Bats and Wind Energy Cooperative
4th Science and All Committees Meeting

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National Wind Technology Center

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Final 2015 Workshop Proceedings

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Executive Summary

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 reduce to the greatest extent practicable or, where possible, prevent mortality of bats at wind energy facilities. The BWEC is overseen by Bat Conservation International (BCI), the U.S. Fish and Wildlife Service (USFWS), the American Wind Energy Association (AWEA), the U.S. Department of Energy (USDOE), the National Renewable Energy Laboratory (NREL), and the U.S. Geological Survey (USGS). BWEC's Oversight, Science Advisory, and Technical Advisory Committees met in Louisville, Colorado at the National Wind Technology Center from January 6–8, 2015 for the 4th Science and All Committees Meeting to examine progress of the BWEC, review existing monitoring and minimization strategies, discuss emerging issues, assess the effectiveness of BWEC, and establish priorities for the Cooperative for the years 2015 to 2018.

Research Priorities and Emerging Issues

The BWEC committee members discussed and identified potential priorities for 2015–2018 in the following categories. Further detail on a wider range of possible activities is included later in this report. Discussions were informed by BWEC progress to date, BWEC participant research initiatives, and guest presentations. The priorities the BWEC developed during the meeting were designed to inform Oversight Committee decision-making and did not represent final decisions on specific activities.

<u>Operational strategies to reduce impact</u> – The BWEC should prepare a summary report on impact reduction strategies to describe the current state of the science, the challenges and opportunities of existing impact reduction strategies, and areas of future research. The BWEC also agreed to advance understanding in two high priority areas: 1) options to refine operational minimization such as feathering below manufacturer's cut-in speed or considering start/stop times when implementing operational minimization, impacts of changing wind technologies (turbines with lower cut-in speeds) and the effect of ramp-up speeds on fatality, and 2) the costs of implementing impact reduction strategies in wind energy projects.

Ultrasonic acoustic deterrents – Given the advancement of deterrent technology and the promising findings of acoustic deterrents to date, the BWEC should advance the development of deterrents and research their effectiveness. In particular, the BWEC should design and implement a study to compare the effectiveness and costs of acoustic deterrents and operational reduction strategies, using a 2-factorial randomized block design.

Pre- and post-construction monitoring and data collection – The BWEC should support the compilation of site and project level data into a large database that is considered a trusted and credible data source for research purposes by industry, government agencies, academic institutions, and conservation organizations. It was also agreed the BWEC should examine landscape patterns of activity and fatality and site covariates to identify potential predictors of risk.

Fatality estimation and modeling – A general fatality estimator should be developed to help standardize fatality estimation and modeling. The BWEC recommended that weather patterns and peak fatality events should be analyzed to determine whether or not a relationship exists that could help predict when peak fatality events might occur and thus enable turbine operators to implement and refine impact reduction strategies to minimize fatalities.

Bat behavior at various scales – Thermal video technology and analysis tools should continue to be used and advanced to study bat behavior and draw conclusions about when and how bats interact with turbines and how deterrent devices could be positioned to reduce impacts. The BWEC should monitor advances in strike-detection technology that may help pinpoint the times of impact and the environmental and operational conditions under which strikes occur.

Population estimation, modeling, and data collection – Population estimation, modeling, and data collection is a high priority. This work is mostly being undertaken by scientists in academic institutions with the support of state and federal resource management agencies. BWEC should continue to support these efforts through the provision of tissue and hair samples as needed and through help coordinating research efforts conducted by population geneticists.

International network and emerging issues – The BWEC should expand its network of international partners and seek opportunities to exchange knowledge in order to better understand bat and wind turbine interactions, and reduce fatality in North America and throughout the world.

Chapter 1: Introduction

About the BWEC and the 4th Science and All Committees Meeting

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 reduce to the greatest extent practicable or, where possible, prevent mortality of bats at wind energy facilities.[1] The BWEC is overseen by Bat Conservation International (BCI), the U.S. Fish and Wildlife Service (USFWS), the American Wind Energy Association (AWEA), the U.S. Department of Energy (USDOE), the National Renewable Energy Laboratory (NREL), and the U.S. Geological Survey (USGS). 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 technical and 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.

Members of all three BWEC Committees met at the National Wind Technology Center in Louisville, Colorado from January 6–8, 2015 for the *BWEC 4th Science and All Committees Meeting*. The meeting purpose was to examine progress of the BWEC, review existing impact reduction strategies, discuss emerging issues, assess the effectiveness of BWEC, and establish priorities for the Cooperative. Invited speakers offered presentations and participated in conversations on fatality estimation, bat behavior and migration, population modeling, and impact reduction strategies. Patrick Field and Eric J. Roberts, of the Consensus Building Institute, facilitated the meeting.[2]

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[1] The first two paragraphs of this introduction are taken from the BWEC Charter, as revised in November 2011.

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

Meeting Agenda and Overview

The meeting agenda was structured to allow ample time for conversation, both to discuss specific presentations and to allow for collaborative prioritization of research needs and tasks. The format was primarily presentations and facilitated plenary discussions, with one time block dedicated to detailed discussion of potential priorities in small breakout groups. [3]

After introductions and welcomes from Karin Sinclair (NREL) and Cris Hein (BCI), the morning of Day 1 was focused on the wind industry trends, updates on BWEC progress between 2012 and 2014, ongoing research, and fatality estimation; the afternoon focused on BWEC progress and ongoing research on bat behavior and migration and bat population analysis. During Day 2, the BWEC reviewed and discussed impact reduction strategies in the morning; the afternoon consisted of small group sessions to discuss impact reduction strategies and, in plenary, learn about and discuss emerging issues and technologies and international bat and wind issues. The group also discussed the effectiveness of BWEC in plenary during the afternoon. At the end of Day 2, each individual participant listed potential priorities for BWEC in the coming years. During the morning of Day 3, the BWEC developed BWEC priorities for 2015–2018, and learned about and discussed barotrauma research during lunch. The afternoon was spent with BWEC committee members only; they discussed BWEC business, committee membership, and financials, and revised the charter.

Ultimately, the Oversight Committee will make final decisions on BWEC priorities and activities for 2015–2018. 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, roles and responsibilities, or financing.

Workshop Proceedings Document

This document is a summary of the BWEC workshop proceedings, including presentations, discussions, and draft 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. It may be best reviewed together with presenters' PowerPoint presentations, many of which are available at: www.batsandwind.org.

[3] See the Final Agenda, included as Appendix 2.

Chapter 2: Background and Overview

Changes in the economic, political, regulatory, and environmental landscape have influenced the development of the wind energy industry, the populations of bats, and the measures taken to better understand bat populations and the interactions between bats and wind turbines. Despite the changing context, the BWEC has remained an effective mechanism for collaboration between research scientists, the wind industry, regulatory agencies, and conservation organizations. The following section provides an overview of political, economic, and environmental forces that have influenced changes in the wind industry, the emergence and rapid spread of white nose syndrome (WNS), and forthcoming changes to regulations that are designed to help government agencies more effectively manage bat populations.

Wind Industry History and Perspective Regarding Bats and Wind Energy Development

John Anderson, of the American Wind Energy Association (AWEA), described the history and current state of wind energy development. The wind industry grew significantly over the past 11 years despite a boom-and-bust cycle caused by on-again/off-again federal energy policies. Approximately 60,000 Megawatts (MW) of wind energy have come on line since 2003; as compared to the thirty years it took to bring the first 10,000 MW on line. The Renewable Electricity Production Tax Credit (PTC) aided this increase. However, uncertainty surrounding the extension of the PTC significantly and adversely affects projected energy production. For example, scenarios to analyze potential wind energy build out with and without the PTC as part of the Midwest Habitat Conservation Plan projects an increase over the next 15 years of approximately 10,000 MW with the PTC or 1,000–2,000 MW without the PTC.

During this same period of growth, wind industry representatives became increasingly aware of the need to address wind energy impacts on wildlife in general and on bat populations in particular and of the role of wind energy will play in solving climate change issues. Although initially focused on reducing the impacts on birds, wind developers increasingly focused on bat impacts over the past 10 years as wind developers recognized that bat impacts could limit siting opportunities or raise development and long-term operation costs. Lenders also began to recognize siting issues as a top-tier issue to address. Concerns have also grown about the impacts of climate change on wildlife, including bats. From a global, long-term perspective, wind energy will be required to address climate change and limit the impacts of climate change on wildlife. However, in the meantime, the industry has recognized their responsibility to proactively address bat impacts to more easily facilitate wind energy development and encourage the switch from fossil fuels to renewable energy sources such as wind. Accordingly, the AWEA Siting Committee identified bat, eagle, and grouse species impacts as major concerns and is currently drafting industry policies to limit impacts to these animals.

Government supported research or action helps to address existing uncertainties and other more well-known factors that influence wind development. For example, although much information has been developed over the past 10 years, there is still uncertainty regarding the relative impacts of turbines on bat populations, how fatality rates at wind energy facilities compare to population size, and how climate change and WNS also affect bat populations. Deterrent research looks promising but larger-scale studies are needed to prove their efficacy. More data and information on impact reduction strategies would help the industry to reduce uncertainties about installation and maintenance costs and potential loss of energy production, which would in turn provide investors with more certainty when investing in a potential project. In addition to the extension of (or lack thereof) the PTC, factors such as carbon regulations, removal of tax incentives for oil and gas development, renewable portfolio requirements, the Clean Power Plan, and listings of other bat species as threatened or endangered could impact how and where new wind energy facilities are developed.

WNS Update (Link to Presentation)

Mylea Bayless (BCI) presented an update on WNS. In January 2012, the USFWS estimated that WNS had killed more than 5.5 million bats. The USFWS has not sought to refine or update this number, but the geographic extent of WNS continues to expand and WNS-related mortality is thought to be increasing. Although the removal of Oklahoma and the cave myotis (*Myotis velifer*) from the WNS distribution map retracted the extent of where the causative fungus *Pd* (*Pseudogymnoascus destructans*) affects bats, WNS has expanded into new areas farther west and south than where it was located during the last BWEC All Committees Meeting.[4] A detection of *Pd* in Mississippi marks the most southern distribution of the fungus in North America to date. Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) and the eastern red bat (*Lasiurus borealis*) tested positive for *Pd,* and were added to the list of species impacted by WNS in 2014. All the bat species that have tested positive for WNS are insectivorous cave-dwelling species that

[4] *Pseudogymnoascus destructans* was formerly called *Geomyces destructans*

hibernate. Federal and non-profit organizations continue to support WNS response efforts. The USFWS allocated nearly $19 million to combat WNS since 2008. BCI and The Nature Conservancy (TNC) have awarded $375,000 in grants since 2008.

New species continue to be considered for listing as threatened or endangered species in the U.S. and Canada primarily due to WNS. In 2013, the eastern small-footed bat (*M. lebii*) was considered for but ultimately not listed under the Endangered Species Act (ESA). The northern long-eared bat (*M. septentrionalis)* as endangered or threatened is currently under consideration.[5] The decision will be made in 2015. The USFWS is currently internally reviewing the little brown bat (*M. lucifugus*) and the tri-colored bat (*Perimyotis subflavus*) for listing, too. In Canada, three species (*M. septentrionalis, M. lucifugus, and P. subflavus*) were listed as endangered in 2014.

Advances have been made in WNS detection efforts and research on biological controls. A new ultraviolet light method has been found effective for screening WNS. The light exposes the locations of microscopic skin lesions that are currently used to diagnose WNS. Lab tests indicate that the application of *Rhodococcus rhodochrous* may help treat and prevent WNS. Field-testing recently began. Another control tool is RNAi-mediated gene silencing, which would silence genes in *Pd* to control the fungus. This research is still several years from field-testing.

Other research provides some hope for stabilizing the mortality caused by WNS. In areas where WNS has been found for several years, it appears that the little brown bat population is stabilizing (albeit at very low population levels); however, this is not the case with northern long-eared bats and the little brown population remains only 10% of the estimated historical population. Other research indicates that WNS may not be density dependent and decreasing *Pd* loads have been found in some sites, which is a new discovery. Another new discovery is that wing healing has been identified in some bats.

Regulatory Update

Christy Johnson-Hughes (USFWS) briefed the BWEC participants on proposed regulatory changes that will soon be released publicly. The USFWS is currently reviewing and revising the USFWS mitigation policy. Historically, ESA species were excluded from the

[5] The northern long-eared bat was listed as threatened under the ESA in early 2015. The listing will become effective in May 2015.

mitigation policy but the new policy will explicitly include ESA species and open the opportunity to talk about mitigation for ESA listed species. The goal for this change is to open conservation opportunities at the population and landscape levels. The revised mitigation policy could include the following—conservation and in-lieu fees for ESA species under section 7, and the option to use research as a mitigation opportunity under section 10(a)(1)(A). The research as a mitigation opportunity could be used to complete research at a specific site when take of ESA species is anticipated.

Another potential element of the revised policy is to enable the USFWS to implement programmatic or regional HCPs, which would help the USFWS to better manage limited resources. For example, if a regional or programmatic HCP is established and a proposed project incorporates mitigation elements based on anticipated species risk and the USFWS agrees with the proposed mitigation, it could more easily issue a take permit for that particular project. The USFWS plans to convene a stakeholder group to further consider some of these draft options.

Other potential elements of the revised policy include assumptions regarding bat presence and tools for migratory bird assessments to help manage the USFWS's limited resources. The USFWS is considering the inclusion of an assumption that bats are present in some instances. In these cases, they would seek weather pattern and insect pattern data to support the assumption. The migratory bird assessment tools would help industry to collect data used to assess and determine the extent of migratory bird impacts. The USFWS would then review the data and analysis and decide whether or not to issue permits.

After Ms. Johnson-Hughes's presentation, the group discussed the proposed change to section 10(a)(1)(A). Some commented that the 10(a)(1)(A) permit option is a valuable opportunity to bridge BWEC, management, and industry, especially if there is a specific issue to address or deterrent device to test. Another said it would be very valuable for the industry to rely on research permits rather than require take permits.

The group also discussed the programmatic permit idea. Some supported the idea of a programmatic permit saying it could allow adaptation and cover a range of anticipated issues. In response to a participant question, Ms. Johnson-Hughes clarified that the programmatic permit would likely incorporate adaptive management to determine what is working or what might need to be changed.

BWEC Effectiveness

The participants spent some time identifying specific successes of the collaboration since its inception in 2003. The discussion identified several key points. An early success was the speed and efficiency with which BWEC started. The BWEC was formed, funded, and investigating bat fatalities less than a year after the fatalities at the West Virginia site initially raised strong concern. This swift action was attributable both to the BWEC's organizational model and the BWEC management.

A notable success is the BWEC's multi-stakeholder organizational model, which engages representatives from government agencies, the wind industry, research scientists, and conservation organizations. Generally, representatives of stakeholder groups are intimately aware of their groups' interests and concerns; but they may not fully understand the interests or concerns of the 'other' groups. The BWEC has successfully served as a forum for stakeholder groups to share information and gain understanding of the others' interests and concerns. In doing so, the BWEC also successfully fostered cross-disciplinary collaboration to set research priorities and conduct research. After the priorities are established, BWEC participants or the BWEC Coordinator completes the research and the results are reviewed and vetted by other BWEC members upon completion. This collaborative approach to setting and completing research priorities, which some participants view as a model for addressing complex systematic issues, led to several additional successes and impacts, including establishing a high level of scientific credibility.

Another success of the BWEC has been the creation of a credible and useable source of bat and wind energy facility data that is valued by government agencies, industry representatives, research scientists, and conservation organizations. Little information was available about interactions between bat and wind turbines in the U.S. before 2003. Since then, BWEC efforts established a baseline dataset for bat and wind turbine interactions. The impact of the BWEC research efforts can be seen in the use of the data. Government agencies, wind industry representatives, research scientists, and conservation organizations use BWEC data when developing, permitting, studying, or monitoring wind energy facilities. Two specific examples of BWEC impact come from the USDOE. First, during reviews of the USDOE research and development program, the BWEC consistently ranks among the highest programs. Second, participation with BWEC enabled the USDOE to develop solutions in a relatively short period of time and those solutions are beginning to be adopted by the wind industry.

Other BWEC successes are attributable to the BWEC participants. For example, BWEC participants regularly reflect on BWEC progress and are willing to change course as needed to continue advancing their collective understanding. BWEC participants also create a wide-reaching network that helps to facilitate progress on BWEC initiatives. Finally, the BWEC's ability to leverage support from multiple organizations, either through direct funding or indirect funding such as in-kind donations, was positively regarded.

The BWEC identified several opportunities for future growth and consideration to be more effective. Some BWEC participants suggested the BWEC should strive to better communicate the findings of their work to a broader audience and raise exposure of the Cooperative. The BWEC also suggested adding or inviting new participants to the Cooperative and specifically suggested inviting women participants, original equipment manufactures (OEMs), and a representative from the Association of Fish and Wildlife Agencies (AFWA). Some participants also suggested inviting participants from the Mexican and Canadian governments to increase the international perspective and influence the way wind energy is implemented across North America. Potential new participants could be engaged via webinar; this may be particularly useful for the OEMs. The group noted that the speed with which BWEC develops and implements projects has waned since initial formation of the BWEC and that this might be an opportunity for improvement. Fundraising was also identified as a potential and perpetual area of improvement. Throughout the workshop, some participants suggested that the BWEC move from a strict science focus to include the development of policy recommendations; others, particularly those representing government agencies, felt this shift could challenge their participation in the BWEC due to their agency requirements of maintaining policy neutrality.

Chapter 3: BWEC and Partner Updates

BWEC committee members and invited speakers provided presentations to update meeting participants on BWEC progress and new developments. Each presentation was followed by a facilitated discussion, in which participants asked questions, made comments, and offered suggestions. The presentations are briefly summarized below. Key themes from facilitated discussions that do not appear in this chapter are included in bullet format in the following chapters.

BWEC's History, Progress Between 2012 and 2015, and Next Steps (Link to Presentation)

The BWEC has made significant progress in priority research areas and in making relevant science and information available since forming in 2003. Overall, the public, industry, and legislators now consider bat impacts more frequently. The last BWEC Science and All Committees Meeting was held in 2012, and resulted in the following priority topics: synthesis and meta-analysis of several topics; minimization strategies (herein referred to as impact reduction strategies) including operational minimization and acoustic deterrents; bat behavior and migration; population estimation, modeling and data collection; post-construction monitoring protocols; and emerging issues. Progress on these priority topics between 2012 and 2014 is summarized below. Moving forward, BWEC will continue working on these priorities, increase collaborations with international partners, and monitor emerging issues and technology.

Synthesis and Meta-Analysis

In 2012, BWEC decided to analyze existing datasets to help answer a variety of research questions. Presented below are progress updates on efforts to synthesize and complete meta-analyses on factors influencing nightly variability in activity or fatality; correlation between pre-construction acoustic activity and post-construction fatality; correlation between post-construction acoustic activity and post construction fatality on a nightly basis; and species specific fatality rates. Data synthesis was also completed on impact reduction strategies; the update on this synthesis is included in the section *Operational Strategies to Reduce Impact*.

- *Factors Influencing Nightly Variability in Activity or Fatality:*
  The synthesis of data on factors influencing nightly variability in activity or fatality has been completed on a project-by-project basis, but not synthesized over multiple wind energy facilities. Because the relationship between fatality and weather is inconclusive, with the exception of the general relationship with wind speed and temperature, BWEC participants are considering researching the relationship between peak fatality events (e.g., finding ≥3 bats on a single day) and weather variables. Since spikes in bat fatality can be identified, the research would try to identify trends in weather patterns a day or night before the peak fatality event. Identifying these trends could then be used to predict when peak fatality events might occur and inform operational strategies to reduce the potential impact. The BWEC has fatality data from four sites located in

Pennsylvania and West Virginia to use in this analysis and would work with industry partners to use the associated weather data collected using the wind turbines and/or met towers on site.

- *Correlation between pre-construction acoustic surveys and post construction fatality monitoring:* As a follow on to the 2012 BWEC meeting, Bat Conservation International, the Theodore Roosevelt Conservation Partnership (TRCP), and Western EcoSystems Technolgy, Inc. (WEST), collected and synthesized data from 111 pre-construction acoustic surveys and 131 post-construction surveys from regions across the U.S. and Canada. Although a large data set was compiled, the analysis is limited due to a lack of paired datasets—only 12 of the sites had both pre-and post-construction data in a given period of time. Analysis of the paired datasets showed a slightly positive trend between increasing bat activity and bat fatalities, which suggests that pre-construction surveys might help to identify potentially problematic areas. However, the relationship was not significant; it had a low R^2 value; and, the prediction intervals were wide and crossed zero. Additional paired data would be needed to prove or disprove any predictive relationship. Regardless, pre-construction studies provide insight on the activity patterns and relative activity of bats prior to construction. However, there was skepticism among some BWEC participants that extensive pre-construction monitoring would provide as much value as an increased focus on impact reduction strategies and post-construction monitoring might provide.

  Several challenges surfaced with this research, but future approaches could yield useful insights. Ensuring quality and consistent data is challenging because of variation in the duration of the study, number of detectors, detector height, the detector type/weatherization, etc. Access to data was also a challenge—the data used in the analysis represents only a small fraction of the total existing data. Much of the data were also unusable and discarded because either post-construction data was available but no pre-construction data were collected (or vice versa) or the pre-construction data was collected prior to WNS and the post-construction data was collected after WNS. Future research in this area might benefit by separating the data by region, detector height, or by species or species group, or by identifying methods to ensure both pre- and post-construction surveys are completed.

  Participants discussed whether or not a regional approach would be useful. Some noted that regional analysis could provide useful insight; however, the scale at which some people would want to use the data is more localized than what could be shown in a regional analysis. Others noted that the findings of this type of research, whether approached regionally or otherwise, had yet to yield findings that could be used by wind developers. From a regulatory perspective, the regional approach would be helpful in light of new species listings.

- *Correlation between post-construction acoustic surveys and post-construction fatality monitoring:*
  Data were collected on post-construction acoustic surveys and post-construction fatality monitoring at several sites. Data analysis and production of the draft findings will be completed in 2015.

Impact Reduction Strategies (formerly called operational mitigation in the 2012 proceedings)

In 2012, the BWEC prioritized research to identify methods that would simultaneously maximize turbine operations and minimize bat fatalities. Presented below are progress updates on several of these research efforts. In addition to the following research updates, BWEC also served as a technical advisor on the study design of research completed by others, disseminated information through the National Wind Coordinating Collaborative (NWCC), an American Wind and Wildlife Institute (AWWI) Technical workshop, and a United States Fish and Wildlife Service (USFWS) broadcast series.

- *Synthesis of operational strategies to reduce impact in the U.S. and Canada (Link to Presentation)*:
  Ed Arnett (TRCP) presented findings from a synthesis conducted by the TRCP, BCI, and WEST of available studies investigating operational strategies to reduce impact of wind turbines on bats. The synthesis discusses two primary approaches to reducing impact, raising the cut-in speed and changing the blade angle (pitching/feathering), using existing data from many sites across the U.S. and Canada. Overall, the analysis found that raising cut-in speeds and feathering can significantly reduce bat fatalities by an average of approximately 50%. However, not all turbines can take advantage of this finding because not all turbines have the same ability to change how they operate. Remotely operated turbines can easily adjust cut-in speeds, while other models may require retrofitting to enable changes to their operation. This suggests that if sites with moderate to high fatalities are identified then curtailment strategies should be implemented; but understanding unknown factors such as the time and conditions under which fatality events occur (see suggested research above on *Factors Influencing Nightly Variability in Activity or Fatality)*, could help to maximize operation and minimize fatality.

- *Optimizing operational strategies to reduce impact:*
  BCI participated in additional site-based studies at the Pinnacle Wind Farm, West Virginia to investigate optimization of impact reduction strategies. The objective was to test whether the time of night influenced fatality. During the first year of study, BCI tested 2 treatment groups, raised cut-in speed of 5.0 m/s for the entire night and 5.0 m/s for the first four hours

past sunset, versus a control group (i.e., normal cut-in speed of 3.0 m/s). There was no significant difference in fatalities between the control group and the 5.0 m/s for the first four hours past sunset. BCI observed a 47% reduction in bat fatalities at the 5.0 m/s all night treatment, but only when an outlier (i.e., a night when 7 fatalities occurred at a turbine experiencing the treatment) was removed. In the second year, BCI removed the 5.0 m/s for the first four hours treatment group and replaced it with 6.5 m/s all night treatment. Similar to previous studies, BCI observed a significant difference between treatment and control groups, but the fatality rate for the 6.5 m/s treatment was not significantly lower than the fatality rate for the 5.0 m/s treatment. BCI observed a 54.4 (95% CI: 17.7–74.7) and 76% (95% CI: 49.1–88.8) reduction in bat fatalities for the 5.0 and 6.5 m/s treatments, respectively. BCI will conduct a 3rd year of study in 2015.

- *Incorporating Weather and Bat Activity*
  Relationships between weather and bat activity research have been infrequently conducted in the U.S.; but some efforts are beginning to focus on this topic (see the above section, *Factors Influencing Nightly Variability in Activity or Fatality*).

- *Measuring and reducing the number of bat fatalities at wind turbines in Europe through operational mitigation algorithms (Link to Presentation)*
  Oliver Behr (University of Erlangen, Germany) and others attempted to standardize strike measurement to better inform wind energy planning by modeling collision and developing bat-friendly operational algorithms. In Europe, where all bat species are protected regardless of population size, the study and consideration of bat impacts from wind facilities is mandatory and, in Germany, sometimes leads to restricted operation or denial of permission to operate. However, the lack of standard methodology to measure and address bat collisions produces uncertainty in the permission process for agencies, developers, and investors. To help reduce the uncertainty, researchers attempted to identify standard methods to estimate the number of bats killed at a specific turbine, predict times of high mortality risk, and mitigate the impacts on bats by stopping the rotor during times of high mortality risk.

  Recognizing that accurate fatality searches are infrequently or inadequately completed, the researchers sought to find alternative methods to quantify collision risk. To do this, the researchers conducted fatality searches and acoustic monitoring at select wind energy facilities to estimate the number of bat impacts. They measured the number of acoustic recordings, wind speed, and fatalities found per turbine per night. They also estimated scavenging rates and fraction of the area searched per turbine, and searcher efficiency per searcher. To estimate the number of bats killed through fatality searches and acoustic readings, the researchers combined the acoustic recordings, wind speed, and fatalities with the estimations of scavenging rates, fraction of area searched, and searcher efficiency. They estimated that 10 fatalities would occur using either the acoustic model or the fatality search model (corrected for biases) for the entire year. Their data also showed that fatality increases with the number of bat recordings and that most bats are struck when the wind speed is 3 to 5 m/s. The researchers further explored the latter finding with the assumption that bat strikes could be reduced if the turbine was shut down in low wind speeds.

During 2011 and 2013, the researchers worked with 16 turbines at eight different sites over a three-month period to evaluate bat strikes during normal operating conditions and conditions under a curtailed operational algorithm. The goal was to see if bat strikes could be reduced from a mean of 12 bats/year to a mean of 2 bats/year. They expected the ratio of fatalities with curtailment to fatalities without curtailment to be 1:6. They measured the ratio of fatalities with curtailment to fatalities without curtailment at 1:6.2. The research found that chosen curtailed operating conditions reduce bat fatalities to 1.9 fatalities per turbine.

The researchers also calculated the estimated loss of revenue from the bat-friendly operational algorithm. They predicted the median loss in revenue would be 1.4% with a maximum of 4.1%. However, the actual loss of revenue will vary among wind facilities.

Although the use of bat-friendly curtailment algorithms is increasing in Europe, the researchers developed an acoustic sampling (BATmode-System) and software analysis (ProBat) package to help more companies collect acoustic data and adopt the algorithms. The ProBat software enables the turbine operator to calculate the number of expected fatalities per year using acoustic sampling data, and to calculate a bat-friendly operation algorithm for a user-defined and entered number of bat fatalities per year. Acoustic data from Avisoft, Anabat and Batcorder can be input into the system.

Bat Behavior and Migration

Bat behavior and migration was not identified as an individual priority area in 2012; however, behavior and migration studies were suggested under the deterrent priority and the population estimation, modeling, and data collection priority and several advances were made in this area. The Bat Behavior and Migration section was added in 2015 given the progress on bat behavior and migration under the two aforementioned priorities of 2012.

- *Advance video monitoring surveillance*
  The USGS and other BWEC participants completed studies in Hawaii, Pennsylvania, Indiana and Colorado to observe and better understand bat-turbine interactions that lead to fatality events. Although much work was completed between 2008 and 2012, the research significantly advanced in 2012 when easy-to-use, digital thermal imaging cameras that are encased in weatherproof housing became commercially available for less than $4,000 per unit. This development enabled the team to capture thousands of hours of data, which the team is analyzing using MATLAB, a matrix-based statistical software. MATLAB automates data analysis; but requires the researchers to write the code for the analysis. The co-authors published the results and code with the hopes of initiating a shared-code movement to help expand and refine the applicability of video monitoring and automated image processing.

  Field tests could yield useful conclusions to guide operational strategies to reduce impacts and the placement and orientation of deterrent devices. Generally, research in Indiana found that tree bats regularly approach wind turbines, sometimes very closely, especially when the blades were stationary or moving slowly. The research also found that bats most often approach from the leeward side of the turbine and may mistake non- or slow-moving turbines for trees. The leeward approaches are influenced by wind speed and blade rotation. For example, approaches increased when blades were not rotating and decreased when blades were rotating. The researchers hypothesized that approaches may increase when blades are not turning because the wind pattern on the leeward side of the turbine resembles that of a large tree trunk. When the blades are moving fast, turbulence on the leeward side of turbines may disrupt the wind pattern that would otherwise resemble the pattern found on the leeward side of a tree trunk resulting in fewer approaches. This insight on focal behavior suggests that tree bats may expect to encounter important resources when arriving at the turbine. The findings may also suggest that the frequency of intermittent, blade-spinning wind gusts could be an important predictor of risk.

  Researchers also investigated the interaction of endangered Hawaiian hoary bats (*Lasiurus cinereus semotus*) with wind turbines during field tests in Hawaii. Findings from this study concluded that bats do not appear to spend much time investigating the wind turbine—the median duration of a visit was less than three seconds. The results also indicate that, in general, when insect tallies are high so are the number of bat detections.

Some similarities and differences were observed between the Indiana and Hawaii studies. In both the Indiana and the Hawaii studies, investigative-like flight was observed by bats flying near the nacelle. Also observed in both locations was 'blade-bouncing,' which is when bats follow and touch the blade occasionally. However, foraging activity was not observed in Indiana but was observed in Hawaii. Additionally, the bats in Indiana were likely migrants encountering a novel structure whereas in Hawaii the bats were probably local bats encountering a familiar structure.

The team will complete more studies and continue trying to reduce the cost of the experiments to make them more easily replicated. As costs for data collection go down and the data analysis software is refined and made public, the team hopes other researchers will attempt to replicate or complete new studies to further understand bat-turbine interactions and how to minimize fatalities. Future studies may focus on how bats approach large isolated trees or how bat behavior is influenced by deterrent devices. It was noted that one of the challenges of such work is the time and cost-effective analysis of such large amounts of data that can now be collected.

- *Efforts to better characterize migration behaviors (Link to Presentation)*

The USGS, the USFS, the National Park Service (NPS), and BCI are collaborating on a GPS research project to test two types of tracking devices—Passive Integrated Transponders (PIT) and global positioning systems (GPS) tracking tags—that would enable them to better understand the seasonal or migratory movements of hoary bats, which are widely distributed but rarely encountered. The long-term goal is to be able to collect data over the course of one year. The identification of migratory or habitat use patterns could serve to better inform wind energy siting decisions.

In Northern California in autumn 2014, the team implanted PIT tags into 128 hoary bats (*Lasiurus cinereus cinereus*) to track their movement and to determine how many hoary bats are moving through a particular area, when the movement occurs, and whether they repeat the same migration or frequent the same locations. Of the 128 tagged bats, only 9 bats were recaptured during the 2014 study. Two of the bats were captured twice and one was captured four times. The team encountered several challenges with the PIT tag data collection in addition to recapturing the bats. Collecting data from PIT tags is only possible if other researchers know to scan for the tag (the procedure to insert the PIT tag leaves no external mark) and they have a scanning device. If other researchers scan a tagged bat, retrieving that data from the researchers also could be a challenge. However, websites exist where these data can be posted. Recovery of PIT tags can occur via mist-netting and fatalities of bats at wind energy facilities. The cost of PIT tag readers is relatively inexpensive and can easily be incorporated in the cost of a fatality-monitoring project for the site.

Advances in small GPS devices led the team to experiment with suturing Lotek Pinpoint 8 GPS tags onto the back of bats. Previously, GPS devices were too large to attach to small bats without causing harm; however the Lotek device is sufficiently small and light-weight so that it presumably causes no harm to the bat. The devices collect 8 GPS points, are rechargeable and reprogrammable, and should stay on the bat for approximately 180 days. Initial trials with big brown bats (*Eptesicus fuscus)* in Colorado and hoary bats in California proved successful and identified some challenges. For example, to collect the data and to recharge the batteries the bats must be recaptured, the act of which is often a combination of good luck and site fidelity. GPS accuracy is another challenge influenced by how many satellites the device can access during data capture. However, the tags collected GPS locations both during the day while bats were roosting in the forest canopy and at night while bats were foraging. During the fall 2014 study, several bats with GPS tags were recaptured and showed movements of up to 70 km from the capture site.

The team hopes to expand the GPS to other high-density hoary bat sites in New Mexico (Spring 2015), the Humboldt Redwoods (Autumn 2015), and the Rocky Mountains (Autumn 2015).

- *Using acoustic detectors to assess bat activity and migration (Link to Presentation)*

  Kevin Heist (University of Minnesota) and Doug Johnson (USGS) presented the research findings of a collaborative effort between the University of Minnesota, the USFWS, and USGS to learn whether or not bats are subject to the same migration constraints as birds. The research compared Great Lakes region activity to sites and activity outside the Great Lakes and compared near shore activity with farther inland activity.

  Several conclusions were drawn from the nearly 1.2 million data points collected between 2011 and 2012. Regionally, the data shows that bat passes and activity in general are high along the coasts of the Great Lakes when compared to sites in southwest Minnesota (low bat pass) and in central Minnesota, Iowa and Wisconsin (medium bat pass). Some sites in the Great Lakes Region recorded 100s of passes per night on average while sites in central or south-central Minnesota recorded approximately 40 passes per night. When comparing inland activity and near shore activity, the researchers found significant differences in bat activity—the near shore sites recorded more activity than the inshore sites. The research also identified the proportions of bat species encountered in various regions or at various sites, which showed that relative species abundance varies by region. Little brown bats were frequently observed in northern Michigan and Wisconsin. The researchers also compared the acoustic data to fatality data; but no pattern was identified. Participants noted that these kind of studies can provide landscape information potentially helpful to wind energy siting more broadly.

- *Using marine radar to assess bat activity and migration*
  Dan Nolfi (USFWS) presented the findings of research completed by USFWS, USGS, and the University of Minnesota to document bat migration along the great lakes using avian radar and acoustic monitoring. The goals of the research were to determine what species of bats are present and when and where they are present; document migratory behavior at the landscape level; assist USFWS field offices and other state and local governments with wind energy development; develop recommended cut-in speeds; and evaluate the cumulative impacts to long-distance migratory bats. The findings indicate that lakeshores are important migration corridors and that lakeshore habitat is important as a stopover and as a refuge as migrants come off the water at dawn.

  To collect the data, the researchers used dual S-band scanning antenna with weather stations and acoustic monitors. The radar units have both horizontal radar and vertical radar which allowed the researchers to sample both high and low altitude targets, identify the targets direction of travel, and estimate the target height. Acoustic monitoring was usually completed simultaneously with the radar data collection.

  The combination of radar and acoustic monitoring yielded useful information about bat migration and insights for future consideration. Analysis of the radar and monitoring data shows a strong correlation between bat activity observed with acoustic monitoring and the radar pulses. This suggests that bats are active and migrating during the same weather periods as passerines (night migrants). The data also suggest a strong correlation between bat activity and radar pulses during dynamic weather patterns—bat activity was shown to increase following a few days of nice weather or a few days of inclement weather (e.g., wet, windy, stormy or extreme cold conditions). This research showed that radar is useful to document migration, especially for nocturnal migrants. It also identified recommendations for future investigations. For example, unless supporting data are available, the surveys should be conducted for the entire spring and fall seasons, and multiple years of data may be needed to account for year-to-year variability.

Ultrasonic Acoustic Deterrents

BWEC agreed to continue working on ultrasonic acoustic deterrent studies in 2012. In particular, the group focused efforts on advancing video monitoring approaches lead by USGS (see above) and on the delineation of deterrence effects on bat behavior to determine which frequencies and periodicity deter bats. Updates from efforts between 2012 and 2014 follow below.

- *Test and refine deterrent technology (Link to Presentation)*
  BWEC did not advance deterrent research and design between fall 2010 and 2013. However, in April 2013, the BWEC held a webinar to discuss the current state of knowledge of the effectiveness of using ultrasonic acoustic deterrents to reduce bat fatalities at wind turbines. The webinar was a primer to a technical workshop held at the National Wind Technology Center in August 2013. The workshop participants discussed next steps for deterrent research and decided to continue the research and development of the device designed and manufactured by Deaton Engineering, Inc. (DEI) as opposed to starting from scratch. The BWEC's progress to test deterrents between 2013 and 2015 are below.

  BCI investigated the effects of deterrents on the behavior and activity of Hawaiian hoary bats. Similar to previous studies between 2009 and 2012, this study suggests that acoustic deterrents can reduce bat activity and suppress focal behavior (i.e., use of a preferred foraging habitat). In the 2013 study, use of deterrents decreased bat activity and when the use of the deterrent was discontinued the bat activity returned to levels observed under the control conditions. The researchers also tested a deterrent device on Brazilian free-tailed bats (*Tadarida brasiliensis*) in 2014. This test showed that bats avoided the air space containing the ultrasonic broadcast produced by the deterrent so long as the deterrent was activated. Overall, the BWEC research suggests that deterrent devices can reduce bat activity and suppress behavior, and shows promise in reducing fatalities at wind energy sites. In 2015, the team will design and conduct a comparative study of deterrents to control situations, to higher cut-in speeds, determine whether higher-cut in speeds and deterrents create synergistic effects, and compare costs associated with each approach.

- *Understand deterrent effects on bat behavior and determine the optimal periodicity and frequency output.*
  This was not completed because deterrent devices did not have the capability of producing different waveforms; however, the next-generation device designed by DEI will be able to produce white noise, targeted frequencies, and sweeping or pulsing frequencies (see update from Pete Garcia, DEI). Some participants raised doubt that sound forms could be tailored to species or higher deflection of bat activity and that the basic white noise may remain the "deterrent" of choice.

- *BWEC Device Research and Design (Link to Presentation)*

  Pete Garcia (DEI) updated the BWEC on research and development of the deterrent designed and manufactured by DEI. The 2010 version of the deterrent device only produced white noise across a frequency range from 10 kHz to 100 kHz. The current version of the design includes two configurable options for the output waveform, continuous white noise across a frequency range with user-defined limits or a single frequency output at a specific user-defined frequency. Future variations on the device may allow for user-defined fixed-pulse variations, randomized pulse variations, or frequency sweeps.

  The design of the device and configuration on the turbines has evolved since 2010. In 2010, the device included 16 ultrasonic transducers in a single plane in a 4x4 matrix; the configuration on the wind turbine used 8 deterrent boxes pointed down with reflectors on two of the boxes. The current design concept also has 16 ultrasonic transducers but they are situated on two planes (like the roof of a home) in a 2x4 matrix; the configuration of the current design concept is to place six deterrent boxes facing down and two facing up. The goal of the current design is to expand coverage while not limiting the effective range. Future designs could have variations on the transducer geometry and configuration of boxes on the turbine.

  The hardware layout also advanced since 2010. In 2010, 8 deterrent boxes, which housed both the transducers and amplifiers, were placed outside of the nacelle and cables from the boxes led to two boxes placed in the nacelle that contained the power supply. One amplifier circuit was dedicated to each bank of 16 transducers and the equipment was all passively cooled. This design occasionally showed water ingress. The design required operators to manually set the system in on/off configurations. In the current design, only the transducers are placed outside of the nacelle. Eight boxes are placed inside of the nacelle to house the amplifiers, power equipment, and other hardware, which require forced air-cooling. The new design will hopefully eliminate water ingress, and allow operators to select different wavelength configurations for each bank of four transducers remotely via Ethernet.

- *Determine the optimal placement and orientation of deterrents on turbines*

  This has not been completed. The BWEC could conduct a study at an operational wind energy facility to advance this priority.

- *Determine whether or not the deterrent effect diminishes over time*

  BWEC research on bat deterrents seems to show that bats do not appear to habituate to the deterrent over a one- to two-week period; however, no long-term studies have been completed to investigate deterrents and habituation patterns.

- *Tests of acoustic deterrents in the United Kingdom (Link to Presentation)*

  Gareth Jones (University of Bristol, England) presented research on the use of deterrents to minimize problems caused by bats in historic buildings in the United Kingdom. As previously noted, all bat species are protected in Europe, even if they typically roost in frequently utilized buildings such as churches. In the UK, bats and humans came into conflict when bat droppings and urine began to damage historic and cultural artifacts or affected the use of the church for worship or other community functions. The goal of the research was to minimize impacts on the churches while protecting the bat populations.

  The research examined the range of effectiveness of several approaches to mitigate the problems, the impact of each approach on the bats, and the cost of the different deterrent approaches. The approaches they examined included heated bat boxes for artificial roosts and deterrents such as artificial lighting, the BWEC deterrent device, and a radar device. Ultimately, the investigation focused on the use of lighting and ultrasonic deterrents since the radar was potentially more expensive and did not show as much promise as the light and ultrasonic deterrents.

  Both lighting and the BWEC device showed promising results for different applications, while the artificial roosts and radar were not as effective. Since the roosting bats are averse to light, the researchers illuminated the roost entrances; but this only served to entomb the bats in the roost. Once the lights were removed, the bats exited the roost. The lighting was also used to create 'no fly zones' by illuminating sections of the church away from the roost where researchers did not want the bats to fly. This appeared to work for bats in the genus *Myotis* but not bats in the genus *Pipistrellus*, which exhibited hints of habituation. Application of the BWEC device shifted the roost location of nearly all the bats in the church within two days. The BWEC device did not appear to have any adverse effect on foraging behavior; but partial exclusion may have occurred at smaller churches containing relatively large numbers of bats. The bats showed no signs of habituation to the BWEC device over a two-week period. No bats shifted to the artificial roosts during the experiment, but some evidence suggests limited use of the boxes post-experiment.

  Additional studies will be completed in 2015. A PhD student will further examine the use of radar and, as a follow on to the research presented to the BWEC, a one-year study will be completed in select churches to examine the response of bats to deterrents in the spring and fall and tailor the application of deterrents and other mitigation measures to individual churches. Eventually, guidance documents and a policy and licensing framework will be developed to provide a management toolkit for use at other qualifying churches in the future.

- *Results from General Electric (GE) Deterrent Study and Update on GE Device*

  Kevin Kinzie (GE) presented the results of GE's research of a deterrent proof of concept. GE's goals were to develop a deterrent device that could produce a broad band of ultrasound in the range of 20 kHz to 50 kHz, cost less to use than curtailment options, and be easy to maintain. The device they created is an air jet device powered by a compressor installed in the turbine. The device does not increase the far-field turbine sound level. The 20–50 kHz range was selected because it seemed to be the best combination of effectiveness and air supply.

  GE and Invenergy are collaborating on a 3-year study at Invenergy's California Ridge Wind Facility in Illinois. The study will be completed in 2015. During the study, the device operated constantly under all conditions including when the turbines operated at normal cut-in speed and when the turbines were feathered below cut-in speed. Fatality searches were conducted by people in 2013 and both people and canines in 2014. In 2013, the deterrent effectiveness was estimated at 24.9%. In 2014, after the deterrents were placed at the back of the nacelle and two in the tower, the estimated effectiveness increased to 29.3%. Dr. Kinzie proposed several outstanding questions for future deterrent research including:
    - What are the most effective places to locate a deterrent?
    - What is causing the apparent reduction in effectiveness of turbine mounted deterrents compared to ground tests conducted in bat foraging areas (e.g. engineering effects or biological effects)?
    - What is the most effective acoustic deterrent signal?
    - What level of effectiveness needs to be proven to make deterrents an acceptable alternative to curtailment?

  The group discussed the ability to project frequencies to the blade tips and the potential to install devices on the blades. Dr. Kinzie said the GE device has an estimated range of approximately 20–40 meters based on ground studies, which does not reach the blade tip on most modern turbines. Mounting the deterrents on the blades could extend their effective range, however this solution likely adds complexity and cost, and the value of blade mounting is not yet obvious. In response to a participant question, Dr. Kinzie said devices could be installed in the blades provided the manufacturers are engaged in the design. He noted that installing devices on new blades on the ground before the blade is installed on the turbine would be a much simpler implementation than field retrofits, but neither blade mounted solutions has been developed.

Population Estimation, Modeling, and Data Collection

BWEC studies provided genetic and hair samples to several partners working on projects related to the species most affected by wind turbines. BWEC also helped to disseminate research on population estimation and modeling but has not provided significant support on individual efforts to model bat populations or to validate parameters for population models. The following is a summary of efforts on this topic to date.

- *Efforts to identify long-term monitoring sites*
  Monitoring studies at proposed or operating wind energy facilities are often short-term. Pre-construction acoustic surveys are typically 1 year and post-construction fatality monitoring studies are often 1–2 years in duration. The U.S. Forest Service (USFS) is collecting acoustic data at a long-term monitoring site in northern California. Dr. Amanda Hale from Texas Christian University is partnering with NextEra to study the long-term fatality patterns of bats a wind energy facility in north Texas. More long-term studies are needed to understand the long-term impacts of a wind energy facility on bats.

- *Investigating population size of long distance migratory tree bats*
  Dan Nolfi (USFWS) presented USFWS ongoing research designed to better understand the population levels of hoary, eastern red, and silver-haired bats (*Lasionycteris noctivagans*) that would be needed to sustain the population given cumulative/yearly take of bats by wind energy facilities. When complete, the research should provide insight on the actual impacts of wind energy on migratory bats by modeling past, present, and future population numbers and help to evaluate how current protection efforts are (or are not) functioning.

  The bat species share several common characteristics, both unknown and known, which required the researchers to incorporate many assumptions into the model. The population size, population growth rates in the past, present and future, and the actual quantities of these bat species that are affected by wind energy developments are not well understood. Each of the bat species is also affected by habitat loss, and current and future wind energy developments. The researchers made several assumptions while focusing their initial efforts on the hoary bat population. Some of the assumptions included that the estimated fatality rates were plausible, development of wind energy facilities would be linear, and the take was uniform.

  The research team developed a model that incorporated significant expert input and guidance. For example, they met with experts prior to the North American Society for Bat Research (NASBR) in 2014 to solicit input about biological parameters, evaluate the USFWS and independent models, and narrow the list of unknown inputs for the models. They also sought input on alternative methods of evaluating bats and investigated surrogates to incorporate into the models. The guidance raised additional questions and led the team to initially focus on the hoary bat, various components of the model, and to seek additional data.

The team continues to collect data and refine the model. Currently, they are finalizing assumed adult and juvenile survival and breeding rates to determine the population growth rate before wind energy development. They are also collecting estimates for wind energy development in the U.S., Canada, and Mexico. Build-out rates for U.S. wind energy facilities will be based on USDOE projections. After the model is completed for the hoary bat population, the team will refine the model for the eastern red, silver-haired, and possibly other bats. Scenarios will be run to evaluate a range of possibilities. For example, one scenario will look at maximum energy facility build-out without protection measures in place. Another could look at meeting a percentage of the current 2030 build-out goal with some level of protection for bats in place.

BWEC discusion after the presentation focused on estimates for wind development. A participant suggested the researchers do not use the Federal Aviation Administration wind turbine build-out estimates because they are over-inflated.

Fatality Estimation

The BWEC prioritized efforts to refine and publish methods on fatality estimation and evidence of absence/absence of evidence determinations in relation to post-construction monitoring protocols. Advances in this area are presented below.

- *Recent Advances in Estimating Fatality*

  Manuela Huso (USGS) presented on recent advances in estimating fatality at wind power facilities. Simple counts of observed carcasses cannot be used as an index of fatality because detection rates can be very different for each carcass. The primary factors affecting detection include fraction of all turbines at a site that are searched, the configuration of the searched area relative to the area where carcasses could possibly land, searcher efficiency and carcass persistence. Some frequently used estimators include Erickson's (2000), Shoenfeld's (2004) and Huso's (Huso 2011, Huso et al. 2012), although others have been proposed, e.g., Korner's (Korner-Nievergelt et al. 2011, Korner-Nievergelt et al. 2012, Korner-Nievergelt et al. 2015), Wolpert's (2013), Peron's (Peron and Hines 2013, Peron et al. 2013) and Etterson's (Etterson 2013). The estimators differ in their assumptions about the detection factors and how those factors should be appropriately combined to reflect the overall probability of detecting a carcass.

Some factors are more easily incorporated into estimators than others, which lead to differences in how the factors are accounted for (or not) and the resulting accuracy and precision of the estimators. For example, the fraction of turbines searched is easily incorporated because it is typically a sampling issue and not a modeling issue. On the other hand, the configuration of the searched area relative to area where carcasses could possibly land is often ignored in estimates presented in fatality monitoring reports. Because carcass density is not constant spatially a simple adjustment that accounts only for the proportion of a designated search plot that was actually searched without accounting for the change in density will typically result in an overestimate of fatality. Early estimates often ignored this factor, while more recent estimates often consider it.

Another highly influential factor is searcher efficiency (the probability a searcher will find a carcass that is present in the search area), which is in part determined by the terrain in which a carcass is located (e.g. open, short grassy field vs. rows of 2.5 foot tall soy bean plants), and the size and coloration of a carcass. An important component that differentiates the current estimators is how they address the probability of discovering a carcass missed in a previous search. Erickson's estimator assumes the probability of detecting a carcass is the same on any search; Huso's estimator assumes that only carcasses believed to have been killed in the interval preceding the search are included in the fatality data, satisfying the assumption that the probability of detecting a carcass once missed is zero. Estimators developed by Korner-Nievergelt, Wolpert, Etterson, and Peron all allow for non-constant searcher efficiency, although most monitoring protocols do not result in adequate data to estimate the needed parameters. Carcass persistence is another highly influential factor and different persistence models can result in very different fatality estimates from the same data.

The estimators have been refined over the years to address specific shortcomings, although some shortcomings persist in each model. For example, Erickson (2000) advanced to include adjustments for carcass persistence and searcher efficiency, but shortcomings include the assumption that carcass arrival and persistence are in a steady state and, when the search interval is short relative to persistence time, a negative bias is almost guaranteed. Shoenfeld (2004) advanced to include a correction factor to Erickson (2000) to eliminate the need for a steady state assumption; but Shoenfeld assumes exponential persistence times and constant searcher efficiency. These differences can lead to markedly different estimates of fatality.

Estimates should be interpreted with caution when effects such as change in searcher efficiency with each search and carcass persistence patterns are not appropriately incorporated into the estimators. Dr. Huso recommended development of a generalized estimator, changing searcher efficiency trial protocols to allow for multiple opportunities to discover carcasses, and assuring that carcass persistence models accurately capture time dependence instead of assuming exponential persistence. She also cautioned that since older estimates contain unknown degree of bias, it is important to consider the value of metrics like 'industry average' before applying them to policy or project-specific decisions. The metrics could be recalculated using a generalized estimator if key input variables can be collected from the original studies and reasonable assumptions can be made about searcher proficiency probability distributions. This would enable a standardized approach with unbiased project-specific results that can be meaningfully compared.

In January, a group of researchers convened to begin discussing the development of a generalized estimator with initial support from AWWI. Next steps for this group may include creation of a joint publication on a generalized estimator and the development of software to help people complete the calculations. The group must also seek funding for both of these steps. BWEC participants were supportive of moving forward on this work.

- *Evidence of Absence/Absence of Evidence*

  Manuela Huso (USGS) also discussed when observing no carcasses of a rare species during monitoring can be interpreted as evidence of absence or when it simply reflects absence of evidence. Several wind energy companies have applied for incidental take permits which would allow limited take of a species of concern at a facility, and may require mitigation if it is determined that the limit has been exceeded. Current monitoring protocol and estimators are not designed to detect when a set limit is exceeded, and in particular give no information if the observed count is zero.

  If the overall probability of detecting a carcass is high, then observing no carcasses of this species of concern can generally be interpreted as evidence of absence (i.e., there were not likely to be many that were missed during searches). However, if the overall probability of detection is low, then we cannot rule out that there may be several carcasses of the species of concern that we simply missed in our searches. We only have absence of evidence. What has now come to be conventional search protocol at wind facilities often results in low overall probability of detection, but this does not pose any serious problems when the objective of monitoring is to estimate total mortality of large groups, e.g., birds and bats, and when numerous carcasses are discovered. But this protocol cannot assure compliance with take limits when detection probabilities are small and few or no carcasses of the species of concern are found. A potential solution is to design monitoring protocols in order to achieve a target level of assurance that the given limit was not exceeded.

In summary, the optimal protocols are very different when the objective is to estimate total fatality for general groups of animals versus individuals of a single species. Not finding any carcasses can only be interpreted as evidence that few or none were actually killed if the overall probability of detection is fairly high. Little inference can be derived from monitoring involving low observed counts and low probability of detection. Future work will focus on developing methods to determine indicators of lack of compliance (triggers) based on protocol and observed carcass counts.

Post-construction Monitoring Protocols

Ed Arnett (TRCP) and Erin Baerwald (Ph.D. student from the University of Calgary) summarized fatality patterns from post-construction monitoring results in 2013 and NREL organized a team of experts to draft and review a framework for monitoring the effects of impact reduction strategies on bats. "BWEC approved" protocols have not been developed and disseminated as a stand-alone document; but BWEC members helped to draft existing protocols for BWEC research projects, which are disseminated via peer review reports, publications, presentations and workshops, including the National Wind Coordinating Collaborative's (NWCC) Comprehensive Guide to Wind and Wildlife Interactions and the USFWS' Land-based Wind Energy Guidelines. BWEC supported USGS in the publication of papers in scientific journals on evidence of absence and density-weighted proportions. To improve the effective use of carcasses, BWEC has provided genetic and hair tissue samples to various laboratories. BWECs efforts to identify comparable sites and risk factors to reduce the need or intensive monitoring at all sites was constrained by the high variability in fatality rates at sites in close proximity to one another and between sites that share similar habitat features. Future action may involve helping to coordinate among laboratories and other researchers to help improve the effective use of carcasses.

Emerging Issues and Technology

In 2012, the BWEC identified several emerging issue areas to monitor and to engage as appropriate. The issue areas included international work, offshore wind, endangered species, regional expansion of wind, and small-scale wind projects. Progress in some of the aforementioned issue areas is presented below. BWEC has not yet conducted a gap analysis to identify opportunities for regional expansion nor has BWEC focused significant effort on small-scale wind projects.

- *Expand the network internationally and build capacity*
  BWEC has considerably advanced the development of an international network of wind energy facility representatives and biologists. In 2012, the BWEC program coordinator attended the Conference on Wind Energy and Wildlife Impacts (CWW), Stockholm, Sweden to meet with European colleagues and present BWEC research. The coordinator also attended the International Bat Research Conference in Costa Rica, hosted a lunch with international partners, and co-organized a bat and wind symposium with Dr. Barclay (University of Calgary). BCI sponsored a Puerto Rican and a Chilean representative from RELCOM (The Latin American Network for the Conservation of Bats) to attend the first Bats and Wind Energy Workshop in 2013. In 2014, the BWEC coordinator was invited to participate in the development of guidelines for the Chilean government, to speak at the first COLAM (The Latin American Bat Congress) in Ecuador, participate in the finalization of guidelines for the South African government, and to speak during the first International Energy Agency (IEA) Task 34 webinar. In 2015, the BWEC coordinator will again attend CWW and present BWEC research, engage with and exchange information with international colleagues via the IEA Task 34 website/blog, translate BWEC research to Spanish with colleagues from RELCOM, and post a literature review of European Bats and Wind Research on the BWEC website.

- *Offshore: engagement on issues as appropriate and provide expertise on land-based wind energy issues*
  Both anecdotal and scientific observations have been made of bats offshore. In 1902, for instance, a British streamer reported a large migration of bats 16 kilometers off the coast of Delaware. Cryan and Brown (2007) discussed hoary bat movement patterns 48 km offshore on Southeast Farallon Island. Ahlen (2009) documented bats offshore near turbines in Scandanavia. Sjollema (2011) documented bats at an average distance of 8.7 kilometers off the mid-Atlantic coast. More recently, Pelletier et al. compiled a literature review of potential bat interactions with offshore wind facilities in 2013. BWEC participants are not expecting off-shore wind impacts to be a major concern due to distance of wind facilities from shore (more than 10 miles or 16 kilometers) and minimal bat populations present, but they will monitor the issue. BWEC members are currently working on a collaborative project with Oregon State University to develop an integrative detection system for offshore collisions that incorporates strike detectors, thermal video cameras and acoustic detectors.

- *Small-scale wind turbines and distributed wind facilities*

Small Wind Turbines (SWT), defined by AWEA as less than 100 kW, have been installed in the US and throughout the world. As of 2013, an estimated 806,000 units operate globally and at least 155,000 in the US. Although investigations of the impact of SWT on bats have been limited, bat fatality estimates from UK range from 161-3,363 at approximately 20,000 SWT (Minderman et al. 2014). Siting guidance may help to reduce strikes, as SWT sited near certain habitats (e.g. water, hedgerows, forest) have reported bat fatality (BCT 2007). Distributed wind turbines range in size from 5 kilowatts to multi-megawatt turbines. Some research indicates that distributed wind turbines, particularly single multi-MW turbines, can have higher per-turbine fatality rates than utility-scale wind projects. In Delaware, Butler et al. (2013) estimated 111.1 bat fatalities at a single turbine. In Iowa, Crotty et al. (2014) reported 27 bat fatalities compared 4 bat fatalities at similar turbines within a multi-turbine facility, although these counts were uncorrected for survey effort. However, given the broad distribution and limited scale of these small-scale turbines, BWEC participants are not expecting significant impacts compared to utility-scale wind energy developments.

- *Endangered Species*

  BWEC completed an investigation at a wind energy facility on Oahu, Hawaii using acoustics, video, and fatality surveys to assess bat behavior and risk, and whether or not behavior differs between resident and migrant hoary bat populations. Additional research is needed regarding the impacts to other existing and potentially listed species in the Midwest and Northeast U.S. Significant work is taking place on this topic via USFWS potential listings and through region-wide HCPs.

- *Technology*

  Advances in contact sensor technology (i.e., strike indicators) may provide opportunities to better understand bat and wind turbine interaction. Vanderbilt University developed a helicopter blade strike indicator that could be applied to turbine blades to detect when strikes occur; BWEC was contacted to discuss testing. Oregon State University developed an integrated sensor array to indicate strikes and BWEC supported preliminary tests, which seemed promising. ID Stat developed an acoustic strike detection technology capable of detecting strikes by objects as small as 2.5 grams. The contact sensor/strike indicator technology could be applied to assess offshore impacts or identify the timing of fatalities onshore.

  Non-contact sensors such as thermal, near-infrared, and radar are also advancing (see Bat Behavior and Migration section); but software to detect targets is still needed. The USGS is updating the open access software they developed. BWEC could test software developed by PNNL and Matzner (2014). Preliminary testing of software by Ornicept, (Conrad 2014) is ongoing.

Advances in turbine technology could have positive or negative impacts on the interaction between bats and wind turbines and influence current minimization strategies. Newer turbines are increasingly operating at lower wind speeds, which are the wind speeds when bats are more likely to be struck by the blades. However, if turbines can generate power at lower wind speeds (e.g. during the day when bats are inactive), then turbines could possibly be curtailed during periods when bats are more active (e.g. at dusk and nighttime). Alternative turbine technology such as the Makani Kite turbines have much larger rotor swept zones and higher operation heights which may put the turbines in the normal flight space of some species.

Investigating Bat Barotrauma Using Computational Fluid Dynamics Simulations

Mike Lawson, NREL, presented the findings of an investigation using computational fluid dynamic (CFD) simulations to study the pressure changes a bat may experience when flying near operating turbines and correlate the pressure changes with estimates of survival pressure change limits. The research was designed to provide insight on whether or not barotrauma is a significant cause of death in bats that interact with regions of low-pressure that are created around spinning wind turbine blades.

Bats could be impacted by blast overpressure (spikes in pressure) or blast underpressure (pressure drops). Studies completed on mice, which have approximately the same mass as bats, showed a zero mortality rate for overpressures below 30 kPa. Blast underpressure studies on rats, which are approximately 10 times heavier than bats, showed that rats could survive pressure drops as large as -64/2 kPa without injury. Correlated to mice, this suggests that deaths and barotrauma in bats would occur at about 20 kPa.

Three scenarios of bats flying near turbines were investigated. Scenario one was in the rotor plane with the bat passing at three distances (1 mm, 100 mm, and 200 mm) from the blade; four wind velocities were investigated (5, 7.5, 10, and 12.5 m/s). Scenario two was through the rotor plane with the bat passing at the aforementioned distance and wind velocities. Scenario three was through the tip vortex (at the end of the blade) with a wind velocity of 5 m/s.

The pressures a bat experiences when flying near a turbine were estimated by tracking the modeled flight path and pressure histories. The simulations showed that pressure change was most negative when a bat flew within a millimeter of the blade, at which point the blade would also likely strike it. During the worst case scenario, the 12.5 m/s path through the rotor plane, a bat would experience 1.5 to 2.5% of atmospheric pressure change. The farther away from the blade the bat flew the greater the pressure change drops, or in other words, the pressure change drops off rapidly with increasing distance from the blade.

The researchers concluded that the estimated fatality from barotrauma is low. The pressure changes determined by the simulations are significantly smaller than those required for death in mice and rats. Additionally, the proximity to the blade required to experience the largest pressure changes almost guarantees the blade would strike the bat.

The BWEC provided the following questions and comments:

- The anatomy of bats and rats is very different, which could mean different types of impacts from barotrauma. For example, the lung volume of bats is proportionally greater and the internal surface areas are roughly twice as extensive, their eardrums are much thinner, and they possess echolocation anatomy. These differences may make bats more susceptible to barotrauma.
- Two potential things remain to be explained. First, how can we explain no traumatic impact injuries in bats? Second, why do we not see those same impacts to birds? The assumption is that a pressure of ≥ 20 kPa is necessary before a bat is injured; but if this assumption is wrong then bats could be harmed at different pressures.

Chapter 4 – Priorities for 2015-2018

The draft lists of prioritized actions and activities produced during the meeting were designed to inform Oversight Committee decision-making; this prioritization did not represent decisions on specific projects, plans, roles and responsibilities, or financing. The Oversight Committee made final decisions on BWEC priorities and activities for 2015–2018, as seen in the following section. Comments and themes from the facilitated BWEC participant discussions that did not appear in the previous chapters are included in bullet format under the appropriate issue area in Chapter 4.

Pre- and Post-construction Monitoring and Data Collection

The BWEC identified pre- and post-construction monitoring and data collection as an important priority area in 2015. High importance was placed on compiling a large and trusted dataset, and examining landscape and weather covariates in relation to bat activity and fatality. Medium and low priority rankings were applied to the creation of a research framework for assessing impact reduction strategies and updating existing guidance documents with advances in technologies and methodologies, respectively. Participants offered the following questions and considerations about pre and post construction monitoring and data collection:

- If post construction fatality data with medium to high mortality exists, could site conditions be examined to draw conclusions about what makes the site or site conditions problematic, then identify lessons learned and create best management practices for siting? This would require a large sample of sites to look at variability between low and high mortality sites.
- Datasets from facilities with consistent monitoring protocols are needed. The BWEC discussed the possibility of working with the Pennsylvania Game Commission use pre- and post-construction monitoring dataset
- A guidance document, or synthesis of existing post-construction monitoring protocols would be useful for state agencies.

Table 1: Pre and post construction monitoring and data collection priorities for 2015-2018.

Priority	Time Frame	Objective	Action	Who	Notes
H	Short-Term	Compile large datasets	• Working with industry, USFWS, and others to support "third party" methods of aggregating confidential data from various sites/projects to build a trusted database for research.	AWWI	Support AWWI in building & maintaining their database
H	Short & Medium-Term	Examine landscape and site covariates with activity and fatality	• Keep current with efforts on identifying landscape patterns of activity (e.g., acoustic, radar, etc.) to identify potential key covariates (e.g., weather, season, etc.) that that may help predict risk • Connect with PA Game Commission to analyze state-wide fatality dataset • Use AWWI database to investigate landscape patterns of bat fatality	AWWI & BCI	Identify specific parameters that could refine impact reduction efforts to specific days/times of season, weather conditions, insect density, etc.
M	Short-Term	Create framework for research	• Develop standard framework for monitoring effectiveness of impact reduction strategies to ensure comparability across research projects	NREL	Support NREL development of a research framework
L	Medium-Term	Update existing methods and metrics documents	• Identify advances in technology and methodology and update existing documents, such as USFWS's Land-based Guidelines and NWCC's Comprehensive Guide	AWWI, BCI & USFWS	Identify experts on new technology or methodology to draft updates

Fatality Estimation and Modeling

In 2015 the BWEC determined that the development and publication of a generalized estimator is a high priority that could lead to consistent data collection and analysis methods across study sites. The BWEC also placed high priority on analysis of existing BWEC data to determine whether or not peak fatality events could be predicted using weather covariates.

Comments from participant discussion included:

- Weather data collected by wind developers may be available for use to analyze the link between weather patterns and peak fatality events. It would be interesting and useful if this research could help turbine operators adjust the turbine operation accordingly to reduce impacts both to bats and their costs of implementation.

Table 2: Fatality estimation and modeling priorities for 2015-2018.

Priority	Time Frame	Objective	Action	Who	Notes
H	Medium-Term	Develop and publish a generalized estimator	• Consolidate numerous estimators to create a single, generalized estimator that accounts for various factors	AWWI, BCI, USGS & others	Support statisticians in convening workshops, generating funds to develop software, and disseminating findings
H	Short-Term	Predict peak fatality events	• Use existing BWEC data from multiple sites to compare peak fatalities to weather covariates	BCI	Need to define peak fatality events
M	Short-Term	Promote use of appropriate use of fatality estimators	• Ensure use of appropriate fatality estimators and discourage use of outdated estimators	BWEC	Disseminate BWEC research
L	Long-Term	Develop decision tool for evidence of absence	• Develop decision tool comparing variable survey designs to achieve the same statistical probabilities	USGS	Use evidence of absence software to determine rare/endangered species compliance

Bat Behavior at Various Scales

The BWEC ranked the use of thermal videography to study bat behavior and staying abreast of and supporting the development of strike detection technology as medium priorities in 2015.

Participants offered the following comments and considerations about bat behavior studies during the workshop:

- Behavior research, including that of migration, should focus on specific questions that can influence siting or management decisions. For example, does migration data identify the highest risk points along a migration route or are there refined management techniques that would help to reduce bat and turbine interaction.
- Landscape data is good for a preliminary review and might help to identify areas of heightened risk; but detailed data is needed for siting at the local level.
- With the exception of consistently high fatality rates on Appalachian ridges, trends between fatality risk and landscape elements at any scale are not yet clear.
- Migration data linked to forest parcel size could be useful to help identify mitigation options.
- It would be interesting to use video data to determine when fatality occurs, then compare or relate these data to weather patterns. Similarly, video data could be paired with strike indicators and acoustics to identify what causes strikes and when they occur.

Table 3: Priorities for research on bat behavior at various scales between 2015-2018.

Priority	Time Frame	Objective	Action	Who	Notes
M	Short- and Medium-Term	Use thermal videography to study bat behavior	• Use video technology and analysis tools to provide insight on bat behavior and methods to reduce impact (e.g., how to position and orient deterrent devices)	BCI & USGS	Effective software is essential for automatic processing of large amounts of data
M	Short- and Medium-Term	Monitor strike detection technology	• Follow, support, and test efforts to develop strike detection tools that can identify more exact times for impact, correlate strikes with turbine RPMs/speed, temperature, time of night, and/or other parameters	BWEC	Support OSU and others efforts on integrated detection & strike indication system

Population Estimation, Modeling and Data Collection

The group identified population estimation, modeling, and data collection as an important topic; but not an area where BWEC should lead research efforts. Instead, this group agreed that state and federal agencies are responsible for estimating population sizes. Given the uncertainty with population data, the group expressed concern about unknown population numbers and assumed that some bat populations will be affected by wind energy development.

Comments from participant discussion included:

- Three years ago, red bats were the best understood population, but now other researchers are publishing data on population structure within other specific species. New methods such as genomic studies, such as have been applied to peregrine falcons, are also developing and could be applied to bats.
- Population estimations are important when making decisions that will impact how bat populations are affected. In a recent management example, the Pennsylvania Game Commission used population estimates to set curtailment thresholds.
- Population studies could help to answer the question of whether or not populations are stable and at what build-out point wind energy facility development will likely impact the population.

Table 4: Population estimation, modeling, and data collection priorities for 2015-2018.

Priority	Time Frame	Objective	Action	Who	Notes
H	Medium-Term	Support population analyses	• Provide tissue and hair samples as needed • Track and consolidate efforts of population geneticists • Encourage and support development of others' work	BWEC	Support efforts of academia and government agencies

Operational Strategies to Reduce Impact

In 2015, the BWEC prioritized several actions with regard to impact reduction strategies. High priority actions include the development of a white paper describing the current state of knowledge of impact reduction strategies, identifying challenges and opportunities of the current strategies, and highlighting areas of future research; investigate options to refine operational minimization; and assess the financial impacts of operational minimization strategies. Medium and low priority actions include advancing understanding of impact reduction strategies across species or regions and investigating the development of an impact reduction decision tool, respectively.

Participants offered several comments and considerations about impact reduction strategies in small group discussions and in plenary during the workshop:

- More tailored or refined curtailment strategies are needed, especially at low wind speeds. Curtailment strategies could be refined based on predictive parameters such as weather variables (temperature, etc.)
- Decision support tools such as ProBat could help developers and the USFWS to identify and permit projects that maximize conservation benefit and turbine operation efficiency. The tools could also help turbine operators know what type of curtailment to implement and when.
- Industry, conservation organizations, and agencies need to collaboratively develop and agree upon triggers and thresholds for determining when and how to curtail. Standardization/consistency in regulations may help government agencies more evenly apply curtailment requirements (and this would add consistent levels of protection between states); but it might also create challenges for wind energy developers.
- Turbine operators are sometimes hesitant to implement curtailment operations because they fear that curtailed operation would void the turbine warranty because it would require the turbine to operate outside of normal conditions. It may be necessary to seek the support of turbine manufacturers if and when suggesting curtailment operations that are outside the normal operating conditions. Verification of manufacturer support for curtailed operating scenarios and assurance that such operation would not void the warranty would also be important to project financers.
- Given the complexity of calculating and comparing lost revenue from curtailment across sites, loss of generation could be used to describe the impacts of curtailment. Unintended financial impacts such as wear and tear, maintenance, etc. should

also be considered, but may be difficult to compare across turbines. Percent of revenue lost could be another option for communicating loss from curtailment.

- Old turbines could be retrofitted to enable curtailment; but it may be expensive.
- Outstanding questions
  - Could there be compensation for implementing curtailment? For example, could curtailment and the resulting loss in revenue be viewed as a donation to mitigation?
  - What is the benefit of feathering below the manufacturer's cut-in?
  - What is the cost benefit ratio of bat protection to energy generation?
  - Are there times of the year when seasonal variables suggest different curtailment scenarios? For example, when temperatures begin to drop bats tend to emerge to forage and prepare for winter hibernation.
  - Are there certain species that curtailment is effective at protecting or is it effective across all species? Should curtailment efforts be focused on a particular species?

- White Paper Outline – The BWEC discussed creating a white paper that could be supported by all BWEC participants. Some participants expressed concern that this effort would not necessarily lead to operational adjustments. Others believed it would have the potential to have influence because it was created and supported by conservation and industry representatives. Some suggested that both agencies and wind energy developers could use the paper to inform curtailment strategies. Others suggested that this document should be a living document that is updated frequently. The group decided not to include policy recommendations and put forth the following draft outline:
  - Define the issue
    - Include disclaimer that research is ongoing and economic analysis must be completed.
  - Synthesize curtailment studies as the current state of the science
  - Describe the impediments to implementation
    - Examples include, cost of implementation, flexibility in software and hardware, variation in the regulatory environment, flexibility of lack thereof in power purchase agreements, voided warranties/contracts
  - Future Research
    - Other species/other regions
    - Refinement

Table 5: Priorities for 2015-2018 in the category of operational strategies to reduce impact.

Priority	Time Frame	Objective	• Action	Who	Notes
H	Short-Term	Prepare White Paper on impact reduction strategies	• Building off of "Synthesis of Operational Minimization Studies", prepare a concise white paper discussing the opportunities and challenges of impact reduction strategies, and areas for future research • Publish in peer reviewed journal	BCI	BCI will develop draft and submit to BWEC Committees for review (1 June, 2015)
H	Medium-Term	Examine options for refining operational minimization	• Investigate effectiveness of feathering below manufacturer's cut-in speed • Examine start/stop times when implementing operational minimization • Explore effect of ramp-up speed on fatality levels	BCI	Secure funding and study sites to conduct experimental research
H	Short-Term	Advance understanding of impact reduction strategies & financial impacts	• Obtain and synthesize financial data from facilities implementing operational minimization, such operational costs, wear and tear on equipment, revenue loss, etc. • Inform USFWS mitigation policy	AWEA & BCI	AWEA expects initial industry results in Feb 2015 What is desired rigor of legitimacy?
M	Medium-Term	Advancing understanding of impact reduction strategies across species/regions	• Inventory of impact reduction strategies in priority regions or where priority species occur to determine effectiveness • Examine gaps in impact reduction strategies with respect to species/regions	BCI	BCI to identify regions/species of priority and review with SAC
L	Longer-Term	Impact Reduction Decision Support Tool	• Begin with proof of concept with existing U.S. data and German model • Develop algorithms and a decision support tool that can aid regulators and operators in refining operational minimization while considering economic factors	USFWS, USGS & BCI	Model might build off of related variables as wind speed, bat activity, temperature, time of year, time of night, and other actors

Ultrasonic Acoustic Deterrents

The BWEC prioritized work on ultrasonic acoustic deterrent studies in 2015. In particular, the group placed high priority on the development and implementation of a comprehensive investigation to determine the effectiveness of acoustic deterrents and compare the costs associated with use of deterrents to the use of operational minimization techniques. The BWEC will also support the advancement of acoustic deterrent development.

Participants offered several comments and considerations about acoustic deterrents in plenary during the workshop:

- Avoid the use of frequencies or pulsed sounds that may mimic a bat call and attract bats to the deterrent device and turbine.
- Deterrents should not be designed to repel a particular species (e.g. threatened or endangered species). Instead, the deterrents should be designed to repel all bat species so that more options/tools are available to reduce impacts when wind development moves into new areas. Alternatively, some participants suggested that population size and relative impacts to a species may warrant the design of a deterrent focused on specific species.
- Research on the interaction of deterrents and bats that are infrequently killed at wind turbines (e.g. little browns which do not frequently fly at turbine height) may not yield useful information; future research should be appropriately focused to yield useful information that can reduce impacts.
- Potential areas of future research:
    - Determine whether or not nacelle-mounted deterrent devices are pushing bats to the tips of the blades where they are more prone to strikes.
    - Determine whether or not the bats develop learned responses to the deterrents.

Table 6: Priorities for ultrasonic acoustic deterrent research in 2015-2018.

Priority	Time Frame	Objective	Action	Who	Notes
H	Short-Term	2-factorial randomized block design with acoustic deterrents and operational minimization	• All turbines equipped with deterrents, but on any given night ○ 4 control turbines ○ 4 deterrent turbines ○ 4 operational minimization turbines ○ 4 deterrent and operational minimization turbines	BCI & USGS	What is the appropriate cut-in speed to test? Compare effectiveness of deterrents and compare costs of deterrents to operational minimization
H	Short- to Long-Term	Advance deterrent approaches	• Advance next generation acoustic deterrents • Assist others with testing technology/product development, as appropriate • Identify those developing devices in blades & connect technology developers to site operators to test devices • Draw information and potential collaborators from AWWI RFI, DOE RFI and RFP • Investigate different deterrent options (e.g., UV deterrents)	BCI, AWWI, DOE & USGS	IP Issues: address quality control and dissemination concerns, conflict of interest/ confidentiality/ transparency Consider synthesis paper on "what we know about deterrents" in next 2 to 4 years

International and Emerging Issues

The BEWC will continue to build an international network and stay abreast of emerging issues in 2015.

Participant discussion of international and emerging issues tended to cover the following topics:

- International: BWEC capacity to do projects internationally is limited and much work remains to be completed in North America, including enhancing coordination with Mexico and Canada. Additional representation on BWEC from Canadian and Mexican government, civil-society, and wind developers may be needed to positively influence the way wind energy is implemented across North America. At the international level, BWEC resources may best be used as a facilitator and synthesizer of information to help other countries think about and develop solutions to bat and wind energy facility interactions, potentially in advance of wind energy industry development in some countries.

- Small scale wind development: Since small wind turbines are broadly distributed and limited in scale, the BWEC should focus on utility scale wind developments which may have greater impacts on bat populations. However, BWEC information could be useful for siting small wind turbines.
- Offshore: BOEM is not focusing on offshore bats since the quantities of bats observed offshore are orders of magnitude lower than those observed on the coast. Offshore development in the Great Lakes is unlikely.

Table 7: Priorities for 2015-2018 regarding international and emerging issues.

Priority	Time Frame	Objective	Action	Who	Notes
H	Short- to Long-Term	Expand network of international partners	• Conduct webinars with and for international partners on key topics • Participate in key international activities and meetings (e.g., CWW) • Invite international participants to appropriate BWEC meetings • Collaborate on research projects, as appropriate • Collaborate with IEA's Task 34 to connect international partners	BCI, NREL, Barclay, Medellin & Jones	Expand potential funders; build capacity and transfer knowledge to others; learn from others
L	Short to Long-Term	Monitor off-shore wind development	• Track various studies (e.g., DOE-funded Stantec study) • Participate in workshops/meetings as appropriate	BWEC	Use knowledge of land-based impacts to inform potential bat impacts off-shore
L	Short- to Long-Term	Monitor small scale wind development	• Assess impacts of small-scale wind on bats	BWEC	Questions/issues include: current data on height; likely also to be less concentrated (i.e., scattered across landscape); cumulative effects; capacity contribution

Appendix 1: Final Agenda

Reception: Monday 5 January 2014

19:00–21:00 The Tap Room (Omni Hotel Bar)

Day One: Tuesday 6 January 2014

07:00	**Assemble in hotel lobby & board shuttle to NREL** *Shuttle will depart Omni at 07:15*
07:30–08:00	**Check-in & breakfast-provided by NREL** Bring your ID/Passport
08:00–08:10	**Welcome & introductions** Karin Sinclair & Robert Thresher, NREL
08:10–08:25	**Review purpose of meeting, agenda, ground rules** Pat Field, CBI
08:25–08:40	**Industry perspective regarding bats & wind energy development** John Anderson, AWEA
08:40–09:10	**BWEC update (2012–2014 Review) & current research** Cris Hein & Michael Schirmacher, BCI
09:10–10:00	**Facilitated discussion on BWEC past & ongoing research** Pat Field, CBI *-How well have we done in the past 3 years?* *-What has worked & what needs more attention?* *-Should the BWEC adopt a set of monitoring guidelines?* *-Where do we go with relating pre-construction/post-construction data?*

10:00–10:20 **BREAK**

FATALITY ESTIMATION

10:20–10:40 **Estimating fatality (recent advances in estimators)**
Manuela Huso, U.S. Geological Survey (USGS)

10:40–11:10 **Facilitated discussion on advances to estimators**
Pat Field, CBI
-*What are the advantages of these new methods for estimating fatality?*
-*How will these advances in fatality estimation impact effort/cost?*
-*How do we discourage use of outdated/flawed estimators?*
-*How do we raise the funds needed to develop necessary software?*

11:10–11:30 **Evidence of absence/absence of evidence (estimating rare events)**
Manuela Huso, USGS

11:30–12:00 **Facilitated discussion on estimating fatalities**
Pat Field, CBI
-When is this analysis applicable?
-What confidence intervals are statistically/biologically reasonable?

12:00–13:00 **LUNCH-Catered lunch onsite-provided by NREL**

BAT BEHAVIOR & MIGRATION

13:00–13:20 **Using infrared imaging to study behavior of bats near turbines**
Paul Cryan, USGS & Marcos Gorresen, University of Hawaii
-*Case studies in Indiana & Hawaii*

13:20–14:00	**Facilitated discussion on using infrared imaging to study bats** Pat Field, CBI -*What are the limitations to using this equipment/software?* -*Are there alternative placement options to optimize observations?* -*How can we capture fatality events with thermal cameras?* -*What methodology should be paired with thermal cameras?* -*How can behavioral studies be used to inform minimization strategies?*
14:00–14:20	**Using tracking devices to assess bat migration** Ted Weller, USFS (presented by Cris Hein, BCI) -*GPS transmitters, PIT tags, and other advances in technology* -*Long-term monitoring stations*
14:20–14:35	**Using acoustic detectors to assess bat activity & migration** Kevin Heist, University of Minnesota (UM) & Doug Johnson, USGS -*Midwest & Great Lakes case study*
14:35–14:50	**Using marine radar to assess bat activity & migration** Dan Nolfi, USFWS -*Midwest & Great Lakes case study*
14:50–15:10	**BREAK**
15:00–16:00	**Facilitated discussion on bat migration & siting** Pat Field, CBI -*Can these studies inform siting decisions?* -*Can these studies inform minimization strategies?* -*Are the data useful in assessing risk?* -*What are the pros/cons of these technologies?* -*When is it appropriate to use these technologies?*

POPULATION ANALYSIS OF BATS

16:00–16:20 **Status of bats, WNS update & regulatory challenges**
Mylea Bayless, BCI & Christy Johnson-Hughes, USFWS

16:20–16:35 **Update on population effects of wind energy development**
Dan Nolfi, USFWS

16:35–17:15 **Facilitated discussion on population status of bats**
Pat Field, CBI
-How can the BWEC be effective on estimating populations?
-What data/funding are needed to expedite this issue?
-What is BWEC's role in disseminating impacts of wind energy on bats?
-What are other uses of genetic data?

17:15–17:30 **Day 1 wrap-up**
Pat Field, CBI

18:30–20:30 **Hosted reception & dinner (Buca Di Beppo)**
615 Flatiron Market Place Drive, Broomfield, CO (<1 mi from Omni Hotel)

Day 2: Wednesday 7 January 2014

07:00 **Assemble in hotel lobby & board shuttle to NREL**
Shuttle will depart Omni at 07:15

07:30–08:00 **Check-in & breakfast-provided by NREL**
Bring your ID/Passport

08:00–08:10 **Day 1 follow up & agenda for Day 2**
Pat Field, CBI

IMPACT REDUCTION STRATEGIES

08:10–08:30 **Measuring & reducing the number of bat fatalities at wind turbines in Europe**
Oliver Behr & Martina Nagy, Friedrich-Alexander University

08:30–08:50 **Synthesis of operational minimization studies in the U.S. & Canada**
Ed Arnett, TRCP

08:50–10:00 **Facilitated discussion on operational minimization**
Pat Field, CBI

-*What is an acceptable cost/benefit ratio?*
-*What is needed to optimize strategy to reduce cost?*
-*How do we assess potential impacts on the turbines?*
-*How do we work with the manufacturers on warranty issues?*
-*Are there different levels of implementation for different species (e.g., Indiana bats vs. migratory tree bats)?*

10:00–10:20 **BREAK**

10:20–10:40 **Acoustic deterrent update-brief history & current status**
Cris Hein, BCI

10:40–11:00 **Tests of acoustic deterrent in United Kingdom**
Gareth Jones, UB

11:00–11:15 **R&D update on the Deaton device**
Pete Garcia, DE

11:15–11:30 **Results from GE deterrent study & update on GE device**
Kevin Kinzie, GE

11:30–12:30 **Facilitated discussion on acoustic deterrents**
Pat Field, CBI

-What R&D remains?
-How do we measure success for deterrents?
-How does the cost of deterrents compare to operational minimization?
-What are the priorities to study (e.g., placement, frequency pattern)?
-Are there more effective designs or ways of producing sound?
-How do we design/manufacture a device and commercialize it without others misusing the specifications?

12:30–13:30 **LUNCH-Catered lunch onsite-provided by NREL**

13:30–14:10 **Breakout groups to discuss impact reduction strategies**
-How best to optimize operational minimization
-Next steps for acoustic deterrents
-Are there additional minimization strategies we should explore?

14:10–14:40 **Report out from groups on minimization strategies**
Pat Field, CBI

14:40–14:55 **International bats & wind issues**
Cris Hein, BCI

14:55–15:10 **Emerging issues & technology (e.g., offshore wind, strike indicators)**
Michael Schirmacher, BCI

15:10–15:40 **Facilitated discussion on international & emerging issues**
Pat Field, CBI
-What is BWEC's role?
-What are reasonable responses to addressing the concerns?

15:40–16:00 **BREAK**

16:00–16:45 **Breakout groups to discuss the effectiveness of BWEC**
-How is BWEC research used by others?

-How can we improve the effect of BWEC research?
-What is BWEC's role in assessing/disseminating level of impact?
-How can the BWEC help facilitate research?
-research permits?
-access to data that is not publicly available?

16:45–17:30	**Report out from groups** Pat Field, CBI	
17:30–17:45	**Day 2 wrap-up** Pat Field, CBI	
19:00–	**No host dinner at a local restaurant (TBD) or dinner on your own**	

<u>*Day 3: Thursday 8 January 2014*</u>

07:00	**Assemble in hotel lobby & board shuttle to NREL** *Shuttle will depart Omni at 07:15*
07:30–08:00	**Check-in & breakfast provided by NREL** Bring your ID/Passport
08:00–08:10	**Day 2 follow up & agenda for Day 3**
08:10–09:00	**Breakout groups to discuss BWEC priorities** *-What else should BWEC be focused on (i.e., any new priorities)?* *-Should we remove any existing priorities?* *-Rank priorities* *-What are the immediate vs. long-term priorities?* *-Who should take the lead on priorities?*
09:00–10:00	**Report out from groups** Pat Field, CBI

10:00–10:20	**BREAK**
10:20–12:00	**Meeting overview & next steps** Pat Field, CBI *-Putting it all together* *-BWEC Action Items* *-Assignments & Timeframes*
12:00–13:00	**LUNCH-on site BBQ** **Discussion of barotrauma and results from NREL testing** Mike Lawson, NREL
13:00–14:30	**BWEC Business Meeting** Pat Field, CBI *-Review/Revise Charter* *-Committee membership* *-Financials & sources of funding* *-New business*
14:30–16:00	**BWEC business meeting wrap up**
16:00	**Adjourn meeting**

Appendix 2: List of Participants (in alphabetical order)

Taber Allison	American Wind Wildlife Institute	Science Committee
John Anderson	American Wind Energy Association	Oversight Committee
Ed Arnett	Theodore Roosevelt Conservation Partnership	Science Committee
Mylea Bayless	Bat Conservation International	Oversight Committee
Robert Barclay	University of Calgary	Science Committee
Oliver Behr	University of Erlangen	Invited Presenter
Joceyln Brown-Saracino	New West Technologies	Invited Guest
Paul Cryan	U.S. Geological Survey	Science Committee
Scott Darling	Vermont Fish and Wildlife Department	Technical Committee
Sam Enfield	MAP Royalty, Inc.	Technical Committee
Patrick Gilman	U.S. Department of Energy	Oversight Committee
Cris Hein	Bat Conservation International	Program Coordinator
Kevin Heist	University of Minnesota	Invited Presenter
Manuela Huso	U.S. Geological Survey	Invited Presenter
Christy Johnson-Hughes	U.S. Fish and Wildlife Service	Oversight Committee
Gareth Jones	University of Bristol	Science Committee
Kevin Kinzie	General Electric	Invited Presenter
Denis Krusac	U.S. Forest Service	Technical Committee
Jim Lindsay	NextEra Energy, Inc.	Technical Committee
Rodrigo Medellin	National Autonomous University of Mexico	Science Committee
Dan Nolfi	U.S. Fish and Wildlife Service	Invited Presenter
Michael Schirmacher	Bat Conservation International	Projects Manager
Karin Sinclair	National Renewable Energy Laboratory	Oversight Committee
Heidi Souder	University of Colorado	Invited Guest
Tim Sullivan	U.S. Fish and Wildlife Service	Technical Committee
Robert Thresher	National Renewable Energy Laboratory	Oversight Committee
Raphael Tisch	New West Technologies	Invited Guest