high interest. Mortality monitoring is particularly useful in data-poor areas (e.g., areas with little pre-existing wind energy development)

<u>3.2.3 BWEC Committee Discussion</u>

- <u>Large Datasets</u>
    - Are there regions that have sufficiently enough data to reduce monitoring requirements?
    - Data from industry remains a challenge. The Electric Power Research Institute (EPRI) developed a white paper that describes these challenges for industry and insight on industry involvement with large database efforts.
- <u>Mortality Estimation</u>
    - All estimators come with uncertainty; GenEst has the advantage that it gives the level of uncertainty. It can also support parsing estimates out to explore subsets (e.g., estimates/individual turbine), although this inherently increases uncertainty.
- <u>Value of Mortality Monitoring</u>
    - Mortality monitoring serves as management agencies' most widely accepted management requirement for project permits.
    - Identifying the species is important and should be recorded and reported using genetics as necessary to confirm species identity. Carcasses and genetic analyses help accurately identify species.
    - Forecasting potential mortality still has high uncertainty and would likely require mortality monitoring to verify estimates.
- <u>Alternatives to Standard Mortality Monitoring</u>
    - How can we use statistics and modeling to better understand risk at a landscape scale? Can models be robust enough to address regulators and others' concerns and result in more efficient and lower cost approaches and management requirements?
    - Developing good models requires good data, which are not available.
    - Should the BWEC help develop guidance on new technologies and methods (e.g., drones, cameras, strike detectors, etc.)?
    - Some states will accept a tradeoff (e.g., reduced mortality monitoring if the project implements curtailment strategies), which helps address industry's concerns with high

  - monitoring costs. However, some committee members cautioned against widely adopting this approach without thoroughly considering the unintended consequences (e.g., reduced data inhibits the ability to validate strategies, detect or track risks, etc.).
  - Alternatives such as acoustic detectors, camera systems, and strike detectors can help identify and analyze the specific conditions under which a fatality occurs; a level of specificity that standard mortality monitoring cannot do. These alternative methods would lend themselves to more responsive and effective adaptive management.

Additional information and comments can be found in the BWEC 2023–2026 Priorities Table ***Section 6.2****: Mortality estimation, modeling, and sampling.*

4.0 Bat Behavior

4.1 Bat Behavior at and around Wind Turbines

4.1.1 Progress toward 2018 Priorities

Cris Hein (NREL) shared the status for the following 2018 BWEC research priorities for bat behavior at and around wind turbines:

2019–2021 Objective	Action	Notes	Activities or Reports focused on Action
A decision framework for behavior studies	Research questions for behavioral studies (primarily focused on thermal video) ranked by species, & priority, & what methods/tools are best suited	Can thermal video cameras… 1) Quantify bat-turbine interactions 2) Compare behavior among treatments 3) Correlate observed bat collisions with wind speed, temperature, etc. 4) Assess the location of collisions 5) Refine placement of deterrents?	• BWEC 2021.
Use thermal videography to understand bat activity & behavior near wind turbines	Conduct experimental studies to refine how thermal videography can be used to answer specific questions		• Gorresen et al. 2020 • Goldenberg et al. 2021
Refine thermal videography field, analysis, and modeling methodology	Refine equipment, methods, processing & modeling, including 3D analysis	Consider how to use in conjunction with other methods (e.g., acoustics or fatality estimation surveys)	• *thruTracker* • *ThermalTracker-3D* • Other systems in development by NREL & Wildlife Imaging Systems
Monitor strike detection technology	Support efforts to develop fatality detection tools that can identify timing & conditions of impacts	Support efforts on integrated detection & strike systems Combine technologies to get ID species	• Ongoing research through Oregon State University & WEST

4.1.2 Bat Behavior at Turbine Scale Overview and Updates

Pre-recorded webinar: Bat Behavior and Interactions with Wind Turbines (Turbine Scale and Landscape Scale): https://rewi.org/webinars/bat-behavior-and-interactions-with-wind-turbines/

Cris Hein (NREL) summarized several of the research updates mentioned in the webinar related to bat behavior at or around wind turbines. Key insights included:

- Seasonal increased interactions and risky behavior with turbines were observed at a study area in Boulder, Colorado: in late summer-early fall, bats spent more time in and around the rotor swept area.
- Many studies have explored various hypotheses related to bat attraction to turbines, including potential drivers (roosting, foraging/water, and mating), signal cues (noise, light, and olfaction), and sensory mechanisms (sight, hearing, and olfaction).
    - Drivers: studies found evidence for multiple drivers supporting the theory that bats may be attracted in some way to turbines and exhibiting "risky" behavior (e.g., flying through the rotor swept area).
    - Cues: for triggers, not much evidence links anemometer noise with bat mortality; different species may cue to different light wavelengths; structures may be marked (by bats, insects, etc.) attracting other individual bats (no concrete evidence yet).
    - Sensory mechanisms: bats may be responding to a series of sensory pollutants that may mask, distract, or mislead behavior.
- Advances in data-sharing and analysis tools are helping to produce more cost-effective information, including 3D flight tracking, real-time analyses, calculated velocity, and pairing observations with other data.

4.1.3 BWEC Committee Discussion

Workshop participants discussed the following issues:

- Sensory Cues
    - Committee members speculated that insectivores and solitary species may not rely on olfaction as much as their counterparts (fructivores and colonial species, respectively). That said, there still could be olfaction cues that trigger a behavioral response among insectivores/solitary species (e.g., insects marking, or bat strikes with the turbine).
    - Studies have focused on olfaction recently in part due to evidence of sequential and concentrated attraction within a relatively short time ("flash mob" behavior)
- Turbine Features and Activity
    - Bats are observed interacting with wind turbines when they are operational and non-operational.
    - Do bats respond differently depending on turbine height, size, etc.?
    - How does bat behavior change among a group of turbines or at a facility-level?
- Research and Management Considerations
    - How well can thermal cameras detect bat movement when bats are flying at their highest speeds? It would be interesting to better understand bat activity at high flying speeds when turbines are also at full speed rotation.

- Committee members reiterated the implications of the wide diversity in bat behavior among species.
- Several committee members suggested focusing on the attractants that can inform different management actions.

*Additional information and comments can be found in the BWEC 2023–2026 Priorities Table **Section 6.3**: Bat behavior at and around wind turbines.*

4.2 Bat Behavior at Landscape Level

4.2.1 Progress toward 2018 Priorities

Cris Hein (NREL) shared the status for the following 2018 BWEC research priorities for bat behavior at and the landscape level:

2019–2021 Objective	**Action**	**Notes**	**Activities or Reports focused on Action**
Assess temporal & spatial movements	1) Relate movements to minimization 2) Support MOTUS 3) Continue tagging	1) Coordinate effort for MOTUS 2) Use PIT tags & provide readers to projects conducting monitoring 3) Use of GPS/Geolocater tags	• Ongoing efforts
Assess fatalities & landscape features	Use spatial modeling to determine if features relate to bat fatalities in predictable ways	May be useful in siting wind energy development in areas of low risk	• Farnsworth et al. 2021 • Wieringa et al. 2021 • Davy et al. 2020
Collect & submit acoustic data in BatAmp & NABat	Provide pre-construction acoustic data (& other data) to USGS & USFS	Connect interested stakeholders to address privacy protections	• Upcoming NABat status & trends report
Synthesize movement data	Use acoustic data, stable isotopes & tags to inform movements	Associate movement patterns with weather & landscape variables	• Brewer et al. 2021 • Murtaugh et al. 2019

4.2.2 Bat Behavior at the Landscape Scale

Pre-recorded webinar: Bat Behavior and Interactions with Wind Turbines (Turbine Scale and Landscape Scale): https://rewi.org/webinars/bat-behavior-and-interactions-with-wind-turbines/

Cris Hein (NREL) summarized several of the research updates mentioned in the webinar related to bat behavior at the landscape scale. Key insights included:

- A large dataset in Canada found species-specific changes in mortality linked with landscape-scale features. Mortality increased among tree-roosting bats with woodlot cover, and big brown bat mortality decreased with elevation.
- For migratory species, their routes might differ depending on the season.
- Species of concern (e.g., hoary bat) had significantly high seasonal occurrences in developing/prospective wind energy areas (e.g., southwest), underscoring a need to gather more information in these data-limited regions.

- New or enhanced advancements in tracking technologies and frameworks play a major part to address larger-scale bat movements. MOTUS stations are increasing but are still sparse in west and Midwest. Tracking frameworks and installations should aligned with bats' migration.

4.2.3 BWEC Committee Discussion

- What features affect bats at the landscape scale, and if/when/how does behavior change as they get close to a wind farm or wind turbine?
- Are bats attracted to offshore turbines?
- Are there attractants to draw bats away from wind farms?

Additional information and comments can be found in the BWEC 2023–2026 Priorities Table ***Section 6.4****: Bat behavior at the landscape scale).*

5.0 Minimization Strategies

5.1. Curtailment

5.1.1 Progress toward 2018 Priorities

Cris Hein (NREL) shared the status for the following 2018 BWEC research priorities on curtailment:

2019-2021 Objective	Action	Notes	Activities or Reports focused on Action
Summarize curtailment studies	1) Summarize effectiveness 2) Assess difference among species & regions 3) Quantify industry implementation 4) Identify barriers to adoption & ways to increase		• Whitby et al. 2021 • Adams et al. 2021
Replicate smart curtailment studies	1) Assess in different landscapes, species, etc. 2) Develop standard metrics 3) Refine parameters		• Hayes et al. 2019 • DOE-funded studies, including Stantec, REWI, EPRI, and Natural Power
Verify effect of feathering to the manufacturer's cut-in speed	Replicate studies & assess for different species & turbines		
Develop a curtailment decision tool	Consider feasibility of a support tool to assist in designing practicable curtailment strategies		

5.1.2 Curtailment Overview and Updates

Pre-recorded webinar: Bat Impact Minimization Part 1: Curtailment: https://rewi.org/webinars/bat-impact-minimization-webinar-curtailment/

Cris Hein (NREL) summarized several of the research updates mentioned in the webinar related to curtailment. Key insights included:

- Curtailment synthesis reports concluded that, in general, higher cut-in speeds can further reduce mortality but noted several important caveats to consider and suggested additional studies are needed.
- Smart curtailment (e.g., bat activity-based) has shown significant reductions in fatality while reducing the loss of AEP. In a report by EPRI, models showed a reduction in Annual Energy Production (AEP) using smart curtailment relative to blanket curtailment; however, some experts have concerns that AEP tells a limited story on the financial impact.
- Obtaining data to better understand curtailment costs and the financial impact for industry remains a challenge for researchers.
- Technological advancements such as acoustic technologies have substantially helped researchers better understand mortality and bat activity when exposed to turbine operations. Researchers are exploring broad wind-related weather variables that could help predict when high activity or risk may occur. It has long been known that temperature is an important predictor of bat activity but its consideration in curtailment regimes has only recently been adopted.

5.1.3 BWEC Committee Discussion

Workshop participants discussed the following issues:

- Data Analyses
    - Consider examining the proportion or amount of time at a site when the wind speed is greater or less than the cut-in speed being tested. Exploring this factor may help deal with some of the variance across different sites.
- Curtailment costs and conservation value
    - Increased cut-in speed and AEP loss are not linearly proportional. The higher the cut-in speed, the much greater loss in AEP.
    - How does cut-in speed relate to conservation value? Where does the conservation value ever begin to level off even with increasing cut-in speed?
- Evaluating Effectiveness
    - Many committee members emphasized the importance of setting clear conservation goals (e.g., mortality reduction percentages or mortality thresholds). Different stakeholders need to be part of this conversation. For instance, industry can convey what they can financially absorb to reach a particular mortality reduction target; however, they will need other stakeholders to confirm if that mortality reduction target is acceptable (e.g., ensures a certain level of population sustainability).
    - Several committee members suggested approaching curtailment in terms of target level of mortality reduction rather than cut-in speeds.
- Management and Policy Considerations
    - Can industry and agencies explore regulatory mechanisms for implementing minimization strategies for non-listed species that offer some assurances even if the species becomes listed later in the future?

- Several committee members conveyed the scientific community, regulators, and industry need to discuss more broadly how to advance the conservation goals and address challenges for implementing minimization strategies like curtailment. Committee members cautioned this topic, while important, seemed outside the BWEC's scope.

Additional information and comments can be found in the BWEC 2023–2026 Priorities Table ***Section 6.5****: Curtailment.*

5.2 Deterrence

5.2.1 Progress toward 2018 Priorities

Cris Hein (NREL) shared the status for the following 2018 BWEC research priorities related to deterrence:

2019-2021 Objective	Action	Notes	Achievements
Advance deterrent technologies	1) Conduct research on existing technologies 2) Monitor emerging technologies	Enhance studies by incorporating 3D thermal videography	• Romano et al. 2019 • Weaver et al. 2020 • BCI 2020 • Cryan et al. 2022 • NREL and DOE-funded projects, including Mide, Iowa State U., and UMass-Amherst
Investigate the effective range of ultrasonic acoustic deterrents	1) Evaluate ways for greater coverage 2) Investigate using smaller RSA		• NREL-led study using flight cage (In prep)

5.2.2 Deterrence Overview and Updates

Pre-recorded webinar: Bat Impact Minimization Part 2: Deterrence: https://rewi.org/webinars/bat-impact-minimization-webinar-deterrence/

Cris Hein (NREL) summarized several of the research updates mentioned in the webinar related deterrence. Key insights included:

- Overall, deterrent studies have found deterrent effectiveness often varies across species (i.e., responses can vary even within the same genus).
- Researchers continue to explore different acoustic deterrent technologies (e.g., pneumatic air systems and piezoelectric transducers).
- Some species, such as red bats, are difficult to deter regardless of the acoustic technology.
- Little research exists exploring combinations of curtailment and deterrent strategies. One study found some evidence that a combination of curtailment and deterrence could work for silver haired bats (variability was still high though).

- Blade-mounted technologies are still in lab and preliminary testing phases.
- UV light illuminating turbines did not significantly change bat, insect, or bird activity. Count and duration of bat detections trended positive with UV light but was not statistically significant.

5.2.3 BWEC Committee Discussion

Workshop participants discussed the following issues:

- Species Specific Considerations
  - Several committee members reemphasized studies should analyze different deterrence strategies at the species level.
  - Are there deterrent technologies that work for specific species, especially species of concern like the Hoary bat?
  - With the help of acoustic identification software or AI, could deterrence technologies modulate acoustic frequencies based on the detected species present?
- Viability Considerations
  - Committee members generally support further exploring deterrent technologies, but many feel the strategies are not sufficiently viable for broad adoption and implementation.
  - Do deterrents need to cover the full rotor swept area?
  - How might deterrent technologies need to adapt to evolving turbine features and arrangement (i.e., taller, larger turbines that are spaced further apart)?
  - Industry pointed to multiple challenges for adopting new deterrent technologies, including: the company developing the deterrent no longer exists or supports the technology; the turbine manufacturer may be unable to modify the structures without voiding warranties; limited terms and conditions under the power purchase agreement; and other unanticipated costs to install and implement new technologies.
- The BWEC's Role
  - Should the BWEC play a role to advance deterrent technology, and if so, what role should the Cooperative play? Should the BWEC concentrate support to a particular approach (high investment, high rewards), broadly support multiple promising approaches, etc.?

Additional information and comments can be found in the BWEC 2023–2026 Priorities Table ***Section 6.6****: Deterrence.*

6.0 Priorities for 2023–2026

The draft set of prioritized objectives and actions produced during the meeting are intended to inform BWEC decision making and, more broadly, provide the bats and wind energy stakeholder community a set of research recommendations. BWEC committee members were asked to rate each individual objective by **P = priority** (1= high; 5 = low) and **F = feasibility** (1 = easy; 3 = difficult). Average ratings are presented. In general, lower scores indicate a higher priority. Scores for priority and feasibility are based on BWEC committee members that were present and voted on the day the priority topic was discussed and do not reflect the average of the entire BWEC committee membership. These objectives and actions do not represent decisions on specific projects, plans, roles and responsibilities, or financing.

These tables reflect the discussion and feedback of BWEC committee members at and after the workshop and are listed in order of priority.

6.1 Population Estimation, Modeling, and Data Collection

P	F	Objective	Actions	Comments
1.3	1.6	A. Summarize existing data on bat populations considered at risk from wind turbine strikes	• Summarize population estimates for each species and include methodology, data gaps, etc.	• Potentially be an online tool • NABat is working towards this goal • Assess the proportion of the population of bats that move/migrate offshore
1.5	2.1	B. Use available data and advance methodologies to corroborate findings on population status and trends	• Build a weight of evidence on the population status and trends using acoustic, genetic, and other data sources	• Effectiveness increases with data sharing • NABat collects data using several methodologies
1.7	1.6	C. Contributing acoustic data to NABat and BatAMP	• Contribute data associated with wind energy projects	• Continue to address barriers to sharing data. • Consider specific data needs or priorities by species, region (identifying gaps) • EPRI trying to gather acoustic and other data from members that could contribute • The Bat Acoustic Monitoring Portal (BatAMP) is another repository for acoustic data

P	F	Objective	Actions	Comments
2.6	1.6	D. Use large scale datasets to answer questions related to sustainability	• Relate population data collected from NABat, or other sources to bat mortality data from Birds Canada, REWI, WEST, or other sources	• NABat is able to report out on the status of many species • NaBAT cannot do causality or correlation, but can provide context relevant data (location, trends, and changes in distribution) and at different scales (down to 10x10 km) for mortality questions and species differences
3.0	1.8	E. Develop infrastructure and communication system for genetic data	• Establish repositories/nodes for genetic data and provide guidance on how to access data for use in various studies	• This effort is underway, but requires additional support

Average Ranking are based on an informal poll, conducted using Mentimeter). Number of participants ranged from 17 – 19 committee members. F = Feasibility (1=Easy, 3 = Difficult); P = Priority Level (1 = High, 5 = Low). For more details (e.g., spread of responses), refer to the screenshots of results in Appendix C.

6.2 Mortality Estimation, Modeling, and Sampling

P	F	Objective	Actions	Comments
1.5	2	A. Evaluate alternatives to standard post-construction mortality monitoring	• Comparing results between standard post-construction mortality monitoring with new approaches, (e.g., strike detectors, camera systems, drones, etc.) • Identify biases from other tools to monitor mortality	• Alternative methods of mortality monitoring can provide timing and conditions of fatality • NREL is planning a workshop on mortality monitoring methods (e.g., roads and pads searches) and technologies (e.g., drones, camera-based systems, strike detectors)
1.8	1.8	B. Contribute mortality data to already established repositories (e.g., Birds Canada, REWI, WEST) and update bat mortality estimates	• Fill in data gaps within existing databases • Use large databases to update mortality estimates at the regional, country, continent scale	• The total bat mortality estimates published in peer-reviewed literature due to wind strikes are outdated (>10 years old) and biased • Need to get data from Mexico

P	F	Objective	Actions	Comments
2.1	1.4	C. Assess mortality at a regional level or species range	• Use large data sets to assess mortality at the regional-scale or species range	• Birds Canada, REWI, and WEST already have large databases, but accessibility may be limited. Additional data sources can come from industry, government agencies
2.1	2.7	D. Estimate total population sizes, and sustainable mortality	• Build on Friedenberg & Frick 2021 publication for hoary bats and develop targets for other species.	• Options include conducting an expert elicitation for some species (e.g., silver-haired bats) or using existing population data from hibernacula counts (e.g., little brown bats)
2.2	1.7	E. Determine whether post-construction acoustic monitoring relates to mortality	• Relate post-construction acoustic activity and mortality, specifically using activity data when turbines are operational (or exposed activity).	• Peterson et al. (2021) is an example of this, and additional studies are underway. • If a relationship exists, a) it may be used to assess mortality levels in lieu of standard post-construction monitoring, and b) used to inform curtailment strategies
2.6	1.6	F. Determine how changes in turbines dimensions relate to mortality	• Use large data sets to compare mortality to different turbine types (e.g., height, rotor-swept area) • Determine whether larger turbines require larger search plots for standard post-construction monitoring	• Renewable Energy Wildlife Research Fund supporting a project with TetraTech to evaluate this relationship with AWWIC and Birds Canada data • Huso et al. (2021) found fatality rate was constant per unit energy produced, across several sizes and spacings of turbines in a wind energy area in Southern California
2.6	1.8	G. Assess mortality in new regions with different species	• Conduct post-construction mortality monitoring at sites in the regions where wind energy deployment is limited but increasing	• It is important to have these data accessible to understand the potential impact on species in these new regions • At minimum contribute data to established data repositories (REWI and WEST) and publish results

P	F	Objective	Actions	Comments
3.0	1.5	H. Determine if different turbine models have different fatality rates	• Use large data sets (e.g., Birds Canada, REWI, WEST) to relate turbine characteristics (e.g., cut-in speed) and mortality	• Perhaps different turbine types have different attractive properties.

Average Ranking are based on an informal poll, conducted using Mentimeter). Number of participants ranged from 17 – 19 committee members. F = Feasibility (1=Easy, 3 = Difficult); P = Priority Level (1 = High, 5 = Low). For more details (e.g., spread of responses), refer to the screenshots of results in Appendix C.

6.3 Bat Behavior at and around Wind Turbines
(*Several of these priorities are the same or complement research goals outlined in the BWEC (2021) Research Goals for Studying Bat Behavior at the Wind Turbine-scale report)

P	F	Objective	Actions	Comments
1.6	2.0	A. Characterize bat behavior at the turbine- or facility-scale	• Relate bat observations with spatial, temporal, operational, and weather conditions. • Investigate potential attraction hypotheses. • Assess species-specific behaviors including attraction • Estimate the distance bats alter direction to interact with wind turbines	• Requires multiple technologies to address gaps in behavior • Understanding these and other behavioral and physiological drivers may help improve minimization strategies (e.g., what is the best deterrent stimuli to reduce interactions)
1.2	2.1	B. Evaluate the response by bats to minimization strategies	• Examine how bats respond to deterrent stimuli. • Assess optimal placement options for deterrents. • Evaluate potential habituation to deterrents.	• Quantifying the response behavior to deterrent stimuli may improve technologies or placement options for deterrents • These studies can be done at a flight cage, in natural settings, or at wind energy facilities

P	F	Objective	Actions	Comments
			• Assess whether cameras are an effective technology for smart curtailment	• Cameras have a larger detection field than acoustic detectors and can observe bats when they may not be echolocating • What is the scalability of the technology solution to existing and new wind farms?
1.8	2.0	C. Advance technology, methods, and analysis tools for behavioral research studies	• Fully automate video detections, classifications, and flight tracks. • Standardize field methods for setting up equipment, reporting, and transmitting data • Identifying the minimum number of sensors and their positioning, needed	• What is the scalability of the technology solution to existing and new wind farms? • Assess whether it is possible to use high-definition video together with AI to ID species?
1.9	2.1	D. Characterize bat strikes with wind turbines	• Identify where bats are in the rotor-swept zone • Identify if there are specific locations bat collisions occur. • Relate bat strikes with spatial, temporal, operational, and weather conditions • Assess the effectiveness of camera position to quantify mortality.	• Understanding this may help focus where to monitor with cameras, where to place acoustic detectors to get the best relationship between activity and mortality, and where to focus deterrent stimuli • Requires both visual and acoustic tools • Machine learning algorithms are making it more efficient to process and analyze acoustic and video data • The larger field of view of a camera relative to the volume of airspace that can be sampled acoustically certainly provides more behavioral data
2.8	2.8	E. Determine whether bats are attracted to offshore wind turbines	• Use a suite of technologies to monitor bat interactions with offshore wind turbines	• Are the potential attractions the same as observed at land-based wind turbines? Knowing this information may help with

P	F	Objective	Actions	Comments
				siting and providing the right deterrent stimuli to reduce interactions • Radar, tags, cameras, acoustic arrays. • Need to establish the infrastructure (Motus stations, locations to place monitoring equipment, etc.)

Average Ranking are based on an informal poll, conducted using Mentimeter). Number of participants ranged from 17 – 19 committee members. F = Feasibility (1=Easy, 3 = Difficult); P = Priority Level (1 = High, 5 = Low). For more details (e.g., spread of responses), refer to the screenshots of results in Appendix C.

6.4 Bat Behavior at the Landscape Scale

P	F	Objective	Actions	Comments
2.1	2.2	A. Advance tagging devices and tools for tracking bats	• Partner with developers on miniaturization • Need a concerted effort to tag numerous bats	• Reduce mass/size of tags to be used on bats for GPS monitoring • There are several types of tags (e.g., GPS, radio, satellite) that vary in cost, mass, etc.
2.1	2.8	B. Determine how and why bats use the landscape and whether there are any relationships related to where wind energy facilities are sited (either land-based or offshore wind)	• Increase Motus stations, especially near existing and proposed facilities • Prioritize attachment of tags to species most impacted by wind energy • Use remote sensing (e.g., radar and lidar) to monitor movement near proposed and existing facilities • Use existing data to relate species-specific mortality to landscape conditions	• Start in areas with high Motus coverage (NE U.S.; Great Lakes) & build on the network by adding stations near wind energy facilities • Pair movement data with weather data • Need to establish the infrastructure to monitor offshore activity and work with the wind industry and OEMs on integrating monitoring technologies with wind turbines • Identify shifts in migration or other changes in occurrence over time

P	F	Objective	Actions	Comments
2.7	2.3	C. Determine whether potential attractants can be used and/or managed	• List attraction hypotheses (e.g., roosting) along with scale, whether it applies to land-based and offshore wind, and the potential approaches to manipulate or manage the attractant • Review non-wind attraction studies and how to apply findings to wind energy studies	• Can the attraction be managed during project siting, turbine design, or turbine operation? • If attractants are identified, can they be used to lure bats outside of a wind energy facility and is it a practicable minimization approach? • Examples include creating adjacent foraging or roosting habitat to draw bats from turbines • Might be relevant with tracking/tagging bats as well to capture for tagging • Recent studies have attempted to lure Florida bonneted bats and hoary bats to mist nets

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6.5 Curtailment

P	F	Objective	Actions	Comments
2.1	2.5	A. Evaluate the effectiveness of curtailment strategies for rare species (e.g., threatened and endangered bats)	• Use exposure rates, as measured by nacelle-mounted acoustic data, at different cut-in speeds. Use data from multiple sites to increase sample size	• Is it possible to analyze these data given low sample size? Can a meta-analysis be conducted? • Exposure rates can be determined from acoustic data if properly collected
2.3	2.2	B. Assess the economics of curtailment	• Analyze empirical turbine operation data vs. weather data to see how turbine operation varies and how such variation relates to mortality • Build a standardized tool that allows operators and regulators to estimate	• For example, comparing RPM vs wind speed from 0–8 m/s • DOE-funded studies are looking into some of the economic aspects across 4 studies. • Some factors to consider are wind speed conditions, market price, and turbine type

P	F	Objective	Actions	Comments
			lost AEP at various cut-in speeds based on meteorological data. • Identify and quantify all costs related to implementing curtailment	
2.3	2.2	C. Assess where curtailment would be the most beneficial	• Use existing data to map mortality rates, weather data, and estimated effectiveness of curtailment strategies to assess which sites are best suited for curtailment • Evaluate the conditions at offshore wind energy facilities (e.g., nightly wind speed, turbine cut-in speed, etc.) to determine the applicability of curtailment	• Curtailment may not be necessary everywhere and it may be beneficial to evaluate where curtailment would have the greatest impact on a species
2.4	1.6	D. Examine and summarize data on the number of facilities using curtailment across North America	• Determine how many sites are using curtailment and detail the specific curtailment scenario being used at each site (e.g., what is the cut-in speed, when it is implemented over the period of a year and from year to year), are there other factors, such as temperature being used, etc.)	• Some data are available (e.g., facilities with Incidental Take Permits), other data needs to be gathered from those curtailing voluntarily. Some States/Provinces have requirements for curtailment based on permitting and/or thresholds • The AWWIC database does ask whether a site is curtailing, but the technical reports exclude sites with curtailment. It is possible to explore what data are available in the AWWIC and other databases • Knowing how many sites are implementing curtailment can help inform future modeling efforts

P	F	Objective	Actions	Comments
				• Determine how many sites are following the Best Management Practice established by the American Wind Energy Association in 2015?
2.7	2.1	E. Identify an alternative metric for curtailment effectiveness than carcass counts	• Determine if sensor-based data (e.g., acoustic detectors or thermal cameras) can be used to quantify the effectiveness of curtail	• Acoustic exposure has shown a positive correlation with fatality rates in some cases (Peterson et al. 2021). There is ongoing research in different regions • Need to establish recommended practices for measuring acoustic data at the nacelle (e.g., placement, equipment reliability, survey effort needed to yield sufficient sample size, data analysis methodology). • Can also pair cameras and acoustics to measure exposure. Acoustics provide information on species composition but can sample only a small proportion of the rotor-swept area. Thermal cameras can monitor a larger area, but at present provide no species-specific information
2.7	2.3	F. Determine whether deterrents + curtailment is added value	• Conduct experimental study using control turbines and treatment turbines, including deterrents, low speed curtailment, and both	• BCI (2020) Report from DOE-funded study • Good et al. 2022. Study in Illinois • In association with the study, include the economic aspects of this approach (i.e., is it economically feasible to curtail and purchase/installation/maintenance/replacement of deterrents)
3.2	2.4	G. Determine whether large-scale weather patterns can predict risk	• Investigate the relationship between large-scale weather patterns and bat movement, activity, and risk	• Mortality varies from night to night, therefore it may be possible to predict the nights of greater mortality (e.g., if 80% of

P	F	Objective	Actions	Comments
				mortality occurs on 10% of nights between July and October) • Build on existing studies

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6.6 Deterrence

P	F	Objective	Actions	Comments
1.5	2.2	A. Determine species-specific responses to deterrent sounds	• Use a flight cage, or other appropriate setting, to determine the 1) sound pressure level needed to deter different species of bats, 2) the frequency range that is most effective, and 3) the signal pattern (e.g., sweeps, constant, pulsed) that is most effective	• Flight cage length will need to at least 100 m. • Need flight cages in different regions to capture different species • May be able to conduct studies at a natural setting or wind energy facility if there are few species in the area or you have a way to measure species-specific responses
1.9	2.0	B. Investigate optimal signal patterns	• Quantify what signal pattern (e.g., constant, sweeps, or pulsed) improves effectiveness of deterrents and/or limits potential habituation on different species	• Can conduct initial studies at ground-based locations (e.g., ponds or flight cages).
1.9	2.2	C. Evaluate whether longer turbine blades negate the sole use of nacelle-mounted deterrents	• Quantify the physics of deterrent signals, including 1) the distance sound travels per frequency for a set of SPLs, and 2) the weather conditions that inhibit sound.	• Although turbine blades continue to increase in length, there are still 1,000s of wind turbines with relatively small blade lengths. • Does an average set of weather conditions (e.g., a give temperature and humidity level) negate the use of deterrents at certain locations?

P	F	Objective	Actions	Comments
1.9	2.6	D. Determine the feasibility and effectiveness of blade-mounted deterrents	● Advance the R&D of blade-mounted deterrents to determine their effectiveness (e.g., what is the sound pressure level emitted from the device, how many are needed along the blade, what frequency range is used, etc.) ● Conduct experimental study using blade mounted deterrents	● Advancing R&D includes conducting ground-based studies (e.g., flight cage), but also small-scale deployment studies attaching to wind turbines ● Assess the feasibility of weatherizing deterrents for offshore wind energy applications ● Help connect technology providers with OEMs and blade engineers to discuss installation logistics
1.9	2.7	E. Determine the long-term effectiveness of deterrents	● Conduct preliminary ground-based studies and measure the response by bats over an extended period to assess habituation ● Conduct a study at one or more wind energy facilities over several years after the site(s) have installed deterrents	● May be best to start with a relatively easy study at a location with high bat activity (e.g., a pond) before conducting at a large-scale wind energy facility
2.0	2.6	F. Determine the positioning of deterrents on a wind turbine and deployment of deterrents within a wind farm	● Conduct experimental studies to determine if deterrents at 1 turbine cause bats to go to adjacent turbines. ● Conduct experimental study to determine whether nacelle- plus blade-mounted deterrents are added value	● Likely blade-mounted deterrents need to be distributed on all 3 blades for balance (check with OEMs/engineers) ● Studies should include both mortality monitoring & behavioral monitoring (i.e., cameras)

P	F	Objective	Actions	Comments
2.1	1.9	G. Advance hardware research	• Ensure deterrent technologies have remote access to monitor the health and status of the devices. • Continue to improve the durability and longevity of deterrent technologies	• Reducing maintenance and replacement costs will improve commercialization and competitiveness of technologies (assuming they also reduce mortality)
2.4	1.3	H. A Review the State of the Science on Deterrents	• Synthesize the available data regarding the effectiveness of deterrents, which species/regions respond to deterrents, & next steps for research & adoption	• Weaver et al. 2020, BCI 2020, and Good et al. 2022 – NRG deterrent • Romano et al. 2019 – GE deterrent • Arnett et al. 2013 – Deaton deterrent • Flight cage studies (acoustic and thermal cameras) Fall 2022 – NRG deterrent • Cryan et al. 2021 – dim UV light
2.4	1.8	I. Determine costs and other barriers of different deterrent deployment strategies	• Assess the costs of deploying deterrents across the entire wind energy facility, including permitting, purchasing, installation, powering the technology, maintenance, and replacement). • Determine costs of installing blade-mounted deterrents during manufacturing vs. after construction	• Will need to work with several OEMs to determine costs as its likely to vary among turbine types • What are the opportunities and barriers to adopting deterrents? Who has adopted deterrents and what were some of the deciding factors
2.9	2.1	J. Evaluate the effectiveness of dim UV light on reducing bat mortality	• Conduct a pilot study on a small sample size of turbines to evaluate effectiveness	• To assess the effectiveness, mortality monitoring will be necessary along with using cameras to record bat behavior at control and treatment wind turbines

P	F	Objective	Actions	Comments
3.1	2.4	K. Develop adjustable deterrent technologies that are triggered based on bat interactions	• Conduct an experimental study comparing standard deterrents (constant sound emission) vs. trigger-based deterrent signals (i.e., deterrent signal is triggered by the presences of bats)	• Ground-based studies have observed an effective startle response when the deterrent is first turned on. Bats scatter from the area, but will then eventually start to return and probe the area within the deterrent airspace

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6.7 Top Overall Priorities

At the end of the March 4th workshop, participants briefly considered priorities across categories via an informal poll that asked participants to choose their top three to five objectives among 31 objectives (those that had received an average 2.5 Mentimeter poll score [1=high priority/feasibility]). Results are presented in Appendix C. The poll results do not reflect BWEC decisions, and not all workshop participants completed the poll.

Approximately five objectives rose to the forefront:

- [Turbine-Scale Behavior] Evaluate the effectiveness of strategies to reduce bat mortality at wind turbines.
- [Bat Populations] Estimate population sizes and, if necessary, the mortality reduction targets for various species of interest.
- [Mortality Monitoring] Evaluate alternatives to standard post-construction monitoring.
- [Mortality Monitoring] Determine if there is a relationship between turbine size and mortality.
- [Bat Populations] Estimate population sizes and, if necessary, the mortality reduction targets for various species of interest.

<u>6.7.1 BWEC Committee Discussion</u>

- We need to figure out less expensive, less intensive ways to monitor the industry's impact on bat populations.
- To reduce bat mortality, we need to identify the technological and economically viable options.
- Deterrents may have received fewer responses in general because of the greater number of deterrent priorities compared to other categories. Many deterrent technologies are also still in R&D stages, and there is an urgency to identify and implement strategies that will reduce bat mortality. It is still important to improve deterrents.
- Time of fatality is a critical data gap that can significantly inform how to improve minimization strategies.

- Some objectives are nested within broader ones; more specific objectives that did not receive “votes” are still important. Consider indicating how various objective relate to each other to help further guide prioritization and implementation. This will help ensure we consider both short- and long-term goals.
- Some overarching funding issues are how much funding is needed to answer these key questions, whether that funding is being adequately invested, and who can/should be providing that funding.
- The BWEC has an important role in balancing research focus and breadth -- ensuring we advance top research priorities while still supporting the range of research questions to have a comprehensive understanding of wind industry’s impact on bats and potential approaches to minimizing that impact.

7.0 BWEC Business

7.1 Making BWEC More Effective

Participants engaged in a discussion of what the BWEC is doing well and how it could be more effective at advancing wind-wildlife research and collaboration.

7.1.2 Eliciting Input

Per DOE and NREL direction, CBI facilitators elicited feedback from individuals familiar with BWEC on the status, value, and future direction for the BWEC. In July 2022, CBI conducted four focus group interviews (NGO/researchers, federal agencies, state agencies, and industry) and six individual interviews with those who were highly familiar with the BWEC. An online survey was also sent to approximately 45 people with at least some familiarity with the BWEC and received 15 responses by mid-September. CBI summarized results and presented major themes to DOE, NREL, and committee members at the BWEC Business meeting.

7.1.3 BWEC Business Meeting

The September 7 the BWEC Business meeting focused on sharing the interview/survey findings, then reviewing the BWEC charter to outline next steps.

7.2 BWEC Review Feedback and Recommendations

Based on the interviews, online survey, and the BWEC Business meeting discussions, key takeaways include:

- Cross-sector collaboratives like the BWEC provide important value as a common neutral forum for sharing and learning. BWEC offers a unique space focused solely on bats and wind impacts with most of its work geared toward upstream/earlier scientific research.
- Bat and wind energy issues have grown much more complex, making it harder for sectors to find common ground. For instance, the BWEC has never been a conservation advocacy organization but with the threats to non-listed species now clearer, it is now in a precarious position about what it should do/say on threats.
- Funding for the BWEC has decreased over time (for various reasons), which has contributed to current capacity challenges.
- Going forward, many recommended that the BWEC have strategic planning discussions to prioritize efforts and advance efforts with clearer intention:
    - Role and Organization: What is the BWEC's role/niche today? What refinements to its mission and objectives are needed? How can the BWEC's structure and processes be improved to ensure cross-sectoral trust?
    - Activities: Should the BWEC reengage in some kinds of direct research again and if so, what kind? Should the BWEC improve its communications and if so what, how and to whom?
    - Support: Could DOE increase its funding? Does funding need to be reinvigorated beyond DOE?

- Most responses indicated that the BWEC's niche involves supporting an inclusive cross-sector forum focused on bats and wind. The BWEC should continue to focus on more upstream technology/innovation research. The BWEC could help set research priorities but also a strategic plan to fund and advance those priorities. Both communications/coordination and research are important, but the Cooperative may have important niche for research questions (i.e., synthesis and gap filling).
- The BWEC charter should be updated after holding these strategic planning discussions.

Appendix A: Final Agenda

Meeting Purpose: *To review progress of the Bats and Wind Energy Cooperative (BWEC), review progress toward priorities established at the 2018 meeting, discuss emerging issues, and establish priorities for the next 3–4 years.*

7 Feb (Day 1): Bat Behavior & Minimization Strategies

1:00 Welcome, Agenda Review, Zoom Check-In

1:05 Introductions: Name, Affiliation, One Goal for this Meeting

1:25 Progress Toward 2018 Priorities on Bat Behavior: *Cris Hein, NREL*

1:35 Summary of Findings from Bat Behavior Webinar: *Cris Hein, NREL*

- Turbine Scale
  - Update on hypotheses for attraction
  - Identify ongoing/future studies
  - Developing a video database
  - Analysis tools/software
- Technologies to address larger-scale movements and their pros/cons (e.g., tags, lidar, radar)

1:50 Discussion of Behavior Findings and Potential Priorities: Full Group

- Priority research, analysis tools, technologies for mid-range studies
- Initial identification of key priorities by
  - Time: Complete within the designated number of years (1–3)
  - Feasibility: Easy (E), Medium (M), or Difficult (D)
  - Overall priority: Scale of 1–5, with 1 being the highest priority

2:20 Progress Toward 2018 Priorities on Minimization: Cris Hein, NREL

2:30 Summary of Findings from Curtailment Webinar: *Cris Hein, NREL*

- Model-based
- Real-time activity based
- Capturing cost of curtailment

2:40 Discussion of Curtailment Findings and Potential Priorities: Full Group

- Blanket curtailment studies necessary, smart curtailment approaches, capturing the cost of curtailment
- Initial identification of key priorities
  - Time: Complete within the designated number of years (1–3)
  - Feasibility: Easy (E), Medium (M), or Difficult (D)
  - Overall priority: Scale of 1–5, with 1 being the highest priority

3:10 Break

3:20 Summary of Findings from Deterrent Webinar: *Cris Hein, NREL*

- Next steps for acoustic deterrents
- Status of blade-mounted technologies
- Other deterrent technologies

3:30 Discussion of Deterrent Findings and Potential Priorities: Full Group

- Nacelle-mounted deterrents, blade-mounted deterrents, other technologies
- Initial identification of key priorities
  - Time: Complete within the designated number of years (1–3)
  - Feasibility: Easy (E), Medium (M), or Difficult (D)
  - Overall priority: Scale of 1–5, with 1 being the highest priority

3:55 Wrap Up

4:00 Adjourn for Day

8 Feb (Day 2): Bat Populations & Fatality Estimation

12:00 Welcome, Agenda Review, Zoom Check-In

12:05 Wind Industry Update: *Stu Webster, ACP*
- Discussion of current & future wind deployment

12:40 Progress Toward 2018 Priorities on Population and Fatality Estimation: *Cris Hein, NREL*

1:00 Overview of Bat Populations and Impacts from Wind Energy: *Winifred Frick, BCI*
- Update on NABat Status and Trend Modeling
- Summary of the Friedenberg & Frick 2021 paper

1:20 Discussion of Population Findings and Potential Priorities: Full Group
- Building on Population Models (Friedenberg & Frick 2021), Collecting & Managing Data, (Short-term and Long-term actions); other
- Initial identification of key priorities

1:50 Break

2:05 Overview of Mortality Estimation: *Cris Hein, NREL*
- Gen Est simulation results
- Automated fatality monitoring (e.g., camera systems)
- Getting the most out of large datasets (RENEW, AWWIC, Bird Studies Canada)

2:20 Discussion of Mortality Findings and Potential Priorities: Full Group
- GenEst proven to be the best estimator, purpose of mortality monitoring, new approaches to mortality monitoring, getting the most out of large datasets
- Initial identification of key priorities

2:55 Wrap Up

3:00 Adjourn for Day

25 Feb (Day 3): Priority Setting

12:00 Welcome, Agenda Review, Zoom Check-In
- Reminder of the work ahead.
- Hone and refine actions; begin to prioritize
  - Feasibility (cost, logistics, complexity, etc.): Easy (E), Medium (M), or Difficult (D)
  - Overall priority: 1 = High, 2 - Medium; 3 = Low

12:05 Update on Offshore Wind & Bats: *Cris Hein, NREL*
- Brief Overview
- Discussion: Role of BWEC & OSW

12:35 Priority Setting: Curtailment
- Review draft themes and actions; Refine

1:05 Priority Setting: Deterrents
- Review draft themes and actions; Refine

1:35 Break and Organize Mentimeter Poll

1:45 Poll on Curtailment
- Share results; Discuss

1:55 Poll on Deterrents
- Share results; Discuss

2:05 Priority Setting: Populations
- Review draft themes and actions; Refine

2:35 Break and Organize Mentimeter Poll

2:45 Poll on Populations

- Share results; Discuss

2:55 Wrap Up
3:00 Adjourn

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4 Mar (Day 4): Priority Setting

1:00 Welcome, Agenda Review, Zoom Check-In
- Reminder of the work ahead.
- Hone and refine actions; begin to prioritize

1:05 Priority Setting: Bat Behavior at the Landscape-scale
- Review draft themes and actions; Refine

1:35 Priority Setting: Bat Behavior at the Turbine-scale (Refer to BWEC Priorities)
- Review draft themes and actions; Refine

2:05 Break and Organize Mentimeter Poll
2:10 Poll on Behavior
- Share results; Discuss

2:30 Priority Setting: Mortality Monitoring
- Review draft themes and actions; Refine

3:00 Break and Organize Mentimeter Poll
3:05 Poll on Mortality Monitoring
- Share results; Discuss

3:20 Break and Organize Mentimeter Poll
3:25 Looking at the Whole
- Discuss
- Poll on top three across themes
- Show results and discuss

3:55 Next Steps
4:00 Adjourn

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7 Sep (Day 5): BWEC Business

5 min Welcome & Agenda Review
20 min Overview of the Charter
45 min Review of survey and focus group findings
60 min BWEC Business
- Charter
- Committee membership
- Working groups
- Feedback and Focus Groups on the BWEC

5 min Wrap Up
End Adjourn

Appendix B: List of Participants

BWEC members, guest speakers, BWEC staff, and consultants

BWEC Members

Greg	Aldrich	Duke Energy Renewables
Taber	Allison	Renewable Energy Wildlife Institute
John	Anderson	Energy & Wildlife Action Coalition
Robert	Barclay	University of Calgary
Mylea	Bayless	Bat Conservation international
Christi	Calabrese	EDP Renewables
Janine	Crane	NextEra Energy Resources
Paul	Cryan	US Geological Survey
Meaghan	Gade	Association of Fish & Wildlife Agencies
Amanda	Hale	Western EcoSystems Technology
Manuela	Huso	US Geological Survey
Mona	Khalil	US Geological Survey
Dennis	Krusac	US Forest Service
Rachel	London	US Fish and Wildlife Service
Sean	Marsan	US Fish and Wildlife Service
Laura	Nagy	Avangrid Renewables
Christian	Newman	Electric Power Research Institute
Joy	Page	US Department of Energy
Trevor	Peterson	Stantec Consulting Services
Tim	Sullivan	US Fish and Wildlife Service
Bob	Thresher	National Renewable Energy Laboratory
Stu	Webster	American Clean Power Association
Ted	Weller	US Forest Service
Michael	Whitby	Bat Conservation international
Laura	Zebehazy	Texas Parks and Wildlife

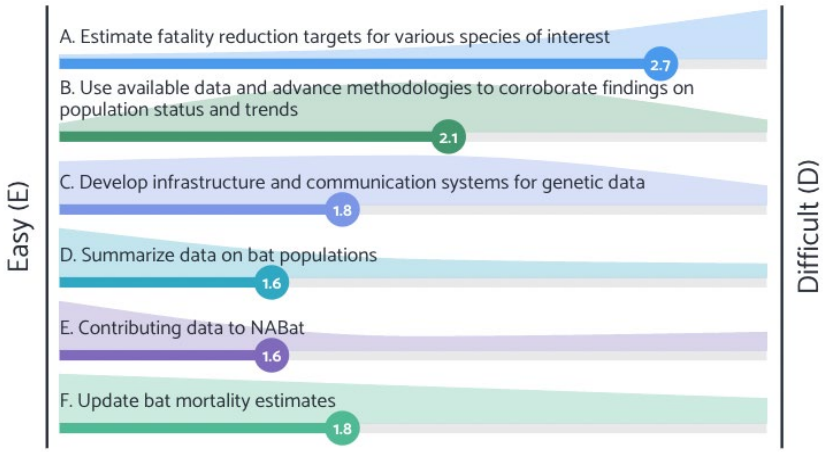
Alternates, Staff, or Consultants

Karen	Hardin	Texas Parks and Wildlife
Karin	Sinclair	National Renewable Energy Laboratory
Tom	Vinson	American Clean Power Association
Winifred	Frick	Bat Conservation International
Raphael	Tisch	US Department of Energy
Cris	Hein	National Renewable Energy Laboratory
Patrick	Field	Consensus Building Institute
Stephanie	Horii	Consensus Building Institute

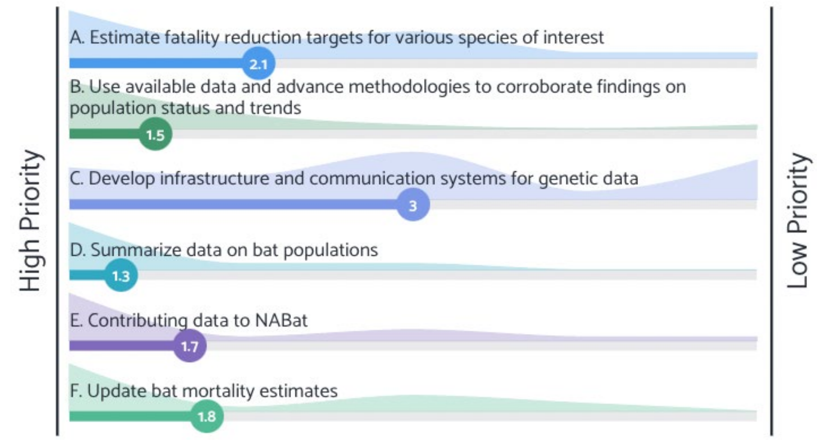
Appendix C: Informal Polling Results

Bat Populations – Menti Results (N=18-19 respondents)

Feasibility (E, M, D)

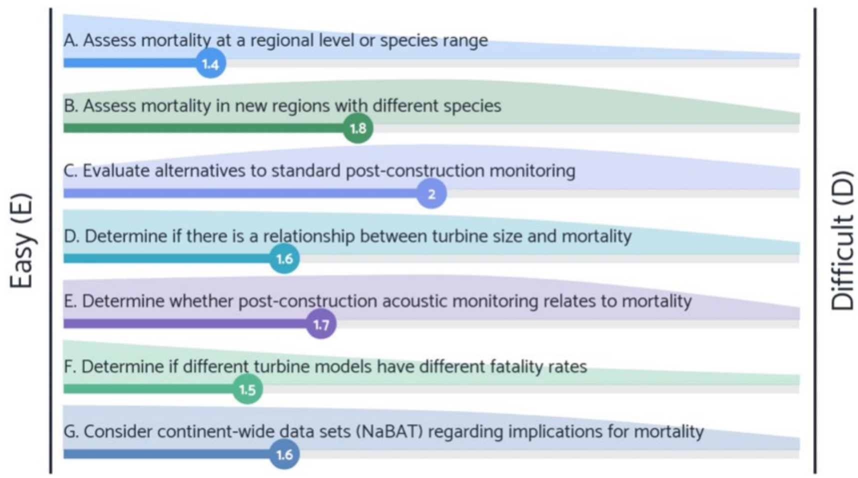


Overall Priority

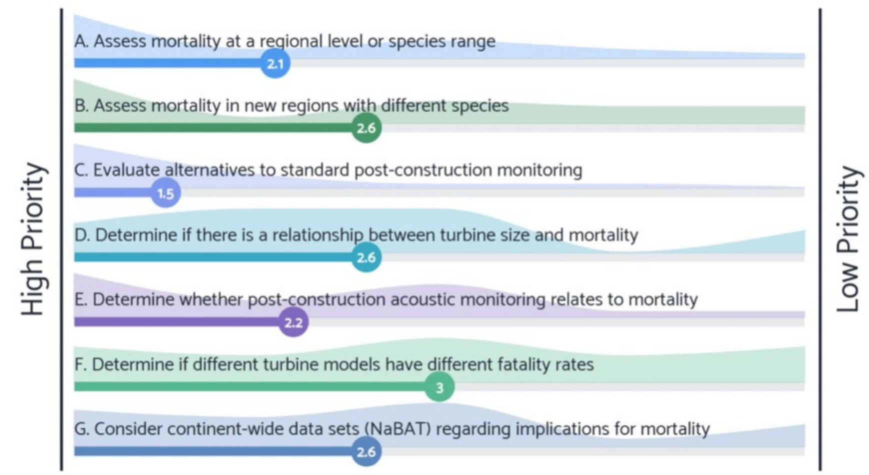


Mortality Monitoring – Menti Results (N=17-19 respondents)

Feasibility (E, M, D)

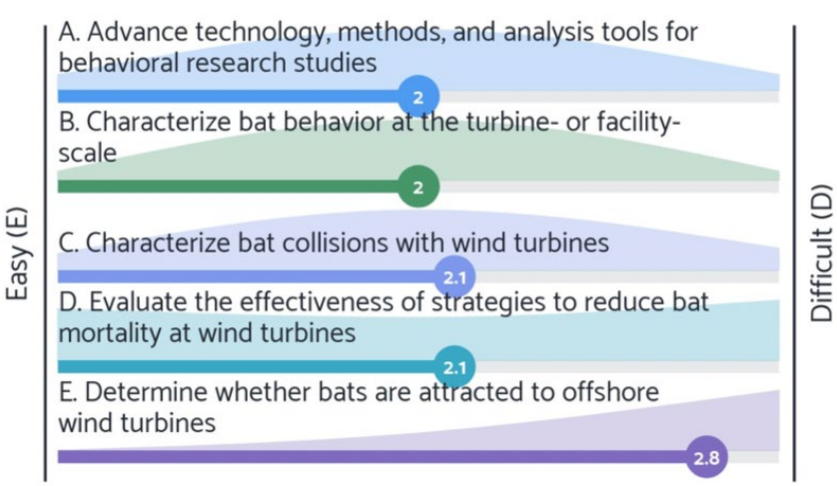


Overall Priority

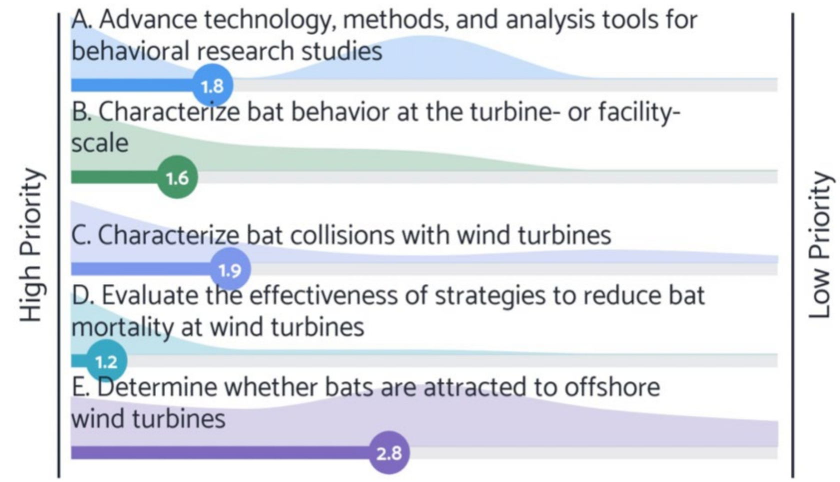


Turbine-Scale Bat Behavior – Menti Results (N=17-18 respondents)

Feasibility (E, M, D)

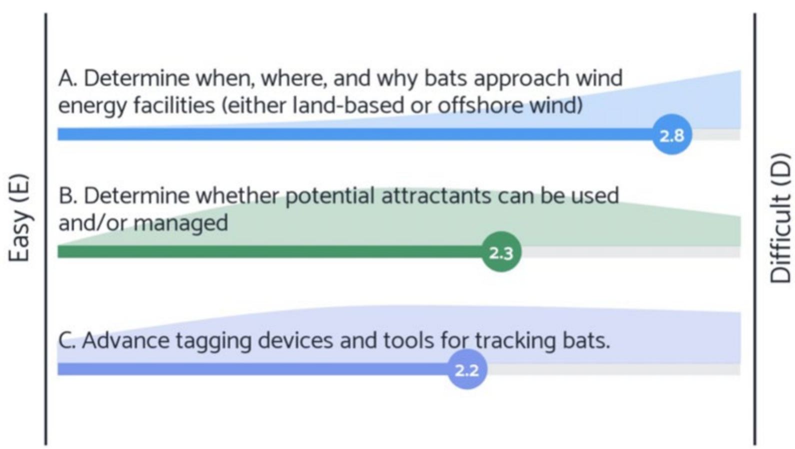


Overall Priority

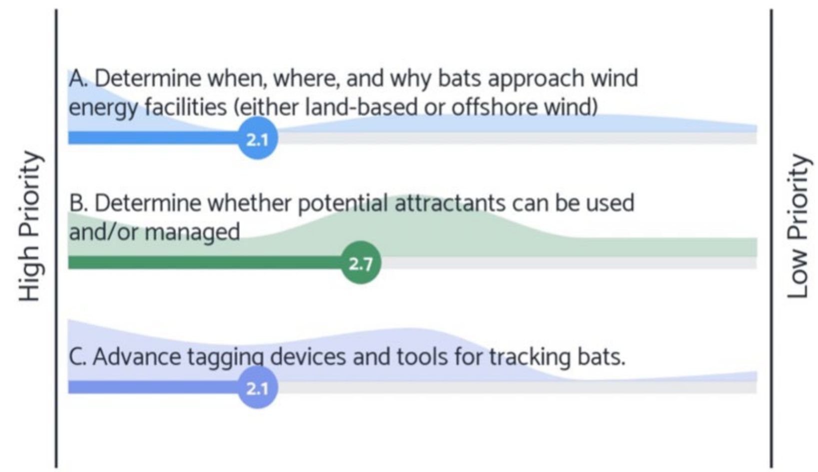


Landscape-Scale Bat Behavior – Menti Results (N=18 respondents)

Feasibility (E, M, D)

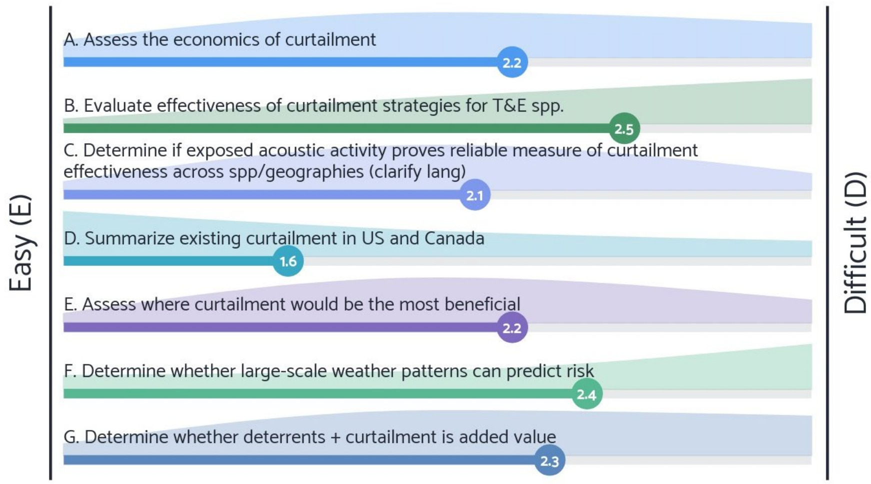


Overall Priority

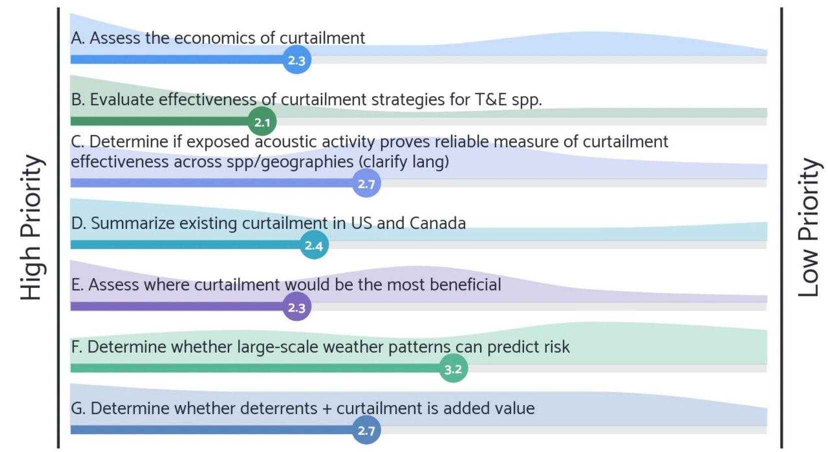


Curtailment – Menti Results (N=17-19 respondents)

Feasibility (E, M, D)

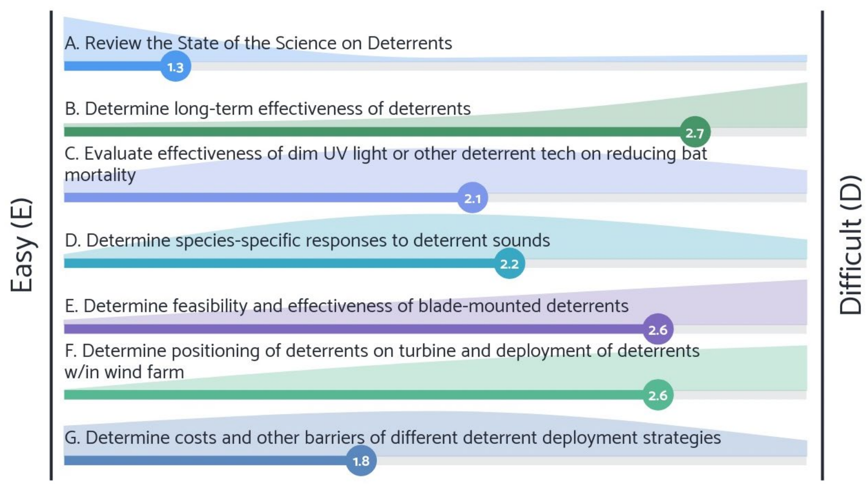


Overall Priority

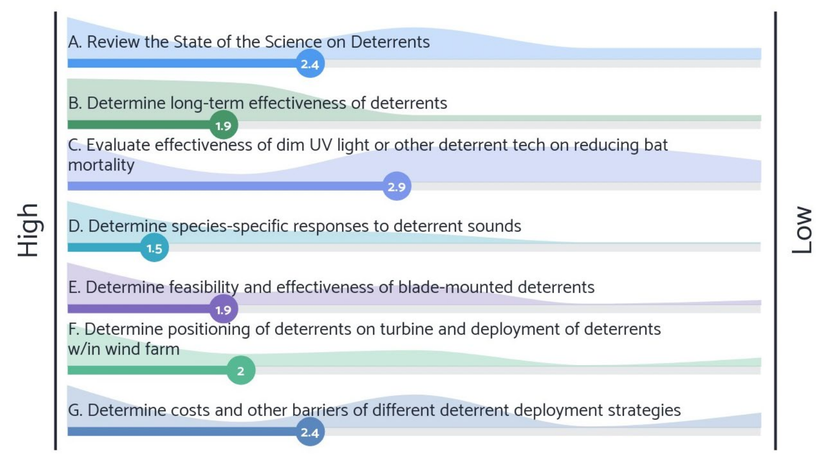


Deterrents – Menti Results (N=18-20 respondents)

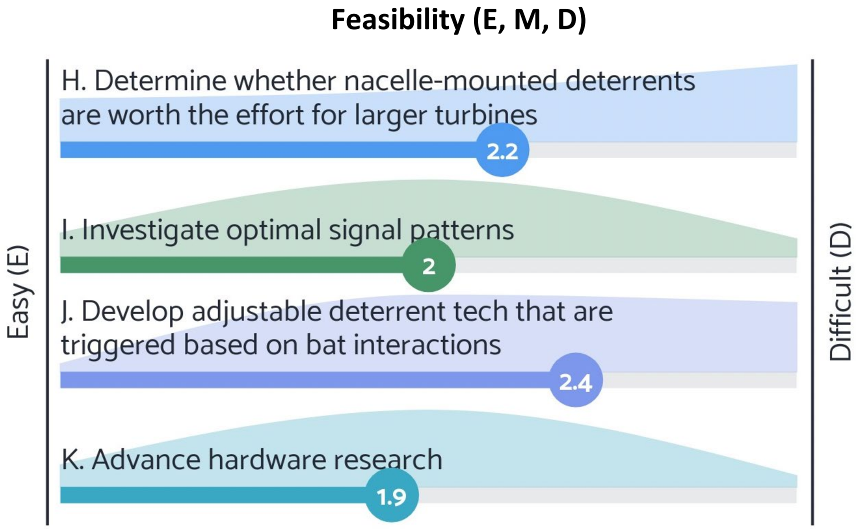
Feasibility (E, M, D)



Overall Priority



Deterrents – Menti Results (Continued)



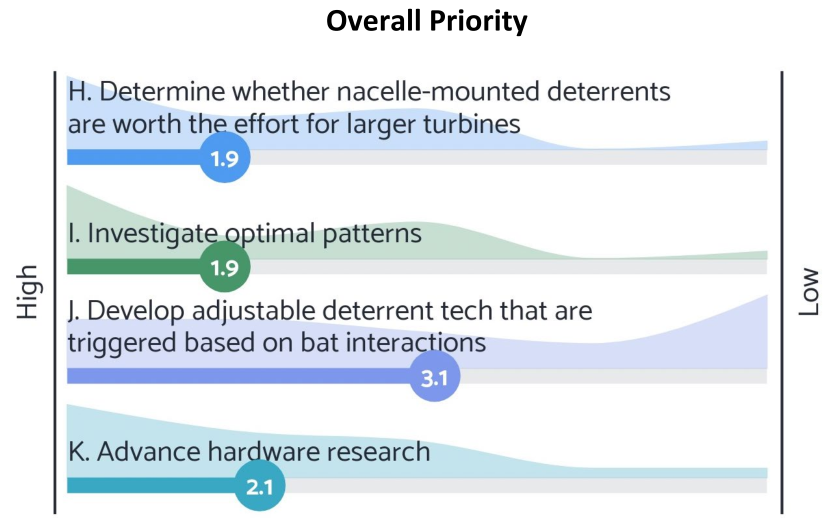


Table 6.7.1.1 Top Overall Priorities Informal Mentimeter Poll Results (N=20): Bar Graph by %

Table 6.7.1.2 Top Overall Priorities Informal Mentimeter Poll Results (N=20): Table by % & # of Respondents

Objective	Response (%)	N=20
BAT POPULATIONS		
[Pop] A. Estimate population sizes and, if necessary, the mortality reduction targets for various species of interest	**55%**	**11**
[Pop] E. Contributing acoustic data to NABat	25%	5
[Pop] B. Use available data and advance methodologies to corroborate findings on population status and trends	5%	1
[Pop] F. Update bat mortality estimates	0%	0
[Pop] D. Summarize existing data on bat populations	0%	0
MORTALITY MONITORING		
[Mort-Mon] C. Evaluate alternatives to standard post-construction monitoring	**55%**	**11**
[Mort-Mon] E. Determine whether post-construction acoustic monitoring relates to mortality	15%	3
[Mort-Mon] A. Assess mortality at a regional level or species range	5%	1
BEHAVIOR - TURBINE-SCALE		
[Turb-Beh] D. Evaluate the effectiveness of strategies to reduce bat mortality at wind turbines	**60%**	**12**
[Turb-Beh] A. Advance technology, methods, and analysis tools for behavioral research studies	15%	3
[Turb-Beh] B. Characterize bat behavior at the turbine- or facility-scale	15%	3
[Turb-Beh] C. Characterize bat collisions with wind turbines	10%	2
BEHAVIOR - LANDSCAPE-SCALE		
[Land-Beh] C. Advance tagging devices and tools for tracking bats	20%	4
[Land-Beh] A. Determine when, where, and why bats approach wind energy facilities (either land-based or offshore wind)	15%	3
MINIMIZATION - CURTAILMENT		
[Curtl] E. Assess where curtailment would be the most beneficial	35%	7
[Curtl] A. Assess the economics of curtailment	30%	6
[Curtl] B. Evaluate the effectiveness of curtailment strategies for T&E species	15%	3
[Curtl] D. Summarize existing use of curtailment in the U.S. and Canada	15%	3
MINIMIZATION - DETERRENTS		
[Detr] D. Determine species-specific responses to deterrent sounds	25%	5
[Detr] G. Determine costs and other barriers of different deterrent deployment strategies	25%	5
[Detr] B. Determine the long-term effectiveness of deterrents	20%	4
[Detr] E. Determine the feasibility and effectiveness of blade-mounted deterrents	20%	4
[Detr] I. Investigate optimal signal patterns	15%	3
[Detr] H. Evaluate whether longer turbine blades negate the sole use of nacelle-mounted deterrents	5%	1
[Detr] A. Review the State of the Science on Deterrents	0%	0
[Detr] F. Determine the positioning of deterrents on a wind turbine and deployment of deterrents within a wind farm	0%	0
[Detr] K. Advance hardware research	0%	0

Appendix D: Literature Cited

Below is a list of literature related to progress towards BWEC 2018 priorities. This list does not represent an exhaustive list of resources on bats and wind energy development. For additional resources, visit the Tethys knowledge base (https://tethys.pnnl.gov/knowledge-base-wind-energy).

Adams, E. M., J. Gulka, K. A. Williams. 2021. A review of the effectiveness of operational curtailment for reducing bat fatalities at terrestrial wind farms in North America. PLoS ONE 16(11): e0256382.

Bats and Wind Energy Cooperative. 2021. Research goals for studying bat behavior at the wind turbine scale. Available at www.batsandwind.org.

Bat Conservation International. 2020. Evaluating the effectiveness of an ultrasonic acoustic deterrent in reducing bat fatalities at wind energy facilities. Technical Report DOE-BCI-0007036 submitted to the U.S. Department of Energy. https://doi.org/10.2172/1605929.

Brewer, C. T., W. A. Rauch-Davis, and E. E. Fraser. 2021. The use of intrinsic markers for studying the migratory movements of bats. Animals 11, 3477. https://doi.org/10.3390/ani11123477.

Chipps, A. S., A. M. Hale, S. P. Weaver, and D. A. Williams. 2020. Genetic approaches are necessary to accurately understand bat-wind turbine impacts. Diversity. https://doi.org/10.3390/d12060236.

Cornman, R. S., J. A. Fike, S. J. Oyler-McCance, and P. M. Cryan. 2021. Historical effective population size of North American hoary bat (Lasiurus cinereus) and challenges to estimating trends in contemporary effective breeding population size from archived samples. PeerJ 9:e11285. http://doi.org/10.7717/peerj.11285.

Cryan, P. M., P. M. Gorresen, B. R. Straw, S. Thao, and E. DeGeorge. 2022. Influencing activity of bats by dimly lighting wind turbine surfaces with ultraviolet light. Animals 12, 9. https://doi.org/10.3390/ani12010009.

Dalthorp, D., M. Huso, M. Dalthorp, and J. Mintz. 2022. Accounting for the fraction of carcasses outside the searched area and the estimation of bird and bat fatalities at wind energy facilities. https://doi.org/10.48550/arXiv.2201.10064.

Davy, C. M., K. Squires, and J. R. Zimmerling. 2021. Estimation of spatiotemporal trends in bat abundance from mortality data collected at wind turbines. Conservation Biology 35: 227–238. https://doi.org/10.1111/cobi.13554.

Electric Power Research Institute. 2020. Population-level risk to hoary bts amid continued wind energy development: assessing fatality reduction targets under broad uncertainty. Technical Report 3002017671. https://www.epri.com/research /products/000000003002017671/.

Farnsworth, A., K. Horton, K. Heist, E. Bridge, R. Diehl, W. Frick, J. Kelly, and P. Stepanian. 2021. The role of regional-scale weather variables in predicting bat mortality and bat vocalizations: potential for use in the development of smart curtailment algorithms. AWWI Technical Report. Washington, DC. Available at https://rewi.org/resources/wwrf-regional-scale-weather-variables-in-predicting-bat-mortality-and-acoustic-activity/.

Friendenberg, N. A., and W. F. Frick. 2021. Assessing fatality minimization for hoary bats amid continued wind energy development. Biological Conservation. https://doi.org/10.1016/j.biocon.2021.109309.

Goldenberg, S. Z., P. M. Cryan, R. M. Gorresen, and L. J. Fingersh. 2021. Behavioral patterns of bats at a wind turbine confirm seasonality of fatality risk. Ecology and Evolution. https://doi.org/10.1002/ece3.7388.

Gorresen, P. M. 2020. Hawaiian hoary bat (Lasiurus cinereus semotus) behavior at wind turbines, Maui Island 2018. U.S. Geological Survey data release. https://doi.org/10.5066/P937H9LO.

Hale, A. M., C. D. Hein, and B. R. Straw. 2022. Acoustic and genetic data can reduce uncertainty regarding populations of migratory tree-roosting bats impacted by wind energy. Animals 12,81. https://doi.org/10.3390/ani12010081.

Hayes, M. A., L. A. Hooton, K. L. Gilland, C. Grandgent, R. L. Smith, S. R. Lindsay, J. D. Collins, S. M. Schumacher, P. A. Rabie, J. C. Gruver, and J. Goodrich-Mahoney. 2019. A smart curtailment approach for reducing bat fatalities and curtailment time at wind energy facilities. Ecological Applications 29, e01881. DOI: 10.1002/eap.1881.

Murtaugh, R. A., A. P. Capparella, J. C. Kostelnick, and G. D. Johnson. 2019. Red bat fatality: geographic extents through deuterium and niche models. Journal of Wildlife Management 83: 1347–1351. DOI: 10.1002/jwgm.21721.

Udell, B. J., B. R. Straw, T. L. Cheng, K. Ennis, W. F. Frick, B. Gotthold, K. M. Irvine, C. Lausen, S. Loeb, J. Reichard, T. Rodhouse, D. Smith, C. Stratton, W. E. Thogmartin, and B. E. Reichert. 2022. Status and trends of North American bats: summer occupancy analysis 2010-2019. https://doi.org/10.7944/P927I36K.

Romano, W. B., J. R. Skalski, R. L. Townsend, K. W. Kinzie, K. D. Coppinger, and M. F. Miller. 2019. Evaluation of acoustic deterrent to reduce bat mortalities at an Illinois wind farm. Wildlife Society Bulletin 43: 608–618. https://doi.org/10.1002/wsb.1025.

Weaver, S. P., C. D. Hein, T. R. Simpson, J. W. Evans, and I. Castro-Arellano. 2020. Ultrasonic acoustic deterrents significantly reduce bat fatalities at wind turbines. Global Ecology and Conservation 24, e01099. https://doi.org/10.1016/gecco.2020.e01099.

Whitby, M., M. Schirmacher, and W. Frick. 2021. The state of the science on operational minimization to reduce bat fatality at wind energy facilities. A report by Bat Conservation International submitted to the National Renewable Energy Laboratory. Available at https://tethys.pnnl.gov/publications/state-science-operational-minimization-reduce-bat-fatality-wind-energy-facilities.

Wieringa, J. G., B. C. Carstens, and H. L. Gibbs. 2021. Predicting migration routes for three species of migratory bats using species distribution models. PeerJ 9:e11177. DOI: 10.7717/peerj.11177.

Appendix E: Additional Resources

Below are hyperlinks and other references mentioned during the workshop session discussions.

Workshop Session #1 – February 7

- ThermalTracker-3D: https://www.pnnl.gov/available-technologies/thermaltracker-3d
- ThruTracker: https://sonarjamming.com/thrutracker/
- Candidate Conservation Agreement example: https://www.fws.gov/savethemonarch/ccaa.html
- Exploring potential barotrauma in bats: An investigation into the potential for wind turbines to cause barotrauma in bats Michael Lawson, Dale Jenne ,Robert Thresher, Daniel Houck, Jeffrey Wimsatt, Bethany Straw

Workshop Session #2 – February 8

- Offshore wind energy leasing plan 2021-25: https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/OSW-Proposed-Leasing-Schedule.pdf
- Electrification links: https://mitpress.mit.edu/books/electrify
    - https://www.electrification2022.com/
- Historical effective population size of North American hoary bat (*Lasiurus cinereus*) and challenges to estimating trends in contemporary effective breeding population size from archived samples: https://peerj.com/articles/11285/
- WEST webinar on potential listing of bats: https://www.youtube.com/watch?v=wSsZXqDUyi4
- Conservative Estimation of Population Size from Trend and Fatality Information: https://www.epri.com/research/products/000000003002017926
- Dalthorp, D.H., Huso, M.M., Dalthorp, M., and Mintz, J.M., 2022, Density-weighted proportion (dwp) tool suite: U.S. Geological Survey Software Release. https://doi.org/10.5066/P9QWO5I0.
- EPRI Bat Database Feasibility Assessment https://www.epri.com/research/products/000000003002021571

Workshop Session #3 – Feb 25

[No additional hyperlinks listed in Zoom Chat]

Workshop Session #4 – March 4

- Huso et al. 'Relative energy production determines effect of repowering on wildlife mortality at wind energy facilities': https://besjournals.onlinelibrary.wiley.com/doi/10.1111/1365-2664.13853

Workshop Session #5

- Regional Wildlife Science Collaborative for Offshore Wind: https://rwsc.org/