Approaches to Addressing Environmental Challenges with Wind Energy in the United States

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Horizon Scan Wind Energy and Nature Conservation

Host: German Federal Environmental Foundation (DBU)

Location: Osnabrück, Germany

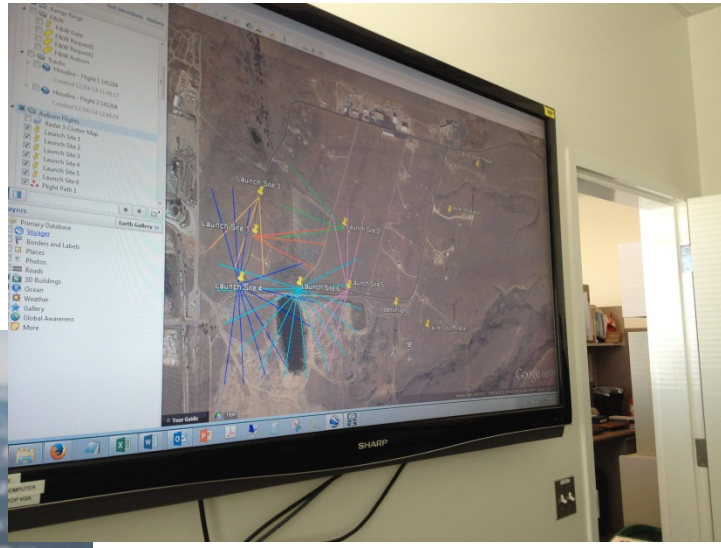
Date: September 20, 2017

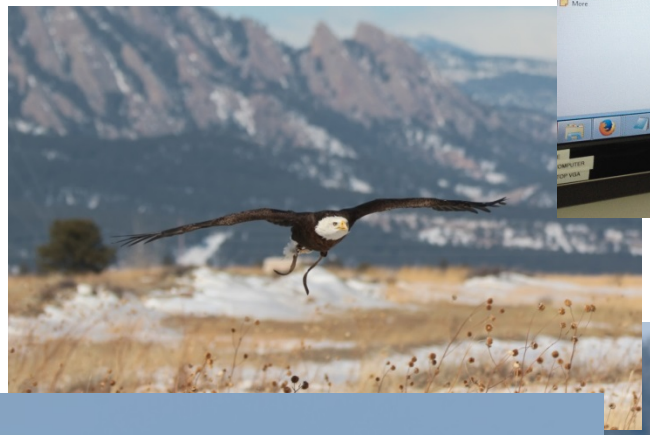
NREL/PR-5000-69071

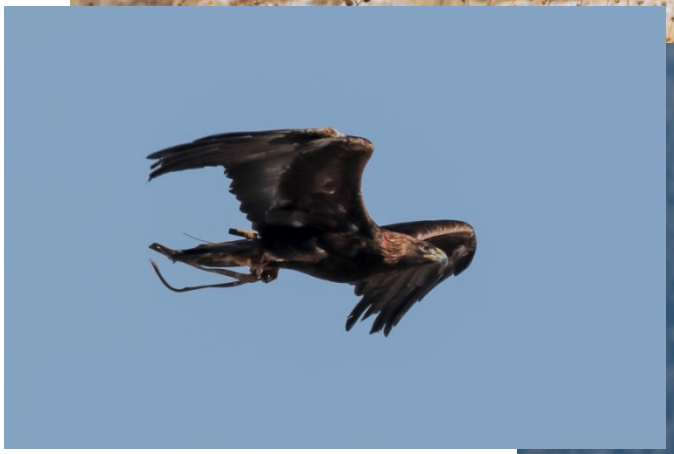
At the Smøla wind farm in Norway, white-tailed eagles and willow ptarmigans commonly collide with wind turbines. Concerns about their collision rates triggered research to test the efficacy of various mitigation measures, including painting one of three rotor blades black at four turbines to alert white-tailed eagles and reduce collision risk. Similarly, up to 10 tower bases (0–10 meters [m]) were painted black to raise the horizon and reduce collision risk in willow ptarmigans, which collide with the actual tower. *Photo by Roel May, Norwegian Institute for Nature Research*

Outline

1. Wind Energy Development
2. Impacts to Wildlife
   - Overview
   - Challenges
3. Federal Activities
4. Research
5. Collaboratives
6. State Activities
7. Conclusion







American bald eagle (top left) and golden eagle (bottom left). Both birds were part of research being conducted at the National Wind Technology Center at the National Renewable Energy Laboratory (NREL). Birds were released to gather pre-determined flight pattern data (top right) from a crate attached to an elevated man lift (bottom right). *Photos by Lee Jay Fingersh and Karin Sinclair, NREL*

Early Wind Energy Development and Emergence of Concern for Impacts to Wildlife

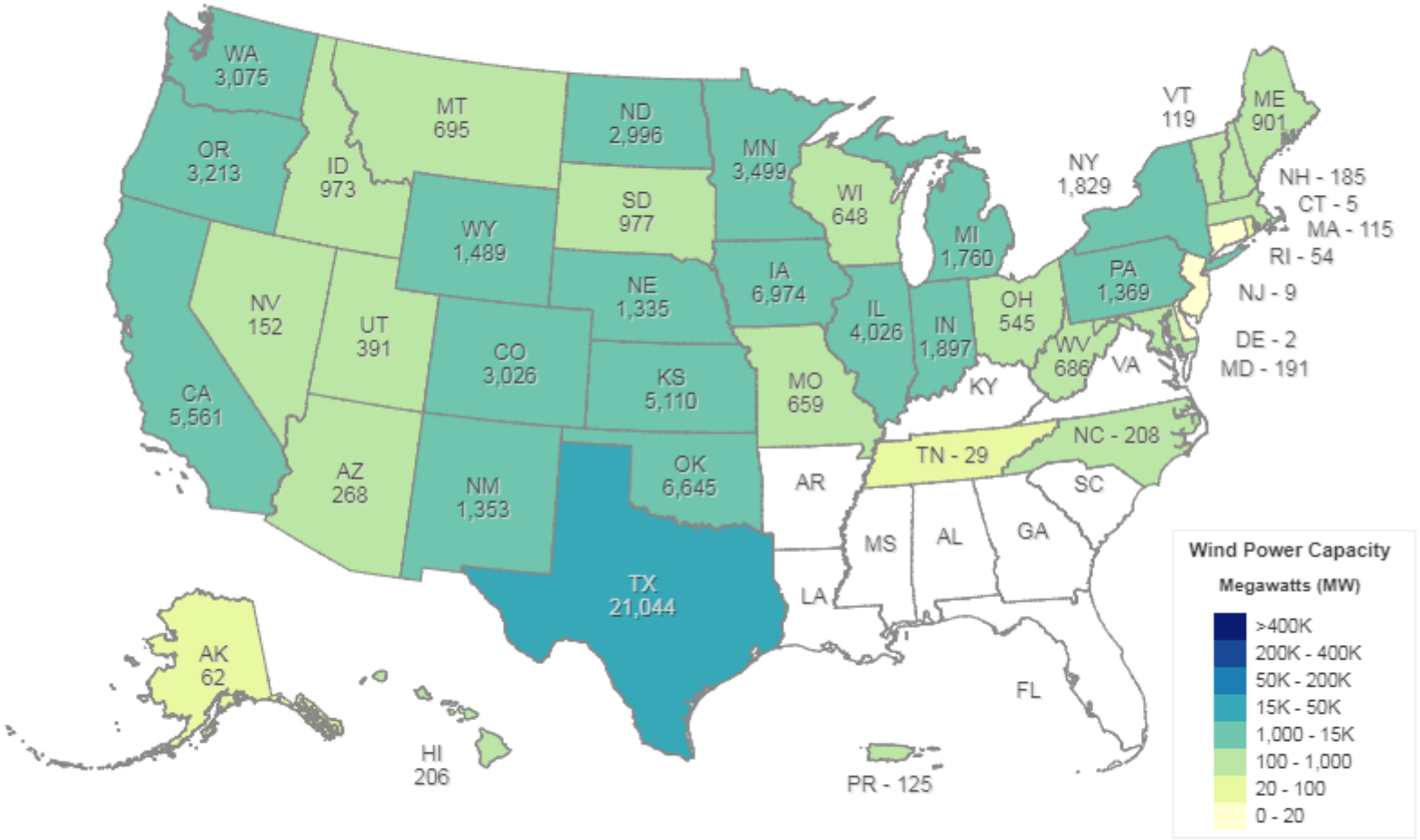
Issue: Wind turbines may impact wildlife (especially birds and bats) and habitats

- The discussion of wind turbine impact on wildlife began at the Altamont Wind Resource Area in California in the late 1980s and early 1990s.

Five GE 1.6-megawatt (MW) turbines at the Junction Hill Top Wind Farm in Iowa. *Photo by Tom Wind, NREL 26494*

Kenetech 56–100 kilowatt (kW) turbines at the Altamont Pass Wind Resource Area in California. *Photo by Shawn Smallwood, NREL 17329*

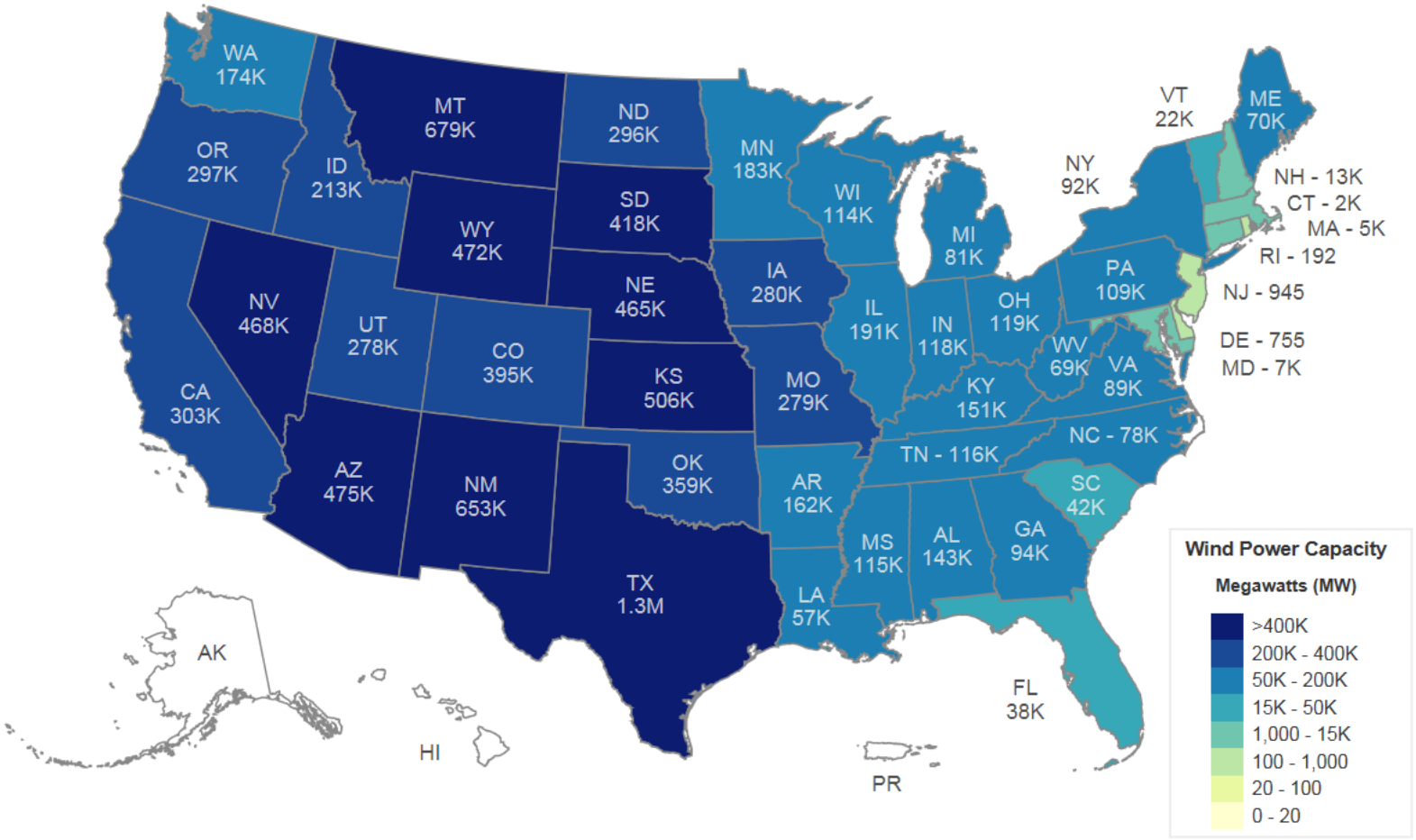
Q2 2017 Installed Wind Power Capacity (MW)



Total Installed Wind Capacity: 84,407 MW

Source: American Wind Energy Association Market Report

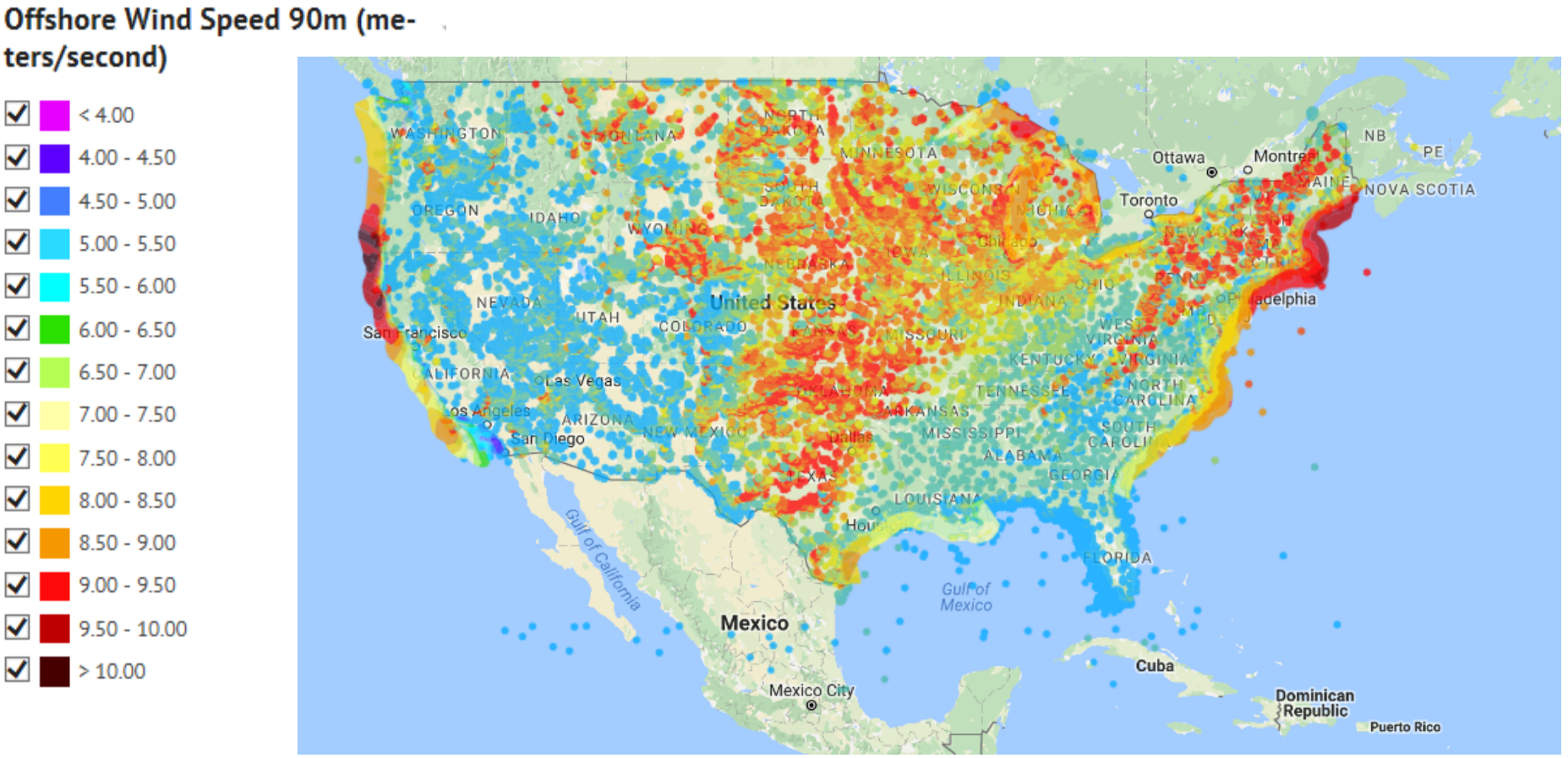
U.S Potential Wind Capacity in Megawatts (MW) at 80 Meters



Total Potential Wind Capacity: 10,640,080 MW

Source: AWS Truepower, NREL

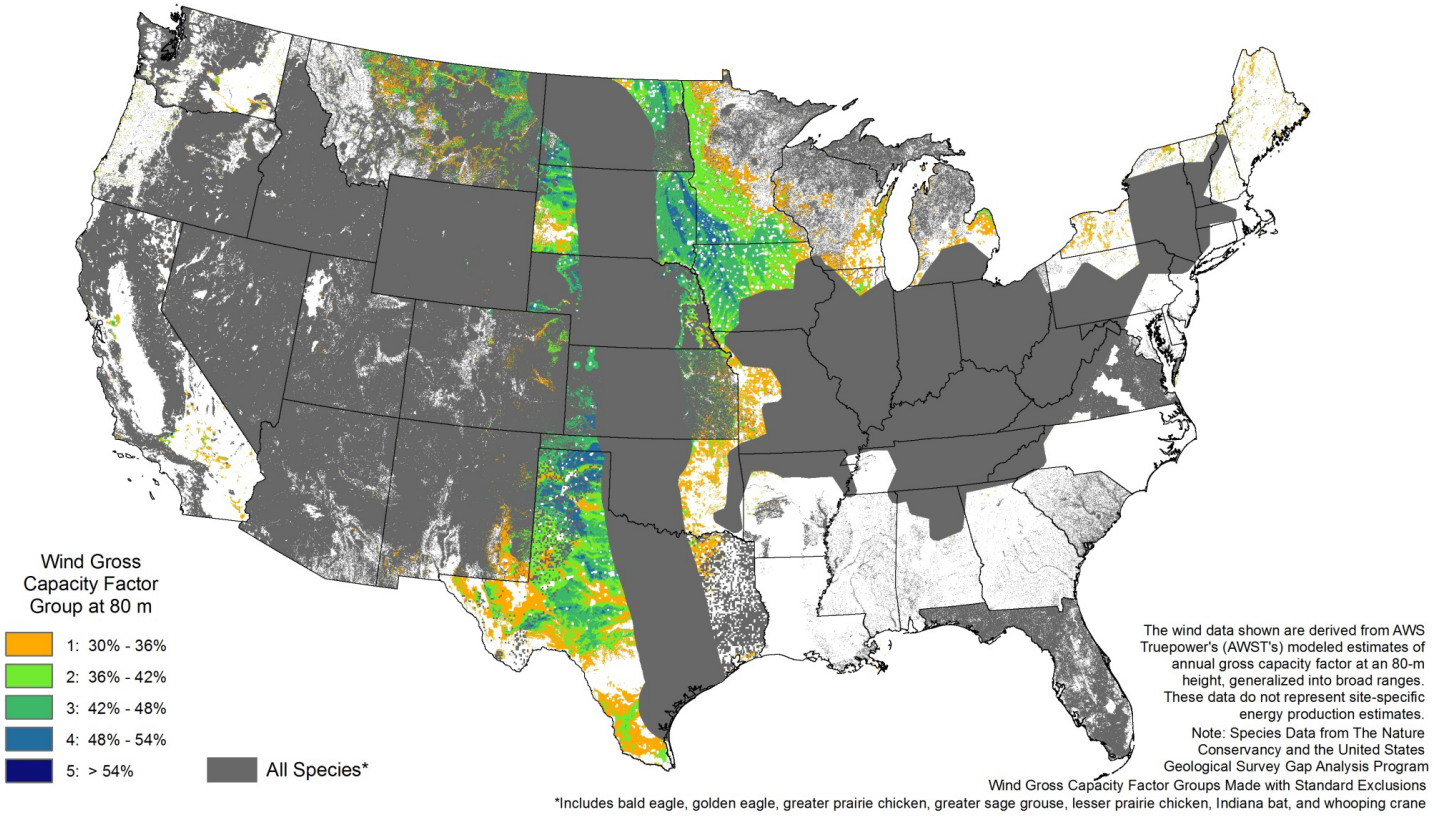
U. S. Wind Resource at 90 Meters Includes Offshore Wind Potential



Source: NREL Wind Prospector

https://maps.nrel.gov/wind-prospector/?visible=wind_3tier_site_metadata#/?aL=p7FOkl%255Bv%255D%3Dt%26dXykOt%255Bv%255D%3Dt%26dXykOt%255Bd%255D%3D1&bL=groad&cE=0&lR=0&mC=40.21244%2C-91.625976&zL=4

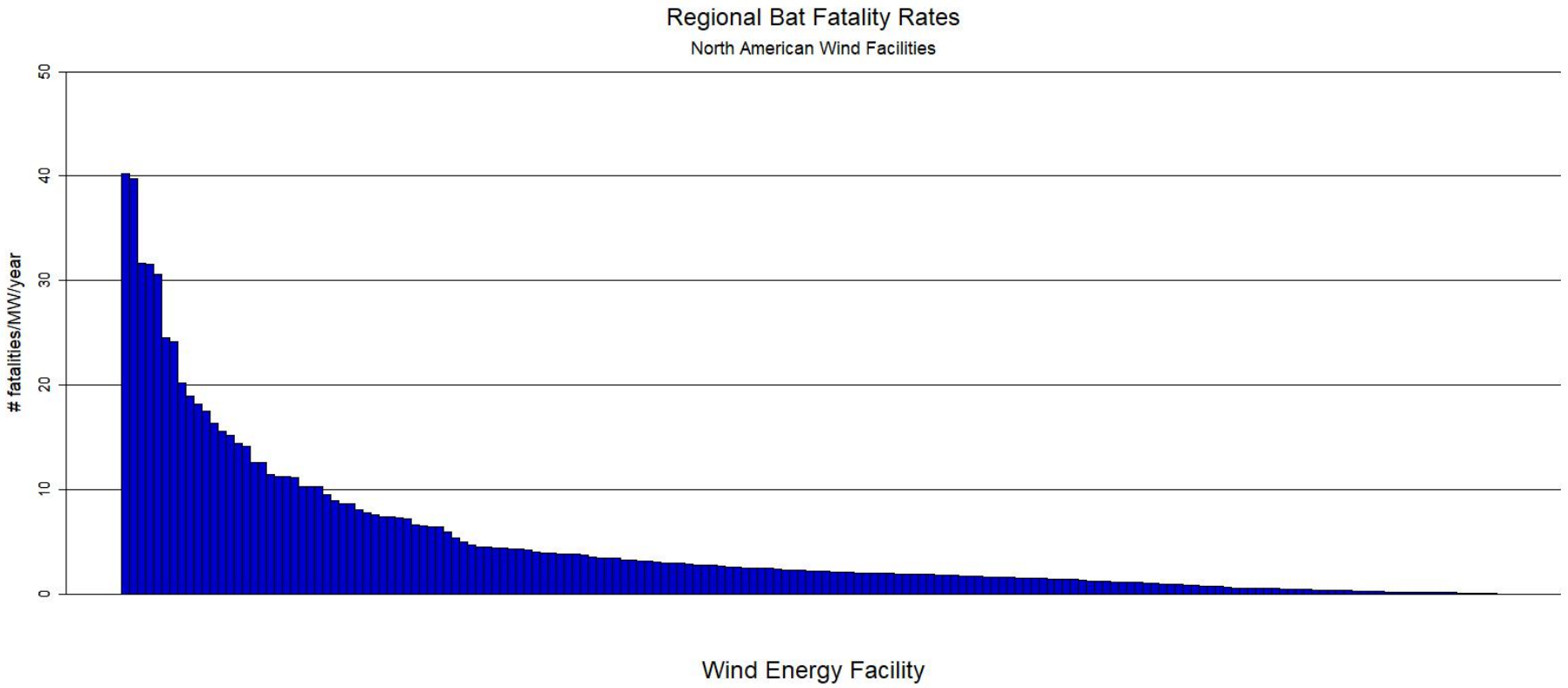
Habitat Distribution of Seven Key U.S. Species



Areas in gray indicate where wildlife species live, breed, and migrate. These areas are *not* no-build zones, but are of special concern for developers that could increase costs and time or lead to project delays or cancellation.

Wildlife distribution can impact local areas very differently. On a national scale, 44%–53% of land could be affected.

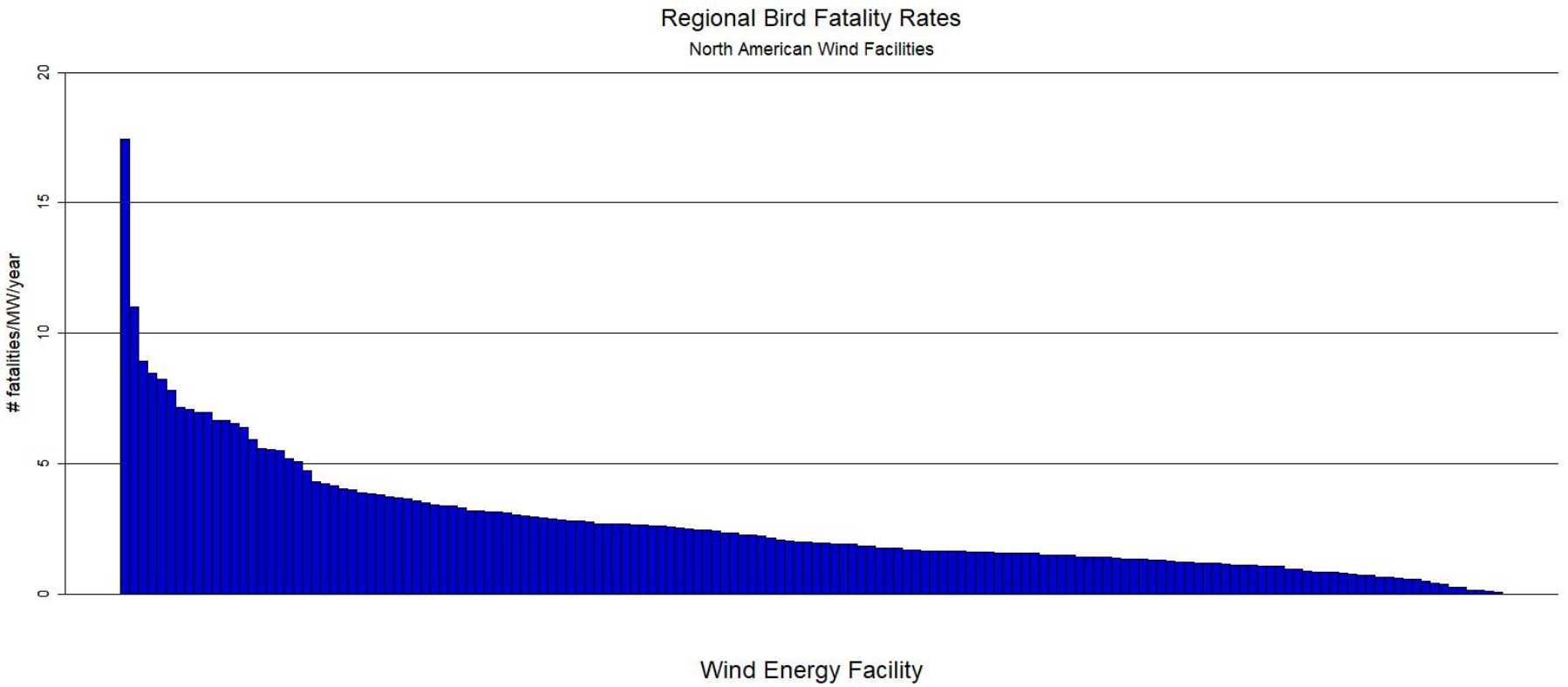
North American Bat Fatality Rates



Note: Wind energy facilities are arranged from highest to lowest fatalities, by facility.

Source: Western Ecosystems Technologies (WEST). All data are publicly available. Analysis was conducted by WEST and represents a mix of data from studies conducted by WEST as well as other publicly available studies. Analysis of 172 studies suggest an average of 4.84 bat fatalities per MW per year.

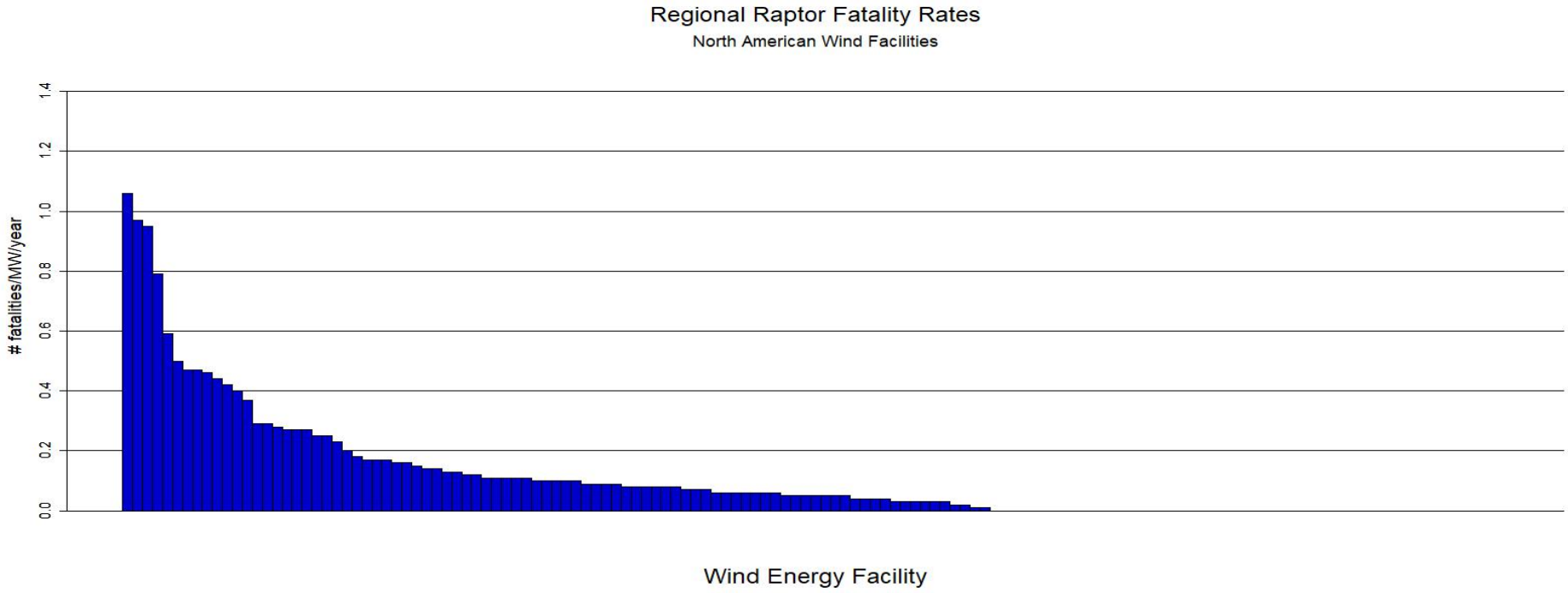
North American All-Bird Fatality Rates



Note: Wind energy facilities are arranged from highest to lowest fatalities, by facility.

Source: Western Ecosystems Technologies (WEST). All data are publicly available. Analysis was conducted by WEST and represents a mix of data from studies conducted by WEST as well as other publicly available studies. Analysis of 152 studies suggest an average of 2.69 bird fatalities per MW per year.

North American Raptor Fatality Rates



Note: Wind energy facilities are arranged from highest to lowest fatalities. 52 of these facilities estimated zero raptor fatalities (thus zero fatalities are represented on the right tail of the graph).

Source: Western Ecosystems Technologies (WEST). All data are publicly available. Analysis was conducted by WEST and represents a mix of data from studies conducted by WEST as well as other publicly available studies. Analysis of 139 studies suggest an average of 0.11 raptor fatalities per MW per year. Removing the 52 reports which reported zero fatalities, and assuming these projects underestimated raptor fatalities, results in an average of 0.18 raptor fatalities per MW per year.

Overview: Main Points

- Real or perceived wildlife impacts can be a challenge for development.
- Misinformation on potential of impacts is rampant.
- Impacts are species- and habitat-specific.
- Impacts are site-specific; micrositing is critical to reducing these impacts.

Combination of 221 Mitsubishi Heavy Industries 1-MW turbines and 53 GE 1.5-MW turbines at the Cedar Creek Wind Farm in Grover, Colorado. *Photo by Dennis Schroeder, NREL 30593*

Eight Nordex N60 1,300-kW wind turbines in Garrett, Pennsylvania. *Photo by Green Mountain Energy Company*, *NREL 09699*

Challenges to Wildlife

Wildlife challenges include:

- Habitat and species impacts vary by climate, topography, and location
- No single solution to reduce impacts

Ways of addressing the challenges:

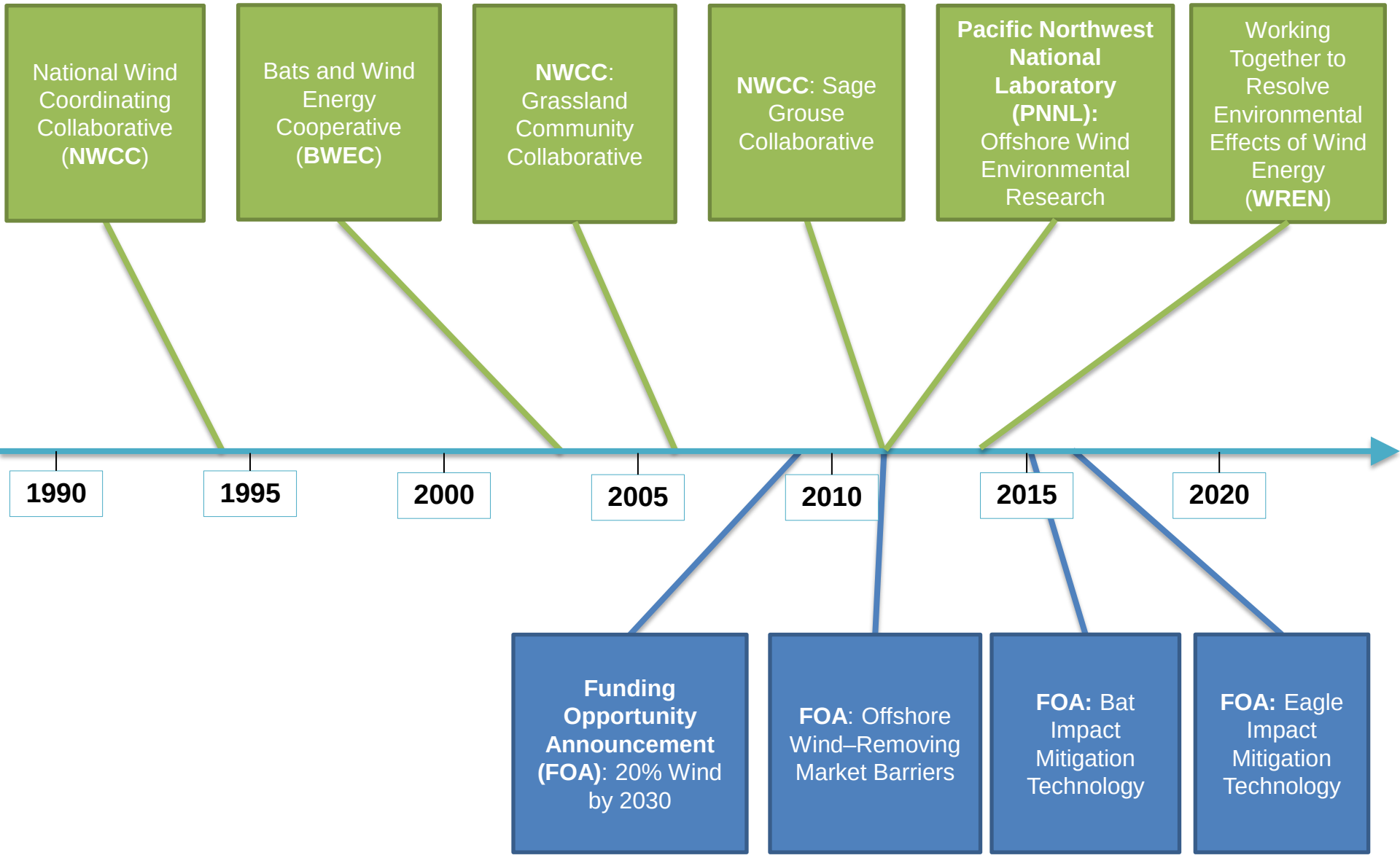
- Identify near-term research needs
- Use a multipronged approach
- Involve multiple stakeholders
- Garner support for collaborative field research, methods and metrics refinement, tools, mitigation strategies, and deterrent development and testing
- Disseminate information.

Federal Overview: U.S. Department of Energy's (DOE's) Wind Energy Technologies Office Mission

- Reduce challenges to project development to accelerate deployment of appropriately sited wind energy.
- Support the *20% Wind Energy by 2030* initiative (Advanced Energy Initiative).
- Accelerate wind energy capacity growth and development of domestic energy options (Energy Policy Act of 2005).

100-kW Northwind 100 wind turbine in Hempstead, New York.
Photo by Town of Hempstead, NREL 28963

Research Timeline



Research Focus Areas

Mitigation research focuses on:

- Deterrent development
- Correlating wind speed to utilization
- Correlating weather patterns to fatality patterns
- Offsite compensation
- Micrositing
- Turbine size
- Blade visibility
- Seasonal shutdowns
- Habitat manipulation
- Artificial roosts.

Technology/modeling research is focused on:

- Radar validation
- Thermal imaging cameras
- Near-infrared cameras
- Stable isotopes
- Species identification algorithms
- Predictive models.

Greater prairie chicken. *Photo by Mark Herse, Kansas State University, NREL 27970*

Infrared camera.
Photo by Dennis Schroeder, NREL 20338

Benefits of Collaboratives

Benefits of collaboratives include:

- Access to third-party, unbiased research
- Involvement of accepted experts
- Agreement on study design
- Development of relationships (trust)
- A safe forum for discussion
- Ability to engage early and often
- A framework for transparency and credibility
- Opportunities to leverage funds
- Project access
- Access to interim results
- Agreement on research results
- A model for future interactions.

705-MW project in Tehachapi Pass Wind Resource Area, California.

Photo by David Hicks, NREL 18455

Collaboratives

- The NWCC is an open forum available to all interested parties. The Grassland and Shrub Steppe Species Subgroup (GS3) consists of two voluntary cooperative endeavors to identify the impacts, if any, wind energy has on grassland and shrub steppe avian species
  - The Grassland Community Collaborative
  - The Sage Grouse Collaborative.
- BWEC is an alliance of experts from government agencies, private industry, academic institutions, and NGOs.
- The American Wind Wildlife Institute (AWWI) is a partnership that includes industry and NGOs.
- International Energy Agency Wind Task 34 (WREN) includes 11 countries, plus networks within those countries.

National Wind Coordinating Collaborative

The NWCC was formed in 1994. Founding members included NREL and DOE, the American Wind Energy Association, the National Audubon Society, the Electric Power Research Institute, and the Union of Concerned Scientists. Membership currently exceeds 2,000 people.

Major features of the NWCC include:

- Multistakeholder
- Facilitated, with ground rules for engagement
- Coordinated field research
- Information dissemination (e.g., website, coordination of report preparation and publication, and presentations at meetings)
- Biennial research meeting
- Grassland Community Collaborative (prairie chicken research)
- Sage Grouse Collaborative (sage grouse research).

http://www.nationalwind.org/

Bats and Wind Energy Cooperative

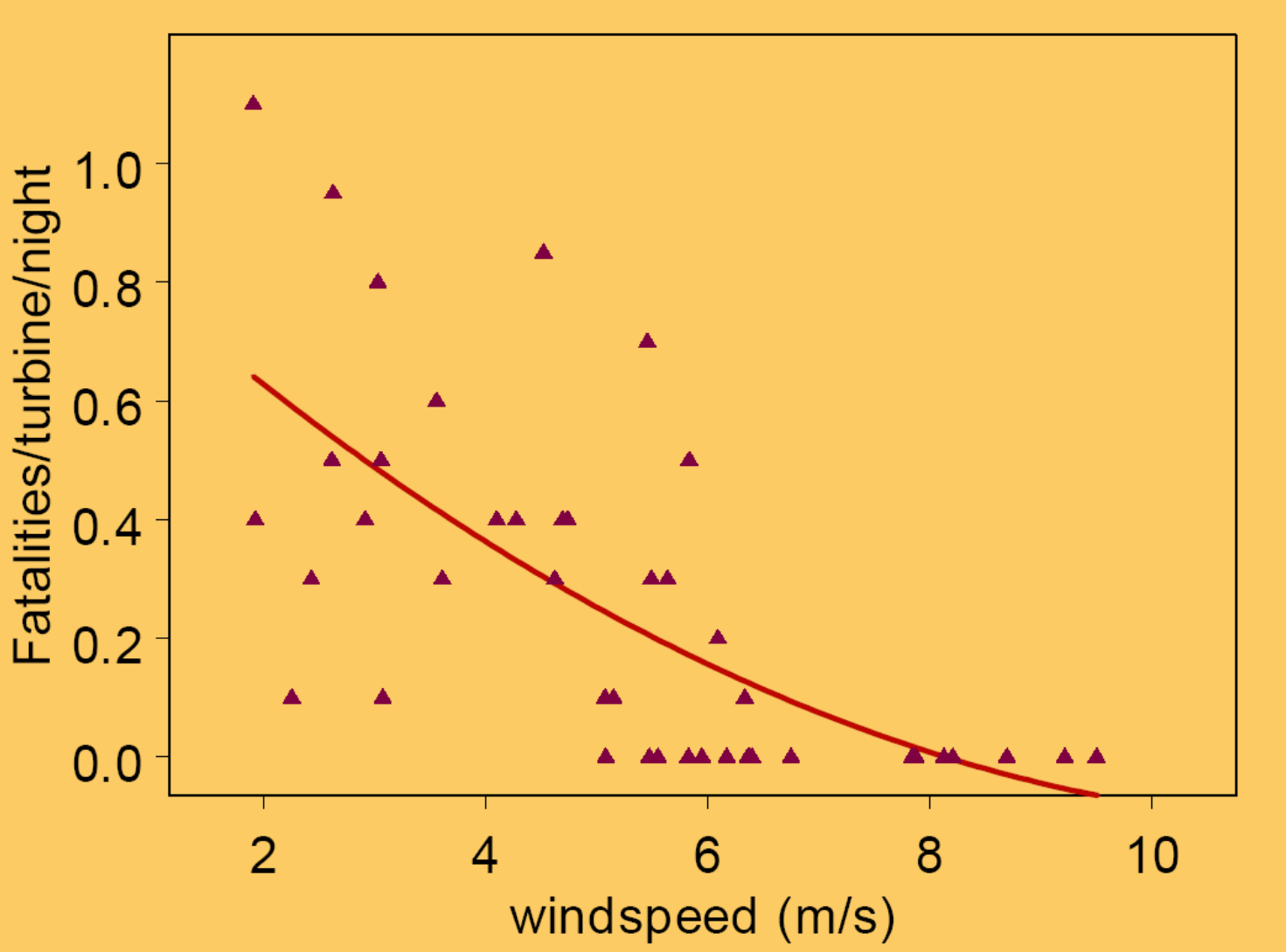
The BWEC was formed in 2004. Founding members included the American Wind Energy Association, Bat Conservation International, the U.S. Fish and Wildlife Service, and NREL, with DOE and the U.S. Geological Survey joining later. Major features of the BWEC include:

- Objective, science-based
- International expertise
- Organizational structure includes an oversight committee, technical committee, and science committee
- Coordination of field research (e.g., operational curtailment and acoustic deterrent)
- Information dissemination (e.g., website, coordination of report preparation and publication, and presentations at meetings)
- Frequent science meetings.

http://www.batsandwind.org/

Researchers conducting bat fatality monitoring at wind energy facility. Bat carcass being recorded for future data analysis. Source: Arnett, et al. 2008. *Effectiveness of Changing Wind Turbine Cut-in Speed to Reduce Bat Fatalities at Wind Facilities*

Bats and Wind Energy Cooperative Study Results



Source: BWEC Report 2005

2015 Bat Impact Minimization FOA

This FOA aimed to advance the readiness of impact mitigation technologies in order to expand the number of unique technologies available for development and testing (Topic Area 1) and to support field testing and evaluation of near-commercial technologies (Topic Area 2) to provide wind farm owner-operators with cost-effective tools to reduce bat impact risks and ease regulatory uncertainty.

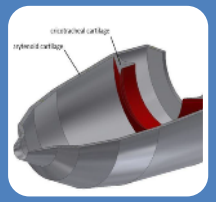
Topic Area 1: Focused on the development of technology designs, initial prototypes and systems, and conducting laboratory-scale testing in a controlled setting to demonstrate the effectiveness of a minimization technology concept. Additionally, it sought to establish the effectiveness of a prototype technology in a controlled laboratory or small-scale setting and iterative design improvements based on initial performance.

Topic Area 2: Supported the demonstration of impact-minimization technologies at an operational wind facility at a scale sufficient to determine a statistically significant reduction in impact in mortality, including an analysis of the full costs of the technology to establish a basis for cost comparison with existing impact-minimization measures.

DOE-Funded Research (Bats)

Texas Christian University (TCU): *Texturizing Wind Turbine Towers to Reduce Bat Mortality*

- Bats may perceive turbine towers as resources for water and foraging. TCU will alter the surface texture of wind turbine towers to test this hypothesis and test effectiveness in the lab and the field.



University of Massachusetts Amherst (UMass): *A Biometric Ultrasonic Whistle for Use as a Bat Deterrent on Wind Turbines*

- UMass will design and prototype a range of blade-mounted, whistle-like devices based on a bat larynx, mechanically powered by air flow over the wind turbine blade and designed to produce a broadband ultrasound signal at a range of pressure gradients and wind speeds.

Frontier Wind: *Mounted Bat Impact Deterrence System*

- Frontier Wind will develop and test a novel, blade-mounted, ultrasonic acoustic deterrent system, seeking to overcome the challenge of ensonifying the entire rotor-swept zone of a wind turbine.

General Electric (GE) Company: *Ultrasonic Bat Deterrent Technology*

- GE will advance the development of a turbine-integrated ultrasonic pneumatic jet that has shown promising results deterring bats both in controlled settings and operational trials at a wind facility.

Bat Conservation International (BCI): *Evaluating the effectiveness of an ultrasonic acoustic deterrent in reducing bat fatalities at wind energy facilities*

- BCI will advance an existing electronic ultrasonic acoustic deterrent device and include reliability and field testing.

2016 Eagle Impact Mitigation FOA

The goals of this FOA are to 1) better understand eagle physiology and behavior to optimize deterrent systems, 2) advance eagle detection, identification, and deterrent technologies by testing them in the lab and in the field, and 3) to validate the effectiveness of near-commercial detection, identification, and deterrent systems at operational wind farms.

Topic Area 1: *Eagle Physiology and Behavior*

Goal: To support research on the eagle's ability to sense and respond to stimuli in an effort to identify signals that will serve as optimal deterrents.

Topic Area 2: *Prototype Advancement through Laboratory and Small-Scale Field Testing*

Goal: To support development and testing activities for bald and golden eagle impact minimization systems, such as a prototype eagle detection, deterrent, or integrated detection and deterrent systems.

Topic Area 3: *Operational Demonstration and Validation*

Goal: The successful demonstration of TRL 7+ eagle impact minimization systems at an operational wind facility at a scale sufficient to provide an accurate demonstration of the efficacy of the system at a reasonable cost compared to current eagle detection and risk minimization methods.

Photo by Lee Jay Fingersh, NREL

DOE-Funded Research (Eagles)

Topic Area 1—University of Minnesota (UMN): *Detection and Perception of Sound by Eagles and Surrogate Raptors*

Study of bald and golden eagle hearing capabilities to inform development of optimal auditory eagle deterrent signals. UMN will also investigate red-tailed hawks as a test surrogate.

Topic Area 1—Purdue University: *Understanding the Golden Eagle Sensory World to Enhance Detection and Response to Wind Turbines*

This project will characterize the sight and hearing characteristics of golden eagles to inform development of optimal visual and hearing deterrent signals.

Topic Area 2—Laufer Wind Group, LLC: *Eagle Take Minimization System*

This project will develop and demonstrate an automated eagle-detection system comprised of far-seeing radar for detection and visual cameras for identification of eagles flying near turbines. The system is intended to inform automated turbine shut-down if eagles are in danger.

DOE-Funded Research (Eagles)

Topic Area 2—Oregon State University: *A Heterogeneous System for Eagle Detection, Deterrent, and Wildlife Collision Detection for Wind Turbines*

This project will develop an integrated system that uses 360-degree cameras to detect eagles near wind turbines, deters them using simple visual deterrent systems, and then determines whether collision events occur using blade-mounted detection systems.

Topic Area 3—AWWI & Renewable Energy Systems: *Evaluating the Effectiveness of a Camera-Based Detection System to Support Informed Curtailment and Minimize Eagle Fatalities at Wind Energy Facilities*

The project will independently evaluate how the camera-based eagle detection system, IdentiFlight, compares with humans in identifying eagles and reducing collision risk under a variety of environmental conditions.

Topic Area 3—AWWI & Liquen Consultoria Ambiental: *Evaluating the Effectiveness of a Detection and Deterrent System in Reducing Eagle Fatalities at Operational Wind Facilities*

This project will evaluate the effectiveness of a camera-based detection and auditory deterrent technology called DTBird by assessing how well DTBird cameras detect eagles, how strongly eagles respond to the sounds emitted by the system, and how much the DTBird technology reduces the overall risk to eagles.

Offshore Wind Research

Biodiversity Research Institute

HiDef Aerial Surveying, North Carolina State University, City University of New York, Duke University, U.S. Fish and Wildlife Service, U.S. Geological Survey, Memorial University of Newfoundland

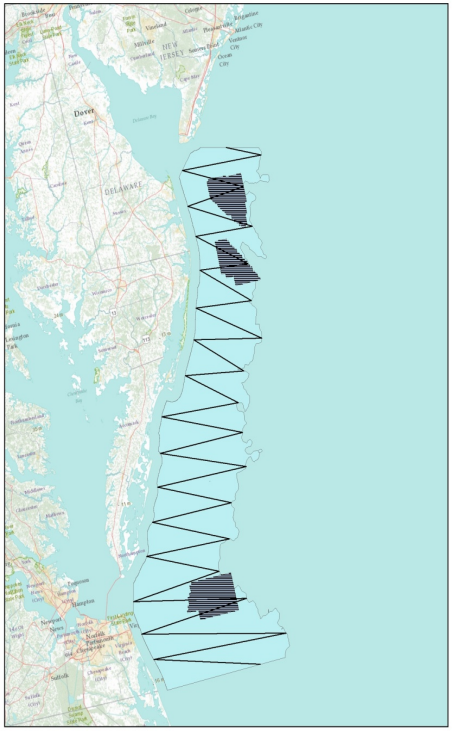
Project Title: Gathering data and modeling wildlife densities and habitat use across temporal and spatial scales on the Mid-Atlantic continental shelf

- Performing **baseline surveys** of species of **bird, sea turtle, and marine mammals**:
  - High-definition **aerial video** and **boat-based** (16 surveys) surveys over two years
  - **Aerial-boat** survey **comparison** study
  - **Individual tracking** of key avian species (northern gannets, red-throated loons, surf scoters, and peregrine falcons)
  - **Nocturnal migration studies**.
- Developing predictive and risk assessment frameworks
  - Hierarchical modeling of animal abundance.

Geographic Scope:

- Southern border of New Jersey to Virginia/North Carolina border. 3 nautical miles from shore to 30 m isobath.

Final report, website, and associated materials:
http://www.briloon.org/mabs



Map of aerial and boat survey transects for the Mid-Atlantic Baseline Studies and Maryland Projects. High resolution digital video aerial survey transects are shown in gray and black and boat based survey transects are shown in red and blue. Source: Final Report

Offshore Wind Research

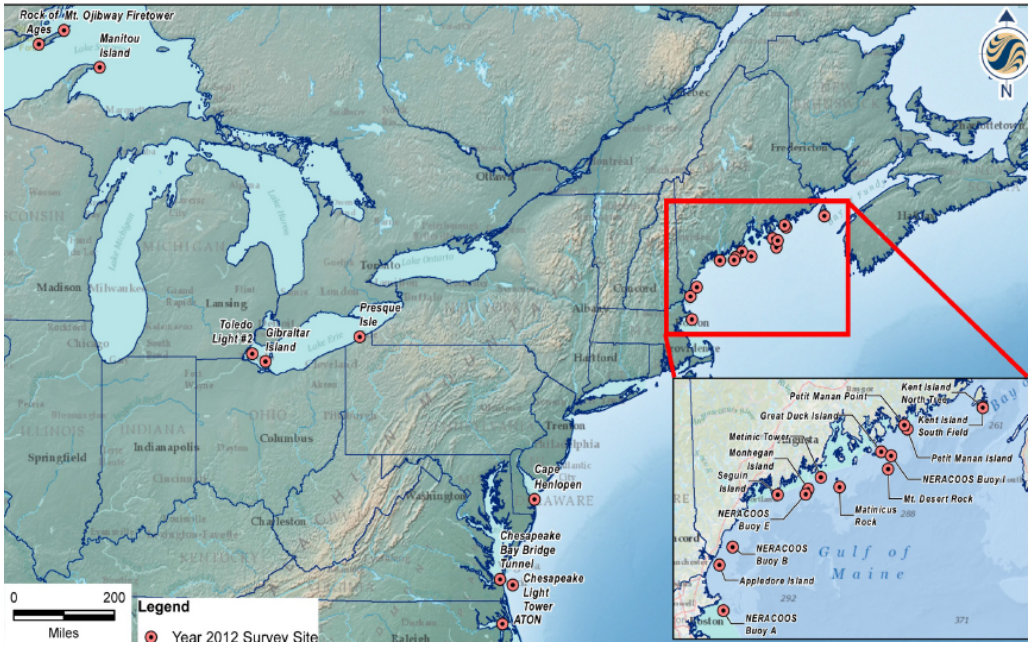
Stantec

- Multiyear study of patterns in offshore bat activity and species composition in the Gulf of Maine, Great Lakes, and Mid-Atlantic coastal states that analyzed spatial and temporal use patterns.

Study indicated that bat activity offshore trends with season, distance from shore, percentage forested area within vicinity of survey site

Geographic Scope:
Gulf of Maine, Mid-Atlantic, Great Lakes

Final report:
https://tethys.pnnl.gov/sites/default/files/publications/Stantec-2016-Bat-Monitoring.pdf



Location of sites surveyed in three regions over the course of this research. Source: Adapted from Final report.

Offshore Wind Research

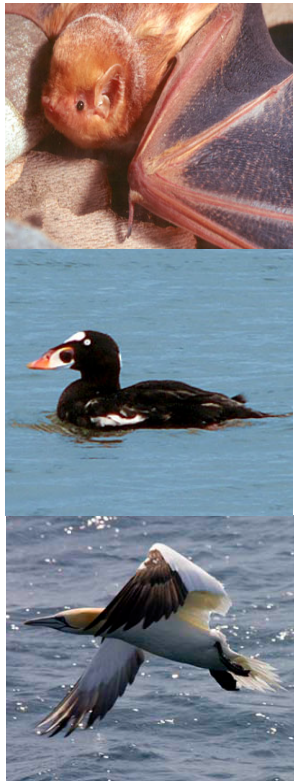
Oregon State University

Remote Monitoring of Bird and Bat Interactions with Turbines

Collaborators: University of Washington, H.T. Harvey & Associates, NREL

Oregon State University
College of Engineering

GOAL: Monitor avian and bat collisions with offshore wind turbines using a fully integrated sensor array monitoring system with on-board custom-designed data post-processing and statistical-based software.



- Developed synchronized sensor array, which includes accelerometers, visual and infrared spectrum cameras, and acoustic monitors.
- Provided remote access to the recorded images and sensor data, making it possible to quantify interactions, including collisions, and identify organisms involved to the lowest taxonomic grouping possible.
- Convened an industry advisory group experienced in offshore design as well as scientists who specialize in avian- and bat-impact studies.
- Engaged offshore wind industry collaborators to develop plans to design, test, and weatherize the array in advance of full-scale coastal or offshore deployment.

Final Report: https://tethys.pnnl.gov/publications/synchronized-sensor-array-remote-monitoring-avian-and-bat-interactions-offshore

American Wind Wildlife Institute

Formed in 2008, the AWWI's board members consist of 50% industry and 50% NGOs.

Primary activities include:

- Researching
  - Technology verification
- Developing data repository: American Wind Wildlife Information Center
- Creating landscape tools: Landscape Assessment Tool
- Using expert elicitation to develop mitigation strategies for eagle 'take' at wind facilities
  - Two models under development to predict the numerical effects of compensatory mitigation on golden eagle survival and reproduction: lead abatement and vehicle collision reduction strategies
- Providing a forum for information exchange.

http://www.awwi.org/

Golden eagle with a transmitter on its back.
Photo by Randy Flament, NREL 23585

IEA Wind Task 34

Formed: Approved by International Energy Agency (IEA) Wind Executive Committee in 2012; currently planned through September 2020.

Rebranded: Working Together to Resolve Environmental Effects of Wind Energy (**WREN**).

Active Members (11): Canada, France, Ireland, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States. Mexico considering joining. Germany was one of the original members.

Objective: Facilitate international collaboration to advance the global understanding of the environmental effects of offshore and land-based wind energy development.

Strategy: Create a shared global knowledge base and community around research, monitoring, and management of the environmental effects of wind energy development.

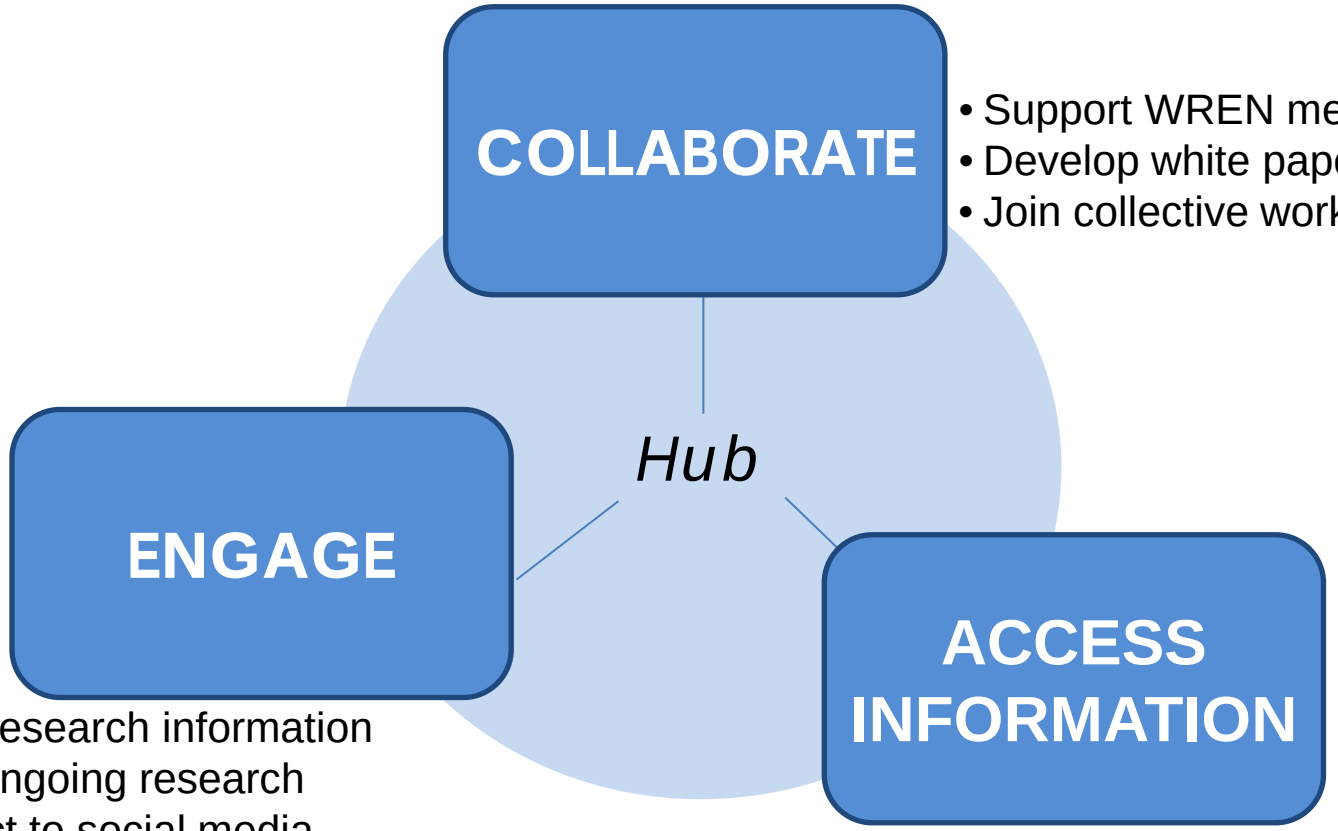
Primary Products

- **WREN Hub** is a dedicated, publicly available, centralized knowledge management system providing easy access to existing information pertaining to wind-wildlife issues for both offshore and land-based wind energy.
- **White papers** on adaptive management, individual impacts to population effects, green versus green, cumulative impacts on wildlife, and risk-based management.
- **Outreach and engagement** through short science summaries, webinars, factsheets, conferences and meetings, workshops, expert forums, and other strategies.

Wind turbines in Jura, Switzerland.
Photo by Karin Sinclair, NREL

WREN Hub

https://tethys.pnnl.gov/



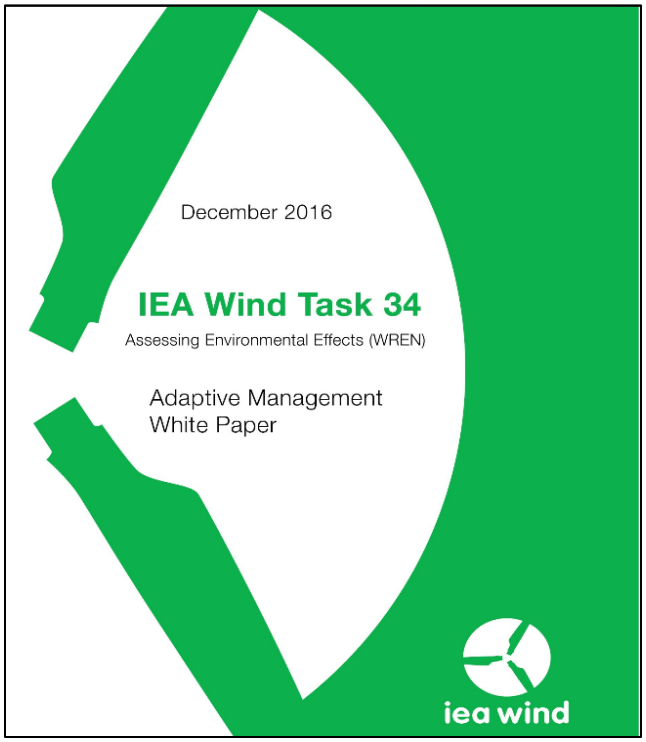
- Support WREN meetings
- Develop white papers
- Join collective workspace

- Share research information
- Track ongoing research
- Connect to social media
- Manage events calendar
- Convene topical webinars

- Access environmental effects information
- Find experts
- Search linked databases
- Compare country-specific information

Adaptive Management White Paper

- The WREN Hub site* for the *Adaptive Management White Paper* contains the following items:
  - Summary of the report
  - Link to the white paper
  - Fact sheet describing the white paper.
  - Translated to French; will likely be translated to other languages

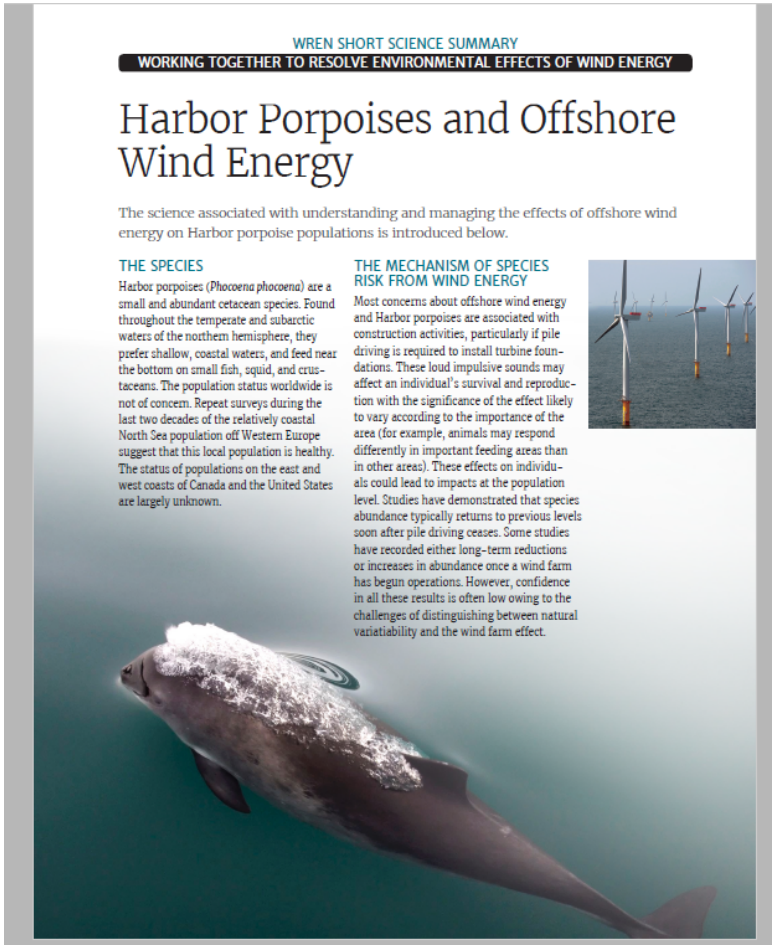


* https://tethys.pnnl.gov/publications/assessing-environmental-effects-wren-white-paper-adaptive-management-wind-energy

Short Science Summaries

Harbor Porpoises and Offshore Wind Energy:

Harbor porpoises (*Phocoena phocoena*) are a small and abundant cetacean species. Found throughout the temperate and subarctic waters of the northern hemisphere, they prefer shallow, coastal waters, and feed near the bottom on small fish, squid, and crustaceans. Most concerns about offshore wind energy and harbor porpoises are associated with construction activities, particularly if pile driving is required to install turbine foundations. This short summary represents a general overview of the research.



https://tethys.pnnl.gov/short-science-summary-harbor-porpoises-and-offshore-wind-energy

State Activities

- Western states collaborated to develop a greater sage grouse conservation plan based on habitat (as opposed to population level); plan is now under review by current administration.
- **Governors Wind and Solar Energy Coalition**: 20 member states call for increase in research and development funding.
- **U.S. Conference of Mayors**: 250 mayors approved resolution to transition to 100% clean energy by 2035.
- **Midwest Wind Multi-Species Habitat Conservation Plan**: Covers Indiana bat, Kirtland's warbler, piping plover, least tern, northern long-eared bat.
- **Wind Energy Whooping Crane Action Group** (WEWAG): Creating the Great Plains Wind Energy Habitat Conservation Plan to responsibly develop the wind energy resources in the central United States. WEWAG is collaborating with Region 2 (the Southwest) and Region 6 (Mountain-Prairie) of the U.S. Fish and Wildlife Service, as well as the state wildlife agencies of the nine states (North Dakota, South Dakota, Montana, Colorado, Nebraska, Kansas, New Mexico, Oklahoma, and Texas) included in the Plan Area. Species included in HCP (HCP): whooping crane, interior least tern, piping plover, and the lesser prairie chicken.

Deepwater Wind's 30-MW Block Island Wind Farm, the first offshore wind project in U.S. *Photo by Suzanne Tegen, NREL*

Conclusions

- Wind-wildlife impact concerns are complicated.
- Micrositing is key to avoiding, minimizing, and mitigating impacts; some locations may just not be appropriate for wind development.
- Research and development of tools is ongoing.
- Collaboratives provide opportunities to leverage resources to find solutions for common challenges.

GE 1.5-MW turbines at Grand Ridge Wind Energy Center in Lasalle County, Illinois. *Photo by Invenergy, LLC, NREL 16040.*

Thank You!

Photo by Dennis Schroeder, NREL 25880

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