WIND WORKSHOP MINUTES

Assessing Risks to Migratory Wildlife from Wind Energy Development

Sponsors:
Cornell Lab of Ornithology, The Johnson Foundation, American Bird Conservancy
With additional support from the Leon Levy Foundation

17-19 June 2009
Wingspread Conference Center, Racine, WI

Overview and Impetus:
Wind offers an alternative energy solution that appears to be environmentally friendly and sustainable, yet considerable uncertainty remains as to the risks and potential impacts on migratory and resident wildlife from construction and operation of wind facilities. Migratory birds and bats, and resident diurnal raptors, are three groups known to be vulnerable to lethal interactions with operating turbines. Preliminary data suggest that impacts to bird populations are not as great as once feared, whereas impacts on bats may have been underestimated. Regardless, the scale and landscape diversity of ongoing and contemplated wind developments worldwide outstrip both available data and our ability to forecast wildlife risks with confidence. Specifically, basic understanding of bird and bat distributions, densities, and movements in relation to a host of key environmental and topographic variables currently are insufficient for accurately estimating risk to individuals and populations across different landscapes or for modeling and predicting cumulative impacts as wind installations proliferate.

This workshop was convened to address the following central questions:

- *What knowledge gaps constrain current ability to assess risk and predict impacts reliably at wind facilities?*
- *What primary scientific research (e.g., specific data, field experiments, etc.) must be accomplished to reduce the uncertainties and point to wildlife-compatible solutions?*
- *What steps are required to develop accurate predictive models to forecast migratory traffic and assess risk to birds and bats at active and potential wind turbine facilities in different settings?*
- *What complementary actions (e. g, follow-up research and monitoring and/or operational experiments and guidelines) will be critical for long-term success in developing wind energy as a large-scale solution that remains wildlife-compatible?*

Attendees:

Richard Anderson – Retired, California Energy Commission
Bart Ballard – Associate Professor, Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville
Peter Bloom – Zoologist, Bloom Biological, Inc.
Michael Burger – Conservation and Science Director, Audubon New York
Kraig Butrum – President and C.E.O, American Wind and Wildlife Institute
Christopher Clark – Bioacoustics Research Program Director, Cornell Lab of Ornithology
Mark Desholm – Scientist, National Environmental Research Institute, University of Aarhus
Robert Diehl – Assistant Professor, Department of Biological Sciences, University of Southern Mississippi
John Ehrmann – Senior Partner, Meridian Institute (workshop moderator)
William Evans – C.E.O., Old Bird, Inc.
Andrew Farnsworth – Postdoctoral Research Associate, Conservation Science Program, Cornell Lab of Ornithology
John Fitzpatrick – Executive Director, Cornell Lab of Ornithology
Peter Frumhoff – Director of Science and Policy, Union of Concerned Scientists
Michael Fry – Conservation Advocacy Director, American Bird Conservancy
Sidney Gauthreaux – Professor Emeritus, Biological Sciences, Clemson University
Douglas Johnson – Research Statistician, USGS Northern Prairie Wildlife Research Center, University of Minnesota
Imogene Johnson – Board of Trustees, The Johnson Foundation
Thomas Kunz – Professor and Director, Department of Biology, Center for Ecology and Conservation Biology, Boston University
George Ledec – Lead Ecologist, Latin America and Caribbean Region, The World Bank
David Mazrahi – Vice President, Research and Monitoring, New Jersey Audubon Society
David Pashley – Vice President, Conservation Science, American Bird Conservancy

Martin Piorkowski – Project Coordinator/Biologist, Conservation Science Program, Cornell Lab of Ornithology
David Redell – Bat Ecologist, Bureau of Endangered Resources, Wisconsin Department of Natural Resources
Kenneth Rosenberg – Director, Conservation Science Program, Cornell Lab of Ornithology
David Stout – Division of Habitat Conservation Chief, United States Fish & Wildlife Service
Dale Strickland – President and Senior Ecologist, Western EcoSystems Technology, Inc.
Genevieve Thompson – Vice President, American Wind and Wildlife Institute and Executive Director, Audubon Dakota
Rafael Villegas-Patraca – Research Associate, Applied Ecology, Instituto de Ecologia AC

Invited, but absent
Ed Arnett – Conservation Scientist and Co-Director of Programs, Bat Conservation International
Rene Braud – Director, Horizon Wind Energy
Ray Harris – Mesa Power

Day One (17 June):

Welcome
- John W. Fitzpatrick, Cornell Lab of Ornithology (CLO)
- David N. Pashley, American Bird Conservancy (ABC)

Overview of Technology for Predicting Broad-scale Migration and Pinpointing Local Concentrations in Real-time
- Andrew Farnsworth, CLO
    - Discussion with Google Earth map showing ~150 WSR-88D (NEXRAD) stations overlaid with existing wind facilities.

- Michael Fry, ABC

A brief summary of wind history, development, potential build-out and its relation to possible bird interactions were the main points of introduction. He explained some general trends of what we know and have documented at existing wind facilities and published in primary literature.

Key points brought up in this discussion included:

Build-out to include 20% of US energy needs by 2030;
Migration bottlenecks;
East shows little documented bird mortality, but disproportionately more bats;
Fatalities seem to be weather dependent to some extent;
Little known about interactions between wind turbines and nocturnal migrants.

He posed a few general questions to think about during the workshop.

1) Can we use current technology to predict risk and possibly reduce collisions at turbine sites?
2) What are the limits of technology?

3) What about concerns pertaining to specific species of concern (e.g., Whooping Cranes, Bald/Golden Eagles, etc.)?

- Andrew Farnsworth, CLO

  Andrew expanded on this topic by addressing seven current methodologies and associated technologies, and briefly explaining potential benefits unique to each. The seven methodologies were: 1) Acoustic Monitoring, 2) Radar, 3) Thermal Imaging, 4) Moon Watching, 5) Tagging (bands, radio/cell tags, etc.), 6) Stable Isotopes, 7) Direct Visual Observations (Avian Knowledge Network, Christmas Bird Counts, eBird).

  Dr. Farnsworth finished by addressing how we might use some of the technologies (WSR-88D, acoustics, etc.) to monitor wind and interactions with birds and bats.

Roundtable: Knowledge Gaps

Each participant highlighted 1-5 gaps. These are presently loosely organized into the groups aligned with the "tiered" approach that the draft FACA document uses. Several late-arriving participants provided their gaps after this session.

1. **Evaluation Gaps**
   a. Basic spatial biology and ecological characteristics of species in poorly studied parts of the world
   b. Maps of high concentration (stopover, staging, etc.) migration pathways from archived data (radar, visual, acoustic)
   c. Multi-dimensional (X, Y, Z, T) distribution of densities, gradients, and species composition relative to additional factors such as topography, meteorology, and geography.

2. **Characterization Gaps**
   a. Does information that we collect now during pre- and post-construction studies have the same meaning to facilities existing in 50 years?
   b. Quantification of migratory movements under precipitation, especially offshore.
   c. How do we include landscape changes between pre- and post-construction studies in assessing the biological impacts of turbines?
   d. What criteria can define various risk-zones for wind power development in terms of potential impacts to wildlife [traffic signal analogy: red (stop), yellow (proceed with caution), green (proceed)]?
   e. Knowledge of habitat use by special concern species (e.g. Mountain Plover movements in WRA) in areas of high wind resources.
   f. Migratory trajectories and relative densities of bats.
   g. Maps of habitat and potential turbine/facilities sites at multiple scales.
   h. How to standardize detectability of dead animals, estimate mortality rates from observed data, and confidence of mortality estimates and extrapolated mortality estimates from these data.
   i. How do we scale local studies to reach regional or continental conclusions?
   j. How do we scale and apply terrestrial monitoring techniques to offshore studies?

k. How to standardize technologies and methodologies (e.g., for mortality searches, radar calibrations).
l. How to address lack of information on impacts to birds and bats in poorly studied areas with exceptionally rapid energy industry development.
m. Which data gaps can be filled quickly to inform siting now?

3. **Operational Gaps**
    a. More hypothesis testing is needed across the board
    b. Need to know target detection bias for estimating exposure risk
    c. Resolution of current technology (e.g. how fine scale can we gather data)
    d. When are birds/bats at their greatest risk of collision?
    e. Mechanisms that kill bats (e.g. attraction to blades, vortices) and quantification of bat fatalities as a result of turbine interaction
    f. What is scale of interaction mortality relative to population size?
    g. Do density of migrants and actual mortality correlate, and is interaction risk simply density-dependent?
    h. Species-specific behavior and avoidance rates to clarify high-risk species in wind developments
    i. Correction factors on mortality studies to obtain true mortality estimates and to understand how different variables affect search design and efficiency for detecting fatalities
    j. Where and how to detect impact mortality of different species under different conditions (e.g., small bird/bat mortality might be grossly underestimated)
    k. Replicating fatality studies in poorly sampled areas (e.g. many fatality studies inland, but few data from coastal sites)

4. **Post-construction Gaps**
    a. Cumulative impacts with follow-up, long-term monitoring in subsequent years
    b. Replication of pre- and post-construction studies using controls; within and across sites and studies; and across species specific populations
    c. Relationship of fatalities to cut-in speeds and other factors
    d. Relationships between migration magnitude and fatal interaction risks
    e. What structural and operational components of turbines mitigate fatalities?
    f. Spatial distribution of mortalities within and among farms, regions, etc.
    g. Relationship between pre-construction population data and post-construction fatalities

Day Two (18 June)
Roundtable Discussion - Research Directions

- John Fitzpatrick and Andrew Farnsworth, CLO

  Drs. Fitzpatrick and Farnsworth led discussions to refine and organize the topics from yesterday. Smaller break-out groups continued to refine and tighten some of the categorical topics and pushed deeper into the details. Some major comments were discussed before breaking into smaller groups, and these are listed as follows:

  - Key comments before session break-out:
    - Need to identify migration patterns in multi-spatial context

- Technology advantages and limitations, including resolution of various sensor options
- Identification and prioritization of targets (species, functional groups, taxonomic groups, sympatric groups)
- How do we address various knowledge gaps? Break knowledge gaps into topics or other groupings
- Regardless of predictive models, we need post-construction data to validate and refine the models
- Prioritization of what is important: What do we need to know first in order to address subsequent questions?
- Hypothesis testing (e.g., Is risk strictly density-dependent?)
- How is "risk" defined? Which birds or bats are at risk and when?
- Need to understand bird and bat movement and its relation to turbine, facility, and total development layout.
- Need to understanding "discrete" events and understanding the exceptions and how to incorporate these into research needs and focus
- How and when to sample

- **Plenary Session I Small Group Reports on Research Topics**

  Three breakout groups addressed three major sub-headings and reported these "Research Direction" topics. The fourth category, data management, was created after these breakout sessions in summaries produced by Lynn Broaddus, David Pashley, Martin Piorkowski, and then Andrew Farnsworth.

1. **<u>Post-construction Monitoring</u>**
   a. Need post-construction access to conduct research to test hypothesis that "bad zones are actually bad."
   b. Agreement and standardization of fatality measurements to compare multiple variables across wind facilities (include sub-lethal collisions and barotrauma)
   c. Standardization of exposure and risk of targets within 3-dimensional space across time.
      i. Need to standardize techniques and cross-compare between techniques (e.g., acoustic sensors vs. radar sensors, WSR-88D vs. marine radar?)
      ii. Understand the relationship between exposure and impact, and how that is confounded by weather variables.
   d. Need for multi-modal integrated survey methods (e.g., exposure and strike indicators, monitoring techniques).
   e. Mechanistic effects of avoidance and/or attraction to turbines and its significance on energy expenditures.
   f. Operation mitigation to reduce fatalities (e.g., avoid locations, curtailment, trade-offs).
   g. Offshore pre- and post-construction monitoring methods.
      i. Measurement and quantification issues.
      ii. Exposure estimates.
      iii. Avoidance estimates and energetic costs.

iv. Collision mortality, potential population estimate loss, and species-specific cumulative impact.

h. We considered this exercise as a potentially missed opportunity of understanding our current knowledge and how comfortable we are with that information.

2. **Species-level Patterns**
   a. What is the actual risk based on their avoidance capacity and/or attraction? Examples include
      i. Raptors (migratory)
      ii. Migratory bats (daily events: feeding, swarming, etc.)
      iii. Shorebirds
      iv. Known distributions of gregarious species (or concentrations)
   b. Overlay known conservation priority factors with specific risk factors with respect to wind in order to identify and/or describe a set of species at risk.
   c. Understand, pinpoint, and investigate migratory pathway behavior of priority species for spatially explicit outputs.
   d. Population estimates for baseline comparisons (to understand mortality impacts).
   e. Investigate activity and movement of over-water species relative to offshore wind development.
   f. Focus research activities to critical hemispheric areas (e.g., Isthmus of Tehuantepec).

3. **Broad-scale migration patterns**
   a. Produce detailed map of bird/bat densities across space and time with respect to key variables (landscape features, topography, weather, time of day, season, etc.), at scales relevant to wind-turbine site decisions.
      i. What space, if any, should we focus on in order to identify risk?
      ii. From specific studies at landscape features (ridges, coastlines, riparian zones, etc), develop and test general predictive models for fine-scale behavior of migrant birds/bats within 200 m of ground as related to such features across the continent as a whole
   b. Automate data-gathering process for measuring migrants across space and time.
      i. Develop and test real-time data-processing algorithms and handling software for detecting and identifying targets in flight
      ii. Radar data
      iii. Thermal imaging data
      iv. Acoustic data (to allow species recognition)
   c. Develop functional devices, protocols, and data-bases for implementing these algorithms and software across continental scales to achieve the desired fine-scale species-specific maps of movements

4. **Data Infrastructure Management**
   a. Which data gaps can be filled quickly to inform siting now? How do we convert data to go/no go decisions (or use the traffic light analogy: Red, Yellow, Green)?

b. How to address lack of information on impacts to birds and bats in poorly studied areas with exceptionally rapid wind power development?
c. How will data be centrally stored and organized?
d. How will leadership and organization in bird/bat/wind conservation be defined and implemented? (Journal and Popular Media)

- **<u>Questions and comments on Plenary I</u>**
  - Are there thresholds (fatalities) for the Go/No-go conditions? (These thresholds don't really exist at this point?)
  - Management implications and biological significance (Species dependent, also age and sex as important variables in biological significance, general demographics of species).
  - Want Industry to build in a responsible manner and minimize impacts to wildlife. Careful not to get bogged down in specifics species (at this point we are looking at migration as a whole, there will always be species specific exceptions).
  - We need to consider where the highest priority of mortality occurs (wind plume fall-out).

- **Plenary Session II Small Group Reports on Turbine Siting Criteria ("red" and "green" zones that indicate levels of real or potential risk of interaction mortality)**

  How do we identify "Red Zones (areas of greatest risk or high potential risk of interaction mortality)" with birds and bats? How can we integrate these methodologies to answer these questions?

  Three breakout groups addressed red zones and criteria for identifying them. After the fact, we realized that we missed an opportunity to use this discussion to generate explicit research questions based on red zone criteria and definitions of these. However, we think that the effort was still informative and in the end provided some useful information to the research question and gap identification.

  - **Note -** Small group discussions of Red/Green Zones "Synthesis of criteria for evaluating relative risk of a site for development" should be considered in the context of their severity (a continuum of risk), and the ease of avoiding, minimizing or mitigating the risk.

  1. Areas of unusually high density of passing migrant wildlife within the rotor swept area as a function of physical location, timing of concentrations, and conditions influencing concentrations
  2. Areas with a relatively high probability of occurrence of highly volant endangered species within the rotor swept area
  3. Maternity and summer roosts, hibernacula, and swarming sites for bats, with emphasis on species of concern
  4. Near large avian breeding colonies, e.g., heron rookeries
  5. Areas of unusually high density of resident wildlife within the rotor swept area as a function of physical location, timing of concentrations, and conditions influencing concentrations

6. Known major stopover and staging sites for migrating wildlife
7. Level of disturbance
8. Features in the environment that concentrate wildlife, such as shorelines of oceans, major lakes and rivers, offshore shoals, estuaries, and islands
9. Areas that have relatively high densities of breeding special concern species
10. Commuting corridors for birds (shorebird flight passes) and bats
11. Listed critical habitat and protected habitat relative to commercial wind-power generation
12. Coastal, shorelines, riverine, deciduous woodlands, ridges, and passes + wind resources areas with transmission grids
13. Seasonal variables and events, temporal issues and overlaying maps and species distributions by time
14. Climatic variables and risk/fatalities - low wind speed (bats), low visibility (birds), frontal passage (birds, bats)
15. Climate change and effect to movement patterns (also weather patterns over longer time frames)
16. Anthropogenic variables – artificial lighting (in area of light absence), noise

- **<u>Questions and comments on Plenary II</u>**
  1. Easier to identify "Red-Zones" than "Green-Zones." Identifying red zones was much easier in some groups than identifying green zones. It followed that much discussion was directed entirely at identifying areas where development should not occur, or at least where development would require more evaluation. There was discussion in the larger group to the effect that what is needed is information that can be used to evaluate sites, and that we do not know enough to judge most areas on whether they are suitable for development.
  2. Industry is moving forward now. We need to understand what can be done quickly to answer some questions now. Some information is better than none.
  3. Need access to data at existing wind facilities to help inform our predictions.
  4. Financial obligation of wind industry to study impacts for permitting. Need the same thing for post-construction surveys. Other financial support through other agencies and foundations.
  5. Access to information is important to industry competition.
  6. Reward companies willing to disclose data.
  7. We need data to make these predictions, improve predictive ability, and to validate existing predictions.
  8. If we can define "Red-Zones" and wind facilities already exist, this would be a good place to begin collecting data.
  9. We need replication of studies.

Day Three (19 June): Review and Discussion of Draft Consensus Statement

What follows are the individual comments about how to draft a statement and reach consensus, not the consensus of the group (yet). These thoughts highlighted directions to proceed and some organization necessary to draft such a consensus statement.

- The conveners of the workshop indentified 4 documents to result from workshop
    - **Press Statement** – News release (see Appendix I)
    - **Detailed Report** – signed by all participants to be reviewed by peers and sent to congress
    - **Action Items** – lays out objectives, research priorities (see Appendix II), and timeline
    - **Peer-reviewed journal manuscript** – authored by all participants

- Press statement (Appendix I)
    - Unique to this release, is that "we" has a broad represented group that could be attractive for a press release. Include other "unique" characteristics of this workshop. How do we separate our workshop from others?
    - Timeliness with the Energy Bill (June 24, 2009). This can be a great opportunity to publicize the progress of this workshop outcome. "This is what it will take to fill in these gaps of knowledge."
    - Need to identify what the problem is and display this to the general public as a concern. Point of this is not "against" wind power but to do it right. "Scientists propose solutions to bird and bat fatalities at wind facilities."
    - Need to identify the consensus of the problems with birds and bats quickly in the press release. W. Evans comment - perhaps it would be useful to take advantage of the timeliness of the first Bald Eagle killed at a turbine site in Ontario, killed earlier this year (i.e. timely message about the potential hazards of wind turbines.)
    - Tone of scientists' approaches to industry may engage wind developers - focus on "we" in embracing wind power development, but that "we" need to continue research and improve understanding at the same rate that wind development is increasing.
    - Do not want to damage reputation of any parties involved (especially wind industry).

- Action Items to Prioritize (for research priorities see Appendix II)
    - Define and understand cumulative impacts. Need standardization through Federal regulation.
    - Need to focus on putting teeth in to regulatory agencies. Need to get permits that have standard guidelines
    - Outreach to industry (**target pro-active participants**) and public.
    - Need to explain the expectation of industry participation and what spatial scale. E.g. We need to ask **pro-active** wind industry participants how to involve others.
    - Groups like AWWI are going to be needed to pull these players together.
    - Expanding and additional development of wind energy needs to include both increasing energy production and doing it in such a way that reduces environmental impacts (solving 2 problems simultaneously).
    - Collaboration with major players. How do we deal with this scale of coordination? Almost Super-bodies of coordination.
    - How do we keep data open, available, and dynamic (able to be searched and modified with new data)?
    - Approach CEQ to take action plan to White House.

- We choose to address fatalities only, not habitat effects. This may limit our partners. We focused on one component of the "problem" but that is not the whole story.
- Next step: determining process to develop research needs and management of collected data. Multiple, parallel tracks to keep things together in terms of keeping all of these collaborators interested in and engaged.
- Use of Avian Knowledge Network as a starting point to help data management.
- Identify Subgroups for Action Plan.
- What is the "Why" of these research needs? What are the objectives of these research needs?
- Use of Red-Zones as an exercise to ferret out additional gaps. Can we determine Red-Zones? There is just too much that we don't know.
- What are the timelines of various priority topics? Focus on the questions that we can be addressed quickly?

- Mechanism to maintain momentum after today.
  - Created steering-committee.
    - Andrew Farnsworth – CLO
    - Michael Fry – ABC
    - Kraig Butrum – AWWI
  - 4 Functions that need to be carried forward
    - Research – refining (e.g. proposals) what we developed from workshop (Marty P., Dale S, Dave R, Sid, Bill, Rob, Tom K, Dave M, Dick A, Chris C, Pete Bloom)
    - Coordination – Guideline development (Peter F, Doug S, Michael F, Genevieve T, Ken R)
    - Interaction with wind industry (Noel, Ed Arnett, Steering Committee, Rene?)
    - Funding – to carry-out research needs (David Pashley, Fitz)
  - Comment from G. Ledec: output should include/could be e.g., zoning maps (even for smaller areas), curtailment mortality curves (e.g., cut-in speeds)

- Possible "fine-tune" workshop to measure our progress in one year. Some suggested that we meet sooner than 12 months, possibly a smaller group at 6 months.

Appendix I

Scientists to Investigate Impacts of Wind Energy on Migratory Wildlife

Industry and conservation representatives set research priorities

Racine, WI & Ithaca, NY, July 23, 2009—Thirty top wildlife scientists have announced agreement on some of the highest research priorities to help America's rapidly growing wind energy industry produce much-needed alternative energy—while also providing safe passage for birds and bats. This coalition of scientists from industry, government, nongovernmental organizations, and universities met recently in Racine, Wisconsin, to address unanswered questions about how continued wind energy development will affect migrating birds and bats. The meeting was hosted by the Cornell Lab of Ornithology, the American Bird Conservancy, and The Johnson Foundation at Wingspread.

"We see great potential in wind energy for addressing global climate change and reducing America's reliance on fossil fuels," said Dr. Michael Fry of the American Bird Conservancy. "It's critical we act now to understand the interactions between wind energy installations and birds and bats."

"Billions of birds migrate annually, taking advantage of the same wind currents that are most beneficial for producing wind energy," said Dr. Andrew Farnsworth of the Cornell Lab of Ornithology. "We know that in some locations a small percentage of wind turbines may cause the majority of bird and bat deaths. For example, Altamont Pass, east of Oakland, California, is an extreme case: in an area used regularly by migrant and resident raptors, only a fraction of the 5,000 turbines are responsible for most of the raptor deaths annually. As wind power develops further, we need to know more about how placement, design, and operation impact birds and bats as well as how habitat and weather conditions affect potential hazards."

The scientists addressed some of the critical information that could be collected using cutting-edge tools such as weather surveillance radar, thermal imaging, and microphones directed skyward to map migrations by day and night. New research will build upon monitoring and research studies of birds and bats before and after construction of existing wind energy facilities as well as work done by other researchers. The coalition appointed working groups to move this new research agenda forward. Top research priorities identified by the coalition include:

- Studying bird and bat behaviors, and more accurately estimating mortality at existing wind turbines

- Using current and newly-obtained information on bird and bat population numbers and distribution to focus research on critically important migratory routes and timing

- Documenting how interactions of birds and bats with turbines are affected by factors such as weather, topography, and their distribution within airspace swept by wind turbine blades

- Establish standardized methods for pre- and post-construction studies for assessing bird and bat behavior at wind facilities

- Conduct research on best practices for mitigating the impacts of wind energy development on birds and bats

"Conducting this research will help the wind industry make informed, science-based decisions about where future wind energy projects can be built, and how they can be operated to minimize the impact on migrating wildlife, while still providing much-needed alternative energy," said Dr. John Fitzpatrick, director of the Cornell Lab of Ornithology. "It will also help flesh out specific guidelines for wind farm construction being developed by the U.S. Fish and Wildlife Service."

"Imagine if a similar effort had taken place at the turn of the 20th century with the auto industry and air quality," said Kraig Butrum, President and CEO of the American Wind Wildlife Institute, an umbrella organization for the wind energy industry and environmental groups. "We'd probably be in a completely different place when it comes to global climate change and energy dependence, because we considered environmental impact from the start."

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The American Wind Wildlife Institute is a nonprofit organization focused on timely and responsible development of wind energy while protecting wildlife and wildlife habitat through research, mapping, mitigation and public education on best practices in wind farm siting and wildlife habitat protection. Visit the AWWI website at www.awwi.org.
The Cornell Lab of Ornithology is a nonprofit membership institution dedicated to interpreting and conserving the earth's biological diversity through research, education, and citizen science focused on birds. Visit the Cornell Lab's website at www.birds.cornell.edu.

The American Bird Conservancy is a not-for-profit organization whose mission is to conserve native wild birds and their habitats throughout the Americas. Visit the ABC website at www.abcbirds.org.

The Johnson Foundation at Wingspread seeks to be a catalyst for environmental and community solutions using leading-edge convening models at a unique, world-class conference center. The Foundation brings together leading scholars and decision-makers from the public and private sectors, forms partnerships, commissions research and shares information to broaden the dialogue around environmental challenges and solutions. Guided by the belief that new solutions are needed to ensure the sustainability of environmental systems, the Foundation does not advocate specific solutions nor bring preconceived ideas to its work on any issue.
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Appendix II

Wind Energy and Migratory Wildlife: Priorities for Research

The Cornell Lab of Ornithology, American Bird Conservancy, and The Johnson Foundation convened a workshop in Racine, WI from 17-19 June 2009 entitled "Assessing Risks to Migratory Wildlife from Wind Energy Development." Thirty top scientists from industry, government, non-governmental organizations, and universities developed the following research priorities to help the wind industry make informed, science-based decisions about where future wind energy projects can be built, and how they can be operated to minimize the impact on migrating wildlife. These priorities address the most important knowledge gaps that limit our understanding of how migratory bird and bat populations may be affected by rapidly expanding wind energy development.

- **Standardize methods and definitions used in pre- and post-construction studies of bird and bat impacts at wind facilities.**
    - At present, comparisons of potential and real impacts across individual turbines, sites, seasons, and years are extremely difficult due to the variation in methods and metrics used in pre- and post-construction wind studies.
    - Standardized definitions of exposure risk and protocols for measuring fatalities and assessing population-level impacts will be essential for understanding the "big-picture" affects of wind-energy development on birds and bats.

- **Develop methods and models for assessing and forecasting risk to migrating birds and bats that can inform pre-construction siting decisions.**
    - Use existing data on migratory and other movements of birds and bats to develop predictive models of exposure risk;
    - Use new and emerging technologies, including radar, acoustics, and thermal imaging, to fill gaps in knowledge of bird and bat movements; focus studies at potentially important landscape features (e.g. ridges, coastlines, riparian corridors);
    - Develop new analytic and modeling techniques for combining datasets on animal presence and movements with environmental and topographic factors potentially affecting exposure risk;
    - Identify factors that influence movement of wildlife within the rotor-swept area of wind turbines and that are useful in identifying potentially hazardous and "safe" sites;
    - Identify specific species or sets of species most at risk in areas of high potential wind resources;
    - Map risk factors with wind energy potential to 'score' the potential effect of proposed wind facilities on critically important migration and movement corridors.

- **Document the lethal and sub-lethal effects of existing wind facilities on migrating wildlife to assess population-level impacts and validate forecasting models**

    - Use post-constructions measurements to better identify the mechanisms and variables involved with both lethal and sub-lethal interactions;
    - Determine effectiveness of risk-factor mapping 'score' with post-construction measurements;
    - Continue refining pre-construction forecast models, using data and information gathered from post-construction measurements and observations;
    - Develop automated and real-time data-processing algorithms and software to measure and map movements of birds and bats through the rotor-swept zone; integrate this process into forecast models;
    - Use comparisons of predicted risk and post-construction impacts to develop criteria for operational mitigation (e.g. reduced cut-in speeds or curtailment);
    - Focus post-construction research in areas of greatest predicted risk to migrating birds and bats (e.g. Isthmus of Tehuantepec, Mexico).

- **Secure data access, site access and data management for researchers.**

    - Allow and maintain site access for researchers during post-construction to test research protocols and measure impacts;
    - Develop and maintain the ability to manage and access data in commonly shared and securely archived databases;
    - Define how the research community disseminates information in appropriate peer-reviewed and popular media venues that address proprietary concerns of industry;
    - Improve access and data presentation for use in comparative studies;
    - Institute measures that encourage industry to share access and data without fear of retribution or loss of profits.

These priorities build on the growing body of excellent research being conducted at existing and new wind facilities across the U.S. and in other parts of the world. Although these research priorities highlight the utility of pre-construction risk assessment to inform siting decisions, workshop participants emphasized the critical importance of accurate and standardized post-construction measurement of actual impacts. In short, we cannot understand the real impacts of wind-energy development on wildlife until we construct facilities, measure fatalities, and continue to monitor impacts with standardized protocols. Instituting measures to increase access to post-construction sites and data, *without jeopardizing industry production or profits*, will be key to ensuring that decisions and policies regarding wind-energy development are based on the best available science. Developing an open and honest partnership among industry, government, and academic scientists is the most important next step in implementing this research agenda.