National Wind Coordinating Collaborative

Wind Wildlife Research Meeting IX

Presented by American Wind Wildlife Institute

Meeting Proceedings

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November 28-30, 2012

Broomfield, Colorado

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Published
May 2013

Prepared for:
National Wind Coordinating Collaborative
by Susan Savitt Schwartz

National Wind Coordinating Collaborative
c/o American Wind Wildlife Institute
1110 Vermont Avenue, NW, Suite 950
Washington, DC 20005-3544

Acknowledgments

The meeting and agenda for the Wind Wildlife Research Meeting IX were planned by the American Wind Wildlife Institute (AWWI) with support from a Planning Committee of volunteers from the National Wind Coordinating Collaborative (NWCC) Wildlife Workgroup (see below). Dr. Taber Allison, AWWI's Director of Research and Evaluation, chaired the Planning Committee and meeting.

The NWCC is funded by the U.S. Department of Energy's Wind and Water Technologies Program through the National Renewable Energy Laboratory and is co-funded and facilitated by AWWI. The Wind Wildlife Research Meeting IX was funded by AWWI with the generous support from meeting sponsors.

AWWI wishes to acknowledge and thank the following companies, organizations, and individuals for their support in planning and executing the meeting:

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Members of the **Wind Wildlife Research Meeting Planning Committee**, who contributed extensive volunteer hours in planning this meeting, as well as all others who provided input: John Anderson, *American Wind Energy Association* • Rob Bouta, *Tetra Tech* • Rene Braud, *Pattern Energy Group* • William Burnidge, *The Nature Conservancy, Colorado* • Christina Calabrese, *EDP Renewables* • Hugo Costa, *bio3* • Wing Goodale, *Biodiversity Research Institute* • Celia Greenman, *Colorado Parks and Wildlife* • Tim Hayes, *Duke Energy* • Bronwyn Hogan, *U.S. Fish and Wildlife Service* • Manuela Huso, *U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center* • Caroline Jezierski, *Nebraska Cooperative Fish & Wildlife Research Unit* • Christy Johnson-Hughes, *U.S. Fish and Wildlife Service* • Christy Johnson-Hughes, *U.S. Fish & Wildlife Service* • Kim Peters, *Massachusetts Audubon* • Jerry Roppe, *Iberdrola Renewables* • Jill Shaffer, *U.S. Geological Survey, Northern Prairie Wildlife Research Center* • Lynn Sharp, *Tetra Tech EC, Inc.* • Karin Sinclair, *National Renewable Energy Laboratory* • Dale Strickland, *WEST, Inc.* • Bob Thresher, *National Renewable Energy Laboratory* • Kim Wells, *BP Energy* • Jim Woehr, *Bureau of Ocean Energy Management* • Terry Yonker, *Great Lakes Wind Collaborative*

Those who volunteered their time to **review submitted abstracts**.

The **meeting volunteers** who offered their time to support the meeting logistics.

AWWI's 2012 Sustaining Partners and Friends: **Sustaining Partners:** American Wind Energy Association • Association of Fish & Wildlife Agencies • BP Wind Energy • Defenders of Wildlife • EDF Renewable Energy • EDP Renewables • Environmental Defense Fund • First Wind • GE Energy • Iberdrola Renewables • National Audubon Society • National Wildlife Federation • Natural Resources Defense Council • NRG Systems • Pacific Gas & Electric Co. • Pattern Energy Group • RES Americas • Shell WindEnergy • Sierra Club • The Nature Conservancy • Union of Concerned Scientists • Vestas Americas • **Friends:** AES Wind Generation • AWS Truepower • Clean Line Energy Partners • Clipper Windpower • Duke Energy Renewables • Edison Mission Energy • Element Power • Ridgeline Energy • Terra-Gen Power

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 pertaining to wildlife fatalities; habitat and behavioral impacts; cumulative and landscape-scale impacts to species; mitigation techniques and technologies; and offshore considerations.

Suggested Citation Format

This volume:

PNWWRM IX. 2013. Proceedings of the Wind-Wildlife Research Meeting IX. Broomfield, CO. November 28-30, 2012. Prepared for the Wildlife Workgroup of the National Wind Coordinating Collaborative by the American Wind Wildlife Institute, Washington, DC, Susan Savitt Schwartz, ed. 175 pp.

Preceding volumes:

PNWWRM VIII. 2011. Proceedings of the Wind-Wildlife Research Meeting VIII. Lakewood, CO. October 19-21, 2010. Prepared for the Wildlife Workgroup of the National Wind Coordinating Collaborative by RESOLVE, Inc., Washington, DC, Susan Savitt Schwartz, ed. 197 pp.

PNWWRM VII. 2009. Proceedings of the 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.

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, Lakewood, CO, July 1994. Repot DE95-004090. RESOLVE, Inc., Washington, DC, and LGL, Ltd., King City, Ont., 145 pp.

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Abbreviations

Above-ground level (AGL)
Advanced Conservation Practices (ACPs)
American Wind Energy Association (AWEA)
American Wind Wildlife Institute (AWWI)
Avian Powerline Interaction Committee (APLIC)
Best management practices (BMPs)
Bird and Bat Conservation Strategy (BBCS)
Bird Conservation Region (BCR)
Bureau of Land Management (BLM)
Bureau of Ocean Energy Management (BOEM, formerly Bureau of Ocean Energy Management, Regulation and Enforcement, or BOEMRE, and previously Minerals Management Service, or MMS)
California Energy Commission (CEC)
California Wind Energy Association (CalWEA)
Eagle Conservation Plan (ECP)
Endangered Species Act (ESA)
Environmental Coordinators (ECs)
Environmental impact study (EIS)
Federal Aviation Administration (FAA)
Global positioning system (GPS)
Global system for mobile communications (GSM)
Great Plains Wind Energy Habitat Conservation Plan (GPWE HCP)
Habitat conservation plan (HCP)
International Panel on Climate Change (IPCC)
Incidental Take Permit (ITP)
Landscape conservation cooperatives (LCCs)
Megawatt (MW)
Migratory Bird Treaty Act (MBTA)
National Environmental Protection Act (NEPA)
National Marine Fisheries Service (NMFS)
National Wind Coordinating Collaborative (NWCC)
Next Generation Radar (NEXRAD)
Non-governmental organization (NGO)
Resource information system (RIS)
Resource selection functions (RSF)
Supervisory control and data acquisition (SCADA) system
United States Department of Agriculture (USDA)
United States Department of Energy (USDOE or DOE)
United States Department of Fish and Wildlife Service (USFWS or FWS)
Wildlife Monitoring and Reporting System (WMRS)
White nose syndrome (WNS)
Wind energy area (WEA)
Wind resource area (WRA)

Welcome and Introduction to AWWI

Welcome

Abby Arnold, Executive Director, AWWI

This is the ninth Wind-Wildlife Research Meeting since the National Wind Coordinating Collaborative (NWCC) convened its first research meeting here in Colorado in 1994. This biennial meeting provides an internationally recognized forum for researchers and wind-wildlife stakeholders to hear contributed papers, view research posters, and listen to panels synthesizing the most recent wind power-related wildlife research, including assessing risks and impacts, estimating fatalities, planning for cumulative impacts, offshore wind energy siting and assessment, and synthesis across projects.

Many of the people in this room have been working together on these issues for 20 years. Through the ebb and flow of wind power development, there has been a consistent and methodical increase in interest in these issues. This year we have about 40 oral presentations, 70 posters, and over 360 attendees – a record number. Welcome to those who are new to this meeting.

NWCC Research Meetings

NWCC Wildlife Workgroup's mission is *"to identify, define, discuss, and through broad stakeholder involvement and collaboration address wind-wildlife and wind-habitat interaction issues to promote the shared objective of developing commercial markets for wind power in the United States."* The purpose of the NWCC Wind Wildlife Research Meetings is to increase our common understanding of goals and methodologies, to share results, to synthesize lessons learned and begin thinking about the next set of questions.

The planning process for this meeting was consistent with the approach NWCC has used in the past. The Planning Committee provided input on the organization of the agenda, session topics, and other aspects of the science aspect of this meeting. We received a total of 114 abstracts, each of which was peer-reviewed by at least three reviewers. Based on those reviews, the Planning Committee decided which would be oral presentations and helped sort them into session topics. (We appreciate submitters being flexible in this regard.) The poster sessions are extremely important; for many kinds of information, posters are superior in terms of generating information and discussion.

American Wind Wildlife Institute

Taber D. Allison, Ph.D., Director of Research and Evaluation, AWWI

The American Wind Wildlife Institute (AWWI) now facilitates and works with the NWCC Wind-Wildlife Workgroup. The mission of the Workgroup is consistent with AWWI's mission: to facilitate timely and responsible development of wind energy, while protecting wildlife and wildlife habitat. This meeting is one of the Workgroup's key activities.

AWWI was created and is sustained by a unique collaboration of environmentalists, conservationists, state wildlife agencies, and wind industry leaders. AWWI partner organizations are committed to these principles:

- Comprehensive, high-quality science will reduce uncertainty and guide informed decision-making about the most difficult siting issues.
- The best creative problem-solving happens through cross-sector collaboration among diverse, committed stakeholders.
- Leaders from the wind industry, environmental nonprofits, and state wildlife agencies, working together, will build powerful momentum for change.

AWWI seeks to help lay the scientific groundwork and best practices for wind farm siting and operations, through four targeted initiatives: wind-wildlife research, development of landscape assessment tools, mitigation, and education/outreach. AWWI's Board is made up of people from the conservation and science communities and the wind industry. Our work is supported by private sector, foundations, and government funding.

AWWI has modest amounts of funding to support the development of research tools and contribute to wind-wildlife research projects. Our project selection criteria were developed with the input of scientists and other members of the AWWI research community:

- Emphasizes near-term results to inform decision making and regulation
- Applies across a broad geographic range or addresses a critical issue
- Leverage the Research Information System
- Lays the groundwork to address long-term research questions
- Offers distinctive AWWI role
- Attracts funding from the public and private sectors

<u>Eagle Initiative</u>

- Develop predictive models to evaluate how potential compensatory mitigation measures will numerically compensate for eagle mortality
- Options need to be rigorous and verifiable
- Start by prototyping with one (or few related) mitigation methods, iterative process with partners & experts
- Long term vision to develop toolbox of reliable compensatory mitigation options

The first expert workshop was held in August 2012 in Denver, Colorado. Preliminary options and approaches were defined and next steps identified for developing predictive models; initial models were developed and refined with input from experts. A second workshop is tentatively scheduled for late 2012/early 2013. Models will be externally peer-reviewed, and the project is expected to complete in early 2013.

<u>Research Information System (RIS) Prototype</u>

AWWI is working with Oregon State University to build a database that will assimilate all wind-wildlife research data. The system will take at least a year to set up. The system design includes four independent portals that will make data available while protecting confidentiality interests of the data providers..

- ***Company (Validation) Portal*** – allows data providers to review and validate their company's data.
- ***AWWI (Literature Curation) Portal*** – allows AWWI staff to upload and validate documents (gray literature or copies of published reports)

- ***Analyst (Query) Portal*** – AWWI approves analysts access to data on specific projects. Each analyst sees only the data for which he/she has received approval.
- ***Public Portal*** – allows anyone to search and view gray literature and reports approved for public access; no user ID or password is required.

Phase I of the RIS pilot has been completed, and we are now approaching wind companies to ask for data. The next step is to test functionality. Assuming all goes well, we will then move forward with developing a more comprehensive database that would include pre- and post-construction data.

Updates on Policy/Regulations, the Wind Industry, and Department of Energy

Moderator: Abby Arnold

David Cottingham is a Senior Advisor to the Director of the US Fish and Wildlife Service (USFWS). His interest is focusing on finding ways to make wind development and wildlife compatible. He has worked on many wildlife issues under the Endangered Species Act, the Marine Mammal Protection Act, and other legislation.

John Anderson is Director of Siting Policy for the American Wind Energy Association (AWEA), working on issues concerning more than just wildlife, such as visual, sound and other impacts. Prior to joining AWEA, he was senior permitting and environmental policy advisor for BP Wind and has 20 years of professional experience in the areas of environmental analysis, planning, permitting, regulation and policy.

The Department of Energy (DOE) has supported the NWCC over its 18-year history. José Zayas is the Director of the Wind and Water Power Technologies Office in DOE's Office of Energy Efficiency and Renewable Energy. (The Wind and Power Power Technologies Office is comprised of a Wind Program and a Water Power Program.) Jose comes to this position with decades of experience, and he understands the importance of wind-wildlife issues, and the value of the NWCC. Although DOE will no longer be the major source of funding for the NWCC (DOE's share of the NWCC budget will be reduced over the current five-year contract, and AWWI will make up that funding), it will continue to be a partner in this work.

Policy and Regulation Update

David Cottingham, U.S. Fish and Wildlife Service

<u>Overview</u>

Climate change impacts are being felt now. That brings home the importance of renewable energy. Two recent examples:

- In the wake of Hurricane Sandy, more governors are now talking about global warming.
- The International Panel on Climate Change (IPCC) recently came out with a report on how sea levels are rising more quickly than we thought.

The states are taking the lead in establishing renewable production standards. Congress is stymied. Federal agencies are finding ways to implement wildlife protection statutes consistent with development of commercial scale renewable energy. USFWS field offices are dealing with oil and gas shale production as well. We are working with all traditional and renewable industries to find ways to achieve wildlife compatible development.

U.S. domestic energy demand is leveling off. The Energy Information Administration predicts that electricity production from coal will go from 50% to 30%, while renewables will produce more electricity. This is just a start; we have to wean ourselves from coal and the CO_2-based fuel diet. Wind, solar, and even hydro and geothermal energy are going to be a very important part of our energy future.

Wildlife Concerns

- USFWS is dealing with utility-scale wind projects as a relatively new industry in locations that have not been developed before, and with respect to species about which we know relatively little.
- Wind involves development into aerial space – we need to verify assumptions about selecting locations that will minimize impact.
- We need to better understand migratory and distribution routes – what species are using which spaces and why.
- Several papers and presentations given here on newer technology will help us improve our understanding of wind-wildlife interactions.

USFWS Programs

- The USFWS Wind Energy Guidelines came out in March 2012. We are implementing them. Over 175 people attended the November training session.
- Under the Bald & Golden Eagle Protection Act, the USFWS is on the verge of issuing our first programmatic take permit for a wind project in Oregon.

The Eagle Conservation Plan Guidance is about ready to roll out. The Service has received a letter from 16 environmental and wind industry groups that want to help us improve the Eagle Rule. We have begun preliminary conversations with them. The question has come up: what should the term of an eagle take permit for a project be? USFWS has issued a proposed rule to extend the permit term to 30 years. Staff is looking at comments and preparing responses.

Several wind companies are preparing individual project habitat conservation plans (HCPs) under the Endangered Species Act. We also are looking at programmatic HCPs, trying to come up with solutions that will protect species like Whooping Cranes and Indiana Bats throughout their range.

Some federal agencies have been challenged for authorizing projects that lack Migratory Bird Treaty Act authorization to take birds. For example, the Bureau of Ocean Energy Management (BOEM) recently issued a permit for the Cape Wind project, and was promptly challenged in court. How do we deal with the fact that the Service doesn't issue MBTA permits? From our agency's perspective, if a company meets with us, develops a conservation plan, and follows our recommendations to avoid and minimize impacts to birds, then we are comfortable with not issuing take permits.

We need wildlife-compatible renewable energy. There are a lot of unknowns, but it is great to see this kind of collaboration among AWWI, NWCC, AWEA, USGS, environmental organizations and others.

QUESTIONS

Q: How is the Service going to measure the effectiveness of the new voluntary guidelines, and how share that with public?

A: The Service has a system for tracking technical assistance that we provide. It is an internal system and the reports are not publicly available. When people come to us with any project, we work with them to incorporate the Tier 4 data collection reports (generated as a result of the new voluntary guidelines) into that tracking system.

Q: Given USFWS' acknowledgment that ecosystems will shift hundreds of miles north by 2050, is it possible for the Service to write permitting policy and guidelines that incorporate bird and bat impacts from projected climate shifts, and subsequently expedite USFWS wind permitting?

A: USFWS uses strategic habitat conservation to incorporate surrogate species and is setting up landscape conservation cooperatives (LCCs) to work through some of these types of issues for climate change. None of us know how climate change will affect this or that landscape or species. Except for golden eagles or listed species covered by HCPs or Section 7 consultations, the Service does not authorize take or issue permits for wind energy projects.

Q: When will new ECP guidelines come out?

A: I do not know.

Q: When will USFWS issue a 12-month finding on the potential Endangered Species listing of the Northern Long-eared Bat and the Eastern Small-footed Bat?

A: The timeline is for it to be issued in spring 2013 (most likely early June).

Q: When will Service put same pressure on mountaintop coal mining to be wildlife compatible?

A: I do not know.

Industry Update

John Anderson, American Wind Energy Association

In the 30 years since the first utility-scale wind energy installations – and especially over the past eight years – the wind has grown exponentially. In 2012, we passed the 60 GW threshold, which is enough energy to power over 18 million homes. This growth has been made possible by the 1992 Energy Policy Act, which created the Production Tax Credit (PTC) that provides a 2.2 cent per kW subsidy for energy that is generated in the first ten years of facility operations.

The PTC has been allowed to expire several times over the past 20 years, creating a boom-bust cycle for the wind industry. It is due to expire at the end of 2012 and has been very challenging to move forward, despite bipartisan support in both the House and the Senate. Now that we are in a lame duck session, it is even harder to get congress to focus on PTC, but we remain hopeful. Even if extended, we still have a battle ahead with respect to getting tax policy that is more stable than what we have had. This will be part of the tax reform discussions of the next four years.

Nationally, we are seeing lower energy demand in general, and indeed the next decade is being coined a "lost decade" across all energy sectors, with flat to negative load growth projected. Therefore, even if we get the PTC renewed and get stable tax policy, wind energy development is expected to be more protracted. In some ways this is good, because we can focus more on issues at hand without going at a breakneck speed.

Stepping back, all forms of energy production and generation have an impact on the environment. There is no free ride – whether direct or indirect – but it is harder to measure the indirect impacts of fossil-fuel based energy forms. Where the wind industry has been very forthcoming in working with agencies, academia to study these issues and apply solutions, our counterparts in the traditional energy industries

have not been as transparent; these industries have been reluctant to address questions and issues associated with wildlife impacts, while the wind industry has gone above and beyond to address these issues and fill knowledge gaps. In 2012, the 40 largest wind producers submitted a letter to Secretary Salazar supporting the use of the USFWS voluntary guidelines that were developed over a three-year period through serious collaboration. These guidelines hold the wind industry to a higher standard to study, avoid, minimize and mitigate for its impacts than any other energy industry.

It is important to keep this in mind, and when combined with the positive attributes of wind energy – such as no harmful emissions, including greenhouse gases, which are undoubtedly driving climate change, no hazardous waste, and no water consumed in the generation of electricity, it becomes clear that wind energy is by far the least impactful form of energy generation available to our society today. As scientists, hopefully we can agree that this is real and an important consideration when making choices about which energy sources to support.

As we saw with the effects of Hurricane Sandy throughout the northeast recently, climate change is having an immediate and real impact on our society. Further with scientists around the world predicting that climate change will cause the extinction of 30% or more of all species globally within our lifetime, this is the true and greatest threat to wildlife populations and their habitat. We do not have time to wait – fossil-fuel-based energy puts species and our very way of life at risk. Now is time for action, now is time for an immediate change in the way we produce and consume energy. Waiting 10 or 20 years to figure out the risks associated with wind energy is not an option. We need to keep asking the tough questions, and together we will find solutions and help advance this critical industry.

Updates from the Department of Energy

José Zayas, U.S. Department of Energy

This presentation touches on the high-level challenges facing the wind industry, including how better understanding and mitigation of wind-wildlife interactions fit into the Department of Energy's (DOE) wind research portfolio. DOE values the NWCC's thoughts and recommendations, and wants to leave conference participants with the message that this remains an important area for DOE.

The goal of the DOE Wind Program is to achieve wind power market penetration targets of 20% by 2030. The Administration has talked about as much as 80% of our energy coming from clean resources by 2050 – but how do we come together to make this happen? In 2012, the U.S. wind industry totaled more than 50,000 MW installed power capacity, over 16% of the 300,000 MW needed to achieve 20% by 2030. As we enter a period of slower wind energy development, we must focus on the making most critical investments during the tough times that will support and facilitate greater deployment in the good times.

DOE is sometimes thought of primarily as a technology development organization. Historically, it's true that the agency has invested a lot in technology R&D to bring the wind technologies to market. However, we also have a robust and vibrant market acceleration and deployment portfolio that supports a lot of the activities that are being discussed at this conference. We will continue to look at operational infrastructure and technical developments that can enhance the compatibility of wind energy with wildlife.

We cannot ignore the fact that challenges to wind energy deployment such as permitting, siting, transmission are increasing quite rapidly as more wind is deployed. Increasing cost-competitiveness through technology advancement is important, but wind energy will not realize its full potential to provide clean, renewable power to the nation unless these market barriers are addressed as well. There is a very real concern that non-cost barriers are large enough to derail wind development in some places. DOE is trying to forecast what we think may be the showstoppers or key impediments – challenges which involve multiple stakeholders and agencies – so that we can be proactive in addressing them.

Land-based wind is important, but we are also looking at what we can do to mobilize offshore wind energy development: what are the opportunities; what lessons learned from land-based wind can we put to use offshore; and what are the new challenges we will face?

DOE has supported wind energy for decades and will continue to do so into the foreseeable future. We are very proud of the accomplishments that NREL and other partners have made to date, and we want to make certain there is a plan in place to ensure that efforts like the NWCC can continue independently (or more independently), as industry increases support in addressing these barriers.

We know that there is going to be a significant slowing down over the next couple of years in terms of deployment of wind energy facilities due to policy and regulatory uncertainty. How do we take advantage of this lull to make key investments today that will help wind come out of this period ready for more robust development in the near future?

I look forward to hearing from AWWI and conference participants. When you look at DOE's wind research portfolio, are we prioritizing the right things? Are we looking at the things that matter, moving forward? DOE is committed to making sure we have the best portfolio possible to support responsible wind energy development. We value opportunities to learn from the industry, so please share your thoughts about the challenges and the opportunities that you are facing. DOE is poised to work with stakeholders to make a better program.

Assessing Risks to Birds and Bats

Using spatial models to predict relative collision risks of Horned Larks and Hoary Bats at wind farms in the central United States

Presenter: Greg Forcey, Normandeau Associates

Presentation

Authors: Greg M. Forcey, Christian Newman, Crissy Sutter (Normandeau Associates)

PROBLEM / RESEARCH NEED

Studies of avian and bat collision mortality most often occur at the site-specific scale of the wind power facility; however, relationships at larger scales such as the multi-state level may also exist. Exploring possible relationships between collision mortality and landscape features at the multi-state level requires a different approach from the field studies that traditionally conducted at the site level.

The central US Prairie pothole region is an important wind corridor as well as home to many sensitive bird and bat species. In 2009, with a grant from DOE, we set out to develop spatial collision models for select bird and bat species based on biological and environmental variables. We chose nine focal species representing different bird and bat taxa, species with previous reported mortality, and species that would be well represented in existing data sets. Our goal was to increase understanding of collision risk factors, and to generate maps useful for predicting risk at wind facilities in the central United States.

Objectives

Our specific objectives for this project were to:

- Develop spatial collision models for select bird and bat species based on biological and environmental variables
- Map relative predicted collision mortality for each focal species
- Increase understanding of large-scale factors influencing collision risk
- Generate maps useful for large-scale environmental planning

This presentation focuses on two of the nine species, the Horned Lark (HOLA) and the Hoary bat (HOBA).

APPROACH

Using large-scale existing data sets, we modeled predicted relative collision mortality of Horned Larks and Hoary Bats in the central United States from North Dakota to Texas. Over 20 years of bird data were compiled from three datasets: the North American Breeding Bird Survey, Christmas Bird Counts, and eBird (quality-controlled migration data). Environmental data included weather (from the National Climate Data Center), topography and forest stand age (Landfire.gov), and land use (the National Landcover Dataset 2001).

Separate models were constructed for each species for each season given differences among species life history, habitats, and behavior. For birds, we built hierarchical linear mixed spatial models based on known associations with habitat variables, and then incorporated weather and behavioral information, which can influence exposure to turbines, into the exposure portion of the model. Bird abundance was

modeled as a function of land use at multiple scales, from 1,000 to 100,000 hectares. Seasonal-specific abundance models, were used to form a cumulative measure of predicted collision probability across all seasons for an entire year.

In the absence of large-scale bat datasets, bat habitat was identified in the landscape based on habitat preference information from the literature, combined with the existence of habitat features known to influence occurrence: percent forest, forest edge density, forest stand age, percent open water, and distance to water. For HOBA, the pertinent weather exposure variables hypothesized to increase collision risk were: average night hours with less than 10 m/s wind speed, with no rain, and with temperatures over 50°F. Each season was considered separately, and seasons were weighted temporally and behaviorally to produce a cumulative annual species collision model.

Model evaluation was performed at two levels:

1) Mortality predictions were compared to mortality recorded at seven publically available studies within the study region. (Mortality was standardized as number of birds/bats killed per turbine per year.)
2) A sensitivity analysis was performed to evaluate how different weighting of abundance/habitat and exposure influenced the models' ability to predict collisions.

Model evaluation for Horned Larks revealed the model using only habitat data and no weather information performed the best (r=0.55 for observed vs predicted mortality). Model evaluation for Hoary bats showed the best fit model occurred when habitat was weighted half as much as exposure (r=0.85 observed vs predicted mortality).

FINDINGS

Model outputs take the form of maps based on the sensitivity analysis; only the best performing models as determined by the sensitivity analysis are shown. Each map shows a species-specific relative collision probability; collision probabilties are not absolute and cannot be compared among species, only within a species. In the case of Horned Larks, although abundance was modeled at the 1,000 and 10,000, and 50,000 ha scale, coarse-scale models (100,000 ha scale) had the best predictive results [slide #16]. In addition to habitat, latitude and longitude showed strong effects. Relative collision predictions for Horned Larks were highest in the western-central and northwestern portions of the study region and lower elsewhere.

Hoary Bat collision risks were driven primarily by weather variables with less influence from habitat. Higher risk was predicted in areas containing tree cover and along stream and river corridors. Relatively higher risk was also found in the extreme southern portion of the study area (i.e., Texas); lower risk was found elsewhere [slide #17].

CONCLUSIONS / APPLICATIONS

This large-scale modeling exercise was useful for understanding the relative importance of habitat and weather variables in influencing collision rates at wind farms in the central United States. A web-based interface can be found at:
http://www.normandeau.com/pages/environment/services/WindWildlifeRiskMap/. This interface allows the user to view model outputs (by state and by species), to zoom in and out, and to overlay on different maps. Data can be downloaded in ArcGRID format for use with GIS software.

Lessons learned

- Collision risk is highest in areas where habitat and exposure conditions are favorable.
- The influence of abundance and habitat v. exposure variables on collision risk varies depending on species.
- The models' predictive ability ranges from moderate (HOLA) to excellent (HOBA).

Limitations

- Collision risk is a relative measure so risk predictions cannot be compared among species, only within a species. Higher or lower predicted risk does not necessarily imply an overall high or low collision risk.
- Applicability is limited to large-scales, and so cannot be used for micro-siting turbines.

Future research

- Field studies are needed to validate models at smaller scales.
- Sensitivity analysis would benefit from larger sample size. (Only seven data points were available for the model evaluation exercise for this particular region.)
- We would like to apply the model to other geographic areas, especially where more post-construction mortality data are available – e.g., the Northeast, the West coast.
- We would like to evaluate the influence of abundance and weather on collision mortality for other species.

Applications

Our research has application to regional-scale siting of wind power facilities, making comparisons of relative collision probabilities among sites, and developing site-specific priorities for additional research. This modeling approach can also be expanded to other species and geographic regions in the United States to aid in siting wind power facilities at large scales.

Questions & Discussion

Q: Relative risk may be ten times higher in one area or another, but overall risk may still be low. (Analogy to buying lottery tickets: probability of winning increases by factor of ten if you buy ten tickets, but overall probability of winning still extremely low.)

A: That is correct. This model shows relative risk within a landscape, not absolute risk. "Red" doesn't necessarily mean risk is high, only that it is high relative to other areas in the risk map with lower levels of risk.

Q: By what principle do you justify extrapolating to the entire central U.S. from only seven data points?

A: The seven data points were used to evaluate the model, not to build it. The model was built with over 5,200 counts from the Breeding Bird Survey, over 2500 counts from the Christmas Bird Count, and over 350 counts from eBird. It would still be better if we had more than 7 data points to validate the model.

Q: The correlation between predicted and observed outcomes was at best 56%. Is that the r-squared value in linear correlation? Why do you consider that "moderate to excellent" correlation?

A: 56% is the *r* value, which is the Spearman's rank correlation coefficient. We had two species. The correlation coefficient for observed vs. predicted mortality for Horned Lark was 56%, which we

described as moderately good. For the Hoary Bat, the correlation between observed and predicted mortality was 85%, which we considered excellent. The "moderate to excellent" notation considers the range between both species, not specifically the Horned Lark.

Q: You stated that the higher for Hoary Bat collisions in the south is due to warmer temperatures. Why is this the case? Are hoary bats thought to be more abundant in the south?

A: The model predicted higher collisions in the south due to warmer temperatures which tend to be related to increased bat activity. Temperature data for the southern part of the region leads us to believe that bats will be more active there, and thus at higher risk for collisions.

Q: How robust is your bat model considering it was constructed from habitat parameters rather than actual bat distribution data, considering that many species ranges are considerably narrower than known historical ranges?

A: The best indicator of that is from our model evaluation exercise where we compared observed v. predictive mortality. There is a good correlation (~85%) between observed and predicted mortality, which suggests that the bat model is performing well.

Q: Are your results publicly available?

A: Yes; the results are available to view or to download:
http://www.normandeau.com/pages/environment/services/WindWildlifeRiskMap/

Competing resource selection modeling predicts risk for preventing and mitigating Impacts to flying birds from industrial wind energy development

Presenter: Tricia Miller, West Virginia University

Authors: Tricia Miller (Division of Forestry and Natural Resources, West Virginia University & Riparia, The Pennsylvania State University); Robert P. Brooks (Riparia, The Pennsylvania State University); Michael Lanzone (Cellular Tracking Technologies); Charles Maisonneuve, Junior Tremblay (Ministère des Ressources naturelles et de la Faune, Canada); Jeff Cooper (Virginia Department of Game and Inland Fisheries); Kieran O'Malley (West Virginia Division of Natural Resources); Adam Duerr, Todd E. Katzner (Division of Forestry and Natural Resources, West Virginia University)

PROBLEM / RESEARCH NEED

The costs of wind energy development are not equal among (or within) wind energy facilities, seasons, or species. Golden Eagles are one of the species most at-risk for collision. The indirect effects of development are harder to measure, but increasingly important as more facilities come on line.

In eastern North America, a small population of about 3,000 Golden Eagles migrates through the Appalachians twice a year. There are 41 existing or planned facilities in Pennsylvania with more than 1,191 turbines. This could pose a significant conflict. This research, initiated in 2006, seeks to provide a balanced approach to risk management by providing managers with a tool to reduce direct and indirect effects on migratory Golden Eagles.

APPROACH

Animals select resources that improve their survival and fitness and similarly industries select resources that are important for their bottom-line and thus survival. Risk, or the probability that a negative interaction will occur, can be described by overlaying resource selection models for the species (in this case Golden Eagles) and industry (wind energy) in question. The resulting risk model can then be used to spatially adjust wind energy development in a Golden Eagle-friendly way.

We combined resource selection probability functions for migrating Golden Eagles and for wind energy facilities to create a risk map for Central Pennsylvania. The region was divided into three study areas:

- Northern Plateau (NP)
- Ridge and Valley (RV)
- Allegheny Mountains (AM)

Resource Selection Function Inputs

Golden Eagles - Satellite telemetry units were used to track Golden Eagles during spring migration. The study began in 2006, but this presentation is based on data obtained from using higher resolution data units placed on 30 birds beginning in 2009. From 2009 to 2012, we collected 30-second telemetry data from spring migrants: a total of over 37,000 observations of 30 birds. Random points generated along directed correlated random walks represented available habitat. Birds flying at less than 150 m AGL were considered to be at risk of collision or displacement, and we used those data to represent use.

Sub-region	Number of birds observed	Observations in risk zone
Northern Plateau	18 birds	1,481 observations
Ridge and Valley	23 birds	2,278 observations
Allegheny Mountains	14 birds	586 observations

Wind Turbines – Federal Aviation Administration obstruction database was used to identify sites used for turbines, and random points generated in random blocks were selected to represent unused areas. There are nine wind energy facilities currently in the Northern Plateau region, 22 in the Allegheny Mountains, and 15 in the Ridge & Valley region.

Environmental Covariates

Using data from the US Geological Survey, National Renewable Energy Laboratory, and The Nature Conservancy's Ecological Land Units database, we mapped a total of eight environmental covariates: elevation, northing, easting, updraft potential, good winds, side slopes, steep slopes, and summits. Covariates were mapped at a 30-m resolution, with point values extracted from standardized layers. These were then mapped on to the eagle and turbine data to create regional spatially-explicit risk models.

The eagle and turbine input data were used with these variables to calculate binary generalized estimating equations (GEEs) for both eagles and wind developments in each region. We used 75% of the data points to build the model, leaving out 25% for validation purposes. Individual eagles and individual wind turbine facilities were the repeated measures. We used backwards stepwise selection, keeping variables with $p<0.05$. Following Manly 2001, we then calculated spatial models of the resource selection function for eagles and the resource selection probability function for turbines.

Model Validation

We reclassified the region into four Eagle habitat quality bins (poor, fair, good, and excellent), and did the same for turbines. Using the eagle validation data set, we compared observed with expected for each habitat quality bin, regressing our results for each bin against an ideal model (slope = 1, intercept =0) v. a random model (slope = 0). We also assessed our models in terms of goodness of fit. Fit was found to be excellent for the Ridge and Valley area, and the other two areas had good fit ($R^2 > 0.98$). Wind models were validated (pre-reclassification) using two standard procedures, area-under-the curve (AUC) and Kappa.

Habitat quality maps for eagles and for wind power were then combined to generate a risk map. Areas with poor "habitat" for both eagles and wind power are characterized as "low value." Poor eagle habitat with fair to excellent wind power potential is "low risk." As eagle habitat and wind power habitat improve, risk increases.

FINDINGS / RESULTS

The proportion of the various risk areas were found to vary regionally. The Allegheny Mountains were found to have the highest proportion of area available for development that does not overlap with eagle habitat (14%), while the Ridge and Valley area has the lowest percentage of low-risk, high development potential (2%). The model finds very little room for low-risk development in either the Northern Plateau or Ridge and Valley regions. Of the total Ridge and Valley area suitable for development, 80% falls into the high-to-highest risk category, v. 22% for the Allegheny Mountains and 16% for the Northern Plateau.

APPLICATIONS

In addition to determining regional levels of risk, the model gives us the ability to identify where wind resource and eagle use do and do not overlap at individual sites. This tool can be used to suggest the best locations to site turbines. The spatial risk model also can be developed using wind companies' predictive maps, rather than ours, and combining those with our eagle resource selection function used here, to help developers come up with the best siting locations.

Questions & Discussion

***Q: Three questions focused on whether there have been any documented collisions – and what basis there is to suggest that eastern Golden Eagles are at risk of collision – east of the Mississippi River.* …If so, are they associated with migration or wintering? …Should the risk scale should go from "low" to "lowest" rather than from "extreme" to "low"? …Have any of your eagles been killed by a wind turbine?**

A: There have been no reported collisions in the east, but there are plenty of recorded Golden Eagle collisions elsewhere (Smöla, California, Wyoming) – and given that, we consider that Golden Eagles are possibly at risk in the east as well.

Q: Why did you use random points rather than eagle data from >150 m AGL as unused?

A: I did try that. I did use those data, but there was considerable overlap in habitat use between the two, making it difficult for the model to discriminate; so I used random data to represent available habitat.

Q: Was the experimental unit individual detection or the individual bird? Should the bird somehow be incorporated into the validation and error?

A: The experimental unit was the bird. The model would probably benefit from incorporating individuals into the validation as well, but we have not yet done that.

Q: Is the risk equal between spring and fall? Any reason why fall was not studied?

A: First want to say one more thing about the sampling unit for the model. When I ran the models I included individuals.

The telemetry units are programmed to collect 30-second data across PA. The birds return late in the fall, and the battery levels tend to be much lower on their return flights, so until this fall, we hadn't collected enough data to specifically look at fall migration. Based on the data we have collected so far this fall, and also based on hawk watch observations, they are probably at greater risk in the fall. Because of weather differences between seasons they are flying at lower altitudes in fall. We will be making a fall model.

Q: How accurate are estimates of elevation from the tags? Do the large tags affect movements of eagles or possibly handicap them in any way?

A: Vertical accuracy is within 30 meters. Based on visual observation of the birds in flight, I don't think their flight is handicapped by telemetry tags. These are backpack units placed at the bird's center of body mass rather than tail or wing-mounted units.

Q: What will it take to extend your eagle risk model throughout the migration routes of the eastern Golden Eagle population?

A: More work would be required. I have 30-second data from 39 degrees latitude, up to 42 degrees – we could extend to southern NY, down to northern VA and WVA. We will also be working on winter risk models and do some modeling in the California desert.

Q: Were wind resource grids used for wind potential, or only proposed FAA points?

A: Not sure what the wind resource grids are - NREL data? Wind potential was not actually important in building this model; topography was important.

Q: The eagle risk model's use of wind as the sole proxy for good wind development areas seems to ignore other critical features such as proximity to transmission lines. Have other variables been considered or could they be?

A: There were eight variables included in the models, all of which are based on topography. The only limit to including other variables would be the availability of those data. Certainly including information about the location of transmission lines would improve the wind models, but overall, I don't think that there would be much difference in categorizing risk at proposed and existing facilities.

Using avian radar to quantify bird and bat migration along the shorelines of Michigan and implications for analysis and pre-construction surveys

Presenter: Jeff Gosse, U.S. Fish and Wildlife Service

Presentation

Authors: Jeffrey Gosse, Erik Olson, Tim Bowden, Daniel Nolfi, Nathan Rathbun, Rebecca Horton, David Larson (U.S. Fish and Wildlife Service)

PROBLEM/RESEARCH NEED

Bird and bat presence along shorelines of the Great Lakes during migration has been previously documented, however the migration patterns and magnitude of numbers remains unknown in many areas, especially for bats. This uncertainty leads to regulatory burdens when it comes to addressing the impacts of wind power development.

For the past two years, the United States Fish and Wildlife Service (the Service) has been using avian radar systems, acoustic monitors, historic observations, and incidental bird observations to document migration along the shorelines of the Great Lakes. The purpose of the research is to survey whether avian and bat migration is occurring along the landward United States shorelines, in order to identify areas that should be avoided by wind facilities.

This presentation provides some initial findings demonstrating variations on avian and bat migration – information which may be useful in designing improved pre-construction surveys to demonstrate the presence or absence of migrational corridors. The data presented also demonstrate preliminary methods for predicting heavy migration periods. The presentation will focus on what we have learned from avian radar systems, and to explain how our research would influence Tier III review of a project that used radar as part of an environmental risk assessment for migration. This presentation represents data collected by the Service's Region 3 and does not currently represent all of the Service since we have not had a chance to share the data with them. The data focuses primarily on nocturnal migration of passerines and bats. Other migrants may fall outside of the seasons, timing, and patterns presented here. (Two posters include other aspects of this research.)

APPROACH

Using two avian radar units (Merlin, DeTect Inc.)[1]and up to 34 acoustic/ultrasonic monitors, the U.S. Fish and Wildlife Service has collected migration specific data from multiple locations near the Great lakes shorelines during spring and fall of 2011 and 2012. This presentation will focus on fall 2011 data collected from two sites, one located along eastern Lake Michigan and the other on the west shore of Lake Huron. I will discuss patterns of migration documented at these two locations.

Equipment

The avian radars that we are utilizing have a common design featuring two marine radar antennas (Slide #4) used simultaneously for detecting targets, each measuring something different:

- ***Horizontal scanning radar (HSR)*** is set to detect targets out for two nautical miles, and is good for providing direction-of-travel information, as well as a bird's-eye view of how migration is occurring over the landscape.

- ***Vertical scanning radar (VSR)*** provides altitude and a measure of the number of targets passing within a 1-km band over a period of time, typically 1 hour.

One concern that of the Service in reviewing project proposals is the lack of standardization among avian radar equipment systems. This confounds comparison and understanding of results.

For this project, the Service purchased self-contained units that automated all aspects of the data collection process, including tracking, processing, and storage of data. The units were successfully field tested for integration of hardware, software and electronics, and came with continuing support. Automated tracking software has the advantage of being able to identify and track numerous targets simultaneously, while eliminating observer bias and fatigue. Selecting a system with a proven track record that incorporates these features is advantageous.

This presentation demonstrates the type of data that would ideally be provided to document the presence or absence of bird and bat migration and suggests ways to analyze and present the data. Such analyses would ideally include observations on a seasonal, daily, and hourly basis.

RESULTS / FINDINGS

The HSR provides information on direction of travel for targets. As targets move through the horizontal plane they often become temporarily blocked from the radar's view and are double counted when they re-appear. For this reason the VSR is generally considered more reliable to provide estimates of the number and height of targets.

The information collected by the two antennae is automatically represented in graphics, called trackplots, which are typically summarized in 1-hour or 15-minute increments. Slide 5 shows a 1-hour trackplot of the HSR on the left and a 1-hour trackplot of the VSR on the right during a heavy migration period. For the HSR trackplot, the color of the lines indicate the direction of travel with the color wheel in the upper right serving as the key, with blue representing north and red representing south. On the VSR trackplot, the solid labeled grid lines represent 1,000 feet each in altitude.

Contaminants and Noise

Radar target counts can be contaminated by tracking non-targets such as ground clutter, rain, insects, and even air particulates. A defined method for identifying and removing contamination is necessary. Radar systems should be equipped with a means to suppress stationary clutter and prevent clear air from being tracked and counted. In addition, observers need to be able to efficiently scan through the radar data to flag and remove time periods contaminated by tracking of non-targets.

Slide # 6 shows images of targets tracked by the vertical scanning radar during a rain event and during an insect bloom, with each image representing a 15-minute time interval. During the first season (Spring 2011), we used primarily X-band VSR which picked up insect blooms. VSR data collected with S-band radar was not contaminated by insect blooms and is the bandwidth we will use for the duration of the study. Slides shown during the rest of the presentation do not contain contamination.

Sample Study Data

Slides #7-15 display study data from a typical 24-hour period, from noon on September 8th to noon on September 9th, using avian radar positioned on the east shore of Lake Michigan, approximately 20 miles south of Luddington. (In the slides, the HSR image is shown on the left, the VSR image on the right.)

- At 1200 and 1800 hours, there are not many targets, and no strong directionality.
- By 1900 hours, activity is picking up with directionality in the SW to SE directions; it is dusk, and nocturnal migrants are beginning to move.
- At 2000 hours, continuing through 2:00 am, we continue to see large numbers of targets continuing to move in a generally southerly direction.
- By 5 am, birds are coming in from offshore and moving to the southeast. On the VSR, relatively fewer targets are observed at the higher altitudes than earlier in the night.
- By 6 am, there is a strong tendency of targets to come in from the east and northeast, moving to shore in order to land so they can avoid predation.
- By 12:00 pm on September 9, the pattern is similar to the previous day.

If you examine the previous series of slides, you will observe that at times the HSR is showing a fair number of targets while the VSR is not, particularly when the targets are moving in an east/west orientation. As shown in Slide #16, the VSR is sampling a narrow slice of the sky, typically oriented slightly off of east-to-west which would be slightly off perpendicular to the anticipated direction of travel for migrants along a north/south shoreline. When targets are traveling roughly in the direction of the VSR orientation, many of them will be missed. Target counts are commonly reported as an index of the number of targets that pass within a 1 km front of the VSR unit during some specified period of time, referred to as the target passage rate. The surveyed volume increases with distance from the radar unit, so that low-flying targets pass through a band that is only 60 m wide. At higher altitudes we are sampling a wider area. However, as survey volume increases the amount of energy available to be reflected back to the radar decreases. This scenario creates a sweet spot somewhere in the middle where the probability of detection is likely greatest and tapers off closer to the ground or higher into the atmosphere. This bias is inherent in all avian radar of this design and is discussed in the literature (Schmaljohann et al. 2008). Thus, the VSR will miss targets traveling parallel to the line of orientation and also those moving low or high in the sampled area. Until good correction factors are developed, this bias must be kept in mind.

Slide #17 shows hourly counts from the VSR and HSR during the fall 2011 at the Huron County, Michigan survey location, illustrating the pulses of migration over the course of the season.

Slide #18 provides a closer look at part of this time series. The date label and corresponding vertical lines occur at midnight.

- The top graphic shows early September during a migration pulse. Both horizontal and vertical radars show peaks of activity near midnight as migration builds starting near dusk and subsides as dawn approaches.
- The bottom graphic shows the end of October and beginning of November. By this time most migrants have moved past our location and we see a very different pattern than in September. The midnight peaks are mostly gone and the horizontal radar's bi-modal peaks occur near dawn and dusk on a daily basis representing more local bird traffic rather than migrants. This is an agricultural area so there is a fair population of local birds active.

In Slide #19, we show the data we would have collected if we had chosen to sample once weekly over a month period as is sometimes proposed or done for economic reasons. The data are for the VSR antenna. We would probably conclude that except for a small peak of activity on November 4, there is little indication of migration in this area. Slide #20 shows the actual data we collected, operating 24/7.

The tan ellipses indicate the proposed sampling periods from the previous slide. Note that there were major peaks of migration that we would have totally missed by sampling on a regular intermittent basis.

Target Passage Rate

Target passage rate is frequently used as an index of the number of targets that fly within a 1 km front above the radar. In slide #21, we report the mean daily and nightly target passage rate (number of recorded targets per km front per hour averaged over a night or day) for two sites. The Huron county site was located along Lake Huron and the Oceana site was located about 300 km away at a similar latitude on Lake Michigan. The difference between night and day activity is one indication that migration is occurring and here again we see the timing of migration pulses during the season. While we wouldn't expect the timing of migration to follow exactly the same pattern at these distant sites, we find it encouraging that there is some similarity. The first two rectangles for each location indicate similar patterns of migration. The last rectangle for each location indicates that nocturnal migration is decreasing at both locations.

Due to the amount of variation inherent in monitoring target passage rate with the vertical scanning radar these data do not indicate to us that more targets passed through the Oceana site than the Huron site – even though the mean target passage rate for all nights during the season was higher at Oceana. To draw that conclusion there would need to be a much larger difference between target passage rates. As the index is relative to a site, the daytime observations are important in providing a baseline to compare the night index against.

Again, because migration occurs in pulses, sampling intermittently may miss those pulses and miss the picture entirely.

CONCLUSIONS / APPLICATIONS

USFWS has found avian radar to be highly effective – indeed, the best tool available – for monitoring migration timing and patterns, particularly for nocturnal migrants such as passerines and bats. However, radar is not without limitations. Additional sampling techniques (e.g. acoustic monitors or visual observations) may enhance its utility.

We found that nocturnal migration was indicated by a general uniformity in the direction of travel, high numbers of targets, and a general increase and decrease in the number of targets over the course of the night. Comparisons between vertical and horizontal scanning radar are useful when one or the other shows something different. There is an inherent bias in altitude measurements, making it difficult to conclude whether targets are flying in the rotor swept zone.

Given the sampling bias inherent to vertical scanning radar as well as the potential differences among radar systems and tracking algorithms, it is unrealistic to base a risk assessment solely on mean target passage rate or height. Using some of the graphics displayed in this presentation and comparing the horizontal and vertical data against each other is more meaningful. The Service supports using vertical scanning radar to quantify the target passage rate index, but it is important to use it to reflect differences between day and night counts as well as changes in passage rate over the course of a season. The extent to which the vertical radar misses low flying targets will bias height estimate toward higher altitudes and misrepresent risk at turbine height. Besides this, even high-flying targets need to land at some point, and flights among stopover habitat while migrants are refueling is well documented.

This information highlights the importance of determining timing, frequency, and length of surveys in order to document patterns of migration in a particular area along with appropriate techniques for documenting migration. In particular, the time sequence graphs [slides #17-21] demonstrate how migration changes through the season, and the implications for sampling. Surveys should be conducted for the entire spring and fall season to observe both the pattern and duration of migration. If a partial season is sampled, sampling should occur steadily throughout that time. Multiple years may be necessary to understand seasonal variations or if a developer is trying to prove that migration does not occur in a given corridor. This preliminary data illuminates the importance of separating daytime and nighttime data – and indeed the need to analyze migration data on an hourly basis, rather than on 24-hour averages, or even nocturnal averages.

Reference

Schmaljohann, H., F. Liechti, E. Bächler, T. Steuri & B.Bruderer. 2008. Quantification of bird migration by radar—a detection probability problem. Ibis 150(2):342–355.

Questions & Discussion

Q: ***Three questions focused on whether there is a "clear relationship" between migration pulses and increased risk of bird/bat mortality at wind farms.***

A: There have not been enough studies using techniques such as avian radar in areas where there is both high migration and wind facilities to document a "clear relationship" between migration pulses and increased risk of fatalities. However, as indicated in the Service's Wind Energy Guidelines, migration corridors and stopover sites are considered areas to avoid. Logic would appear to indicate that whatever the collision odds are for an individual passing through a wind facility, they are then multiplied by the number of migrants passing through the area. Two incidents during fall 2011 migration in West Virginia are indicative of what can happen when facilities are located within migration corridors. Both incidents involved inclement weather, lighting, and migrating birds and resulted in large numbers of migrant fatalities. We also know that communication towers can have high fatality rates during migration periods, particularly during inclement weather. I would argue that the burden of proof needs to be upon the developer to demonstrate that they could safely construct and operate facilities within migration corridors without increased risk of fatalities.

Q: What is the typical cost of the horizontal and vertical radar units, and what are the costs to operate the radar on a daily and seasonal basis?

A: The units we used cost about $250,000 apiece. Our operating costs are on the high side – $250,000-$500,000/year (including data analysis). Our staff costs are higher than what might otherwise be typical – first, because we have full-time staff in the field to ensure the higher quality that comes with experienced and consistent staffing, and second, because we are paying per diem at the Federal rate. Power costs in remote locations are also higher, because we need to use diesel generators rather than relying on grid power. We try to have staff at each site on a fairly steady basis to minimize data loss; however, costs could potentially be reduced by not having staff at the site on a full-time or steady basis.

Q: Did you examine the relationship between prevailing winds and nightly migration data?

A: We have wind and other weather data, but haven't yet made correlations of migration and weather data. One of our posters (*Meteorological Data and Bat Activity: Developing Conservation Measures for Wind Energy*) does give some analysis between bat calls and weather data. One problem with 24/7 data

collection is that it generates data faster than we can analyze it – but we will be looking at these relationships in the future.

Q: Please discuss the use of NEXRAD to understand regional migratory patterns and how it can or should influence the need for site-specific radar.

A: I have not personally worked with NEXRAD and therefore cannot discuss it in any detail. We have had discussions with other researchers who are using NEXRAD. They can pick up some overview, typically in early evening. Some of their information appears to support what we are seeing, although we need to do a thorough job of comparing our data. As evening wears on and migrants spread out, it is harder for NEXRAD to pick up the more dispersed migrants. Also, the NEXRAD radar locations are fixed, which means that in regard to migrants, there are areas that are relatively well covered and areas that are not well covered – either because the radar is shooting above the height of most migrants, or because there simply isn't NEXRAD coverage.

I think that where NEXRAD indicated that migration is occurring, there should be avian radar studies to document more precisely what is occurring in the area. However, where NEXRAD doesn't find migrants, it should not be assumed that there is no migration. It may be that there is inadequate coverage – in other words, a false negative. Eventually, I believe we will find that NEXRAD and avian radar tend to complement each other rather than either replacing the other.

Q: Would you characterize the movement as broad-front? (Does this work say anything about concentration along shorelines?)

A: At this point, we can only talk about the areas we're measuring, which is about a 5 km-wide band inland from the shoreline. We cannot say more with any certainty, although I would anticipate that patterns do not end immediately beyond our current radar range. We are adding longer-range capability to one of our units this winter which will allow us to reach up to 10 km. Some literature does define passerine migration as a broad-front, and that may be true in some places; however, land forms can funnel or concentrate migrants. We think the shorelines of the Great Lakes support concentrations of migrants as they navigate along north-south oriented shorelines and stage along east-west oriented shorelines prior to or after crossing open water. Our data clearly indicate strong migratory movements along the shorelines we studied. We have not made comparisons to inland areas at this point.

Q: Could you speak to all the low targets on your vertical antenna figures – we are always told migrants are flying at high altitudes – it doesn't appear this way over Lake Michigan.

A: We believe the vertical antenna is not picking up low-flying targets at the same percentage as medium-height targets as I mentioned in my presentation. However, I believe that the VSR is giving us extremely accurate altitudes for the targets it does pick up. In other words, I don't think that the lower-level targets are being observed in error. A reasonable portion of migrants do fly at high altitudes, but they also land daily and will alter flight height with environmental conditions. We see relatively lower flight heights at dusk, with heights increasing as the night progresses and then decreasing again toward dawn. The issue is more in the reduced detectability of low-flying targets which are probably undercounted by us and by others using radar. The "sweet spot" is in the middle height – targets which are high enough to be picked up, but not so high as to be out of range.

Two questions focused on whether/how data from radar units located along shorelines would translate to locations farther inland. "Given that migration occurs statewide on same nights, why not have multiple stations across the state that all developers could tap into?"

A: The reason for placement along the lakeshore is that we have a long history of visual observations indicating these are heavy use corridors. We're not trying to predict what's happening further inland. If someone has the funding to put up more radar inland, that would be great.

Q: Why the "bullseye" in radar traces?

A: Good observation. The radar antennae are digital; they have a short, medium, and long pulse. We use short and medium. There is a gap during the switch from the short to the medium pulse. It occurs in both the vertical and the horizontal. The radar manufacturer has made some adjustments in the horizontal but not in the vertical antenna yet. The adjustments have improved the data but are not quite where we'd like to see it yet. The lack of targets at the very middle of the track-plot graphics results from the intensity of the radar signal when it first goes out, resulting in an area immediately adjacent to each antenna where targets will not be observed.

Q: Can you speculate on wind project siting or mitigation measures based on your migration data?

A: To a very limited extent. What I have presented and what we are showing in our two posters are just some of the data findings from our studies. How these data are ultimately utilized to address project siting and mitigation falls more in the policy realm, which is another issue. Any recommendations that we make regarding policy have to work up through our management both at the regional and possibly at the national level. The Service's current Wind Energy Guidelines state that wind energy development is not supposed to occur in heavy bird concentration areas, whether they are refuges or migration corridors.

ADDITIONAL QUESTIONS

These questions were submitted but not answered during the conference.

Q: What did you see for bat migration?

A: At this point, we are not able to separate data from the radar units into bird and bat data. It is possible that we will eventually be able to do this utilizing the multiple parameters that are recorded for each target. We have also utilized a prototype radar unit during Fall 2012 (VESPER model, DeTect Inc.[1]) that is intended to be able to better identify targets. However, we are waiting for the software to be further refined and the data to be analyzed to see how well this will separate out birds and bats. We do have two acoustic/ultrasonic monitors deployed with each radar unit, and these do a very good job of recording bat calls. From these monitors and the weather stations in each radar unit, we are able to get some good information regarding bat activity and weather parameters as shown in one of our posters (*Meteorological Data and Bat Activity: Developing Conservation Measures for Wind Energy*). We also have up to thirty additional acoustic/ultrasonic monitors deployed around the Great Lakes shorelines providing data particularly on bat activity. As indicated on a second poster (*Determining Migration Corridors Along the Great Lakes*), when we plot bat activity from the acoustic monitors over radar activity, we appear to have good correlation – suggesting bats often are moving/migrating at similar times to night time bird migrants (passerines).

Q: How were insects removed from both the X& S-band radars?

A: The S-band radars tend to not pick up insects because of the longer wavelength. To date, we have not identified any insect activity on the S-bands. During spring 2011, we utilized X-band on the VSR for

[1] Use of trade names does not indicate endorsement by the U.S. Fish and Wildlife Service

the majority of the season, and this did pick up insect activity. We have several methods for removing this data. We initially review all of our data and remove any time periods that have rain or high amounts insect activity or clutter. We do this for both X and S-band. We then employ an editor that can individually or in groups remove tracks that we believe are insects or simply clutter based upon their location, directional consistency, and other parameters. Generally, S-band radar needs less manual editing than X-band radar and has fewer time periods thrown out due to rain, insects, or clutter.

Q: Can you please briefly explain the radar imagery: colors, spots, etc?

A: On the track-plot graphics, dots represent each time a target has been identified by the radar and the lines connecting the dots indicate the assumed path of the target as it is tracked. We generally use colors to represent heading direction within the graphic track-plot but have the ability to select other attributes within the data as well – e.g., target size, reflectivity, and speed. On the HSR, we adjust the track-plot graphic to show north as up. Thus, the color(s) of each group of lines and dots represents the spatial direction of the target's travel path. The color wheel, typically located in the upper right corner of the graphic, shows the various colors and the cardinal direction they represent. Blue is north, green is east, red is south, and light violet is west. On the VSR, the graphic track-plot colors generally represent the target's path within the track-plot graphic only (up, down, left, right) rather than cardinal direction (N, S, E, and W). Translating how this relates to the three-dimensional world is complicated and beyond the scope of this answer. We have some ability to understand targets traveling through the radar beam from the front of the radar antennae as well as those traveling through the beam from the back (direction in relation to only two cardinal points). In addition, targets can be seen ascending (up on the track-plot graphic) and descending (down in the graphic) in flight. As with the HSR, we can also select other attributes to be represented by these colors – notably target size, reflectivity, and speed.

Birds and Wind Energy: Assessing Habitat-based Impacts

Effects of wind power development on Greater Prairie-Chickens in Kansas

Presenter: Brett K. Sandercock, Kansas State University

Presentation

Authors: Brett K. Sandercock, Lyla M. Hunt, Virginia Winder (Division of Biology, Kansas State University); Andrew J. Gregory (School of Forestry, Northern Arizona University); Lance B. McNew (USGS Alaska Science Center); Samantha M. Wisely (Department of Wildlife Ecology and Conservation, University of Florida)

RESEARCH NEED

We have been investigating the impacts of wind power development on the demography, movements, and population genetics of Greater Prairie-Chickens at three sites in north-central Kansas since 2006.

The broad context for this research is the need to understand the possible impacts on Greater Prairie-Chickens (GPC) of anthropogenic development. While most bird-wind energy interaction research has focused on collision mortality, for the GPC, potential direct impacts include reduced reproductive effort. Potential indirect impacts include disturbance of lek activity, behavioral avoidance, and changes in predator numbers or foraging activity.

APPROACH

Male birds were trapped at the leks (communal display sites) and marked with color bands; females were fitted with radio collars allowing us to track movement, fecundity, the location and success of nesting, mortality, and environmental variables of nesting sites. Over a six-year period, we monitored 23 lek sites, 251 radio-marked females, and 264 nesting attempts, and genotyped approximately 1,700 birds at a total of three sites:

- Flint Hills: 3 years of preconstruction data at two sites (North and South Flint Hills)
- Smoky Hills: 2 years of preconstruction *vs*. 3-4 years of postconstruction data

Before-After Control-Impact (BACI) and Analysis of Covariance (ANCOVA) with distance to turbines study designs were used to test for seven possible impacts of wind power on GPC population performance:

- lek attendance
- breeding behavior
- use of breeding habitat
- fecundity
- natal dispersal
- female survival
- population numbers

All three of the sites were characterized by a mix of grassland and agricultural land.

FINDINGS

Lek attendance

Wind power development had a weak effect on lek attendance. The probability of lek persistence increased with distance from turbines, and most abandoned lek sites were located within 5 miles of turbines (the current buffer zone recommended by USFWS). Lek persistence was high, but habitat and lek size had the strongest effects on lek persistence; leks in native grasslands with > 10 males had the highest probability of persistence.

Movements of radio-marked females

We found a high degree of overlap in space use between pre- and post-construction movements of radio-collared females; a comparison of core-use areas indicates that 68% of pre-construction core use area overlapped with post-construction core use area. There is no evidence for behavioral avoidance of wind turbines, but this finding must be qualified by the fact that this is a highly-fragmented landscape, with lots of agricultural land dispersed throughout the grassland GPC habitat. (In other words, there is not much opportunity for displacement.)

Reproductive Performance

Female GPCs will make additional attempts if their first nesting attempt fails, but for this study we looked only at first nesting attempts. In the case of nest site selection, we found that, after controlling for the heterogeneity of the landscape, there was no strong correlation between nesting effort and proximity to wind turbines.

Reproductive success of prairie chickens is a limiting demographic factor, and is strongly influenced by high rates of nest failure and losses to predation. The strongest correlate of nest survival was vegetative cover at the nest site, with medium-height grass preferred for nesting. Reproductive success was not related to distance to turbines.

Overall Survival

A surprising conclusion of this research is that GPC survival *increased* after wind development, and that distance to turbines had no effect on this. Post-construction hazard rates were highest during lekking (weeks 1-10) and nesting (weeks 11-26), but winter mortality (weeks 27-52) was relatively low.

We hypothesize that turbines may have disrupted foraging behavior of raptors that kill prairie chickens. During the post-construction period, risk of mortality was reduced during the lekking season. The proportion of raptor to mammal kills increased, but the raptor kills tended to take place farther from turbine sites than during the pre-construction period. Mortality from collisions or harvest were rare events.

CONCLUSIONS / IMPLICATIONS

In summary, Greater Prairie-Chickens were not strongly affected by wind power development in north-central Kansas. Negative impacts include a trend for reductions in lek persistence near turbines, behavioral avoidance of turbines by females during their breeding season movements, and changes in the genetic structure of males at leks consistent with reduced dispersal or recruitment. We found no impacts of wind power development on nest site selection, female reproductive effort or nesting success, or population numbers. Positive impacts included an increase in female survival rates. Our results were based on pre- and post-construction comparisons for a broad suite of response variables and robust sample sizes, but we had limited spatial replication with one field site.

Future Research

We studied Greater Prairie-Chickens breeding in fragmented landscapes in the Smoky Hills ecoregion of Kansas, and it will be interesting to see if our results can be extrapolated to other sensitive species. Future studies of wildlife impacts should use similar protocols to investigate interactions between wind power and lek-mating prairie grouse in other habitats.

Questions & Discussion

Q: Did you record new leks being established post-construction – perhaps moving away from turbines?

A: Yes, we did record new leks throughout the study – hard to know if some were just unrecorded previously, but some were new leks established near the turbines. Sites tend to persist year to year, but some new leks a couple hundred meters away may be leks displaced from turbine pad area.

Three questions related to the relationship between wind development and decreased predation of prairie chickens:

Q: You found that predation on prairie-chickens post-construction was farther from turbines. Is it possible that mammalian and avian predators are simply avoiding these areas during post-construction, or that their prey (the prairie-chickens) had moved farther from the turbines, or some other factor?

A: The change in GPC survival rates is one of the most interesting findings. It is clear that survival rates did increase, and because this is a predation-mediated system, we know that something happened with the predators. It would be nice to have data on predator abundance, but because we don't, we're forced to go to the literature, and this becomes a speculative exercise. Clearly something changed in the predation rates, but whether it was an effect on raptors or on mammalian predators or both, we don't know. We can look at the carcasses on the ground, and try to assign cause-specific mortality. However, this is not an exact science; if feathers have been chewed, we would assign to a mammal, but it could have been killed by a raptor and then scavenged by a mammal.

Q: The potential role of a low abundance of displacement habitat is acknowledged, but not studied. If turbines cause some avian predator avoidance of leks, would it be reasonable to expect an increase in avian predation at leks beyond the influence of the turbines?

A: We do have evidence for that. The distance from the kill sites to the turbines was greater for raptor kills during the post-construction period. There was a twofold increase in distances for the carcasses, but sample sizes were small, so the T-test was not significant.

Q: Greater sage-grouse has been shown to have lag time before impacts of development are seen. Might this be the same for greater prairie-chickens?

A: Our study had three years of post-construction data for intensive monitoring of females, and four years of lek monitoring. For the three years of nest survival monitoring there was no evidence of a lag. As far as we could push it, we were not seeing evidence of lags.

I would suspect that if there are impacts of turbines on predators, these would be of less concern – these raptor predators are mobile, and have large ranges relative to wind development in the Smoky

Hills. Roadside surveys by the state wildlife agency KDWPT indicate that mammalian predators are actually increasing in Kansas; it is unknown if they are threatened by wind turbines.

Regarding potential benefits of increased survival for prairie-chickens:
Our demographic models suggest that increases in survival are going to have a large impact on declining populations. In a stable population, reproductive output is key – range management practices could improve this.

Q: What changed in the weather (precipitation, winter severity, etc.) pre- and post-construction?

A: We've compared climatic conditions pre- and post- and found no consistent pattern of difference in precipitation or temperature between pre- and post-construction periods.

Q: Which predator species – raptors or mammals – are more responsible for predation of nests closer to turbines?

A: It is hard to determine – we can look at nests and eggs. We are incorporating predator component in ongoing research (point counts). Evidence from nest camera work suggests that majority of nest losses are to mammalian predators, especially coyotes.

A (Chris): don't have any turbines up, but do see more mammalian predation in general, though it's very hard to tell after a couple of days due to scavenging activity.

Q: Were there any wind turbine collision losses of the prairie-chickens?

A: Yes, a small proportion of our sample (<5%) carcasses were found with gash marks located within 100 m of turbines.

Q: Will your study continue at Smoky Hills? Turbine effects on Greater Prairie-Chickens may take several years to manifest due to male lek fidelity and a lack of alternative nest sites.

A: We have completed field work at Smoky Hills. I would argue that 3 years post-construction is enough to assess lag effects for these short-lived birds. We've done the demographic model; these are short-lived birds with a generation time of 1-3 years, so if there were any lag effect it would have shown up within the 3-year study period.

Q: How applicable are your findings to other grouse species, such as the Lesser Prairie-Chicken? In your opinion, are the species so drastically different that these results have no bearing beyond the study?

A: We did not find negative impacts for Greater Prairie-Chickens, but we're hearing that sage grouse are affected. For the Lesser Prairie-Chicken, most of the research is with oil and gas development, and there is good evidence that noise from pump jacks disturbs the leks. Wind turbines are relatively quiet, so perhaps do not have the same impact. These are all lekking species, they're ground-nesting birds, vulnerable to the same suite of predators. It may be that species responses are going to differ depending on what the context is. Our study site was a fragmented landscape. It is encouraging for the Prairie-chickens that we found no effects; this was a large sample size, and the footprint for these turbines was right in the core of some of the best habitat.

<u>ADDITIONAL QUESTIONS</u>
These questions were submitted but not answered during the conference.

Q: The number of turbines in proximity to a nest/lek may have an effect on behavior or reproduction – not just distance to nearest turbine. Have you examined this for your Smoky Hills dataset?

A: The turbines are in lines along the ridges so proximity to turbine is a better metric than density of turbines.

Q: Realizing you did not investigate the level of development on situations in less fragmented landscapes, can you speculate on the level of development that might trigger negative relationships for the metrics you quantified?

A: Our study site was relatively fragmented with high proportions of grassland rangelands mixed with row-crop agriculture. Behavioral displacement of prairie chickens may be less likely if birds do not move into agricultural fields.

Q: During construction, were seasonal stipulations observed – i.e., no construction during nesting/lek period? Were buffers from leks observed? Also was the existing grassland habitat "high quality"?

A: Site preparation started in April but erection of turbines and other construction was mainly completed after the prairie breeding season. Buffers from leks were not implemented and some turbines were sited on existing lek sites. Grassland habitats were managed rangelands and supported high rates of productivity compared to Flint Hills sites.

Q: Could you speak to the potential long-term effects of reduced predation and increased survival of female prairie-chickens? You noted it as a positive result, but it is not necessarily positive for predators – or for the prairie-chickens – if there are changes to predatory/prey regimes.

A: Our results show that prairie chickens have high reproductive potential and could recover quickly if demographic losses to predators could be reduced.

Q: Does this mean we don't really need to worry about Greater Prairie-Chickens in relation to wind power? With at least some lek abandonment related to development, what threshold should we set relative to assuring long-term conservation success for chickens?

A: Our study results showed that interactions between predation and rangeland management are driving population declines in prairie chickens and that the effects of wind power development are minor. In current work, we are investigating patch-burn/grazing as a rangeland management strategy that might benefit prairie chickens and other grassland birds by increasing nesting cover and heterogeneity in vegetative structure.

Avoidance of wind turbines by grassland birds

Presenter: Doug Johnson, U.S. Geological Survey

Authors: Douglas H Johnson, Jill A. Shaffer (USGS)

RESEARCH NEED

The USGS Northern Prairie Wildlife Research Center has investigated the possible avoidance of wind turbines by grassland birds for ten years, 2003 through 2012. Study has focused on three wind energy

facilities located in four counties, one in Oliver County in North Dakota, one in Hyde County in South Dakota, and the Tatanka facility which spans Dickey County (ND) and McPherson County (SD).

APPROACH

Our study sites were three major wind farms in North Dakota and South Dakota, where we were able to obtain bird data during one year before wind turbines were constructed and during several years afterward. To account for possible differences in bird abundance due NOT only to the wind development but to differences in bird abundance that may be attributed to the year or to location, we are using a Before-After, Control-Impact design and conducting a gradient analysis to compare the number of sightings of birds at various distances from wind generators to the number expected if generators had no effect.

Results are presented by species, demonstrating how densities of each varied in relation to distance to nearest turbine location, and if and how those patterns changed from pre-construction through up to nine years following development.

Bird surveys are conducted throughout the entire area within a grid system of fiberglass fence posts and survey markers. By assigning spatial coordinates to every bird location, we can determine the distance of each bird observation from the nearest turbine. After removing unsuitable habitat for the focal species, we placed 10,000 random points in the area of suitable habitat. We then calculated the distance from each observed bird location to the nearest turbine and the distance from each random point to the nearest turbine. Those distances were then assigned to one of 15 distance categories.

FINDINGS

For the Hyde County, South Dakota site, the pre-treatment year was 2003. Focusing on Western Meadowlarks (WEME), we would expect that birds are distributed randomly relative to *proposed* turbine locations and thus would expect to see no pattern in the scatter plot of Mean Difference by Distance Category. The post-treatment study years for this site were 2004-2006. If WEME were avoiding the turbines, we would expect to see a pattern whereby most differences in the nearer distance categories are negative. Instead, we found that WEME do not appear to be avoiding wind turbines. The same result was found for WEME at the other wind sites studied.

For Grasshopper Sparrows (GRSP) at the Hyde County site, the mean difference between the number of bird observations and the expected number of bird observations tended to be negative out to about 200 m. Therefore, GRSP did appear to be avoiding wind turbines. Similarly, at the Oliver County, North Dakota wind facility, GRSP did appear to avoid turbines, out to a distance of about 150 m. This was likewise the case during the first post-construction year at Tatanka (2009), but by 2010, GRSPs were no longer found to be avoiding the turbines at this site.

We conducted at least two surveys each season. By the second survey, the birds have established their territories. Do they show a delayed response to the presence of turbines? Or, on the contrary, do they acclimate to turbines? Results were mixed. At Oliver County, there was more evidence of avoidance on both the first and second surveys. At Tatanka, there was not much evidence of effect. (There was some evidence of avoidance in 2012, but not much evidence compared to other sites.)

We looked at other species, including Bobolinks and Savannah Sparrows. At Oliver there was some evidence of Bobolinks avoiding turbines, but this is not as common a species, and it is difficult to be sure

with small numbers. Savannah Sparrows and Bobolinks were found to avoid turbines at the Tatanka site both immediately following construction and two to three years out, but again, we are talking about small differences.

CONCLUSIONS

The challenge for this type of study is that we are looking for modest changes in small numbers. Grassland birds occur at low densities, and densities vary greatly both spatially and temporally. The area surveyed near turbines is relatively small, so only a small number of birds would be expected there even if turbines have no effect.

Questions & Discussion

Q: Did you monitor during construction? How soon after construction did you begin to monitor? Could birds be adapting over shorter temporal scale – weeks instead of years?

A: We did not monitor during construction, but went out during the next breeding season. So, if construction was completed by May, we would go out that year, but if construction went beyond May, first post-construction monitoring would have been the following year.

We have not seen birds adapting over shorter temporal scale; that is what we looked for when we compared the first and second surveys from a given season. So far we have not seen such adaptation.

Q: Could the differences in avoidance be explained by habitat / structure? Any statistical analysis of the results?

A: We don't believe habitat explains it, or anticipate that it is a factor. Regarding statistical significance of results, as a statistician I am more interested in consistency of patterns than of any particular result being statistically significant at some arbitrary cut-off point. If we're seeing the same pattern year after year, it's likely not just a fluke. Consistency among years and among sites is important. We would like to have been able to look at more than three sites.

Q: "Expected" seems to be based on "random" bird position. Does this really reflect bird behavior? If concept of expectation is off, results would be off; results are a function of how random numbers are generated.

A: From all random points, we measured the distance to nearest wind turbine, and took the proportion within each 50-meter category – that number was scaled to the number of birds that were there. If there is no difference due to the presence of the wind generator, we would expect the same number of observations among the random points as among the birds. Essentially we generate a large number of random points in order to determine the area available for birds within each 50-m band of distance to nearest turbine.

Q: Was your survey data collected using point counts?

A: No; point counts do not provide the spatial precision we need. We did complete mapping of all birds, walking transects at 100 m distances, and recording exact locations of the birds rather than using a point-count method.

Q: How did you determine the "expected" number of birds?

A: For the total study area, the expected number of birds is the same as the number of observed birds. Conditional on that number of birds observed in our survey area, we determined the expected distribution of those birds relative to the proximity to the nearest wind generator, under the null hypothesis that birds were indifferent to wind generators.

Q: Did you look at variation in population size for your focal species over time, and whether that may have influenced your results?

A: No. Because we were analyzing results within each year, we were just looking at how birds were distributed relative to the wind generator, so variation of population size over time would not bias our analysis.

Q: Do ground-nesting grassland birds avoid wind energy facilities?

A: Some do; some do not.

Q: Did wind company mow around base of turbines? Could that have affected bird avoidance behavior?

A: No treatments, most of the lands were grazed. Roads and pads were graveled, but no other treatments were applied.

Q: Does your research have any implications for mitigation?

A: One could think about grassland management to offset losses. If one took the footprint of a given generator and factored in the number of turbines to estimate total displacement, one could use that value to offset the impacts.

Q: Can anything from your research be extrapolated to other grassland bird species?

A: We can't extrapolate from one species we looked at to another, so I would be very reluctant to generalize beyond the species we looked at to other grassland species.

<u>ADDITIONAL QUESTIONS</u>
These questions were submitted but not answered during the conference.

Q: Did you collect any data on Sprague's Pipit?

A: We recorded all birds we detected but, unfortunately, Sprague's Pipits, as well as Baird's Sparrows, were far too uncommon to analyze.

Q: What is a displacement within 200 m likely to mean with regard to local or regional populations of Grasshopper Sparrows?

A: That would depend upon the total build-out of wind facilities. Making such a projection would be useful, but we haven't taken our results that far yet.

Q: If you restrict the meadowlark analysis to the closest ten categories, it appears there is avoidance. Do you think there may be a threshold distance below which there is a response and above which there is not?

A: Our analytic method was intended to detect such a threshold, if one existed. The pattern described for meadowlarks occurred only in one year at one site, so it was not at all consistent.

In response to question for panel:

Doug Johnson: We did find impact on two species, and also have a basis for estimating impact and providing some mitigation options.

Short-term impacts to Greater Sage-grouse from wind development

Presenter: Chad LeBeau, University of Wyoming; WEST, Inc.[2]

Presentation

Poster

Authors: Chad W. LeBeau (Department of Ecosystem Science and Management, University of Wyoming & WEST, Inc.); Jeffrey L. Beck (Department of Ecosystem Science and Management, University of Wyoming); Gregory D. Johnson (WEST, Inc.); Ryan M. Nielson (WEST, Inc.); Matt J. Holloran (Wyoming Wildlife Consultants, LLC)

RESEARCH NEED

Little information exists about the impacts of wind energy development on Greater Sage-grouse (*Centrocercus urophasianus;* hereafter sage-grouse). Wind energy development is increasing in rangeland habitats, which has raised concerns about direct and indirect impacts to sage-grouse, as these birds are known to avoid tall structures and human activities. To begin to address these concerns and questions, the Sage-grouse Research Collaborative (SGC) was formed in 2010 as a subgroup of the Grassland and Shrub Steppe Species Wildlife Workgroup. SGC has selected three projects, two of which will be presented here and in Christopher Hansen's presentation, below. (A third project, to be led by the Idaho Department of Fish and Game, is on hiatus because the wind project is on hold.)

This presentation focuses on how wind energy development may result in different habitat selection patterns, which are predicted to lead to reduced population fitness. The purpose of this study was to:

- To evaluate the functionality and viability of greater sage-grouse habitat within the influence of a wind energy development
- Determine the short-term impacts of the wind energy development on greater sage-grouse habitat selection patterns, population demographics, and male lek attendance

APPROACH

Study Area

We selected a study area in Carbon County, Wyoming, between the towns of Medicine Bow and Hanna, which included the Seven Mile Hill (SMH) Wind Energy Facility and the area north of US Highway 30 surrounding this facility. The area south of U. S. Highway 30 was considered the non-impacted Simpson Ridge study area. Construction began on SMH in the summer of 2008 and the facility, which consists of

[2] Presentation accompanied by a poster.

79 1.5 MW turbines, 29 km of access roads, 8 km of paved roads, and 26 km of transmission line, began operations in December. A second phase of development had been planned for Simpson Ridge, but has been terminated because the site lies entirely within the sage-grouse core area. The SR control area includes 50 km of paved roads and 17 km of transmission lines. Habitats within both study areas are similar, mainly comprising of Wyoming big sagebrush. Land ownership within both areas is mainly private, with checkerboard state and federal lands.

Data gathering methods

In April 2009 and 2010, we captured 116 female sage-grouse near Medicine Bow, Wyoming and have monitored these grouse for two years to evaluate nest, brood, and female survival, and habitat occurrence.

We also conducted aerial lek surveys to identify any new or unknown leks within both study areas. In each of the years 2008 to 2012, three ground lek counts were conducted 7-10 days apart, to document the highest number of males attending each of the leks identified from the aerial survey.

Resource Selection Analytical Methods

We used a use versus availability study design comparing a set of available points to used points during the nesting, brood-rearing, and summer periods. We utilized forward model selection and information theoretic criterion to select top models. Lastly, we created resource selection functions to predict the relative probability of use within the study area.

Survival Time Analysis

Survival time analysis was used to examine the relationship and magnitude of multiple covariates to survival of an individual.

The Cox Proportional Hazards method was used to model nest survival. However, because broods and females utilized different habitats throughout the survival period, we used the Anderson Gill (AG) formulation of the COX model. The AG model accounts for continuous or categorical covariates that may vary during monitoring – in this case broods and females utilizing multiple habitat types throughout the survival period.

FINDINGS

The proximity to wind turbines does not appear to affect female sage-grouse habitat selection during nesting or brood-rearing, but the relative probability of selection during the summer increased in habitats with close proximity to Seven Mile Hill wind turbines. Female survival was not influenced by wind turbines but nest and brood survival were both negatively affected by proximity to wind turbines. Distance to major roads and transmission lines accurately predicted female survival; however, this model did not differ much from the null model. Male lek attendance decreased on average by 25.6% (90% CI: 17.5–32.9%) every year from 2008 to 2012 within leks located at Seven Mile Hill and Simpson Ridge.

CONCLUSIONS / IMPLICATIONS

This is the first study to evaluate short-term effects of wind energy infrastructure – specifically wind turbines – on sage-grouse fitness parameters and habitat selection.

Future Research
Beyond the two years of research (2011-2012) that will take place under the NWCC Collaborative, we expect to extend this study another three years for a total of seven years of research. Future research objectives include estimating population demographics and looking at both habitat selection and lek recruitment.

QUESTIONS for Chad LeBeau and Chris Hansen follow the summary of Hansen's presentation, below.

Ecology of male Greater Sage-grouse before wind energy development in South Central Wyoming

Presenter: Christopher Hansen, University of Missouri

Authors: Joshua J. Millspaugh (Department of Fisheries and Wildlife Sciences, University of Missouri); Mark A. Rumble (U.S. Forest Service, Rocky Mountain Research Station, Forest and Grassland Research Laboratory); Aleshia Fremgen, Christopher Hansen (Department of Fisheries and Wildlife Sciences, University of Missouri); R. Scott Gamo (Wyoming Game and Fish Department); Jon Kehmeier, Nate Wojcik (SWCA Environmental Consultants)

RESEARCH NEED
This study of the demography, resource selection, and lek ecology of male greater sage-grouse (*Centrocercus urophasianus*) is one of three projects being undertaken by the Sage-Grouse Research Collaborative, a subgroup of the Grassland & Shrub Steppe Species Wildlife Workgroup. Using a before-after/control-impact study of an area comprising 320,000 acres of sagebrush-steppe ecosystem southwest of Rawlins, Wyoming – the proposed site of the Chokecherry and Sierra Madre Wind Energy Projects – this study will look at how development of the proposed 1,000-turbine, 2-3,000 MW wind facility impacts the ecology of male greater sage-grouse. (All results presented are preliminary.)

Specifically, the study will look at:

- Survival
- Movements
- Resource selection
- Lek dynamics:
    - Sightability (probability of detecting a male on a lek if it is there)
    - Lek transition models
    - Lek attendance

APPROACH
In Spring 2011, we placed 20 GPS-PTT (platform transmitter terminal) units and 50 VHF transmitters on yearling/adult male sage-grouse. These animals were equally distributed among five regions within the study area. In Fall 2011, we marked 53 juvenile sage-grouse (25 males and 28 females) with VHF transmitters. The solar-powered GPS-PTTs give us five to nine locations per day; we now have more than 50,000 locations. Aerial telemetry (one flight per month) was used with the VHF transmitters to track survival and lek sightability and transition.

FINDINGS

Findings reported here are from preliminary pre-construction data.

Survival

April to December survival of GPS marked males was 49% (SE= 11); survival of males with VHF transmitters was 51% (SE= 11) and September to December survival of juvenile sage-grouse was 55% (SE= 8).

Movements

Movement data from 2011 indicates that home ranges are much smaller during spring (leks) than they are over summer. Home ranges averaged 65 ha in spring (SE=21) and 422 ha in summer (SE=21). Spatial overlap of seasonal ranges was 7% between spring and summer; 3% between summer and winter; and 29% between winter and spring.

Resource Selection

Males tend to use the same leks they used the spring before. At the microsite resource use level, we quantified vegetation characteristics (canopy cover and height, visual obstruction, and sagebrush density), pairing 43 sage grouse locations with use-dependent random sites 50, 250, and 500 m away. Resource selection by male sage-grouse suggested positive associations with canopy cover of forbs and sagebrush height, but negative associations with sagebrush density and sagebrush canopy cover. We saw high use of riparian zones and hay fields in summer.

Lek Dynamics

Sightability, or the ability to detect a male sage-grouse on the lek if he is there, was determined using two independent observeres, one with telemetry equipment and one without. Sightability averaged 54% (SE= 14) and was negatively influenced by sagebrush canopy cover, vegetation height-density, and distance from observer.

Lek counts were conducted using the Wyoming Game and Fish protocol. Hourly lek attendance averaged 32% (SE= 1) which declined steadily throughout the morning. Daily lek attendance averaged 56% (SE= 3) with peak attendance in early May. (This was earlier than usual, because it was a dry year.)

The probability of male sage-grouse transitioning leks was 0.14 (SE=0.03), and 0.26 (SE= 0.05) for returning to the originating lek. Probability of lek transitions increased later in the breeding season.

Questions & Discussion

Q: Is it likely that decreases in lek attendance could be attributed to turbine noise creating a decrease in the audible range of males using the lek?

LeBeau: We did not find any significant difference between leks near v. far from turbine. May start seeing some trends, then we will be able to look at factors like noise or visual disturbance.

Q: How likely is it that nest failure events are independent of one another and if this assumption of Cox Proportional Hazards is violated, how would that impact your estimates?

LeBeau: We just assumed they were independent of each other; our sampling approach of capturing and tagging random females allows us to assume that. We also testing residuals of the individual models to see where the residuals fell out in that model.

Q: If you check survival once a month, how do you know the date (for your program MARK model)?

Hansen: We know which month the bird because there is a mortality sensor included in the transmitters we use and we complete monthly flights. Thus, we evaluate survival to the month, not day.

Q: Will the study of Simpson Ridge and Sierra Madre/Chokecherry be compared at all?

Hansen: We try to collect data in similar ways so we can look at what impact wind development might have across the range.

Q: Did you look at sage grouse nest and brood survival before wind farm construction, and could nest and brood survival be lower in locations with higher habitat suitability?

LeBeau: No, we did not look at pre-construction data. It could be the case that nest survival is lower in that area. We did incorporate a number of grassland features into modeling. [See LeBeau poster.]

ADDITIONAL QUESTIONS

These questions were submitted but not answered during the conference.

Q: Are female sage grouse nesting and rearing behaviors (site selection, etc.) influenced more as a factor of turbine presence or presence of males/active leks?

LeBeau: This could be; however, we incorporated distance to nearest lek in our modeling to account for the possible spatial autocorrelation that may exist because of the proximity of turbines to active leks.

Q: Did you look at male attendance at leks or nest and brood survival over five miles from turbines?

LeBeau: Yes, we incorporated nests and broods that were located 16 km from the nearest turbine. We also considered leks from the regional population to see if there were similar trends in the regional population.

Raptors and Wind Energy

A review and standardizing of raptor fatality estimates at wind energy facilities in the Columbia Plateau Ecoregion

Presenter: Kimberly Bay, WEST, Inc.

Authors: Wallace Erickson, Kimberly Bay, Michelle Sonnenberg, Elizabeth Baumgartner (WEST Inc.)

RESEARCH NEED

At end of 2011, there was 5086 MW wind energy capacity operational in the Pacific Northwest, with 98% of this generating capacity occurring in within the Columbia Plateau physiographic region, also known as the Columbia Plateau Ecoregion, or CPE. With this development comes the potential for direct impacts to raptors through collision mortality. The objectives of this project were to:

- Develop a cumulative fatality database for raptors at projects within the CPE.
- Provide species-specific fatality rates for raptors.
- These rates can help understand regional cumulative impacts for specific raptor species and may be useful for developing adaptive management thresholds.

APPROACH

We looked at data from 35 studies in the CPE of at least one year in duration. To avoid biasing our results towards multi-year studies, we used an average for those projects. We also looked at the variability of fatality estimates between years at facilities that had been studied for multiple years.

Fatality estimates were calculated using either the Shoenfeld (23 studies) or Huso (6 studies) estimators. Six studies did not document raptor fatalities during standardized searches. For standardization purposes, five of the six Huso estimates were recalculated to Shoenfeld; the sixth Huso estimate was the identical to Shoenfeld, and was left as Huso.

WEST calculated mean fatality estimates, confidence intervals, and other statistical metrics for diurnal raptors, provided a species composition list of raptor fatalities in the Pacific Northwest, and estimated species-specific fatality rates. These mean fatality rates were then used to develop a scientific basis for defining percentiles of fatality estimates using the kernel density estimator. The adjusted fatality estimates and percentiles were used to provide context for the regional cumulative impacts of wind energy development on raptor populations.

WEST provided estimates of population size in the CPE for each species and the associated mortality estimate for the current development and expected expansion of wind energy facilities. Raptor population estimates in the CPE were estimated using Partners in Flight (PIF) data from 1990-99. We used the Oregon and Washington portions of the Great Basin Bird Conservation Region (BCR 9), and scaled that down based on the proportion of area BCR 9 encompassed by the CPE. We provide a high estimate that is unadjusted from the Partners in Flight estimate, which assumes a pair of birds for each bird observed during surveys. We also provide a low estimate, which excludes this pair adjustment. (The

exclusion may be appropriate for raptors as the period of incubation typically occurs prior to BBS surveys in June, per Millsap and Allen 2006.)

To further expand understanding of the factors surrounding raptor-turbine collisions, WEST will conduct a comprehensive analysis of the circumstances of raptor fatalities found at these projects based on protocol approved by ODFW, USFWS, IRI, and ODOE. Detailed maps showing locations of raptor fatalities by species, turbine locations, topography, land cover, and other readily available information will be included in this analysis.

FINDINGS

Raptor fatality rates in the CPE range from 0 to 0.47 fatalities per MW per year.

A frequency histogram of the fatality estimates was used to produce a smoothed curve of raptor fatality estimates for the CPE. Using the kernel density estimate, the probability of occurrence for any particular raptor fatality estimate can be extracted. For example, the 75th and 90th percentile of the kernel density estimate represent the point below which the specified percentage (75% or 90%) of raptor fatality rates occur relative to the smoothed curve. Based on data in the CPE, the 75th percentile was 0.15 raptor fatalities/MW/year; i.e., 75% of the studies had 0.15 fatalities/MW/year. The 90th percentile was 0.24.

The Coefficient of Variation for multiple study years ranged from 0.14 to 1.41 at six facilities. Generally, we found no real large differences in rates among years.

We looked at fatality rates by species at the 75th percentile, assuming equal detection rates for all species. An adjustment was made for American Kestrels, based on the assumption that their smaller size makes them harder to detect. Kestrels make up 40-50% of raptor fatalities in the CPE, followed by Red-tailed Hawks (26-32%).

At the current level of development (5,086 MW), total raptor fatalities are estimated at 771, with adjusted kestrel fatalities totaling 382[3] and Red-tailed Hawks estimated at 204. Species-specific fatality estimates are then extrapolated to look at the possible impact of build-out at the 6,057 MW and 10,000 MW levels for the CPE.

Examples of the study's findings are given for Swainson's Hawks and Golden Eagles. (Estimated fatality rates are based on the unadjusted proportion of raptor fatalities.)

Swainson's hawks

- Estimated fatality rate 75 percentile : 0.0085 per MW per year[4]
- At the current and possible buildout, fatalities equal 1-2% of the estimated population
- Half of all 12 SWHA fatalities, both carcass search and incidental, were found in August
- 83% (5 of 6) of carcasses found during searches were found in August

Golden eagles

- Estimated fatality rate 75 percentile: 0.0012 per MW per year[5]
- At the current and possible buildout, fatalities equal 1-2% of the estimated population

[3] Estimated kestrel fatalities are multiplied by a factor of 1.5 in the adjusted total.
[4] The adjusted fatality rate was 0.0040 Swainson's Hawk fatalities per MW
[5] The adjusted fatality rate was 0.0006 Golden Eagle fatalities per MW per year

- One Golden Eagle fatality occurred in late April, while the other occur in late January
- Given uncertainty in population estimates, suggest more focused understanding of potential impacts on Golden Eagles

CONCLUSIONS / IMPLICATIONS

Combined, the CPE's strong dataset provides a more complete picture of the impacts of wind energy development on raptor populations in the CPE. For most raptor species the proportion of fatalities is small relative to populations, but for some species, such as Ferruginous Hawk and Golden Eagle, more study is needed to understand population impacts.

Additional Research

Additional research will look at improving population size estimates, looking more closely at adjustments for species-specific detection, and reviewing fatality timing data for specific species.

For population size, we will look at more recent (2000-2011) BBS data and determine numbers specific to the CPE, rather than adjusting data from a larger region.

We plan to examine the appropriateness of detection adjustments on a species specific basis, taking detection distance, pair adjustment, and time-of-day adjustment into account.

We also plan to review fatality timing on a species-specific basis, where possible. Timing of fatalities can be compared to life cycle characteristics or environmental clues to enhance understanding of how potential risk changes over time. For example, we noted two obvious peaks for Red-tailed Hawks: early June (shortly after eggs hatch) and Late October (coinciding with migration). We noted two obvious peaks for Red-tailed Hawks (early June and Late October). Can this fatality timing finding be extended to other, less commonly observed *Buteo* species?

In addition to the timing of fatalities, additional research into the characteristics surrounding fatalities can provide clues to improve siting of future projects and management strategies for current projects. We will review landscape features, such as topography and aspect, near fatalities on a small and large scale, including a comparison among facilities where fatalities are found and those where fatalities have not been found.

Questions & Discussion

Q: Explain why fatality rates presented at the 75th percentile? What does this mean, exactly?

A: We presented the 75th percentile to be conservative. We derived both the 75th and 90th percentile – but went with 75th as a good "middle of the road" answer.

Q: What was the 1.5 multiplier for American Kestrel based on?

A: It was just a raw adjustment; we do intend to come up with a more biological defensible number.

Q: In calculating species-specific fatality, why did you have to assume equal detectability?

A: We adjusted American Kestrels because we realized they are not detected at same frequency as other raptor species, due to their size. Very few studies actually use raptors in the bias trials but given the size of the rest of raptor species it was assumed they are approximately equally detectable.

Q: Why was the population estimate for Rough-legged Hawks zero for the CPE? How can fatalities observed exceed what is thought to be present?

A: Partners in Flight (1990s) and BBS surveys – both predicted zero… We were using the best available data sets to determine population estimates, which we recognize is not perfect. We are hoping to get better/more recent data. We recognize that for some species, especially those that do not breed in the area, the BBS surveys don't accurately reflect population sizes.

Q: Were you able to identify correlations for sites with lower raptor species fatality rates?

A: We used standardized fatality estimates for comparison's sake, then determining species-specific fatality rates. We do intend to look further into other possible factors, but we have not investigated any sort of correlations at this point.

ADDITIONAL QUESTIONS

The following questions were submitted but not answered during the conference.

Q: Regarding the issue of displacement, it would be very helpful to have pre- and post-construction use rates as well as fatality data. Do you have such data at any of your sites?

A: We do have pre-construction data for some of the sites but only have a couple of facilities with post-construction use data.

Q: How much are we able to generalize your results to other parts of the country?

A: The methods that we used could be utilized in other parts of the country but the results can't necessarily be generalized to other diversified populations around the country.

Q: Considering that newer technology includes larger turbines with more MW, why [not] choose the fatality metric "per MW" v. "per turbine"? For example, have you found that a single 3MW turbine kills more birds than a 2MW turbine?

A: We plan to present per MW, per rotor swept area and per turbine estimates. We are not aware of any publicly available 3 MW studies in the CPE.

Q: Given that some raptor species only winter or migrate through the CPE, won't your population estimate be off using BBS data? Why not eBird?

A: We are aware of the limitation of the BBS data but based on our research the PIF/BBS data is the best known source of population data. Based on an initial/brief review of eBird I am not sure there is a standardized method occurring that would allow you to extrapolate population estimates.

Q: How do these wind fatalities compare to transmission line fatalities?

A: We didn't compare these rates.

Q: What are the mitigation implications of the monthly peaks of raptor fatality in the CPE?

A: For mitigation purposes if a sensitive species shows a clear pattern of collision, in a short time period, it may be worthwhile for companies to curtail the turbine during the time frame or employ an onsite biologist to call in manual curtailment if a sensitive species is observed.

Q: Were you able to identify correlators for sites with lower raptor species fatality rates?

A: This has not been investigated yet.

Factors affecting bird mortality in wind farms, and mitigation measures; the state of the art in Spain

Presenter: Miguel Ferrer, Doñana Biological Station

Presentation

Authors: Miguel Ferrer, Manuela De Lucas (Department of Ethology and Biodiversity Conservation, Estación Biológica de Doñana (CSIC)); Marc J. Bechard (Raptor Research Center, Department of Biological Science, Boise State University); Antonio-Román Muñoz (Fundación Migres); Guyonne F. E. Janss (Asistencias Técnicas Clave S.L.); Eva Casado (Fundación Migres); Cecilia P. Calabuig (Department of Ethology and Biodiversity Conservation, Estación Biológica de Doñana (CSIC))

RESEARCH NEED

There is clear evidence that the probability of raptor collision depends critically on species behavior and weather conditions, and the topographic factors related to each wind turbine. In Spain where this research took place, environmental impact assessment (EIA) studies have been based on observations of birds before the construction of wind energy facilities. But how accurate are the predictions based on these observations? This question is of major importance, especially for those wind facilities located on the Strait of Gibraltar. The Strait is 14 km across at its shortest distance, which functions as a major migration bottleneck for Paleo-African soaring migrants, such as the Griffon Vulture.

In order to mitigate the impact on raptors, and particularly on the Griffon Vulture, in 2007 a program based on selective stopping of turbines was imposed, in collaboration with the environmental competent authority, on new approved projects. During 2008 there was a reduction in mortality by 48%, which remained in 2009 with a remarkably lower economic cost.

In Spain and elsewhere, including the U.S., the most relevant pre-construction indicator for potential raptor fatalities is considered to be the local density in the wind resource area, usually measured as the number of birds crossing the whole area of the proposed wind facility. Having found that a relatively small number of turbines were responsible for the majority of collision fatalities at our study area, an important objective of this project was to develop better methods for predicting flight trajectories within a proposed wind energy site, to guide siting decisions and minimize both fatalities and the economic costs of mitigation actions.

APPROACH

We focused on the area around Tarifa, on the southern Spanish coast, analyzing data from 53 EIAs in relation to the actual recorded bird mortalities at 20 fully-installed wind facilities to determine whether the methods being used accurately predict the risk posed to birds by new wind facility installations. Our study looked at a total of 252 turbines, ranging from 0.8-2.2 MW, and 50-80 m tower height (without blades).

FINDINGS

No relationship between variables predicting risk from EIAs and actual recorded mortality was found.

Taken altogether, these facilities recorded 337 bird collision fatalities per year, 124 of them raptors. The mean collision rate of 1.33 birds per turbine per year made this one of the higher mortality records published in the world. Yet we found that mortality per turbine per year was significantly different among the wind facilities. The one with the highest mortality of griffon vultures accounted for 23% of total fatalities for the species, followed by another one causing 13%.

We compared bird data from the EIAs with bird collisions per turbine and year at operational wind facilities to identify any relationship between pre- and post-construction studies, but found that there was no relationship between pre-construction density (number of birds crossing the area) and post-construction mortality of birds at the wind farm scale. Moreover, we found a 50% coefficient of variation of vulture mortality among wind facilities, the coefficient of variation among turbines was 150%. Of the 252 turbines we studied, 200 of them caused no vulture fatalities, while ten turbines were responsible for four fatalities each.

Operational Mitigation

- Since 2008, we have been using a selective stopping program to stop turbines when vultures are observed nearby.
- The Griffon vulture mortality rate has been reduced by 65% with only a reduction in total energy production of the wind farms by 0.07% per year.

Improved Turbine Siting

The selective stopping approach is an effective post-construction mitigation measure. But it would be better to improve turbine siting to avoid problematic turbine locations.

To do this, we built a scale model of the wind farm site and used a wind tunnel to simulated three different types of wind and note the main trajectories. When these predicted trajectories were then compared with the real Griffon Vulture movements in the same area, we found no statistical differences between the observed Griffon Vultures' flight trajectories and the three wind passages observed in our wind tunnel model.

Moreover, a significant correlation was found between dead vultures and the predicted proportion of vultures crossing each turbine according to the aerodynamic model ($r_s = 0.840$, $n = 6$. $P = 0.036$) [slide #60].

CONCLUSIONS / RECOMMENDATIONS

The use of selective stopping techniques at turbines with the highest mortality rates mitigate the impacts of wind farms on birds with a minimal effect on energy production.

As a result of this research, new Spanish regulations require Risk Assessment Studies be conducted at the individual turbine scale and recommends use of the Wind Tunnel Test as a good tool.

Questions & Discussion

Q: Could you explain how the wind tunnel test was conducted once the topographical model was built?

A: We introduced a scale model to test our hypothesis that birds would move with the wind currents. Made a prediction based on building scale model of the wind farm and introducing it into a wind tunnel. When we moved back to the real area and tested our prediction, we found it was very accurate. We are likewise looking at distribution of actual fatalities. The wind tunnel test is better for looking at how birds move within a wind farm – not so much how they move from one wind farm to another. We are trying to come up with a model that would replace the need to create a scale model and physically test it in a wind tunnel.

Q: How many turbines were monitored at the 20 wind facilities, and how often?

A: We are monitoring all the turbines – a total of 252 wind turbines – all of them checked daily.

Q: Could you expound on approaches to conducting the turbine by turbine risk assessments you advocate?

A: Past risk assessments were being done on the scale of the entire wind farm site, but we realized that the distribution of birds is not homogenous throughout the wind farm. We therefore proposed to the Spanish authorities that risk assessment be done on a turbine by turbine scale. This means that the wind company must present not just area of farm, but the potential location of turbines within farm, and use the wind tunnel test to predict risk.

Q: What tools could we use to improve prediction of fatalities at individual turbines?
How can we design better pre-construction field studies to be more informative?

A: What we need is real information about the birds – where they are concentrated. We found the use of the wind tunnel tool effective, but it has to be conducted in a specific way. You cannot have estimators that combine species. Focus on birds that are moving close to suggested turbine positions. Based on these kinds of studies, we can suggest different positions for turbines.

Q: How are vultures detected for turbine shut-down?

A: Currently we are on the field looking for birds and sending the wind farm operator a message to shut down the turbine. Griffon Vultures are big, easy to spot, and moving during the day. Perhaps in the longer term we could use radars or cameras to spot.

Q: What are the turbine-stopping techniques? Are turbines completely shut down?

A: We now have field observers who send a message to the wind facility operator, and within one minute a turbine can be shut down. We are able to focus on those turbines that we know pose a higher risk. The hope is that this could be automated at some point, perhaps using radar or cameras.

Condor detection and alert system

Presenter: Crissy Sutter, Normandeau Associates

Presentation

Authors: Crissy Sutter, Chuck Grandgent (Normandeau Associates); Kevin Martin (Terra-Gen Power LLC)

PROBLEM / RESEARCH NEED

In 2009 a California Condor was detected approximately four miles north of Terra-Gen Power (TGP)'s proposed Alta East Wind Energy Facility (Alta East) on Bureau of Land Management (BLM) land in the Tehachapi Wind Resource Area. Given the limited distribution of condors and poor site quality condors are expected to occur infrequently at this facility. However, the condor population is expected to increase and expand its range within California, which may result in greater exposure of condors to turbines over the 30-year life of the project.

The US Fish and Wildlife Service (USFWS) has stated that "it is imperative to use the best scientific and technical guidance available to ensure that wind energy development proceed without compromising California Condor recovery."[6] Although there have been no condor fatalities due to wind turbines to date, even the remote possibility of exposure creates legal and economic uncertainty and a permitting obstacle for wind developers. Terra-Gen Power (TGP) has determined the need for monitoring potential occurrences and avoiding condor exposure to turbines at Alta East. Although such occurrences may be infrequent, failure to detect an event is significant, both legally and biologically.

There is no current standard for condor detection at Alta East. Agencies recommend full time condor observers. This approach is costly (>$2M over 30 years), is negatively affected by observer fatigue, allows for only a short response time (<5 minutes) due to limited visual detection range (<5 miles) that is further reduced by atmospheric conditions.

Nearly all condors carry one or more transmitters (VHF and/or GPS) that are actively managed by wildlife agencies. Each condor can be tracked, monitored and uniquely identified by its frequency number. Making use of these transmitters, TGP and Normandeau are developing a more cost-effective automated detection system. This presentation reports on system testing results.

APPROACH

Agency personnel have identified three issues as critical to regulatory acceptance of an automated system: minimal false negative rates, maximize alert notification reliability, and sufficient alert response time. These concerns were addressed during the development of the Remote Condor Observation Network (ReCON) system prior to the Fall 2012 deployment.

[6] http://www.fws.gov/ventura/species_information/CA_condor_wind_energy/index.html

False Negative Rate

The false negative rate (FNR) is the proportion of tagged condors present but undetected. The FNR was quantified and compared to the recommended human observer using free-ranging condors under field conditions. The FNR for the system is considered "acceptable" if it is less than or equal to the human observer FNR.

Alert Notification Reliability

The alert reliability is the likelihood that a condor is detected but the AEWEF personnel are not alerted. This may result from the malfunction of a system component, power loss, etc. The ReCON system will include internal system health checks and functional assessments that are communicated to AEWEF personnel hourly. Absence of the hourly status update or one describing a system malfunction will trigger corrective action to restore system health.

Alert Response Time

Alert response time is the number of minutes facility personnel have to respond once a condor is detected. The alert response time is estimated to be 20 minutes based on condor flight speeds (28 mph) and system detection radius (16 mi). This estimate was validated at the Alta East site.

FINDINGS

We deployed the detection system on July 10 and 11, 2012 at Bitter Creek National Wildlife Refuge.

- The Detection Rate exceeded a human observer even when the ReCON system was constrained to two to three miles.
- ReCON detected 83 of 84 (99%) of condors vs. 24 (29%) detected by human observers.
- The 1% "missed" was due to the scan rate (approximately eight minutes) which has been reduced to two minutes.

The following measures have been taken to ensure system reliability and ensure that personnel are alerted:

- Ensure System Function
  - Back-up power sources
  - Multiple antennas and receivers
  - System sentinel
  - System health notices
- Alerting Redundancy
  - Four independent alert methods (visual, auditory, text, and email)
  - Multiple recipients

Terra-Gen demonstrated the ReCON system and the results of testing to USFWS, BLM, Kern County Wildlife Resource Commission, and the Audubon Society. Agency acceptance was anticipated by the end of calendar year 2012.

IMPLICATIONS & APPLICATIONS

ReCON provides an additional tool for agencies and developers, allowing for near-normal wind facility operations. It is flexible in scale and scope as condor population and range expand. ReCON can easily provide coverage for some or all of the other 3000 turbines operating in the Tehachapi Wind Resource

Area, reducing financial and legal uncertainty for developers, and reducing the "inevitability" of litigation.

The same technology may have applicability to other large species of birds – Bald and Golden Eagles, Burrowing Owls – as well as to some bats and to desert tortoises and even some ground-dwelling small mammals. Other applications might include pre-construction studies to determine occupancy, and movement/migration studies.

Questions & Discussion

Q: What is the level of risk associated with capturing and tagging condors?

A: USFWS maintains the capture and tagging as part of overall population management.

Kevin Martin (from Terra-Gen Power): A fundamental aspect of this proposal was that we did not want to change anything already happening. We're capitalizing on the fact that USFWS is capturing these birds twice a year to test for lead poisoning.

In the recovery effort right now, they have to recapture these birds. The risk from lead poisoning is far greater than for recapture or for wind.

Q: Do you anticipate that all condors will have transmitters? What percent of condors are VHF tagged? How do you propose to deal with potential take of untagged condors, particularly as condor recovery proceeds and the population grows?

A: The USFWS' intent is that all birds have at least two tags – these get switched out twice a year, so they should be continuously tagged. Roughly 15% at any given time not tagged because they are difficult to recapture.

A (Ashleigh Blackford, USFWS): Right now management of recovery program is to recapture and tag all birds. Over longer term, don't plan to continue tagging. Back-up plan involves visual observers. These are social birds, so we're looking at fact that birds travel together to help us avoid collision events.

Q: Does a "shut-down" mean shutting down all turbines or only some of them?

A: The goal would be to shut down only proximate turbines, not the entire site. That is a risk-based decision that each wind farm operator would have to make.

Q: Is there an effort to join with other wind farms in the area? Are other developers interested in alert system?

A: Yes. In addition to Terra-Gen site, there are several other developers are interested in establishing detection posts at their sites. One idea is to have a separate repository of bird data that could be utilized by numerous wind developments at the same time.

Q: What is the estimated operating cost of the ReCON alert system?

A: Less than $500K – including equipment, cell service, pay for annual servicing.

ADDITIONAL QUESTIONS

These questions were submitted but not answered during the conference.

Q: What is cost associated with capturing and tagging every condor and keeping it tagged over its lifespan?

A: The costs are borne by the USFWS as part of the condor recovery. The condor population is not self-sustaining and requires intensive management. This management includes daily tracking and recapturing the birds every 6 months. The regular captures are used to assess condor health and maintain the VHF tags. The largest threat to the condor population is lead poisoning (due to incidental ingestion when feeding on hunter-killed carcasses) which is treated during these regular captures. As long as lead poisoning remains a threat to the population it will continue to be necessary for FWS to track and capture each condor.

Q: How do you deal with transmitter failures?

A: Currently each bird has 2 VHF transmitters that have sufficient battery power for 12-18 months. The transmitters are replaced, as needed, as part of the regular capture and health monitoring conducted by FWS. The FWS estimates that at any time 15% of the Southern California population is without a functional transmitter. The ReCON system detects these VHF transmitters so it they are absent or non-functional the bird will not be detected by the system (e.g. stealth).

Each wind developer evaluates the risk of a “stealth” bird occurring in the wind facility and colliding with a turbine and determines what other measures may be needed.

Q: Would the next step be to have the monitor shut down the turbine? Essentially remove the human error element?

A: The ReCON system detects VHF-tagged condors. Currently (fall 2012) the system alerts on the ground staff and they assess the risk and make a decision on what avoidance measure to implement. In the next iteration of the ReCON system (spring 2013) the detection information will be sent directly to the SCADA system and shut-down will be initiated.

Q: How would the project be impacted by a collision resulting in condor fatality? Would the entire project be shut down?

A: No condors have been “taken” by a wind energy facility thus the specific consequences of such event are speculative. However, the ESA allows for a broad range of responses including civil and criminal penalties brought by the US Attorney General as well as citizen law suits.

Under the Endangered Species Act (Sections 7 and 10) the FWS can issue an incidental take statement (Section 7) or permit (Section 10) to allow for the take of an endangered species. To date the FWS has declined to issue any such permit for condors. Thus any take would be a violation of the ESA and subject to the civil and criminal penalties described in Section 11 of the ESA (USFWS citation below). Additionally the ESA allows for the Attorney General of the United States to “enjoin any person who is alleged to be in violation of any provision" of the Act. This provision authorizes the Attorney General to file a civil suit, seeking injunctive relief, against a person engaging in conduct that takes endangered or threatened fish or wildlife in violation of the Endangered Species Act (Davison 1995).

In addition, the ESA provides for citizen-initiated lawsuits. As described by Davison (1995) this citizen suit provision authorizes any person, with standing, to enforce the Act through injunctive relief by filing suit against any person alleged to be in violation of any provision of the Act or regulation issued under

the Act. "Congress thus encouraged citizens to 'bring civil suits . . . to force compliance with any provision of the Act.'" Such citizen suits could seek to shut down a project.

Q: Is the ReCON system tied into a SCADA system?

A: Under the current system it is directly tied to the SCADA system. However, in the spring of 2013, such direct integration will be available.

Q: How do you differentiate between VHF frequencies used on condors and those on other wildlife in the area – or on migrating species? Potential for false positives?

A: The possibility of detecting other species is minimal because of the specificity of the transmitter signal and the matching specificity of the ReCON detection unit. The transmitters on the condors in southern California have a frequency between 163.000 and 163.999 Mhz, a Pulse Width of 20 to 24 ms, and a nominal pulse rate of 0.6 p/s (36 p/m). The likelihood of another species carrying a transmitter that matches in all three signal characteristics is small. Additionally, the exact frequency value of each condor tag in the southern California flock are input into the ReCON system and any signal detected is compared against this list.

Q: How would you recommend utilizing VHF technology for species that don't currently have tags?

A: VHF tagging is a significant undertaking and for most species having a significant portion of the population tagged is impractical. Thus deploying a ReCON-like unit for automated alerting is likely impractical.

What is practical however is long term automated detection and monitoring (not alerting) of bird movements using a VHF ReCON-like system. For example, I could foresee deploying ReCON for monitoring movements of Golden Eagles at a proposed wind farm. Under the current BGEPA guidance many wind developers are undertaking long term (3+ years) VHF-based studies of Golden Eagle movement patterns. Much of the financial burden for such a study is the labor expended to locate and track the birds. However, each bird is relocated only intermittently with large time gaps in which their location is unknown.

Alternatively a developer could deploy one or more ReCON units. This would allow for continuous monitoring of the VHF-tagged Golden Eagles in the vicinity of the project.

Q: Would a system like this work for Whooping Cranes along their migratory route?

A: Yes. This system would work for detecting VHF-tagged Whooping Cranes. Compared to condors, a smaller percentage of Whooping Cranes carry VHF tags thus using the ReCON system for alerting and turbine shutdown is probably not realistic for Whooping Cranes. However, the ReCON system would detect the VHF-tagged individuals and that data could be used to:

- Detect the onset and cessation of migration
- Detect flocks. If the Whooping Cranes migrate in flocks then detection of 1 VHF-tagged individual could indicate the presence of a larger flock
- Estimate travel rates. The rates of movement (miles per day) could be derived from measuring the interval between detection events at widely spaced ReCON units. This might be used to estimate when birds will arrive at a location (e.g. a wind farm)
- Identify movement triggers. Having precise information on when migration (or legs of migration) is initiated can provide insights as to what triggers these movements. For other bird species the triggers include temperature, wind speed and direction, and changes in barometric pressure.

Knowing these triggers could reduce the duration of mitigation activities (e.g. operational modifications)

- Identify differential use patterns. Not all areas with the migration corridor are equally suitable for Whooping Cranes and thus not all areas would be expected to have equal use. Areas with lower levels of use may be less "risky" to develop into a wind farm and/or may require a shorter duration for mitigation (e.g. fewer days of turbine shutdown).

Q: How does the Normandeau condor detection system compare to the DETECT radar system?

A: They are two different tools with their own strengths and weaknesses. There is some interest in integrating these two tools but that is likely a few years off.

The ReCON unit:

- can positively distinguish condors from other birds;
- can detect condors more than 20 miles from the wind farm (this allows sufficient time to initiate a turbine shutdown or other response);
- provides relatively imprecise location information; and
- provides relatively imprecise directional information.

The radar unit:

- cannot reliably distinguish between condors and other large birds;
- has a detection range of 2 to 3 miles (maybe more since condors are so large?);
- provides very precise location information; and
- provides relatively precise directional information.

Citations

- USFWS. Endangered Species Act Section 11. http://www.fws.gov/endangered/laws-policies/section-11.html
- Davison, Steven G. 1995. ALTERATION OF WILDLIFE HABITAT AS A PROHIBITED TAKING UNDER THE ENDANGERED SPECIES ACT. Journal of Land Use & Environmental Law. http://www.law.fsu.edu/journals/landuse/vol102/2davison.html

Other resources that might be of interest

- The California Condor Wind Energy Work Group homepage http://www.fws.gov/ventura/species_information/CA_condor_wind_energy/index.html
- The presentations and proceedings of the California Condor, Golden Eagle and Wind Workshop held in Dec 2011. http://www.fws.gov/cno/energy.html
- California Condor Recovery Program homepage: http://www.fws.gov/hoppermountain/CACORecoveryProgram/CACondorRecoveryProgram.html

Eagles and Wind Energy

Meteorological and topographic drivers of migratory flight of Golden Eagles; implications for wind energy development

Presenter: Todd Katzner, West Virginia University

Authors: Todd Katzner (Division of Forestry and Natural Resources, West Virginia University & USA and USDA Forest Service, Timber and Watershed Laboratory); Adam E. Duerr (Division of Forestry and Natural Resources, West Virginia University); Dave Brandes (Department of Civil and Environmental Engineering, Acopian Engineering Center, Lafayette College); Tricia A. Miller (Division of Forestry and Natural Resources, West Virginia University & Riparia, The Pennsylvania State University); Michael Lanzone (Cellular Tracking Technologies LLC); Charles Maisonneuve, Junior Tremblay (Ministère des Ressources naturelles et de la Faune); Robert Mulvihill (Audubon Society of Western Pennsylvania); George T. Merovich, Jr. (Division of Forestry and Natural Resources, West Virginia University); Kieran O'Malley (West Virginia Division of Natural Resources); Jeff Cooper (Virginia Department of Game and Inland Fisheries)

RESEARCH NEED

If we understand the context for birds engaging in different types of flight, we can better predict risk and develop effective strategies and recommendations for siting turbines and minimizing impacts to animals. Migratory flight is unique in terms of the altitude, topography, and direction of flight. We know that migrating birds use deflected air currents (orographic lift) to facilitate migratory flight, and that these features are also attractive to wind energy developers. The Appalachian Mountains are a prime example of a major migratory flyway where wind energy development presents the potential for conflict with Golden Eagles and other migratory raptors.

To evaluate potential risk to eagles and other raptors from wind turbines along migratory routes, we collected high-frequency telemetry data and linked them to other data sets to get a better understanding of migratory flight behavior.

APPROACH

We collected GPS data from a total of 40-50 Golden Eagles (*Aquila chrysaetos*) from West Virginia, Pennsylvania, and Quebec. Eight of these birds were tracked using ARGOS-GPS satellite telemetry (which gave us one data point every 1-4 hours), and approximately 32 birds were tracked using GPS-GSM systems that provided a data point every 30 seconds. The hourly datapoints can be connected to show overall direction of flight, but do not reveal much about actual flight patterns. By contrast, the high-frequency data give us a more detailed picture of flight patterns, including elevation, for a bird following a ridgeline.

Eagle movements during migration were classified as local or migratory and hourly datapoints were characterized based on the type of terrain over which each bird was flying and its distance from wind resources preferred for energy development. Migratory behavior (birds covering >10km/hour) accounted for 21% of the data points. Most of the data came from perching birds (60%) or birds moving

5-10 km/hour. Birds that covered less than 5 km/hour were classified as local; these accounted for 13% of the data. Perching birds were excluded from this analysis.

The high-frequency flight data were linked to external datasets (elevation, landform, publicly-available meteorological data), allowing us to analyze migratory and local flight patterns, including flight altitude above grond level and change of bearing, and responses to topography and weather.

FINDINGS

Migratory v. Local Flight Behavior

Birds engaged in local movements turned more frequently and flew at lower altitude than they did in active migration. This flight behavior potentially exposes them to greater risk from turbines than they experience when engaged in longer distance movements. Local movements are not strongly influenced by landforms below, whereas migratory flight altitude show strong topographic influence: migrating eagles flying at relatively lower altitude over steep slopes and cliffs where they can make use of orographic lift than they do over flats and gentle slopes.

Flight Behavior and Wind Speed

Eagles predominantly fly close to "3+" winds, especially during local movement as opposed to migratory flight. They are more likely to use deflected wind speeds v. thermal lift, which suggests that they may stay closer to the ground when wind speeds are higher. As wind speeds increase, eagle flight altitude is less varied, especially for birds flying at lower altitudes.

Other Weather Variables

By comparing migratory movements with weather data (NOAA, NCEP, Regional Reanalysis) we were able to show that the meteorological conditions during migration (e.g., wind speed, wind direction, and ground heat flux) differ between spring and fall. During spring, migration occurred in low to moderate wind speeds, southwest winds, and negative ground heat flux (atmospheric heating), conditions that facilitate thermal soaring and migration with a tail wind.

During fall, migratory flights were associated with moderate to high wind speeds originating from the west and positive ground heat flux. Fall conditions facilitate use of orographic lift without head winds. (Both fall and spring migrants are less likely to migrate when there are strong headwinds, but spring migrants are more likely than fall migrants to wait for favorable wind conditions.)

CONCLUSIONS

Our research identifies generally how topography and weather interact with raptor migration behavior to drive potential human-wildlife conflict that results from wind energy development. With global climate change, weather patterns in the northeast are expected to change, which will in turn alter migration strategies for Golden Eagles. At potential wind energy development sites, risk assessment for volant birds and mammals needs to incorporate understanding of both local topography and its relationship to the varied types of movement behavior that wildlife can exhibit. In addition, identifying specific weather patterns associated with high-risk flight will allow managers of wind-energy developments to identify when soaring birds are at highest risk.

Implications

Risk to migratory eagles is both predictable and linked to topography and weather. This implies opportunities for mitigation, and may have implications for other species.

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Katzner, T., D. Brandes, T. Miller, M. Lanzone, C. Maisonneuve, J. Tremblay, R. Mulvihill & G. Merovich. 2012. Topography drives migratory flight altitude of golden eagles: implications for on-shore wind energy development. Journal of Applied Ecology. 49: 1178-1186. doi: 10.1111/j.1365-2664.2012.02185.x

Lanzone, M., T. Miller, P. Turk, D. Brandes, C. Halverson, C. Maisonneuve, J. Tremblay, J. Cooper, K. O'Malley, R. Brooks, & T. Katzner. 2012. Stereotyped slight response of migratory raptors to a variable meteorological environment. Biology Letters, 8:710-713.

Duerr, A., T. Miller, M. Lanzone, D. Brandes, J. Cooper, K. O'Malley, C. Maisonneuve, J. Tremblay, T. Katzner. 2012. Testing an emerging paradigm in migration ecology shows surprising differences in efficiency between flight modes. PLoS ONE 7(4): e35548. doi:10.1371/journal.pone.0035548

Questions & Discussion

Q: Based on movement data, would you conclude that resident eagles breeding in the area of wind turbines are at greater risk than migratory eagles?

A: It depends. In the east, we have zero reported Golden Eagle fatalities. Grainger Hunt's work at Altamont suggests that most of the fatalities are non-breeders. May be that the resident birds were more familiar with the threat, and that they were older, more experienced, more skilled flyers. The jury is still out. It would be nice to say that we don't have as much mortality in the east, be we do not have the same density of eagles, so it's comparing apples to oranges.

A (Heather Beeler, heather_beeler@fws.gov): From reports I have read and from my conversations with Grainger Hunt based on his telemetry study conducted in the late 1990s, the eagles that are most at risk are not the local breeders, mostly because the eagles there are resident year-round, they defend their territory, which includes their foraging and breeding habitat. The only breeders that are typically at risk is if their territory overlaps with the wind farm. Foraging birds and birds that are interacting with other birds are most at risk of wind turbine collision. (Can be migrants.) Currently post-construction mortality monitoring conducted in the Altamont by ICF International reports predominantly juvenile and sub-adult eagle strikes in their searches.

Q: When slope soaring, are eagles flying to side of ridge top or above?

A: It depends on the wind conditions and how air is being deflected. (Dave Brandes: they're going to be in both places.)

Q: When will transmitters be small enough for use with other species?

A: We have a newer model of current unit that is dramatically smaller and more power efficient. The current units range from 80-100 grams. The newer model will be as light as 20 grams, though potentially as big as 100 grams – the weight is driven by battery and case considerations. Hope to have that very soon.

Q: Have you analyzed the GPS data for avoidance of things like wind turbines? If not, is that possible?

A: Anecdotally evaluated some situations where eagles have come to facilities and changed or not changed their behavior, but these are low-frequency situations, and without any kind of before-after study design, we cannot look at that behavior and make any conclusions about whether the eagle

changed its behavior around the turbines. We would need more transmitters or another five years to gather data.

ADDITIONAL QUESTIONS

These questions were submitted but not answered during the conference.

Q: FWS has asserted that GPS/GSM telemetry negatively impacts GOEA survivorship and breeding success, but has not made public any data to document these effects. Do you know when/if this or other research that supports FWS' position will be available?

A: There is very little conclusive evidence either way on this issue. Some studies have reported higher than normal mortality and that is a great concern. An important consideration in this discussion will be the different approaches different researchers use to apply telemetry systems.

Q: Do GOEAs navigate during migration using imprinted visual landmarks? Did you examine cloud ceiling and visibility as a weather condition?

A: We don't exactly know how they navigate. We are currently examining a suite of weather variables; wind speed and direction are some of the most important.

Q: Can you distinguish between shorter local movements and longer distance *non-migratory* flights? Are these longer flights similar to migratory flight behavior in terms of altitude, etc.?

A: In the east we have not seen long-distance non-migratory flights. We have seen those in the west and are currently evaluating behavior on those treks.

The Bayesian eagle risk model: Input implications, study design, and fatality estimates

Presenter: Chris Farmer, Tetra Tech EC, Inc.

Presentation

Authors: Chris Farmer, Laura Nagy (Tetra Tech EC)

PROBLEM / RESEARCH NEED

The USFWS now allows for incidental eagle take under the Bald and Golden Eagle Protection Act. One of the critical parts of the permit application is the estimate of take of eagles. For a wind energy project, this value will drive the risk category assigned by USFWS and will provide the basis for the Eagle Conservation Plan, including the amount of compensatory mitigation, allowing wind development companies to manage project risk and economics.

In its 2011 draft Eagle Conservation Plan Guidance, USFWS developed a quantitative model of take derived from pre-construction estimates of use by eagles. In the West Butte Wind Project's Ecological Assessment, the USFWS released a new Bayesian version of the fatality model. In this presentation we:

- Provide an overview of the Bayesian model and its data inputs.
- Explore behavior of the Bayesian model.
- Compare fatality estimates of the Bayesian model to observed fatalities.

- Overview of implications for pre-construction study design

APPROACH

The Technical Guidance (USFWS 2012) recommends point counts as the primary source for fatality estimation data: specifically, using a fixed, 800-meter radius, 1-2 hours per point count, with at least 30% of a 1-km buffer around the turbine sampled during all daylight hours. Eagle positions are identified as being at or below v. above 200 m. We used model simulations to illustrate the effect of decisions regarding the input values.

The Bayesian Fatality Model

The basic premise of Bayesian statistics is an "adaptive management" approach that starts with a "best guess" at the fatality data distribution prior to collecting data. Collected data are then used to revise the best guess at the distribution. The heart of the Bayesian fatality model is $F = \varepsilon\lambda C$, where:

F is annual fatalities (in this case annual eagle fatalities from turbine collisions)

λ is exposure rate (eagle-minutes flying within the project footprint in proximity to turbine hazards) per hr per km^2

C is collision probability (probability of eagle colliding with a turbine given exposure)

ε is expansion factor (product of daylight hours and total hazardous area in km^2)

For the exposure rate, prior was drawn from a gamma distribution which approximates a normal distribution; posterior was drawn from a gamma distribution defined by prior + observed exposure. The model can produce things that sometimes look surprising; if you put a zero input, you can get a non-zero output, because the model is additive. Collision probability was derived from a small number of public domain fatality results published by Whitfield (2009): comprising Golden eagle fatality results from four sites (Altamont, Foote Creek Rim, San Gorgonio, Tehachapi).

FINDINGS

Changes in inputs to the model can have a dramatic impact on the model output. [Slides #10-14: mean annual fatality estimate is the red line; upper 80% and lower 80% credible intervals are indicated with dashed lines above and below the mean. Increasing the number of turbines has a linear effect on fatalities. The upper credible interval (UCI) is important, because that is going to establish the permit number.]

Rotor Size v. Number of Turbines

One of the most significant is the rotor diameter, because radius drives the expansion factor calculation for the hazardous area, or strike zone, such that a small increase in the radius gives a larger (non-linear) effect. The rotor diameter is squared in the calculation of hazardous area, placing a premium on ensuring the correct size of the rotor diameter and resulting in different fatality estimates among different turbine types. Radius matters more in this calculation than number of turbines, so there is an asymmetrical trade-off to be made in terms of facility design between size and number of turbines.

There is a biological question as to whether or not turbine radius has a disproportionate effect on collision risk, and one can easily imagine scenarios where reducing the number of turbines by removing problematic turbines may impact collision risk far more than changing the size of the turbines, but the model does not account for that.

Sampling Design

Slides #12-13 illustrate the implications of survey design. We looked at three different sampling intensities: weekly, bi-weekly, and monthly – in each case holding constant the number of turbines. However you choose to sample, for a fixed number of eagle fatalities, increasing your sampling time dramatically decreases the fatality estimate that comes out of that, with the asymptote at around a 1-hour point count. This is something to take into consideration in designing pre-construction surveys: whether you want to do a lot of one-hour surveys or a smaller number of two-hours surveys. Likewise, the number of times you sample can be optimized [slide#13].

The collision probability that is assumed going into the model very strongly affects the outcome. Slide #14 illustrates this point, showing how a small change in the avoidance assumption (from 98.1% to 99.9%) has a large impact on predicted fatalities, and similarly on the number that will go on a take permit.

Bayesian Model Performance

Slide #5 shows how the model performed in terms of predicted v. actual fatalities at five facilities. At these facilities, the model did not do a good job of predicting actual fatalities, but it is important to keep in mind that the inputs are not standardized, and that – as shown above – small differences in inputs such as collision probability have a big impact on model outputs.

Looking at a specific application of the model at a Kodiak Island, AK facility with three turbines. We have two years of data, 67 30-minute counts recorded 231 eagles flying below 200 m. The model projects 1.4 bald eagle fatalities per year (with an upper 80% credible interval limit of 2.2 fatalities per year); the actual number of observed fatalities to date is zero. At this point, the model does not fit very well; the model may not be accounting for avoidance behavior occurring in this case.

IMPLICATIONS

One strength of the Bayesian approach is that the model can be refined with successive waves of data. On the other hand, Bayesian statistics are not as accessible as some other models.

The most important take-away message is that the Bayesian fatality model forces developers to carefully balance up-front survey cost with potential mitigation and opportunity costs when designing their pre-construction eagle surveys. Specific points to keep in mind:

- Whether realistic or not, the fatality model punishes you more for increasing turbine radius than it does for adding turbines.
- More eagle minutes translates to more predicted fatalities.
- More surveys translates to fewer predicted fatalities.
- Longer surveys translates to fewer predicted fatalities, but the relationship is asymptotic, so there is going to an optimal point in terms of number and length of surveys.
- Inappropriate collision probability has a significant impact on prediction, and further research is needed to understand this dynamic so that we can choose the right input.

QUESTIONS for Chris Farmer and Kenton Taylor follow the summary of Taylor's presentation, below.

Understanding the USFWS Golden Eagle collision risk model

Presenter: Kenton Taylor, WEST, Inc.

Authors: Kenton Taylor, Wallace Erickson, Andy Merrill, Kim Bay, Elizabeth Baumgartner (WEST, Inc.)

RESEARCH NEED

This presentation goes into greater detail about the USFWS' recommended Bayesian approach to predicting the level of Golden Eagle fatalities at proposed wind energy projects, and the factors that have the potential to influence model performance.

There have been numerous inquiries regarding USFWS Bayesian Collision as well as inquiries into the level of take predicted by the USFWS method for currently proposed projects, and on how the wind energy facilities used in model development may impact predictions of eagle mortality at other wind facilities. Guidance will also be given for the utilization of eagle risk metrics in turbine siting, eagle habitat conservation plans, and environmental permitting.

MODEL INPUTS

As outlined in Chris Farmer's presentation (above), the Bayesian approach uses information on Golden Eagle use and mortality at existing wind projects as a starting point or best guess of anticipated impacts (i.e., the "prior distribution"). The USFWS model specifically assumes – based on studies at numerous wind energy sites – that higher pre-construction eagle use will result in higher post-construction mortality. It predicts mortality as a function of exposure times an expansion factor, and a collision risk factor (observed fatality rate per unit of eagle activity).

- Exposure = a pre-construction measure of eagle activity within an area of potential interaction (defined by the USFWS as the expected number of flight minutes per daylight hour across the surveyed area (km^2)
- Expansion factor = a constant that is related to the area of risk (i.e., number of turbines x volume of risk cylinder at turbines)
- Collision Risk = probability of collision per exposure minute

The collision risk factor used in the USFWS model is 0.0067, which is based on observed fatality rates per unit of eagle activity from studies at four older wind sites: Altamont, Tehachapi Pass, San Gorgonio (all California) and Foote Creek Rim, Wyoming.

The distribution of the current prior for exposure in the model has a mean of .352 eagle minutes per hour per km^2. The exposure posterior distribution is additive; the total eagle flight minutes per km2 is added, as well as the number of hours of survey effort.

SIMULATION RESULTS

In the past, both survey durations and the number of observation stations placed on a given landscape have varied. To better understand the influence of overall survey effort (duration and number of surveys) on model performance, we conducted a series of simulations. Holding everything other than hours of survey effort constant, we found that estimates stabilize after about 200 hours of survey effort, and the influence of the prior exposure distribution disappears. The upper 80% credible interval is approximately 1.5X to 2X the point estimate after 200 hours of survey effort. A survey comprising less

than 200 hours of effort that resulted in lower use than the prior would yield a slightly higher prediction than if the sampling effort had extended for at least 200 hours. The inverse is also true (if use is higher than the prior a slightly lower prediction would result than if sampling effort extended for at least 200 hours).

Survey duration in the four projects used to develop the USFWS model (Whitfield 2009) ranged from five to ten to 40-minute surveys. The latest technical appendices are recommending survey durations of one to three or more hours. We looked at several studies that had survey durations of at least one hour. When we standardized for the level of effort and cut the observations off after the first 20 minutes,we found that per-minute observations during the first 20 minutes were significantly higher than for the 60-minute surveys. This suggests that surveys of longer duration may actually underestimate eagle use relative to surveys of 20-minute duration. (USGS is looking into this, and is preliminarily seeing similar trends.)

Model incorporates daylight hours into the expansion factor, using a 12-hour/day annual average number of daylight hours. We simulated the effect on predictions using operational time and incorporating seasonal eagle use at four wind energy sites across the Western U.S., and found that incorporating operating time resulted in a reduction in fatality predictions that is proportional to the change in operating time vs. daylight hours, and incorporation of seasonal operating time and seasonal eagle use also has the potential to influence the model (positive or negative, depending on whether high use coincided with high operating time) in the prediction.

CONCLUSIONS / RECOMMENDATIONS

Key points to take away from this analysis:

- The dominant source of variation in the model (after 200 hours of survey effort) is tied to the ***collision risk factor***; more work must be done to get tighter confidence intervals.
- With 200 or more survey hours, exposure prior has little influence on prediction
- Survey duration may bias results
- Operating time and seasonal eagle use may influence results.
- Modeling approaches should allow for inclusion of other covariates (turbine size, topography, etc.)

At Foote Creek Rim, for example, use at the site as a whole suggests high mortality (>3 eagle fatalities per year), but constraining use to the turbine locations reduces the predicted mortality.

Ongoing Research

The USFWS collision risk factor of 0.0067 was developed from four studies of facilities with older turbines ranging from 100-750 kW. Preliminary results from Altamont suggest that repowering may result in lower fatality rates. Exposure was from post-construction use studies. Tehachapi and San Gorgonio studies had 200-m plot sizes, as opposed to 800-m plot sizes, and survey durations differed. It also appears that the use value from FCR was off-rim, rather than on-rim, where turbines were actually placed. Finally, there is the issue of how to apply a correction factor when you are dealing with rare events.

We're evaluating some potential alternative collision priors, using 13 publicly available studies. Most of these studies include pre-construction use data and post-construction mortality information. They are larger, newer-generation turbines. To date, what we are finding is that the probability of collision per

eagle minute is less than the estimate from the four older Whitfield projects. WEST intends to publish a paper presenting an updated collision risk prior.

"All models are wrong, but some are useful." The results of modeling should be considered as one line of evidence in a weight-of-evidence approach to assessing risk

Questions & Discussion – *Farmer & Taylor*

Q: How does USFWS typically respond to proposals to adjust the eagle collision risk factor to correspond to the rotor swept zone?

Taylor: The Service is open to working with us on what we're proposing or thinking about in terms of an alternative model or approach. It may take longer to review, but USFWS is open to it. The permit will likely be based on FWS output if there's a difference.

Q: When doing eagle point counts, why do you use a fixed radius of 800 meters? (Why specifically 800 m?) How would fewer survey points with a larger search radius impact model performance? For example, a 1-mile v. 800 m radius?

Farmer: FWS would like to keep the radius fixed and short so that detection probability is as close to 100% as possible. I would rather use an actual viewshed approach – for example, I used to work at Hawk Mountain, and I could see an osprey passing behind an obstruction that I knew to be two miles away, and eagles are larger and easier to detect. The problem with that is the variation of detection probability.

Taylor: A lot of recent studies have used 800 m, so it is helpful to keep it standardized. Agree with concerns over detection probability.

Q: How could sampling for a longer period of time reduce estimated fatality? If the exposure rate is consistent, how can estimated fatality decrease?

Farmer: The amount of time spent sampling goes into the denominator; if eagle detection minutes is fixed, and that goes into the numerator, so the number decreases.

Taylor: Assuming that eagle use remains consistent over time, sampling for a longer period of time won't influence the estimated fatality as exposure is standardized by time (hr) along with area (km^2). In other words, if eagle use remains constant and you increase the amount of time sampled, the standardized use value won't change (e.g. 1 eagle observation in 20 min is equivalent to 3 eagle observations in 60 min). There may be a bias associated with longer surveys in which eagle use isn't consistent over time and is actually lower with longer surveys which we have shown has occurred. If this holds true more generally, sampling longer surveys (e.g. 2 hours versus 30 minute surveys) and subsequent lower exposure rates would result in a decrease in estimated fatality.

Q: What would be a better animal fatality risk model given that the current model ($F=\varepsilon\lambda C$) did not perform well?

Taylor: Working on collision prior for existing model is going to help it perform better. A simpler model (e.g., linear regression) may be better for everyone to understand and apply.

Q: In the FWS Bayesian model, you stated that turbine radius is a strong driver of mortality estimates. But fewer, larger turbines would mean fewer mortality locations and potentially greater visibility of each turbine. Do you think this may be one reason for this model's relatively low predictive power?

Farmer: This is a case where the model doesn't necessarily incorporate all the biological realities. It's an asymmetrical trade-off. The model output is very sensitive to turbine radius, but if a small change in turbine radius allows you to reduce the number of turbines on the landscape, the trade-off may be worth it.

Q: Are you developing collision risk factors for Bald Eagles?

Taylor: We are currently working on a model for bald eagles and so is the USFWS.

ADDITIONAL QUESTIONS

The following questions were submitted but not answered during the conference.

Q: Are all turbines created equal? Is the relationship between the number of turbines and collision probability really linear?

Taylor: All turbines are not created equal. We believe that it isn't the number of turbines but rather, the total amount of area with spinning blades that influences collision probability. The current model tries to account for this however; it is likely that many factors influence collision probability. In addition, there is some evidence from some sites (e.g. the Altamont) that smaller turbines do not necessarily have proportionally lower risk.

Q: How does credible limit differ from confidence interval limit or prediction limit?

Taylor: For a complete and technical discussion, please consult a statistics reference. Credible intervals are a Bayesian statistics approach to expressing uncertainty in inferences. Confidence intervals are the frequentist approach to expressing uncertainty in inferences. A frequentist will design the experiment and 90% confidence interval procedure so that out of every 100 experiments run start to finish, at least 90 of the resulting confidence intervals will be expected to include the one true value of the parameter.

A Bayesian credible interval is a method of summarizing the information in the posterior probability distribution. The Bayesian inference is that we collect the data, and then calculate the probability of different values of the parameter given the data. ***Credible intervals*** are a way of summarizing uncertainty by giving a range of values (e.g. eagle fatality rate) from the posterior probability distribution that includes 80% of the probability – i.e., an "80% credibility interval." ***Prediction intervals*** tell you where you can expect to see the next data point sampled. While the confidence interval is a measure of uncertainty of the mean, a prediction interval is a range of error on a predicted or future value. A prediction interval will always be wider than a confidence interval.

Q: Survey duration effect is confounded with the total effort. Three times as many 20-minute surveys should equate to same result as one 60-minute survey. Is that correct?

Taylor: Yes, assuming that you have sampled enough to adequately estimate use and that observed use remains constant with longer duration surveys. However, we have documented differences and biases in eagle observations per minutes of survey when doing 20 minute versus 60 minute surveys.

Q: Given that data for priors in model is limited, outdated, and possibly inaccurate – and has a significant impact on predicted fatality – any plans to update the model? Can WEST do it if FWS will not?

Taylor: Yes we do currently have plans to update the model and are writing a white paper and publication for this

Q: Is the R-code template used in the West Butte EA still applicable given the new USFWS Bayesian model inputs?

Taylor: This question should be posed to USFWS; we have asked USFWS and have not yet received an answer.

Q: With so few Bald Eagle fatalities at wind farms, how is FWS confidently and accurately assigning an avoidance factor?

Taylor: The current model is based on golden eagle data and a better approach would be to utilize bald eagle data (as it becomes available). The publicly available information is limited, and until data is available, the USFWS have indicated this is the best information they have, but likely conservative.

Power pole retrofitting as a compensatory mitigation option for eagle take: opportunities, constraints, and logistical considerations

Presenter: Sherry Liguori, APLIC and PacifiCorp

Authors: Sherry Liguori (PacifiCorp & Avian Power Line Interaction Committee); Mike Best (Pacific Gas & Electric Co. & APLIC)

OVERVIEW

The Avian Power Line Interaction Committee (APLIC) was formed in the 1980s to address avian/ power line issues. Power pole retrofitting has been proposed as one of several possible compensatory mitigation options for eagle take at wind facilities in the U.S. Power pole retrofitting provides an opportunity to quantify mitigation efforts, and provides reasonable assurances of effectiveness, provided that proper retrofitting methods and materials are used. Such retrofitting efforts for compensatory mitigation would expedite proactive retrofitting efforts already being implemented by the electric utility industry.

This presentation discusses the opportunities and benefits of implementing a power pole retrofit program for compensatory mitigation – particularly for Golden Eagles – and the challenges and logistical considerations that would need to be addressed as such programs are developed.

POTENTIAL BENEFITS

Electrocution mortality is well-documented, offering a clear opportunity to reduce eagle mortality risk, particularly for golden eagles. Because electrocutions are typically more likely to be discovered (through outages or line patrols) and reported than other sources of mortality, electrocution is prominent in the literature among sources of Golden Eagle mortality.

Many utilities have large systems with hundreds and thousands of poles, and Avian Protection Plans (APP) are long-term documents that include risk assessments and pole retrofitting plans. Collaborative efforts would have the potential to expedite long-term pole retrofitting efforts.

For companies that have both wind and wires, internal retrofitting programs may provide an opportunity to compensate for eagle take at wind facilities while minimizing concerns (e.g. liability, costs, assurances) that may occur in third party negotiations.

One of the most significant benefits from eagle population perspectives is that quality retrofitting programs have quantifiable results. PacifiCorp has documented 87-100% reductions in mortality at retrofitted circuits.

CONSTRAINTS

To effectively implement a quality program, APLIC recommends that a recipient utility be able to demonstrate:

1) that they are accountable for retrofitting their own known mortality poles;
2) that they have a mechanism in place to identify other high-risk poles that would be eligible for retrofitting as part of a wind mitigation agreement;
3) that they are using retrofitting methods and materials that meet or exceed APLIC recommendations.

Typically, these would be components of an implemented APP. The eagle power pole compensatory mitigation would go above and beyond the commitments of a robust existing APP by either increasing the number of poles being retrofitted or expediting long-term retrofitting timeframes. For example, in addition to retrofitting mortality poles, both PG&E and PacifiCorp retrofit five adjacent poles in each direction as well.

From the mitigation perspective, it is important to have some way to estimate the level of risk associated with a pole for purposes of establishing its mitigation value. Utilities may not have the information in place to know which poles are high versus low-risk.

From the utility perspective, another constraint is tax liability. Depending on the state, and how it is regulated, the mitigation cost contributed by the wind developer could be considered taxable income for the utility. There is also liability for the project itself – who is responsible for which pieces if the retrofit proves not to be effective, or for maintenance and replacement of any components over time. All of these elements must be spelled out clearly in the contract.

Location may be a constraint. Where the utility's mitigation costs are funded by rate payers, public service commissions may require those funds to stay within the state where that customer base is located. At the same time, an eagle take permit for a wind facility may require that mitigation efforts be implemented within the geographic region of the eagle management unit, so it will be necessary to match wind projects to utility service territories. As wind development in a particular geographic area moves towards build-out capacity, the opportunities for mitigation through power pole retrofiting may be exhausted. Electrocution mortality affects not just breeding birds, but also migrating eagles, in which case it may be possible to expand the geographic range of the mitigation effort.

LOGISTICS

How many poles per eagle?

Given the relative absence of actual site data, the USFWS' REA Resource Equivalency Analysis (REA) model is commonly used. As stated above, PacifiCorp uses five poles in each direction from the mortality pole, or an average total of 11 poles per eagle. This was based on data looking at how many eagle

fatalities could be prevented by retrofitting adjacent poles – mortality reduction increase was linear until we got to five poles out, at which point it leveled off.

How to select poles?

Not all poles pose the same risk to eagles; some are high-risk, some are low-risk. Risk also varies seasonally. The risk of electrocution to Golden Eagles tends to be greatest during late fall/winter.

Electrocution risk factors differ slightly for Golden versus Bald Eagles. These factors include: habitat type, geographic location, season, age, pole use, proximity to prairie dog towns (GE), bodies of water (BE), historical nests, jackrabbit population cycles (GE), year, historic mortalities, pole configurations, and perch discouragers. Electrocution risk factors can differ not only between Bald and Golden Eagles, but among other raptor species as well; for example, caution should be used as extrapolation of data from great horned owls to golden eagles may not be accurate.

Retrofitting Methods

Other concerns that would need to be addressed between a wind company and electric utility would include the average cost per pole for retrofitting, monitoring and long-term maintenance of retrofitted poles to ensure they continue to function as avian-safe for the duration of the agreement, and retrofitting methods (e.g., covers versus reframing).

- ***Reframing*** is a permanent, long-term solution, and also the one with the highest cost.
- ***Covers*** are an intermediate-cost solution; they can be effective, but are much more highly variable in terms of quality, useful life, etc. Due-diligence and proper product selection and installationon the part of the company carrying out the retrofit are therefore essential.
- ***Perch discouragers*** are the lowest-cost retrofit solution, and they are not recommended. In some cases they can even increase electrocution risk.

A quality control or inspection program to ensure complete retrofitting and proper installation of products is critical to long-term effectiveness. Retrofitting methods and products should be applicable to local conditions (e.g., wind, salt spray, sun, contamination) to increase the longevity of the retrofit. APLIC does provide guidance on retrofitting methods through its short courses and guidance documents. Having trained inspectors to ensure that products are properly installed significantly improves the effectiveness and longevity of the retrofit.

Audits, monitoring – who is responsible? Is it the wind company, the utility, a third party? Are there access issues? How often does a retrofit need to be monitored? All of these are considerations when developing a retrofitting agreement. Retrofitting costs per pole are influenced by many factors, including not only the type of retrofit (covers, reframe, pole replacement) but also: structure type/complexity, voltage, utility location and labor costs, hot versus outage work, cost of materials, time of year, access, job preparation, inspection, follow-up audits, crew experience, and economies of scale.

CONCLUSIONS

APLIC is working with USFWS and the wind industry to overcome obstacles to making this work. As pole retrofitting agreements are developed between electric utilities and wind companies, lessons learned should be shared with both industries and the USFWS so that subsequent agreements can be improved or refined. Likewise, there should be flexibility when developing such agreements so that local conditions and circumstances, eagle populations, etc. can be considered.

Questions & Discussion

Q: Is there another way to discourage eagles from perching on poles? What does APLIC recommend and why are perch guards not effective?

A: Perch guards were an early mitigation measure, widely used in the 1970s and 80s and into the early 90s; but follow-up research indicates electrocutions and avian use despite perch guards. If a bird chooses to perch on a pole, it will find a way to perch despite the discouragers if it really wants to be there. PacifiCorp has conducted studies in six states over 12 years with over 120,000 poles surveyed, and has documented similar levels of use at poles with and without perch guards, and significant increases in nesting and electrocution rates at poles with perch guards. This research also has documented that perch guards may sometimes push birds to adjacent poles, increasing the electrocution rates of poles nearby.

Based on research and field testing, APLIC has moved away from recommending perch guards. Covers are similar in cost and much more effective in preventing electrocutions.

Q: Do you use detection bias adjustments when estimating fatality at lines?

A: We have not. Most of the birds we're finding are larger birds (raptors, eagles). Where these carcasses are not salvaged by an agency, we will sometimes find bone piles (and even bands) in same spot years later in the same spot, suggesting low scavenging on eagle carcasses.

Q: It is unlikely that 87-100% reduction will occur at poles that have never had a documented fatality – how do you suggest quantifying conservation benefit at these structures?

A: We're measuring before and after mortality on a whole circuit, not on individual poles. The percent reduction in mortality is for the circuit. At the pole level, we look at risk variables and target poles for retrofitting that have high risk potential.

Q: For power pole retrofitting to provide compensatory mitigation benefit, wouldn't it be useful to do a mortality survey on that distribution line to come up with an estimate of eagles saved after retrofitting – to establish a net conservation benefit for that population?

A: Yes, a baseline survey of the line would be needed to identify risk level, particularly for areas where there is not existing data. Also, the survey would be needed to identify which poles pose a high risk and what type of retrofitting is needed/appropriate. Not every pole poses the same risk, and field data is valuable in quantifying risk.

Potential compensatory mitigation options for Golden Eagles

Presenter: Laura Nagy, Tetra Tech EC, Inc.

Authors: Laura Nagy, Chris Farmer, Julie Garvin (Tetra Tech)

PROBLEM / RESEARCH NEED

In 2009, programmatic permits for incidental take of eagles was introduced under the Bald and Golden Eagle Protection Act (BGEPA). The new rule introduces a "no net loss" or preservation standard has significant implications for how companies prepare their permit applications. The implications differ among species; this presentation will focus on Golden Eagles.

In this context, "no net loss" means either "creating" a Golden Eagle, or "saving" an eagle. Creating an eagle could mean increasing reproductive success or survival rate, but this takes a long time and a large area, and our understanding of what is required is limited. Saving an eagle begins with understanding the sources of eagle mortality, and then identifying mitigation measures specific to one or more of those sources. The only example provided in the 2011 USFWS Eagle Conservation Plan guidance is power pole retrofitting. Although this is a reasonable option (see Sherry Liguori's presentation, above), it is not a viable option for most wind projects. Our objective was to evaluate alternative mitigation options.

APPROACH

We began by summarizing the causes of eagle fatalities as reported in peer-reviewed literature, databases, and grey literature/reports. There is some redundancy, and most of this information is anecdotal, not systematically collected. For Golden Eagles, sources of mortality include:

- Collisions (including turbine towers and blades but also vehicles, planes, power poles, etc.)
- Poisoning (e.g., lead, pesticides)
- Other human-related (e.g., electrocution, gunshots, entanglements)
- Other natural sources (e.g., botulism, weather, disease, starvation)
- Unknowns (50% of data)

We then looked at each of the known causes of mortality in terms of identifying opportunities for mitigation ("saving an eagle"). Sources of mortality were ranked (from low to high) in terms of feasibility, measurable results, and cost. Of the 23 identifiable causes of mortality, eight ranked moderate to high in terms of feasibility [slide #9]. Of those, the two that ranked highest in terms of measurability and cost effectiveness were vehicle collisions and lead poisoning. (A third, funding for wildlife rehabilitation centers, was also considered.)

Feasibility Testing

The basic framework for determining how each of these two fatality causes might be translated into a mitigation program is shown in the table below.

Step	Vehicle Collisions	Lead Poisoning
1. Identify a cause of fatalities	Golden Eagles are at risk of collision with vehicles when they forage on road-killed wildlife.	The primary sources of lead exposure for Golden Eagles are embedded lead shot or fragmented bullets ingested from animals wounded or killed with lead-based ammunition.
2. Remove/reduce the probability of fatalities	Can the cause be removed? Yes.	Can the cause be removed? Yes.
3. Quantify actions into eagles saved	Translate into number of eagles saved? Yes, with assumptions.	Can the mitigation be translated into numbers of eagles saved? Yes, with assumptions
4. Evaluate logistic feasibility	Logistically feasible? Yes (any scale).	Logistically feasible. Yes (large scale)
5. Evaluate economical feasibility	Economically feasible? Yes.	Economically feasible? Yes (involves multiple parties).
6. Determine whether data adequate or assumptions can be tested	Can we test assumptions? Mostly. There is data to parameterize some of the assumptions; have to rely on expert opinion for some.	Can we test assumptions? Yes.

Vehicle collisions - Removing carcasses from roadsides is a feasible way to reduce the risk of vehicles colliding with feeding eagles. The reduction in number of eagles killed equates to the number of eagles "saved." To develop the number of miles required to offset an eagle, multiple assumptions are needed such as the number of roadside carcasses available, the percentage of roadside carcasses that have feeding eagles, and the percentage of eagles feeding on roadside carcasses that get hit by cars. This is a viable compensatory mitigation option for a range of take levels, but will require adaptive management throughout the process and will be most successful in areas with high densities of large mammals.

Lead abatement - We reviewed five lead abatement programs, both voluntary and involuntary, and concluded that both types of programs can be successful in reducing lead concentrations in raptors. Success was achieved through educating hunters on the ecological and health impacts of lead ammunition, and providing a financial incentive through free non-lead ammunition. This is a viable mitigation option because the large number of eagles with high lead levels indicates that a lead abatement program could benefit many eagles: success would require implementation on a large scale and financial support across multiple projects.

CONCLUSIONS

Carcass removal and lead abatement both can be successful mitigation options. Each would need to be implemented on a different scale. Ideally, we want to implement a range of options and evaluate

success of programs in different places, testing our assumptions as we do so (adaptive management). It is important that we share lessons learned, so that failures can be addressed in a neutral setting.

Questions & Discussion

Q: If enough carcasses are removed from a roadside, how would that hurt eagle food resources? Should additional carrion be placed in off-road fields?

A: If carcasses were a dominant part of the eagles' diet it might matter. But our understanding is that carcasses are just one portion of their diet, and eagles can adapt. That said, some people do feel that supplementing would be to their advantage.

Q: Transportation departments remove carcasses from roads. Would you be trying to speed up the removal, and how is that incorporated? Do you have data on how many carcasses per eagle kill?

A: It depends on state and even local area. Sometimes they are removed, sometimes not. Sometimes removal is just far enough from the road to make driving safer for humans, not necessarily far enough away from roads to make eagles safer.

We don't know how many carcasses per eagle killed; that would have to be adaptively managed.

Q: Do you know whether most – or how many – states already ban lead ammunition?

A: In terms of big game hunting, as far as I know only the state of California – and only in the areas where the condors are – issues related to control of ammunition are very hot button for the NRA.

Q: What incentives were offered to remove gut piles?

A: Cash incentives.

Navigating the USFWS Eagle Guidance with respect to Bald Eagles

Presenter: Mike Morgante, Ecology and Environment, Inc.

Presentation

Authors: Mike Morgante (Ecology and Environment, Inc.)

OBJECTIVES

The U.S. Fish and Wildlife Service (USFWS) issued Draft Eagle Conservation Plan (ECP) Guidance in February 2011 and a revision is forthcoming. This guidance, issued under the auspices of the Bald and Golden Eagle Protection Act, is intended to assist parties to avoid, minimize, and mitigate adverse effects on eagles and defines the process for obtaining a non-purposeful take permit if avoidance and minimization efforts do not reduce the risk of a take to an "acceptable" level.

The objectives of this presentation are to:

- Gain understanding of the USFWS Eagle Guidance with respect to Bald Eagles
- Evaluate practicability of advanced conservation practices and mitigation for Bald Eagles
- Identify critical issues early in the site development process

- Provide insight on study design approach
- Understand how the exposure modeling results will be used toward permit recommendations
- Identify implications if permit is recommended

Bald Eagles are increasing over much of their range and becoming a siting and permitting issue at more proposed wind sites. (Slide #6 shows the number of breeding pairs identified in 2007 in each of the lower 48 states; this data is already outdated.) Yet impacts on Bald Eagles from wind have been limited and much of the attention on the USFWS guidance has been on Golden Eagles.

APPROACH

This presentation draws upon experience from multiple proposed sites with Bald Eagle issues in the eastern and central U.S., and a review of Bald Eagle occurrence and impacts at existing sites. We reviewed siting challenges and permitting issues, and evaluated advanced conservation practices for feasibility and practicability with wind projects.

FINDINGS

Siting Challenges

In many states, Bald Eagle nests, wintering areas, or migration corridors can be *expected* to occur within 10 miles of project area. Fortunately, eagle sites are usually well documented. We recommend that developers:

- Conduct early site due diligence / consultation
- Find sites and design footprint to be at least several miles from closest nest
- Consider possibility for new nests to occur

Permitting Challenges

The fact that Bald Eagles are widespread, and at the same time there have been few impacts to date makes it difficult to predict risk. Given the lack of precedence for permitting, the USFWS is relying on an adaptive management approach. This is a conservative approach; it is reasonable to ask whether the time and money spent on an effort to protect this recovered species might be better spent on species in greater need of conservation.

Advanced Conservation Practices

Most of the general "Advanced Conservation Practices" (ACPs) provided in the Eagle Guidance are siting and best management practices that are not specific to Bald Eagles. Experimental ACPs mentioned in the Guidance include seasonal shutdowns, radar detection-based shutdowns, and adjusted cut-in speeds, but the merits of these are not known and in need of research .

A key distinction for Bald v. Golden Eagles is that the "no net loss" standard does not apply for Bald Eagle mitigation. Take thresholds are established for Bald Eagles, allowing greater flexibility for mitigation. Potential mitigation practices might include: power pole retrofits, carcass removal on roads and railroads, programs to reduce lead and mercury, support of avian rehabilitation centers, and support for educational programs. As previous presenters have mentioned, the benefit must be measurable to satisfy NEPA requirements.

One possibility would be to establish a conservation fund that would pool many smaller contributions to fund one or more project or program with more significant impact than could be achieved with the sum of the many smaller mitigation efforts.

RECOMMENDATIONS

We need to develop avoidance models that are specific to Bald Eagles. Current values (prior distributions for exposure rate, collision probability) are based on older sites and on Golden Eagles, and are therefore likely to underestimate avoidance and overestimate fatality risk. This is a current data gap and area of research need.

Study Design

- Only conduct point counts inside project area (unless other study objective exists)
- If possible, track Bald Eagle flight directions to and from a visible nest
- Strive for surveys throughout the year
- More survey hours improve model confidence but won't necessarily lower fatality estimates

Interpretation of Risk Model Results

The threshold for when a take permit will be recommended is evolving, so developers should not assume that a finding of, for example, one predicted Bald Eagle fatality per year means that a permit cannot be issued (Category 1 site). If the USFWS does recommend pursuit of a take permit, business decisions with scheduling and budget impacts to be considered include:

- Whether to seek a non-purposeful eagle take permit?
    - provides liability coverage and invokes NEPA
- Whether to consult and prepare a Bird and Bat Conservation Strategy (BBCS) to document adherence to the Guidance and communication with the Service.
    - Lacks liability coverage but avoids NEPA

The NEPA process takes longer, but the goal is to have the take permit in place by start of operation. The BBCS pathway should be shorter but is expected to be in place by start of construction, so in both cases the process needs to be started early. Both the NEPA and BBCS will evaluate more than just Bald Eagle issues.

Questions & Discussion

Q: Where eagle populations are increasing does that constitute no net loss?

A: Conservation for no net loss is based on a sustainable annual yield for an eagle management unit, not for a specific project area. The USFWS established the sustainable annual take thresholds in the Eagle Permit Rule (2009). As Bald Eagles have increasing populations and there is an annual take threshold for each eagle management unit, the no net loss standard (like for Golden Eagle take) is not applicable; however, some form(s) of mitigation is still expected as part of the permit.

Q: What sort of time frame required for the NEPA process, and what is involved?

A: I would shy away from estimating the number of months for the NEPA process. The first few permits coming through for Bald or Golden Eagle will take longer and site-specific issues could also result in delays. It will help everyone involved once there are some precedents that have passed through USFWS and both the preparation of Eagle Conservation Plans and the NEPA process will likely speed up.

As for what is involved, the USFWS needs to prepare an environmental assessment (EA) to evaluate the effects of the proposed federal action (i.e. issuance of a programmatic eagle take permit) and alternatives under consideration. This includes identification of the baseline environmental resources and assessment of the potential impacts (direct, indirect, cumulative effects) of the proposed action and alternatives to the affected environment. There is a public comment period on a draft EA and then the Service prepares a final EA and needs to complete several additional steps in determining whether a take permit can be issued.

Laura Nagy: For context, the permit rule has been in place since 2009, and to date zero permits have been issued and one NEPA document has been noticed.

Q: What are the other sources of Bald Eagle mortality?

A: Closely mirrors what Laura Nagy reported for Golden Eagles. There is still a lot of shooting, and in the east issues come up with high-speed trains hitting eagles foraging on carrion on the tracks. Electrocution is less of a problem for Bald Eagles compared to Golden Eagles, but still occurs. Lead poisoning is a big issue, avian botulism, and other causes similar to Golden Eagles.

ADDITIONAL QUESTIONS

These questions were submitted but not answered during the conference.

Q: There have been very few documented Bald Eagle collisions with turbines. Any concern that people aren't releasing information about collisions (could be applicable for any listed species)? Do you think more eagles are killed by turbines than are documented?

A: Except in some notable cases, raptor mortality from collisions with wind turbines has been relatively low. The very few documented Bald Eagle collisions is consistent with that. It is possible that some more eagles (or any bird species for that matter) collided with turbines and were never found because not every operating turbine is searched for carcasses. While non-reporting is a possibility it would likely be very rare cases at sites without a monitoring and reporting system in place.

Q: If standards for protecting Bald Eagles were relaxed, how would industry deal with the increase in injured eagles? Rehabilitation facilities already have too many Bald Eagles and are euthanizing birds.

A: I'm uncertain what is meant by relaxing the standards for protecting Bald Eagles. While they were delisted from the U.S. Endangered Species Act they are still afforded protection under the Bald and Golden Eagle Protection Act and in many states. Many bird and bat conservation strategies and draft eagle conservation plans include contacts for local wildlife rehabilitators; however, handling of an eagle needs approval from the Federal and State agencies. I am uncertain as to the validity of the second sentence in the question.

Q: Why not add funding breeding Bald Eagle surveys as a mitigation option? USFWS no longer supports state level surveys. Many states would like to continue surveying, but lack the funding.

A: This is a viable option and it has been implemented at one project that I'm involved with. The state agency and USFWS were receptive to the project developer commissioning an aerial survey and having a consultant and state agency biologist search for Bald Eagle nests within ten miles of a project boundary. With the delisting of the Bald Eagle on the federal level and continually increasing numbers, there is less funding support for state level surveys.

Estimating Fatalities of Birds and Bats

An empirical approach to fatality estimation at wind energy facilities

Presenter: Wallace Erickson, WEST, Inc.

Authors: Shay Howlin, Wallace Erickson, Michelle Sonnenberg (WEST, Inc.)

RESEARCH PROBLEM

Post-construction mortality studies are based on standardized carcass searches, generally conducted at regular intervals below a subset of turbines at a wind energy facility. Because perfect detection is not realistic, fatality estimators are used to correct for ***searcher efficiency*** (observers are unable to discover all fatalities within a searched area) and for ***carcass removal*** (scavenging or weathering of carcasses between the fatality event and subsequent searches). The basic formula for fatality estimators is mortality equals observed mean per turbine fatality rate divided by the estimated average probability that a carcass is available to be found during a search and is in fact found.

Historically bias correction factors have been calculated from searcher efficiency and carcass removal trials. Multiple methods for conducting these trials and calculating the resultant bias correction factor have been established. Western Eco-Systems Technology, Inc. (WEST) has developed a novel approach to empirically estimate this bias correction factor. This presentation explains the field methods to calculate this empirical estimator, and compares its performance to four commonly used methods for estimating the bias correction factor: 1) Huso (2010), 2) Jain et al. (2009), 3) Smallwood (2007), and 4) Shoenfeld (2004). We also provide recommendations regarding the appropriate application of each method and their comparability.

BIAS CORRECTION FACTORS

The basic form of the fatality estimator is: mortality is equal to the observed mean per turbine fatality rate divided by the correction factor, or estimated average probability a carcass is available during a search and is found.

The interplay between fatality occurrence, carcass persistence/removal, and searcher efficiency can be illustrated with an example. Six fatalities occur during the course of a month. Four of them occur during the first week. Of these, one carcass is removed before the first search takes place on Day 7, and so cannot be observed by a searcher. Another carcass is observed, but the other two carcasses, although still on the ground, go undetected. During the following week, one of the two undetected carcasses is removed by scavengers, and two additional fatalities occur. When the second search takes place on Day 14, one of these is observed, along with one of the first-week fatalities that had gone undetected during the first search. The other “new” fatality from week 2 goes undetected on the Day 14 and Day 21, but is eventually detected on Day 28.

The purpose of the bias correction factor is to help researchers estimate the “true” number of fatalities (in this case, six) from the number of fatalities observed (four).

There are a number of fatality estimators found in the literature (e.g., Huso (2011), modified Huso, Jain (2009), Smallwood (2007), Shoenfeld (2004)), each defining the bias correction factor somewhat differently. For example, the Smallwood (2007) estimate of carcass removal is the average proportion of carcass remaining across the days in the search interval, whereas the Jain estimate of carcass removal is the proportion of all trial carcasses placed not removed by scavengers after half of the search interval has passed. Caution therefore should be exercised when comparing fatality estimates from different studies in which different estimators were used.

For most estimators, searcher efficiency and carcass removal are measured independently. Carcass removal trials are conducted in which carcasses are placed in the field and then monitored to determine the average length of time they remain in the field. Searcher efficiency trials typically involve separate placement of carcasses, followed by a search effort in which searchers find some percentage of the placed carcasses.

A COMBINED APPROACH

WEST proposes an empirical estimator, in which trials are combined so that the probability of detection is estimated unconditional of availability. Carcasses are placed on search plots at varying times in relation to searches, simulating how fatalities may fall with respect to the search intervals. Searchers turn in the carcasses they find; there is no effort made to separate out the effects of carcass removal from searcher efficiency. The proportion of carcasses found to carcasses placed determines the bias correction factor.

Benefits:

- The combined approach reduces costs for trial carcasses.
- An empirical estimator of probability of availability and detection is simple and generally unbiased.

Limitations:

- If using longer search intervals, staggered start needs to be considered.
- Sample size must be sufficient for searcher efficiency trials even if removal is quick.

Staggered Placement

Staggered placement also alleviates the potential for bias (up or down) that may result from over-seeding the search plot with trial carcasses, which may result in either attracting scavengers (biasing removal estimates up) or satiating scavengers (potentially biasing removal estimates down). It offers a simple method for modeling the effect of carcass aging on detection, without having to sort out or re-combine its effects on removal and on searcher efficiency.

Implementation can be illustrated with a simple example. Three turbines are searched at three-day intervals (i.e.,Turbine #1 is searched on Day 1 and again on Day 4, Turbine #2 on Day 2 and Day 5, etc.) This example consists of two trials in which three carcasses are placed – one at each turbine – on Day 3 and again on Day 8. In this example, two of the three carcasses placed in the first trial are found, and one of the three carcasses placed in the second trial is found. Two of the non-detected carcasses are shown here to have been removed, while the third carcass remained but was never observed by searchers over the course of the trial. However, the fate of the undetected carcasses is not important to the estimator; averaging over the two trials, the correction factor is 3 detections/6 placements = 50%.

Simulation Exercise

To test the combined approach estimator and other commonly used estimators for potential bias, we conducted a simulation exercise. We simulated different levels of fatalities and types of bias trials, and looked at how each estimator performed – and how estimator performance was affected by the following design parameters: search interval, sampling level, carcass removal, searcher efficiency, and length of trials. Real data were used to come up with slow, fast, and medium carcass removal rates.

One estimator, Shoenfeld (2004), assumes that detection is constant over time. We simulated that case, and also two cases in which searcher proficiency falls off over time, either at a moderate or rapid pace. (We also considered a scenario in which searcher efficiency increases briefly and then decreases.)

FINDINGS

In this simulation, the empirical estimator remained relatively unbiased under multiple model designs and assumptions. All other estimators exhibited some bias, dependent on assumptions of search interval, carcass removal, and searcher efficiency.

Empirical fatality estimates decrease in variability with increased searcher efficiency and remain relatively unbiased. As the chance of finding a carcass already missed increases, some estimators (e.g., Smallwood) increasingly overestimate fatality. The variability of the empirical estimator decreases with slower carcass removal rates.

With high detection, bias is relatively low in most estimators. However all of the estimators perform poorly with rare events and low detection rates.

CONCLUSIONS / NEXT STEPS

We can use this type of simulation to come up with standardized bias correction for studies already conducted, facilitating accurate meta-analyses. Given the availability of large data sets on searcher efficiency and carcass removal, we may bring in a Bayesian approach to improve the empirical estimator.

We hypothesize that the combined empirical estimator will reduce costs associated with bias trials, but we need to look at this more closely and compare the costs for different designs. It would also be useful to get better information on how searcher efficiency changes over time for various species. Finally, it is important in all fatality studies to take reference mortality into account.

Questions & Discussion

Q: Your example of searching every three days had searches on Saturdays and Sundays, which are typically days off. How does the empirical estimator allow for varying intervals, either intentional or unforeseen?

A: You can incorporate the interval into the equation. We tried to get our people out on Saturday and Sunday, but you can manage with different intervals.

Q: If a fox den near one turbine results in dramatically shorter carcass persistence at that turbine, do you adjust your calculations to account for that?

A: You had better do a lot of trials at other turbines to get a handle on what is going on at the whole site. There may be other foxes at other turbines that you did not search.

Q: Would you agree that a staggered-start approach is likely also better for carcass removal trials using other estimator methods?

A: Yes.

Q: How does the new estimator produce the data wildlife managers and agencies need in order to determine how quickly scavengers are removing carcasses and whether the searchers are finding the carcasses? This is important; if searcher proficiency is low, different vegetation management or dogs may be needed.

A: It may be good to do some carcass removal trials away from turbines you're going to search, or you could go in and monitor what is happening (in terms of removal) with the carcasses you placed for the searcher proficiency trials. Carcass removal trials take a lot of effort because you have to monitor them every day, so you may want to take a sample.

Q: Are you recommending using this empirical approach as the primary method? If so, do you anticipate resistance (agency inertia) to acceptance of this method?

A: With raptors and other large birds, most estimators give the same results. For smaller birds and bats, it is also a search interval question. We are in the process of publishing our results; the empirical estimator still needs to be tested. Even if it is not widely accepted right away, you can use it and compare the results against estimators you would otherwise use.

Q: Does the empirical estimator account for time-dependent processes as described by Warren-Hicks?

A: Yes, because carcasses are placed at you are staggered times before the searches, the empirical estimator allows you to look at how carcass age affects searcher proficiency without having to model it.

<u>ADDITIONAL QUESTION</u>
This question was submitted but not answered during the conference.

Q: Have you conducted these trials? Did you see diminishing searcher efficiency over time? How long do you leave a trial carcass out?

A: Yes we have. We saw some diminishing searcher efficiency over time but not dramatic drop. We leave them out well past the typical search interval.

Statistical examination of the efficacy of road and pad searches for post-construction monitoring

Presenter: Michelle Sonnenberg, WEST, Inc.

Authors: Michelle Sonnenberg, Andy Merrill, Jon Cicarelli, Wally Erickson (WEST, Inc.)

RESEARCH NEED / PROBLEM

The USFWS guidelines recommend that all wind projects do at least one year of post-construction monitoring to determine impacts to birds and bats from the site. In the Midwestern United States, where land associated with wind farms is primarily used for agricultural purposes, these monitoring studies can be difficult and costly. Where standing crops are present, measures must be implemented to counteract poor carcass detectability conditions.

One such method is the double sampling approach, which consists of searches on a select number of plots fully cleared of vegetation, and a greater selection of plots on the gravel road and turbine pad only. To produce a fatality estimate, the number of fatalities found on the road-and-pad of cleared plots is compared to the number of fatalities on the entire cleared plot. These values are used to calculate a correction factor, which is then applied to the fatalities on road-and-pad searches.

The road-and-pad are high visibility areas, which can be quickly, safely, and efficiently searched. The effective area searched is similar or greater than that of a more typical study, but the chance of finding carcasses within the searched area is increased, and the cost is significantly reduced. Several studies have already been conducted implementing this method. However, since the method is relatively new, it was unknown whether or how the correction factor would change across project sites or time. To determine how much variability might exist in the correction factor and whether this factor is transferrable across projects or years, a study was done examining data from previous projects. The objectives of this study were to:

- Determine whether road/pad searches give similar results to full plot searches
- Determine conditions under which data for full plots could be combined between projects or years
- Determine whether the approach is applicable for long-term monitoring

APPROACH

Drawing on data from Iberdrola Renewables' projects both past and present in which full plot searches were conducted, we used photographs, UTM locations, or notations by observers to determine which fatalities fell on the road-and-pad versus the full plot. We then retroactively calculated the road-and-pad correction factor for 22 Iberdrola studies at 16 different sites.

The road-and-pad correction factors were compared within geographic regions, turbine types, and years of study. A "leave one out" cross-validation methodology was applied to discover how sensitive the correction factor is to changes in project selection, and also to determine which comparison factors lead to the best combined correction factor. The optimal number of turbines that should be selected for clearing to achieve a reliable correction factor was also determined. Finally, correction factors were compared to the standard area correction factor calculated using 10m distance rings.

FINDINGS

Fatality rates at the 16 study sites ranged from <0.5 to 5.5 bird fatalities per MW per year. Bat mortality exhibited an even distribution of fatality rates across studies, with no high or low outliers. We grouped studies geographically to come up with regional correction factors for both birds and for bats. For birds, correction factors ranged from 3.8 in the Northeast to 10.4 for California. Bat correction factors were <2 for California, the Southern Plains, and the Midwest, ranging up to 4.58 for the Southwest. (The Pacific Northwest had a correction factor of 21 for bats, but this was based on only a single study at one location.)

Correction factors were consistent from year to year where we had multiple years of data from the same site, and also for projects with multiple phases (e.g., Dry Lake, Arizona). This was true both for bird and bat correction factors.

Results of the leave-one-out analysis suggest that data can be combined across projects to determine and increase the stability of road-and-pad correction factors. For birds, the covariate grouping that provides the best combination to boost sample size is magnitude of road-and-pad correction factor; the next best covariate grouping is area searched. On average, this overestimates by approximately 25%. For bats, the best covariate grouping is also magnitude of road and pad correction factor. Regional combination is next best, overestimating by approximately 9% on average. Combining all projects underestimates by approximately 1% on average. This is a small enough difference that it is not likely to be significant in terms of project decision-making.

The road-and-pad correction factor sometimes performs similarly to the generally accepted area correction factor, and sometimes quite differently.

Case Studies

We looked at fatality estimates/MW/year at two case study projects with double sampling design, one in the Midwest, and one in the Southwest:

- ***Cayuga Ridge*** – 5 full 100m x 100m plots, 60 road/pad plots out to 100m; weekly searches, with a focus on bats
- ***Dry Lake II*** – 5 full 160m x 160m plots, 26 road/pad plots out to 100m; twice-weekly searches spring through fall, weekly in winter

Road-and-pad with correction factor yielded very similar fatality estimates per MW per year, both for birds and for bats at these two case study sites.

CONCLUSIONS / IMPLICATIONS

Road-and-pad correction factors appear to be similar by region, area searched, and across years, resulting in similar and comparable estimates to full-plot monitoring. A conservative approach would be to monitor a larger number of full plots during the first year post-construction, and thereafter use the road/pad double-sampling approach.

Road-and-pad searches are:

- Safer for observers
- More economical (avoiding crop damage)

- Provide wider spatial coverage (approximately four road/pad searches can be conducted in the time that it would require to search one full plot)
- Can be used long-term as a "pulse" for fatality levels

Questions & Discussion

Q: How is the road and pad correction factor incorporated into the fatality estimate?

A: It is the number by which you would adjust your fatality estimate at the end.

Q: How will you incorporate variance in the double sampling estimate into the fatality estimate?

A: Values for the road-and-pad correction factor are bootstrapped along with the other calculated values in the study. The fatality estimate for each bootstrap repetition is adjusted by the road-and-pad correction factor associated with that repetition. In this way, fatality estimates are also allowed to vary based on the variability of the road-and-pad correction factor within the bootstrap.

Q: Are all fatality data for birds and bats used in the leave-one-out evaluation based on fatalities detected, or are fatality data corrected for undetected fatalities?

A: In the leave-one-out validation I did not correct for bias in any way, because I would be making the same correction for full plot and road-and-pad, and it would just divide out. In practice, it does make a difference.

Q: Are the two case studies in dry environments where vegetation (off roads and pads) is low? Why have you moved away from using mowed strips, and how do you manage search efficiency without mowed strips if vegetation is dense?

A: The first case study was in a dry environment, yes. The second was in Illinois – I am not familiar with the conditions on the ground, but keep in mind that for our full plot searches, the plot was cleared of vegetation, so vegetation height was not an issue.

Q: What causes the road-and-pad correction factor to differ widely between birds and bats?

A: Distance of fatalities to turbine – bats tend to fall closer, so they are more likely to be found on the road and pad. The search plot size also plays a role. If you have a large plot, you will find more birds farther away, but the number of bats won't increase.

Q: How frequently are people injured while conducting plot searches – how much of an issue is this?

A: I would have to ask our safety coordinator, but I personally know a searcher who broke an ankle.

Q: Do you have any cost comparison and time comparisons (search hours) for the road-and-pad approach relative to more traditional search methods?

A: Road and pad search takes about 10 minutes, v. 1 to 1 ½ hour search for full plot. What it allows us to do is to do more frequent searches over a wider area for the same cost in terms of time and other resources.

Q: Does the road-and-pad method allow one to differentiate between bird categories (small, medium, large)? And was there a difference in species composition between full plot and road-and-pad plots? *Related question:* Are larger birds deposited/found at different distances from turbines than smaller birds?

A: Difference in size is going to be the most pronounced factor in detectability. We were not adjusting for bias here, but in practice you would do those separately (to get different correction factors for large and small birds).

I did not look at different species. One issue is that to calculate a road-and-pad correction factor you have to find enough carcasses falling on the road and pad, so it may be difficult to calculate a correction factor for less common species.

ADDITIONAL QUESTIONS

These questions were submitted but not answered during the conference.

Q: Would the road-and-pad methodology work if you didn't have other nearby projects to provide the correction factor? How can you correct?

A: If you don't have a nearby project, you will have to use project-specific data. The best way to do this is to do one year or more of intensive study, with ten or more fully cleared plots. Bias trials should be done both on and off road and pad. This way, you can get a road-and-pad correction factor, which can be used to adjust road-and-pad plot results to the larger search area.

Q: Why do you think that confidence intervals were tighter for full plot v. road-and-pad for your case studies?

A: The road-and-pad estimate has additional variability due to the road-and-pad correction factor. This is accounted for in the bootstrap. A larger number of full plots will reduce some of the variability in the road-and-pad correction factor and therefore reduce the variability in the road/pad fatality estimate. There is a balance that needs to be maintained between precision of the estimate and cost of the study.

Q: How well does the road-and-pad method detect rare events (e.g., endangered species fatalities)?

A: There is a trade-off here. On one hand, every turbine at the project can be sampled at least partially. For rare events this makes the probability of finding a rare event greater than zero for every turbine, whereas if you were sampling a subset, some turbines would have probability of observing a rare event equal to zero just because you didn't sample there. The drawback is that you are only sampling a portion of the plot, so your ability to detect a rare event is limited to the portion of the plot you are searching, plus incidental finds.

Q: How well do you think your method will work for individual species?

A: Because of the wider spatial coverage, this method would work very well for detecting large bird fatalities, such as eagles, because even those that are outside the plot are likely to be observed from a distance on search plots. For other individual species, such as small bird or bat species, it will depend on the number of fatalities of that species that are found and what type of correction is considered acceptable. For example, for particular bat species we would use the road-and-pad correction factor for all bats to adjust species-specific estimates. However, it should be noted that most all of the methods currently being used for fatality estimation are not appropriate for very small sample sizes, such as one

or two observed fatalities. Many of us are looking for better alternatives for estimating fatalities on a species-specific level.

Evaluating the validity of a protocol for long-term, post-construction fatality monitoring to assess wildlife impacts that integrates with operation's activities and personnel

Presenter: Jerry Roppe, Iberdrola Renewables

Authors: Jerry Roppe, Tina Bartunek (Iberdrola Renewables); Michelle Sonnenberg, Wally Erickson (WEST, Inc.)

RESEARCH NEED

The US Fish and Wildlife Service (USFWS) Wind Energy Guidelines (WEG) recommend that all wind projects conduct post-construction (baseline) wildlife fatality monitoring to determine impacts to birds and bats from the site. This monitoring is conducted in accordance with industry standard or regulatory protocol, typically for one to two years, using standardized carcass searches, bias trials for searcher efficiency, and carcass removal conducted by trained biologists. Depending on the protocols implemented, it provides fatality rates for the required period but can be expensive and short-lived without an ongoing mechanism to monitor impacts.

Iberdrola Renewables (IR) has moved beyond developing an Avian Bat Protection Plan policy to develop supporting processes and implement practices – including an alternative or supplemental approach to post-construction (baseline) wildlife fatality surveys using a long-term Operational Monitoring (O&M) program. Integrated with operations and the Company's Wildlife Monitoring and Reporting System (WMRS), this approach presents an opportunity to reduce initial baseline fatality survey effort and expense while providing a means to monitor long-term impacts from wind operation.

This presentation summarizes key aspects of Iberdrola's Operational Monitoring using the road-and-pad approach described in the Michelle Sonnenberg's presentation (summarized above).

APPROACH

Operational Monitoring consists of a systematic approach to post-construction monitoring and reporting of bird and bat casualties, threatened and endangered species sightings, and nest management on plant power lines. Its objectives are to systematically monitor and report wildlife casualties (dead and injured), assess the project's long-term operational impacts and casualty trends, and accumulate long-term data on species composition.

Operation Monitoring consists of three stages – inspections, turbine checks, and incidental observations.

1) ***Inspections*** - A specially trained operations technician designated the Environmental Coordinator (EC) conducts weekly inspections of selected turbines for bird and bat causalities during spring (8 weeks) and fall (10 weeks). The EC, who acts as the on-site representative for implementation of the WMRS, and supporting O&M personnel survey the areas surrounding the turbines (the number depending on the size of the facility) and search an 80-meter (m) transect

along the access road on either side of each turbine. Turbines were inspected at 31 projects in 2011, and at 41 projects in 2012.

2) ***Turbine checks*** - Trained personnel visit every turbine monthly, checking around the turbine base (gravel pad) for any bird or bat casualties.

3) ***Incidental observations*** - All operations personnel are trained to report any wildlife incidents (i.e., fatalities, injuries, nests, sightings) observed on the project during their daily work activities. This component is carried on fleetwide (41 projects in 2011; 44 projects in 2012).

FINDINGS

Over 3,000 inspections were conducted in 2011, and over 4,200 were conducted in 2012. We have noticed that there are similarities in species composition and seasonality of bird and bat fatalities between the operational monitoring activities and baseline fatality monitoring. No large events have been observed. There also seems to be consistency in the overall pattern of fatalities discovered for both birds and bats in 2011 and 2012.

In 2010, we had fewer than a dozen incidental reports of bird or bat fatalities. After training personnel and implementing the Wildlife Reporting Monitoring System, incident reporting has increased to over 175 incidental reports called in per year. A high percentage of the incidentally reported bird fatality reports have been raptors and other large birds. We conducted limited blind testing in shrub-steppe habitat, and found that had our operations personnel had high detection rates with decoy carcasses.

While low sample sizes and uncertainties related to the correction factor prevent direct comparison between inspection results and baseline fatality findings, the inspection results are useful for identifying deviations in numbers or patterns between years and among projects. We are developing a trend index (fatalities per 100 inspections) that we can use to look at percent change over time and also to assess some qualitative measures.

CONCLUSIONS

Training operational personnel to perform road-and-pad monitoring in the context of Iberdrola's Wildlife Reporting Monitoring System provides many benefits. It is cost-effective, relying on operational personnel who are already in the field, and who have demonstrated a high level of detection and consistency. Awareness and acceptance of the program is high, and as a result, field personnel are now much more supportive of the company's monitoring program as a whole.

Questions & Discussion

Q: Did the Environmental Coordinators (ECs) locate bats as well as birds during searches? Were the carcasses photographed to confirm species, or were they collected and examined by a biologist to determine species?

A: Yes, a majority of the carcasses discovered by the EC during inspections are bats. All carcasses are photographed and forwarded with data sheet to IR biologists for confirmation of species identification and data storage. The EC leaves all carcasses on-site with a unique marker to avoid duplicate counts. If the carcasses is a suspected state or federal threatened or endangered species or eagle, the carcasses is not collected but secured (covered with container) on site. Photos for these carcasses are forwarded to subject matter experts for confirmation. Based on identification, state or federal agencies may be

contacted and a consulting biologist with appropriate state and federal permits may be dispatched to the site for collection or storage. All photos are reviewed at year-end as a QA/QC of identifications. The ECs had about 80% searcher efficiency on roads and pads. Their incidental finds included bats as well as birds. We photo-documented all finds.

Q: Is your wildlife policy/procedures available for review so that other companies can incorporate similar practices?

A: We are glad to share this information. It is available on our web site and we are glad to discuss. It is important to note that processes and practices that IR uses to meet our policy and state and federal regulations are designed to integrate with our operations. Each company needs to determine what processes and practices fit with their operations and policies.

Q: How effective is it for bat detections?

A: EC inspections have detection levels near 80% for small birds and bats. For inspections and incidental observations, bats are a majority of the carcasses discovered. However, the number of raptor fatalities found by incidental observation appear to represent a disproportionately high (>25%) of the avian fatalities. This number likely relates to higher detection and longer carcass retention of larger v. smaller birds. The majority of incidental observations are bats.

Q: How frequently do you train operations personnel?

A: There is an initial training on general environmental awareness (with emphasis on wildlife issues) of the all site personnel with annual refreshers. Note these are in their annual performance standards/goals. If there are site-specific conditions or if there is an exception to policy or procedures at a site, ancillary training sessions specific to that condition or issue may be conducted as corrective action. In addition, the EC is given a series of training and hands-on sessions on the program. Initially, Iberdrola Renewables and consulting biologists act as coaches and mentors to the ECs with follow up and QA/QC checks (e.g., data inspection, phone calls, site visits, testing). Ongoing training with the EC and their plant managers includes quarterly webinars. We also monitor the data that is coming in, so if we have a site that is not reporting, we do spot checks, phone calls, field visits.

<u>ADDITIONAL QUESTIONS</u>
These questions were submitted but not answered during the conference.

Q: Has any effort been made to compare or factor incidental fatality observations into fatality estimates from carcass searches?

A: Yes, as one analysis all operations monitoring (inspections, turbine checks, and incidental observations) findings are assessed and compared to baseline (formal 3rd party) fatality monitoring findings. Patterns in overall fatality occurrence (species composition, seasonality, regional fatality numbers, etc.) for operation monitoring have generally been similar to baseline.

Q: You stated that mortality detected was "low" – why do you believe that fatalities were low?

A: This is an overall qualitative assessment based on the relative few numbers of carcasses discovered during the operation monitoring. Detection trials with 3rd parties (consulting biologist) have found high discovery levels by ECs and plant personnel. Although this varies by location, season, and species group; if" high" or unusual numbers of fatalities were occurring it appears that operation monitoring is capable

of giving us an indication or detecting the occurrence. Based on an occurrence or trend, follow up (root cause) assessment may be needed.

The fatality levels observed for a species may be "low" but requires a different assessment if the species is rare, threaten, or endangered.

Q: Why only spring and fall?

A: EC inspections are conducted for 8 weeks in the spring and 10 weeks in the fall to survey migration. This is typically the period of highest bird and bat fatalities. This survey may be expanded or shifted depending on site-specific conditions or concerns (breeding or wintering use). Incidental observations and turbine checks are done year round.

Improving methods for estimating fatality of birds and bats at wind energy facilities: modeling time dependence due to searcher proficiency and carcass persistence and implications for monitoring design

Presenter: William Warren-Hicks, EcoStat / Cardno Entrix

Authors: William Warren-Hicks (EcoStat/Cardno Entrix); Brian Karas, Loan Tran (EcoStat, Inc.); James Newman (Normandeau Associates); Robert Wolpert (Duke University)

RESEARCH NEED

Wind energy and wildlife stakeholders have collaborated to survey avian and bat activity and study the impacts of wind project operations, and policymakers have incorporated research protocols into the permitting process. The California Energy Commission (CEC) awarded a Public Interest Energy Research grant to the California Wind Energy Association (CalWEA) to rigorously evaluate the procedures provided in the California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development (the CEC Guidelines) for estimating mortality of birds and bats associated with collisions with wind turbines. The goal of this project was to conduct research to improve the accuracy of methods for estimating the number of bird and bat fatalities at wind energy facilities by evaluating the effect of time-dependency on the probability of bird and bat scavenging and removal (carcass persistence) and detection by searchers (searcher proficiency). This study is the first to quantitatively document the long-term relationship between carcass age and the ability to detect the carcass and offers lessons and implications for experimental designs and the field monitoring recommendations provided in the CEC Guidelines.

APPROACH

Bird and bat carcasses were placed and data were collected from selected turbine strings located in the Altamont Pass Wind Resource Area near Livermore, CA from January 7 to April 30, 2011. These data were used to create traditional scavenger removal and searcher proficiency functions, novel combined and cumulative proficiency functions, as well as to test commonly used searcher proficiency functions.

- In all cases, prior to searches, the true number and location of carcasses known to Project Field Managers (PFMs), but not to Field Technicians (FTs).

- Each string was searched for up to 60 days, or until all carcasses were removed.
- Turbine strings were selected to represent various environmental conditions, including grass height, slope, vegetation type
- Carcasses were tagged and followed consistently by PFMs.

The carcasses we used were mostly Big Brown Bats, Brown-headed Cowbirds (small birds) and incidentally found large birds (e.g., Red-tailed Hawks).

FINDINGS

Searcher Proficiency

Data from the field study was used to show how findings from a typical detection trial compare with what field personnel are likely to find on average in the course of conducting fatality searches during post-construction monitoring. The first column shows the percentage of carcasses detected on the first observation: 14% of bats; 22% of small birds, and 83% of large birds. These percentages represent what a typical detection trial would conclude to be the searcher efficiency coefficients for those types of fatalities. The problem is, freshly placed carcasses do not adequately represent what fatality searchers find on average in the field. By extending our detection trials over a period of weeks, not hours, at each block of turbine strings, we determined that the average percentage of detected carcasses over all trials for all observers is lower: only 8% for bats, 17% for small birds, and 68% for large birds. We also determined that, while large bird carcasses will eventually be found, there are a sizeable percentage of carcasses (over 80% of bats and almost 70% of small birds) that are never found.

The field data demonstrate that searcher proficiency falls off over time, the longer a carcass remains on the ground. By 30 days from its initial placement (or, in the case of a monitoring study, from the date of the fatality) the probability of detection for a bat or small bird has decreased markedly, and after 35-40 days, the likelihood that it will ever be detected is negligible.

At the Altamont, vegetation height was also shown to influence searcher proficiency. Topography did not prove to be an important covariate at this study site, but that may be different for another project site. The important point is to think about which covariates impact searcher proficiency at the site in question; these factors have to be taken into account, either in the estimating equation or in the survey design.

Persistence probability

The probability that a carcass persists – that it will still be there to be found when a field searcher goes to look for it – is treated somewhat differently in the various estimating equations. As with searcher efficiency, the CalWEA field study looked at persistence data over a much longer timeframe than the typical one week to 10-day persistence trial. In the Altamont, bat carcasses persist longer than small bird carcasses. As far out as 50 days from initial placement, bat carcasses have a 30% chance of persisting, whereas for small birds the persistence probability drops off much faster.

Note also that persistence data were fit much better using a Weibull distribution rather than an exponential distribution.

IMPLICATIONS

This field study has several implications for survey design.

- Searcher proficiency is a time-dependent process. To capture this requires either extending searcher proficiency trials over multiple weeks, or embedding them in the actual study.
- Ecological conditions (e.g., vegetation height) are important for survey design.
- Small birds have lower time-dependent persistence than bats
- Carcass persistence is time-dependent process, fits best with a Weibull distribution
- Searcher proficiency for bats is considerably less than for small birds

The CalWEA study also has implications for equation selection. The commonly-used fatality estimation equations are black boxes to most people, but each has a set of implicit mathematical assumptions. If any of those assumptions are violated, the results can be quite biased. For example, some of the equations assume that if you don't find a carcass in first search interval it does not remain to be found in subsequent searches. However, given a trend towards shorter search intervals, and given the kind of persistence times we found in the CalWEA study, such an assumption can lead to large overestimates of mortality. Some of the underlying mathematics can be found on our poster, and the CalWEA report goes into much more detail.

This finding of increased persistence of bats relative to birds may not be expected based on the current literature, and, coupled with the lower detection rates of bats than birds, could lead to gross error in the expected mortality of bats if new bat-specific estimating equations are not fully developed and tested. Study results indicate that searcher proficiency is a function not only of environmental variables but of carcass age. The study's finding that carcasses have the highest chance of being detected during the first two weeks has implications for study design. Further, searcher proficiency trials should occur on a year-round basis, and should be conducted over time periods recommended by the study. Conducting the trials at multiple times throughout the year is recommended to capture the interaction of carcass age and seasonal environmental changes on searcher proficiency.

Questions & Discussion

Q: With respect to fatalities found in the Altamont study area, were turbines upwind or downwind, and was there statistical difference between the two?

Brian Karas: These are old-generation turbine sites, so they are mainly on ridge tops. However our experiment involved random placement of carcasses, so apart from any incidental finds, upwind v. downwind is not an issue.

Q: Why did you conduct the study during the winter and early spring? Do you think there could be a seasonal effect leading to your much longer carcass persistence rates than those typically reported?

A: That's a biology question – are scavengers hungrier in the winter than they are in the summer? I have not heard anyone at the Altamont ever describe a seasonal difference in terms of scavenging. We performed this study when we did because we had to. The take-home message is that these are things that should be looked at for each study, because the conditions may not be the same in another location. Do not assume that a "black box" method will work the same under all conditions.

Q: What age carcass was represented in searcher proficiency as a function of vegetation height, and what vegetation height when searcher proficiency is plotted as a function of time?

A: Vegetation height varied in both cases.

Q: Can you explain how short intervals and long persistence leads to large biases in fatality estimates?

Bill Warren-Hicks: The differences among the four estimators are principally in how they model the number of discoverable carcasses present at the beginning of the interval: Erickson & Johnson take that to be the steady-state number, Shoenfeld takes it to be all of the carcasses not removed by the search team, and Pollock & Huso take it to be zero. When search intervals are long compared to persistence times, any differences among the models about the initial conditions are swamped by what happens during the long search interval, so all four estimators are nearly unbiased and give nearly identical values. But when the search interval is short relative to carcass persistence times, the differences grow and the assumptions matter. For example, if carcasses persist on average for 15 days, but searches are conducted every two days, the Erickson and Johnson estimator will underestimate the number of fatalities by a factor of almost 68%, while Pollock's and Huso's estimators will overestimate the number of fatalities by a factor of 158%.

Wally Erickson: With search intervals and long persistence times, some of the estimators will underestimate, and many will overestimate; it's the ability to pick things up multiple times, and how do you incorporate that in your model. The big issue is how do carcasses change over time and how does that impact detection. The CalWEA study has produced some data on this, which is good, but we need to gather that kind of data from different environments – for example, in the Northeast, where it's wet, bats kind of "melt" into the ground

Warren-Hicks: There are a few independent problems here. One is the ratio of search interval to persistence, then there is bleed-through (which Wally's slides illustrated nicely) another is the time-dependency of these processes. You have to run the curve out a long time to understand what's going on. It doesn't have to cost more, but you need to incorporate gathering that information into your actual survey.

Planning for Cumulative Impacts

Part I: Collaborative landscape, conservation approach, and benefits of the Great Plains Wind Energy Habitat Conservation Plan (GPWE HCP)

Presenter: Karen Tyrell, BHE Environmental, Inc.

Presentation

Authors: Karen Tyrell, Kely Mertz (BHE Environmental, Inc.); Abby Arnold, Elana Kimbrell (Kearns & West)

RESEARCH NEED

A large group of stakeholders – 17 wind industry companies, in collaboration with the US Fish and Wildlife Service (USFWS) and state agencies – have come together to develop the Great Plains Wind Energy Habitat Conservation Plan (GPWE HCP). The objective of the GPWE HCP is to evaluate and respond to potential impacts to federally listed species related to the future development of wind energy facilities in a nine-state, 200-mile wide region of the central US, extending from Canada to the Gulf of Mexico. This is the first of a two-part presentation, introducing the purpose and benefits of a collaborative effort over the landscape scale.

A COLLABORATIVE APPROACH

Often, the proponent for an HCP is a single entity that prepares a permit application. In this case, wind companies have organized themselves through their affiliation with the American Wind Energy Association's Wind Energy Whooping Crane Action Group (WEWAG) to develop a landscape-level HCP. In addition to the 17 participating wind companies,[7] the collaborative is supported by a technical and a legal team.

- Technical Team: BHE Environmental, Inc.; WEST Inc.; with technical assistance from Sutton Avian Research Center and Platte River Whooping Crane Maintenance Trust. Facilitator: Kearns & West
- Legal Team: Crowell & Moring LLC; Sedgwick LLP

WEWAG works closely with the US Fish and Wildlife Service (USFWS) and with state wildlife agencies from each of the nine states. The collaborative approach provides a centralized forum for accumulating, communicating, and benefiting from experience. The large-scale effort is designed to be more efficient than multiple project-specific permitting efforts would be, reducing the related cost and administrative burden on a resource-constrained federal agency.

[7] Acciona, North America; Allete, Inc.; Alternity Wind Power; BP Alternative Energy; CPV Renewable Energy Company, LLC; Duke Wind Energy; Element Power; EDP Renewables North America LLC; EDF Renewable Energy; Iberdrola Renewables; Infinity Wind Power; MAP Royalty; NextEra Energy Resources; RES Americas; TerraGen; Trade Wind Energy; and Wind Capital Group

Mission Statement

When the process was launched, the companies and USFWS set out a joint mission for the HCP process:

> "…to work cooperatively, to exercise flexibility and ingenuity, and to devote the necessary resources to craft a scientifically and legally defensible HCP that provides a means for reasonable wind power development in the planning area, that will support the survival and recovery of the species covered in the HCP." (December 2009).

The purpose of the HCP is not to dictate where wind development will occur throughout the plan area, but to allow for flexible and responsible development of projects.

CONSERVATION BENEFITS OF THE GPWE HCP

- A comprehensive, integrated approach for species conservation has advantages over a piecemeal conservation management approach.
- Both impacts and conservation measures are considered across a significant portion of the species' ranges.
- Scientific rigor and the best available biological information are being used to develop and maintain the conservation program.
- The plan has clearly-stated biological goals and objectives developed by species experts and scientists and supported by industry, federal and state wildlife agencies, and conservation groups.
- Use of funds from multiple stakeholders will be leveraged to maximize conservation benefits, supported by long-term financial and legal commitment.

The conservation program will be comprehensively evaluated and carefully monitored, and conservation measures will be adjusted to ensure ongoing effectiveness and compliance.

OVERVIEW OF THE HCP

The GPWE HCP is analysing potential impacts resulting from the proposed development and operation of wind energy facilities on:

- three federally endangered species - the whooping crane, interior least tern, and the piping plover
- one federal candidate species - the lesser prairie-chicken
- other federally-listed species addressed by avoidance or compliance on project-specific basis

The GPWE HCP and correspondng Incidental Take Permit (ITP) will provide legal coverage under the Endangered Species Act (ESA) for potential take of covered species during the course of otherwise lawful activities (i.e. the development and operation of wind facilities). Developed in accordance with the ESA, the GPWE HCP will replace project-by-project permitting with a holistic, landscape-level assessment for included wind energy projects over the course of 45 years. Through this broad-scale assessment, the GPWE HCP/ITP will allow industry to continue to develop wind energy resources while responding to the conservation needs of covered species.

Extensive and robust modelling approaches are being used to describe the proposed build-out of wind energy facilities to be covered by the HCP, as well as to determine the potential impacts of both the

proposed covered activities and the conservation measures described in the plan. These models are being developed using the best available scientific information about species behavior and presence. Modelling is used to evaluate the unpredictable facility build-out over a geographically large area, and address the dynamic nature of habitat change over time.

Part 2 of this presentation (below) provides an example of the landscape level approach, describing how WEWAG is modeling potential impacts to migratory whooping cranes from wind power development within the GPWE HCP.

MILESTONES / SCHEDULE

[*Note: This schedule is tentative and subject to change.*]

- 2009 to 2013 - WEWAG develops Draft HCP, in coordination with USFWS and state wildlife agencies
- Fall 2013: Public Comment Period on Draft HCP
- Summer 2014: Final HCP is approved

Additional Information

For questions related to WEWAG, please contact John Anderson at janderson@awea.org or 202-383-2516. Additional information about WEWAG and the GPWE HCP can also be obtained online:

- Download the Great Plains Wind Energy HCP Fact Sheet at http://www.greatplainswindhcp.org/documents/fact_sheet.pdf
- See the USFWS HCP website at http://www.fws.gov/midwest/endangered/permits/hcp/hcp_wofactsheet.html
- See www.fws.gov/southwest for information on the NEPA process (then click on "Great Plains Wind Energy" in column on right side of page)
- Visit the USFWS Endangered Species Webpage at http://www.fws.gov/endangered/

Questions & Discussion

Q: Is there any opportunity for incorporating state listed species into the HCP process?

A: Because issuance of the permit is a federal action to authorize take of federally listed species, the HCP process focuses on federally-listed species. However, by virtue of the avoidance, minimization, and mitigation measures that will be implemented on behalf of the covered species, state species will benefit from implementation of the GPWE HCP.

Q: Will decommissioning of the wind farms be covered? Are there site restoration plans included in the HCP?

A: The entire life cycle of a wind project has been considered in evaluating activities addressed under the HCP. Working with WEWAG, we identified potential impacts from early siting through operation and decommissioning, to establish BMPs that will minimize impacts throughout the entire project life cycle. The next step was to look at those activities and identify which of those could lead to take, and address each of those.

Q: Are there mechanisms to allow for changes in species ecology or distribution (e.g., in response to climate change) over the 45-year duration of the HCP?

A: Yes. Given the long duration and wide geographic range covered under this GPWE HCP, we need to consider changes over time. We plan to address this in part through an adaptive management process. Mitigation measures must be evaluated through two different kinds of monitoring, to address the following questions: 1) are the requirements of the ITP being followed; and 2) is the conservation plan working? The second type of monitoring will help stakeholders understand the need to make adjustments in conservation measures going forward.

Q: It appears that state agencies can provide a lot of needed information and expertise to a regional HCP, but how does doing so benefit state agencies? Wouldn't a state agency's conservation needs possibly be diluted by the needs of industry, other states, and USFWS?

A: While the GPWE HCP addresses federally listed species, we do not anticipate that this process and resulting plan will dilute or otherwise negatively impact state-specific wildlife conservation. We have invited state agencies to actively participate and address their concerns regarding the covered species. Because of this participation, we have been able to benefit from the states' expertise in managing resources at regional level. Through this collaboration, we believe the GPWE HCP will be more compatible with the states' internal conservation efforts rather than being at odds with them.

ADDITIONAL QUESTIONS

These questions were submitted but not answered during the conference.

Q: How will the HCP deal with states that do not permit take of their state threatened and endangered species?

A: The GPWE HCP addresses potential impacts to the covered species. Projects impacting protected species (state or federal) that are not covered species will need to be addressed outside of this GPWE HCP by the project developer.

Q: Will the HCP be available for use by wind companies not currently funding or involved with the plan's development?

A: The participation criteria for the GPWE HCP are currently under development. Because WEWAG members have different roles in project development (i.e. construction only, operation only, etc.) the specifics regarding participation will need to address the different scenarios in which a project may participate.

Q: Does the HCP, EIS and Section 7 consultation include future transmission lines built within the corridor? If not, how will the required new lines be evaluated and permitted?

A: The GPWE HCP does not address future transmission lines. Impacts to federally listed species from future transmission would be subject to compliance with applicable laws, as is any potential source of impacts. However, evaluation of impacts of future transmission is beyond the scope of the GPWE HCP.

Q: Did some wind developers drop out of the WEWAG? Have seen it listed elsewhere in the literature as 19, not 17 developers.

A: Yes, due to company restructuring and other business related decisions, not for any reasons related to the process, some industry members have elected to drop out of WEWAG.

Part 2: Collaborative landscape conservation approach: modeling potential impacts to migratory Whooping Cranes from wind power development

Presenter: Chris Nations, WEST, Inc.

Authors: Christopher S. Nations, Shay Howlin, David P. Young (WEST, Inc.)

RESEARCH NEED

Seventeen wind energy companies in collaboration with the US Fish and Wildlife Service and state wildlife agencies are developing a regional Habitat Conservation Plan, the Great Plains Wind Energy Habitat Conservation Plan (GPWE HCP) that includes the US portion of the whooping crane (Grus americana) migratory corridor, a 200-mile wide swath connecting the wintering grounds in south Texas with the breeding grounds in Canada. The HCP will address potential incidental take of whooping cranes resulting from construction and operation of wind facilities over the next 45 years. (See above for overview of the GPWE HCP.)

This presentation focuses on our efforts to project build-out of wind energy facilities and to estimate indirect and direct impacts from wind project development throughout the migration corridor. Because there is very litle data – few whooping cranes and very few observations of cranes encountering wind projects – we must rely on modeling both to project where wind development might occur and to estimate impacts.

APPROACH

Our approach to estimating potential take of cranes over the 45-year duration of the HCP entails multiple interdependent mathematical and statistical components. Impacts are categorized as either indirect (energetic cost due to avoiding wind facilities) or direct (collision with wind turbines).

Modeling Wind Energy "Build-out"

We projected future wind energy development within the corridor by developing a "development potential" map based on landscape features (e.g., wind resource, proximity to transmission line, and proximity to demand) ranked in importance by industry participants.

Total megawatt capacity within the corridor, based on US Department of Energy projections for 20% renewable energy goals by 2030, was allocated among states with areas such as critical habitat, urban areas, and state and national parks excluded. Within the build-out model, wind facilities of specified capacity are added to the landscape sequentially using an unequal probability sampling approach; areas with higher development potential have higher selection probability. (In addition to the whooping crane migratory corridor, within the GPWE HCP we were also looking at the Lesser prairie-chicken footprint, which overlaps the whooping crane corridor.)

We established three build-out horizons, or phases: 8,000 MW, 16,000 MW, and 24,000 MW. The process stops when total capacity is reached (about 100 projects of ranging in size from 100 to 900 MW). Slide #7 shows the distribution of projected wind energy facilities and capacity by state, and also mapped on the migratory corridor. Note that this was a predictive – *not* a prescriptive – approach, projecting the location of future wind projects for modeling purposes only. That is, build-out was used

in assessing potential impacts, but was not intended to represent recommended size and shape of wind projects nor areas where projects should be developed.

Resource Selection Function (Stop-over Habitat)

The second component is a statistical model that predicts roosting/stopover habitat throughout the corridor. Resource selection function (RSF) models were fitted to data on confirmed sightings of cranes at stopover locations, separately for the fall and spring migratory seasons. Landscape-level covariates in both models included distance from the migratory corridor centerline, distance to water and to wetlands, area of water and density of wetland, proximity or acreage of agriculture, and latitude. The model predicts the *relative* probability of use based on habitat characteristics.

Simulation Model

The third component is a simulation model for whooping crane migration that uses both the build-out and the RSF results. RSF predictions influence selection of simulated roosting locations, while the build-out presents wind projects that may be encountered in flight. The objectives of this model are to estimate indirect impacts in terms of additional distance flown in avoiding projects, and to calculate the rate at which projects are encountered for subsequent estimation of direct impacts.

The simulation is based on the following key assumptions.

- Daily migratory flights include longer, high-altitude soaring flight segments as well as shorter, low-altitude flapping flight segments.
- Wind projects encountered only during low-altitude flight, including ascent from overnight stopover and descent from high-altitude flights (e.g., for mid-day breaks), and foraging flights.
- Encounters with wind projects are a function of migratory routes and the distribution of wind projects over the landscape. (For instance, preliminary results indicate that at the second build-out horizon, the encounter rate is estimated to be 15% - that is, there is a 15% chance that any given crane will encounter at least one wind project during the each of its seasonal migrations.)
- Encounters are accompanied by avoidance – deliberate detours around wind projects.
- Roost selection depends on RSF.

In a simple example, with the current population of 300 whooping cranes, an encounter rate estimated at 15%, and an avoidance rate of 75%, the estimated passage rate would be 11.25 flights through wind projects per season.

Collision Risk Model

The final component is a collision risk model. We relaxed the avoidance assumption from the migration model, allowing some cranes to fly through wind projects and assessing collision risk based on whooping crane characteristics and assumptions regarding wind project layout, turbine size, and wind conditions. Key assumptions of the collision risk model included the following.

- All low-altitude flights are within turbine heights (between 10 m and maximum rotor tip height).
- Avoidance rates: for the wind project as a whole (0.75); of active rotors (0.90-0.95); of stationary structures (0.95-0.99)
- The typical wind project comprises 100 3-MW turbines, 112 m rotor diameter
- The ability to monitor and curtail operation assumed, and compared with a “no operational mitigation” scenario.

FINDINGS

Initial results indicate that indirect impacts are negligible and that the encounter rate, while low, may be important as build-out progresses. Preliminary simulations show that collision risk for cranes is high compared to other avian species, as expected given their large size and low flight speed. Slide #17 shows collision probabilities under two scenarios (operational mitigation v. no mitigation), with lower and higher avoidance rates for both the stationary towers (95-99%) and rotating turbines (90-95%). In the best case scenario, given operational mitigation and 99% and 95% avoidance for towers and rotor blades respectively, the model indicates 0.3 collisions per 100 bird passages. In the worst case scenario (no mitigation, 95% tower and 90% rotor avoidance), the model indicates up to 1.1 birds per 100.

Using realistic assumptions of avoidance probabilities, final estimates of collision risk are combined with encounter rate estimates from the migration model and with projected population sizes to yield predicted take over the 45-year permit duration. Depending on the collision avoidance rates, we estimate between 0.7 and 2.5 collisions per year at the 45-year build-out. This also assumes that the whooping crane population has experienced continued exponential growth to nearly 2000 birds. Under more realistic assumptions of density-dependent growth, both population size and annual collisions would be lower.

CONCLUSIONS

A draft of the HCP is now in progress with input from WEWAG and agencies. We are refining both the input variables and the output summary, incorporating some new data and conducting model validation. We are trying to make these adaptable tools for assessing both indirect and direct impacts. Additional demographic analysis of direct impacts is still needed.

Questions & Discussion

Q: What type of logistic model did you use to develop the resource selection function (RSF)? What type of model did you use to create your whooping crane migratory tracks?

A: Shay Howlin was largely responsible for developing the RSF model, based on fairly standard logistic regression. To create WC migratory tracks, we used an individual-based simulation model that we developed ourselves.

Q: How did you simulate the Whooping Crane flight patterns? Do you plan to use the actual flight patterns obtained from the telemetry data now being collected?

A: With access to those data we could use them to validate our simulated crane flight pattern model as well as our RSF model for stopover habitat.

Q: In the build-out scenario, is there a buffer around excluded areas so that the model does not assume a facility might be built adjacent to a wildlife refuge, city, or other feature?

A: Yes. For certain of the excluded areas (parks, rivers, wildlife areas) there was a 2-mile buffer. There was no buffer for urban areas.

Q: What assumptions are your collision rate estimates based on?

A: A lot of assumptions go into model. Avoidance rates – in terms of wind project avoidance, the initial assumption that migrating cranes would avoid projects came from expert opinion (in particular, Tom

Stehn). Other avoidance rate assumptions were based on admittedly limited information from the literature. There is not much literature on cranes, so we had to look at what is known for other species, and use those species as surrogates.

Q: Have you looked at changes in migratory corridor's shape over time?

A: No, we have assumed the corridor is static as defined.

Q: Why include distance to centerline in the whooping crane model? It seems cyclical considering the corridor width is already based on the observations?

A: The *width* of the corridor is based on observations, but observation data are more densely clustered closer to the centerline. In developing the RSF model for stopover habitat, we initially considered other covariates not including distance to the centerline. Then, when distance to centerline was added, we found that it improved the fit considerably. Therefore, it seems to be quite important.

Q: Swainson's hawks congregate in large numbers in the southern part of the Great Plains wind energy corridor. Are your efforts at all focused on Swainson's hawk migration routes?

Karen Tyrell: The HCP addresses impacts to covered species, but developers would still follow other protocol and practices that address non-covered species. Other species concerns would be addressed through compliance with other requirements and by following other voluntary guidance (e.g., USFWS guidelines).

<u>ADDITIONAL QUESTIONS</u>
These questions were submitted but not answered during the conference.

Q: With all the oil and gas development activity, has there been any effect on flight patterns and resting sites of the whooping crane?

A: This isn't known at present.

Q: Can you briefly explain the model component "distance to agriculture"? Do you know whether whooping crane use of agricultural land varies throughout the migration corridor?

A: The RSF model predicts lower probability of use with increasing distance from agriculture in both Spring and Fall. This effect is most likely due to cranes' foraging habits – cranes are known to forage in agricultural fields as well as wetland habitats. Whooping cranes use similar habitat throughout the migratory corridor, although the distribution and abundance of these habitat types vary throughout the corridor. Furthermore, the RSF model assumed constant use patterns, with respect to habitat, throughout the corridor.

Q: You used simulated whooping crane flight patterns. Do you plan on also using the actual flight patterns recorded with satellite telemetry data currently being collected?

A: We are in the process of determining how the telemetry data may be used to inform the whooping crane risk analysis.

Q: [Several questions touch on the issue of take, given that the model apparently predicts build-out resulting in about 8,800 to 12,000 wind turbines in the migration corridor.] **How much whooping crane**

take does your model currently predict? What is the requested level of take given the build-out and pass-through rate? What is triggered when mortality occurs?

A: The model is still under development, and we do not yet have a final take estimation, nor has the permitted level been established. Mortality events trigger a series of reporting requirements, and may trigger modifications in conservation measures and or monitoring, but these relationships are still being developed in the HCP.

Q: Are predicted collisions reflective of both turbine interactions and transmission line interactions?

A: The model is not designed to be predictive of potential impacts of transmission line interactions.

Q: Have your collision estimates been included in a larger population-level risk assessment to quantify true population effects from numbers of fatalities?

A: The HCP does address the effects of any predicted takings, including population-level impacts, however analysis and quantification of these impacts using the model described today is still under consideration.

Lessons learned from the frontline: challenges and solutions to habitat conservation planning for Indiana Bats

Presenter: Cara Meinke, WEST, Inc.

Presentation

Authors: Cara Wolff Meinke, Dave Young (WEST, Inc.)

PROBLEM / RESEARCH NEED

Windpower development within the range of the Indiana Bat (*Myotis sodalis*) has grown from 500 MW in 2001 to 16,000 MW in 2011. Fatalities of five federally endangered Indiana Bats at wind power projects over the past four years have increased awareness of the potential impact to this species from wind power development and have highlighted the need for proactive conservation planning for the species.

While no permits have yet been issued, there are three publicly-available Indiana Bat habitat conservation plans (HCPs),[8] and several more under development. Biologists at Western Ecosystems Technology, Inc. (WEST) are preparing seven project-level HCPs and one programmatic HCP for Indiana Bats for wind power projects across the species' range. Drawing on this experience, WEST biologists have come to understand the challenges of preparing robust and scientifically defensible HCPs that are acceptable to both project proponents and the U.S. Fish and Wildlife Service. This presentation reviews some of the key challenges to habitat conservation planning for Indiana Bats, presenting currently available methods and approaches that offer potential solutions.

CORE HCP ELEMENTS

The three core elements that have proved to be most challenging across all HCPs are:

[8] Indiana Bat HCPs have been developed for Buckeye, OH; Beech Ridge, WV; and Criterion, MD.

1) Estimating the amount of take likely to occur from operation of the wind facility;
2) Understanding and accurately determining the biological impacts of this taking; and
3) Designing a conservation strategy that adequately minimizes and mitigates this impact.

Estimating Take – *without mitigation*

When the first Indiana Bat (INBA) fatality occurred at a wind project three years ago, virtually nothing was known about the species' interactions with wind turbines. We still have limited information, but we now have some site-specific information on impact to Indiana Bats from wind facilities. Using this information, we have developed three methods for estimating take in the absence of mitigation, each with benefits and drawbacks:

Method	**Benefits**	**Drawbacks**
Species composition	+ Site-specific data (for operational projects with documented take) + Easy to understand and compute	- Small sample size - Few facilities have documented INBA take - Sampling may not have been designed to detect rare events
Surrogate species approach	+ Large sample size + Easy to understand and compute	- Risk may not be equal for both species - Regional fatality may not be applicable - Species ratio data may not be applicable to season of risk
Collision risk model	+ Useful where empirical data lacking +Can be refined over time with new data	- Complex and difficult to understand - High level of uncertainty in model inputs – it is important to document inputs to increase transparency.

Little Brown Bats have typically been used as a surrogate. To date, little brown bats have represented about 10% of fatalities at eastern wind projects, and about 6% in the Midwest. Mist-netting data and counts from hibernacula are used to get a ratio of Little Brown Bat to Indiana Bat abundance.

Estimating Take – *with mitigation*

How much will minimization efforts reduce take? The Bat-Wind Energy Collaborative (BWEC)'s work in the area of curtailment has demonstrated fatality reductions with raising cut-in speeds and feathering turbines below cut-in speeds. Adaptive management can be built in to the implementation plan to factor seasonal, temperature and time-of-night considerations in to curtailment strategies to maximize fatality reductions while minimizing impact on power production. The data are unclear as to whether progressively increasing cut-in speeds will continue to reduce bat fatalities [slide #10], but most HCPs either supply an average percent reduction or include a minimum 50% fatality reduction based on available data.

Deterrents also show some promise, but challenges to widespread application remain.

Determining Impacts

One of the most challenging aspects of the HCP is determining the biological impact of take. Two measures of impact are reduced reproductive capacity and reduced survival probability. Understanding the extent to which take from the project affects these two variables enables us to determine the total number of individuals to be mitigated, and also whether the take is likely to result in an appreciable reduction in survival and recovery of the species (jeopardy standard).

Mitigation number – To determine the extent to which reproductive capacity is reduced, an estimate of the number of females taken is necessary. A first step is to determine the proportion of take that is female is looking at proximity of the project to maternity colonies and hibernacula. The next step is to look at seasonality of take and to apply demographic assumptions about survival and fecundity. For example, for a project that is likely to take 50 Indiana Bats over 20 years, if that project is located over 100 miles from the nearest hibernacula, we could assume that about 70% – or 35 of the 50 bats taken – are females, and that those females would have produced a total of 47 pups over their remaining lifetimes. The total mitigation number would thus be 50 + 47 = 97 Indiana Bats.

Appreciable reduction in survival and recovery? To answer the question of whether take would result in an appreciable reduction in survival and recovery of the species, we would need to define and estimate the size of the population at risk and make assumptions about population structure and expected future reproductive and survival rates. The two basic alternatives to determining the impacts of take are a simplistic approach (used in the Beech Ridge and Criterion HCPs), or a population viability analysis (used in the Buckeye HCP).

- ***Simplistic approach*** – evaluating the take in terms of the total population and determining whether that proportion is discountable
- **Population Viability Analysis (PVA)** – uses a basic Leslie matrix model:
  Population size (year t+1) = (Population size [year t] * λ) - additive mortality – non-recruitment

There is a lot of uncertainty about what inputs to use, and USGS and USFWS are working together on a PVA model that would provide standardized inputs.

Another key component of determining whether take is likely to result in jeopardy is understanding what population units are affected. The relevant population unit might be a maternity colony, a recovery unit, or even the range-wide population, depending on the scope of development and of the HCP. The number of colonies affected will be a function of migration distance and direction, how many maternity colonies are likely to be located in the HCP area (typically estimated based on the amount of suitable habitat), and the population size in local hibernacula.

Mitigation Strategies

We have described the various strategies that have been used to minimize take, including feathering turbine blades below different wind speeds and consideration of various factors such as temperature and time of night adjustments to curtailment. In the case of unavoidable take, the HCP must include strategies that demonstrably increase either survival probability ("saving a bat") or reproductive potential ("creating a bat"). Types of projects may include protection or restoration of summer or swarming habitat; protection of hibernacula through gating or microclimate adjustments. Protecting habitat that is under threat of harm or loss yields the largest demonstrable benefit.

CONCLUSIONS

Remaining challenges include developing cost-effective monitoring techniques, estimating the effects of White-Nose Syndrome, responding to changing circumstances (such as may be anticipated from climate change), and addressing cumulative impacts. Although each individual project will require a unique approach tailored to its specific needs, these lessons learned provide insight that can be used to guide

development of future HCPs that support the survival and recovery of Indiana Bats, while minimizing the time and resources needed from both wind power developers and the federal government.

Questions & Discussion

Q: Have you figured out how you will measure benefits (increased survival, reproductive success, etc.) of mitigation? Is this a big issue?

A: Yes; it will vary based on the project. There are a couple of strategies we have come up with so far. For a project protecting swarming habitat, we came up with likely foraging distance based on population size of the hibernaculum that was the focus of that mitigation effort. We then looked at the amount of suitable habitat within that distance, and estimated the number of bats per acre that were using that habitat as a way to target the total acreage of foraging habitat needed at another project site. There was a value system applied that was based on the likelihood of development for that acreage – essentially the probability of threat to that habitat. This gets at the survivability issue, because if that habitat were to be removed it would not be available to those bats and thus lowering their survival probability. That is one example; there are other examples, e.g., protection of maternity habitat.

ADDITIONAL QUESTIONS

These questions were submitted but not answered during the conference.

Q: Does the development of new large turbines that operate at low wind speeds (4 m/s) raise any concerns for bat fatalities?

A: Since bats are generally most active at lower wind speeds, the introduction of turbines that can produce power at lower wind speeds have the potential to lead to higher rates of bat mortality than those that are not spinning at the same speeds. Turbines that can produce power at lower wind speeds may also have larger rotor diameters. There have been published studies that have correlated larger rotor swept area with higher rates of bat mortality, so this aspect of new, more efficient turbines could have an effect on bat mortality rates as well.

Q: Do you need high bat fatality counts for change in cut-in speed to be considered effective? What do we consider "high" bat fatalities? (3 bats/MW? 6? 10? 20?)

A: Not necessarily – curtailment can still be considered effective if only a few individuals are saved, if the value of each individual is high, such as the case with rare species (e.g., Indiana Bats). However, curtailment will generally have the most benefit for the greatest number of species in areas that are susceptible to high rates of bat mortality. What is considered a "high" rate of bat mortality will depend on the size of the population affected. Also, what is considered a high rate of mortality is somewhat subjective, since bat mortality rates vary widely across projects and regions. However, some states/provinces have developed thresholds to define what is considered a significant level of mortality. For example, Ontario has set a threshold of 10 bats/turbine/year as a level above which they consider mortality to be significant
http://www.mnr.gov.on.ca/stdprodconsume/groups/lr/@mnr/@renewable/documents/document/stdprod_088155.pdf

For comparison, based on 19 studies at 12 sites in Pennsylvania from 2007 to 2012, the average fatality rate was 25 bats/turbine/year and ranged from 5 to 59 bats/turbine/year (Tauscher et al. 2012).

Q: Why are so many bats being taken by turbines? What are the latest theories?

A: The current thinking is that bats are attracted to turbines for one or more reasons. Several theories have been posited and studies are currently under way to test some theories of attraction. However, no empirical data are currently available to definitively answer this question.

Avoiding the Unmanageable: Renewable Energy Siting and Biodiversity in a 4° C World

Taber Allison, American Wind Wildlife Institute

Co-authors: Terry L. Root, Ph. D. (Biology), Stanford University; Peter C. Frumhoff, Ph. D., Director of Policy, Union of Concerned Scientists – both lead authors on the 4th Intergovernmental Panel on Climate Change (IPCC).

THE PROBLEM

The responses to climate change fall into two categories, each with a corresponding community of scientists, policymakers, and advocates:

1) ***Adaptation***, or "managing the unavoidable" – developing measures that enable wildlife to survive already occurring climate change
2) ***Mitigation***, or "avoiding the unmanageable" – taking action to reduce the effects, reduce greenhouse gas emissions. In this context, renewables development is an important strategy

Warming impacts today are from carbon released years ago; adaptation is necessarily part of current reality. But beyond a certain point, adaptation is no longer possible. In 2009, the premise was that a 2° C increase in global temperature would be manageable: *"Hold the increase in global temperature below 2° degrees Celsius and take action to meet this objective consistent with science and on the basis of equity"* (2009 Copenhagen Accord).

Slide #9 graphs the increase in global average surface temperatures relative to pre-industrial levels, with projections out to the end of this century under a variety of carbon emissions scenarios. Despite a slight decline in 2009, even with current pledges to cut CO_2 emissions, we are sure to exceed the 2 ° C ceiling proposed in Copenhagen. Carbon emissions are not only increasing, but increasing exponentially, putting us on a trajectory to exceed a 4° C increase by the end of this century.

In a 2012 report, the President of the World Bank stated: "a 4° C world can and must be avoided."

Can we think about benefits of avoiding emissions? How do we develop a framework for this conversation that incorporates and makes explicit our concerns about the impacts of climate change? Does or should our tolerance for risk and uncertainty change with the prospect of a 4° C world?

"Climate change biologists" Dr. Terry Root and Dr. Peter Frumhoff approached the American Wind Wildlife Institute with the following proposition:

> *Efforts to expedite renewable energy expansion while protecting biodiversity need to factor in both (a) the biodiversity risks of renewable energy siting and related transmission AND (b) the benefits of avoided emissions on reducing the global biodiversity risks of high-magnitude warming.*

BIOLOGICAL IMPACT OF WARMING

Biologists are already observing changes in wildlife ranges and migration timing as a result of global temperature change. Even if we are able to hold the increase in global temperature to 2° C, the implications for human and wildlife are enormous. The 4th IPCC reports that an average global temperature increase of 2° C would result in extinction of approximately 400,000 species; an average 4° C increase would result in approximately a million species' extinction.

Slide #13 illustrates the massive shift in wildlife ranges determined by a 4° C global temperature increase. Species living in red zones will have to move 500-1000 miles to find temperatures comparable to what they live now. With 4° C warming, monthly temperatures in 86% of the world's terrestrial biodiversity "hotspot" ecoregions will exceed their baselines by 2 standard deviations. Nor is the impact restricted to terrestrial ecoregions. Slide #12 shows how temperature changes and resulting decrease in pH of the world's oceans will result in loss of coral reefs.

THE CHALLENGE

Avoiding a 4° C world will require massive shifts of energy production. Slide #18 illustrates the kinds of US carbon emission budgets required to keep climate change to 2° C.

NREL has modeled the potential for high penetration of renewable energy. A 2012 study, which focused on markets, cost, and infrastructure rather than on wildlife, concluded that 80% of US electricity could be generated from renewables by 2050, reducing annual emissions by nearly 81% and cumulative carbon emissions by 40 Gt CO_2e. Under this scenario as much of half of this electricity (40% of total consumption) could come from wind. These models were neither predictive nor prescriptive, but they demonstrate the possibility of wind and other renewables making the kind of difference that would be required to mitigate temperature increases in excess of 2° C.

These research meetings have familiarized this audience with the potential impacts of wind energy on wildlife. The U.S. Fish and Wildlife Service is charged by Congress with enforcing the Migratory Bird Treaty Act, the Bald and Golden Eagle Protection Act, and the Endangered Species Act. We are able to measure the direct effects of wind energy facilities on raptor and bat fatalities, and are beginning to better understand the indirect effects – habitat fragmentation, displacement, and so on – that will be increasingly hard to avoid and mitigate as wind energy builds out to capacity.

Despite these very real concerns, we have to ask ourselves explicitly, ***to what extent do wildlife concerns delay climate change mitigation efforts?***

Can we establish a framework for addressing this concern? When Massachusetts Audubon was involved in looking at the Cape Wind project, our concerns about climate change and impact on biodiversity led us to look for ways to manage local impact concerns, and Mass Audubon ultimately supported the Cape Wind project. This is one example, but the wind-wildlife community needs to move beyond project by project assessments and decisions. We must examine our baseline tolerance for risk and uncertainty. We must develop a framework that systematically:

- Promotes efforts to minimize impacts
- Recognizes inherent uncertainty in *both* risks – of wind energy development and of climate change
- Reconciles risks of siting projects with risks from climate change

NEXT STEPS

Meeting this challenge – fulfilling the proposition put forward by our climate change biologists – requires that we continue to explore how we can best work together as a community. The following strategies will be essential to our success:

1. Supporting successful implementation of USFWS guidelines
2. Exploring innovative mitigation strategies, e.g., Great Plains Wind Energy HCP
3. Developing tools to improve assessment – AWWI is working with Earth Science Information Partnership to develop a decision-making tools catalog that will enable tool developers to advertise their tools, and for users to find tools best suited to their purpose.
4. Sharing and analyzing existing data – AWWI's Research Information System is our top priority, and we are hopeful that it will help us reduce uncertainty and facilitate decision-making.

As we move forward with "thinking globally and siting locally," we must address the following questions:

- Can we agree on basic premises? Often the disagreements among stakeholders have to do with definitions of basic terms. For example, what do we mean by "significant" impacts?
- Can we incorporate range shifts into risk assessments for projects with 30-year lifespans, given what we project about wildlife adaptation to climate change?
- Are we prepared to make difficult trade-offs? One of the challenges we will have in this discussion, is that many of the species that are at greatest risk from climate change are not the same species that are most at risk from wind energy development.

CLOSING

The problem of climate change is urgent – we are going to have to make major siting decisions without being able to close major information gaps. So we somehow need to be able make major decisions without resolving major uncertainties about the risks. We need to rethink how we apply the pre-cautionary principle when we make decisions about renewable energy siting. Given the risks associated with climate change, on which side do we err – uncertainty about impacts due to development versus uncertainty about impacts of climate change if we don't act?

This will be a challenging conversation requiring a lot of trust within the wind-wildlife community, because we have different value propositions. The success of the NWCC over the past 20 years in building trust among different stakeholders involved in this industry gives us reason to hope that we can be successful.

Bats and Wind Energy: Assessing Risks and Impacts

A computational and analytical study of bats flying near wind turbines: implications regarding barotrauma

Presenter: Daniel Houck, NREL

Presentation

Authors: Daniel R. Houck, M. J. Lawson, Robert W. Thresher (National Renewable Energy Lab, National Wind Technology Center)

PROBLEM / RESEARCH NEED

Dead bats are found around wind turbines with injuries that are indicative of barotrauma (trauma caused by a change in pressure) which could be caused by the low-pressure regions around operating wind turbine blades. Recent studies (Baerwald et al. 2008, Kunz et al. 2007) have hypothesized that barotrauma may be a significant cause of bat fatalities, although more recent research (Rollins et al. 2012) calls this hypothesis into question. To date, no research has studied the pressure variations that bats are exposed to while flying near modern utility-scale wind turbines to determine if these variations are large enough to cause fatal barotrauma.

APPROACH

There were two components to this study. The first was to determine what pressures and pressure changes are survivable for small mammals. The second was to estimate the range of pressure-time histories (i.e. pressures and pressure change durations) that bats are exposed to while flying around operating utility-scale wind turbines.

Survivable Pressure/Pressure Changes

Because there are no reference data for survivable pressure-time histories for bats, the best comparisons are studies in which other small mammals are put into shock tubes and exposed to positive (overpressure) and negative (underpressure) shock waves. Overpressure studies use mice, which have the same mass as bats. Underpressure studies, which are less prevalent, use rats, which are ten times heavier than bats.

Simulating Turbne-caused Pressure/Pressure changes

We performed 2D and 3D simulations using Star CCM+ to predict pressure fields around rotating turbine blades from a typical utility-scale turbine in current use. The 2D simulations were used to evaluate pressure drop on the suction side of the turbine; the 3D simulations were used to evaluate pressure drop in the trailing tip vortex of the turbine.

We then used Lagrangian particle tracking to study possible pressure-time histories experienced by bats flying near operating wind turbines. “Bat” particles were injected into the flow field under three different scenarios (within the rotor plane, through the rotor plane, and through the blade tip vortex), and pressure was tracked along their paths. The particle’s trajectory is determined by its properties (area, mass, density, initial velocity, drag, and lift) and interaction with the flow field. Because

disturbances from turbines are highly localized and effectively instantaneous, even wide variations in any or all of these parameters have negligible effects on trajectories.

Tracked pressures were then compared to measured data from the overpressure and underpressure studies on other mammals to determine potential for barotrauma.

FINDINGS

The mortality data from over and underpressure studies are divided into long and short duration overpressure blasts. If the pressure change lasts for a long time, peak pressure is the only factor in survivability. If the duration of the pressure change is short, animals can withstand higher peak pressure. The lethal dose scales with the animal's mass. For overpressures below 30 kPa, mortality is 0% in mice. Correlation suggests that this is equivalent to -23 kPa of underpressure; rats (which are 10 times heavier than bats) survived pressure drops as large as -64.2 kPa without injury.

Slide #13 summarizes the results of the pressure field simulations. Maximum pressure drops range from 0.957 to 1.147 kPa in the rotor plane, and from 0.853 to 1.536 kPa through the rotor plane. 3D simulation found a maximum pressure drop of 0.796 kPa through the tip vortex.

CONCLUSIONS

Pressure changes determined in simulations are at least one order of magnitude smaller than those required for any death in overpressure and underpressure studies. Proximity to blades to experience pressure-time histories in simulations all but guarantees getting hit by the blades, regardless of possible barotrauma. Assuming bats' responses to pressure changes are similar to other mammals and comparisons to overpressure and underpressure are at least reasonable, death due barotrauma appears unlikely.

Future Research

Two areas for possible further research would be, first, to clearly separate instances of impact trauma from barotrauma using synchronized cameras or the like; and, second, to determine survivable pressure-time histories for bats rather than rely on comparisons with mice and rat pressure studies. In addition to determining lethal doses and mortality curves specific to bats, research might include performing necropsies on underpressure subjects to clearly identify physical trauma typical of underpressure, and to determine the roles of peak pressure, duration of peak pressure, and time to peak pressure in survivability.

Questions & Discussion

Q: Your simulated bat had a mass of 16 g. Many bats in the Northeastern US are only 5-6 g. How would this influence your results?

A: Probably not at all. Sixteen grams was the average mass used in the simulations; we tested over a range of mass, and this variable did not affect trajectory.

Q: Is it possible that adaptations for flight make bats more susceptible to barotrauma than mice of the same weight?

A: Yes. Studies of underpressure using bats would help answer this question.

Q: Do bats' respiratory systems differ from those of mice (adapted, perhaps, for flight) and could their respiratory systems have different pressure sensitivities?

A: I am not a biologist, so cannot say much about this. I do know that one of the reasons the barotrauma theory has been put forward is that bats' respiratory systems are different from birds'.

Q: Is it possible that even small pressure changes at tip vortices could cause sub-lethal barotrauma, disorienting bats and indirectly causing them to collide with blades or crash?

A: That is possible and may be an area for further exploration. This simulation did not address that, apart from looking at the trajectory, which does not account for the bats' reactions. In the simulations, the bats are deaf, dumb, and blind. In reality, we've actually seen that they do react to oncoming blades and at least appear to get caught in tip vortices. The actual fluid dynamics of these situations are too complex and each possible scenario too specific for simulations to be of much help. There are studies of sub-lethal and repeated overpressure using rats. These studies are a weak comparison since they use overpressure and rats and involve results that are more difficult to quantify than mortality, but they point toward the possibility that sub-lethal and repeated exposure to barotrauma in bats could cause problems with vision, appetite, and activity level.

Q: Could you speculate as to why Baerwald and others found evidence of barotrauma from wind turbines?

A: My understanding is that barotrauma developed as a theory from what researchers weren't seeing rather than what they were seeing. They weren't seeing injuries that they thought to be consistent with impacts (though that is now in question), they weren't finding bats as far from turbines as they did birds, and they weren't seeing bats, which see and echolocate well enough to catch insects in the air, avoiding the turbines.

Q: Why are so many bats being taken by turbines? What are the latest theories?

A: I don't know the latest theories, but I'd like to point out the need for specificity when we ask "why" questions like these. There are reasons why bats are directly being killed and there are reasons why bats are coming near turbines, and it's really questions regarding the latter that are important to mitigation. Whether bats die of impact or barotrauma or something else entirely, the solution is the same: keep them away from turbines and/or keep turbines away from them.

Ted Weller: Agreed. Whether barotrauma or collision, we know that in these instances a bat got too close to a blade and was killed. That is what we should be focusing on.

Regional analysis of wind turbine-caused bat fatality

Presenter: David Drake, University of Wisconsin, Madison

Presentation

Authors: David Drake, Jian-Nan Liu (Department of Forest and Wildlife Ecology, University of Wisconsin-Madison); Christopher S. Jennelle (Iowa Department of Natural Resources); Steven M. Grodsky (Department of Forestry and Environmental Resources, North Carolina State University); Susan Schumacher (We Energies); Mike Sponsler (BHE Environmental, Inc.)

RESEARCH NEED

Wind energy has been the fastest-growing renewable energy source in the United States. Studies have estimated bat fatalities at wind facilities, but direct comparisons of results is difficult and can be misleading due to the numerous differences in protocols and methods used. We had a unique opportunity to perform a meta analysis of bat mortality, comparing fatality estimates from three wind facilities in southeastern Wisconsin. The three facilities are contained within two neighboring counties with similar land use (agriculture) and land cover, have turbine models that are close in size and nameplate capacity, and all became operational within 7 months of each other in 2008. All three of the sites used similar post-construction study methodologies.

APPROACH

The sites we compared were located between Lake Michigan and Lake Winnebago in Southeastern Wisconsin. Key bat-relevant features of the surrounding landscape are the Neda Mine hibernaculum, Horicon Marsh, Kettle Moraine State Forest (mature mixed forest), and the Niagara escarpment. Links to the final reports are listed for each of the study sites:

- Forward Energy - http://psc.wi.gov/apps35/ERF_view/viewdoc.aspx?docid=152052
- Cedar Ridge - http://psc.wi.gov/apps35/ERF_view/viewdoc.aspx?docid=146174
- Blue Sky Green Field (BSGF) - http://psc.wi.gov/apps35/ERF_view/viewdoc.aspx?docid=126370

Our first objective was to examine species composition and temporal and spatial patterns of bat mortality within and across the three sites.

Our second objective was to look at the influence of landscape variables. Combining bat mortality across all three facilities and using standardized, non-corrected bat mortality as our response variable, we investigated whether select structural, habitat, and landscape features influence mortality,analyzed predictor variables on a fine scale, a broad-scale, and a combination of the two:

- ***Fine scale predictor variables:*** windfarm, season, distance to nearest building, road, wetland, woodland, turbine;
- ***Broad scale predictor variables:*** windfarm, season, distance to Lake Michigan, Lake Winnebago, Horicon Marsh, Neda Mine, Kettle Moraine State Forest, Niagara Escarpment

For each turbine searched, we measured the distance to the variables of interest, and then analyzed the data using a linear mixed effects package. (If we found co-linearity between two variables, we randomly eliminated one of the two.) We compared both Poisson and negative binomial regression models with each of the sets of predictor variables and assessed the fit.

FINDINGS

Temporal patterns of bat mortality were similar across all three wind facilities, and consistent with the literature. Our analysis suggested that the fall season (late July to early September) was the predictor variable that best explained bat mortality. We did not see any spatial patterns at or across any of the sites.

Differences across the three wind facilities included species composition of the bat fatalities [slide #13] and the raw and corrected number of bat carcasses recovered. Little Brown Bat, Hoary Bat, and Silver-haired Bat were the most commonly found species at BSGF, Cedar Ridge, and Forward Energy, respectively. Big Brown Bats were among the top three species found at BSGF and Cedar Ridge. (This is consistent with higher than previously reported numbers for Big and Little Brown Bats at midwestern agricultural sites in recent monitoring.) The Forward site had the highest overall estimated mortality, but Cedar Ridge had the highest estimated number of fatalities per turbine per day [slide #1].

Corrected bat mortality ranged from 20-49 bats per turbine. We took the further step of converting bats/turbine/day to bats/turbine/study period across the entire wind facility, to facilitate comparison with other bat mortality studies in the literature. Although not perfectly comparable, bat mortality rates at these three sites were higher than reported in most other previous research at wind energy sites on agricultural lands in the midwestern United States, and indeed rival mortality levels found at some sites in the northeastern U.S. (Arnett et al. 2008 reported $\leq$ 8 bats/turbine in the Midwestern U.S. v. 21-70 bats/tubine in the Eastern U.S.)

For the landscape analysis, the Poisson broad scale model received the most support in terms of its AIC values, although binomial regression with the broad scale suite of variables also received some support. Of the individual predictor variables, season was the only one we found to be significant (p=.001 v. p values of 0.26-0.56 for other broad scale landscape features).

IMPLICATIONS

In addition to the unexpectedly high overall mortality levels, noteworthy findings from this study include the mix of species composition, the variability of fall mortality, and the fact that landscape variables do not appear to play a significant role.

- Because species composition was extremely mixed within as well as across the three wind facilities, we strongly recommend that individual wind facilities conduct project-specific pre- and post-construction monitoring rather than rely on published results from other wind facilities.

- Perhaps the most surprising finding was that none of the structural habitat or landscape variables proved to be significant. This does not support the strategy of micro-siting turbines to reduce bat mortality.

- Finally, while the vast majority of fatalities occur during the late summer and early fall, fall mortality was highly variable, with no fatalities occurring approximately half the time, and as long as a 22-consecutive-day period without fatalities during one fall season. We strongly recommend further investigation of this variability to support cost-effective curtailment strategies.

Questions & Discussion

Q: Did you look at combining any of the other variables with season?

A: When I spoke of the over-parameterization of the model, we did look at season and one other randomly-selected variable from both the fine and the broad scale. We did not find that the model was over-parameterized.

Q: Did you allow for over-dispersion in your Poisson models?

A: Yes.

Q: Was age a factor in bat mortality since you found a higher mortality rate in the fall?

A: We did not examine age as a factor, so could not say.

Q: What do you think was the reason for the high percentage of Little Brown Bats at Blue Sky Green Field if the habitat and structural features were not significant?

A: That is a good question! We were very surprised, because Neda Mine is so close to all three of those facilities. Blue Sky Green Field is situated between Lake Winnebago and Lake Michigan – a natural funnel for migrants – and we thought maybe Little Brown Bats were making short-distance migrations between Neda Mine and elsewhere. We were surprised we did not statistical significance with the variable "Neda Mine"

Q: Any generalizations or take-home messages?

A: Typically bats are found closer to turbine bases than you find birds. Is it because they die more immediately than birds do? We also are trying to understand why bats don't react more quickly to blades? They know the blades are there but can't react quickly enough. Steve Grodsky thinks there is sub-lethal effect, and that many bats come away with ear damage, don't turn up in fatality observations, but do end up dying somewhere else.

Monitoring the environmental conditions that predict bat activity at wind energy facilities can improve mitigation efficiency

Presenter: Theodore Weller, USDA Forest Service, Pacific Southwest Research Station

Presentation

Authors: Theodore J. Weller, James A. Baldwin (USDA Forest Service, Pacific Southwest Research Station)

RESEARCH NEED

Fatalities of migratory bats, many of which use low frequency (<35 kHz) echolocation calls, have become a primary environmental concern associated with wind energy development. Accordingly, strategies to improve compatibility between wind energy development and conservation of bat populations are needed. Curtailment studies have shown very promising results. Arnett et al. 2011 found that raising the cut-in speed from 3 m/s to 5 or 6.5 m/s greatly reduced bat mortality, that the cost in terms of lost

energy production was relatively low, and that it was quite feasible to implement. Yet this type of operational mitigation has not been readily adopted by the industry, perhaps because of sensitivities to the notion that wind is an unreliable energy resource, and because of uncertainty as to how curtailment might affect operations.

Bat activity is correlated with a wide variety of environmental conditions, of which wind speed is just one. Our objective was to create models of bat activity that considered a wider suite of variables. Nightly variations in bat activity are likely correlated with weather, but there also are seasonal changes in patterns of bat activity that correspond with their changing physiological needs. In essence, bats likely respond differently to environmental conditions depending on the season. This study uses occupancy analysis to predict bat activity at wind energy facilities with the goal of reducing the amount of time turbines are operated at higher cut-in speeds, and of predicting how often that might be the case.

APPROACH

To link echolocation data with meteorological data at Iberdrola Renewables' Dillon Wind Facility in the San Gorgonio Pass area near Palm Springs, we mounted echolocation detector microphones directly on the meteorological towers at 2m, 22m and 52m above ground. Iberdrola gave us access to meteorological data that was measured every 10 minutes. We oversampled bat activity to get at survey effort questions.

Activity rates at this particular site were quite low; indeed, we found that we only detected bats at all between 18% and 69% of the nights, depending on the season. This led us to the site occupancy paradigm, which allowed us to model the probability bats are present as function of environmental variables (wind speed, date), while accounting for detection probability.

The probability of detecting bats was modeled as a function of the height of detectors on the towers. Our focus on detection probability was the height at which we could best detect bats that used low-frequency (<35kHz) calls, associated with migratory bats which comprise most bat fatalities. (All of the fatalities found at this study area were of species that used low-frequency echolocation calls.) Although the overall number of bat passes recorded at each height was similar, the detectors at 52 m recorded only low frequency echolocation calls, while those at ground level recorded about half as many.

We transposed the spatial and temporal axes of the conventional detection history matrix such that occupancy represented proportion of nights, rather than monitoring points, on which low frequency echolocating bats were detected. We found that 5 detectors at 22m or 52 m were needed for an 80% chance of detection low-frequency calls and about 10 detectors would be required to achieve a 95% probability of detection.

FINDINGS

The output of these models are a series of statistical reports [slide #13] that help us select the best model and determine the most important variables for predicting bat presence. To facilitate the use of these models by decision-makers, we looked for ways to simplify the outputs. For example, whether variables were positive or negative predictors of low frequency bat presence gave us some encouraging results that confirmed what other studies have found: that the presence of low-frequency bats was associated with lower wind speeds and (with one minor exception) higher temperatures in every season. However, not all variables yielded such straight-forward results, and moreover this

simplification does not shed much light on what are the most important variables for a particular season.

The best models in most seasons included more than just wind speed and temperature, and the inclusion of other variables – moon illumination, Julian day, wind direction – often improved the model, even when wind speed and temperature were the most important variables [slide #15].

IMPLICATIONS / APPLICATIONS

Slide #16 illustrates the model visualization tool. The x-axis gives the date within the time period. The y-axis is the probability that low frequency bats were present. The visualization tool illuminates an important point, which is that the *date* within a season was often an important predictor of bat activity. In other words, bats (like other animals) follow a phenological cycle each year; their response to conditions on a given night will be partly a function of where they are in that cycle. In this case we can see that given *identical weather conditions*, there is a higher chance of bat presence at the end of August than in the middle of November.

The finding that inclusion of other variables, such as date, improves modeling is somewhat intuitive, but it is also important for optimizing a facility's operational mitigation strategy. For example, during fall 2008, out of a total of 92 nights, about a third of those had mean wind speeds that were in the range considered during previous mitigation experiments. However, if we set a threshold of 90% probability that bats would be present, and if we consider the full suite of environmental conditions, only 19 of the 33 nights with wind speeds of 3-6 m/s meet the criteria. The site occupancy model achieves a 42% reduction in the number of nights when turbine operations would be curtailed.

Feedback that we have received since our paper was published (April 2012) touches on the following points:

- The tool is site-specific; our findings cannot be extrapolated to other sites. Fortunately, at most sites, both echolocation and MET data are already being collected, and it is relatively easy to produce a site-specific model based on our approach.
- Is the occupancy approach applicable to other sites that have higher bat activity rates? Yes; presence can be defined not as the absolute presence or absence of bats, but as activity above the median level of activity for some time period.
- Our models were built using mean nightly values, which cannot be known until the end of the night. Perhaps moreimportant, bats probably respond to hourly weather conditions as opposed to mean nightly conditions.

These points are all well-taken. Having established that the best models of bat activity will include more than just wind speed, and that responses to weather variables may differ seasonally and even at the night-within season level, the next step is to work on predicting bat presence at the hourly level and thinking about how such models could be incorporated directly into turbine operation systems.

Does Echolocation monitoring predict fatalities?

We found that echolocation activity during the weeks prior to which a fatality was found was about twice as high as activity during periods in which no fatalities were found. Species composition of echolocation calls also was similar to composition of fatalities, so at least for this site it appears that echolocation monitoring is a reasonable predictor of fatalities – with the important caveat that

detectors must be placed as far above-ground as possible to give us the best chance of accurately characterizing activity by low frequency and presumably migrating bats.

Could such a model be integrated into the SCADA systems that operate individual turbines? Ideally, a module could be designed to monitor the full suite of factors that predict bat presence, as opposed to just wind speed, and continuously plug that data into an algorithm that would constantly update the probability that bats (or lots of bats) were likely to be present.

Questions & Discussion

Q: Is there a limitation for using your occupancy model for birds (e.g., raptors)?

A: No. It can be used for any taxonomic group as long as you use multiple samples so you can take advantage of the occupancy paradigm.

Q: How do you think the low activity affected model results, and could the results be strengthened with additional data?

A: No, the low activity did not matter because we were just looking at whether bats were "present" or "not present." One could define occupancy differently, i.e., take some mean level of activity over a given period and assign any mean level below that as a zero, and above it as a one, and still use this paradigm. Why would you want to do that? Because you could take advantage of simultaneously factoring in detection probability, which is as important for activity studies as it is for fatality studies.

Q: Was the detection probability affected by the low bat activity rates? Would a site with higher bat activity still require 17 ground detectors to achieve 95% detection?

A: It depends on the spatial distribution of those detections, and how homogeneously or heterogeneously bats are using a site. Certainly one would need at least three detectors.

Q: Did you attempt to separate hoary bats from Mexican Free-tailed Bats?

A: Yes. About 20% of calls that could be identified to species, but within those, Mexican Free-tailed Bats made up about 50% of calls and fatalities at the site.

<u>ADDITIONAL QUESTIONS</u>
These questions were submitted but not answered during the conference.

Q: Does the development of new large turbines that operate at low wind speeds (4 m/s) raise any concerns for bat fatalities?

A: Yes because multiple studies have shown that bat fatality rates are highest at low wind speeds.

The influence of specific atmospheric variables on fall bat activity varies among geographic regions and species

Presenter: Lauren Hooton, Normandeau Associates, Inc.

Presentation

Note: slides show preliminary results

Authors: Lauren Hooton, Allison Costello, Crissy Sutter, and Greg Forcey (Normandeau Associates)

RESEARCH NEED

Normandeau Associates has been acoustically monitoring bat activity at proposed wind energy facilities throughout North America since 2008. The broad geographical range of installed acoustic monitoring equipment, combined with consistent collection and data analysis methods, have provided us with a large multi-year dataset – and with a unique opportunity to examine broad-scale patterns in activity of the bat species most at risk of turbine-associated mortality. The objective of this study was to elucidate weather-specific patterns in bat species activity, and to determine which atmospheric variables had the greatest influence on bat activity. This information will help us to be able to predict bat activity based solely on atmostpheric conditions, which in turn will enable us to focus curtailment mitigation strategies.

APPROACH

Data collection took place from July 1-October 31 over a three-year period (2009-2011). Acoustic detectors were placed at 15m and at 60m on a total of 31 towers at 12 sites, divided between two geographic regions:

- ***West*** (23 towers at seven sites in Arizona, California, and Nevada)
- ***Midwest*** (8 towers at five sites in Iowa and Missouri)

Migratory tree bats (MTB) constitute >75 % of bat mortality at wind energy facilities. Species considered in this study were the Hoary Bat (*Lasiurus cinereus*), Eastern Red Bat (*Lasiurus borealis* - midwestern sites only), and Silver-haired Bat (*Lasionycteris noctivagans*). Free-tailed Bats can be hyper-abundant within the range of wind energy facilities in the western U.S. This study included data on the Mexican Free-tailed Bat (*Tadarida brasiliensis* - western sites only).

For each species in the two regions, we examined the relationship between acoustic bat activity (mean passes/night) and four atmospheric variables: temperature, wind speed, wind direction, and relative humidity. All models were controlled for the random effects of year, tower, and weeks since July 1.

FINDINGS

Overall, temperature and wind speed had the strongest influence on bat activity.

The activity of each species increased with temperature. In the Midwest, where nightly temperatures were low enough (15 v. 18° C in the West) to impact bat energetics, temperature was the only individually significant variable.

- Hoary Bat ~ **Temperature** + Wind Speed

- Eastern Red Bat ~ **Temperature**
- Silver-haired Bat ~ **Temperature** + Wind Speed + increased with northerly and easterly **Wind Direction** +**Relative Humidity**

In the West, where wind speeds are high enough (max 23.5 m/s, v. 12.5 m/s in the Midwest) to impact bat energetics, wind speed had the strongest effect on activity of all three species studied. Although all three species were found to be active at over wind speeds over 15 m/s, the activity of each species decreased with increasing wind speed. Wind direction was also a factor in the West. For the Mexican Free-tailed Bat, all the variables mattered.

- Hoary Bat ~ decreased with **Wind Speed** + **Wind Direction (increased with northerly wind)** decreased with Relative Humidity
- Mexican Free-tailed Bat ~ increased with **Temperature** + decreased with **Wind Speed** + increased with northerly and easterly **Wind Direction** + **Relative Humidity**
- Silver-haired Bat ~ Temperature + **Wind Speed** + Relative Humidity

Validation

We gathered both acoustic monitoring and meteorological data at three towers at independent sites in Indiana and Illinois, and used those data to validate model predictions for each Midwestern species based on the four weather variables. For the Hoary Bat, we can predict bat activity within five bat passes, 91% of the time. For the Eastern Red Bat, we could predict activity within five bat passes 96% of the time. For Silver-haired Bats, the model did not help us predict activity, in large part because Silver-haired and Big Brown Bats are difficult to distinguish acoustically, and our model was built using only the fraction of bat calls that we could conclusively distinguish as Silver-haired Bat calls.

CONCLUSIONS / APPLICATIONS

Our preliminary results suggest that multiple environmental variables influence bat activity at potential wind energy facilities across the United States, but that the influence of individual weather variables varies among geographic regions and species.

This kind of modeling can be used at two levels of specificity:

- ***Site screening*** – The **regional** (e.g., Midwest) models can be used to get predictions of *relative* activity, based solely on weather data.
- ***Curtailment schemes*** – Bat and weather data can be collected to build **site-specific** models to determine how weather influences activity at each site, allowing for a more focused curtailmnet strategy to be implemented.

We are continuing to refine the models, drawing on more data and looking at additional variables such as the percentage of moonlight, broad weather fronts, and habitat features. We also want to extend the model to be able to predict not just activity, but also mortality.

Questions & Discussion

Q: Temperature is likely correlated with dates (i.e., warmer temperatures earlier in the fall). Did you look at the effect of date v. temperature in your models?

A: Yes, we did control for it in the sense that "time since July 1" was included as an independent variable.

Q: Your experimental site had observed activity over 100, but your test site apparently did not. How well do you think that you were able to predict high activity nights?

A: We were able to predict some of the nights with higher activity, but not all. However, we were able to predict the approximate times of year (in both 2010 and 2011) when activity would be highest at those sites (graphs not shown in presentation). Additionally, the model was able to predict that activity would be much lower in 2011 than 2010. We are planning to continuously add to and improve our model and modeling techniques, which should improve our predictions of the level (as well as the timing) of high activity nights.

Q: What would a graph of observed v predicted look like for sites you used to develop the models?

A: Good question – that is something we are going to look at when we validate our western model. We will redevelop the models using 80% of the data, leaving out 20% to use as validation.

Q: How did you identify bat species? And how confident are you with your Silver-haired and Free-tailed Bat classifications?

A: We do most of our identification by eye, but we also use SonoBat to look at specific call parameters. It is hard to distinguish Silver-haired from Big Brown Bats. However, there is one specific call shape that is distinctive to Silver-haired Bats, so those are the only ones we used for the Silver-haired Bat analysis. If there were discrepancies, we just did not use those calls in the model. With Free-tailed versus Hoary Bats – there is always going to be some uncertainty and overlap, but we are fairly confident with these classifications.

Q: If you combine calls by silver-haired bats and big brown bats, would that improve predictability in the Midwest?

A: That is something to consider. We did find some differences by the specific species you were looking at, but similar size bats may have similar requirements.

Wind development in a post-white nose syndrome world

Presenter: Brad Steffen, BHE Environmental, Inc.

Presentation

Authors: Bradley J. Steffen (BHE Environmental, Inc.)

PROBLEM

White nose syndrome (WNS) is an emerging disease currently affecting cave-roosting bats in the eastern and midwestern U.S. and parts of Canada. Caused by the cold-loving fungus, *Geomyces destructans*, it has been rapidly spreading since its discovery in New York in winter 2006-2007, and is currently documented in 21 states and four Canadian provinces. Though not known to affect humans, this fungus has been responsible for the death of 5.7-6.7 million bats since 2007. This presentation examines the regulatory changes enacted or contemplated at the state and federal level within the range of Indiana and Gray Bats and identifies potential measures that can be taken during project siting, development and operation to address conservation concerns related to WNS.

IMPACT OF WNS

Symptoms

In addition to appearing on the nose, the fungus also manifests on other parts of the body [slide#2]. Affected bats arouse more frequently and spend more time awake, resulting in very low body weights and no subcutaneous fat reserves. They also exhibit other aberrant behaviors, such as shifting to colder parts of the cave or mine, and even leaving the mine to try to find food. Affected bats that survive the hibernation period have extensive wing damage, but most do not survive.

Mortality

Mortality rates in affected caves can reach 100 percent, and local extirpation of several species is possible. Surveys of 42 sites in Vermont, New York, Pennsylvania, Virginia, and West Virginia where we have pre- and post-WNS data show an 88% decline in total numbers, amounting to 362,000 individuals. Looking more closely at these data, not all species were affected at the same rates. Northern Long-eared Bats at these sites experienced a 98% overall decline, while Big Brown Bats declined by 41%. Mortality also was found to vary significantly among sites; two closely-situated sites in New York State, for example, were found to have very different rates of mortality (100% v. 52%).

The map in slide #5 shows where WNS has been found to date. Schoharie County in New York State is "ground zero;" a photograph of bats taken in 2006 shows evidence of the fungal growth. During the 2008-09 hibernation season, we saw big jumps down the Appalachians, which led to the hypothesis that the spread of WNS may be human assisted. Laboratory studies have shown that the disease can spread from sick to healthy bats, and it is within the realm of possibility that bats are responsible for the disease spreading. Transmission may also take place via spores resident in hibernacula.

Some Good News?

An army facility in Fort Drum, NY is home to one of the largest Little Brown Bat maternity colonies in the northeastern United States. According to a recent study (Dobson et al. 2011), as of 2008, some 1,200 individuals were using an abandoned building on the grounds; by 2009, that population had declined 73% to 320 individuals, and by 2010 the population had declined to 145 individuals (down 88% from the pre-WNS 2008 numbers).

The good news is that they are seeing evidence of reproduction among females that were found to have WNS-related wing damage early in the season; later in the season the damage had healed, and there was evidence of lactation. Individuals found with wing damage in 2009, were caught again in 2010 with new (different) wing damage – evidence that they had survived hibernation and been able to return to the maternity colony the following year. Survey results released this year by the New York Department of Environmental Conservation indicated that populations in previously-documented WNS sites were stabilizing, and one site actually increased from 1,496 animals in 2011 to 2,402 in 2012.

REGULATORY IMPACTS

Of 45 bat species occurring in North America, 25 species hibernate. Of these, seven species are shown to be affected by WNS. Two federally endangered species, the Indiana Bat (*Myotis sodalis*) and Gray Bat (*Myotis grisescens*), are known to be affected.

In June 2011, the USFWS initiated a formal status review of Eastern Small-footed and Northern Long-eared Bats. Following this review, the USFWS will issue a 12-month finding stating whether Endangered Species Act (ESA) listing and critical habitat designation is warranted. While the formal process for listing species can be lengthy and time consuming, emergency ESA listing could be initiated due to the rapid decline of hibernating populations in the Northeast and the rapid spread of WNS into the Midwest. The USFWS is also requesting data regarding a additional cave-roosting species – Little Brown Bat, Big Brown Bat, Tri-colored Bat, Cave myotis (*Myotis velifer*), and Southeastern myotis (*Myotis austroriparius*)– potentially in anticipation of additional status reviews. Several states (MA, MN, NY, OH, VT, WI) have already afforded legal protection of varying degrees – from species of concern to endangered – to cave roosting bat species in light of WNS [slide #9].

IMPLICATIONS

With the possible, perhaps likely, expansion of the endangered species list in the near future, wind developers may be required to consider newly listed bat species when completing pre-construction surveys and environmental documentation, including documents prepared in compliance with ESA or the National Environmental Policy Act (NEPA). This may result in new survey guidelines, management, and monitoring actions to conserve bats. Understanding the need for, and application of, new survey and monitoring methods will help developers effectively plan project budgets and schedules.

Finally, the range of the Little Brown Bat covers most of North America, so the potential for WNS to spread quite extensively may be a matter of time.

Questions & Discussion

Q: How does the average life expectancy of bats with WNS compare with that of healthy bats?

A: This varies among species. Little Brown Bats have lived up to 20 years. If they come down with WNS late in the season, they may survive, but likely they will go back to the same hibernacula and will succumb the following year. As far as we know, life expectancy with WNS is zero.

Q: Is WNS the direct cause of death, or is it starvation?

A: Bats do starve to death, because they arouse more frequently to scratch and groom. Every arousal event uses up fat reserves equivalent to a week or more of hibernation time.

Q: Is introduction of the fungus related to human activity? If not, is there a known cause?

A: The fungus comes from Europe, where it is widespread. We don't know how it got here, but it is not unique to North America. We have anecdotal evidence from Europe since the 1980s, but we are not seeing the widespread response in Europe that we see here.

Q: Would bats with WNS be more likely to collide with wind turbines?

A: We don't know; possibly.

Q: Has anyone examined using an aerosol anti-fungal treatment as a way of treating large numbers of bats while they are hibernating? This type of treatment has been effective in combatting other infectious diseases (e.g., West Nile virus) and may warrant consideration.

A: It is being looked at. The Nature Conservancy built an artificial cave in Tennessee to test such an approach. The problem is that hibernacula caves are sensitive ecosystems.

Q: Is there any consideration of transplanting Little Brown Bats from other parts of North America to restore communities in the east?

A: I am not aware of any plans to do so. It is not a question of if but when WNS spreads to western North America. We may find that some bats turn out to be more resistant, though so far most are not.

Q: It may be that development is a relatively small effect on bat population – can you speak to the natural history significance of WNS among bat species? Is it a natural phenomenon and is wildlife capable of withstanding natural fluctuations in population?

A: One hypothesis is that mass deaths occurred a long time ago in Europe, and that what we're now seeing are remnant populations. Given the rate of mortality we are now seeing, it will take geologic time scales for populations to recover.

Offshore Wind Energy: Siting and Assessment

Moderator: Steve Pelletier, Stantec

Department of Energy data suggest that offshore electrical generating potential is four times what it is on land, and quite close to some of our largest population centers. But we know even less about the potential impacts of offshore wind energy development than we know about terrestrial development.

While the other panels focused on models, strategies, and tools to assess avian and bat risk associated with terrestrial wind projects, this panel followed a different, more interactive format, broadly touching on biological, ecological, and regulatory aspects of offshore wind energy development. Following introductions, panelists responded to questions from the moderator as well as some from the audience.

Panelist Introductions

Jim Woehr, Bureau of Ocean Energy Management

On October 1, 2011, the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), formerly the Minerals Management Service (MMS), was replaced by the Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE) as part of a major reorganization. BOEM is responsible for energy development in waters more than three nautical miles from the Atlantic coast, and more than nine nautical miles from land along the Gulf Coast. As BOEM's lead avian biologist, Jim Woehr is responsible for proposing and overseeing BOEM research contracts on the Atlantic.

Woehr: *"The research ideas we pursue come from many discussions and brainstorming both within and between agencies. We encourage you to stimulate our thinking."*

Kate Williams, Biodiversity Research Institute

The Biodiversity Research Institute (BRI) is a nonprofit independent ecological research group based in Maine. BRI assesses threats to wildlife and ecosystems and advises decision makers. Its mission is to produce high-quality science to inform decision making – such as baseline migration studies related to renewable energy projects. BRI is under contract to DOE to conduct several ongoing offshore wildlife surveys in the mid-Atlantic, looking at animal abundance, distribution and movements. BRI is also leading collaborative efforts to identify both data gaps and known effects to wildlife from offshore wind energy.

Williams: *"Our idea is that developers and government agencies should have the high-quality scientific data they need to make sound decisions."*

Caleb Gordon, Normandeau Associates

Like Kate Williams, Caleb Gordon comes to offshore issues as an ornithologist. Formerly with the Pandion group, based in Gainesville, Florida, he has spent the past 20 years studying migratory bird ecology. Gordon has also been involved with AWEA's offshore wind working group; he brings together science, industry and agency perspectives.

Gordon: *"BOEM is making a tremendous investment to do research studies to understand the science so that they can make informed decisions about the rules."*

Eric Kershner, US Fish and Wildlife Service

Within the U.S. Fish and Wildlife Service (USFWS), the Division of Migratory Bird Management's mission is to ensure the trust responsibility of USFWS. The Division is headquartered in Arlington, Virginia, but most of the work is done in the field offices, with partners, trying to develop collaborative efforts to collect data and understand systems. Much of this work is funded by BOEM.

Kershner: *"Our role [at headquarters] is to advise our folks in the field, and to make sure that no matter what region USFWS is working in, we're taking a consistent approach, even as you deal with site-specific issues."*

Terry Yonker, Great Lakes Wind Collaborative

The Great Lakes Wind Collaborative (GLWC: www.glc.org/energy/wind) was formed in 2008. It is made up of U.S. and Canadian federal agencies, states, provinces, developers, and environmental NGOs. Projects include the Great Lakes Wind Atlas group and the development offshore siting guidelines. The Great Lakes region constitutes the world's fourth-largest economy, with the potential to generate 1000 GW of power – nearly ten times the amount needed to serve the region's42 million people.

Yonker: *"In 1986-87, the [National Research Council] wrote a report advising the Great Lakes Water Board and the International Joint Commission to start thinking about climate change. Last winter, I was in Antarctica – and the changes are profound. Climate change is real."*

Questions

What is the definition of "offshore," and what does it include? How far from land does it extend? How does the offshore regulatory process differ from on-land processes?

A Definition of "Offshore"

From BOEM's perspective, "offshore" means federal waters: everything beyond three nautical miles along the Atlantic coast, and beyond nine miles along the Gulf Coast. Waters inside that limit are defined as "near-shore," and are subject to state jurisdiction. That said, USFWS is responsible for conserving and protecting trust resources in *all* waters (state and federal).

Offshore developers are tending to look at sites about 12 miles from the coast, where winds are stronger and coastal viewsheds are less of a concern. Near-shore development may look more like terrestrial development, in terms of data collection and the pre-construction process.

The Offshore Regulatory Process

Unlike terrestrial wind resource areas, offshore ocean waters are under the management and regulatory purview of the Bureau of Ocean Energy Management (BOEM), and are therefore subject to the National Environmental Protection Act (NEPA) process. From a development standpoint, this means that every project is a NEPA project.

BOEM is undertaking broad-scale research – collecting data that goes beyond Tier 1 and Tier 2 in the Guidelines for land-based wind energy development – to identify offshore wind energy areas (WEAs), eliminating known sensitive areas to define areas that may be suitable for wind energy development. BOEM then issues a competitive leasing Request for Interest for the area(s) identified in Tier 1 as "least impact." Developers that compete successfully receive exclusive rights to the area for a 5-year period. During that period, the developer would be expected to complete a site characterization assessment and submit a site-specific project construction and operations plan prior to a project being permitted in federal waters.

Nothing precludes developers from proposing projects outside BOEM-identified wind energy areas (WEAs), but the work BOEM has done to vet the WEAs does funnel most proposals into those areas. While USFWS may not hear about a (land-based) project until a developer has a site in mind for which it plans to seek a permit, BOEM typically is past the Tier 2 stage of the Guidelines for land-based wind energy development before it issues an RFI.

Although Federal waters are under BOEM jurisdiction, offshore projects are likely also to require state agency permits, insofar as energy generated offshore still needs to be transmitted through coastal waters onto shore, where the energy market is. Federal-state task forces are one attempt to gather information and concerns about the areas under consideration. In addition to working with state agencies, BOEM must work with local, tribal and other federal stakeholders to facilitate the commercial leasing process for offshore renewable energy development.

The Great Lakes

States own the lake bed out to the border with Canada. The Army Corps of Engineers declined to undertake a programmatic EIS for Great Lakes wind energy development, having earlier invested in an EIS with the gas and oil industry only to have the states ban gas and oil development. In March 2012, the Council on Environmental Quality, five of the Great Lakes states, and ten Federal agencies signed a Memorandum of Understanding to create the Great Lakes Offshore Wind Energy Consortium, with the goal of streamlining the NEPA and state environmental review processes. The Army Corps of Engineers would likely still serve as the lead agency.

From USFWS' perspective, data collection and pre-construction in state waters and on the Great Lakes more closely resembles the terrestrial development process. For both the Great Lakes and for the Gulf of Mexico, the focus tends to be on land bird migration across bodies of water.

What are some of the major biological differences between offshore and terrestrial sites– or even differences from one offshore region to another?

At a landscape level, animals act certain ways around "barrier" bodies of water: the Great Lakes, the Gulf of Mexico. Along a more linear coastal region, like the Atlantic coast, beyond a certain distance from shore the abundance of birds can drop off rapidly, though abundance of seabirds remains highly patchy and is likely related to habitat characteristics such as bathymetry and prey distributions. (That said, along the Atlantic Coast of the U.S., Maine is exceptional in that there are enough islands 20 miles off the coast to create conditions that in some ways more closely resemble coastal conditions than offshore conditions in Federal waters further south.)

Land v. Sea Biology Differences – Where to start?

We know less about the offshore migration activity of passerines and bats than about their onshore movements. Oceans are very dynamic, and patterns change over time, and with them come changes in bird feeding and movement patterns. Climate change makes this even more challenging. Also, putting a structure in the water creates artificial reefs – in effect, new habitat – which has to be taken into account. (For example: if a structure creates habitat for aquatic prey animals, does that attract birds?)

Every area has its own species composition, and all areas are not equal in terms of what species live there and how wind energy development might impact them. For example, the Atlantic Right Whale is an endangered species whose range looks very much like a map of offshore wind resources. We have much poorer baseline knowledge than we have for onshore species. There are different suites of behaviors to consider, in the context of a more dynamic environment.

One obvious challenge is that methods used to monitor fatalities or even map spatiotemporal distributions on land cannot readily be applied in the ocean. We have no comparable methods and metrics document for offshore like the Guidelines for land-based wind energy development.

The Great Lakes are "very busy places" in terms of avian and bat activity. One factor is that the lakes freeze over during the winters. Birds feed on the ice, and bats have been found feeding around buoys 40 miles out in the middle of Lake Michigan. The other factor (for both the Great Lakes and the Gulf of Mexico) is that birds migrate in huge numbers across these waters. This has implications for offshore development as well as development impacting stopover habitat on the shores.

How much of what we've learned on land is relevant to offshore? Is there anything we've learned from European countries' offshore experience?

Lessons from terrestrial development

Weather matters. One thing that we have learned on land is that weather matters; passage rates do not explain all of the collisions at terrestrial sites. Flight altitudes associated with weather fronts and headwinds may better explain these events.

Climate change matters. Climate change is also relevant to both terrestrial and offshore development. On the Great Lakes, we are expecting water levels to drop 4-6 feet by the end of this century. We are already seeing significant impact on animal movement patterns, available stopover sites, and migration timing.

Lessons from Europe

BOEM is very interested in learning from the Europeans. There are at least 20 wind farms in the North Sea that are operating at least 10 K from land, and have been there at least 10 years, but publications are few and far between. BOEM is trying to convene scientists and regulators; to date we have not heard much from the Netherlands, Sweden, and Germany – so far we are mostly hearing from the United Kingdom and Denmark.

The Europeans acknowledge that certain groups of birds are vulnerable to collisions, but collision mortality is difficult to measure, and offshore studies have tended to focus on displacement and barrier creation effects. BOEM has directed its resources at identifying hot spots where there are

concentrations of birds and cold spots where there is lower bird presence. BOEM is also using satellite telemetry to identify offshore migration corridors.

Large assessments are needed. While the Europeans did some quite long-term studies in fairly large areas, panelists observed that many Europeans:

- Wish they had tackled the question of cumulative impacts much earlier—e.g., figuring out how to compare and collate data from multiple sites, using it in combination with baseline data on animal populations, and estimating effects on populations from both individual projects and multiple projects (in multiple countries) in combination.
- Wish they had done a more comprehensive marine spatial planning effort—that is, mapping existing uses and thinking strategically about the best use of various areas of the ocean where there are competing priorities. (British researchers in particular have raised this point.)

This type of work is required to provide a context for what is happening at individual projects.

Positive indicators [*Gordon*]: Some of the research emerging from Europe is encouraging:

- Water fowl are pretty good at avoiding wind turbines and whole installations.
- Of the three classes of possible effects – collisions, avoidance/displacement, and barrier effects – collision seems to be less of an issue than on land, while avoidance/displacement is more of a focus. In Denmark, for example, scoters that had seemed to be displaced have since come back (following the post-construction return of razor clam beds).
- Work on energetic expenditures – how much extra energy does it take for animals to avoid wind facilities – seem at least initially to indicate that large diversions are par for the course for birds migrating across open ocean. This suggests that even large offshore developments may not pose a problem from an energetics perspective, but no one has gone so far as to estimate the cumulative energetics effects of maximum build-out.

Caveats [*Williams*]: The recent European research does emphasize displacement and avoidance over collision. However:

- There has not been a lot of work done on nocturnal migrants such as passerines, and the fact that we do not have the data does not mean collisions are not happening. (In one case where platform collisions were studied, 98% of fatalities were passerines. It should be noted that the platform was lit with continuous white light, which is known to be a risk factor and easily avoidable.)
- With respect to diversion of migrants, while energetics are not likely to be an issue, the timing of when birds arrive in their breeding grounds can be a real factor in reproductive success.
- There has been some work done in Europe as to what risk factors are – gannets and other diving birds might be more vulnerable. Studies coming out of the UK on terns indicate that effects to their prey species – e.g., construction during herring spawning time – can have significant impacts.

Lower flight heights offshore. Over land, migratory flight tends to be over 200 m, but over ocean waters, bird migration flight is lower, and often below 200 m. Some evidence suggests that bats also

tend to fly and echolocate at lower levels over the ocean. Neotropical migrants in the Great Lakes fly at higher altitudes during broad front seasonal migration and have been observed descending from those higher altitudes when approaching shoreline stopover sites and when trying to avoid rain shields and headwinds.

Regulations require a minimum of 40 m between ocean surface and lowest blade tip. BOEM is also looking at the effect of lights, with a lighting study that was proposed for the Gulf of Mexico.

What are your thoughts about post-construction monitoring? How do we set up mitigation?

Post-construction monitoring
Post-construction surveys are needed to determine whether there are any changes in the things being measured pre-construction: abundance, distribution, movements. Post-construction monitoring must be linked to pre-construction surveys asking specific questions.

Mortality monitoring out over the ocean is a challenge. So far, the technologies being researched – infrared video, vibration technologies – have not proved feasible, but for now these are all we have to work with. Apart from the infeasibility of using terrestrial techniques to monitor for collision fatalities, offshore turbines once we finally get them will be huge – 5-8 MW turbines – and widely spaced. Unlike land-based wind energy development, where birds that encounter a facility have to fly through an array of turbines – each turbine encounter will be a discrete event, with huge turbines arrayed a km apart over an area of perhaps 100 square miles. Monitoring techniques that have been tried cover just a fraction of the turbine area. Given that collision fatalities are likely to be rare events, we have to ask ourselves what it is we would be trying to find out by monitoring fatalities at an offshore wind turbine.

On the other hand, we may be able to apply the precautionary principle in the Great Lakes based upon existing, but incomplete, knowledge about adverse weather conditions that impact broadfront migration. Curtailment under these rare conditions might be warranted for just a few hours per year.

Mitigation options
The Migratory Bird Treaty Act (MBTA) doesn't allow for take of birds; USFWS cannot authorize fatality mitigation. It is not as clear how habitat mitigation would apply to ocean habitat.

On the Great Lakes and Gulf of Mexico, we know enough about the impact of weather on migration to begin to identify specific weather-related conditions when certain migratory species would be at risk. So, for example, we may want to apply curtailment strategies to mitigate weather condition-related risks to neotropical migrants passing through the Great Lakes.

Out over the Atlantic, the context is very different. There are not large numbers of neo-tropical migrants passing through, fatality monitoring is extremely difficult, and collision events are likely to be rare. Given this context, we have to ask ourselves, what is the critical value of the parameters that would trigger a change, and where is the science to back that up? For these reasons, BOEM is concentrating almost entirely on siting to avoid birds in the first place.

It may make more sense to put money into some kind of conservation bank rather than put it into expensive post-construction monitoring efforts that shed little light on population impacts.

For terrestrial wind energy development we now have guidelines that spell out what is expected in terms of post-construction monitoring (along with all the other aspects of development). For offshore development, there is neither guidance nor precedent. Agencies and developers are at loggerheads, and the Europeans are all over the map on this. We need to have clear guidelines, so that everyone knows what to expect.

What are the three top data needs?

Williams: It would be quite useful to have a few experimental sites where we can study the impacts exhaustively and fill in some unknowns. Specific data needs include:

- Researching the effects of displacement on individuals and avoidance during migration
- Thinking about cumulative impacts from the beginning

Gordon: Where do the Roseate Terns and Piping Plovers go when they go offshore? Not being able to address ESA concerns with radar puts USFWS in an awkward position.

Yonker: We need to do surveys of pelagic birds on the Great Lakes as part of the Great Lakes Restoration Initiative, especially during the winter. We need to identify stopover sites. And we need to better understand the impact of wind on aquatic organisms.

Woehr: Where are birds (and bats) concentrating out on the open ocean, and where are they *not*. We also need to figure out where the offshore migration corridors are.

Audience questions

Q: Caleb Gordon stated that every offshore project is a NEPA project – what about projects sited in state waters?

Woehr: Even in state waters, NEPA is likely – even inevitable, given Section 10 of the Rivers and Harbors Act, which requires an Army Corps of Engineers permit for the cable coming into shore, boats coming and going from the offshore installation.

Q: What is role of National Marine Fisheries Service?

Woehr: Marine mammals, sea turtles, and all fish are within the purview of the National Marine Fisheries Service (NMFS). All marine mammals are covered by the Marine Mammal Protection Act, sea turtles by the Endangered Species Act. The commercial fishing industry – a major stakeholder with a lot to say about what kind of development takes place in the ocean – is also under the purview of NMFS.

Gordon: Sea turtle monitoring is a good example of methodological changes. In the past, we have gathered broad baseline data on wildlife distributions using aerial observers, but the planes have to fly so close to the surface of the water that observations are usually of turtles diving. Whereas by doing airplane camera surveys using high resolution imagery, we are finding four times the density of turtles in our surveys, because the methodology is so much less intrusive.

Q: What about electromagnetic fields and lobsters?

Woehr: Early indications are that it doesn't make much difference.

Williams: We are seeing really interesting migrations of elasmobranchs (sharks and rays) with the high resolution imagery. I do not think that EMF is going to be a big issue, especially if lines are buried a meter or more below the sea bottom.

Lessons Learned: Syntheses Across Projects

Relating pre-construction bat activity and post-construction fatality to predict risk at wind energy facilities

Presenter: Cris Hein, Bat Conservation International

NOTE: Updated information presented on NWCC Research Webinar; information available here: http://www.nationalwind.org//issues/wildlife/2013researchwebinars.aspx

Authors: Cris Hein (Bat Conservation International); Wally Erickson, Jeff Gruver, Kimberly Bay (WEST, Inc.); Ed Arnett (Theodore Roosevelt Conservation Partnership)

PROBLEM / RESEARCH NEED

Bats became an issue with respect to wind development about a decade ago. With many species of bats known or suspected to be in decline, concerns persist about the potential cumulative impacts of wind energy development on bat populations. Extensive resources are devoted to studying bat activity patterns at proposed wind energy facilities, and there is a strong, but as yet unsubstantiated, assumption behind these efforts that a positive and predictive relationship exists between pre-construction bat activity and post-construction bat mortality. While it makes intuitive sense that higher levels of activity mean greater potential for exposure, it is not necessarily the case that low activity equals low fatality – particularly if bats are attracted to turbines.

Pre-construction bat surveys commonly employ acoustic detectors to assess species composition, spatial and temporal activity patterns, and weather conditions under which bats are most active. These data may assist with on-site decision-making and optimizing potential minimization strategies (e.g., raising turbine cut-in speed during periods of high risk). However, using these data to predict post-construction fatality and quantify risk of a site is unproven. Until recently, our ability to investigate this relationship was limited because so few sites conducted both pre- and post-construction studies. Increases in the number and extent of surveys now make meta-analysis possible for a nation-wide assessment.

Here we present our preliminary findings on whether bat activity, as measured by acoustic detectors, provides a useful metric in predicting fatality and offer ideas on how to best to proceed with future surveys.

APPROACH

In fall 2012, we compiled a list of available datasets and assessed which studies were appropriate for inclusion in our analysis. We came up with seven broad regional boundaries for the continental United States: NE Deciduous Forest, SE Mixed Forest, Coastal Plain, Midwest Deciduous Forest/ Agriculture, Great Plains, Great Basin/SW Open Range & Desert, Western Temperate Forest. This presentation focuses on four of those regions, for which we were able to acquire a total of 242 pre- and post-construction studies.

Region	Pre-Construction	Post-Construction
Basin / Desert	24	43
Great Plains	30	37
Midwest	39	18
Eastern Forest	18	33
TOTAL	**111**	**131**

Pre-construction data were compiled from public and non-public reports, but comprise mostly non-public data. Acoustic data from spring-fall and fall only studies were collected from ground-based stations and meteorological towers. We used the most commonly reported metric: bat passes per night.

Post-construction data also were compiled from public and non-public reports, although most of this data is public. Fatality data were compiled from spring-fall and fall only studies, regardless of how trials were conducted or estimator used. The metric we used was bat fatalities per MW per year.

Regions were categorized based upon broad habitat characterizations (e.g., forest, shrub-steppe habitats) that potentially influence how bats may generally utilize an area. Variables considered in determining strata included features that would serve as migration corridors (i.e., topography, geographic landscape, riparian corridors), behavior of different bat species in a region, and the amount of installed wind capacity. Other factors – e.g., detector height, weather conditions or region – potentially influencing the pre-construction activity/post-construction mortality relationship were also examined.

RESULTS

We see some consistency across regions, with the vast majority of pre-construction studies reporting low bat activity. There are a couple of regions (Midwest and Eastern Forest) with a couple sites reporting very high activity levels [slide #10]. In terms of fatalities per MW per year, the vast majority of post-construction studies show low mortality levels, with a broader distribution of mortality levels – and a few sites reporting high fatality levels – among sites in the Midwest and Eastern Forest regions.

Slide #12 compares mean and 95% confidence intervals for fatalities/MW/year and for bat passes/night for each of the four regions. Again, we tend to see a smaller range of variability in the fatality data than in the bat activity data. Fatality data were relatively consistent in Basin-Desert and Great Plains, while much more variable in the Midwest and especially in the Northeastern Forest region, which had the highest variability and also the lowest number of study sites.

One goal was to compare sites in which both pre/post-con data were collected. Slide #13 illustrates a hypothetical example in which activity (y) is plotted against fatalities (x) thus enabling us to predict fatalities based on pre-construction activity. Given enough sites within a region one could graph the least squares regression line with a 95% confidence interval. This would allow one to look at activity data from a new proposed facility and infer fatality. In the hypothetical example, a site with 15 passes/night corresponds to 12.5 bat fatalities/MW/year; we could predict mortality of 9-16 bats/MW/year with a 95% level of confidence.

Surprisingly, from a database of 111 pre-construction and 131 post-construction studies, there were only three paired sites from different parts of the country. Explanations for this include the fact that different parties conducted pre- and post-construction studies, studies required by permitting agencies

vary, and that there are a number of the sites from which we were able to compile pre-construction data that are not yet developed or operational.

CONCLUSIONS / FUTURE RESEARCH

Given this large dataset, we intend to re-examine the regional boundaries; for example, within the Northeastern forest region, there is high fatality along the Appalachian ridgeline but low fatality further north, suggesting it might make sense to split this into two distinct regions.

This meta-analysis included as many studies as possible, regardless of differences in methodology and analysis. A next step would be to develop more rigorous criteria for inclusion of data, which would ensure greater consistency among studies. Also, there is a small window for incorporating additional data, especially more paired data sets.

Regardless of whether pre-construction data can predict fatality, these studies do have value. They provide insight into nightly and seasonal spatial-temporal activity patterns of bats, which track with what we know about conditions (e.g., low wind, warmer temperatures) correlated with fatalities. They can therefore be useful in refining the timing and extent of potential mitigation strategies (e.g., curtailment).

Questions & Discussion

Q: Did you run a regression on your activity-fatality data, and if so, how tight was the relationship? What was the r-squared value?

A: We have not done that yet; this analysis is still in the preliminary stages, but we have the flexibility with the data that we have and what we hope to have coming in that we should be able to do that.

Q: You showed an example showing what a linear relationship between activity and mortality might look like. Will you also be exploring possible non-linear relationships?

A: Yes. This analysis is still in the preliminary stages, and we will be considering more options for examining this data.

Q: Did activity estimates include acoustic sensor stations at features attractive to bats (e.g., a pond in the desert)?

A: Yes. I don't know the number of sites that did have that. It is something we would have to consider whether we include those sites as we develop more rigorous criteria for inclusion/exclusion of studies.

Q: Does Canada have paired data sets (pre-/post-construction) that might be used to complement this analysis?

A: There are other sites that probably have paired data, we just haven't got that data yet. Sometimes one company does the pre-construction study, and a different company does the post-construction monitoring. Sometimes companies are required to do post-construction monitoring, but not to do any pre-construction studies in order to get a permit. In some cases pre-construction studies have been done, but post-construction hasn't been done yet.

Assessing the impact of wind energy facilities on North American songbirds

Presenter: Wallace Erickson, *WEST, Inc.*

Authors: Wallace Erickson (WEST Inc.), Joelle Gehring (Michigan State University), Douglas Johnson (USGS), Michelle Sonnenberg (WEST Inc.), Kimberly Bay (WEST Inc.) and Elizabeth Baumgartrner (WEST Inc.)

RESEARCH NEED

Songbird fatalities are the most common fatality observed at wind energy facilities, and songbirds are also the most common bird group observed during pre-construction bird surveys in most areas. The most recent detailed summary of songbird mortality at wind energy facilities was a synthesis of 14 studies presented at the National Wind Coordinating Collaborative (NWCC) meeting in 2001 (Erickson et. al. 2001). Since that summary was published, there have been more than 80 additional fatality monitoring studies. An updated evaluation of songbird impacts is needed to provide agency personnel, the wind industry, and other stakeholders a better understanding of the current level of impact to songbirds from wind energy facilities and identify research gaps and future monitoring efforts needed for songbirds.

Our specific objectives were to:

- Synthesize and summarize fatality studies at wind energy facilities in U.S. and Canada
- Estimate bird fatality rates from wind and other sources
- Contrast estimates of species mortality to estimated population size regionally

The analysis assumes that projects with studies are representative of unsampled or unreported sites.

APPROACH

Of all the fatality studies that have been done, data from a total of 110 studies at 71 wind energy facilities across North America were compiled from multiple public sources. Years and project phases were separated where possible for multi-year/phase studies. Some studies were not included due to lack of standardization, older methods of study, too-lengthy search intervals, or older generation wind-energy facilities that are not representative of wind projects going forward. There are some very large studies from recent years that will be available to be added soon, but already the data compiled represent over 100,000 turbine searches.

Fatality estimates were normalized based on the statistical methods used, and species composition and mortality estimates adjusted based on carcass detection and removal rates. (Regional adjustment factors were used for studies that didn't have carcass removal and scavenging adjustments.) The data were then standardized to fatalities/MW/year.[9]

Songbird fatality estimates were calculated nationally and by Bird Conservation Regions (BCRs), which were combined into sub-regions and then into three broad regions: western, mid-western, and eastern. (For some analyses we did look at the BCR scale.) Species and taxonomic group fatality estimates were calculated by region and compared to estimated population sizes.

[9] Eventually, we will look at risk per square meter of rotor-swept area.

Of the 110 studies, 76 specifically included small bird fatality estimates. For the remaining 34 studies, the ratio of small bird to large bird estimates from other studies was used as a multiplier to calculate small bird estimates. Passerines (not including corvids) make up about 61% of the 4,574 observed fatalities, and because they are harder to detect than larger birds, it is assumed that passerines make up an even larger percentage of actual fatalities. The dataset includes 241 identifiable avian species recorded as causalities, including 154 species of passerine. Slides #10 and #11 list the 25 most commonly found species and the 25 most commonly found passerines, respectively; however, note that some regions have more studies than others, so the fatality composition may not be representative.

FINDINGS

Species estimates assume equal detection rates among the small passerine species, which is likely not the case, but this is not significant in terms of the "big picture" estimates. Nationally, we estimate a total of about 150,000 bird fatalities per year based on the current level of development, or about 2.8 per MW installed capacity. (The 90% confidence interval gives us a range of 2.3-3.3 bird fatalities/MW/year.) Passerine fatalities total 112,000, or about 2.2 passerine fatalities/MW/year.

Recognizing the limitations in what the big picture estimates tell us, we are also trying to come up with species estimates at the level of individual BCRs.

CONCLUSIONS / RECOMMENDATIONS

The data suggest that there are likely no population level impacts for passerines, in part because they are shorter-lived, higher reproduction animals than, for example, raptors. Individual and cumulative impacts may still be of concern to stakeholders for listed and other sensitive species and birds covered by the Migratory Bird Treaty Act.

FAA lighting does not appear to affect the probability of large mortality events at wind turbines, a finding supported by results from the communication tower studies. The weight of evidence suggest that large nocturnal migrant fatality events can be avoided by:

- Minimizing lighting on turbines, blinking white or red
- Avoiding substation lighting or using lights that are aimed downward
- Turning nacelle lights off

Even with significant build-out of wind energy capacity, the number of turbine-related fatalities are dwarfed by the number of bird fatalities from other anthropogenic sources, such as communication towers. This kind of database may provide the necessary information for predicting songbird mortality on future projects, thus reducing the high cost of monitoring efforts and potentially freeing resources that could perhaps be better spent focusing on bats and raptors, for example.

Questions & Discussion

Q: Were the Criterion, Peñescal and Gulf Wind studies included? Were the Partners in Flight population data used from the 1990s, or were they more recent data?

A: It is older data [from the 1990s]; we are expecting more recent data to come out soon. Texas sites were not included.

Q: Would 1.5% of species be considered significant? (e.g. Ruby-crowned Kinglets)

A: Using information on annual survival rates, to me it is a very low number compared with typical mortality during the year. Given the population level, it is hard for me to imagine that that is significant. In this case we were looking at BCR, but with Ruby-crowned Kinglets, we know that there are a lot of birds from Canada and other places coming through and not represented in the population estimates.

Q: The data pool that you presented is based on over 100,000 turbine searches. Do the data allow you to estimate the range of variation in carcasses found at individual turbines? Could you estimate turbines that have higher than some criterion mortality that might be called "problem turbines"?

A: The data we're looking at do not go down to turbine level. For some individual studies we can look at the variance and confidence intervals reported to get at turbine to turbine variation, but not across our whole database, no. For songbirds, we do not see extreme distributions suggestive of "problem" turbines. With the exception of turbines closest to lighted substations, variability turbine to turbine is low.

Q: Did you include episodic events such as the two that occurred in West Virginia about two years ago where lights had been left on? (Were large event data included in your analysis?)

A: Our data pool did include one of those projects. The other project with a large event we did not have the report to get the data.

Q: In the two anonymous studies, were blades feathered below the cut-in wind speed?

A: In one of the cases it did – we were aware of that issue. We do have rpms relative to wind-speed, so we could find out if that was the case, but it wasn't done intentionally if it happened.

Q: Have you found that larger (MW) turbines kill more birds? For example, do 3-MW turbines kill more birds than 1 or 2 MW turbines?

A: We have the tower height data, but have not yet analyzed how turbine size impacts songbirds. We did remove the data from the Altamont studies of older turbines – 24 m towers with 8-9 m blades – when we looked at migrating songbirds.

Q: Your final slide gave estimates of numbers of small birds killed annually at wind projects. Will your publication also provide an estimate for large birds?

A: We are estimating all bird mortality, just started a project to do same analysis on raptors, can pretty easily analyze any of these other groups – water fowl, etc.

Q: After your synthesis is published, in what regions or situations might small bird pre-construction surveys be warranted? Are there regions or situations where they would and others where they might not be? Should large bird surveys still be done nearly everywhere?

A: Post-construction, based on all the searches, we can make some strong inferences about what the biological impacts are for songbirds; however, there may be sensitive locations and species that you still need to look at. As far as pre-construction activity being correlated with post-construction fatality, we have yet to see strong correlations.

ADDITIONAL QUESTIONS

The following questions were submitted but not answered until after the conference.

Q: Is there an effort to compare birds killed at energy site to local population estimates? Scaling regional population estimates down to an area similar to the area of take (e.g., a watershed) may be more meaningful.

A: This could be done but a defining a local population is difficult and many of the fatalities are migrants.

Q: How does the number of bird fatality studies at wind projects compare to the number of bird fatality studies for other anthropogenic causes of bird mortality? Why so much focus and attention on studying wind-wildlife impacts when bird fatalities are estimated to be significantly higher for other anthropogenic causes? There appears to be a disconnect somewhere.

A: There are a lot more studies of wind than other sources. It does appear to be a double standard. However, the fact that wind industry has a lot of data in the long term should lead to better inferences regarding the impacts.

Operational mitigation of wind turbine generators to avoid bat fatalities: a synthesis of existing studies

Presenter: Ed Arnett, Theodore Roosevelt Conservation Partnership

NOTE: Updated information presented on NWCC Research Webinar; information available here: http://www.nationalwind.org//issues/wildlife/2013researchwebinars.aspx

Authors: Wally Erickson, Jeff Gruver, David Young (WEST, Inc.); Ed Arnett (Theodore Roosevelt Conservation Partnership); Cris Hein (Bat Conservation International)

RESEARCH NEED

Methods to minimize or reduce bat fatalities at operating wind energy facilities have been sought since August 2003, when a large bat fatality event at the Mountaineer wind energy facility realization that wind turbines can potentially kill large numbers of bats during certain times of year. Results from early fatality studies suggested an inverse relationship between wind speed and bat fatalities, and that bat fatalities might by lower at non-spinning turbines. These key patterns have now been substantiated, and research on the efficacy of operational mitigation supports the hypothesis that reducing or eliminating turbine rotation during specific periods could reduce bat fatalities.

Several studies have investigated the effects of raising the turbine cut-in speed – the wind speed at which the turbine starts generating electricity to the grid – on bat mortality. Raising the cut-in speed can have both economic and contractual ramifications (particularly if it is done post-installation). Apart from these considerations, implementation depends on the turbines themselves, their SCADA systems, whether operators are able to implement the changes. (In general, such measures are more difficult to implement at older turbines.)

Here we present our findings on the factors (both study- and site-specific) that influenced the results of the studies that we reviewed. We present the conclusions that are generalizable to other sites and those results that appear more site-specific. We also present optimal models (least cost for fixed mortality reduction) evaluated across these studies for cut-in speed curtailment.

APPROACH

Data have been compiled from a number of North American and European wind energy facilities that have conducted curtailment experiments to examine the effects of raising the cut-in speed of turbines. To date, six of the studies are completed, while others are ongoing. Results from Europe are not yet publically available and are not presented here.

These studies typically have involved a control-treatment study design with variations in search interval, number of turbines studied, cut-in wind speeds, and feathering of turbine blades. Because of differences in both study design and site-specific conditions, we closely examined study methodologies, including cut-in speeds, fatality search methods, and fatality estimation methods and statistical inferences from this synthesis. We examined site-specific conditions such as differences in turbine height, different turbine designs and the behaviors of turbines below experimental cut-in speeds.

FINDINGS

This presentation focuses on findings from sites in Alberta, Canada, Pennsylvania, Indiana and West Virginia.

Summerview Wind Power Project (Alberta) - Aug 1- Sept 7, 2007
This study compared normally operating turbines to turbines with: a) an adjusted cut-in speed of 5.5 m/s; and, b) turbines that were "idled" below normal cut-in speed (4.0 m/s). Experimental treatments showed a 57-60% reduction in bat mortality, with no difference between experimental treatments.

Casselman Wind Project (Pennsylvania) - July 27-Oct 9, 2008 & July 26-Oct 8, 2009
This two-year study compared normally operating turbines (3.5 m/s cut-in) to two treatment groups with adjusted cut-in speeds of 5.0 m/s and 6.5 m/s, respectively. (Treatments were randomly reassigned across turbines during the study.) Experimental treatments showed a 44-93% reduction in bat mortality between treatment and control, but the difference between the two experimental treatments was not statistically significant. Power loss was <1% of the total annual output.

Fowler Ridge Wind Farm (Indiana) - Aug 1-Oct 15, 2010 & July 15-Oct 15, 2011
The 2010 study was similar to Casselman, with two cut-in speed adjustments (5.0 m/s and 6.5 m/s) and no blade feathering. Experimental treatments showed approximately 50% and 78% reduction in bat mortality. The 2011 study investigated feathering turbine blades below 3 cut-in wind speeds: 3.5 m/s, 4.5 m/s, and 5.5 m/s. Experimental treatments showed 36%, 57%, and 73% reductions in bat fatalities, respectively. This study confirmed that the higher cut-in speeds lowered mortality the most.

Mount Storm Wind Energy Facility (West Virginia) – 2010 & 2011
The 2010 study used a weather forecast approach to "predict" when bat mortality might be high; turbine blades were manually feathered up to the manufacturer's cut-in speed (4.0 m/s). Experimental treatments showed approximately 47% and 23% reduction in bat mortality when comparing all nights; and approximately 72% and 50% reduction in bat mortality when comparing only nights feathering was in effect.

For the 2011 study, turbine feathering was automated; if winds dropped below 4.0 m/s for 6 minutes, a "pause" command was sent to feather the turbine blades – and vice versa – if winds stayed above 4.0 m/s for 6 minutes the turbine was "released" to run normally. This experimental treatment showed 9% bat fatality reduction. However, treatments were in effect only about 9-10% of the nights during the experiment (i.e., it was either too windy or not windy enough).

Additional Sites

- At an anonymous site in the Midwest, a 47% bat fatality reduction was achieved by raising the cut-in speed to 4.5 m/s; and a 72% reduction was achieved with a 5.5 m/s cut-in speed.
- A study at an anonymous site in the Southwest compared four treatments: 4 m/s cut-in; 5 m/s cut-in for half of the night v. all night; and 6 m/s cut-in. Fatality reductions ranged from 20.1% (at 4 m/s) to 38.1% (at 6 m/s); there was no significant difference between the treatment results.
- At a Sheffield, Vermont site, 45 bat carcasses were found at control v. 17 carcasses at turbines with a 6.0 m/s cut-in speed. Current analyses suggest an average reduction in bat fatalities of 60%.

CONCLUSIONS / RECOMMENDATIONS

Studies consistently demonstrate that substantial reductions in bat mortality can be achieved with marginal loss in operating time. Results can be expected to vary depending on the species composition of fatalities; at the southwestern site, Mexican Free-tailed Bats, which can and do fly at wind-speeds well above the tested cut-in speeds, represented a high percentage of fatalities.

Power loss is variable and not all studies are currently reporting it. However, a decrease of less than one percent of total annual production has been documented where cut-in speeds were raised.

The main recommendation from this research is to implement operational mitigation broadly at sites with moderate to high fatalities. The ultimate goal is "bat friendly" turbine automation that self-regulates based on several variables – not just wind speed but also (for example) date, time of day, and temperature. One relatively simple practice that has been shown to reduce bat fatalities without impacting energy production is to adjust the turbine blade pitch when the wind speed is below the normal manufacturer's cut-in speed to substantially slow or eliminate rotation of the blades when the turbine is not producing electricity into the grid.

Questions & Discussion

Q: People may be using the terms curtailment, cut-in speeds, feathering differently. How do you define them?

A: Curtailment is any time the turbine is not operating the way it normally would be. Changing the cut-in speed is telling the turbine computer system not to start generating electricity at a particular wind-speed. Feathering is changing the pitch of the blades so that they don't freewheel below the cut-in speed.

In our synthesis, we use the following definitions:

Curtailment: The act of limiting the supply of electricity to the grid during conditions when it would normally be supplied. This is usually accomplished by cutting-out the generator from the grid and/or feathering the turbine blades.

Cut-in speed: The wind speed at which the generator is connected to the grid and producing electricity. The manufacturer's set cut-in speed for most contemporary turbines is between 3.0 and 4.0 m/s. For some turbines, their blades will spin at full or partial RPMs below cut-in speed when no electricity is being produced.

Feathering or Feathered: Adjusting the angle of the rotor blade parallel to the wind, or turning the whole unit out of the wind, to slow or stop blade rotation. Normally operating turbine blades are angled perpendicular to the wind at all times.

Free-wheeling: Blades that are allowed to slowly rotate even when fully feathered and parallel to the wind. In contrast, blades can be "locked" and cannot rotate, which is a mandatory situation when turbines are being accessed by operations personnel.

Increasing cut-in speed. The turbine's computer system (referred to as the Supervisory Control and Data Acquisitions or SCADA system) is programmed to a cut-in speed higher than the manufacturer's set speed, and turbines are programmed to stay feathered at 90° until the increased cut-in speed is reached over some average number of minutes (usually 5–10 min), thus triggering the turbine blades to pitch back "into the wind" and begin to spin normally.

Q: Wind speeds vary over the night, and curtailment might occur in small time blocks – e.g., 10-minute, 20- or 30-minute blocks. What should be the minimum length of time for curtailment?

A: Current evidence suggests the first four hour time-block is important, but there are also reductions during the latter part of the night before dawn as well. The problem is that we cannot get a "time stamp" on exactly when fatalities occur, so a curtailment regime has to be set up based on a combination of key variables. There is fairly substantial evidence that we can achieve greater reductions in mortality when curtailment occurs earlier in the night. We would need to look more closely at time blocks, whether there is anything additive for full night curtailment v. first or second half of night curtailment.

Q: Is anyone looking at the relationship between turbine/tower color and attractiveness to insects – possibly influencing of bird/bat activity (attraction to insect prey)?

Ed Arnett: I am not aware of ongoing work beyond some European studies that have looked at color patterns – I don't see anything conclusive there.

Q: Can you summarize what the data says about what cut-in wind speed is most cost-effective – that is, most effective at reducing fatalities without impairing the financial success of the wind energy project?

A: Not empirically – in part because we don't have the financial data as it relates to "impairing" the financial success of a project. There does appear to be somewhat of a linear relationship with fatality reduction and higher raises of cut-in speed, but there must be a threshold when fatality reduction goes to 100%. We don't know what that is yet, but it is likely very costly and possibly prohibitive for many sites. We do see bat activity well above the wind cut-in speed thresholds we're looking at now (around 5-6.5 m/s), but we would have to look species by species. The balance will have to be a compromise

between what's financially feasible and incremental biological benefit. Even just feathering the blades when the wind is below the manufacturer's cut-in speed would reduce bat fatalities on the order of 70% at some sites without costing operators anything beyond operations time to implement the treatment, assuming the turbines are capable of being automated and do not require manual adjustments to curtail, which is logistically and financially challenging. Feathering blades below the manufacturer's cut-in speed is low-hanging fruit, and should be implemented at all facilities where possible.

The wild card is population size – we still have no idea what bat populations are, especially for non-cave hibernators. It doesn't hurt to reduce fatalities on the 70-90% order of magnitude, but without an idea of the population size, we have no context. But the absence of population data should not be an excuse not to employ this mitigation strategy; population data may take decades to amass if we ever decide to embark seriously on obtaining it. Curtailment data are solid and represent the only proven mitigation strategy.

ADDITIONAL QUESTIONS

The following questions were submitted but not answered until after the conference.

Q: Do you have any concerns with the new GE turbines that operate at lower wind speeds (3-4 m/s)?

A: I suspect the threats to bats are the same unless they are spinning so slowly that bats aren't killed. The real issue, of course, will be a change in the economics and increasing costs of curtailment. I still believe that can, and should, be factored into the economics upfront to ensure mitigation costs are accounted for.

Q: There seems to be huge variation from year to year in bat fatalities – e.g., 30-40 bats/turbine/year down to 7-9 bats the following year. Is it possible that cut-in speed reductions of bat fatalities may be attributable to nothing more than yearly variation?

A: No, because the data represent experiments where fatalities from fully operational turbines are compared to curtailed turbines, and the data consistently demonstrate usually 50%+ reductions in fatalities, independent of year.

Q: Do you think acoustic deterrents may be more effective for reducing Brazilian free-tailed bat fatalities given the southwest curtailment study and the fact that TABR echolocate at lower frequencies in dry climates (properties that help sound travel farther)?

A: It is possible, but it has yet to be tested. But indeed the lower humidity and lower frequency echolocations of this species are factors that would favor significant reductions based on what we found in Pennsylvania.

Estimating direct fatality impacts at wind farms: how far we've come, where we have yet to go

Presenter: Manuela Huso, *US Geological Survey*

Presentation

Authors: Manuela Huso (USGS Forest and Rangeland Ecosystem Science Center)

RESEARCH ISSUE

Measuring the potential impacts of wind farms on wildlife can be difficult and may require development of new statistical tools and models to accurately reflect the measurement process. This presentation reviews the recent history of approaches to estimating wildlife fatality under the unique conditions encountered at wind farms, their unifying themes and their potential shortcomings. Avenues of future research are suggested to continue to address the needs of resource managers and industry in understanding direct impacts of wind turbine-caused wildlife fatality.

FATALITY ESTIMATES

Estimating the number of fatalities resulting from wind turbine collisions requires us to know about the probability of detecting fatalities when we look for them. Statistics can help us refine how we think about the uncertainty inherent in our estimates, but it does not eliminate that uncertainty. How do we use what we do know to make useful estimates of what we do not know, especially when we are dealing with relatively rare events – hence small sample sizes?

The problem of estimating fatality given a certain number of observations and a known probability of detection can be illustrated with a coin toss example. If someone says they tossed a coin some number of times and observed seven heads, and then asks a colleague to guess how many times they tossed the coin, the colleague's best guess would be "14 times" – that is, the number of observations (7 heads) divided by the probability of each of those observations (50%). But in this example, it happens that the coin had been tossed only ten times.

Slide #5 illustrates the problem graphically, with the possible number of coin tosses on the x axis and the probability of each of observing 7 heads (for a given number of tosses) on the y axis. The **lower limit** for the number of times the coin was tossed is 7. The **most likely** number of tosses is 13 or 14. We can bound the range of values (number of coin tosses – or of fatalities) by establishing a confidence threshold: in this example, given 7 heads observed, there is a < 5% probability of observing 7 heads if the number of tosses was < 9 or > 21.

In conducting fatality searches, the number of carcasses we observe is analogous to the number of heads in this example. What we really want to estimate is the number of fatalities, analogous to the number of "tosses" in the example. The key point of this example is that knowing the probability of detection with exactitude does not eliminate uncertainty in our fatality estimates. That said, the greater the probability of detection, the more narrowly we can bound our "best guess" with a high level of confidence.

BIAS CORRECTION FACTORS

Prior to fatality monitoring in the Altamont Wind Resource Area, fatality observations were made without any attempt to correct for the major sources of imperfect detection:

- probability of persisting (~Carcass Persistence CP)
- *p* = probability of observing a carcass (Searcher Efficiency SE)
- *a* = fraction of carcasses in searched area

Carcass Persistence

Carcass persistence was first estimated by placing trial carcasses on the ground, and determining the fraction that persisted at the end of a seven-day interval. The problem with using this fraction as a correction factor is that it implicitly assumes that the carcasses searchers are looking for all died exactly seven days before the search occurred, which of course is not the case. A variation on this approach is to assume that, *on average*, everything died at the mid-point during the search interval. This is better, but still not very flexible.

More recent approaches involve modeling persistence time using survival analysis models, which allows researchers to calculate carcass persistence for any period. In developing a fatality estimator, Huso (2010) assumed an exponential distribution, but noted that survival time modeling (and her fatality estimator) can use a number of different distributions: e.g., exponential, Weibull, log-logistic, log-normal. Slide #12 illustrates the conceptual model of carcass persistence indicated by the different distributions. Log-normal, for example, would be appropriate for situations in which carcass removal is slow during the first few days, and then speeds up – indicative, perhaps, of olfactory scavengers that are not attracted to fresh carcasses. By contrast, the Weibull distribution gives a better fit in situations where the rate of carcass removal is highest immediately following a fatality, but then tapers off after a few days.

The point is not that one distribution is "better" but that different distributions may be a better fit for different species and different weather and scavenging conditions. Ideally, the estimator used to correct fatality observations for carcass persistence should have the flexibility to be used with whichever distribution is most appropriate.

Searcher Efficiency

The method used to measure searcher efficiency (SE – sometimes referred to as searcher *proficiency*) is fairly consistent. Carcasses are placed on a search plot, and the number of carcasses placed is divided by the number of carcasses found. The debate is over how the resulting correction factor is used.

Shoenfeld (2004) assumes that SE is both constant and independent from one search to another. The implication is that, if searchers look for a carcass enough times and the carcass persists, eventually a searcher will find it. We have some empirical evidence to the contrary; as the CalWEA study (presented by Warren-Hicks et al.) demonstrated, there are some carcasses that searchers just never find. Where this is the case, the Shoenfeld estimator will *underestimate* the number of fatalities.

The estimator Huso proposed assumes the opposite: if searchers miss a carcass during one search, that carcass will never be found during subsequent searches. In cases where search intervals are short and carcasses more likely to persist from one search interval to the next, this assumption is less likely to hold true, and will result in *overestimating* the number of fatalities.

Warren-Hicks and Wolpert (2012) are proposing an estimator that incorporates a "bleed-through" factor, that is, the probability that a carcass that is missed during one search remains to be detected during a subsequent search. This proposal addresses the fact that, depending on the species, the site conditions, the search interval and other factors, carcasses not found during one search may be found during a subsequent search, but that the probability of a searcher detecting a persistent carcass will not be constant from one search interval to the next.

Area Searched

The density of carcasses within a search plot is not constant, so *where* we search matters.

One approach is to use a ratio estimator. The road-and-pad correction factor described by Michelle Sonnenberg is an example of this approach: fatalities found on the road-and-pad only is compared with the total number of fatalities found on an entire cleared search plot, and the resulting ratio is used to adjust observations made at other turbines looking at the road-and-pad only. Another approach is to model carcass density as a function of distance to the turbine, but because distance is not the only factor, modeling the density of distribution around the turbine is somewhat more complex [slide #14].

Both of these exercises are designed to facilitate more efficient fatality monitoring.

THE PROBLEM OF VARIANCE

Variance is the measure of precision of the estimate. As noted in the coin toss example above, we can never be certain that our estimate is accurate. However, we *can* be certain of the variance around our estimate. If that variance – our confidence interval (CI) – is too large, then the estimate is not useful. For example, the early estimates of raptor fatalities in the Altamont had such large variance that the CI included negative numbers (e.g., 82 raptor fatalities $\pm$ 451).

The coin toss example [slide #5] illustrated the importance of setting a lower limit; there cannot be a negative number of fatalities. "Incidental" finds outside the search plot can be useful for establishing a lower limit. For example, if no fatalities are found in the search plot(s), but two incidental fatalities are found at unsearched turbines, then 2, rather than 0, should become the lower limit of our confidence interval.

Bootstrapping

It is not easy to write an equation for variance of the inverse of a product of random variables. Wolpert and Warren-Hicks have proposed a closed-form solution for calculating variance, but other closed-form solutions that have been published almost always result in lower limits that are below zero; and in that case I would argue that it is better to use bootstrapping to calculate the variance.

CONCLUSIONS & NEXT STEPS

If someone provides an estimate without a variance, and without being transparent about how that variance was calculated, that estimate should not be considered useful.

Next Steps - Analysis

In addition to improving the fatality estimates we make going forward, the more modern estimators can be used to re-analyze existing data, potentially resulting in a better understanding of cumulative impacts and regional patterns. In either application, it is important for researchers to be aware of – and critical of – the assumptions that underlie our models. For example:

- Are the surrogate species being used in carcass persistence and searcher efficiency trials appropriate surrogates for the species of interest?
- Are SE & CP factors derived from nearby sites or previous years appropriate to the monitoring observations to which they are being applied?

These are questions for biologists to answer. As for applying fatality estimates to decision-making, it is most important to be critical of how we use what we measure to predict what is likely to happen. Remember that the precision of a confidence interval about a mean should not be confused with being able to predict with any precision the value for a given site.

Next Steps - Estimators

All the estimators we've looked at are Horvitz-Thompson estimators, and there is a lot of work being done to improve these estimators by reflecting more realistic assumptions. This includes the work of Wolpert & Warren-Hicks on searcher efficiency; Bispo on carcass persistence and removal rates; Erickson et al. on the combination of SE and CP; and Hull & Muir, Huso & Dalthrop, Sonnenberg et al., Ong et al., and Kosciuch et al. on search area.

There is a new (non Horvitz-Thompson) class of estimators specifically designed to help us with estimates of rare events. In the case of rare events – such as Golden Eagle or Indiana Bat fatalities – we may expect to find zero fatalities, but what we need to know is the *probability* of a significant non-zero number of fatalities, given zero detections. There is some useful work being done in this area by Peron & Nichols, Huso & Dail, and Dalthorp & Huso.

Next Steps – Study Protocols

From a statistician's perspective, it is important that researchers have standardized methods for determining what fraction of turbines to search, what the appropriate search interval should be, trial sample sizes, etc. To the extent that we can provide researchers with study design tools that facilitate consistent decision-making about these choices, our work will benefit.

Fatality monitoring is expensive. Methods such as the road-and-pad approach that allow us to search high probability-of-detection areas and high density areas, and then extrapolate to the rest of the area around the turbines, have high value.

Finally, we will need completely different approaches to monitoring fatality at offshore wind energy sites. There is work being done with impact sensors (Delprat et al., Suryan et al.), and with monitoring cameras (Cryan & Gorreson, Bart et al.

"Statistics means never ~~having~~ being able to say you're certain."

Questions & Discussion

Q: How would you go about estimating fatality when you have zero carcasses found?

A: That's a whole other presentation! Briefly, you can go back to the original analogy of estimating fatality as a parlor game: I can look at the probability of flipping zero heads given that I flipped the coin 0, 1, 2, 3, 4, etc. number of times. Recall, the number of heads is the number of observed carcasses and the number of flips is the actual fatality. If I observe zero heads, the maximum likelihood estimate for number of flips is 0.

However, depending on what my detection probability is, or in this analogy, the probability of flipping a heads is, the probability that I actually flipped one or more times (or had one or more actual bird fatality) may be quite significant. So, if I detected zero birds, but the probability of detecting a carcass is only 15%, then my confidence interval would extend all the way from 0 to perhaps 20 potential carcasses. That's too many for us to have useful information regarding take. If we can get a probability of detection that's bigger than that, like 50%, then when we observe zero fatalities we might be able to say with 95% confidence that there are fewer than, say, four undetected carcasses out there.

This is not the Horvitz-Thompson approach, but given searcher efficiency, we can estimate the likelihood that estimated mortality is within a certain range, even with zero fatalities observed.

Q: From your experience with the data on bats, do you think it would be better to increase the number of turbines searched and use fixed-radius plots?

A: In an unpublished study, we looked at model variation based on detection probability, and sample variance (fraction of turbines searched) – classic statistical response: you need more samples. Search more turbines, don't search as often. Daily searches are important only for research purposes, that is, if you are looking for correlation with other data, or if carcass persistence is extremely low. If you are not doing that, there is usually little reason to be out there looking every day, unless scavenging rates are extremely high.

Q: Why is the density of fatalities higher near the turbine tower, rather than the outer portion of the blade?

A: Some people have used ballistics to model the distribution of carcasses under wind turbines. Keep in mind that even if a bat is hit by the tip of the blade (as opposed to colliding with the tower), the rotating blade is at right angles to the tower twice in each rotation, so there is a reasonable chance that they would fall near the tower as well. Also, the area within a ring around a turbine quadruples with each doubling of the radius, so you might have twice as many bats landing between 10 -20 m as 0-10m, yet the density (bats/m^2) in the closer ring will be higher.

Concluding Discussion

The meeting closed with an open brainstorming session for all attendees to consider and share their key takeaways from the meeting. The following list summarizes points raised during this session in topic categories.

DATA NEEDS

The lack of paired pre- and post-construction data makes it difficult to do the kind of meta-analysis that we want to be able to do.

Consistency and reliability of data still needs to be emphasized. There need to be standardized approaches to data gathering so that we know data are reliable and can compare data from one site to another.

SHOULD FATALITY MONITORING BE A SPENDING PRIORITY?

Regarding the discussion of post-construction monitoring statistics, it is nice to hear that daily searches are not necessarily needed. Some of the money we spend on that could be better spent on conservation efforts.

The Wind Energy Guidelines workshop presented a tiered approach, with more focus on species of concern at a particular site. Yet the fatality monitoring presentations we have heard focused on conducting a full-year of fatality monitoring on every species. Can we start tailoring our fatality monitoring to focus on species of concern – seasonally for bats, or whatever it may be at a particular site? There tends to be agency inertia towards doing the same thing we've been doing.

Abby: It sounds like we may be getting enough information about certain things that we could convene a discussion about approaches that answer questions relevant to Tier 3.

PROJECT v. LANDSCAPE-LEVEL

Mortality estimates need to be placed in context. We need to have better estimates of population size, *and* we need to know whether this mortality is additive or compensatory – all these things matter in terms of whether or how much mortality matters for a given species.

A counterpoint: more species-specific studies really provide ground-breaking practical mitigation measures we can take home, that our engineers can start using right away.

We are seeing the fruits of collaborative labor with BWEC's work as well as with the grassland birds. Short-term research has to link into longer-term research. For example, Sandercock's prairie-chicken study was one situation in a fragmented landscape. At some point there will be an impact. This kind of work does need to be put in the context of landscape level development, which requires even more collaboration, especially to determine the effectiveness of mitigation strategies on a project and landscape level.

MITIGATION

The quality of the work that is going on now is amazing, but we have to prioritize this work. Two important items are:

1) Eagles – we need a better understanding of how/why eagles use the landscape and how that relates to siting and mitigation. For Golden Eagles, the highest research priority is to identify methods and technologies that help us do smart-from-the-start siting. We also need to figure out resource equivalents so that we can figure out more mitigation measure options.
2) Sage grouse – we are finding that prairie-chickens are not so strongly affected by wind development, but sage grouse are. The problem for sage grouse is not just wind energy development, but to develop wind energy, we have to figure out how to mitigate those impacts.

We are starting to get at answers but would add to the above list the need to get beyond direct impacts and displacement. Ultimately, the critical issue is fragmentation of eco-systems and native intact systems.

Understanding the mechanism of avoidance in specific animals can help us understand how to mitigate. We need to take the research results a step further to create decision support tools: where to site, where to most effectively mitigate, and with the best, most ecologically and economically effective measures. Tricia Miller's Golden Eagle study is a good example – we have the tools to do spatial modeling, work with nonprofits and developers to guide development.

HOW DOES RESEARCH INFORM INDUSTRY PRACTICES?

The research presentations are very informative, but how is this work informing what the industry is doing in terms of siting and operations?

We are seeing a lot of evidence for the effectiveness of curtailment – we are seeing reductions even just by feathering below normal cut-in speeds. What does the industry have to say about the likelihood of a volunteer initiative to keep common species common through volunteer implementation of these curtailment practices on a widespread basis? How hard would that be to do? What would be involved?

State regulators focus on a wide range of issues, noise, visual impact, etc. It is important that industry be able to inform regulators so that we are better equipped and have a common understanding as we work among ourselves.

We should have turbine manufacturers here at this meeting, to be able to understand what happens at cut-in speed.

OFFSHORE

Regarding what the Europeans are doing with offshore wind – collisions are in fact a showstopper, at least in UK waters. It is true that it is not easy to get knowledge from Europe, because we are not well organized that way. But we did hold a first European conference in Norway last year, inspired by the 2010 Denver meeting, and will meet in Sweden next year. The US can learn a lot from Europe about offshore research; you do not have to start from scratch. There is also a lot that can be learned from the offshore oil industry.

When it comes to knowing what's happening out there in North Sea in the middle of winter, we can model all you like, but what is needed is to get out there and see what is happening. Joint industry projects to look at barrier effects, marine mammals.

Smölna was mentioned – we have a good laboratory in place, and have been conducting research there on White-tailed and Golden Eagles since 2005. We are dealing with low numbers, but with GPS and video equipment we can really see how birds behave, how they respond to visual or audio deterrents. We had a small presentation on the work at Smölna at the 2010 research meeting, and hope to come back next time with bird deterrent information from our research there. When we know we have a system that works on shore, we can adapt it to offshore.

BIG PICTURE v. PROJECT LEVEL?

We talk about the details of impacts and mitigation without thinking why we're doing this in the first place. As scientists and as an ex-agency person, get so focused on the trees – need to keep in mind the big picture, as Taber Allison's talk reminded us.

The Federal government knows that this president supports renewable energy. There is always a tension in terms of compliance with federal laws. It is a very public process, and sometimes that creates delays. The best way to get wind power on the ground is for industry to collaborate with regulators, and that is occurring, but if we trust each other, we can move quickly on compliance. It slows things down when companies try to game the process, because it undermines trust.

The three Habitat Conservation Plans out there now hopefully will provide a model going forward.

Posters

The posters presented at the meeting are listed below. For posters that were available for posting, links to these posters on the NWCC website are included. Some posters contain proprietary or preliminary information and are not available for distribution at this time.

Assessing Risk to Birds and Bats

Comparison of banding, acoustic, and NEXRAD radar data for studying passerine migration in upstate New York: A complementary approach (#1)
E.M. Adams, K.A. Williams, C. Anderson, J. Fiely, R. Lambert, D. Yates (Biodiversity Research Institute); P.B. Chilson, C.M. Kuster, (School of Meteorology and Atmospheric Radar Research Center, University of Oklahoma)

The role of population modeling in risk assessment at wind energy facilities (#4)
Robert A. Pastorok, Damian V. Preziosi, **Matthew E. Behum** (Integral Consulting)

Reproductive success of birds in relation to wind turbine proximity in Iowa (#24)
Molly K. Gillespie, Stephen J. Dinsmore (Iowa State University Department of Natural Resource Ecology and Management)

Bird responses to wind turbine proximity in Iowa (#25)
Molly K. Gillespie, Stephen J. Dinsmore (Iowa State University Department of Natural Resource Ecology and Management)

Understanding migration corridors along the Great Lakes (#26)
Jeffrey Gosse, David Larson, Daniel Nolfi, Nathan Rathbun, Rebecca Horton, Tim Bowden, Erik Olson (U.S. Fish and Wildlife Service)

Effects of wind energy development and ranch management on Greater Prairie-Chickens in the Flint Hills of Kansas (#32)
Greg Johnson (WEST, Inc.); Jerry Roppe (Iberdrola Renewables)

Bird and bat movement patterns and mortality at the Montezuma Hills Wind Resource Area, California (#33)
Dave Johnston, Judd Howell, Scott Terrill, Jim Castle, Nellie Thorngate, Jeff Smith (H. T. Harvey & Associates); Todd Mabee (ABR Inc.)

A comparison of pre- and post-construction avian use at a northern Arizona wind energy facility (#37)
Thomas J. Koronkiewicz, L. Dickson, E. Koster (SWCA Environmental Consultants)

A critical review of the effects of tall structures on birds (#38)
Karl Kosciuch, Jason Jones (Tetra Tech); Kim Walters (HEMMERA)

Short-term impacts to Greater Sage-Grouse from wind energy development (accompanies a presentation) (#41)
Chad W. LeBeau (Department of Ecosystem Science and Management, University of Wyoming & WEST, Inc.); Jeffrey L. Beck (Department of Ecosystem Science and Management, University of Wyoming); Gregory D. Johnson (WEST, Inc.); Ryan M. Nielson (WEST, Inc.); Matt J. Holloran (Wyoming Wildlife Consultants, LLC)

Minnesota Department of Natural Resources guidance for commercial wind energy projects (#44)
Kevin Mixon (Minnesota Department of Natural Resources)

The conservation of airspace and habitat in a major bird migration corridor (#53)
Anna Peterson (Conservation Biology Program, University of Minnesota); Gerald J Niemi (Natural Resources Research Institute, University of Minnesota); Douglas H Johnson (U.S. Geological Survey, Dept. of Fisheries, Wildlife, and Conservation Biology, University of Minnesota)

Research priorities for wind energy and migratory wildlife (#54)
Martin D. Piorkowski (Arizona Game and Fish Department); Ronald W. Rohrbaugh, Andrew J. Farnsworth, Kenneth V. Rosenberg, John W. Fitzpatrick (The Cornell Lab of Ornithology); Michael Fry (U.S. Fish and Wildlife Service)

A synthesis of bird and bat fatalities in Quebec wind facilities between 2008 and 2011 (#65)
Junior A. Tremblay (Ministère des Ressources naturelles et de la Faune)

Estimating Fatalities of Birds and Bats

"Catch you scavenger!" Camera trapping of carcass removal by scavengers at two Portuguese wind farms (#7)
João Paula, Pedro Pereira, **Joana Bernardino**, Hugo Costa, Miguel Mascarenhas (Bio3)

Siting wind farms for wildlife: predicting bird and bat fatality risk at prospective wind farm sites using acoustic detectors (#28)
Kevin Heist (University of Minnesota Conservation Biology Graduate Program); Douglas H. Johnson (Northern Prairie Wildlife Research Center)

A projectile motion modeling approach for estimating carcass distributions of avian and bat fatalities at wind farms (#49)
Adam Miyamoto, **Ling Ong**, Chad Cross (SWCA Environmental Consultants); Dave Cowan, Robert Roy, Greg Spencer, Mitchell Craig (First Wind)

Post-Construction Monitoring at Arizona's First Commercial Wind Farm (#63)
Joel Thompson, Kimberly Bay (WEST, Inc.)

Improving methods for estimating fatality of birds and bats at wind energy facilities: evaluation of accuracy of existing equations, including assumptions and statistical bias (#68)
Robert Wolpert (Duke University); **William Warren-Hicks** (EcoStat/Cardno Entrix), Brian Karas (EcoStat, Inc.), Loan Tran (EcoStat, Inc.); James Newman (Normandeau Associates)

Raptors and Wind Energy (Including Eagles)

Long term survey of wind farms impacts on Common Kestrel's populations and definition of an appropriate mitigation plan (#8)
Ana Cordeiro, **Joana Bernardino**, Hugo Costa, Miguel Mascarenhas (Bio3)

Implementation of compensation and offset measures for large birds of prey (#9)
Joana Santos, Ana Teresa Marques, Anabela Paula, **Joana Bernardino**, Miguel Mascarenhas, Hugo Costa (Bio3)

High-resolution modeling of updrafts to investigate Griffon Vulture (*Gyps fulvus*) collision risk with wind turbines (#16)
David Brandes (Department of Civil & Environmental Engineering, Lafayette College); Luis Barrios (Greensigns S.L.); Alejandro Rodríguez (Department of Conservation Biology, Estación Biológica de Doñana CSIC)

Ridgetop modeling: identifying critical raptor migration corridors for conservation and wind development planning (#22)
Markus Mika, **Kylan Frye Christensen**, Steven J Slater, Shawn Hawks (HawkWatch International)

Flight behavior of Griffon Vultures near wind turbines in Tarifa, Spain (#17)
Brian A. Cooper, Robert H. Day (ABR, Inc.); Richard C. Curry (Curry & Kerlinger LLC)

Impacts of wind turbines on buteo hawk fledgling mortality in the Columbia Plateau Ecoregion (#36)
Patrick Kolar, Marc Bechard (Department of Biology Boise State University)

Bald Eagle flight path data comparison (#39)
Scott Schubbe Krych, Bruce Jon Moreira (HDR Engineering)

Raptor behavior at a wind power project in Oaxaca, Mexico: implications for U.S. species (#42)
Todd J. Mabee (ABR Inc.); Rafael Villegas (Instituto de Ecologia)

Bald Eagle breeding habitat model (#57)
Jon Schubbe, Sean Tuohey, Scott Krych, Bruce Moreira (HDR Engineering)

Bald eagle behavior before and after construction of the Pillar Mountain Wind Project at Kodiak, Alaska, and its effect on modeled collision risk(#58)
Lynn Sharp, Christina Herrmann, Robert Friedel, Chris Farmer (Tetra Tech); Richard MacIntosh

A roadmap for mitigating raptor risk at windfarms: application of advanced avian radar technology (#67)
Karen Voltura, Adam Kelly, Tim West, Jesse Lewis, Jenny Davenport (DeTect, Inc.); Andreas Smith, Javier Vidao (DeTect EU)

Bats and Wind Energy: Assessing Risks and Impacts

Can resource and activity hotspot mapping predict bat fatalities at wind turbines? (#5)
Victoria J. Bennett, Amanda M. Hale (TCU)

Can bat fatality be predicted from bat acoustic activity within the rotor-swept zone? (#6)
Victoria J. Bennett, Amanda M. Hale (Dept of Biology, TCU); Crissy Sutter, Alison Costello (Normandeau Associates); Kevin W. Heist (Conservation Biology Graduate Program, University of Minnesota)

First approach to pre-construction bat monitoring at 5 South African Wind Farms: initial results and potential issues at a regional level (#10)
Presenter: **Joana Bernardino**; Authors: Karen Jodas, Robyn Kadis (NatureCounts); Bárbara Monteiro, Miguel Mascarenhas (Bio3)

Variation in bat activity in Portuguese uplands: effects of wind speed, temperature and moonlight in different biotopes (#11)
Bárbara Monteiro, Rita Ferreira, Joana Santos, Teresa Marques, **Joana Bernardino**, Miguel Mascarenhas, Hugo Costa (Bio3)

Meteorological data and bat activity: developing conservation measures for wind energy (#14)
Tim Bowden, David Larson, Jeffrey Gosse, Daniel Nolfi, Rebecca Horton, Nathan Rathbun, Erik Olson (U.S. Fish and Wildlife Service)

Reduction of *Myotis* activity relative to total bat activity in long-term acoustic bat surveys pre- and post-exposure to white nose syndrome (#15)
Sarah Boyden, Trevor Peterson, Kristen Watrous (Stantec)

Use of pre-construction acoustic bat and meteorological data to design and forescast site-specific curtailment scenarios (#18)
Trevor Peterson, **Jessica Costa**, Kristian Omland (Stantec Consulting)

The effects of weatherproofing on acoustic bat detection (#19)
Allison Costello, Lauren Hooton, Crissy Sutter (Normandeau Associates)

Comparing the efficacy of various monitoring technologies for the detection of bats on wind farms (#23)
Presenter: **Robert Gierschick**; Authors: Ian Agranat, Sherwood Snyder (Wildlife Acoustics)

Can genetics and stable isotopes be used to gain geographical insights into the seasonal movement patterns and population structure of Eastern Red Bats (*Lasiurus borealis*)? (#27)
Amanda M. Hale, Jennifer M. Korstian, Victoria, J. Bennett, Dean A. Williams (Dept. of Biology, TCU)

Novel approach to bird and bat mortality reduction using high intensity ultraviolet lights (#55)
Donald Ronning (Lite Enterprises, Inc); Steve Pelletier, Trevor Peterson (Stantec Consulting Services)

Relating post-construction bat activity and fatality at a Pennsylvania wind power project (#56)
Cris Hein, **Michael Schirmacher** (Bat Conservation International); Manuela Huso (US Geological Survey Forest and Rangeland Ecosystems Science Center, Forest Sciences Lab); Ed Arnett (Theodore Roosevelt Conservation Partnership)

Activity rates and call quality by full-spectrum detectors (#59)
Donald I. Solick, Christopher S. Nations, Jeffery C. Gruver (WEST, Inc.)

Indiana Bat home range size and habitat use in a midwestern project area dominated by agriculture (#60)
Bradley J. Steffen, Andrew R. Carson (BHE Environmental, Inc.); Timothy C. Carter, (Department of Biology, Ball State University)

A data visualization tool for incorporating migratory bat records into wind energy development siting decisions (#69)
Theodore J. Weller (USDA Forest Service, Pacific Southwest Research Station)

Planning for Cumulative Impacts

Compliance Management System (#3)
Tina Bartunek, Nadine May (Iberdrola Renewables)

Wind & Biodiversity project: integrated solutions for managing biodiversity in wind farms (#12)
Miguel Mascarenhas, Hugo Costa, **Joana Bernardino** (Bio3); José Vieira, Carlos Bastos (IEETA – Instituto de Engenharia Electrónica Telemática de Aveiro); Maria João Pereira, Carlos Fonseca (Departamento de Biologia & CESAM, Universidade de Aveiro)

Wind development and wildlife mitigation: a primer (#31)
Anne Jakle (Ruckelshaus Institute of Environment and Natural Resources, University of Wyoming)

Facilitating progress: wildlife monitoring and mitigation measures for wind energy in the United States (#34)
Nathan Jones, Liba Pejchar (Colorado State University)

APLIC recommendations for power pole configurations at wind energy projects (#43)
Andrew Milner, Jerry Roppe (Iberdrola Renewables); Sherry Liguori (PacifiCorp); Mike Best (Pacific Gas and Electric), Jim Burruss (Cardo Entrix), and Jim Lindsay (Florida Power and Light)

Part 2: Collaborative landscape conservation approach: modeling potential impacts to migratory Whooping Cranes from wind power development (accompanies a presentation) (#47)
Christopher S. Nations, Shay Howlin, David P. Young (WEST, Inc.)

Part 1: Collaborative landscape, conservation approach, and benefits of the of the Great Plains wind energy HCP (GPWE HCP) (accompanies a presentation) (#46)
Karen Tyrell, Kely Mertz (BHE Environmental); Abby Arnold, Elana Kimbrell (Kearns & West)

Offshore Wind Energy: Siting and Assessment

Guidelines for offshore renewables in the Portuguese Pilot Zone based on a pre-construction assessment (#13)
Helena Coelho, Rita Ferreira, Sandra Rodrigues, **Joana Bernardino**, Miguel Mascarenhas, Hugo Costa (Bio3); Ruth De Silva, Chris Pendlebury, Richard Walls (Natural Power Consultants)

Monitoring and mitigation alternatives for protection of North Atlantic Right Whales during offshore wind farm installation (#20)
Presenter: **Corey Duberstein** (Pacific Northwest National Laboratory); Authors: Andrea Copping, Tom Carlson, Shari Matzner, Michele Halvorsen, Jessica Stavole (Pacific Northwest National Laboratory)

Avian risk assessment for offshore wind projects (#48)
Christopher S. Nations, Dale M. Strickland (WEST, Inc.)

Update on current progress of offshore bat research activities in Atlantic and Great Lakes regions (#50)
Steve Pelletier, Trevor Peterson, Kristian Watrous, Sarah Boyden (Stantec)

Integrated ecological monitoring plans (IEMP) for offshore wind projects (#52)
Chris Pendlebury, Jane Lancaster, Sarah Canning, Kate Grellier, Richard Walls (Natural Power Consultants)

Selection of mixed effects models for bird and marine mammal analysis undertaken for Robin Rigg offshore wind farm, Solway, Scotland (#51)
Chris Pendlebury, Gillian Lye, Sarah Canning, Richard Walls (Natural Power Consultants); Sally Shenton (EON Climate & Renewables)

The Mid-Atlantic baseline studies project: study design and results to date, with a focus on high-definition aerial surveying and video analysis (#70)
Kathryn A Williams, Iain J Stenhouse, Evan M. Adams (Biodiversity Research Institute), Andrew Webb (HiDef Aerial Surveying, Ltd.), Emily Connelly (Biodiversity Research Institute)

Offshore wind development in the United States: a review of known and hypothesized impacts to wildlife and current research needs (#71)
Kathryn A Williams, Wing Goodale (Biodiversity Research Institute)

Emerging Issues

Integrating sportsmen's values and outdoor-based economic analyses into landscape-scale wind energy planning (#2)
Ed Arnett, Neil Thagard, Tom Franklin, Steve Belinda, (Theodore Roosevelt Conservation Partnership)

Whooping and Sandhill Crane use monitoring at five operating wind facilities in North and South Dakota (#21)
Clayton Derby, Terri Thorn, Melissa Wolfe (WEST, Inc.)

The impacts of wind power on terrestrial mammals – a review (#29)
Jan Olof Helldin (Swedish Biodiversity Centre, SLU, Uppsala); Jens Jung (Dept of Animal Environment and Health, Swedish SLU,Skara); Jonas Kindberg (Dept of Wildlife, Fish and Environmental Studies, SLU,Umeå); Niklas Lindberg (Enetjärn Natur, Umeå); Wiebke Neumann (Dept of Wildlife, Fish and Environmental Studies, SLU, Umeå); Mattias Olsson (EnviroPlanning, Gothenburg); Anna Skarin (Dept of Animal Nutrition and Management, SLU, Uppsala); Fredrik Widemo (Swedish Association for Hunting and Wildlife Management, Nyköping)

The impact of energy sprawl on biodiversity and ecosystem services: a landscape scale assessment in Colorado and Wyoming (#35)
Nathan Forrest Jones, Liba Pejchar (Colorado State University)

Whooping and Sandhill Crane behavior at an operating wind farm (#45)
Laura Nagy, Karl Kosciuch, Jenny Taylor (Tetra Tech)

Ecological impacts of wind farms on mammalian mesocarnivores (#61)
Brian P. Tanis, Elmer J. Finck (Fort Hays State University, Department of Biological Sciences)

Winter survival risk for pronghorn encountering wind energy development in south-central, Wyoming (#62)
Katie L. Taylor, Jeffrey L. Beck (Department of Ecosystem Science and Management, University of Wyoming)

Black bear use response to a wind energy facility in Vermont (#64)
David Tidhar, Cecily Costello, Trent McDonald (WEST, Inc.); Forrest Hammond (Vermont Fish and Wildlife Department, Vermont Agency of Natural Resources)

Additional Resources

The following can be found on the NWCC's Wind Wildlife Research Meeting IX webpage:

- Final Meeting Program
- Presenter Bios
- Presentation and Poster Abstracts
- Powerpoint Presentations (pdf)
- Posters (pdf)

To learn more about NWCC, please visit: www.nationalwind.org.

To learn more about AWWI, please visit: www.awwi.org.