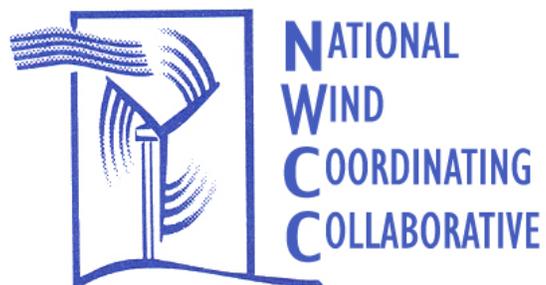


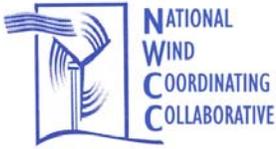


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WIND WILDLIFE RESEARCH MEETING VII MEETING PROCEEDINGS

OCTOBER 28 - 29, 2008
MILWAUKEE, WISCONSIN





Wind Wildlife Research Meeting VII

MEETING PROCEEDINGS

October 28-29, 2008

Milwaukee, Wisconsin

PUBLISHED

June 2009

Prepared for:

National Wind Coordinating Collaborative

By Susan Savitt Schwartz

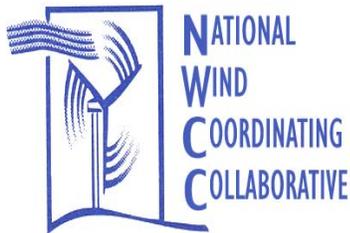
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ACKNOWLEDGEMENTS

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ACKNOWLEDGEMENTS

We wish to thank the following planning committee members, who contributed extensive volunteer hours in planning this meeting.

Dick Anderson, *California Energy Commission*
Rene Braud, *Horizon Wind Energy*
Melanie Cousineau, *Environment Canada*
Noel Cutright, *We Energies*
Michael Fry, *American Bird Conservancy*
Rick Greiner, *Babcock & Brown*
Laurie Jodziewicz, *American Wind Energy Association*
Al Manville, *U.S. Fish & Wildlife Service*
Sara McMahon Parsons, *Iberdrola Renewables*
Jerry Roppe, *Iberdrola Renewables*
Lynn Sharp, *Tetra Tech*
Karin Sinclair, *National Renewable Energy Laboratory*
Dale Strickland, *Western EcoSystems Technology, Inc.*
Steve Ugoretz, *Wisconsin Department of Natural Resources*

The planning and execution of Wind Wildlife Research Meeting VII, in addition to the production of this document, was supported in part by the United States Department of Energy under Contract No. DE-AT01-07EE11218. Financial support by the Department of Energy does not constitute an endorsement by the Department of Energy on the views expressed in this document.

Abstract

Wind energy is able to generate electricity without many of the environmental impacts (conventional and toxic air pollution and greenhouse gases, water use and pollution, and habitat destruction) associated with other energy sources. This can significantly benefit birds, bats, and many other plant and animal species. However, the direct and indirect local impacts of wind plants on birds and bats continue to be an issue. The populations of many bird and bat species are experiencing long-term declines, due to the effects of a wide range of human activities, including energy production and consumption. These proceedings document current research on the impacts of wind energy development on wildlife and habitat and discuss the most effective ways to mitigate impacts.

Suggested Citation Format

This volume:

PNWWRM VII. 2009. Proceedings of the NWCC Wind Wildlife Research Meeting VII. Milwaukee, WI October 28-29, 2008. Prepared for the Wildlife Workgroup of the National Wind Coordinating Collaborative by RESOLVE, Inc., Washington, DC, Susan Savitt Schwartz, ed. 116 pp.

Preceding volumes:

- PNWWRPM VI. 2007. Proceedings of the NWCC Wildlife Workgroup Research Planning Meeting VI. San Antonio, TX November 14-15, 2006. Prepared for the Wildlife Workgroup of the National Wind Coordinating Collaborative by RESOLVE, Inc., Washington, DC, Susan Savitt Schwartz, ed. 138 pp.
- POWIWD-V. 2005. Proceedings of the Onshore Wildlife Interactions with Wind Developments: Research Meeting V. Lansdowne, VA November 3-4, 2004. Prepared for the Wildlife Subcommittee of the National Wind Coordinating Committee by RESOLVE, Inc., Washington, DC, Susan Savitt Schwartz, ed. 120 pp.
- PNAWPPM-IV. 2001. Proceedings of the National Avian-Wind Power Planning Meeting IV, Carmel, CA, May 16-17, 2000. Prepared for the Avian Subcommittee of the National Wind Coordinating Committee by RESOLVE, Inc., Washington, DC, Susan Savitt Schwartz, ed., 179 pp.
- PNAWPPM-III. 2000. Proceedings of the National Avian-Wind Power Planning Meeting III, San Diego, CA, May 1998. Prepared for the Avian Subcommittee of the National Wind Coordinating Committee by LGL, Ltd., King City, Ont., 202 pp.
- PNAWPPM-II. 1996. Proceedings of the National Avian-Wind Power Planning Meeting II, Palm Springs, CA, September 1995. Prepared for the Avian Subcommittee of the National Wind Coordinating Committee by RESOLVE, Inc., Washington, DC, and LGL, Ltd., King City, Ont., 152 pp.
- PNAWPPM. 1995. Proceedings of the National Avian-Wind Power Planning Meeting IV, Denver, CO, July 1994. Report DE95-004090. RESOLVE, Inc., Washington, DC, and LGL, Ltd., King City, Ont., 145 pp.

Ordering Information

These Proceedings are available in PDF format with accompanying powerpoint presentations available as separate pdf files. Proceedings may be downloaded free of charge from the NWCC website: www.nationalwind.org

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INTRODUCTION

Welcome

Noel Cutright (Member of the Planning Committee and Emeritus Scientist with We Energies) introduced Rick Kuester (We Energies) and Gloria McCutcheon (Wisconsin Dept. of Natural Resources).

Rick Kuester, *Executive Vice President, Wisconsin Energy Corporation and President and CEO, We Generation*, noted that wind power is the fastest-growing form of renewable energy in the world. We Energies, a generation and (electric and gas) distribution utility, and the largest utility in Wisconsin, currently has 18,000 participants using renewable power (wind, biofuels, solar) through its “Energy for Tomorrow” program. In May 2008, We Energies brought the Blue Sky Green Field wind power project (88 turbines, now generating 145 MW) on line. The utility has begun work on the Randolph wind project (100-200 MW, projected in service by late 2010 or 2011).

Gloria McCutcheon, *Wisconsin Department of Natural Resources*, recognized We Energies for its work in placing two demo wind turbines in operation, and for its generous support of this meeting. She also recognized Noel Cutright’s long role in the National Wind Coordinating Collaborative (NWCC) Wildlife Workgroup, noting that the efforts of the NWCC have provided agencies like Wisconsin’s DNR with the knowledge “to make the right decisions as we expand the wind resource on the land and on the Great Lakes.”

Abby Arnold, *NWCC Facilitator*, thanked Rick and his We Energies staff for hosting the meeting, a contribution that exemplifies the spirit of collaboration essential to the work and purpose of the NWCC. She recognized the conference Planning Committee (see below) and co-sponsors – including the U.S. Department of Energy (DOE), which supports the NWCC – and introduced the facilitation team (Abby, Taylor Kennedy, who serves as full-time staff to the NWCC, and Dana Goodson).

Purpose of the Meeting

This is the seventh in a series of meetings organized by the NWCC’s Wildlife Workgroup (formerly the NWCC Avian Subcommittee). Bringing together researchers, regulators, state, federal, and tribal agencies, wind energy developers, policymakers, utilities, renewable and environmental advocates, and other interested parties, these meetings are convened to examine current research on the impacts of wind energy development on wildlife and to discuss the most effective ways to mitigate such impacts.

The purpose of this year's two-day research meeting is twofold:

- to hear about the most recent wind-wildlife research pertaining to wildlife fatalities, cumulative and habitat impacts, and mitigation techniques and results;
- to assess how research results pertain to existing questions or impact current beliefs and understandings.

The Wildlife Workgroup convened two days of presentations to prioritize remaining research needs and discuss avenues for supporting needed research.

The Facilitator reviewed the draft agenda circulated before the workshop (Appendix A). The Planning Committee decided to start this conference with an update on a range of activities that apply what we have learned and are learning from the research. There followed a series of plenary sessions, each devoted to a general category of research. Each presentation was followed by a question-and-answer session. These Proceedings present summaries of each presentation (presentation slides may be downloaded from www.nationalwind.org as a series of separate Powerpoint files), along with a corresponding question and answer session summary.

NWCC Wildlife Workgroup Overview

The National Wind Coordinating Collaborative (NWCC) was established 15 years ago to come up with a better way to address wildlife impacts of wind energy development. The work of the NWCC – identifying issues, establishing dialogue among key stakeholders, and catalyzing appropriate activities to support the development of environmentally, economically, and politically sustainable commercial markets for wind power – is carried out through voluntary collaboration, with three paid staff (one full, and two part-time).

While our mission has expanded to encompass a wider range of issues that affect the use of wind power, the Wildlife Workgroup continues to exemplify the NWCC's mission. How can we maximize what we learn and minimize impacts so that we can move forward together? Volunteers represent all the stakeholders: the wind industry, utilities, regulatory agencies, non-governmental organizations, and academia. These research meetings have been an opportunity for us to learn from one another.

Members of the NWCC Wildlife Workgroup Planning Committee are listed below, along with their affiliations. A list of the panel moderators and presenters, their affiliation and their topic, follows. Appendix A provides a full list of speakers and participants and their contact information.

Planning Committee

Dick Anderson, *California Energy Commission*
Rene Braud, *Horizon Wind Energy*
Melanie Cousineau, *Environment Canada*
Noel Cutright, *We Energies*
Michael Fry, *American Bird Conservancy*
Rick Greiner, *Babcock & Brown*
Laurie Jodziewicz, *American Wind Energy Association*
Al Manville, *U.S. Fish & Wildlife Service*
Sara McMahon Parsons, *Iberdrola Renewables*
Jerry Roppe, *Iberdrola Renewables*
Lynn Sharp, *Tetra Tech*
Karin Sinclair, *National Renewable Energy Laboratory*
Dale Strickland, *Western EcoSystems Technology, Inc.*
Steve Ugoretz, *Wisconsin Department of Natural Resources*

Presenters

Ed Arnett, *Bat Conservation International*
Deanna Dawson, *USGS Patuxent Wildlife Research Center*
Scott Downes, *Northwest Wildlife Consultants, Inc.*
Wally Erickson, *Western EcoSystems Technology, Inc.*
Joelle Gehring, *Michigan State University*
Manuela Huso, *Oregon State University*
Karl Kosciuch, *Tetra Tech EC, Inc.*
Ron Larkin, *Illinois Natural History Survey*
Charles Maisonneuve, *Ministère des Ressources naturelles et de la Faune*
Al Manville, *U.S. Fish & Wildlife Service*
Jon T. McRoberts, *Texas Tech University, Department of Natural Resources Management*
Amanda Miller, *Tetra Tech EC, Inc.*
Tricia Miller, *Pennsylvania State University and Carnegie Museum of Natural History*
Jonathan Plissner, *ABR, Inc.*
Michael Ross, *McGill University*
Michael R. Schirmacher, *Bat Conservation International*
Jill Shaffer, *US Geological Survey, Northern Prairie Wildlife Research Center*
Richard Sojda, *U.S. Geological Survey, Northern Rocky Mountain Science Center*
Manuel Suarez, *U.S. Fish & Wildlife Service*
John E. Toepfer, *Society of Tympanuchus Cupido Pinnatus, Ltd.*
Rafael Villegas-Patracá, *Institute of Ecology*
Ted Weller, *USDA Forest Service, Pacific Southwest Research Station*

SESSION I: SECTOR UPDATES

This session comprised updates on non-research activities underway in the United States, particularly guidelines being developed at state and federal levels. The research being shared at this meeting helps to inform development of these guidelines.

Wind siting guidelines recently adopted in Oregon and Washington State

Suzanne Leta Liou, *Renewable Northwest Project*

Background

The Renewable Northwest Project (RNP) is a nonprofit coalition of consumer interests and renewable energy companies. Since 1994, RNP advocates for responsible development of new renewable energy resources in the Northwestern U.S. The project's objectives are to establish proper siting of projects, advance policies that promote new renewables, and expand retail markets for renewable energy in Oregon, Washington, Idaho and Montana.

The Northwest has excellent renewable resources, and has made significant strides towards developing these resources over the past ten years. [*Powerpoint slides #6 & 7: compare maps showing renewable projects in 1998 and 2008.*] There are over 2,300 MW of wind energy serving the Northwest load, primarily in the Columbia plateau eco-region (CPE), or Columbia River gorge area, where there are both good resources and good access to transmission. A number of new projects have been proposed in southeast Oregon and western Washington and Oregon.

But developing these resources also requires land access, permits, and transmission in order to get a buyer (power purchase agreement), which in turn is a prerequisite for getting financing. Montana, for example, has an enormous wind resource (116,438 MW v. 6,000-8,000 MW resource potential in each of the other NW states: Idaho, Oregon, and Washington), but transmission to markets is an issue.

State siting guidelines

The purpose of state siting guidelines is to ensure wind projects are developed in a manner that is protective of wildlife and habitat and provide certainty to project developers. Washington

developed state siting guidelines in 2003; these are being updated this year (by December 2008). Washington projects are considered to be under county jurisdiction, but developers can opt to follow state energy facility site council guidelines instead. Oregon's guidelines, developed in 2008, are specific to the Columbia plateau and include a cumulative impact white paper in the appendix. In Oregon, depending on size of project, developers permit a project either through the county or the state energy facility siting council.

Key components and issues

Key guidelines components include macro-siting and critical issues assessment, pre-project surveys, construction and operational monitoring, and mitigation. Guidelines call for creation of a Technical Advisory Committee (TAC). The length of pre-project surveys is always a major discussion point, with survey periods typically ranging from one to two years. The duration of operational monitoring is also a discussion point. Mitigation requirements depend on the quality of habitat being impacted. (Both Washington and Oregon chose not to refer to turbine curtailment as a mitigation option in their guidelines.) Reference to Federal laws has proved a sticking point, with counties being resistant to it.

Cumulative impacts

Cumulative impacts are defined as additive or incremental effects of past, present and foreseeable future actions taken as a whole. They include both direct and indirect impacts, taking into account a wide range of factors, not just the consequences of wind power.

Existing cumulative impacts research for Washington and Oregon (WEST, Inc.) puts average fatalities per MW at:

- 0.07 for raptors
- 2.2 for birds (general)
- 0.68 for bats (general – with 90% of bat fatalities being hoary and silver-haired bats)

The consensus opinion is that cumulative direct mortality has not revealed population level impacts. However, past studies are not necessarily a good indicator of future cumulative impacts, and there are concerns regarding the potential for wind to impact at-risk wildlife species. Indeed, a single project may have a significant effect on future cumulative impact analysis.

Recommendations

RNP recommends creating a central data repository and coming up with a collaborative design and funding of a cumulative impact analysis for species of concern. Such a model could be used to develop impact thresholds of concern and to be able to address cumulative impacts over time.

Download the Oregon Columbia Plateau Ecoregion Wind Siting and Permitting Guidelines and agency endorsement letter: <http://www.dfw.state.or.us/lands>

Overview and update on American Wind Wildlife Institute

Ron Helinski, *American Wind Wildlife Institute*

The American Wind Wildlife Institute (AWWI) is a first-of-its-kind collaboration between non-governmental organizations (NGOs), government agencies and other industry representatives. Created with support from the American Wind Energy Association Board of Directors and the AWEA Siting Committee, AWWI's mission is to facilitate timely and responsible development of wind energy while protecting wildlife and wildlife habitat. The institute will address regional (rather than site-specific) issues in wind farm siting and wildlife-habitat protection.

AWWI anticipates obtaining its 501(c)3 (nonprofit) status in December 2008. As of Oct 3, 2008, AWWI has a Board of Directors with five industry and five NGO representatives. The composition of the Board includes:

- Association of Fish and Wildlife Agencies
- BP Alternative Energy
- enXco
- GE Energy
- Union of Concerned Scientists
- Iberdrola Renewable Energies USA
- National Audubon Society
- Natural Resources Defense Council
- NRG Systems
- The Nature Conservancy

AWWI has funding commitments from a variety of wind companies and non-governmental conservation organizations, resulting in an operating budget of \$3 million for its first two years. Board chairs have made multi-year commitments to the following four initiatives: research, mapping, mitigation (through cost-effective and predictable regional biodiversity banking solutions will be developed to address the impacts of large scale growth of the wind industry.), and public outreach/education. The focus this year will be on research and mapping.

Research - develop criteria for selecting research projects, with \$1 million banked to fund projects. We plan to have a Director of Research on board by February 2009.

Mapping - put RFP out to get expression of interest from groups to develop landscape maps for 48 states, with emphasis on the Midwest, showing low v. high-risk wildlife areas.

The position of executive director was advertised through November 30. The Board has approved a transition plan to bring someone on board in January 2009. The collaborative spirit of the NWCC is what gave birth to AWWI. Help us find the best staff to help us move forward!

[On Day 2, Deb Hahn of the Association of Fish & Wildlife Agencies introduced herself and the other founding members of AWWI]:

René Braud - Horizon Wind Energy. *AWWI is an unprecedented way to answer questions collaboratively – the idea really came from Jim and Wayne Walker of AWEA, but they wanted to collaborate with NGOs.*

Brandy Gibson – BP Alternative Energy.

Rick Greiner – Babcock & Brown. *Great things will come of this!*

Jon Rogers – Union of Concerned Scientists. *UCS has worked with NWCC Wildlife Workgroup. There is a memorandum of understanding that outlines the complementary roles of NWCC and AWWI.*

Mike Azeka – AES Wind Generation. *Our company has made multi-year commitment to fund and to contribute to AWWI – we're interested in peer-reviewed results.*

Andy Linehan – Iberdrola Renewables. *It will be more powerful when studies come out of a collaborative effort like this. This institute has the potential to work on mitigation on a larger scale, which will be critical, especially as we consider cumulative impacts.*

Ken Popper & Jay Pruett – Nature Conservancy of Oklahoma. *We will collectively decide what research needs to be done, find funding to do it, and get answers out to decision-makers.*

AWWI website: www.awwi.org.

Update on USFWS wind turbine guidelines and Federal Advisory Committee

Dave Stout, U.S. Fish & Wildlife Service

In 2003, the U.S. Fish & Wildlife Service (US FWS) issued interim wind turbine siting guidelines to get input from public. The objective of the guidelines is to avoid or minimize impacts to wildlife and their habitats related to land-based wind energy facilities. We established a Federal Advisory Committee in October 2007 to provide recommendations to the Secretary of the Interior on how to revise and finalize the Guidelines. The Committee convened for the first time in April 2008 with 22 members and four alternates, “hand-selected” to speak for different constituencies. [See slide #6 for list of Committee members and their affiliations.]

Technical subcommittees were created to focus on topics ranging from legal issues to science tools and procedures. Subcommittees were established to review other models, develop guiding principles, and evaluate landscape/habitat evaluation tools. These subcommittees have finished their work and are now inactive. Other subcommittees have (or are) focused on existing guidelines, legal issues, science tools and procedures. An incentives subcommittee is focused on the very important question of how to get people to use the guidelines.

The Committee adopted a tiered approach to decision making. The synthesis subcommittee is now taking the work of the other subcommittees to develop a draft document. A private landowner panel provided their perspectives on wind energy development.

We are looking for opportunities for the wind industry to efficiently satisfy the requirements and permitting processes under the Migratory Bird Treaty Act (MBTA) and the Endangered Species Act (ESA). We want to create incentives for the industry, Tribes, states and local governments and industries to use these voluntary guidelines.

Contact Dave Stout – Chief, Division of Habitat and Resource Conservation:

Dave_Stout@fws.gov (703-358-2161). For more information on the FAC go to http://www.fws.gov/habitatconservation/windpower/wind_turbine_advisory_committee.html.

*Association of Fish & Wildlife Agencies updates and the
status of wind in the states*

Celia Greenman, Colorado Division of Wildlife

The Association of Fish & Wildlife Agencies (AFWA) Energy Policy Wildlife Committee has established a subcommittee on wind energy that will be looking at issues of wind energy development and associated electrical transmission line construction. As a founding member of the American Wind Wildlife Institute (AWWI), AFWA wants to open discussion with industry and interact with public utility commissions to get involved in wind energy facility siting at the front-end. The AFWA energy policy committee is developing a letter for the incoming administration, encouraging support for an extension of production tax credit. A longer-term tax credit would help industry plan for mitigation.

The State of the wind in states (as of October 2008)

New Hampshire

The state of New Hampshire has developed draft guidelines with 15 criteria for ranking projects as low, medium, and high level of concern; however after the ranking, there are no procedures for taking the next step. The guidelines were prepared by an interdisciplinary team of regulators, developers, and NGOs. One wind project is built, another in formal review, and 3-4 are in a preliminary process. A Site Evaluation Committee (SEC) is composed of state agency directors who evaluate renewable projects as well as other projects. The SEC process can take as long as nine months, after which the developer receives all of the permits that he needs. In the legislature, there is an energy subcommittee that performs a formal state review of projects over 30 MW. If guidelines are passed into law, the New Hampshire SEC would have to use them in their review process.

New York

New York State has guidelines, which were prepared from the results of a stakeholders' meeting in August 2006, have been out for comment since January 2008. They have been generally well received; developers say they're easy to read and follow. These guidelines are voluntary. Site characteristics determine whether standard or expanded wildlife surveys are needed, but the state needs to clarify what happens if a site is determined to be sensitive. Mitigation has not been used; the state is exploring the possibility of curtailment measures during the late summer and early fall because of impacts on bats, such as the Indiana bat.

Texas

Voluntary guidelines were developed by the state of Texas' Wildlife Department, and include separate appendices for different eco-regions. They have been implemented as draft guidelines since January 2008, and are now being finalized. Although industry and NGOs have participated in different iterations of the guideline process, the guidelines do not necessarily represent their opinions. The guidelines do not (yet) include any compensatory mitigation provisions. Texas has

a Wind Coalition of companies with wind energy projects. The members of the coalition did commit to using the guidelines for self-oversight.

Indiana

Indiana worked with a template from other states to draft its guidelines, which are currently under internal review. There has been no plan for stakeholder input, and the guidelines would be voluntary. Developers currently request an early coordination review, and the guidelines could be discussed at this point. There are now three projects at different stages in Indiana, with a golden plover stopover site being the main issue of concern. No mitigation measures have been proposed to date.

Colorado

Colorado Division of Wildlife (DOW) also created draft guidelines using other states' guidelines as a template. The Colorado PUC is currently undergoing rulemaking for the state's renewable energy projects with input from stakeholders. Ultimately, a revised version of the DOW guidelines might be part of the PUC process, but there is also a coalition of wind energy companies and NGOs that is working independently on guidelines. There are six projects in operation in the state, but at least another 26 projects in the planning stages. Issues of concern for Colorado wind projects include the lesser prairie chicken, raptors, and the development of escarpment areas and intact shortgrass prairie.

Summary

States have taken different approaches to preparing guidelines for wind energy development. Some state guidelines include different requirements for different habitats. New Hampshire ranks sites based on a list of criteria. In the states mentioned above, the guidelines are currently voluntary and there has been a difference in degree of stakeholder input. However, there has been willingness of developers in all states to work with the state agencies – to offer input, and help develop guidelines. This kind of industry cooperation is very refreshing.

Western Governors Association wildlife initiatives associated with Western Renewable Energy Zones efforts

Carl Zichella, *Sierra Club*

The Sierra Club has created a new position: Director of Western Renewable Programs.

After the production tax credit (PTC), transmission is the biggest hurdle to developing renewables in the western United States. There are three major transmission interconnections in the United States (Western, Texas, and Eastern), with the Western interconnection connecting ten states, two Canadian provinces and Baja Mexico. Developing transmission to bring renewables to market is a big challenge. We have to identify the best areas for development and look at areas that need to be excluded.

In February 2007, the Western Governors Association (WGA) adopted a policy resolution on wildlife corridor protection. In May 2008, WGA launched its Western Renewable Energy Zone (WREZ) initiative, a challenging collaborative effort to help meet the WGA's Clean Diversified Energy goals. In June 2008, the WGA established the Western Wildlife Habitat Council to identify wildlife corridors and crucial habitats, and coordinate implementation of needed policy options and tools for preserving those landscapes. The WGA recognized the need to coordinate the identification and protection of wildlife corridors and crucial habitat with the development of its renewable energy zones.

The WREZ process parallels an effort started over a year ago in California: a statewide initiative (Renewable Energy Transmission Initiative - RETI) to help identify the transmission projects needed to accommodate the state's renewable energy goals, support future energy policy, and facilitate transmission corridor designation and transmission and generation siting and permitting. RETI is an open and transparent collaborative process in which all interested parties are encouraged to participate, working with CA ISO (AB32 – global warming cap law), and now with the WREZ initiative.

California guidelines have been working well to avoid lawsuits challenging wind projects because of wildlife impacts. California's RETI map illustrates what WREZ is seeking to achieve for the entire Western region. The map was developed using both state and privately-generated data (Audubon, Nature Conservancy, etc.) to identify wildlife conflicts. Wyoming alone could supply renewable energy for the entire western interconnection area. The point is that even once sensitive areas are excluded, it is still possible to accomplish what WREZ sets out to do.

Questions following Session I Presentations

Question: Carl, how are you getting developers to use the RETI map?

Response [Carl Zichella]: Developers helped to draw that map. This is the first time environmental and economic interests have worked together to identify where development should take place. It can be very difficult for people to work together, but effective.

Question: There are a lot of wetlands where wind energy is being developed, and that requires an Army Corps of Engineers (NEPA) permit. How are you dealing with the NEPA issue?

Responses

[Dave Stout]: Most of the projects I've seen haven't required a federal permit. But if there's a federal nexus, it does require NEPA process

[Carl Zichella]: Environmental groups and wind companies have joined in a letter asking Senators Feinstein and Reid to staff agencies so that the NEPA process can be expedited –not to cut corners, but just to facilitate permit application processing. Bureau of Land Management (BLM) was so overwhelmed with lease applications that it drafted a programmatic EIS for solar and geothermal. Senator Tester (Montana) and Sen. Feinstein have written a bill to this effect for wind – we hope it will pass next year.

[Suzanne Leta Liou]: In western WA and OR, having federal F&W staff involved in guideline development is crucial to the process. It's not very helpful when a developer just gets a form letter from a federal agency.

Question: At the state level, is the Western Governors Association (WGA) focused at all on increasing efficiency, or just building new renewable?

Responses

[Carl Zichella]: Efficiency is a top priority for WGA and its member states. Don't know if there's an active initiative?

[Abby Arnold]: WGA, with DOE, National Association of Regulated Utility Commissions, and Edison Electric Institute, is starting a series of hands-on workshops with clusters of states to focus on promoting efficiency measures.

Question: How do you step down from the Federal level (US FWS) wind turbine guidelines to the level of state and local permitting agencies?

Response [Dave Stout]: We're looking for incentives for state and local agencies to adopt guidelines – the Wind Turbine Guidelines Advisory Committee wants to get input from states.

Question: Celia – can you give us an update on Colorado's siting guidelines?

Response [Celia Greenman]: Colorado is short-grass prairie, and we're trying to use siting and best management practices to keep it intact. The preliminary input from industry on guideline concepts indicated that the guidelines might be too restrictive. Colorado's Public Utility

Commission is working on rule-making for renewable energy projects. We'll work with the PUC, developers, NGOs.

Question: AWWI is an important and unprecedented step. What are the priorities?

Response [Ron Helinski]: We started to lay the foundation 3-4 months ago for initiatives that we wanted to get going fast. Mapping will be our first focus, having these comprehensive national and regional maps will play a key role in how that national policy is developed. Our other priority is to empower users to make good decisions. Data generated from the mapping and research initiatives will provide the wind industry with the information it needs and will empower companies in their decision-making processes for siting future wind farms. This will enhance wildlife populations and habitats.

A website will be available in November [2008] and can be accessed via www.awwi.org.

Question: Who will manage the centralized database, and will developers actually turn over sensitive data?

Response (Suzanne Leta Liou): That's a good question – we haven't figured out all the answers yet. It's especially important for agencies and county permitting authorities to be able to access data centrally. Industry is not opposed to sharing information; the issue is how public that information becomes. Our programmatic recommendation is to ensure proper funding for state wildlife agencies to collect the monitoring (fatality) data from operating wind facilities.

SESSION II: FATALITY IMPACTS TO BIRDS AND BATS

This session comprised seven presentations focusing on avian and bat fatality research at wind energy facilities. Presenters discussed different estimators of fatality and the influence of search intervals, searcher efficiency, and scavenging rates. Researchers discussed progress in developing predictive models based on comparison of pre-construction avian/bat use survey data with post-construction fatality estimates.

A Summary of Avian and Bat Fatality at Wind Facilities in the U.S.

Wally Erickson, *Western EcoSystems Technology, Inc.*¹

This presentation updated a summary of avian and bat fatality data presented in 2001. Fatality rates were generated based on fatality monitoring information gathered on a 12-month continuous basis using “reasonably similar” field study methods at wind energy sites around the United States. Map (slide #3) shows study locations. Fatality studies are concentrated in the Northwest, California, and upper Midwest, with fewer studies in the East. We can expect to see many more study locations next time; there are a lot of new avian and bat fatality studies getting underway.

Composition of avian fatalities

The composition of fatalities is based on all studies reporting fatalities by species. Excluding California’s Altamont Pass Wind Resource Area, about 74% of wind turbine-related avian fatalities nationwide are composed of passerines. (Graph showing fatalities by species composition, slide #4). This number is probably biased low because it does not account for detection or scavenging bias. About 6% of wind-related fatalities are raptors, and 11% are gamebirds. (This may be overestimated, as it may include gamebird fatalities other than those caused by turbines.) Additional graphs (slides #5-8) show the species composition of avian fatalities on a regional basis.

The current fatality database for the Pacific Northwest comprises 636 records, including 73 species. Horned lark is the most common bird in Eastern Oregon and Washington and the Columbia River basin; it is also the most common fatality – about 32% of all identified avian fatalities. Golden-crowned kinglet represents 6.4% of fatalities (a migrant), and American

¹ Co-authors: Dale Strickland, David Young, Greg Johnson – WEST, Inc., Cheyenne, WY

kestrel and red-tailed hawk another 5.2% combined.

Monitoring objectives

The use of standardized fatality estimates across projects enables us to make some determinations about individual projects:

- whether fatality rates are low, moderate, high compared to other projects (regionally or nationally);
- whether predicted mortality is a reasonable estimate, given what we've measured at similar projects;
- whether a project has "a fatality problem"

Using similar methods and metrics allows for cross-site comparison of fatality data. This enables us to achieve other objectives:

- understanding species risk by comparing fatality rates to exposure or relative abundance;
- estimating the influence of factors like weather and lighting;
- determining the effectiveness of mitigation measures (e.g., seasonal shut-down in Altamont).

Field biases

There are a number of potential field biases that need to be taken into consideration when generating, interpreting, or comparing fatality data.

Carcass removal and searcher efficiency

If field researchers can't be out there searching every day, it is necessary to estimate the rate at which scavengers are removing carcasses. Searcher efficiency – the likelihood that a searcher will find a carcass if it is there to find – also has to be measured. (These two biases interact, as searchers may be less likely to spot a partially scavenged carcass than a whole/fresh carcass.) Low searcher detection and high carcass removal can lead to high uncertainty and high variation of estimated mortality.

Measuring carcass removal and searcher efficiency rates accurately can also be tricky. You cannot push the experimental process by putting too many carcasses out there to test removal, or extrapolate removal or searcher efficiency from non-representative carcasses.

Spatial distribution of fatalities

Another factor that can bias fatality data is the possibility that some carcasses will land outside the search plots. [Slide #12 shows graph of probability that carcass lands within the search plot.]

Background mortality

Sometimes it is clear that a bird (or bat) was killed by colliding with the turbine tower or blades. However, some of the fatalities identified may be part of background mortality, i.e., birds (or

bats) that would have died regardless of the turbine being there. If a fatality is identified on the basis of a feather spot [slide #13], it is hard to know the cause of death, particularly if the search interval is longer. It is possible to estimate background mortality, but this is costly.

Fatality metrics

Metrics matter when you want to be able to compare rates among sites.

There has been a progression in the metrics used to predict fatalities. Fatalities per turbine for smaller turbines doesn't necessarily predict what might happen as turbine size increases. Estimating fatalities per nameplate megawatt capacity rating is a little better, however, the assumption is that fatality rates increase in proportion to the rotor-swept-area (RSA) of the turbine, not necessarily in proportion to the increase in capacity. Repowering with new technology in the Altamont has reduced the RSA per MW, with fewer raptors killed per MW per year at the newer turbines. Ideally, we'd like to be able to estimate fatality as a function of actual production (fatality rate per unit of power produced).

Another type of comparison we can make at the meta-analysis level is among fatalities generated by wind projects sited in different types of landscape. Fatality data from 19 sites is summarized in Slides #18 and 19, with fatalities for all birds (Slide #18) and all raptors (Slide #19) displayed by landscape type: agriculture, agriculture/grass/Conservation Reserve Program, forest, and grass/steppe. One of the two forested sites showed a markedly higher level of overall avian fatalities, whereas raptor fatalities have been high at two sites in California that also have very high raptor use.

Lighting and birds

Our meta-analysis suggests no large differences in fatality rates at lit and unlit turbines for night migrants. We have seen some effects at individual sites, but no statistical significance at the meta-analysis level.

There is some controversy over data [slide # 23] showing that high raptor use of a site is associated with high raptor mortality. We need more data to fill in the gaps. The relationship between use and mortality is species-specific, as some species are better able to avoid colliding with turbines. Monthly use was shown to correlate with monthly fatality rates for red-tailed hawks in the Altamont (2008), but there was no such correlation for American kestrels.

Population impacts

In general, individual projects won't affect populations, but we need to look at cumulative impacts. Slide #27 illustrates an estimate of fatalities accumulating under a future wind development scenario in the Columbia basin. Based on fatality rates from seven studies within the region, we extrapolated the annual number of fatalities for four avian species assuming development of 6000 MW. These figures were compared with estimates of population size for those species to come up with an estimated adult mortality rate. For the American kestrel, for example, 6000 MW of wind power would result in estimated annual fatalities of 207 birds, or

0.12% of the Columbia basin population of adult kestrels. This rate would be considered against a background mortality of 40%. For the red-tailed hawk, we estimate 118 fatalities, or 0.15% of the adult population. These percentages are very low, and indeed negligible when compared to typical background mortality (20%). Ferruginous hawk mortality levels, however, could be a concern and should be focused on.

Bat fatality data

Bat fatalities will be found if you look for them, no matter where the project is. [Slide #30 shows regional patterns of bat fatalities by species; Slide #31 lists bat fatality rates from 20 study locations.] Comparing bat fatality rates is tricky because the metrics used to estimate bias are variable from one part of the country to another. As with birds, there appear to be no significant differences between bat mortality at lit v. unlit turbines. This analysis should be updated with new data.

Summary – Priority Research Needs

We know a great deal about mortality rates in some landscapes (e.g., agricultural land) and some regions – especially the Pacific Northwest. Lack of replication of fatality studies limits our current understanding of mortality in the Northeast and South-central U.S., but new and ongoing studies will be valuable additions. Raptor use and mortality do appear to be related, but studies that include both pre-construction diurnal use data and post-construction fatality data are limited – thus limiting our ability to predict mortality based on use. Fatality data are being used to test the reliability of predictors.

Questions following Presentation

Question: Is there any information about where within the rotor-swept area bats are colliding – visible v. invisible smear area?

Response: We do not have information about what part of the blade is responsible for bat impacts. Models suggest interior of blade are more visible than outer tip, but no data.

Question: What about the age of fatalities?

Response: We look at that when we can. Fatalities are typically a mixture of adults and juveniles, migrating v. local animals. Grainger Hunt's work in Altamont found that fatalities were primarily sub-adults and floaters.

Question: What estimators are you using to account for carcasses landing outside search plots? Are you taking account of carcass density?

Response: Use curve-fitting to estimate the tail of the distribution.

Question: Lighting is always an issue for us. Have you correlated lighting with weather-related fatality incidents?

Response: It's difficult to correlate unless you do daily searches. We're looking primarily at lit v. unlit turbines, without accounting for weather conditions. However, there have not been any large mortality events documented at wind projects.

Question: Is it possible that bats are being crippled, but not killed, and flying off – perhaps dying elsewhere and not being accounted for?

Response [Wally Erickson]: Most of the bats are found close to turbines. Most don't show signs of blunt trauma.

Response [Ed Arnett]: If a bat is crippled, it falls, it doesn't fly off. At Mountaineer, 1/3 of fatalities didn't have blunt trauma. Key issue is attraction to turbines.

Response [Ron Larkin]: Bats can't eat if they can't hear – if they suffer damage to their ears, they could die miles away, and you'd never know it.

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*Big Horn wind power project fatality monitoring results;
comparison to pre-construction avian use estimates and working with a TAC*

Scott Downes, Northwest Wildlife Consultants, Inc.¹

An extensive study of pre-construction avian use composition with post-construction fatality monitoring gives us a chance to examine whether use estimates reasonably predicted fatalities. This presentation describes the methods used to survey use and monitor and estimate fatalities, suggests lessons learned that could be applied elsewhere, and touches on the role of the technical advisory committee (TAC) in study design and implementation.

The Big Horn wind power project is located in the Columbia Basin, in Klickitat County, Washington. The 199.5 MW project became operational in October 2006, and consists of 133 1.5 MW turbines (389-ft to top of blades). The project site habitat is similar to other Columbia Plateau Ecoregion (CPE) sites in terms of vegetation (grass, agricultural land), but different than other CPE projects in that it is closer to the forested mountainous zones of the Cascade and Blue Mountains foothills and is interspersed with riparian zones in canyons. (Turbines are set back from canyon edges.)

Pre-construction use surveys

Pre-construction avian use surveys are used to provide a spatial “snapshot” of avian composition and potential risk, including:

- species of concern and taxa composition (especially for sensitive groups like raptors);
- micro-siting information (are there locations within the project site to avoid?); and
- seasons of higher use (e.g., large migration, breeding or wintering groups)

The common method for doing use surveys is the fixed point plot method. In this case, 800 m radius study plots were surveyed weekly, with 20-minute counts conducted at all times during daylight hours. We collected data on species, number, and flight height.

Commonly used metrics

Mean use – average number of birds observed per survey, an index of relative abundance.

Percent composition – species-specific mean use divided by mean use for all species

Frequency – number of surveys in which a species is observed, a metric that eliminates the bias of large groups in mean use

Index of exposure – amount of time spent in the rotor-swept area (RSA). This is used as an indicator of species risk, based only on flight height, not on any other observed behavior around turbines.

¹ Co-authors: Sara McMahan Parsons, Iberdrola Renewables, Inc.; Bob Gritski and Karen Kronner, Northwest Wildlife Consultants, Inc.

Survey dates

Data for spring and summer use came from the County Energy Overlay Zone programmatic environmental impact study (Johnson and Erickson 2004). This study looked at nine plots within three miles of the project site. A total of 42 surveys were conducted from April 15 to May 31, 2002, and another 33 surveys were conducted from June 1 to July 15, 2002. This spring and summer data was supplemented with surveys conducted at eight plots on the site, including 127 surveys conducted from December 3, 2004 to March 15, 2005, and another 96 surveys conducted from August 30 to November 16, 2005.

Post construction monitoring study

Post-construction monitoring began in October 2006, at the start of operations. All 133 turbines were searched once every two weeks in the fall and again in the spring, and once every four weeks in the winter and summer. (Altogether there were 19 133-turbine searches conducted over a one-year period, or 2,527 turbine searches.) Square search plots (180 m/side, 90 m out from turbine) were used, with transects 6 m apart.

Observed fatalities were corrected using searcher efficiency (SEEF) and carcass removal trials (CRT). [Slides #11 and 12 summarize results of carcass removal and searcher efficiency trials.] Corrected fatality estimates show that searchers found about 24% of all avian fatalities (18% of passerines and 52% of raptors). Slide #14 shows how the composition of observed fatalities was adjusted to account for taxa-specific SEEF and carcass removal bias factors, yielding corrected estimates of the composition of avian fatalities. So for example, 13% of *observed* avian fatalities were raptors, including owls, but given the much higher likelihood of raptor fatalities being found compared to other taxa, we calculate that raptors made up only 6% of *estimated* avian fatalities. ("Estimated" fatalities refers to observed fatalities corrected for carcass removal and searcher efficiency bias.)

Species not well predicted

Although the composition of avian use found in pre-construction surveys did help to predict the composition of estimated fatalities, some species were not well predicted.

Three species *not* found as fatalities despite being common on avian use surveys were: the common raven (the second-most common species observed); the northern harrier (second-most common raptor species observed); and the American robin. A closer look at use survey data indicates that the harrier spends little time in the RSA, and that robin observations were mostly detected in winter flocks, and only associated with riparian and juniper habitat which was not close to where turbines were built. Ravens do not have a collision history and are found as fatalities far less than their abundance indicates at other CPE projects, suggesting perhaps an ability to avoid turbines. Mountain bluebirds were common on avian use surveys but only one fatality was observed. Looking at flight height data, this species spends a small percentage of time in the rotor swept area.

Other species were not observed in the avian use surveys, but did show up in the fatalities. These included one ferruginous hawk (of concern because it is listed by the State of Washington as a threatened species); the short-eared owl, which might have moved into the area after construction. Several species were found in higher percentage of observed fatalities than avian use estimates suggested. These included the American kestrel (three of the eight fatalities found were found during a period – mid-July through the end of August – when no pre-construction surveys had been done); gray partridge (difficult to detect in avian surveys – not clear how many are really wind turbine-related fatalities), mourning dove.

A useful tool for fatality prediction is to examine fatality history of species on nearby projects where fatality monitoring has been completed. We looked at fatality composition for Big Horn in context of fatality composition for projects throughout the Columbia Plateau Eco-region [Slides #19 and 21]. Passerine composition matched other CPE projects, despite proximity to foothills and riparian on-site areas. Proximity to canyons was not a significant factor. All turbine strings had at least one observed bird or bat fatality; there did not appear to be any clustering of fatalities. Only one string did not have any avian fatalities observed.

Lessons learned

The general lesson is that avian use surveys can be useful. In this case, the composition of avian use pre-construction did help us predict composition of estimated avian fatalities. A 12 month study is the most useful to cover all seasons of avian use. However, if there is an interest in the presence of rare species or species that use specific times of the day, it may be necessary to supplement a 12-month use survey with focused surveys for special status or targeted species (such as the ferruginous hawk or short-eared owl, in this case).

When Big Horn was built, there were four other projects already built within the CPE. This data was helpful, just as Big Horn's data will help with future development in the wind resource area. The lesson learned is that post-construction data is available for the Pacific Northwest, and developers should seek out such data from existing projects when developing in other regions as well.

Other than avoiding canyon-edges, pre-construction survey data did not lead to any micro-siting decisions being made.

Finally, while mean use and composition data are important, it is also valuable to look at species collision history. In this case, while pre-construction surveys showed ravens flying in the RSA, ravens have a history of low fatalities at wind projects – and fatality data from the Big Horn site bear this out.

Bat fatalities

Big Horn bat fatality data mirrors trends for the CPE in terms of timing and composition. Bat fatalities peaked during the late summer and early fall, spiking in September. Slide #25 shows the composition of total fatalities for Big Horn. Slide 26 shows the composition and timing for

the CPE – over 95% were silver-haired and hoary bats for both Big Horn and the CPE.

Corrected fatality estimates for all bats and by avian taxonomic groups are shown in Slide #28, including the mean number of fatalities per turbine and per MW per year for bird groups and for bats. It is important to consider the full range of estimated annual fatalities, not just the means. (Ranges are given at the 90% confidence interval.)

Slides #30 and 31 show bird and bat fatality rates (respectively) with projects sorted in terms of the cumulative fatalities per MW per year. Big Horn's rates were above the mean for both birds and bats, but projects ranked differently depending for bird v. bat fatality rates. For example, Klondike II, in Oregon, ranked first in bird fatalities per MW (0.11 v. mean of 0.06), but last in bat fatalities per MW (0.41 compared to a mean of 1.3)

The advantage of searching all turbines is that it provided valuable composition estimates across the project, and makes it possible to identify any problem turbines. The disadvantages are several. In addition to being very expensive, the length of time it takes to search every turbine (two weeks to finish all turbines in a search) prevents more frequent search intervals, potentially sacrificing some precision of fatality estimates. Despite the intensity of the study effort, given the two-week search interval, only about 24% of all avian fatalities were found. The expense of searching all turbines made it impossible to conduct more than one year of study, so annual variation cannot be taken into account.

Is there a way to shrink the search plot area? Slide #32 suggests that bird fatalities were pretty evenly distributed across the search plots. Bats were found much closer to the turbine (Slide #33), and were concentrated on the down-wind side, suggesting it may be possible to shrink the search plot area for bat fatality studies.

Working with a Technical Advisory Committee

Big Horn was the first wind project built in an energy overlay zone developed for Klickitat County, WA. A technical advisory committee (TAC) was assembled to consult and provide advice on the study direction and to help determine whether post-construction results warranted additional mitigation. The TAC comprised a diverse group of stakeholders that met quarterly, discussed methods to be used, and served as peer-review board for the post-construction study.

The TAC cared about getting composition data, and about identifying problem areas – hence the decision to search all turbines. There has been a follow-up meeting to discuss the merits of on-site mitigation. Our experience was that it is helpful to have stakeholders in one place to review, as opposed to having to discuss study design and findings individually with each agency or interested group.

Questions following Presentation

Question: With regard to identifying problem turbines – given that there are relatively low

numbers of fatalities found at each tower – how do you identify whether one tower is significantly worse than others?

Response: You can't really do it on estimated fatalities. The only way you could break fatality rates down by turbine is to increase sample sizes, but that introduces other biases. The only approach is to examine how many observed fatalities per turbine. We are open to hearing ideas about how to do this.

Question: Your mortality predictions were based on day-time surveys only. Why no nocturnal avian use surveys?

Response: There is not much evidence for a lot of fatalities coming from nocturnal migrants in the Columbia region. Most of the species we were finding could be observed during the day.

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Estimating avian and bat mortality and identifying spatial and temporal distribution of avian and bat mortality at a utility-scale wind energy development

Amanda Miller, Tetra Tech EC, Inc.¹

Texas leads the nation in installed wind energy generation capacity, with about 5,600 MW installed. To date, however, no publicly available post-construction mortality studies have been completed in Texas. The objectives of this study of the Red Canyon Wind Energy Center were to:

- assess the incidence and frequency of mortality;
- identify the spatial and temporal distribution of mortality;
- estimate facility-related mortality rates; and
- identify turbine site characteristics that influence bat mortality events.

Red Canyon Wind Energy Center is located in Texas' southern panhandle, a cap-rock escarpment featuring short-grass prairie interspersed with juniper and some ground cover. The Center is sited on three distinct mesas, with 21 turbines located on the west mesa, 17 on the central mesa, and 18 on the east mesa.

Search methodology

The study methodology consisted of standardized seasonal carcass searches, conducted during five time periods including the fall bat migration period. We used a standardized sample of 28 turbines, with about the same number of searched and unsearched turbines on each mesa. We began with a 200' x 200' search plot, but reduced the size of the plots to reduce the interval between searches. During the summer, searches were conducted every three days to deal with a high carcass removal rate. During the bat migration period, searches were conducted every four days every week. Searches were conducted during all weather conditions, including dust storms, and ice as well as good weather.

Each time a carcass was found, the date and time were noted, and each carcass was assigned a GPS location including bearing and distance from the turbine. Carcasses were identified to species, age and sex. Evidence of scavenging was noted.

Correcting for observer efficiency and carcass persistence

Observer efficiency trials were conducted at 28 sample turbines during all seasons, comparing searchers in a double-blind manner across three classes of bird carcass size. Carcass persistence trials were conducted during 28-day periods in the middle of each season. Thirty-six bird carcasses per season were tested (12 per mesa at non-sampled turbines).

Bias correction modifications also were made for bat observer efficiency and carcass

¹ Co-authors: C. Boal, USGS Texas Cooperative Fish and Wildlife Research Unit, Lubbock, TX; and L. Nagy and B. Woeck, Tetra Tech EC, Lakewood, CO.

persistence. Efficiency trials were conducted at 14 sub-sampled turbines, using 3-8 bat carcasses per searcher. Bat carcass persistence trials were likewise conducted at 14 paired, non-sampled turbines, using a total of 24 bat carcasses.

Site and turbine characteristics

We looked at site and turbine characteristics as related to bat fatality events.

The turbine site was defined as the area within a 200 m radius of the turbine. Site variables were defined using bat presence/absence surveys (7-minute acoustic monitoring surveys were conducted at sample sites during summer and bat migration seasons, with two successive bat calls considered a single “pass”); and ArcGIS 9.3 software that included a spatial analyst extension and point distance tool. Turbines were characterized by: bat presence/absence (calls and passes per survey night); elevation; average aspect; maximum and average slope; percent of cap-rock edge; shortest distance to edge; distance to nearest turbine; mesa; and FAA lighting.

Analysis

We utilized both parametric and non-parametric methods to look for spatial and temporal patterns. A chi-squared analysis was used for count data, while continuous data was analyzed using a Kruskal-Wallis test, followed by Tukey’s HSD on ranks. M

Mortality estimation

Slide #20 gives the formula used to estimate mortality during a given time period: total number of turbines (N) x search interval (I) x carcasses detected during a given time period (C) divided by number of sample turbines (k) x mean carcass persistence x proportion of carcasses located during efficiency trials (p).¹

Geophysical characteristics

A geophysical characteristic model using stepwise regression was used to look for spatial patterns in bat mortality, with turbine characteristics being the dependent variables and fall-summer bat mortality detections being the response. A best-fit model was generated based on improvement in AIC score. Mortality categories were based on best-fit model independent variables, with mean values assigned to all turbines.

Avian results

A total of 25 carcasses were detected during standardized searches, and another five carcasses were discovered incidental to the standardized search procedures. A total of nine identifiable species were found, including nine turkey vultures, five great roadrunners and five northern bobwhite. Other fatalities identified as to species included mourning dove, blue jay, great horned owl, northern mockingbird, and red-tailed hawk. Some species located during the carcass searches – a quail carcass, for example – were considered unlikely to have been killed in

¹ Young et al., 2003

connection with the turbines, and so were not included in the results.

Although there was a higher proportion of avian mortality detected on the eastern mesa, the difference was not significant. In terms of temporal distribution, fatalities peaked in the fall (November).

Avian bias corrections

For birds, neither observer efficiency nor carcass removal rate varied by season. As would be expected, both searcher efficiency and carcass persistence were greater for larger birds than for smaller. Thus 76% of large carcasses were detected by observers in efficiency trials, while only 42% of small carcasses were detected. Overall efficiency for observer trials was 63%. Carcass persistence also varied by size class, with large carcasses persisting for 12 days and small ones for three. Overall carcass persistence was 9.5 days.

Avian mortality estimation

Of the 25 avian carcasses detected during the standardized carcass searches, 13 were considered to be collision mortality and were included in the avian mortality estimation. Avian mortality at Red Canyon is estimated at 0.50 individuals per MW per year, with a standard error of 0.024.

Bat results

A total of 65 bat carcasses were detected during standardized searches, with another 11 carcasses detected incidental to searches. Four species were identified: Brazilian free tail, hoary bat, western pipistrelle, and red bat. Spatial distribution among the three mesas is not statistically significant. Temporally, mortality peaks in October, with a smaller peak in June. This is comparable to what has been found elsewhere in the United States.

Bat bias corrections

Bats were not present during the winter, and no bat carcasses were found during this season, so this season was excluded from both observer efficiency and carcass removal trials. Observer efficiency was tested using 57 total bat carcasses, and carcass removal trials were conducted using a total of 60 carcasses. During the “season of occupancy” (fall to summer), observer efficiency was 26%, and carcass removal was one day. During the six-week fall migration period, observer efficiency rose to 43%, and carcass removal took three days.

Bat mortality estimations

Fall-to-summer bat mortality was evaluated as a function of elevation, aspect, percent edge, and FAA lighting variables; however, lighting was highly correlated with cap-rock edge. During the bat migration period, the model looked at cap-rock edge and FAA lighting – but again, because these two variables are highly correlated, lighting was not included.

Low mortality turbines were characterized by higher elevation (above 865 m), southeast aspect, and less than 34% cap-rock edge. Mortality was higher at lower elevations (under 853 m),

south-southwest aspect, and turbine site boundary characterized by greater than 38% cap-rock edge.

Bat mortality was estimated both for the “season of occupancy” (37 individuals/MW/52 weeks) and for the migration period (2 individuals/MW/6 weeks). Though the finding was not statistically significant, the East mesa did have the highest proportion of high and moderate mortality turbines, and overall mortality rate for bats as well as for birds.

Discussion and Conclusions

Species composition (avian and bat)

The avian species composition of fatalities at Red Canyon were unexpected. We saw a lot of turkey vultures at the site, and found a lot of turkey vulture fatalities. Similar species composition has been seen in Spain, but was not expected at Red Canyon.

Bat species composition also was unexpected. Brazilian free-tailed bats are not commonly reported in other monitoring efforts. This species is important as major pest managers for South Texas cotton crops. We also found hoary bats in an area where they were not expected to be.

Temporal and spatial distribution of fatalities

Temporal distribution coincided with periods of high activity and migration for both birds and bats. Spatial distribution of fatalities coincided with the east mesa, where a higher number of turbines are bounded by cap-rock edge, but the difference was not at a statistically significant level.

The following turbine geophysical characteristics are thought to influence bat mortality.

- Gradient in elevation within the wind energy center (not definitive)
- Wind direction (wind generally originates from the southwest-west)
- Cap-rock escarpment provides bat roost sites. (Not much is known about bats in Texas panhandle.)

We cannot control for temporal variation in population levels, migration timing, and roost sites. This analysis is limited by the available data; we would need more data to improve the accuracy of estimation. Bias correction factors disproportionately influence estimation of bat mortality; more data and better methods for calculating correction factors would improve the accuracy of the estimates.

The final presentation slide (#42) shows how mortality estimates for Red Canyon (52 weeks fall through summer, and during 6-week bat migration season) compare with the national average. For birds, the per MW mortality estimate is low: 0.5 v. 3.1 per MW national average. For bats, mortality appears much higher: 37 per MW for the full year and 2 per MW during migration season, compared with the national average of 2.1 bat fatalities per MW. (Note that the

national average is not directly comparable to the Red Canyon data, as it is based on a compilation of studies conducted under differing protocols.)

Questions following Presentation

Question: Can you give a brief description of the geological formation of the cap-rock – were there a lot of openings?

Response: The escarpment has a palisade structure – it looks like the prairie just stops, creating an edge. In some places you find crevices, in others it is just a sheer rock wall.

Question: What was the source of carcasses for searcher efficiency and scavenging trials?

Response: Carcasses came from a local wildlife rehab center. We used only local animals, and not animals that had been very ill. Only fresh carcasses were used.

Question: You found a lower estimated fatality for migration season v. previous year?

Response: Observer efficiency increased, but the number of carcasses found decreased. It may be a function of having used different methods just the two different time periods.

Question: There was another survey in Oklahoma that reported high Brazilian bat fatality rate. How did your findings compare?

Response: Perkowski's thesis (2006) – found higher a number of bat carcasses, but Perkowski used published persistence and searcher efficiency numbers, so one can't compare those results with ours.

Question: Bats are colonial animals – we see huge numbers coming out from caves – with available information, could make rough counts of *Tadarida* in the air?

Response: There was one colony, but its exact location was never defined.

Question: You saw bobwhite carcasses and attributed the fatalities to other than wind. But at Big Horn there was higher than expected mortality of game birds. How can you be sure the fatalities were not caused by turbines?

Response: Some bobwhite carcasses clearly had birdshot or other evidence of hunting – e.g., some of the bobwhite and roadrunner carcasses were consistently found in predator cache locations.

Question: How do you account for the high turkey vulture numbers? Are turkey vultures spending more time in the area due to carcasses?

Response: There were no pre-construction studies done here, so cannot say for sure. We did notice two turkey vulture nests next to a turbine. That may be an explanation. There are updrafts, and we saw a lot of turkey vultures exhibiting kiting behavior.

Question: Acoustic monitoring – were you able to detect species other than those you found carcasses for?

Response: We did two types of monitoring. One just gave us clicks. Tetra Tech also attempted to identify species, but they have not completed their analysis yet.

Question: So you don't know if activity correlated with mortality?

Response: Not yet.

Literature Cited:

Hulbert, S. 1984. Pseudoreplication and the design of ecological field experiments, Ecological Monog. 54. pp. 187–211.

Development of predictive models for estimating numbers of bird fatalities resulting from collisions with met towers and wind turbines at wind energy developments

Jonathan Plissner, ABR, Inc.

There is a need for models that allow us to estimate bird fatalities at wind energy facilities. Why are we interested in this question? Birds will be moving through the airspace wherever turbines are present. Although this may be more or less of an issue in different places, the fact is that birds take advantage of wind conditions that are favorable for wind power generation and are therefore present in the same areas considered for wind energy developments. The question is, therefore, to what degree should we be concerned about the potential for avian fatality impacts at a given site?

Which species of birds are at greatest risk of collision with wind turbines? Examples include raptors; such as the red-tailed hawk, which is the most widespread large raptor that shows up in fatality monitoring studies. Horned larks are also very widespread, and their abundance in areas with wind resource as well as their flight characteristics (both during migration and during breeding season, when flight display behavior puts them in the turbine risk zone) make them potentially vulnerable. Sandhill cranes are species of concern in certain areas of the United States. These big, visible birds are considered a game bird in many areas, and often fly with endangered whooping cranes. Waterfowl, while numerous, do not typically show up in large numbers as turbine fatalities. They tend to migrate at higher altitudes than many other species. Passerines that migrate at night, on the other hand, tend to be vulnerable.

Specific threatened and endangered species may be critical for specific projects. Examples include:

- *Newell's shearwaters* and *Hawaiian petrels* – both are seabirds that nest in colonies in the highland areas of the Hawaiian islands;
- *Marbled murrelets* – these seabirds nest 50 m above ground level in old-growth timber areas in the Pacific Northwest.

Estimating fatality rates

Pre-construction studies look at numbers (and types) of birds present at a site. Post-construction studies look at the numbers (and types) of birds killed. The challenge is trying to connect these two. The goal is to develop a predictive model that wind energy developers (and permitting agencies) can use.

Slide #11 shows a diagram that illustrates the steps toward estimating fatality rates. The first step is to calculate an **exposure rate or index** (EI) of birds per year exposed to turbine structures and other associated structures (e.g., transmission lines, met towers). The exposure rate (birds exposed per year) is a function of *movement rates* (number of birds per year) and

the *probability of interaction*. The EI, combined with the *probability of fatality if interacting* and the *probability of avoiding interaction* yields the **fatality estimate** (birds/year).

Measuring bird movement rates

Although many methodologies may be appropriate for monitoring bird movements, here I will just present the example of mobile radar protocols that we use to determine nocturnal movement rates. In surveillance mode, radar can help us estimate the total number of birds moving, and the direction of movements. (Note that insect contamination can be a problem and should be addressed appropriately for any radar study.) In vertical mode, radar gives us information about the flight altitudes of targets and can be used to determine the proportion of targets at altitudes within the turbine rotor swept area.

For migration studies, in which individual species cannot be differentiated and detectability of smaller individuals varies with distance from the radar, we derive an index that can be compared with mortality data. For larger species, detectability is assumed to be high, and precise estimates of movement rates can be determined. Hourly passage rates are multiplied by the number of hours per day birds are moving and by the number of days of movement per year (and/or season) to yield a **yearly movement rate**.

Interaction probability

Altitude information obtained using radar in vertical mode tell us the probability that birds are flying at or below the maximal turbine height. This provides us with the vertical component of interaction probability. For birds flying low enough to encounter a turbine or met tower, the horizontal component of interaction probability is a function of the cross-sectional area of the structure. For turbines, this area depends on whether a bird is approaching the turbine head-on or perpendicular to the orientation of the turbine. Slide #18 illustrates the difference between the maximal cross section (turbine oriented along axis of primary flight direction) and the minimal cross section (turbine oriented perpendicular to the primary flight direction – i.e., the side view). Met towers supported by guy-wires present a triangular cross section from any direction.

Probability of encounter resulting in fatality

Not all birds passing through the rotor-swept area (RSA) experience collision. Species-specific characteristics are important in determining how vulnerable they might be. Flight speed, rotor speed, the length of the bird, and the dimensions of the blade all factor into the probability of an encounter resulting in fatality. The probability of a fatal encounter with rotating turbines can be calculated as the proportion of the RSA that is actually occupied by rotor blades during the time it takes for a bird to pass through the RSA.

Probability of avoidance

The other factor used to compute a fatality rate is the avoidance rate: what proportion of birds will avoid collision by altering their flight paths? This is largely unknown, but birds generally are good at avoiding collisions with structures (> 50% for most birds under most conditions).

Estimates are usually presented for a range of avoidance probabilities, from 0% to 95%.

Application of the model

We applied the model to Hawaiian petrels, Newell's shearwaters, and marbled murrelets, all of which are fast flyers and relatively easy to detect using radar. The Hawaiian birds fly to and from inland colonies at night, exhibiting both seasonal variations in activity and within-night patterns of movement. Murrelets also fly to and from inland nest sites, with most of this activity taking place within about two hours of sunrise.

Slides #29-31 develop a hypothetical example of the model as applied to murrelets to produce hypothetical exposure and fatality rates. Beginning with a mean daily passage rate of 1 murrelet per day, with 75% of murrelets passing below the maximum height of the turbine blades, a range of exposure rates is calculated based on a minimum horizontal interaction probability rate of 0.002 and a maximum horizontal probability of 0.0175. In this example, the hypothetical exposure rate for murrelets ranges from 0.24 to 0.26 murrelets per turbine per year if the probability of avoiding collision is zero.

The actual number of murrelet fatalities is probably much lower, given murrelets' demonstrated ability to fly through forested areas in all kinds of weather conditions and avoid collision with trees. If 50% of murrelets exhibit collision avoidance behavior, the fatality rate would drop to 0.12-0.13 murrelets per turbine per year. At 95% avoidance probability, the fatality rate drops by an order of magnitude to 0.012 to 0.013 birds per turbine per year.

Several factors that may modify the basic model include turbulence (the "prop wash" effect), lighting effects, variable rotor speeds, spatial (micro-siting) variation, weather, and yearly variation in numbers of birds present. In using the predictive model, it is necessary to make some assumptions about the magnitude and direction of these factors.

Predictive models provide an assessment tool that can be used for permitting decisions and may suggest mitigation opportunities. The model can also contribute to micro-siting decisions and evaluation of the impacts of alternative turbine models.

Next steps

As with any model, the predictive value is only as good as the data that go into it. We need to learn more about avoidance behavior, for example, in order to make accurate predictions about fatality using this or other models. This would require conducting behavioral studies using night-vision optics or other visual techniques to determine the proportion of birds that detect and avoid turbines under various weather conditions.

The next step is to test the predictions of models. This requires collecting concurrent radar, night-vision, and fatality data to determine the percentage of low-altitude migrants that collide with turbines. The more we can do to connect what we see before turbines go up with what happens after they go up – the better we can make predictions, and the better siting decisions

we can make.

Questions following Presentation

Question: How well can you tell birds and bats apart with nocturnal radar studies? When using night vision, did you see both bats and birds?

Response: You have to use night vision to make that distinction. Yes, we did see both bats and birds.

Question: If you were able to count fatalities and found a discrepancy, where in your model would you look to account for that discrepancy?

Response: Avoidance behavior. We have looked at this for petrels in Hawaii.

Question: What if fatalities discovered were higher than estimated?

Response: We would look at estimates of flight altitudes. For some species, it is hard to come up with good altitude data.

Question: Given the goals for renewable power standards, can you extrapolate from this type of model to look at cumulative impacts for multiple species if we were to implement these renewables goals?

Response: It would be difficult to do that. It's going to take some time to get enough correlations between what we observe with these individual indices and mortality rates to be able to extrapolate to cumulative impacts on a large scale.

Estimating survey effort required for precise estimates of bat activity at a wind energy facility in Southern California

Ted Weller, U.S. Forest Service¹

Bats are vulnerable when migrating, but we do not have good state-level information about the timing and location of migration events in California or elsewhere. California encompasses a huge diversity of landscapes and climates, and there is huge variation in bat activity from night to night and from site to site. Using continuous echolocation monitoring (microphones mounted high on met towers) helps us obtain the kind of data we need – the question becomes, what level of survey effort is required to get precise estimates of bat activity at a site.

Site selection criteria

We sought to select a research site that met the following criteria:

- high probability of a wind project being built on the site so we could compare pre-construction activity rates to post-construction fatality rates;
- developer that would provide site access and facilitate attachment of echolocation equipment high on multiple meteorological (met) towers, and share met data in a timely way.
- meet short time frame required for use of state funds; and,
- matching funds from developer.

The site selected was the Dillon Wind project (Iberdrola, developer) in Southern California's San Geronio Pass wind resource area. Drawbacks included that it was far along in development process and on outskirts of a highly developed wind area.

Objectives

The project had four defined research objectives.

- 1) Describe year-round patterns of bat activity in San Geronio WRA.
- 2) Select models to explain bat activity based on meteorological variables.
- 3) Estimate amount of survey effort required for precise estimates of bat activity.
- 4) Contribute to the evaluation of echolocation detectors as a risk assessment tool.

Tools

ANABAT echolocation detectors were attached at 2, 22, and 52m on met towers. These were supplemented by detectors mounted at 2 and 22 m on temporary towers. Slide #9 shows the configuration of towers at the Dillon Wind site.

Study design

Monitoring began in the late fall (pre-construction) and continued through winter and spring to the following summer. The facility began operations in March 2008. We sampled a total of 50

¹ USFS Pacific Southwest Research Station, Arcata, California

nights in the late fall, and 77 nights in each of the following seasons (winter, spring, summer), for a total of 281 nights of monitoring (through July 31, 2008), or 4,197 detector nights. Although we lost all but one of the 22 m towers over the course of the project, we still had pretty good coverage.

We categorized echolocation recordings passes as high frequency (>35.1 kHz) or low frequency (<35.1 kHz) bat passes. High frequency calls generally represented smaller, mostly non-migrating bats – mostly Western Pipistrelle – also Myotis bats echolocating at 50 and 40 kHz. Low frequency passes were comprised of calls from larger, mostly migratory species – mostly Mexican Free-tail bats, but also Hoary bats (and Big Brown bats). We also detected a number of very low-frequency free-tailed bats, such as Pocketed Free-tail and Western Mastiff bats. Very little is known about these bats; they may be important in the Southwestern corner of the U.S. Slide #11 include examples of typical echolocation files, which must be filtered to separate low-frequency extraneous noise from low frequency bat noise of these free-tailed bats.

Echolocation and meteorological data were collected between late afternoon (16:00) and 7:30 in the morning. Meteorological data was summarized from values measured at 30 m on four met towers. Bat data was associated with the nearest met tower. The following meteorological variables were measured:

- mean wind speed (m/s)
- maximum wind speed (m/s)
- minimum wind speed (m/s)
- mean temperature (°C)
- proportion of measures > 6 m/s
- wind direction (sin/cos)

Model-building

Our independent variables were the met data, height of the sensors, and date. The dependent variable was the number of high and low at passes per detector. We did eight modeling exercises: two species groups by four seasons, 197 models each. We performed Maximum Likelihood Estimation using Generalized Linear Models (GLMMIX in SAS), resulting in estimates of low and high frequency activity by height and season.

Summary of Results

A total of 1,315 bat passes were recorded, or 0.31 bat passes per detector per night. This is not a lot of activity. The highest level of activity recorded in a single night was 76 passes on April 12, 2008. The most passes recorded by a single detector was 15 passes at 52 m on March 3, 2008. The highest mean wind speed recorded with a bat pass occurring was 19.2 m/s, but 76% of bat activity occurred at wind speeds under 6 m/s.

Seasonal activity was highly variable, as expected. We also looked at how altitude of activity varied seasonally, for both high and low-frequency bats. High frequency bats were detected at

lower heights (check slide), while low-frequency bats were more often detected at greater heights. High frequency bats are active around sunset, while low frequency bats were active throughout the night – especially 2-7 hours after sunset.

We looked at the seasonal variation of wind speeds and correlation of wind speed and nights when bats were or were not detected [Slide #22]. We also looked at how temperature and wind speed affected bat activity in different seasons.

Modeling bat activity patterns

The study began in late fall, as the fall migratory period was tailing off. There was very little (almost no) activity during the winter, especially for high frequency bats. The highest period of echolocation activity occurred during spring, though the mean activity rate was still very low (0.58 low freq.passes/det/night). Highest bat activity was correlated with the lowest mean wind speeds. Echolocation activity was low during the early part of summer; after mid-July, bat activity picked up again, a pattern that was more pronounced marked for low-frequency bats.

Slide #30, showing highly correlated variables, points to wind speed being the key meteorological variable in bat activity.

Estimating survey effort

We did not see much variability from one tower to another. This is attributed to the fact that the Dillon Wind site is characterized by little to no topographical relief or habitat variation.

Precision

Slides #33-34 show how precision increases with the number of towers used to collect data on bat passes. A 95% confidence interval ($x = 0.500$) is achieved at about four to five towers – beyond this optimal point, marginal increases in precision may not be worth adding detectors on another tower – at this site and during this time period.

Lessons learned

This study adds another datapoint in another habitat that can be added to those conducted in the upper Midwest and Northeast to improve understanding of the ability to link measured activity with estimates of fatalities. This study confirmed results from other studies, notably that lower frequency bats are detected at greater heights above ground, and that bat activity is higher when wind speeds are lower.

In addition to confirming these findings, we learned that there was relatively low bat activity at the Dillon Wind site, that presumed migratory activity was observed during spring, and that there was little activity between November 15 and February 28. (The caveat being that this is a one-year study at a single site.)

In terms of the question of level of survey effort needed, we found that we could get precise estimates with detectors mounted on 4-5 towers. (Again, the caveat results apply to a single

site in this WRA that was homogenous in terms of landscape and habitat.)

Next steps

We will continue echolocation monitoring at the Dillon site through Mar 2009, linking echolocation and fatality data from Mar 2008 – Mar 2009.

Future goals include trying to replicate this project at additional sites and habitats in California. Our goal is to be able to combine data sets to provide quantitative guidance on the level of survey effort required (and its variability).

Questions following Presentation

Question: You looked at variation in bat activity from tower to tower – what about variation of temperature and wind speed from one tower to another?

Response: There was not much variation in temperature and wind speed from tower to tower. Meteorological variation is much greater from night to night than from tower to tower on the same night.

Question: Congratulations on your rigor in talking about activity and detections. I'm also interested in numbers of bats. Do you have any idea whether you are seeing the same bat at different towers?

Response: We don't know if we're picking up more than one bat or the same bat in different places. Given so few detections, we should be able to determine if nightly detections were temporally correlated to gain some insight into this question.

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Spatial patterns of nocturnal bird migration in the Central Appalachians

Deanna Dawson, *U.S. Geological Survey*¹

The purpose of this study was to increase our general understanding of the spatio-temporal distribution and flight characteristics of nocturnal songbird migrants in the Appalachian region of Maryland, West Virginia and Virginia. Our first goal was to identify where or when migrants might be at risk from wind power development, and to use this knowledge to inform siting and operational guidelines as well as to assess potential risk to migrating populations. Our second goal was to identify important migration pathways for conservation actions.

Specific objectives of the study were to:

- document broad-scale migration patterns;
- document site-specific passage rates, flight directions, and altitudes;
- obtain information on identify and relative abundance of bird species that call while migrating;
- model effects of location, topography, weather, etc. on migrant abundance and flight characteristics.

The study was multi-faceted, but this presentation focuses on the use of sound recording to produce site-specific indexes of the abundance of migrating birds that call while in flight, and to measure the relative abundance of species or species groups.

Methods

We used commercial components: two microphones with built-in pre-amps, powered by a 12V battery, and an MP3 recorder with a 100 GB hard drive, powered by 6V batteries. We built housings for these components so they could be set in the field for extended periods of time and were portable. The recording units were relatively inexpensive (< \$500). They were well suited for use in forested or remote locations, and allowed us to economically sample across a wide geographic area. The microphones can record flight calls up to 300 m above ground level (agl), so detect the low-flying migrants that are of interest in regard to wind power development. The limitation of the technique is that not all migrating birds call in flight, or call at all times. Also, it generated a huge volume of recordings that take considerable time to manage and process in order to extract the flight call data.

To sample migrant passage, we recorded continuously at 30 sites during Fall (mid-August to early November) of 2005-2007 and again during the Spring (April-May) of 2006 and 2007. These sites were not at proposed or developed wind sites, but on public or Nature Conservancy lands – most on ridge-tops, with a few in valley locations. We also sampled eight additional sites –

¹ Co-authors: Tim Jones, USFWS; David Mizrahi, New Jersey Audubon Society; Michael Lanzone, Powdermill Nature Reserve; JoAnna Leachman, Frostburg State University

five in western Maryland and three in southwest Pennsylvania – these data are not included in this presentation, but will eventually be analyzed with the data we are presenting today.

Sound recording was paired with portable radar sampling at three sites during 2006. Radar samples a larger volume of airspace – out to 1.85 km and up to 1,400 m above radar level (ARL) – and detects “all” targets, including bats. However, the radar equipment requires larger clearings, with better road access, for successful operation than does sound recording, which limits (along with cost) the sites that can be sampled by radar. In both spring and fall, about 30% of the targets detected by the radar were flying at less than 200 m ARL, so could also be sampled acoustically.

Data analysis

To analyze the sound files, we used XBAT (Extensible BioAcoustics Tool), software developed by Harold Figueroa at the Cornell Lab of Ornithology, to scan the recordings in search of flight calls. XBAT allows the user to specify the range of frequencies, duration of sounds, and other parameters to focus the search. We conducted two scans of each recording, one set to detect short, high-frequency calls (warblers and sparrows), and the other to detect, longer lower-frequency calls (thrushes, tanagers, grosbeaks).

Often there are other sounds recorded with the same frequencies and duration as flight calls (e.g., raindrops, the wind in vegetation, insects, spring peepers), so it is necessary to review detections (by viewing the spectrograms, the digital representation of the sounds) to filter out non-bird sounds. We then tallied calls for each site-night, and clipped and exported the calls for later identification to species (accomplished by comparing the call spectrograms to a reference set). This is difficult to do, both because many species have similar calls and because many calls, especially those at the outer limits of a microphone’s range, are not clearly recorded.

Data from 2006 show that, at all sites, flight calls were scattered throughout the night-time hours, not just at dusk and dawn, indicating that we were sampling migration ‘traffic’, not just the calls of migrants emerging from or settling back into day-time stopover sites. Preliminary analysis of the data shows there is much variability from night to night in migrant abundance through each season, but some patterns do emerge. For example, in 2006, spring migration was later than expected for thrushes, with the peak nights occurring in the last days of May. It will be interesting to see if that holds true in the Spring 2007 data, which have not yet been analyzed. Generally, there was agreement among sites on the nightly levels of migration, with the dates of high and low migrant abundance similar among sites.

We will be working to compare acoustic and radar data. In a preliminary comparison of patterns, there is not a strong agreement between the two data sets for spring, though we do see a somewhat better agreement for fall. However, this is based on acoustic data from all sites, not just the three with radar data, so a more detailed analysis is required.

More calls were recorded in some places than in others. To verify that these results are real, we

are checking that differences are not due to differences in the nights recorded (at all sites, occasional nights were missed because of equipment problems) or in microphone sensitivity. We are examining several descriptors of the topography at and surrounding the recording sites to identify which correlate most strongly with the flight call counts [Slide #25]. When all recordings are processed, we also will examine how temporal factors (i.e., time of night or season, weather conditions) affect the abundance of migrating birds. The final outcome will be a model that predicts where and when migrating birds are likely to be abundant in the lower airspace. The results also will provide context for interpreting results of pre-construction surveys of migrating birds over proposed wind power development sites in the region.

More detailed analysis and final results will be available in Fall 2009.

Estimators of wildlife fatality: a critical examination of methods

Manuela Huso, *Oregon State University*

When we seek to estimate mortality rates at wind energy facilities, we are trying to understand the impact of the wind turbines on populations of animals – particularly rare or endangered populations. We may want to explore and understand how pre-construction activity at a site is related to post-construction mortality. We may want to compare sites or to compare mortality rates under various conditions (e.g. nightly activity, wind speed, temperature, and other environmental conditions). Or we may want to evaluate the efficacy of curtailment, deterrents, and other mitigation strategies. To do any of these, we need to first start with an unbiased estimate of mortality.

In this presentation, I will start by developing a conceptual model of mortality. I will consider the current protocol for estimating mortality and review the estimators and why and how they are used. I will then propose a new estimator, and compare the accuracy and precision of three different estimators of bird and bat fatality, examining the influence of searcher efficiency, average carcass persistence and search interval on these.

Conceptual model of mortality

The mortality rate is a measure of deaths – in this case turbine-related deaths – of some population, scaled to the size of that population, per unit time. We can divide a timeline into any sized intervals of time, and count the dead animals we find at a particular turbine during each of the intervals, but this does not give us total mortality. We need to use estimators because we know that some fatalities won't be found. The two main sources of bias – that is, reasons that dead animals won't be found – are scavenging (some carcasses will be scavenged by other animals before an observer looks for them) and searcher limitations (some carcasses simply will not be detected).

Use of estimators

If the total number of carcasses we find on the site is not how many actually died, the question becomes, “How do we use how many we counted to figure out how many were killed?” If 20 animals die during an interval, but only 75% are unscavenged by the time someone goes to count them, then the most carcasses a searcher could find would be 15. If the searcher's “efficiency rate” is about 33%, however, we could expect that the fatality count would only be 5. If we know the scavenging rate and the searcher efficiency rate for the search interval and conditions under which we are searching, we can work our way back from the count (5) to the actual number of fatalities that occurred (20) during the interval.

The conceptual model looks like this:

$$m_{ij} r_{ij} p_{ij} = c_{ij}$$

where m_{ij} is the actual number of dead animals at turbine i during interval j and c_{ij} is the number of carcasses counted at turbine i at the end of interval j , r_{ij} is the proportion of animals that died in the interval that remain unscavenged (i.e., observable) and p_{ij} is the detectable proportion (i.e., proportion of animals that died in the interval, remain unscavenged, AND are actually observed). Given c_{ij} , r_{ij} , and p_{ij} , we can estimate m_{ij} as $c_{ij} / (r_{ij} p_{ij})$. Both c and r are a function of how much time has passed since the fatality occurred, and so are going to be affected by the length of the search interval. The proportion of carcasses detectable (p) does not depend (very much) on how much time has passed since death.

There are many estimators of fatality that appear in the various fatality monitoring reports of studies carried out at wind power facilities. I will focus here on two of the more commonly used estimators and relate them to the conceptual model, then ask:

- How were they derived?
- Are they unbiased?
- How precise are they?
- Can we improve them?

What makes a good estimator

A good estimator needs to be both unbiased (accurate) and precise (useful). Slides #12-13 illustrate the point with a target diagram, in which the center of the target represents an accurate measure of mortality. In the first slide, bullets clustered near the outer ring of the target are precise (they are closely clustered), but they are inaccurate or *biased*, not on target. Bullets scattered around the center of the target are accurate – on average they yield the correct value – but they are not precise. The second example shows scattered bullets that are neither accurate nor precise, as well as a cluster of bullets in the center that have the qualities of a good estimator: accuracy *and* precision.

An unbiased (accurate) estimator is important because you want your estimate to be right, and also because you want to be able to compare estimates across studies. (If your estimator exhibits a constant bias, you wouldn't get an accurate estimate, but you could still make comparisons. If your estimator exhibits a non-constant bias, however, you have a big problem because you will neither have accurate estimates nor will you have accurate comparisons.) Precision is important because it makes the estimate more useful.

In addition, if there are no unknowns and you sample the entire population, a good estimator should equal what you measured. In this situation, if there are no scavengers and searchers detect every carcass, i.e. they are 100% efficient, then what is counted on the searches will equal the actual fatality, so our estimator should simply use what we count as the best estimate of fatality.

Review of currently used estimators

Slide #16 shows the first estimator that is currently used to generate mortality rates. It first appeared in about 2000, and while it has been replaced in many studies by the second estimator, it is still in active use. In addition to the m_{ij} , c_{ij} , and p_{ij} (proportion of carcasses likely to be observable at the i^{th} turbine in the j^{th} interval) that appear in the conceptual model, this estimator uses the ratio of t/l , the average number of days a carcass will persist unscavenged, to l_{ij} , the length (number of days) of the j^{th} interval at the i^{th} turbine, in place of r_{ij} , the proportion of animals that died in the interval and remain unscavenged. However, t/l is not a proportion and does not represent r . In fact, t/l can be quite a large number if the carcass persistence time is long and the search interval is short. The effect of dividing c by a large number would be to reduce our estimate of mortality to below what we counted! If we assume for a moment that all carcasses are observed, and that t is a much larger number than l (as when there are no scavengers), then $t/l > 1$ and $m_{ij} < c_{ij}$ – in other words, we would estimate that fewer animals had died than the number we actually counted. This violates one of the properties of a good estimator, that when there are no unknowns, it returns what was measured.

The second estimator [Slide #18] is a modified version of the first estimator, and so suffers from its inherent flaws, as well. Consider what we would estimate in the case where searchers observe very few of the observable fatalities. As searcher efficiency, p , becomes smaller, rather than compensating for it, the estimate of m approaches that of the previous estimator.

I propose a different estimator that satisfies the properties of a good estimator outlined above. The proposed estimator looks like this:

$$\hat{m}_{ij} = \frac{c_{ij}}{\hat{r}_{ij} \hat{p}_{ij} \hat{e}_{ij}}$$

where e -hat is the estimated “effective interval,” a function of the search interval and average persistence time, t . If the average persistence time is short (say, 2 days), then any carcass killed will almost certainly be removed by 9 days. Nine days is the amount of time it takes for 99% of the carcasses to be removed, if their average persistence time is 2 days. If the average search interval l is long (say, 27 days), then whatever is found almost certainly died within the last 9 days, so our count doesn’t represent the fatality of the full 27 day interval, but only about 1/3 of it. The ‘effective interval’ then is the ratio of the amount of time it takes for 99% of the carcasses to be removed to the actual interval, or 1, whichever is less. In this example it is $9/27=0.33$. If the search interval is short enough or the persistence time long enough that less than 99% of the carcasses will be removed before the end of the interval, then the ‘effective’ interval is 1. The effective interval changes depending on the average carcass persistence time and the actual search interval.

The proposed estimator has three proportions (each <1) in the denominator. If there are no

uncertainties, i.e. if searchers see everything, then p_{ij} will be 1; if there is no scavenging, then r_{ij} will be 1; and if there is no scavenging, the effective interval e_{ij} will be 1 and the estimate of mortality will be what we count, satisfying one of the properties of a good estimator. With this estimator, precision will be based on how well we estimate p and r .

Comparing estimators

In evaluating and comparing estimators, we want to know:

- 1) Whether these estimators of mortality are accurate under realistic conditions
- 2) What search interval is optimal to achieve acceptable precision
- 3) What trial sample size is necessary for precise and accurate estimation of searcher efficiency and carcass persistence.

Simulation is an ideal way to compare estimators. By simulating fatality at turbines, we know what the 'true' fatality is and we can see which estimator does the best job in estimating the 'true' fatality under a variety of conditions. But it is not enough to simulate fatality. We also need to simulate the carcass removal process, the searcher efficiency process and the search interval itself that lead to the fatality count data that are collected in the field. Once the count data are simulated, then the estimators can be applied to the counts and bias and precision of the estimators evaluated under varying conditions of average carcass persistence times, searcher efficiency and search interval.

Count simulation

I started with real activity data from Pennsylvania, preserving the temporal correlation and seasonal trend, and mimicking the erratic nature of activity and hence mortality. The number of dead animals was simulated by taking approximately 10% of activity recorded at each tower on each night (generated as a Beta(50, 450)).

For each simulated carcass, I then varied three factors:

- Average carcass persistence (7 levels: $t = 1, 2, 4, 8, 16, 32,$ and 64 days)
- Searcher efficiency (3 levels: $p = 20\%, 50\%,$ and 80%)
- Search interval (6 levels: $I = 1, 2, 4, 7, 14, 28$ days)

Thus for each "known" total number dead, I had 126 (7x3x6) different simulated *counts* of observed carcasses.

Searcher Efficiency and Carcass Persistence Trial Simulations

In parallel with the count simulation, I also simulated results from carcass persistence trials and searcher efficiency trials using 10, 25, 50 and 100 carcasses and the average searcher efficiencies and carcass persistence times above.

Simulation of mortality estimate

To each count, I applied the three estimators using *known* values of searcher efficiency, p , and

average carcass persistence time, t , to calculate estimated fatality. Because simulation allows us to *know* how many died, I was able to calculate PRB as:

$$PRB = \left(\frac{\hat{m} - m}{m} \right) * 100$$

This reflects how far off an estimate was in terms of percent of actual fatality. An estimator that is unbiased will have a PRB of 0. An estimator that underestimates fatality will have a PRB < 0 and one that overestimates fatality will have a PRB > 0.

In addition, I calculated the multiplying factor

$$\text{Multiplying Factor} = \left(\frac{1}{1 + PRB/100} \right) = \frac{m}{\hat{m}}$$

as the factor by which one would have to multiply an underestimate of fatality to reach the actual amount. I repeated this entire simulation process 1000 times and I compared average PRB of the three estimators to see which one does the best job estimating the known fatality. Note that the carcass count from which the estimates of fatality are calculated are always the same for the three estimators.

Results

Results for one SE level and daily search intervals are graphed [Slide #33] showing percent relative bias (PRB) on the Y axis, and average carcass persistence time on the X axis. PRB of each estimator is represented by a different colored line. When searches are conducted daily, and searcher efficiency is 50%, the proposed estimator has very little bias, regardless of average persistence time. The second estimator always underestimates fatality low and is strongly influenced by average persistence time, with its bias increasing as average persistence time increases. At persistence times of 64 days, the fatality estimates from this estimator would have to be doubled to reflect actual fatality. The first estimator also always under estimates fatality and is strongly affected by average persistence times. When average persistence time is 64 days, the fatality estimates from this first, naïve estimator would have to be multiplied by a factor of over 60 to reflect actual fatality!

The next sequence of graphs represents the same Y and X variable, but search interval is increased from 1, 2, 4, 7, 14, to 28 days, and the effect of the increase on PRB of the three estimators is apparent. As the search interval increases, the proposed estimator remains essentially unbiased until the interval exceeds 7 days, at which point estimates begin to become slightly biased low at long carcass persistence times. As search interval increases, the other estimators remain biased low when carcass persistence times are long. When carcass persistence times are short and search intervals are long, however, they exhibit much less bias and their estimates coincide with those of the proposed estimator.

Effect of searcher efficiency and carcass persistence on estimator precision

Going back to the formulation of any of the estimators, it is apparent that anything that reduces the precision with which p and r are estimated will reduce the precision of the estimates of fatality. As I did in the earlier simulations, I applied the three estimators to each count, this time using estimated values of p and r based on varying numbers of carcasses used in searcher efficiency and carcass persistence trials. I found that 50 or even 100 carcasses are needed to get a good estimate of searcher efficiency. Likewise, one needs a comparable number of trial carcasses to get a good estimate of carcass removal.

The expansion factor associated with SE is of course, a function of the SE itself, but its precision is determined by the trial size. Slides #37-38 show how the expansion factors for searcher efficiency and carcass removal affect confidence intervals at different trial sizes. Of course the cost of effort required to obtain accurate and precise estimates of p and r and to search plots frequently must be balanced against the need for accuracy and precision in the estimates.

We can address this balance by understanding what we can and cannot control? The search interval (I) can be selected in the design of the monitoring study. Searcher efficiency (p) cannot be controlled, but it can be improved – through training, vegetation control, selection of sites – and the precision in estimate can be increased through selection of sites (reduced heterogeneity) and approaches used for searcher efficiency trials (i.e. trial size). Likewise, carcass efficiency (r) cannot be controlled, but precision in estimate can be increased by approaches used for estimating scavenging rate (i.e. trial size).

Summary

Two contributions of the proposed estimator are:

- 1) A distributional assumption of carcass persistence allows estimate of proportion remaining, r , for any interval.
- 2) The definition of “effective interval” allows for correction when the search interval is much greater than the average persistence time, t .

Commonly used estimators can be highly biased under realistic conditions, and their bias differs with carcass persistence and search interval as well as searcher efficiency, making direct comparison across sites with different conditions meaningless. Although none of the estimators is unbiased under all realistic conditions, we can control bias by designing shorter search intervals. We can also control the variability of estimates by estimating r and p by using large trial sample sizes.

Practical recommendations:

- Use an unbiased estimator to allow comparability across sites and even turbines
- Use shorter search intervals (maximum of 7-10 days)
- Use adequate sample sizes in searcher efficiency and carcass persistence trials (at least 50 carcasses per factor)
- Bootstrap variance based on resampling carcass persistence and searcher efficiency

trials *only if the trial sample size is adequate.*

Next steps

I am looking at refining the estimator, deriving the variance of the estimator (with Dave Birkes), develop more efficient models of p and r using covariates, and developing software for estimator and bootstrapped confidence intervals (this will be made publicly available). I am also doing further research into fatality study design, specifically the trade-offs between the number of turbines v. the optimal search interval.

Questions following Presentation

Question: The estimate under simulations gave fewer animals killed than actual – were individuals counted every day? (Could the same animal have been counted more than once?)

Response: Actual reports (in the actual literature) give fewer animals than were actually counted, this is not just a simulation result. The probability that an animal would be seen was a function of the animal – if you had a chance of seeing it. Animals were counted only once.

**SESSION III:
CUMULATIVE IMPACTS AND IMPACTS TO
WILDLIFE HABITAT AND BEHAVIOR**

Influence of ridge-top habitat manipulations on bat activity and species composition at a proposed wind facility in South-Central Pennsylvania

Michael R. Schirmacher, *Bat Conservation International*

Can indices of bat activity gathered at a site pre-construction be used to predict post-construction bat fatalities? This was the subject of our primary study initiated in 2005. A secondary study at the same proposed wind facility sought to determine the influence of habitat manipulations on bat activity and species composition. Specific objectives were to assess the predictability of fatalities and to define protocols for pre-construction acoustic surveys of bat activity.

The secondary study focused specifically on the question of whether timber harvesting along the ridge top would have a positive or negative impact on bats. Harvesting timber reduces roost trees, but small openings and thinned stands create edge habitat which is beneficial. Edge habitat increases activity: increasing insect levels, reducing clutter, providing navigational landmarks and enabling bats to stay in acoustic contact. It also creates protection from predators and from wind.

Study Design

The study site consisted of 23 wind turbines located in Somerset County, Pennsylvania on two ridges (15 turbines on the west ridge, and 8 turbines on the east ridge). We established a Cut “treatment” site (n=9) and used uncut sites (n=4) as the control area.

Habitat manipulation

The timber was harvested April to June 2007, with the cuts constituting approximately 2.0 hectares and a road 20 m wide. An area dug to build a turbine foundation left a depression that sometimes filled with water.

Acoustic monitoring

Bat activity was surveyed from the beginning of August through the end of October in each of three years (2005-2007), for 30 minutes before sunset and another 30 minutes after sunrise.

Anabat II detectors were mounted at 1.5 and 22 m on portable towers, approximately 40 m west of the proposed turbine location.

Data and statistical analysis

All Anabat call files (a call was defined as two or more pulses) were processed and cleaned using customized filters. Using Discriminant Function Analysis we quantitatively identified search-phase calls to species and used multiple calls to establish species presence on a given night. Data were accumulated and analyzed for a total of 13 sites, including seven sites that were sampled all three years, and another six sites that were sampled only in 2006 and 2007.

An analysis of variance (ANOVA) test was used to analyze data using repeated measures (2005, 2006, 2007) and a split-plot design (two heights: 1.5 m and 22 m).

Results

Slides #9 and 10 show how activity varied from cut to uncut sites as measured at different heights among years: a significant activity increase was detected for the cut sites at 1.5 m microphone, but not at 22 m microphone.

Slides #11 and 12 show how average nightly activity and species richness varied between treatment and control sites. We saw more activity at treatment sites than at control sites, as well as greater species richness, particularly at 1.5 meters. Indeed, for some species, we saw no activity prior to treatment, with these species only detected after treatment. Northern Myotis was documented at a couple of sites prior to treatment. As was expected for this interior forest species, its activity decreased after timber harvest.

The presence of water (due to temporary ponds created as a result of ground preparation for the turbine pad) did correlated with a high level of calls, but did not explain all the activity increase as there were equally high levels of activity when water was not present.

The habitat manipulation clearly created an edge effect – activity levels were higher closer to the edge compared to sites further from the edge.

Site 23 was an anomaly – a street light had been installed, and both the level of activity and species richness went up significantly. (Bats are opportunistic predators; insects are attracted to the light and bats are attracted by the presence of the insects.)

Discussion

The lower microphone showed significant difference in bat activity after the cut, whereas the 22 m microphone did not which may suggest there was a shift from horizontal (canopy) to vertical edge (tree line).

Previous studies have shown bats utilizing leeward edge as a wind break during periods of high wind. Sites 7 & 8 (both leeward), had our highest levels of activity. Edge may be important on a

ridge top where wind levels are high; bats may utilize the edge as a wind break during periods of high wind but when the wind levels decrease bats can utilize the entire ridge-top area. This maybe supported by the slight increase in activity during the treatment year (2007) even at the control sites.

Multiple years of surveying and multiple detectors are needed to decrease variation. (Placement of detectors clearly matters and must be considered.)

When to survey

It is important to note that habitat manipulation does influence bat activity. If the acoustic survey had been done before the habitat had been manipulated, we would not have detected silver-haired bats, and would have detected only a few sites with eastern pipistrelle, red and hoary bats. After habitat manipulation, all species detected have since been found as fatalities, with multiple species being found at multiple sites, similar to the acoustic data.

Next steps

Post-construction fatality surveys are being done (April 2008 - Nov. 2009). We will attempt to correlate pre-construction activity with post-construction fatality, running correlations using 2005, 2006, and 2007 data independently to further evaluate the influence of manipulation predictions and future pre-construction survey protocols.

Question following Presentation

Question: Would street lights between (but away from) turbines deter bats?

Response: No.

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*Determining where, in eastern North America, there is the greatest potential for conflict
between Golden Eagles and wind power development*

presented by

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Tricia Miller
Pennsylvania State University and Carnegie Museum of Natural History

Wind energy development in Quebec, Canada currently consists of 450 turbines in operation, with 1,900 turbines planned to be operating by 2015. About 1,250 (65%) of these would be concentrated in the Gaspé Peninsula. The Gaspé constitutes part of the south shore of the Saint Lawrence River, extending into the Gulf of Saint Lawrence and separated from New Brunswick by the Baie des Chaleurs and the Restigouche River. Gaspé provides habitat for three listed species of raptors – bald and golden eagles, and peregrine falcons. It is the southeast limit of the breeding range for the golden eagle, of which there are 50-65 breeding pairs in Quebec, where they are designated a vulnerable species. (This is about the number being killed at Altamont Pass WRA every year.) Given their vulnerability, “one bird dead is one bird too many.”

Objective 1: reduce collision risk

Our objective is to reduce collision risk at wind farms planned in proximity to vulnerable species’ nests in the Gaspé peninsula. We are targeting nests of these species located within 20 km of planned wind farms to capture and equip birds with satellite transmitters. [Slide #5 shows the location of nests with buffer zones surrounding them.] Our approach is to track the animals to delineate their home ranges, so that we can see whether there is overlap with the wind farm perimeter.

Methods

In 2007-2008, we captured and marked 6 adult and 2 juvenile bald eagles, 5 adult and 2 juvenile golden eagles, and 2 adult peregrine falcons, using Argos/GPS solar transmitters. The transmitters give us the bird’s location and altitude (with 15 m precision) up to 15 times per day. We are using these data to delineate the birds’ home ranges.

Slides #8-10 show examples: Golden eagle #60 (known nest site) has a home range of 755 square km that includes several areas not contiguous with the area around the nesting site. Golden eagle #605 has moved from the southern to the northern coast of the peninsula at the end of August, possibly after nest failure. Golden eagle #62 offers a good example of why simply creating a 20-km radius buffer around the nesting area doesn’t give good protection, because its home range stretches to the south of nesting site.

At a Golden eagle nest which is the closest to a wind farm site (with construction planned for

2009), no nesting took place in 2008, so capture was not possible. It will be too late in 2009 to site turbines according to the home range of these birds, but we nonetheless plan to mark an adult in 2009 to examine its behavior before and after construction takes place.

Preliminary conclusions

Golden eagles have large home ranges compared to bald eagles, and this increases the chance of overlap with a wind facility. In situations of confirmed overlap, we will need to look more closely at data within the overlap zone, to see what mitigation possibilities there are. For example, we will examine the flight altitude data; if birds are flying over turbine height within the overlap zone, collision risk is reduced. We will also examine seasonal use; if the overlap zone is used only because of the presence of a seasonal food source, some manner of curtailment may serve to mitigate the risk. If not, we may need to exclude turbines completely from the overlap zone.

Objective 2: develop habitat model

We cannot mark every Golden eagle in the province whose nest will eventually be located near a wind facility. Our objective is to carry out a geographic information system (GIS) habitat analysis of home ranges from marked individuals, develop a habitat model, and then use that tool to delineate potential home ranges at other nest sites, based on habitats available around these nests.

Objective 3: identify potential conflicts during migration

In addition to delineating home ranges in the Gaspé Peninsula, we are also focusing on potential conflicts that may arise during eagle migration. To conserve energy when migrating, raptors use thermal lift, as well as updrafts caused by wind hitting a ridge and being deflected upward. Because ridges allow eagles and other migrants to conserve energy, migrants concentrate along the linear ridges of Pennsylvania.

During fall migration, golden eagles are spatially and temporally segregated by age class. Adults are more abundant along the western ridges, juveniles along eastern ridges. Spring migration is less segregated; golden eagles concentrate along the central and western ridges. Because these ridges are also being targeted for wind power facilities, there is a potential for negative wind-wildlife interactions. Behaviorally, eagles may be the most at risk species. Farmer (2006) found that 88% of eagles passing Hawk Mountain were within the strike zone of a 90 m turbine.

The migration study area encompasses the ridge and valley province of Pennsylvania. We are examining how weather and topography affect flight altitude and position relative to ridges so that we can identify the potential for collision risk at any point in the study area.

In addition to daily and seasonal activity, altitude, and age-class migratory patterns, we created a *sinuosity* index, which is a measure of how directly birds travel from wintering grounds to breeding grounds. The higher the sinuosity index, the greater the distance a bird is actually flying to get from point A to point B. We found that young birds have a higher sinuosity index

than adults, indicating that their potential for negative interaction may be greater. Eventually, this index will be one of the many variables used in a population level model.

Roost site habitability model

Negative effects of wind power development in Pennsylvania include, not only collision, but also indirect effects such as habitat loss. To examine the potential loss of migratory stopover habitat, we generated a roost site habitat suitability model and compared turbine sites with optimal, suitable, marginal and unsuitable roost habitat. Slide #24 compares turbine sites more and less likely to conflict, based on the roost habitat model.

We then compared 36 turbine sites within the study area to predicted habitat within 100 m and 500 m. 86% of proposed or existing turbine facilities are within 100m of suitable habitat and 59% are within 100m of optimal roosting habitat.

Direct habitat loss was measured within these same two buffers. Within a 500m buffer of a turbine facility, the mean area of suitable habitat is 254 ± 55 ha. The mean area of suitable habitat within 100m of a turbine facility is 22.9 ± 5.4 ha. These results suggest that most wind power facilities will negatively impact migratory roost sites. With a limited number of wind power facilities, this may not be an issue, but cumulative effects of a large number of wind facilities must be considered.

Temporal migratory patterns of golden eagles in eastern North America

We obtained tracking data of golden eagles during migration using GPS satellite telemetry. Mean departure and arrival dates are consistent with observations from hawk watches, with birds departing wintering grounds March 15 ± 18 days and arriving at breeding grounds on April 9 ± 23 days. Fall departure and arrivals are more tightly concentrated, with birds departing breeding grounds October 21 ± 15 days and arriving at wintering grounds on November 22 ± 12 days. Peak migratory activity occurs between 9:00 am and 3:00 pm.

Conclusions

Spatial patterns of migration differ among age classes. Juveniles have a higher sinuosity index than adults – that is, they move around a lot more rather than migrating directly to their destination. This puts juveniles at greater risk.

Nearly all proposed or existing wind facilities will affect migratory roost habitat, however, the current model needs to be improved. Brandes & Ombalski (2004) identified coarse-scale migratory routes through Pennsylvania by tracking Southeast winds through the south-central part of the state. Using this theoretical model to further refine the study area may improve prediction of roost sites.

We need to get more data on golden eagles in the East to improve and quantify our understanding of their behavior throughout the annual cycle. Slide #38 shows birds on a forested ridge-top – a very different picture than what we would expect based on how golden

eagles behave in the West.

We can use daily and seasonal peak movement timing data, for example, to guide sampling design for pre-construction surveys. Furthermore, these data could be used to guide seasonal/daily shutdown of hazardous facilities. One of the most important efforts necessary to assessing, minimizing and mitigating risk during migration, is to relate flight characteristics to topography and weather.

Most of the routes through Pennsylvania are relatively straight, but it is not enough just to map one state; we have to look at bird routes thru New York and New England as well as the mid-Atlantic states. Satellite data are useful for modeling habitat and home ranges, and coarse migratory corridors, but don't give us a very precise idea of migration routes. High frequency data can show more precisely where problems might exist, and also help us understand behavior in relation to topography, e.g., "thermaling," and how birds respond to existing wind turbines. Our eventual goal is to create a 3-D model to identify strike probability and respond with micro-siting changes.

Questions following the presentation

Question: USFWS has a real concern about the impact of wind development on the sub-population of golden eagles in the East. How did you come up with a 20 km buffer for nesting area?

Response [Charles]: The 20 km buffer was based on the literature, on the maximum distance traveled from the nest. It's just a baseline limit, however. We've been marking birds further than that.

Question: What about buffer for roosts?

Response [Tricia]: We are assuming that the buffer should be at least 500 m, but we don't really know how installation of turbines will affect behavior.

Question: Why are there so few golden eagles in the East to begin with?

Response [Charles]: We don't know.

Response [Bob Russell]: There are other golden eagle populations in the Midwest: 100-200 birds come down through Duluth to spread out to wintering grounds in SW Wisconsin and Tennessee. A second fall flyway (a somewhat smaller population) goes down Hudson and James Bay and crosses the Detroit River.

Question: Can you explain a bit about the migratory route model Dave Brandes is trying to develop?

Response [Tricia]: The idea is to model updrafts based on topography, and then using that to map route probabilities, because the birds make use of these updrafts.

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*Displacement effects of wind developments on grassland birds
in the Northern Great Plains*

Jill Shaffer, U.S. Geological Survey¹

This paper represents the content of a presentation given at the National Wind Coordinating Collaborative's Wind/Wildlife Research Meeting held in Milwaukee, Wisconsin in October 2008. This paper briefly discusses the biological issues that led to the inception of a grassland-bird displacement study conducted by the U.S. Geological Survey, Northern Prairie Wildlife Research Center (NPWRC). It explains the methodology of the displacement research and discusses preliminary data. For the purposes of this paper, the Northern Great Plains refers to North Dakota and South Dakota.

From a wind-resource perspective, both North Dakota and South Dakota have excellent wind resources. Among the top 20 wind-producing states, North Dakota is ranked No. 1 for wind-production potential by the National Renewable Energy Laboratory. South Dakota is ranked No. 4. Much of the reason for those high rankings is due to two prominent geological landforms.

The Missouri River roughly bisects the two states. Rising east from the river breaks is the Missouri Coteau (or Missouri Plateau). The Missouri Coteau is a dead-ice moraine formed by the slow retreat of the Wisconsinan glacier. In some areas, the Coteau forms a very steep escarpment, with elevations of over 640 m (2100 ft). The Missouri Coteau is characterized by numerous depressions, called potholes. Wind development is occurring rapidly along the Missouri Coteau. In South Dakota, the Prairie Coteau, like the Missouri Coteau, was formed by stagnant glacial ice melting beneath a sediment layer. Wind developers have expressed considerable interest in developing the wind resource along the Prairie Coteau, as well as along the Pembina Escarpment and Missouri Slope.

Six years ago, North Dakota had no major wind facilities. The state currently produces 470 MW from 313 turbines. Likewise, South Dakota had no major wind facilities six years ago, and currently produces 180 MW from 120 turbines. Because of the competitive nature under which wind developers must operate, it is difficult to discern the exact number of proposed wind facilities in the northern Great Plains. From media reports and applications before the North Dakota Public Service Commission and the South Dakota Public Utility Commission, we estimate that about 5,427 MW (from over 3,385 turbines) have been proposed for North Dakota. The proposed number of wind turbines in South Dakota is upwards of 7,000 MW from over 2,500 turbines. These numbers, however, change very quickly. A lack of adequate transmission capacity in the Dakotas remains an obstacle to development of the wind-energy resource.

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North Dakota and South Dakota are located within prairie ecosystems. However, both states have lost over 70% of the grasslands that were present prior to European settlement. Most of this loss is due to agricultural operations. Portions of North Dakota and South Dakota lie within a glaciated portion of the Northern Great Plains known as the Prairie Pothole Region, a primary breeding area for many of the continent's ducks (the so-called "duck factory of North America"), as well as for grassland songbirds. Grassland-dominated, wetland-rich landscapes within the Prairie Pothole Region are vital to duck and songbird populations.

The Dakotas are also key habitat for grassland passerines. The Baird's Sparrow is a species endemic to the northern Great Plains, with a very restricted breeding range in the U.S. Some of the densest concentrations of this range are along the Missouri Coteau, making it a pivotal area for the production of this species (and for birdwatchers). The Sprague's Pipit is another species with a very limited range. The Missouri Coteau is one of the areas that harbor the densest concentrations of this species. However, most grassland bird species are showing a long-term and persistent decline, regionally as well as state-wide. The migratory path of the federally-endangered Whooping Crane also lies along the Missouri Coteau.

In North and South Dakota, one of the most effective means of protecting native grasslands is the US Fish & Wildlife Service's (USFWS) Grassland Easement Program.

The Grassland Easement Program has been very successful in protecting grasslands. A grassland easement is a perpetual contract between the landowner and USFWS. Land acquired for the management, conservation, and protection of fish and wildlife resources remains privately held but protected (e.g., no plowing) to provide cover and food for wildlife – particularly waterfowl and endangered species.

Study objective and approach

The Northern Prairie Wildlife Research Center sought to answer whether wind turbines were compatible with USFWS' Grassland Easement Program. Specifically, our objectives in this study were to determine whether wind turbines in native prairie will affect the presence and abundance of grassland birds – and, if so, which species and how far does the turbine exert an influence?

Working with FPL Energy (which funded a portion of the study and which is now NextEra Energy), NPWRC looked at two wind-facility sites, one in Oliver County, North Dakota (22 2.3-MW turbines and expanded to an additional 32 1.5-MW turbines), and one in Hyde County, South Dakota (27 1.5-MW turbines). We also looked at two sites developed by Acciona Energy (120 1.5-MW turbines in Dickey County, North Dakota and neighboring McPherson County, South Dakota) and a proposed joint project of Clipper Windpower and BP Alternative Energy in Hand County, South Dakota. Data presented here are from the FPL Energy sites.

Approach and methodology

Our aim was to identify patterns of avoidance of wind turbines by grassland-nesting birds. In order to adequately address our research questions, we must take into account possible

differences in bird abundance due not only to the wind developments but also to other factors that may be attributed to the year or to location. For example, precipitation can differ between years, or it can differ between two areas within a year. To account for these differences, we used a Before-After Control-Impact (BACI) design:

Before: conducted bird surveys in areas where wind turbines were to be constructed (pre-construction)

After: conducted bird surveys in the same locations in the years after construction

Control: conducted bird surveys on non-turbine sites that were similar to the impacted sites in terms of topography, habitat, and land use

Impact: conducted bird surveys on turbine sites

Birds were mapped within a census grid designed to maximize the area around each turbine location that was censused. Census grids, composed of fiberglass fence posts spaced 50 m apart within a line and 200 m apart across lines, extend 0.8 km from all sides of a string of turbine where land use is mixed-grass prairie and where landowner access has been permitted. Observers walk transects within the census grid and note the location of all birds identified by sight or sound, plotting those locations relative to the grid markers. These individual bird locations are then assigned GPS coordinates. We have GPS coordinates for the turbine locations as well. In this way, the distance of birds from the nearest turbine can be determined.

Mapping habitat and avoidance patterns

General habitat types, such as prairie-dog towns and wetlands, are delineated and the area within each study plot that is deemed suitable breeding habitat for the focal species is determined. For example, at the South Dakota Wind Energy Center, Grasshopper Sparrows are not detected in either prairie-dog town or wetlands. The area occupied by these habitats is removed from the area deemed suitable breeding habitat for the Grasshopper Sparrow. In a post-construction year, we further remove the area of previously suitable habitat that was impacted by construction, so would remove, at a minimum, the turbine pads.

Within the area deemed suitable breeding habitat for each of the focal breeding species, 10,000 random spots are assigned within each study plot. The distance of each random point from the nearest turbine is calculated and assigned to one of several distance categories, based on the size of the study plots. The distances of each individual bird observation from the nearest turbines is assigned to the same distance categories.

In order to identify patterns in avoidance, we then compared the observed distances of individual bird locations from the nearest turbine from the expected distances based on random points. The mean difference between the number of observations within each distance category and the number of random points within each distance category was computed in order to determine whether birds were distributed non-randomly relative to turbine locations. We calculated the difference between the number of bird observations within a distance

category and the number expected based on random locations. We averaged these values across all of the site and year combinations. Averages were computed separately for pre-treatment and post-treatment combinations.

Scatter plots of Mean Difference by Distance Category were developed separately for the pre-treatment and the post-treatment years. Based on the preliminary data gathered thus far from the South Dakota Wind Energy Center, we examined displacement trends for Western Meadowlark, Grasshopper Sparrow, Chestnut-collared Longspur, and Killdeer. Based on the preliminary data gathered thus far from the Oliver I Wind Facility in Oliver County, North Dakota, we examined displacement trends for Western Meadowlark, Grasshopper Sparrow, Clay-colored Sparrow, and Killdeer. We plotted pre-treatment graphs for 2003 for the South Dakota Wind Energy Center. We plotted pre-treatment graphs for 2006 for the Oliver I Wind Facility in North Dakota.

Findings

In pre-treatment years, we would expect that birds are distributed randomly relative to the *proposed* turbine locations and thus would not expect to see a pattern in the scatter plot of Mean Difference by Distance Category. At both wind facilities and for all species save two, we detected no appreciable difference from a random distribution relative to the *proposed* turbine locations, as expected. The two exceptions were Killdeer at both wind facilities and Clay-colored Sparrow at Oliver I. Both species exhibited some degree of “avoidance” pre-treatment, but obviously not to the turbines which were not yet constructed. Very likely, the habitat in those nearer distance categories were not preferred breeding habitat. Differences in habitat may be detectable, but were not captured by our vegetation measurements or visual inspection.

For Western Meadowlark at both wind facilities, no avoidance was detected in the post-treatment years, which were 2004-2006 and 2008 at the South Dakota Wind Energy Center and 2007 for Oliver I. At Oliver I, Chestnut-collared Longspur showed no avoidance. Killdeer, which prefer to nest on gravel substrates like that provided by the roads between turbines, appeared to be attracted to wind turbine areas at both wind facilities. At Oliver I, avoidance was more pronounced post-treatment. The results for Clay-colored Sparrow are ambiguous, and we will be returning to Oliver I during summer 2009 to gather more data.

At both wind facilities, Grasshopper Sparrows clearly exhibited avoidance to the turbines out to about 200 m. Breeding Bird Survey trends indicate that the Grasshopper Sparrow is declining along the glaciated Missouri Coteau area, at a steep 6% per year. There are very few areas range-wide where this species is increasing. Looking at range-wide results for Clay-colored Sparrow, the species is declining at 1.3% per year. However, the species is faring relatively well in the northern Great Plains, emphasizing the importance of this region’s remaining grasslands to this species.

None of the common species that were encountered during the pre-treatment surveys at the wind facilities disappeared post-treatment, but there is an indication that densities decreased.

In particular, Grasshopper Sparrow densities appeared to drop post-treatment.

These are preliminary results. The data in this paper are from only two wind facilities, and the research is still ongoing. The data from additional sites and for other species have not yet been analyzed.

Acknowledgments

We thank Acciona Energy, BP Alternative Energy, Clipper Windpower, Global Wind Harvest, NextEra Energy, and numerous landowners for allowing land access. We thank the many hard-working biological science technicians who gathered the data. Dave Azure, Deb Buhl, Mick Erickson, Betty Euliss, Neal Niemuth, Ron Reynolds, and Bob Vanden Berge provided essential logistical support. This study is funded by the U.S. Geological Survey and NextEra (FPL) Energy.

Questions following Presentation

Question: Are there any indications of characteristics in these birds' habitat needs that were associated with their avoidance or attraction?

Response: With Killdeer, yes, they are attracted to gravel roads. Grasshopper Sparrows prefer more xeric areas, such as ridgetops, which is where wind turbines typically are located, as opposed to other species, such as Western Meadowlarks, that have less specific habitat requirements.

Question: Did you compare your pre-treatment to post-treatment?

Response: Yes, we look at the scatter plots of mean difference by distance category for pre-treatment years separately from the scatter plots for post-treatment years.

Question: Why might birds be avoiding turbines?

Response: We are not aware of studies showing that Grasshopper Sparrows are intolerant of human disturbance – we're not really looking at behavior here – so no, we're not sure why they're avoiding them.

Comment: Historically, these birds were common across the northern prairie. There's been a tremendous loss of those birds historically.

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*Prairie grouse display ground and nest distribution and population trends
relative to wind generator complexes
in northwestern Minnesota and the sandhills of Nebraska*

John E. Toepfer, *Society of Tympanuchus Cupido Pinnatus, Ltd.*

Tympanuchus cupido pinnatus is the scientific name of the greater prairie chicken. The mission of the Society (STCP) named for the greater prairie chicken is to save it from extinction. See also: www.prairiegrouse.org.

We have been studying the dynamics of increasing and stable populations of prairie chickens in Northwest Minnesota since 1992, and in the sandhills of Nebraska since 2006. Genetic research indicates that, small isolated populations because of their small numbers and isolation due to the fragmentation of their grassland habitat have experienced dramatic declines in genetic diversity.

The best index for determining the status of a prairie chicken population and the influence of human activities is to count the cocks on the booming grounds and monitor the distribution of booming grounds. Prairie chicken cocks use their booming grounds or display grounds year-round except during July and August when they are molting their feathers. There are typically 10-12 cocks per booming but some have been as large as 60 cocks. Because their populations require large acreages of undisturbed grassland habitat their presence and status make them a keystone or umbrella species for other grassland wildlife. Unlike most grassland birds the prairie chicken is non-migratory and they remain on the prairie year-round. Their movements occur within and on the fringe of the distribution of the booming grounds. It is estimated that at least 60,000 acres of undisturbed grassland habitat are necessary to sustain a viable prairie chicken population.

The addition of tens of thousands of acres of grassland in the Conservation Reserve Program (CRP) has led to dramatic increases in prairie chicken numbers in northwestern Minnesota – more grass means more chickens. We expect to see the opposite trend as grasslands are removed from CRP and put back into agricultural production.

Prairie chickens require short cover for booming grounds and if cover gets too tall the cocks will abandon such grounds (unharvested corn) and shift display activities to an area where cover is shorter so they can see (predators) and be seen (attract hens for breeding). They use plowed fields regularly in northwestern Minnesota for their booming grounds. In an increasing prairie chicken population with lots of grassland such as in northwestern Minnesota we find booming grounds showing up in places near houses, and even near towns if the grassland cover remains nearby. Nest success can be high variable and very susceptible to small sample sizes of 10-15 radioed birds. We have found nesting success as high as 70% in one location near a 1,000 cow dairy barn and in other places almost zero.

Likewise, with a lot of grass present the birds do not seem to be affected by the presence of wind turbine towers. They appear to be affected more the by type of habitat or ground cover and loss of grassland. We have monitored the booming grounds and nests of radio-marked prairie chickens associated with a three-tower wind generator complex located near Felton, Minnesota since 2001. The mean distance for the 32 nests of radio-marked hens within a mile of the nearest tower 2006-2008 was 0.601 miles and nest success was 53.4%. The mean distance from nearest tower to random points was 0.701 miles. In Nebraska where a wind farm with 36 turbines was placed in a leased pasture containing 11,520 acres of grassland, less than 1% of that area was taken out of grassland for turbines, roads, etc. while the rest remained in prairie grouse habitat consisting of lightly grazed pastureland. We have yet to find any negative impacts from the wind development on booming ground distribution within two miles of the three tower and thirty-six tower complex as long as the grassland cover surrounding the towers and within the complex remained intact.

While the turbines themselves do not appear to be a problem when grassland habitat is not degraded, we are more concerned that roads, transmission lines and other development associated with the wind farms (houses, factories etc), will have a greater impact on the fragmentation and loss of grassland habitat than the actual towers. To avoid any such conflicts, we recommend placing the towers near existing transmission lines, avoid migratory corridors and critical wildlife habitats such as grasslands, wetlands and woodlands and place them in the millions and millions of acres of plowed ground in the Great Plains.

Refining the protocol for a rapid assessment methodology for wind development scoring, and developing a matrix/key to integrate pre- and post-construction monitoring for commercial wind projects based on risk

Albert M. Manville, II, Ph.D., *U.S. Fish & Wildlife Service*¹

Airspace as a habitat is a relatively new concept, including for Federal agencies such as the U.S. Fish and Wildlife Service (USFWS). As wind turbines continue to increase in size, now with rotor blades reaching as high as 440 ft. above ground level and rotor swept areas approaching 4 acres, their potential to impact wildlife in this airspace grows. More than 25,000 industrial turbines now operate in the U.S. (46% growth in 2007 alone) and there are calls for achieving as much as 20% of our energy generation from wind by 2030 (where it now contributes just over 1%). Such rapid growth of wind energy means large areas of airspace already are and certainly will be affected. This growth presents challenges as well as opportunities.

USFWS' goal as an agency is to do no harm. However, there are few options to avoid or minimize collisions once turbines are operating (*e.g.* blade feathering/idling, possible changes in blade cut-in speed, turbine set-backs from ridge edges, and replacement of end-of-row turbines with pylons), so proper site selection is critical. The selection of a site depends on many variables, including but not limited to, good to excellent wind resources, large plots of available (ideally private) lands, proximity to an available electric grid with unused capacity, ease in development, permitting requirements, cost, and ecological issues. From our agency's perspective, the rapid expansion of wind energy development means that we need to improve our ability to assess, rank, and quantify the ecological risk at a potential wind site prior to construction. We also need to be prepared to assess cumulative impacts as wind development expands.

Rapid assessment methodology (RAM)

In 2002, USFWS developed a potential impact index (PII) site ranking and scoring protocol that became part of our 2003 voluntary land-based wind turbine guidelines. The PII was developed to quickly assess risk and to rank sites prior to construction. PII workshops were planned to field test, evaluate, and fine-tune the protocol, but they were cancelled. In part as a result, the industry did not generally embrace the PII, it had limited use by the industry, and the PII lacked a component addressing the temporal and spatial use of airspace, which from our perspective is a shortcoming.

To address these needs, and recognizing that there is pressure (given expiring tax credits and renewable portfolio standard thresholds) on developers to move quickly, we have developed the framework for a "rapid assessment methodology" (RAM). The purpose of the RAM is to provide developers with a tool to assess risk at a site prior to construction, building on efforts

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already created for the PII. We encourage developers to contact the nearest USFWS Ecological Services field office at the outset of any proposed development, not merely as an afterthought.

Assessing site risk prior to construction

There are various approaches to assessing site risk, but they are mostly used for addressing risk following construction, not at the initial site-survey review level. The PII was designed to provide a “first-cut” site suitability review, developed to quickly assess risk and to rank sites prior to construction. Other pre-development approaches include “fatal flaw” analysis, studies to characterize site risk, and Environmental Impact assessments. A pre-construction tool recently developed jointly by Environmental Resources Management and WEST, called the “Critical Environmental Issues Analysis” (CEIA), includes components such as site mapping, biological evaluation, and expert judgment. CEIA makes use of site scoring components not unlike the checklists developed for the PII scoring tool. Like the PII, it allows for multiple site analysis, but it does not include a “reference site” (i.e., the ecologically worst site in the immediate area where wind energy could be developed) as suggested in the PII protocol.

Developing and refining a rapid assessment methodology (RAM)

Building on what went into developing the PII protocol, USFWS now proposes a rapid assessment methodology (RAM) that can be used both for macro and micro-siting of facilities and individual turbines, also with the opportunity to fine-tune landscape features for conducting micro-site reviews. The RAM is intended as a first-cut analysis of a site’s suitability, establishing and quantifying the potential impacts and risks to wildlife species present on the site or in the immediate area, and the potential risk to habitats that may be impacted.

The RAM will contain 2 major components: 1) an on-site visit, and 2) an off-site search for pertinent available information. Data collection and on-site assessment of risk at a proposed site can be performed in as little as a day. Where access to a site becomes an issue, and a visit to the actual site is not possible, access from a nearby site or even access by aerial overflight may be conducted. For the off-site components of the RAM effort – such as a literature review, relevant map and GIS assessments of the area, and previous adjacent site surveys – this would take more than a day’s effort, especially if the area is newly proposed for development.

The RAM is intended to provide a site assessment methodology that:

- is consistent and standardized;
- can be conducted in an expeditious and inexpensive way;
- relies on existing information;
- is user-friendly and can be conducted quickly and easily in the field;
- can access studies made available to the public conducted at adjacent sites;
- is iterative, allowing for feedback from previous study results;
- is based on the rigor and scientific validity of existing information; and
- minimizes subjective reviews.

Reducing subjectivity

The issue of subjectivity in determining species presence was raised with PII scoring, especially in regard to the site scoring components used in the PII's Species Occurrence and Status checklist. The RAM addresses the subjectivity issue by:

- giving state and Federal threatened and endangered species additional weight resulting in comparatively higher scores based on the imperiled status of the species in question compared to more common species;
- scoring or ranking species or groups of birds and bats based on their collision risk as a measurement category as determined from published information (such as a "red list" of species at high risk of collision including nesting Golden Eagles and bats in maternity colonies); maintaining flexibility to include new information as it becomes available; and
- maintaining transparency to minimize subjectivity and maintain reliability; and including a screening tool and weighting criteria for episodic events that would incorporate birds or bats at serious risk of collision – including events such as migratory fall-out along coastal areas, incidence of hurricanes and other weather events, and areas with a high magnitude of daily bird/bat movements.

Development of the RAM

RAM development is one of three projects prioritized by the USFWS for initiation under the Science Support Program for Fiscal Year 2009. We have been approved for funding to develop and field test this RAM beginning in 2009, and principal investigator Douglas Johnson welcomes feedback from project collaborators and other specialists interested in fine-tuning this protocol. As a starting point, Johnson's team will assess, review, update, and modify – where necessary – the three PII checklists, and add a fourth checklist that addresses temporal and spatial use of airspace. The latter should include (but would not necessarily be limited to):

- Relevant GIS data layers (e.g., key migration corridors, important breeding habitats, staging and roosting areas, hibernacula, ridgeline features affecting migration, and the degree of cultivation and crop monoculture shown to reduce bird and bat presence);
- NEXRAD (Doppler) and other radar data to better understand broad-front migration movements, use of stopover sites, and improve tracking of flying vertebrate "targets";
- Thermal imagery studies that help identify "target" levels and habitat use;
- Soil survey data on vegetative associations and their attraction to birds and bats;
- Data on habitat fragmentation and habitat suitability indices;
- Other information on "broad front" bird movements, raptor survey results, sensitive species surveys, and assessments, migration corridor use, and key bird stopover and staging areas;
- Data on bird and bat roosting sites, presence of bat maternity colonies and hibernacula, and use of forest edges;
- Datasets and results from bird and bat radio-telemetry studies;

- Site-specific information on wind speeds, cloud ceilings, and incidence of inclement weather that may indicate rapid temporal variability in conditions that may affect collision risk varying from minutes to hours as opposed to nightly or seasonally; and
- Pertinent information on blade wake turbulence, blade-tip vortices, and the wind wake phenomenon that has been shown to negatively affect birds, bats, and insects found on the site.

There should be an inherent ability to customize any of the checklists to fit a specific site. Provided the above information is available and user-friendly to those familiar with site assessment, the RAM should include information specifically from the proposed development site, or at a minimum from an immediately adjacent site.

Use of RAM and Next Steps

Investigators plan to develop, refine, and field test the RAM beginning this year. In addition to refining the site ranking process, they will evaluate the use and utility of a “reference site,” as suggested in the PII.

Bird, bat, and habitat issues will be the key components of any RAM protocol. These may be integrated into a single RAM calculation, or assessed separately, based on the review and field testing.

The output of the RAM is a site ranking score. Scoring and site ranking will be re-examined and may be significantly modified based on previous recommendations. Once a RAM is performed and a site ranking score is obtained, information from that site should ultimately be made available to anyone for use in assessing adjacent sites that may subsequently be considered for development.

Once the RAM is field-tested, fine-tuned, and adopted, we will perform training workshops on how to use it. These would be similar to the electric utility “short courses” used to instruct line workers in avoiding and minimizing electrocutions and collisions at power lines. Ideally, investigators and USFWS would collaborate in offering these courses.

Proposed decision tree / matrix

The metrics and methods used to assess and rank sites and determine risk using pre- and post-construction monitoring protocols vary greatly, depending on site characteristics, available time and budget, the nature and scope of the review, and the qualifications of those performing the review. There is often a huge disconnect between the collection and analysis of pre- and post-datasets, and the integration between pre- and post-construction research and monitoring, making it difficult to come up with predictive models.

Using the RAM as a preliminary assessment tool, the second part of this presentation briefly discusses the future development of a tool to determine, estimate, and validate risk hypotheses. The tool takes the form of a matrix or “decision tree” to align and validate research

efforts, review and validate (or negate) hypotheses involving risk, and to review any models being created to assess risk. The matrix is intended to be a “tool” to suggest what pre- and post-construction monitoring *should* be conducted, and at what frequency, duration and intensity studies *should* be conducted (commensurate with the level of risk a site is perceived to pose.)

Decision-tree analysis is used to align post-construction monitoring efforts with pre-construction risk determinations, using a tiered approach based on the risk at a site. The matrix will be developed to closely align and integrate with valid research protocols and guidance documents [see slides #29-30]. With limited funding and time constraints, during the upcoming year the matrix will not be included as part of the RAM development, but should be completed in the near future since the RAM and the matrix are closely aligned.

The RAM protocol will be field-tested, validated, and refined at several study sites around the country during the coming year. The matrix will hopefully follow, once it is developed, field tested, and refined. The decision tree should provide a generic, systematic, and consistent approach to suggesting what valid research protocols to use. It is hoped that these tools will “level the playing field” such that site assessment is conducted consistently at all levels (regional, local, and site-specific), with significant positive implications for management.

Questions following Presentation

Question: This looks like a set of guidelines for developing wind sites using a particular assessment process – how will this be dovetailed with the guidelines USFWS has undertaken to produce with its Federal Advisory Committee (FAC)?

Response: This process was initiated well before the FAC was approved. The FAC will provide USFWS with recommendations – that is part of this effort, but certainly not by any means all of it.

Response [Dave Stout]: This is just one small part of the process – the first/fatal flaw analysis. This work will not duplicate or conflict with the broader set of guidelines that the FAC is creating for the USFWS.

Question: We discussed this topic a lot in developing Oregon’s state guidelines. Some of the components you listed appear to be new analysis v. existing literature review. Would this include having the developer do new analysis (e.g., radar studies)?

Response: RAM is an initial suitability analysis, and probably would not include radar studies. The decision tree analysis could, for example, suggest three years of pre-construction studies that might include radar studies if risk were perceived to be high.

Question: Your team is mostly USFWS people; I didn’t see anyone from wind industry. You mention a tiered analysis – the wind industry does do some in-depth research at a minimum, even in disturbed areas.

Response: We encourage any industry representatives who would like to get involved in this as collaborators to come forward. (Collaborators are not the co-authors.) This is a preliminary proposal. PII was never field-tested with the industry, which led to confusion about how its use was intended. We don't want to reinvent the wheel, but we do want and need to get industry input and field test the proposed methodology.

Comment: There are some things [industry does] that are simply due diligence. We always do a threatened and endangered species analysis for a site no matter what kind of site it is.

Response [Dave Stout, USFWS]: Iberdrola has announced a corporate avian and bat protection plan, and USFWS applauds them as the first wind energy company to adopt such a plan, that includes the declaration that the company "will reduce risk to birds and liability under the MBTA."

Comment [Andy Linehan, Iberdrola]: We see this as a tool to implement guidelines and raise the bar internally to consistently develop better sites, as the electric utility industry has done with power lines.

Comment [Al Manville]: We've been working in partnership with the electric utility industry since the 1970s, and we hope others in the industry will take a look at [the Iberdrola] template and think about doing something similar.

Comment [Facilitator]: Good work, Andy and Iberdrola – Horizon and other companies are also taking initiatives.

Impact of wind turbines on the migration of raptors in Baie-des-Sables, Quebec

Michael Ross, McGill University¹

Wind is an attractive source of clean energy that has experienced 51% annual growth since 2000 in Canada – 113% growth in 2006 alone. In Quebec, there are about 450 turbines currently, and the figure is expected to increase more than four fold (to about 1,900 turbines) by 2015. About a thousand of these turbines are projected for the south shore of the St. Lawrence River.

For birds, wind energy development in this region poses potential risks including collision, habitat loss, a potential barrier effect for migratory species, and also a potential barrier between breeding and other habitat. The Baie-des-Sable wind farm comprises 73 turbines, 120 m in height, situated over 24 km² of rolling hills with mixed vegetation. Birds migrating north follow the St-Lawrence River coastline to a point where it narrows, thereby crossing Baie-des-Sables.

Study objectives and design

This study was conducted at the Baie-des-Sables wind energy facility and a nearby control area during spring migration in 2007 and 2008. The objectives of this study were to determine whether raptors change their migratory behavior in the presence of wind turbines, and whether the abundance of raptors varies between the Baie-des-Sables facility and a control area. We predicted differences in both behavior and abundance for lower-flying raptor species.

We used a stratified random design to select observation sites within and on the periphery of the wind farm. Over two years, four observers conducted simultaneous one-hour observations at 12 locations within the wind site and 12 locations outside the wind farm. With respect to flight behavior, observers recorded flight altitude, direction, and the type of flight behavior observed (soaring, flapping, gliding, kiting). Within the wind farm, altitude was noted with reference to the range of the rotating blades (approximately 40-120 m above ground level). In the control areas, observers used wind sensors and transmission lines to indicate flight altitudes.

Abundance was recorded for birds flying within 1 km of the observation period, with species, altitude, and observation times noted.

A total of 14 species were recorded, but the focus of this presentation is on the following raptor species: broad-winged hawk, osprey, red-tailed hawk, bald eagle, golden eagle, rough-legged hawk, sharp-shinned hawk, northern harrier, and peregrine falcon.

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Data Analysis

Flight behavior

We analyzed flight behavior using a Kruskal-Wallis test to determine differences between altitude intervals (below, within, and above the rotor-swept area). Most of the birds we observed flew at heights significantly above the rotor swept area (RSA). The exceptions were the Northern harrier, which flew at altitudes significantly lower than the RSA, and the peregrine falcon, which flew both within and above blade height.

Comparing interior and periphery observations, we found no significant difference in terms of flight height for birds flying inside and outside wind energy area. More bald eagles tended to glide outside as opposed to inside the wind area, but the sample size is very small. Likewise, we saw no significant difference in direction change behavior between birds flying interior to the wind site v. the peripheral control site.

Abundance:

Overall, we found no significant difference in abundance between wind site interior and periphery, although the difference for broad-winged hawks was almost significant.

Discussion

The wind energy facility we studied was situated in low-lying topography, so these findings should not be applied to areas where turbines are placed on ridges or elevated areas.

Based on these findings, collision risk does not appear to be significant during migration (with the possible exception of the peregrine falcon, which is an issue in Quebec). However, collision risk may be an issue for hunting birds

Questions following Presentation

Question: Did you do any fatality surveys?

Response: We did not; however, there was another company (Pesca Environnement www.pescaenvironnement.com) conducting fatality surveys.

Comment (1): Given the small sample size, I don't think you should necessarily require a 0.05 p value to determine significance. Consider using a 0.1 p value

Comment (2): If you do 50 statistical tests, should expect at least one .09 value in a random sample – I'd argue the opposite of the above.

Comment (3): With regard to fatalities, a 2-year study of raptors migrating over Great Lakes that included intense fatality searches revealed three raptor fatalities – it seems mortality is not

much of an issue for these birds.

Comment (4): Recommend that you abandon non-parametric statistics. They are weak and wasteful of data – you are not testing the hypothesis you think you are, and are likely to get a Type 2 error, which is at least as much of a concern as a Type 1 error in this situation.

Response: I would like to talk to you more about that.

Facilitator: Would a seminar on statistics related to wind-wildlife issues be of interest to people? [Yes.]

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Lesser prairie chicken conservation and wind development in the Texas panhandle: a case for proactive wildlife management

Jon T. McRoberts, *Texas Tech University*¹

The lesser prairie chicken (*Tympanuchus pallidicinctus*) inhabits portions of the Texas panhandle, a region indentified for extensive wind energy development. The lesser prairie chicken has seen large-scale population declines (approximately 97%) since the mid-1900s. The species is currently a candidate for listing under the Endangered Species Act. In 1998 the lesser prairie chicken was deemed “warranted, but precluded” from listing and the population status is reviewed annually. The lesser prairie chicken is sensitive to environmental changes. Potential impacts include habitat alteration and fragmentation, development, mismanaged grazing, and the construction of vertical structures. As development of wind energy facilities accelerates across the Great Plains, grassland species such as the lesser prairie chicken may be threatened through increased habitat loss and fragmentation.

Proactive cooperation and management are essential for wildlife stakeholders, wind industry developers, and others if we are to learn how to manage the coexistence of lesser prairie chickens and renewable energy. The issues are not site specific, but instead transcend the entire lesser prairie-chicken range of Texas, New Mexico, Oklahoma, Colorado and Kansas.

Potential impacts of wind development

This presentation focuses on potential impacts to lesser prairie-chicken from wind energy development in the Texas panhandle, and on research by Texas Tech University and the Texas Parks and Wildlife Department to determine whether wind energy impacts do exist.

Wind energy development has the potential to impact lesser prairie chickens through:

1. **Fragmentation and alteration of grasslands** – conservation and recovery must center on a habitat-based approach.
2. **Establishment of vertical structures** – potential avoidance, especially by females during nesting activities, is one concern; increased predation associated with the construction of vertical structures is another.
3. **Anthropogenic disturbances** – these include increased traffic, noise, and construction activity.

Wind energy is booming in the Texas Panhandle. As of October 2008, the state has 5,604 MW of installed utility-scale wind power, or 28.7% of the U.S. total – including three of the largest wind developments (by installed MW capacity) in the U.S. Another 3,162 MW are currently

¹ Co-authors: Warren B. Ballard and Matthew J. Butler, Texas Tech University, Dept. of Natural Resources Management; Heather A. Whitlaw and Kathy Boydston, Texas Parks and Wildlife Dept., Andrew H. Swift, Texas Tech University, Wind Science and Engineering Research Center

under construction, and the state's *potential* capacity is 136,100 MW based on an analysis done by the American Wind Energy Association. Wind energy development is expected to continue to increase. Additionally, 2,158 miles of new 345-kV transmission lines will be constructed over the next five years. Some of the new transmission lines will pass through lesser prairie-chicken occupied habitat. The northeast and southwest corners of the Panhandle are currently inhabited by lesser prairie-chickens; however, it is the population in the northeast corner that may be most susceptible to the impacts from wind development. There are excellent wind resources in this part of the state and the proposed transmission corridor could deliver the wind-generated energy to the load center of the state. [Slide #10 shows how lesser prairie-chicken habitat overlaps with Competitive Renewable Energy Zones, or "CREZ".]

Research to determine wind energy impacts

It is critical to isolate impacts on the lesser prairie-chicken from wind energy development. To do this, a number of control studies are needed to account for natural or non-wind anthropogenic impacts. Texas Tech University has undertaken a suite of research activities to help isolate the impacts resulting from wind development. Current research activities include: aerial surveys to locate leks; reproduction and brood ecology research to determine reproductive output and habitat requirements for successful broods; survival and mortality studies to determine longevity and predation rates; and habitat use and movement studies to determine natural dispersal rates and movements among useable habitat and active leks.

Study design and methodology

To determine the impacts of wind development on lesser prairie chickens we will utilize a study site slated for wind energy development in the northeast Texas Panhandle. The site is located on the edge of the lesser prairie-chicken range. In the spring (from 2009-2013) we will trap lesser prairie-chickens on leks using walk-in funnel traps and rocket nets. We will equip captured birds with radio collars and then track them to determine cause specific mortality, survival rates, habitat use, nesting locations, brood recruitment, and displacement from vertical structures. We will collect data pre-, during, and post-construction at the wind energy facility.

Control site research will allow explanation of natural population fluctuations and movements that could mistakenly be attributed to wind development. Future research will allow identification of potential impacts on lesser prairie-chicken populations from wind development. It is our intention that this research will provide mitigation and management recommendations for coexistence of wildlife and wind energy development.

Conclusions

Listing the lesser prairie-chicken under the Endangered Species Act could drastically change wildlife management and wind development opportunities in the Texas panhandle and elsewhere within the lesser prairie-chicken range. Partnership among Texas Tech University, Texas Parks and Wildlife Department, non-governmental organizations, and the wind industry will facilitate proactive management of lesser prairie-chicken populations for mutual gains. Our research will commence in 2009. Our hope is to provide a more complete understanding of the

potential impacts of wind energy development on lesser prairie-chicken populations.

Using geographic information systems (GIS) and available habitat data to evaluate the potential of a proposed wind power project area to serve as stop-over habitat for migrating cranes.

Karl Kosciuch, *Tetra Tech EC, Inc.*¹

The whooping crane has been listed as a Federal endangered species since 1970. Whooping crane breeding and wintering and four critical stop-over areas are protected, but what about the rest of the bird's 200-mile wide migratory corridor? This corridor stretches from the Canadian border to South Texas (Aransas National Wildlife Refuge). There is good to outstanding wind resource along this corridor, especially in North and South Dakota, where there is no protected whooping crane habitat.

Development impacts

Development results in both direct (collision mortality) and indirect (avoidance) impacts on whooping cranes. While there is no record of whooping cranes having been killed by wind turbines, in the 2007-08 whooping crane activity report, Tom Stehn identified wind power as posing a risk of both direct and indirect impacts.

Direct impacts

Cranes fly at heights of 1,000-6,000 feet, but during landing and take-off, they fly at 30-60 feet and move awkwardly, which has resulted in collision with power lines near stopover sites. There have been 44 recorded instances of death or serious injury resulting from such collisions since 1956, and it is the number one source of mortality for fledged cranes. Moreover, there is evidence that development near wetlands results in avoidance of otherwise appropriate habitat. If cranes avoid wind power developments in their migratory corridor, this constitutes habitat loss.

Loss of stopover habitat

Cranes primarily use palustrine wetlands for roosting, and rely on upland crops (winter wheat, corn stubble) for foraging. There is a relationship between roosting and foraging habitat, such that 67% of feeding sites are within 0.8 km of palustrine roosting sites. This wetland-agricultural land matrix is where we would see whooping cranes landing, taking off, and flying at low altitude.

Evaluating site suitability

We evaluated two fictitious wind sites in Kansas, using existing generalized area partitioning (GAP) data and Playa Lake Joint Venture data to calculate the percentage of wetlands in the project area, within the 10-mile surrounding buffer area, and the total percentage in the total area. We used a hierarchical approach, beginning first with the location of the project, then assessing its landscape relative to surrounding landscape, and finally assessing the habitat

¹ Co-authors: Eric Lubell, Alicia Oller, and Laura Nagy, Tetra Tech EC, Inc.

suitability of the project area itself.

1. **Corridor** – where is the project located, relative to the migratory corridor?
2. **Landscape** – does the project contain more wetlands than the surrounding 10-mile area?
3. **Project** – are there areas of high wetland density? What is the extent of the wetlands-agricultural matrix?

In our fictitious cases, project area 1 was located within the corridor (75% of migrating birds), while project area 2 was located along the edge of corridor (25% of birds). Area 1 has 70% of suitable wetlands, while Area 2 has 30% of the suitable wetlands in the total area. Area 2 has a broader distribution of wetlands, low-density wetlands, and more agriculture. It thus has a broader distribution of wetland-agriculture matrix than does project area 1, but has a much lower proportion of suitable wetlands than the surrounding area.

Thus project area 1 has a higher likelihood of cranes being in the vicinity during the life of a wind project, a high likelihood of serving as roosting habitat, and enough matrix to indicate that cranes, if present, would be likely to be flying at low altitudes. Project 2 has a lower likelihood of cranes being present, and relatively little roosting habitat. Yet the distribution of wetlands-agriculture matrix does suggest that cranes if present would likely be flying at low altitudes.

Conclusion

Evaluating a wind project in the context of whooping cranes is important for projects in the Midwest. Understanding the distribution of wetlands and other landscape features will allow developers to evaluate potential project sites to determine what site is likely least attractive to cranes and thus minimize risk to the species.

Questions following Presentation

Question: Have you looked at other potential risk-factors? For example, do whooping cranes tend to fly in low-visibility weather conditions? Are they attracted to lighting?

Response: Not for this analysis, but yes, there are multiple factors that will need to be considered – for example, where the transmission lines are sited in relation to the wind turbines.

Question: The USFWS model includes not only roosting and feeding habitat but also a buffer from human activity.

Response: Agreed. For the sake of this presentation, we kept it to wetlands and foraging habitat, but one could also use GIS mapping to add those kinds of factors (roads, other human activity).

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SESSION IV: MITIGATION TECHNIQUES AND TECHNOLOGY

This session focused on research to assess the effectiveness of specific mitigation strategies, and on tools for mapping bird corridors and migration movement for mitigation purposes.

Minimizing avian collisions via strategic use of FAA obstruction lighting systems

Joelle Gehring, *Michigan State University, Michigan Natural Features Inventory*¹

We know that collisions with tall structures result in bird fatalities. Tall buildings are the number one cause of fatalities (98-980 million collision fatalities per year), communications towers are second, and wind towers are third (10,000-40,000 collision fatalities per year). We also know that lighting plays a role, particularly for night migrating songbirds. These birds use stellar constellations, sunrise and sunset, and magnetic fields to help them navigate. During inclement weather, these birds are attracted to lighted structures.

Study variables

In this study, we were able to use police communications towers in the state of Michigan to evaluate the impact of different variables on collision fatalities. Having access to the police communications towers was a scientist's dream, because we were able to look at the impact of various lighting configurations on both guyed and unguyed medium-height towers and on tall towers. The lighting variations included blinking v. non-blinking, and red v. white light.

Compared with tall guyed towers, both guyed and unguyed medium-height towers are involved in far fewer mean numbers of bird fatalities. But what can we do at existing towers? This brings us back to the lighting question.

For this study, Michigan State Police changed lighting systems on communications towers on 18 towers around the state. Tall towers were fitted with red incandescent non-blinking lights. We randomly assigned several different lighting systems to medium-height towers:

¹ Co-authors: Paul Kerlinger, Ph.D., Curry & Kerlinger, LLC; Albert Manville, Jr., Ph.D., US Fish & Wildlife Service; Wallace Erickson, Western EcoSystems Technology, Inc.

- White strobe (guyed v. unguyed towers)
- Red strobe (guyed v. unguyed towers)
- Red incandescent lights (guyed v. unguyed towers)
- Guyed tower with red strobes and solid-on lights
- Guyed tower with red-blinking incandescent and solid-on lights at 1000 feet above ground level (agl)

Results

We did an analysis of variance and Fisher Least Significant Differences multiple comparisons of the numbers of bird carcasses observed at medium-height, guyed towers with different lighting systems ($P < 0.10$), using data from both the spring and fall of 2005. The towers with both red strobe and non-blinking lights were involved in more avian fatalities than all other lighting systems combined. The elimination of non-blinking red incandescent lights on medium-height towers resulted in a 50-70% reduction in fatalities.

What about tall towers?

We compared avian fatalities at tall towers with different lighting systems; specifically, white strobe, red blinking incandescent lights, and red blinking incandescent lights combined with non-blinking lights. We found that tall towers with white strobe, and tall towers with red blinking incandescent lights resulted in about the same number of bird fatalities as medium-height towers. However, tall communications towers with steady-burning red lights were a significantly larger source of avian fatalities.

The Federal Aviation Agency (FAA)'s advisory circular stipulates that any tower lit with red requires steady burning lights. But this FAA rule is based on research done three decades ago. The FAA is now going to do conspicuity testing (2009) to see if it is safe for aviators if the steady burning lights are turned off. If yes, this will give the tower industry the inexpensive and effective option of simply turning off steady lights on existing towers.

What about wind towers?

How does this relate to the wind industry? Wind towers are not required to have steady-burning lights, and all turbines are not required to be lit. A meta-analysis of avian collisions looked at per-turbine night migrant fatalities and compared lit to unlit turbines at four different wind facilities:

- Stateline, OR/WA
- Wisconsin
- High Winds, CA
- Vansycle, OR
- Nine Canyons, WA

Overall per turbine night migrant fatalities at these facilities were one per year or fewer, and there was no difference in fatalities between lit and unlit turbines at any of these sites.

Other variables

In addition to tower and turbine lighting, another variable to consider is external lighting of wind farm infrastructure, which should be minimized. Future considerations include the question of whether an increase in turbine height will lead to an increase in turbine lighting, as well as the question of what lighting will be required for offshore wind development to prevent navigation hazard, and the potential for avian attraction/collisions to result.

We also need to learn more about how bats are affected by these lighting variables.

Reducing bat fatalities at wind energy facilities by changing turbine cut-in speed

Ed Arnett, *Bat Conservation International*

The idea of seasonal shut-downs or turbine operation curtailment is not a new one – although this mitigation option was not well received when first brought up in 2004, we have since come a long way. Why curtail operations if bats hit non-moving turbines? Bats generally do not hit non-moving objects, but there are records of strikes with buildings, towers and other human-made structures, but not nearly to the extent that birds do. The Mountaineer and Meyersdale data sets included one turbine (#11) with no bats found; this turbine was non-operational, whereas the mean number of fatalities found at operational turbines at Mountaineer was 10.6. Evidence from the Casselman wind energy site supports this: during a 20-day period when turbines were not operational, only one old bat skeleton was found.

Thermal imaging videos of bats flying around a wind turbine on low-wind night demonstrate that bats are not striking non-moving turbines, but are being struck by moving blades. The majority of bats are struck on low-wind nights when bat activity is higher and when turbine blades are spinning at or near full rotation.

This suggests that bats are not flying into stationary objects, and that curtailing turbine operation during low-wind periods could reduce fatality. A hypothetical analysis using the 2004 data from Mountaineer and Meyersdale indicated that curtailment during night when median wind speed was <6 m/s between sunset and sunrise would have reduced 85% of fatalities at Mountaineer and 82% at Meyersdale. As a practical matter, however, we cannot predict what the median wind speed will be over a given night. So the question becomes “does changing the cut-in speed of turbines reduce bat fatalities?”

Curtilment research to date

The results of a curtilment study conducted in Germany in 2006 were publicly presented, but the data have not been published. When the cut-in speed was changed to 5.5 m/s, a 50% fatality reduction was found.

A similar study conducted in South Alberta (Baerwald, Barclay), looked at 19 experimental turbines for which the cut-in speed was increased, and also at 10 control turbines. There was no difference in the fatalities between the two sets of turbines before the cut-in speed was changed. After the change, researchers found a 58% reduction in fatalities at the experimental turbines.

Casselman study

BWEC implemented the first U.S.-based experiment on the effectiveness of changing turbine cut-in speed on reducing bat fatality at wind turbines at Iberdrola’s Casselman Wind Project in Somerset County, Pennsylvania. The objectives were to 1) determine the difference in bat

fatality at turbines with different changes in the cut-in-speed relative to fully operational turbines, and 2) determine the actual economic costs of the experiment and estimated costs for the entire project area under different curtailment prescriptions and timeframes.

Study design

Twelve of the 23 turbines at the site were randomly selected for the experiment and we employed three turbine treatments with four replicates of each treatment on each night of the experiment: 1) fully operational, 2) cut-in speed at 5.0 m/s (C5 turbines), and 3) cut-in speed at 6.5 m/s (C6 turbines). A completely randomized design was used and treatments were randomly assigned to turbines each night of the experiment, with the night when treatments were applied being the experimental unit.

Daily searches were conducted at these 12 turbines from 26 July to 10 October 2008. During this same period, daily searches also were conducted at 10 different turbines that were part of a different study effort to determine if activity data collected prior to construction with acoustic detectors can predict post-construction fatalities, and to meet permitting requirements of the Pennsylvania Game Commission's (PGC) voluntary agreement for wind energy (herein referred to as "PGC" turbines). These 10 turbines formed an alternative 'control' set to the curtailed turbines.

Analyses conducted

Two different analyses were used to evaluate the effectiveness of changing turbine cut-in speed to reduce bat fatalities, one using the 12 turbines in the study designed to determine differences in fatality between the two curtailment levels, and one using 22 turbines designed to determine differences in fatality between curtailment and fully operational turbines. The experimental unit in the first analysis was the turbine-night and turbines were considered a random blocking factor within which all treatments were applied. In the first analysis, the total number of bats estimated to have been killed the previous night (herein referred to as "fresh" fatalities) in each treatment at each turbine was modeled as a Poisson random variable with an offset of the number of days a treatment occurred within a turbine (due to the slight imbalance of the design).

For the second analysis, the turbine was the experimental unit, with 12 turbines receiving the curtailment treatment, 10 the control (fully operational at all times). All carcasses found at a turbine were used to estimate the total number of bat fatalities that occurred at each turbine between 26 July and 10 October 2008 and fatalities were compared using one-way ANOVA.

Findings

A total of 32 fresh bat fatalities were found at the 12 treatment turbines between 26 July and 10 October 2008. Each treatment was implemented at each turbine at least 25 nights, with one treatment implemented for 26 nights. At least one fresh fatality was found at each turbine, and 10 of the 12 turbines had at least 1 fatality during a fully operational night, indicating that fatalities did not occur disproportionately at only some turbines, but were well distributed

among all turbines. There was strong evidence that the estimated number of fatalities over 25-26 nights differed among turbine treatments ($F_{2,33} = 8.99$, $p = 0.008$).

There was no difference between the number of fatalities for C5 and C6 turbines ($\chi_1^2 = 0.83$, $p = 0.3625$, 95% CI: 0.11, 2.22). Total fatalities at fully operational turbines were estimated to be 5.4 times greater on average than at curtailed turbines (C5 and C6 combined; $\chi_1^2 = 14.63$, $p = 0.001$, 95% CI: 2.28, 12.89). Estimated bat fatalities per turbines were 1.56 to 3.28 times greater (mean = 2.26) at PGC turbines relative to curtailed turbines, further supporting the contention that reducing operational hours during low wind periods reduces bat fatalities.

Economic impact of curtailment

The lost power output resulting from the experiment amounted to approximately 2% of total project output during the 76-day study period for the 12 turbines. Hypothetically, if the experimental changes in cut-in speed had been applied to all 23 turbines at the Casselman site for the study period (approximately ½ hour before sunset to ½ hour after sunrise for the 76 days we studied), the 5.0 m/s curtailment used would have resulted in lost output equaling 3% of output during the study period and only 0.3 % of total annual output. If the 6.5 m/s curtailment were applied to all 23 turbines during the study period, the lost output would have amounted to 11% of total output for the period and 1% of total annual output. In addition to the lost power revenues, Iberdrola also incurred costs for staff time to set up the processes and controls and to implement the curtailment from the company's offsite 24-hour operations center.

Next steps

BWEC plans to initiate a second year of post-construction fatality searches at the PGC turbines beginning 1 April and continuing through 15 November 2009 and will initiate searches for the curtailment study beginning in mid- late July and continuing through the second week of October in 2009 at the Casselman facility.

A key question is "How much of a fatality reduction is enough?" Fifty percent? Seventy-five percent? Biologically, 50-92% certainly would seem to be biologically significant, but population impacts remain unknown at this time. Implementing curtailment options must balance biological, financial, and policy-related issues (e.g., renewable portfolio standards), and will vary among facilities and regions of the country.

Questions following Presentation

Question: Prior to cut-in speed, were blades stopped from rotating (free-wheeling)?

Response: They were feathered, so for all practical purposes, yes, they were not rotating. On low-wind nights, you have no treatment, which is why you have to look at all contact hours.

Question: Any idea from Germany, Alberta, Casselman about the change in output?

Response [Andy Linehan. *Iberdrola*]: The cost was about \$20,000 for doing the experiment, about 2% of Casselman project revenues, which is what we predicted. We would be looking at 3-4 times that amount if the treatment was applied for the entire project, but we're still crunching the numbers.

Question: Did you look at habitat and proximity to forest-edge?

Response: Fatalities were at least as high on mine-reclaimed site as on forested ridge (my sense).

Question: Importance of dogs to searcher efficiency?

Response: We published paper on that in 2004 – the dogs are extremely useful.

Question: Was curtailment implemented from sunrise to sunset? Depending on the bat species of concern, that curtailment period potentially could be reduced. If you did not have to do it all night, that would reduce the economic impact.

Response: We did the experiment from an hour before sunset to an hour after sunrise. This is why we're doing observations with radar and thermal imaging – to get a better fix on bat activity and when bats may be at risk.

Question: What's the next step?

Response: We need to look at different regions, different habitats and conditions. Once we get these data reported, we'll do a second year, reevaluate our study-design, and maybe make some alterations, use different tools.

For more info about BWEC, www.batsandwind.org.

Tools for mitigating the impact of wind power generation on birds and bat collisions in Isthmus of Tehuantepec, Mexico

Rafael Villegas Patraca, *Institute of Ecology*

Wind energy is a relatively new development in Mexico. Mexico's National Electricity Company (CFE) along with Iberdrola and other private Spanish wind energy developers, are working to develop several large-scale wind farms on the Isthmus of Tehuantepec in Oaxaca – one of the largest wind resource corridors in Latin America. Tehuantepec is also an important hawk migration corridor. During migratory season, 2.5 to 4 million raptors pass over this isthmus, creating a situation with a serious potential for environmental conflict.

The World Bank, which is supporting construction and operation of La Venta II wind power facility on the Isthmus of Tehuantepec, agreed to pay for an environmental impact study conducted in cooperation with Semarnat (Mexico's environmental agency) and CFE. The study included pre-and post-construction monitoring, utilizing radar to detect the approach of large migrating flocks, on-site observations of bird activity to determine exposure risk while birds are passing through the wind farm, and fatality monitoring to estimate bird and bat collision fatalities. The aim of this research was to assess the effectiveness of scheduling temporary turbine shut-downs based on early detection of approaching flocks using marine radar.

Methods

We used three different methods for this study:

1. Marine radar was used to detect large numbers of birds approaching the isthmus during the peak daytime hours of the peak migratory season (45-day period in March-April and a 75-day period in the fall).
2. On-site observers during the same period performed bird counts and made identifications as to species – in part to confirm that the radar targets were in fact birds, and to get both count and species information as well as determine whether birds migrating through the wind farm site were within or above the turbine rotor swept area (risk zone). Both diurnal and nocturnal radar were used to help assess flight altitudes within the wind park.
3. Bird and bat fatality monitoring was carried out by walking (and bicycling) transects to count and identify dead birds and bats. (Dogs were also used to help locate carcasses.)

Acoustic monitoring, mist netting and bird and bat banding, bird nest and bat cave searches were also used to about use of the site by local as well as migratory species. (The radar "early alert" system does not apply as a mitigation measure for local sparrows, shorebirds, passerines, and other local species.)

Findings

A total of 102 species of birds and 16 species of bats were identified using the wind park site, and 49 bird nests were identified. Under Mexican law, 16 of the bird species identified at the La Venta II site have conservation status, and one species of bat is considered at risk. (Another 12 species are considered at risk by the International (ICUN?)

The preliminary test of the “early alert” marine radar method showed 84 hours of potential shut-down during both (fall and spring) migration periods. However, of the 3 million birds identified by radar as approaching the wind park, only 32% actually pass through the park. Of these, 13% were flying between 25 and 72 m altitude (high risk altitude). On-site surveys showed 36% of all wildlife interactions (including local species as well as migrants) occurring within the rotor risk zone.

A total of 97 bird carcasses (comprising 19 species) were found during the transect searches, and 67 bat carcasses (comprising 16 species).

Next steps

The economic cost of temporary turbine shut-down should be minimized through careful scheduling of turbine maintenance. The challenge is that peak wind production occurs in late October, which coincides with the fall migration period. Another consideration is that the radar alert method does not work for local birds.

This fall season (2008), we will be using night vision goggles and looking at impacts on other vertebrates (non-flying mammals, amphibians, and reptiles).

This mitigation tool has been developed as part of a contingency plan in the environmental manual for the operating life of La Venta II. We are also looking at night lighting. (Tower lighting is required by law in Mexico, and is currently recommended as a bird mortality reduction measure. White strobe lights are used, with the longest possible interval between pulses, and the pulses synchronized for all turbines within the wind farm.) However, the main protocol being employed is the use of temporary shut-downs in response to “early-alert” radar detection of approaching flocks. In practical circumstances, mitigation will likely consist of a collection of techniques, which may vary on a site-to-site basis.

Questions following Presentation

Question: Do you have breakdown of different types of birds found as carcasses – songbirds, shorebirds, etc.?

Response: Raptors found included kestrel, white-tailed hawks, and turkey vultures; we also found passerines and shorebirds.

Question: You noted that you have three million raptors coming through. What kinds of

numbers for shorebirds, etc.?

Response: There are about 10 million migrating birds of all kinds passing through the whole isthmus.

Question: Is La Venta's risk typical of the other wind parks in the area?

Response: La Venta is in the corner where there is a major hawk corridor. Other developments have some hawks passing, as well as some seagulls and passerines.

NEXRAD: a resource for evaluating bird migration

Manuel Suarez, Robert Kratt, Eileen Kirsch, Melissa Meier, *U.S. Geological Survey*
Patricia Heglund, *U.S. Fish and Wildlife Service*

The NEXRAD network of WSR-88D radars produces publicly available data for weather stations all over the country. The types of signals that you can see with NEXRAD include: broad front songbird migration, migrating geese, and mayfly hatches (see accompanying slides).

We are primarily interested in the use of radar in the study of bird migration, and the usage of stopover locations from year to year. We collected weather radar data for nine stations in Wisconsin and surrounding states for the years 2002-2007, both spring (April-May) and fall (September-October). This amounted to approximately one terabyte (TB) of data. As a proof of concept, we developed a prototype software tool to visually summarize the radar reflectivity across years using synchronized animations.

The purpose of such a tool is to allow scientists to visually scan through vast amounts of radar data, and then to focus their energy on particular sites and times of interest. We would like to expand its use and functionality to make it more accessible, and to link the animations to raw data. Currently a few background layers, both imagery (e.g. topographic relief) and line work (e.g. rivers, political boundaries) are incorporated, both of which we would like to expand to arbitrary user layers, e.g. power lines and wind turbines. Ultimately we envision an application which blends the benefits of highly interactive, synchronized, temporal animations with the power of GIS.

Using NEXRAD for mapping bird migration corridors to mitigate some effects of wind energy development

Richard Sojda, *U.S. Geological Survey*¹

A site characterized as an agricultural field may not at first glance appear biologically important, but if migrating birds make use of the site as stopover [slide shows photos of cranes in crop stubble at the base of a turbine], there are implications for that site's suitability for wind energy development. This presentation is based on research that a computer science master's student (Reginald Mead) is doing to develop a decision-support toolbox that includes the use of NEXRAD data to map bird migration.

Experts are able to interpret NEXRAD images to get information about bird activity. Given the large number of NEXRAD sites around the country, this is a resource with the potential to contribute to our understanding of bird migration. The difficulty is the time that it takes to sift visually through radar scans to find biological activity. By automating the data analysis process and using machine learning programs, we are now able to identify biologically interesting radar sweeps. Using sweeps identified by experts as prototypical examples of sweeps that are "all weather" v. "all birds", we hope to create algorithms that can sift through the tera and petabytes of information NEXRAD stations provide.

NEXRAD data organization and characterization

NEXRAD data are organized in a three-dimensional hierarchy rooted at the volume, that is, a complete scan of the three-dimensional space around a radar installation. Volumes are divided along elevation angles into multiple sweeps, and sweeps are further subdivided into rays, which are analogous to spokes on a bicycle. [See slide #10.]

A single unit of three-dimensional space within the volume is called a pulse volume. There are hundreds of thousands of pulse volumes within the entire 3D space scanned by a single radar. Each pulse volume is characterized by three features:

Reflectivity – a measure of returned signal strength, or echo, normally given in decibels (dBZ), which is a nonlinear function of target size [slide #14]

Radial velocity – which measures the direction of a moving target (towards or away from the radar)

Spectrum width – which measures the variability of velocity within a pulse volume

¹ Co-authors: Reginald Mead and John Paxton, Montana State University; Robert H. Diehl, University of Southern Mississippi; Eileen M. Kirsch, USDI-Geological Survey, Upper Midwest Environmental Sciences Center; Albert Manville, USDI-Fish & Wildlife Service, Office of Migratory Bird Management

Derived features

Derived features are statistics describing the neighborhood of a pulse volume. We derive three “second order” features for each of the three base features (reflectivity, radial velocity, and spectrum width). The second order features are *variance*, the classical measure of variation familiar to scientists; *skewness*, a measure of skew or lop-sidedness; and *kurtosis*, a measure of “peakedness” in the values.

Pre-processing the data

Before the data can be analyzed, it is first necessary to remove clutter and ambiguous data, to re-align the azimuth, etc. We select a 0.5 elevation angle sweep from the volume, and construct pulse volumes by spatially aligning the features. Pulse volumes are then filtered by: removing clutter-prone data (the first 20 km); removing velocity ambiguous data (145 km); removing bad or range-folded reflectivity values; and clearing bad or range-folded Doppler values. We then calculate the second-order features.

Our algorithm

The first step is to have human experts select prototypical examples of biological and non-biological sweeps to be used as training data. Machine learning classifiers are trained using these training data, which appear to the classifier as a stream of pulse volumes, each having the classification of its parent sweep. Ten-fold cross-validation is used to determine the classification accuracy of the machine learning algorithm.

Classifiers used

We worked with three types of artificial intelligence (AI) classifiers: K-nearest neighbor; naïve Bayes, and a neural network classifier. [See slides #22-24.]

Validation process

We performed a ten-fold cross-validation by randomly dividing the training data into ten groups, then training the classifier using nine of the groups. The accuracy of the classifier is then tested (verified) using the remaining group. We repeat this process ten times, leaving out a different group each time.

Recent results

We now have four data sets including the original data, but so far have tested only the first three. The second and third data sets are more complex than the original set. The fourth data set is an entire migration season without specific training data. Average classification accuracy for the K-nearest neighbor classifier was 88%, while naïve Bayes and the neural network classifiers were 85% accurate in classifying sweeps. We are now applying these classifiers to more complex data.

The naïve Bayes and neural network classifiers required a fraction of the time required by the K-nearest neighbor classifier. However, our new server allows us to use all pulse volumes from

the 40 test sweeps rather than having to subsample, improving the accuracy of the neural network classifier to 91%.

Next directions

The initial training data were prototypical, potentially producing overly-optimistic results. Next we'll apply the algorithm to broader assortment of locations and weather patterns. We will need to develop segmentation and boundary detection techniques to enable validation for sweeps containing mixed data (both biological and non-biological targets – e.g., birds or mayflies as well as clouds/precipitation). We also want to expand the spatial and temporal capabilities of the algorithm, facilitating investigations of bird migration patterns in three spatial dimensions as well as in time.

We already have NEXRAD data downloaded for Fall 2007 and Spring 2008 for Great Falls, Montana, and Green Bay and Milwaukee, Wisconsin. This hourly data amounts to 12,437 individual sweeps, or 560 million individual pulse volumes. This resulted in 23 GB of data once second order features were calculated and added to the database.

We plan to collect additional field data, specifically on geese. [Slide #34 shows NEXRAD stations from which data will be collected to look at goose migration in five different locations across the United States.]

By using the digital elevation models and subtracting the bottom of pulse volume values, we can identify when geese are within the airspace corresponding to the pulse volume. Slide #38 shows the overlap between the Green Bay and Milwaukee NEXRAD sweeps. The aim here is to identify what's going on in the individual pulse volumes within that sweep.

Our plan is to provide peer reviewed methods in the public domain. We would also like to better delineate migration corridors, show temporal shifts, if any, in those corridors, come up with better ways to display the results of classifying large numbers of sweeps visually, and develop a decision support toolbox to help wind developers identify migration staging areas.

Decision Support Toolbox

In addition to our NEXRAD research, we are developing a decision support toolbox which can help assess waterfowl and crane movements in landscapes where wind energy development is being considered. Such a toolbox would be capable of helping:

- Evaluate what species are vulnerable within a given landscape;
- Evaluate where a group of turbines should be placed to minimize effects (including habitat avoidance) on birds;
- Evaluate how individual turbines might be managed to minimize mortality based on factors such as timing of migration, diurnal flight patterns, life stages and age structure of the flock, geomorphology, and weather patterns;

Simulate alternative turbine locations within the landscape.

Such a toolbox would need to provide a visual display (in four dimensions) of simulated movements from roosting and loafing concentrations to feeding sites; the three-dimensional risk birds encounter while making local movements in relation to wind turbines; and overall habitat use/avoidance in relation to groups of turbines. It should provide a map of overall risk to birds from a wind energy development. We hope to create this tool, using portable marine radar, or visual observations to know more precisely where the birds are.

Websites of interest – working collaboratively –

<http://www.fort.usgs.gov/Radar>

<http://nrmsc.usgs.gov/science/nexrad>

<http://crane.cs.montana.edu/nexrad> (Reggie Mead's site)

Questions following Presentation

Question: Given the geographic area included in the sweep, can you tell within what proportion of that area birds are flying?

Response: Yes. The lowest elevation (half degree) is the only one that provides local information of any significance.

Response [Manuel Suarez]: We are trying to model the in-between spaces, but we don't have the radar coverage.

Comment [Ron Larkin]: You presented a slide showing coverage at the height (top of rotor swept height), about 40 km out from the radar. You have to find radar close to where the wind turbines are.

Response: We are not trying to look at wind sites in this case, but rather at bird migration patterns.

Radar observations of birds traveling through mountains

Ronald P. Larkin, *Illinois Natural History Survey, University of Illinois*

The large weather radar (NEXRAD) data are not useful in mountainous areas (Larkin and Kamen 2007¹ report). What we are concerned with here is distinguishing bats (which are a great concern, in terms of potential wind turbine impacts) from flying animals of little or no concern, such as arthropods. We also need to concern ourselves with measuring flight height; animals flying over 150 m above ground level are not likely to interact with turbines.

Our objectives

We have several research objectives:

1. Find out the effects of topography and weather on flying vertebrates
2. Come up with useful techniques for remotely observing migrating birds and bats at night
3. to identify radar techniques other researchers can use to discriminate flying birds, bats, and insects
4. Describe what happens when birds and bats encounter a mountain ridge
5. Come up with guidelines applicable to pre- and post-construction studies

Study sites

We have two study sites in Vermont. Stationary beam and tracking radar are positioned 209 m below summit. (We used a ski slope because we needed a clear area, though in this case we are limited in scope by trees on either side of the ski slope.) The stationary beam radar (a modified Furuno 7252) is used like a flashlight pointing up at the sky. A new tracking radar (WF-100) is used to follow specific animals; it has to be manually pointed at the moving target, then it automatically tracks the target without further human intervention. The tracking radar can focus and track an object the size of a grapefruit nine miles away.

For details on the methods – Robert Diehl and Ron Larkin will give a half-day symposium on these techniques in early November 2008.²

Preliminary data

These are very preliminary data from the 11,000 data files that we were able to gather on 20 of 27 nights in August-September 2008. Slides #9 and 10 each show two presentations of the same data. In both slides, specific bands (shaded in light yellow) of the data displayed in the first and third pictures are expanded in the 2nd and 4th pictures, respectively. For the first data

¹ Report can be found at:

<http://www.refworks.com/refshare/?site=023461151737200000/RWWS1AA1388651/Illinois%20Natural%20History%20Survey%20Technical%20Reports> under “Larkin”

² See Ron Larkin’s website for pertinent information: <http://detritus.inhs.uiuc.edu/~rlarkin/>

set (slide #9), we can tell from the expanded picture that the target is a bird by looking at the wing beat pattern (18.8 beats/sec). For the second data set, we see a different pattern (10.6 beats/sec) that is irregular.

The tracking data allows us to watch birds and bats approach the mountain, climb to a higher elevation, level off, climb, level, etc. A Google-earth type horizontal view presents targets of the type that would show up on weather radar, because they are well-above mountain peaks (and would be above turbine blade tips). Because the tracking radar allows us to follow the target, we can see that a target that appears to not be climbing as it approaches the mountain, is in fact beyond the mountain, going past it.

Slide #17 (two pictures in one slide) shows us how high a bird climbs as it approaches the mountain and also its clearance over the mountain ridge. The picture in the lower corner shows a mountain where a wind permit was denied because of insufficient knowledge of bird and bat behavior. (Clearance at the ridge is shown to be 135 m.)

Slide #18 shows various passages over the ridge, but the purple path shows a bird flying at very low elevation above the saddle.

The graph in slide #19 shows the distribution of targets approaching the mountain at various heights. This allows us to see what proportion of targets are approaching at or below the summit or turbine blade tip elevation.

Questions following Presentation

Question: Were you keeping track of naked eye visibility conditions? Moonlight? Snow?

Response: Yes, we keep track of cloud, moon, and visibility conditions. This is a very dark mountain in NE Vermont. There was no snow at this season.

Question: The last slide indicates you are equally sampling all of these altitudes – how do you do that?

Response: The beam is at various widths at various heights. Radar loses sensitivity as inverse of 4th power of the range. We can reach out to 2 km even with a small pencil beam radar, but we do have to work corrections into the data processing.

The speed at which birds pass through the beam can affect our ability to identify the target – we have to come up with wing beat information from the time they're in the beam.

Question: Are you associating radar targets with species?

Response: We can tell large from small, and we can come up with rough taxonomic categories, but we may not be able to get much farther than that.

Question: How much time is there for post observation analysis to get these trajectories?

Response: We can get trajectories while we're tracking. How high above the earth is it, how is it interacting with topography – that's the harder question. The field work is arduous, but most of the work comes in the data analysis.

Question: Are you tracking one bird at a time, or can you follow more than one bird?

Response: One bird at a time. If we had military radar equipment, we could track hundreds of birds at a time, but we consider ourselves lucky to have this equipment – it's the only tracking radar of its kind in the western hemisphere.

Question: Any impact from the communication cell tower on that site?

Response: There is a microwave tower on top of Mt. Burke. We didn't have any interaction with that tower, and the slight curve of the mountain made it so that we couldn't actually see the tower from our tracking position. It did not affect our accuracy.

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DISCUSSION: REMAINING RESEARCH, POLICY, AND ACTIVITY NEEDS

The facilitators solicited insights from participants at the end of Day 1, and asked for participants to identify key themes of the conference at the end of Day 2. Participant observations from both days are outlined below.

On Thursday, October 30, 2008, the NWCC Wildlife Workgroup Core Group (along with several observers) met to take up these themes, identify next steps, and to discuss and agree on the workgroup's 2009 work plan. The summary of this meeting can be found at: <http://www.nationalwind.org/events/meetings/WildlifeWorkgroupMeetingOctober2008SummaryFINAL.pdf>.

Insights from Day 1:

This was a much more science-oriented meeting than it was a policy discussion. This is a rare opportunity in this arena. There are a lot of places where you can discuss policy, but getting the science is really valuable.

That said, we do need to bridge the gap between the science and application. So a little summary at the end of each talk with implications of the scientific findings presented would be helpful.

Great meeting – a lot to be learned here. The papers reinforced the importance of accurately estimating fatalities in evaluating the effect of wind energy development on wildlife. A number of yesterday's papers were model-based. As the saying goes, "all models are wrong; some are useful" – this is beginning of making improvements, but further development and field evaluation of models are needed.

We still haven't linked bat fatalities to preconstruction data.

Cumulative effects, landscape-scale issues – too often some of us are naïve in thinking it's going to be "wind power or nothing" – there are some parts of the U.S. where properties are going to be developed in some manner; the question for wildlife impacts then becomes one of comparing the relative impacts.

We need more focused studies on displacement effects.

There should be more emphasis on regional and local bat population studies, so that bat fatalities can be placed in context.

There are two approaches to bat mortality estimates, diurnal v. nocturnal – we need come to agreement on how we are estimating bat mortality, be more consistent.

How effective is radar [for measuring bird use] during rain events?

We need to know more about the displacement effects of wind developments on grassland birds.

Wind is being installed faster than our understanding is growing – we may need to make a leap into estimating population effects for bats – maybe jumping ahead to what turbine curtailment would accomplish.

We have made advances in how we estimate mortality and displacement effects. Yet we are still seeing studies using old approaches – which studies are we using to do meta-analysis?

Themes identified at the end of Day 2:

Pre-construction methods should be thoroughly assessed.

There is a need for standardization of pre-construction methods, pre- and post-construction metrics.

Cumulative impacts and habitat merit more attention, while less attention is needed on fatalities.

There is a need for more mitigation research and a suggestion to possibly redistribute funds currently going to fatality research.

Outreach to policymakers is needed.

There is a need to better utilize the following resources in understanding population effects: regional/local species experts, transmission experts familiar with impacts to wildlife, and ecologists outside of the energy field.

It is important to educate developers about the management implications of research.

Presentations at research meetings should include a statement of data limitations (e.g., study duration, seasonality, inter-year variation).

There is a need for consensus on acceptable levels of fatalities and how to balance study goals and budgets.

There is a need for a data repository to assist agencies; however, these questions must be addressed: what data to include, who has access to it, how to protect developer privacy and business interests. Need to develop a protocol for sharing this information.

Poster Presentations

The following poster presentations were displayed at the conference. Contact individual participants (Appendix B) for more information.

Nocturnal avian flight heights relative to risk of collision with wind turbines
S.K. Pelletier, A.J. Gravel, and T.S. Peterson, Stantec Consulting, Topsham, ME

Preconstruction bird and bat surveys, the case for standardized protocol development
William P. Mueller, Joshua M. Kapfer, PhD., and Brian R. Bub, Natural Resources Consulting, Inc., Cottage Grove, WI

The Wild Horse challenge: shrub-steppe restoration and lithosols on Whiskey Dick Mountain
Jennifer Diaz, Puget Sound Energy; co-authors: Ron Bockelman, David Evans and associates; Brent Renfrow, Washington State Dept of Fish and Wildlife; David Bradney, Wildlands, Inc.; Denise Horton, botanist.

Effects of wind energy development on greater sage-grouse ecology
Christian A. Hagen, Oregon Dept. of Fish and Wildlife

Trade-offs in the design of avian surveys: does increasing point count duration provide more information?
Jason Jones, Laura Nagy, and Lynn Sharp, Tetra Tech EC, Inc., Boston, MA

A comparison of cumulative impact analysis methodologies and assumptions
...Wind farms using avian radar
Laura Nagy, Jason Jones, and Lynn Sharp, Tetra Tech EC, Inc., Boston, MA

Framework for mitigation of bird and bat strike risk at wind farms using avian radar and SCADA interface
T. Adam Kelly and Jenny K. Fiedler, DeTect, Inc.

Bird and bat mortality at a central New York wind resource area
Aaftab Jain, Paul Kerlinger, Richard Curry, Linda Slobodnik, Curry & Kerlinger, Ltd.

Lake Michigan's offshore reefs: can wind turbines and lake trout coexist?

John Janssen (WATER Institute, University of Wisconsin-Milwaukee; and Jory Jonas, Michigan Department of Natural Resources, Charlevoix, MI

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APPENDIX A – FINAL MEETING AGENDA

Purpose:

- To hear about the most recent wind-wildlife research pertaining to wildlife fatalities; cumulative and habitat impacts, and mitigation techniques and technologies.
- Assess how research results pertain to existing questions or impact current beliefs and understandings.
- Prioritize remaining research needs and discuss avenues for supporting needed research.

Day 1 – Tuesday, October 28, 2008 – Wind Wildlife Research Meeting VII

7:30 am	Conference Registration & Continental Breakfast	Location: <i>We Energies Headquarters, Auditorium</i>
8:30am	<u>Welcome</u>	<p><i>Rick Kuester, Executive Vice President, Wisconsin Energy Corporation and President and CEO, We Generation</i></p> <p><i>Gloria McCutcheon, Wisconsin Department of Natural Resources</i></p> <p><i>Abby Arnold, NWCC facilitator</i></p>
8:45 am	<u>Introductions and Overview</u>	
	<ul style="list-style-type: none"> ▪ Review meeting purpose ▪ Review & adopt agenda ▪ NWCC Wildlife Workgroup overview 	
9:00 am	I. <u>Sector Updates</u>	
	<ul style="list-style-type: none"> ▪ Updates on non-research activities underway in the US <ul style="list-style-type: none"> ▪ Recently completed Oregon guidelines and the ongoing Washington guidelines update process; brief review of cumulative impacts research and related recommendations in appendix to the Oregon guidelines ▪ Overview and update on American Wind Wildlife Institute ▪ Update on US Fish & Wildlife Service’s Wind Turbine Guidelines Federal Advisory Committee ▪ Association of Fish & Wildlife Agencies activities and the status of wind in states ▪ Western Governors Association wildlife initiatives associated with Western Renewable Energy Zones efforts 	<p><i>Suzanne Leta Liou, Renewable Northwest Project</i></p> <p><i>Ron Helinski, American Wind Wildlife Institute</i></p> <p><i>Dave Stout, US Fish & Wildlife Service</i></p> <p><i>Celia Greenman, Colorado Division of Wildlife</i></p> <p><i>Carl Zichella, Sierra Club</i></p>
10:00 am	Q&A	
10:15 am	BREAK	
10:30 am	II. <u>Fatality Impacts to Birds & Bats</u>	
	<p><i>Updating summaries of avian and bat mortalities from wind energy facilities</i></p>	<p><i>Wally Erickson, Western EcoSystem Technology, Inc.</i></p>
11:00 am	Q&A	

11:10 am	<i>Big Horn Wind Power Project Fatality Monitoring Results, Comparison to Pre-Construction Avian Use Estimates and working with a TAC</i>	Scott Downes, Northwest Wildlife Consultants, Inc.
11:40	Q&A	
11:55 pm	LUNCH	
1:00 pm	II. <u>Fatality Impacts to Birds & Bats (cont'd)</u> <i>Estimating Avian & Bat Mortality and Identifying Spatial and Temporal distribution of avian and bat mortality at a utility-scale wind energy development</i>	Amanda Miller, Tetra Tech
1:30 pm	Q&A	
1:40 pm	<i>Development of predictive models for estimating numbers of bird fatalities resulting from collisions with meteorological towers and wind turbines at wind energy developments</i>	Jonathan Plissner, ABR, Inc
2:10 pm	Q&A	
2:20 pm	<i>Estimating Survey Effort Required for Precise Estimates of Bat Activity at a Wind Energy Facility in Southern California</i>	Ted Weller, U.S. Forest Service
2:50 pm	Q&A	
3: 00 pm	BREAK	
3:30 pm	II. <u>Fatality Impacts to Birds & Bats (cont'd)</u> <i>Spatial Patterns of Nocturnal Bird Migration in the Central Appalachians</i>	Deanna Dawson, U.S. Geological Survey
3:45 pm	Q&A	
3:50 pm	<i>Comparing the accuracy and precision of three different estimators of bird and bat fatality and examining the influence of searcher efficiency, average carcass persistence and search interval on these.</i>	Manuela Huso, Oregon State University
4:20 pm	Q&A	
4:25 pm	III. <u>Cumulative Impacts and Impacts to Wildlife Habitat and Behavior</u> <i>The Influence of Ridge Top Habitat Manipulations on Bat Activity & Species Composition at a Proposed Wind Facility in South-Central Pennsylvania</i>	Michael R. Schirmacher, Bat Conservation International
4:55 pm	Q&A	
5:05 pm	<i>Determining where, in eastern North America, there is the greatest potential for conflict between Golden Eagles and wind power development.</i>	Charles Maisonneuve, Ministère des Ressources naturelles et de la Faune; and Tricia Miller, Pennsylvania State University and Carnegie Museum of Natural History
5:35 pm	Q&A	
5:45 pm	<u>Announcements and Adjourn to Poster Reception</u>	

Day 2 – Wednesday, October 29, 2008 – Wind Wildlife Research Meeting VII

8:00 am	<u>Registration & Continental Breakfast</u>	
8:30 am	III. <u>Cumulative Impacts and Impacts to Wildlife Habitat and Behavior (cont'd)</u> <i>Displacement Effects of Wind Developments on Grassland Birds in the Northern Great Plains.</i>	Jill Shaffer, U.S. Geological Survey

9:00 am	Q&A	
9:10 am	Prairie grouse display ground and nest distribution and population trends relative to wind generator complexes in northwestern Minnesota and the sandhills of Nebraska.	John E. Toepfer, Society of Tympanuchus Cupido Pinnatus, Ltd.
9:40 am	Q&A	
9:50 am	<i>Refining the Protocol for a Rapid Assessment Methodology for Wind Development, and Developing a Matrix/Key to Integrate Pre- and Post-construction Monitoring for Commercial Wind Projects Based on Risk.</i>	Al Manville, U.S. Fish & Wildlife Service
10:20 am	Q&A	
10:30 pm	BREAK	
11:00 am	III. <u>Cumulative Impacts and Impacts to Wildlife Habitat and Behavior</u> (cont'd)	
	<i>Impact of wind turbines on the migration of raptors in Baie-des Sables, Quebec</i>	Michael Ross, McGill University
11:15am	Q&A	
11:20 am	<i>Lesser Prairie-Chicken Conservation and Wind Development in the Texas Panhandle</i>	Jon T. McRoberts, Texas Tech University
11:35 am	Q&A	
11:40	<i>Using Geographic Information Systems (GIS) and available habitat data to evaluate the potential of a proposed wind power project area to serve as stop-over habitat for migrating cranes.</i>	Karl Kosciuch, Tetra Tech EC, Inc.
11:55 am	Q&A	
12:00 pm	LUNCH	
1:15 pm	IV. <u>Mitigation Techniques and Technology</u>	
	<i>Minimizing Avian Collisions Via Strategic Use of Federal Aviation Administration Obstruction Lighting Systems</i>	Joelle Gehring, Michigan State University
1:45 pm	Q&A	
1:55 pm	IV. <u>Mitigation Techniques and Technology</u> (cont'd)	
	<i>Reducing Bat Fatalities at Wind Energy Facilities by Changing Turbine Cut-in Speed</i>	Ed Arnett, Bat Conservation International
2:25 pm	Q&A	
2:35 pm	<i>Wildlife Mitigation Tools of Wind Power Generation Impact in Birds & Bat Collisions in Isthmus of Tehuantepec, Mexico</i>	Rafael Villegas-Patracca, Institute of Ecology
3:05 pm	Q&A	
3:15 pm	BREAK	
3:45 pm	<i>NEXRAD: A Resource for Evaluating Bird Migration</i> <i>Using NEXRAD for Mapping Bird Migration Corridors to Mitigate Some Effects of Wind Energy Development</i>	Manuel Suarez, U.S. Fish & Wildlife Service Richard Sojda, U.S. Geological Survey,
4:15 pm	Q&A	
4:25 pm	Late-breaking research: <i>Flight behavior of birds and bats approaching mountains in Vermont</i>	Ron Larkin, Illinois Natural History Survey
4:25 pm	Discussion: Remaining research/policy/activity needs	
5:45 pm	Adjourn	

APPENDIX B – FINAL LIST OF PARTICIPANTS

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The planning and execution of Wind Wildlife Research Meeting VII, in addition to the production of this document, was supported in part by the United States Department of Energy under Contract No. DE-AT01-07EE11218. Financial support by the Department of Energy does not constitute an endorsement by the Department of Energy on the views expressed in this document.