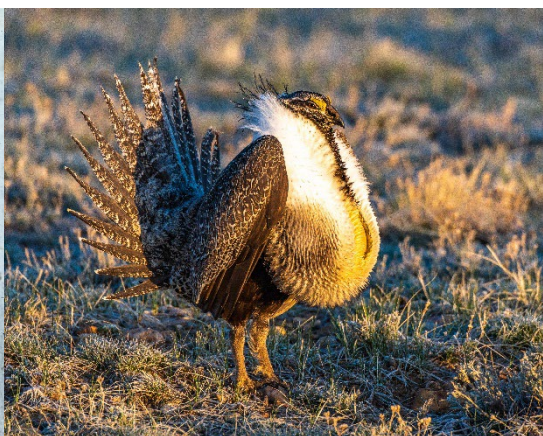**12th**

NWCC
WIND WILDLIFE
RESEARCH MEETING

St. Paul, Minnesota • November 27–30, 2018

PRESENTED BY AWWI

Meeting Proceedings

Published March 2019

Prepared by Susan Savitt Schwartz

Acknowledgments

About the NWCC

The National Wind Coordinating Collaborative (NWCC) was formed in 1994 to provide a neutral forum for a wide range of stakeholders – including government agencies, industry, conservationists, academics, and the general public – to pursue the shared objective of developing environmentally, economically, and politically sustainable commercial markets for wind power in the U.S. Today, the activities of the NWCC focus solely on interactions between wind energy and wildlife. The NWCC is a forum for outreach and collaboration on understanding interactions and solving challenges for wind energy and wildlife, and as needed, facilitates coordinated activities focused on establishing research priorities and supporting research on species of particular interest for wind energy development. The NWCC is funded by the U.S. Department of Energy's Wind Energy Technologies Office through the National Renewable Energy Laboratory (NREL) and is facilitated by AWWI, an independent non-profit organization.

Abstract

Wind energy is recognized as a key component of reducing greenhouse gas emissions from energy production. By generating electricity with lower carbon emissions and water use than fossil fuels, wind energy benefits birds, bats, and many other animal and plant species. Yet wind energy development and operation, like most human activities including other forms of energy generation, can pose risks to wildlife. These proceedings document current research pertaining to wind energy-related wildlife fatalities; habitat and behavioral impacts at the project level as well as cumulative and landscape-scale impacts; and avoidance, minimization, and mitigation strategies and technologies. As the window of opportunity to prevent the most catastrophic consequences of climate change narrows, these proceedings reflect discussions among stakeholders – scientists, wildlife agencies, wind energy developers, and conservation organizations – about how to balance the need to understand and mitigate wind energy impacts with the need to expedite responsible development of wind energy.

Collaborative by the American Wind Wildlife Institute, Washington, DC, Susan Savitt Schwartz, ed. 168 pp.

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Disclaimer

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Table of Contents

Abbreviations

American Wind Energy Association (AWEA)
American Wind Wildlife Institute (AWWI)
American Wind Wildlife Information Center (AWWIC)
Artificial Intelligence (AI)
Bald and Golden Eagle Protection Act (BGEPA)
Bats & Wind Energy Collaborative (BWEC)
Before-After-Control-Impact (BACI)
Bird Conservation Region (BCR)
Breeding Bird Survey (BBS)
Bird Studies Canada (BSC)
Bureau of Land Management (BLM)
Bureau of Ocean Energy Management (BOEM)
Canadian Wind Energy Bird and Bat Monitoring Database (WEBBMD)
Ecosystem-based management (EBM)
Eagle Conservation Plan (ECP) and ECP Guidance (ECPG)
Endangered Species Act (ESA)
Evidence of Absence (EoA)
Generalized Estimator of Mortality (GenEst)
Gigawatt (GW)
Global positioning system (GPS)
Incidental take permit (ITP)
International Bird Area (IBA)
International Energy Agency (IEA)
International Panel on Climate Change (IPCC)
Megawatt (MW)
Migratory Bird Treaty Act (MBTA)
Monitoring Avian Productivity and Survivorship (MAPS)
National Environmental Protection Act (NEPA)

National Oceanic and Atmospheric Administration (NOAA)
National Renewable Energy Laboratory (NREL)
National Wind Coordinating Collaborative (NWCC)
Next generation radar (NEXRAD)
Non-governmental organization (NGO)
Northern Prairie Wildlife Research Center (NPWRC)
Offshore Renewable Development (ORD)
Playa Lakes Joint Venture (PLJV)
Point Count Surveys (PCS)
Post Construction Fatality Monitoring (PCM)
Production tax credit (PTC)
Renewable portfolio standards (RPS)
Risk-based management (RBM)
Rotor-swept zone (RSZ) or area (RSA)
Supervisory control and data acquisition (SCADA) system
The Nature Conservancy (TNC)
Ultrasonic Acoustic Deterrent (UAD)
Unmanned Aerial Device (UAD, or drone)
United States Department of Agriculture (USDA)
United States Department of Energy (DOE)
United States Department of Fish and Wildlife Service (USFWS or the Service)
United States Geological Survey (USGS)
Western Golden Eagle Team (WGET)
White nose syndrome (WNS)
Wind energy area (WEA)
Wind resource area (WRA)
[IEA's] Working Together to Resolve Environmental Effects of Wind Energy (WREN)

Opening Remarks

Retrospective and Looking Ahead

Abby Arnold
Executive Director, American Wind Wildlife Institute

Welcome, and thank you all for attending this 12th Wind-Wildlife Research Meeting. Building on 25 years of collaboration in wind and wildlife science, we now:

- Have collected and are analyzing troves of data that dramatically improve our understanding of risk and uncertainty;

- Know the right questions/hypotheses to pursue;

- Have proven solutions/strategies to minimize impacts that even ten years ago we could not have dreamed of.

Around the AWWI table we are increasingly focused on the question, *what is the best use of resource investments: investing in monitoring, or in applying those dollars to species conservation outcomes?*

At this meeting you will hear:

- That the American Wind and Wildlife Information Center (AWWIC), a data base of public and confidential data representing over 22% of all operating assets as of 2016, can help us target when and evaluate why impacts to avian and bat species are occurring;

- About use of artificial intelligence, machine learning, and improved tools and strategies to minimize impacts; and

- About a recommitment to invest in research to minimize impacts.

Why is all of this work even more critical today than ever before? We are here because of our commitment to conservation and to find solutions to wind's impacts on wildlife – and, at the same time, because many of us understand that we face the biggest conservation challenge: impacts of climate on avian and bat and other wildlife species.

- Last fall the United Nations' Intergovernmental Panel on Climate Change (IPCC) published a special report, detailing the impacts we can expect to see with a [Global Warming of 1.5°C](#) and noting that: "*If the current warming rate continues, the world*

would reach human-induced global warming of 1.5°C around 2040."[1]

- Just last week [Friday, Nov. 23, 2019], 13 federal agencies issued the Congressionally-mandated fourth *National Climate Assessment*, an update from 2014. The authors report that global warming "is transforming where and how we live and presents growing challenges to human health and quality of life, the economy, and the natural systems that support us." And they conclude that "humans must act aggressively to adapt to current impacts and mitigate future catastrophes "to avoid substantial damages to the U.S. economy, environment, and human health and well-being over the coming decades."

  Dr. Gary Yohe, a professor of economics and environmental studies at Wesleyan University and past AWWI Board member, served on a National Academy of Sciences panel that reviewed the Climate Assessment:

  > *"The impacts we've seen the last 15 years have continued to get stronger, and that will only continue,"* and *"We have wasted 15 years of response time. If we waste another five years of response time, the story gets worse. The longer you wait, the faster you have to respond and the more expensive it will be."* - Gary Yohe, quoted in the Washington Post[2]

- The 2018 *DNV-GLs Energy Transition Outlook* projects that wind and other renewables – North America and worldwide – are not expected to ramp up enough to meet the carbon reduction goals set out in the Paris Accord.

This is personal for many of us. I was raised in Santa Monica, California, near Malibu – just one of several California communities hit by incredibly destructive fires these past two years. In my adopted state, Alaska, I started seeing these changes years ago: the northern coastline facing the Arctic Circle is calving huge blocks of *land* – not just ice – and in Juneau, where we have a house, the Mendenhall Glacier is losing the equivalent of two football fields a year.

At our meeting four years ago, we heard in an opening panel from the Assistant to the Director of the US Fish and Wildlife Service that we need to think about climate. But unlike years past, we now have a loud call for urgency. We *are* running out of time. During the final session of this conference, we ask each of us to think about tradeoffs. As we are making historic progress in developing solutions to wind and wildlife conflicts, we need to balance the research questions with steps to ensure the future of wildlife and the planet that supports us all.

I remain optimistic; we can figure this out. As you listen to the studies the next three days, think about what you can do, and what we can learn. Even with imperfect knowledge, we can promote conservation and sustainable wind and other renewables. Let's use what we know as

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[1] https://www.ipcc.ch/sr15/
[2] Washington Post, "Major Trump Administration Climate Report Says Damages Are Intensifying Across Country," November 23, 2018.

we continue to learn how to minimize impacts. Let's think about how we can manage uncertainty so that we make good decisions for the future to mitigate our impacts.

This is a dynamic time – full of potential, with access to new technologies. Through continued collaborative science we have the power to address these issues if we can remain open and allow for some risk, be smart and make the right decisions. There is great hope and promise in the future because of all of you!

Welcome and Review of the Agenda

Taber D. Allison, Ph.D.
Director of Research and Evaluation, American Wind Wildlife Institute

We have an outstanding set of presentations and posters, and I want to thank the panel of peer reviewers who helped shape the program based on submitted abstracts. Learn what investigators are working on now, what they think is important. Take advantage of the opportunity to look at the posters and visit with authors, talk with oral presenters and your colleagues.

As Abby described, the window of opportunity is closing rapidly. All signs point to the importance of reducing greenhouse gases, and wind energy is critical to achieving these reductions. More research is needed, but aggressive reductions cannot wait; we cannot put wind energy development on pause while we do the research. Our closing discussion addresses this issue.

A Conversation with Leaders:

Wind Power Today and Tomorrow and the Status of Conservation in the US

Moderated by Abby Arnold, AWWI

Panelists:

- **Garry George**, Renewable Energy Director, National Audubon Society (Audubon)
- **Sean Marsan**, Deputy Assistant Regional Director, Midwest Ecological Services, United States Fish and Wildlife Service (USFWS)
- **Tom Vinson,** Vice President, Policy and Regulatory Affairs, American Wind Energy Association (AWEA)
- **Steve Colvin**, Ecological and Water Resources Division Director, Minnesota Department of Natural Resources (MNDNR)
- **Jocelyn Brown-Saracino**, Wind Energy Technologies Office Environmental Research Manager, United States Department of Energy (USDOE)
- **Mary Boatman**, Environmental Studies Chief, Office of Renewable Energy Programs, Bureau of Ocean Energy Management (BOEM), United States Department of the Interior

Facilitator Abby Arnold asked panelists to set the stage for the Wind-Wildlife Research Meeting by giving their perspectives on the status and future of wind power and wildlife conservation in the United States. Opening statements from the panelists were followed by a discussion generated by questions from the moderator.

OPENING STATEMENTS

Garry George, *National Audubon Society* –

Emissions reduction is Audubon's number one conservation outcome. In 2015, we reported 314 species of North American birds threatened by range restrictions resulting from climate change. We are not going to make the 2020 goal. We need more emissions reductions, and renewables – wind and solar in particular – are key pieces to any climate strategy. Audubon supports the renewables wildlife impact mitigation hierarchy of avoid first, minimize second and consider effective compensatory mitigation third in siting wind projects. This hierarchy is compatible with the critical outcome of rapidly reducing greenhouse gas emissions.

Sean Marsan, *US Fish and Wildlife Service* –

We truly are interested in balance of species conservation and cost-effectiveness. Thirteen years ago, there were less than two GW of wind on the Midwest landscape; there has been a more than tenfold increase since then. Habitat Conservation Plans (HCPs) are the primary mechanism for assessing and reducing wildlife impacts for endangered species; an HCP is required to obtain a permit for take of endangered species.

New developments for USFWS include a Secretarial order for NEPA that gives us strict time limits and page limits for environmental impact documents (EIS $\leq$ 150-pages, EA $\leq$ 75-pages). The agency is trying to streamline these processes. USFWS remains focused on trying to better understand and minimize risk rather than "retiring risk". In addition, we are trying to streamline the permitting process for projects with low eagle impacts, and take a similar approach for bats in the Midwest.

Tom Vinson, *American Wind Energy Association* –

We will fail to address the urgent threat posed by climate change if we continue with business-as-usual permitting processes. Nationally, we have 90 GW of installed wind capacity, with another 38,000 MW under construction or in advanced stages of development. We are on track to achieve our 2020 goal of 10% of US electricity from wind, but at the current pace, we will not reach 20% by 2030. Keep in mind that, if wind is not built, it will be replaced not generally by solar but by natural gas, which in some cases in the near term is cheaper; this is not a "win" in terms of reducing greenhouse gases. The Federal production tax credit incentive (PTC) and state portfolio requirements have been drivers, along with cost-reductions and corporate and customer demand in recent years, but there are challenges to address:

- *Demand drivers* – not just demand for wind but demand for electricity, the latter of which has been stagnant; a quarter to a half of contracts recently have been with corporations (e.g., tech companies) and customers rather than with utilities, which presents opportunities.

- *Policy* – both carbon policy and federal energy policy is a key driver for wind. In 2015, Congress enacted a phase-down of the PTC. Consultants see project development dropping 2-5 GW per year (from 7-10 GW through 2021) after the PTC phases out. We're open to a variety of policies that can reduce carbon and deploy wind: renewable portfolio standards (RPS), cap-and-trade policies, carbon tax or EPA regulatory policy, among others.

- *Cost* - we can lower technology costs, but permitting and compliance costs are key.

Steve Colvin, *Minnesota Department of Natural Resources (MN DNR)* –

Minnesota has two agencies responsible for permitting wind projects, a Public Utilities Commission (regulatory body) and the Department of Commerce, which receives the siting permit application, conducts the review process and drafts permit. MN DNR coordinates agency review of energy projects for impacts to wildlife and other resources, working both with wind development companies (siting issues, sensitive areas to avoid) and with Commerce, and engaging in the public review process. Permits are then reviewed by the PUC with public input.

Most of the state's electricity is generated in state. We have a 25% renewables goal, with wind currently providing over 17% of MN electricity consumption. The vast majority (98.5%) of installed wind capacity is on private land.

Jocelyn Brown-Saracino, *US Department of Energy* –

DOE helped fund the initiation of the National Wind Coordinating Collaborative (NWCC) 24 years ago and has remained involved in supporting wind environmental research and solution development since that time. The Depart of Energy's Wind Program funds research across a suite of areas: wind technology development, grid integration, economic analysis, and siting and environmental research. Our environmental portfolio includes understanding drivers of risk to wildlife (on land and offshore), the development of solutions, and efforts to disseminate research broadly. Over the past several years DOE has issued a number of competitive solicitations to support environmental work, including funds to support bat deterrent technologies, eagle physiology and behavioral research, and technologies to reduce impacts of wind turbines on eagles. We are continuing our investment in this area; with our current solicitation, we're evaluating proposals for both land-based and offshore wind topics. The current solicitation is the largest to date.

Mary Boatman, *Bureau of Ocean Energy Management* –

The Interior Secretary has spoken about the importance of offshore wind. Within the Department, BOEM is responsible for energy development on the outer continental shelf. Currently, there are 4,000 offshore turbines in Europe; the US has five offshore turbines at Block Island, RI. (Residents formerly burned a million gallons a year of diesel, and now get all their electricity from wind; they can hear the birds now instead of the diesel engines.)

In terms of the environmental impact review process, we work with the National Oceanic and Atmospheric Administration (NOAA) which is responsible for fisheries and wildlife impacts in the offshore environment – and also for climate change, which likewise impacts fisheries. The better we understand the risks, the better we are able to move forward with projects. For Block Island, we have been able to gather data on sound impacts from constructions and early operations, and so while recognizing that sound might pose some risks to marine mammals, for example, we understand that for the greatest impacts are during wind tower foundation installation.

QUESTIONS AND DISCUSSION

Moderator Abby Arnold posed questions for the panel, focusing discussion on: (1) testing minimization impact technologies; (2) near-term research priorities; (3) whether investment could or should be redirected from monitoring towards conservation; and (4) collaboration goals.

(1) How do we support and facilitate testing of impact minimization technologies?

Abby: Wildlife impact minimization technologies need to be tested experimentally in the field. This requires finding a host site, and there are costs associated with getting a permit to test, and with introducing technology into an operational wind project. AWWI's technology [verification program](#) is very expensive. USDOE has been instrumental in leveraging private investment in these projects. *From USFWS' perspective, is there interest in this testing, and how*

do you allow it while remaining in compliance?

Sean: USFWS has a research permitting process; the agency definitely is interested. Research also can be incorporated into the HCP permitting process [see MidAmerican HCP presentation for an example].

Garry: Companies that host these technology tests and deploy them should get some manner of (regulatory) credit for making a commitment to conservation.

Abby: *Are there models (from other industries) for how we think about funding research and development for conservation purposes?*

Garry: Look at the history of hunting in America – [hunters are willing to] "buy" conservation for birds so that they would have birds to hunt – that's a model.

Abby: The Association of Fish and Wildlife Agencies (AFWA) drafted legislation ("Recovering America's Wildlife Act") that is now going through Congress, targeting the offshore energy sector with fees that would go into a pot to support research for non-game species.

(2) *From your perspective what do you see as the top research priorities in the next two years?*

[Panelist responses are grouped by common topics and themes. Specific responses are attributed to Individual panelists.]

Bat fatalities
- Better understanding of variables that affect bat fatalities [Jocelyn]
- White-nose syndrome (WNS), how to address – invest in mitigation? We would prefer to prevent listing, so the better we can understand impacts (to migratory tree bats, for example) and how to avoid or mitigate them, the better. [Sean]

Large-scale impacts
- Conservation outcomes at scale: flyways, full life-cycle of birds [Garry]
- Systematic monitoring at multiple locations to learn what sort of population level effects we may be seeing with bats [Steve]
- More data-intensive questions and the tools to answer them [Jocelyn]

Abby: Our keynote speaker will speak to this question of how we collect and use data.

Monitoring research

- For offshore, we need to conduct baseline surveys prior to construction that allow for identification of changes after construction. We also need to determine what monitoring requirements to include at first point of permitting. [Mary]
- Should particular research protocols be revisited? [Tom]

Permitting

- Habitat conservation planning for species; more clearly defined processes that streamline permitting [Sean]
- Streamlined timeframe and cost of permitting processes for low-risk projects [Tom]

Technologies

- Curtailment – finding the right balance for cut-in speeds [Sean]
- Would like to get regulator acceptance (i.e., greater certainty) for promising technologies, and incentives that provide companies greater operational certainty (limited liability) within some bounds. [Tom]
- Implementation of measures to reduce bat fatalities [Steve]
- We hope we see more technologies that are verified and available. [Jocelyn]

(3) Could investments of monitoring at project sites be better invested in conservation measures?

Garry: This is an important question – definitely something we should be looking at.

Tom: Industry agrees that there are some questions that have been asked and answered, while there are others that really should get the focus of our research investment. Can resources be redirected to higher conservation priorities?

Sean: Monitoring is costly. How can we use the data we have or pool data to better inform monitoring so that it doesn't have to be so expensive for each project?

Mary: One model for making better use of funds that would be spent on project monitoring is to collect that money from each developer and pool it to look at wildlife impacts on a larger scale or address research to aid recovery of impacted species. One example comes from the development of renewable energy, in this case solar, and the California desert tortoise, where habitat is impacted. Rather than requiring each developer to monitor their installation, funds are pooled and used to address research that will help the tortoise to recover, such as reducing predation by ravens.

Jocelyn: Agreed – we need to expand the scale of our understanding, rather than asking questions at project-by-project basis.

(4) What do you hope to accomplish through collaboration in the next two years?

Garry: Audubon is well partnered with wind and solar. We've had some success working with

the Federal government (BOEM and BLM in the western states) and with the California Governor. California is setting aggressive renewable energy goals and meeting them through voluntary planning. Let's look at how states can enter into planning processes that incentivize development in "go" areas vs. just identifying the "no-go" areas.

Mary: With the Block Island project, the developer collaborated with the state, academia, and BOEM. We were able to conduct research to address the most pressing questions with the support of all stakeholders.

Sean: I am encouraged by the level of partnership within wind-wildlife world. Shared goals bring a lot of people together.

Steve: Collaboration and coordination among state agencies and wind producers has been good as we look at wind projects – likewise for solar.

Jocelyn: We could do more internationally, both from the perspective of solution development, and in terms of learning from each other to retire specific risk questions. I am optimistic that this community of stakeholders will find solutions. The dedication to collaboration in this space is phenomenal.

Tom: We could do a better job of communicating our success stories, how well we're collaborating, and how much we are learning. (Props to Audubon for helping get this positive story out.)

Evaluating Indirect Impacts to Birds

Moderator: Anne Bartuszevige
Playa Lakes Joint Venture

A Meta-analysis of Effects
of Wind Energy Development on Grouse Populations

Presenter: Chad LeBeau, *Western Eco-Systems Technology (WEST), Inc.*

[slide presentation]

Authors: Chad LeBeau, Shay Howlin, Karl Kosciuch *(Western Eco-Systems Technology, Inc.)*

PROBLEM / RESEARCH NEED

Grouse (*Tetraoninae spp.*) populations benefit from large intact areas of habitat that satisfy all life cycle requirements. Anthropogenic influences that fragment grouse habitat could affect population growth rates, persistence, or occupancy through negative behavioral responses effectively leading to habitat loss. The extent of negative behavior responses associated with anthropogenic features including wind energy development likely varies and is dependent on size, longevity, and density of structures. In addition, the magnitude of the effect can vary depending on the life-cycle period of the species.

Sage-grouse (*Centrocercus spp.*) and prairie-chicken (*Tympanuchus spp.*) species are experiencing range-wide declines and there are concerns that wind energy development will exacerbate these declines. Further, wildlife management agencies have assumed impact buffers around wind turbines and other infrastructure that, in some cases, are based on a limited number of studies and not a complete synthesis of available research.

There have been numerous publications on grouse behavior. Previous meta-analyses conducted in 2010 and 2014 found that anthropogenic features such as powerlines and especially roads, oil and gas development have adverse effects, displacing grouse from habitat. They also showed that the magnitude of displacement varied based on the season and annual cycle of grouse populations. However, these earlier studies acknowledge that there were not enough studies conducted on the effects of wind energy on grouse populations to include in their analyses.

<u>Objectives</u>

Meta-analysis is powerful tool that allows us to combine many studies' results to learn more. To better understand responses and manage grouse species relative to wind energy development, WEST Inc. synthesized the current peer-reviewed research on the effects of wind energy development on grouse species by conducting a meta-analysis to quantitatively evaluate effect sizes. The objective was to build upon previous meta-analysis to estimate an overall effect size of displacement and survival relative to wind turbines, and determine if the magnitude of effect size varied among season or grouse species.

<u>APPROACH</u>

Since 2014, there have been numerous studies published on wind impacts on grouse. The majority of publications looked at displacement and survival rates, each measured looking at multiple parameters. We retained all peer-reviewed literature that directly measured the effect of distance to turbines on grouse response variables.

- Displacement was measured in habitat use, occupancy, and lek counts where an adverse effect of turbines would equate to large displacement near turbines.

- Survival was evaluated using different fitness parameters including nest, brood, and female survival, where an adverse effect of turbines would equate to low survival near turbines.

For each study result combination that evaluated survival and displacement we calculated Fisher's Z effect sizes (used to test the significance of the difference between two correlation coefficients, r_1 and r_2, from independent samples) and put them into a hierarchal random-effects model (non-breeding vs. breeding effect) to account for within-study correlation where one study may have reported more than one result. We also evaluated the influence of season on displacement and survival and whether the effect varied by species.

We also tested for influential cases and publication bias. In meta-analyses it is important to determine whether one study (an "influential case") influenced the results more than other studies. Publication bias is another issue in meta-analysis because significant results are generally more likely to be published than non-significant results, so we tested for this bias in our analysis.

<u>FINDINGS</u>

Of the 350 matches to our Google Scholar search terms, 13 peer-reviewed studies evaluating the effect of turbines on 4 grouse species (greater sage-grouse, black grouse, red grouse, and greater prairie-chicken) met our study inclusion requirements. From these we extracted 34 study-result combinations which varied depending on the grouse behavior.

Slide #11 shows the effect sizes associated with each study-result combination for displacement. Boxes to the right of the vertical line represent a displacement effect of wind turbines on the studied grouse populations, with the size of the box representing the influence

of each study on the effect size and the blue lines representing the confidence intervals of each effect size. We found some evidence of displacement as the mean effect size was positive and had a p-value less than 0.1.

The overall effect size of survival relative to turbines was negative, meaning that risk was higher in habitats in close proximity to turbines. However, as illustrated in slide #12, this effect was not significant (p-value = 0.646). We did not find any difference in effects between breeding and non-breeding periods. Greater prairie-chicken experienced a greater impact of displacement than other species.

We now have enough information specific to wind turbines and are able to add to the understanding of anthropogenic effects on grouse populations (slide #14). Based on the results of this study, structures like oil and gas and roads appear to have a greater displacement effect compared to wind turbines. Oil and gas structures and roads have a similar ability to fragment the landscape as do wind turbines, but the degree of human presences tends to be lower around wind turbines whereas people are more frequently present on roads and near oil and gas structures. That human presence factor may be the differences in effect sizes between these anthropogenic features, but this should be explored further.

The majority of our study results came from five studies, three of which were in North America. Our analysis considered four grouse species, two of which occur in North America. Studies of grouse species of conservation interest including lesser prairie-chicken and sharp-tailed grouse populations were not included, as no studies met the study inclusion requirements. However, because these species behave similarly to the studied grouse species, we would expect the impacts of wind turbines on them to be similar.

CONCLUSIONS / APPLICATIONS

This meta-analysis determined that the effect of wind turbines is lower in magnitude compared to other anthropogenic features, suggesting conservation measures specific to those features may be applicable to grouse conservation relative to wind turbines.
There is evidence of displacement, but it does not appear to affect survival/ fitness of population. Effects depend on landscape characteristics and grouse populations.

These results do not consider cumulative effects as the studied grouse populations are located great distances apart. As with other forms of development, as more facilities are placed on the landscape, impacts to affected grouse populations are likely to increase.

Questions & Discussion

Q: *In your research, have you identified any large gaps before we can start using this science?*

A: There are quite a few gaps with regard to grouse and wind energy: lesser prairie-chickens and sharp-tails, also cumulative impacts. Studies we evaluated showed evidence of

displacement, but we need to look at size of project and surrounding landscape and connectivity questions. Are they traveling around or through to get to breeding area?

Q: *How did your meta-analysis evaluate publication bias, that is, that studies that reject the null hypothesis are more likely to be published?*

A: We used available techniques for evaluating whether studies only include significant results. We did test for that bias, but did not find any.

Q: *What are your plans to continue your work at Cimmaron?*

A: We are looking for funding to study lesser prairie-chickens in Kansas and sage-grouse in Wyoming to investigate connectivity. We will proceed to publication of this meta-analysis soon.

Q: *Any sense of habitats with greater resilience to turbine placement?*

A: I would like to explore that more. What is the surrounding habitat like? How fragmented? Are there other nearby areas for the birds to utilize?

Estimating Indirect Impacts of Wind-Energy Development for Breeding Grassland Birds and Waterfowl in the Northern Great Plains

Presenter: Jill Shaffer,
US Geological Survey, Northern Prairie Wildlife Research Center

Authors: Jill A. Shaffer (*US Geological Survey*), Charles R. Loesch (*US Fish and Wildlife Service*), Deborah A. Buhl (*US Geological Survey*)

Note: *The method for quantifying displacement on which this presentation was based has been submitted to a journal for publication; therefore, the authors cannot "double-publish" by providing for these Proceedings the actual details and real-world examples of that method. The summary below will be, by necessity, an overview of already-published research that provided the foundation for the method, as well as a general overview of the method.*

PROBLEM / RESEARCH NEED

Wind-energy facilities continue to proliferate across the landscapes of the Great Plains, yet implementation of mitigation tools that ameliorate the loss of habitats or behavioral avoidance (i.e., displacement) of wildlife from wind-facility construction and operation is rare. Two

published research studies conducted in the northern Great Plains by the US Geological Survey (USGS)[1] and by the US Fish and Wildlife Service (USFWS) and Ducks Unlimited[2] have established the displacement impact on breeding grassland birds and waterfowl, respectively. That research provided the capability to develop a method to offset displacement.

Objectives

1. Explain a method that quantifies the displacement of birds by wind facilities by calculating the amount of grasslands or wetlands needed to support the displaced pairs.

2. Provide a displacement rate for grassland birds to complement the published displacement rate for waterfowl.

3. Provide examples of the method for cases where the offset habitat is of equivalent biological value as the impacted habitat, as well as where the offset habitat is not equivalent, using examples for wind infrastructure.

4. Provide a framework for developing decision-support tools aimed at landscape-level conservation delivery.

APPROACH

Results of a Before-After-Control-Impact (BACI) assessment conducted by the USGS Northern Prairie Wildlife Research Center (NPWRC) were used to demonstrate the degree to which wind-energy facilities placed in native mixed-grass prairies displaced breeding grassland birds.[3] In summary, during 2003-2012, NPWRC monitored changes in breeding pair density of eight grassland bird species and one generalist species at three treatment sites (NextEra's Oliver Wind project in Oliver County, North Dakota, Acciona's Tatanka project in Dickey County, North Dakota, and NextEra's SD Wind Energy Center in Hyde County, South Dakota) and on corresponding reference sites. This approach allowed for the comparison of avian density for two time periods: one year pre-project construction with the year following construction (immediate effect), and one year pre-project construction with average annual density for two to five years post-project development (delayed effect). Displacement or attraction was measured as the change in density from pre-treatment to post-treatment years on the treatment sites relative to the reference sites by wind facility, bird species, and distance category (100, 200, 300, and >300 m from turbines) for the two time periods. From these data, NPWRC calculated a displacement rate for the eight grassland bird species, the method of calculating and the results of which will be published in a forthcoming journal article.

To calculate average displacement rate for waterfowl, USFWS used the findings from Loesch et al. (2013)[4]. The study, conducted by USFWS and DU, used a concurrent-year paired-reference

[3] Shaffer, J. A., and D. A. Buhl. 2016. Effects of wind-energy facilities on breeding grassland bird distributions. Conservation Biology 30:59-71. DOI: 10.1111/cobi.12569

[4] Loesch, C. R., J. A. Walker, R. E. Reynolds, J. S. Gleason, N. D. Niemuth, S. E. Stephens, and M. A. Erickson. 2013. Effects of wind energy development on breeding duck densities in the Prairie Pothole Region. Journal of Wildlife Management 77:587-598. DOI: 10.1002/jwmg.481

site design to estimate proportional differences of breeding-pair estimates between wind and treatment sites for five species of dabbling duck species at two wind energy facilities (Acciona's Tatanka project and FPL Kulm/Edgeley Wind Farm, LaMoure County, North Dakota).

To calculate the amount of habitat needed to offset (i.e., provide compensatory mitigation) the avian displacement impacts of wind facilities, the authors described how the displacement rate and several other metrics related to the impact site, as well as one metric related to the offset site (i.e., the site where mitigation would occur), were applied. In addition to the empirical model, landscape-level decision-support tools were developed by USFWS. The tools have a three-fold value: (1) to indicate where suitable (i.e., of equivalent biological value to the impact sites) offset sites are located, (2) to evaluate the value of an individual potential offset site relative to the pool of all available offset sites (e.g., finding offset sites located within a landscape of greater grassland intactness than an isolated offset site), and (3) to indicate locations where the placement of wind facilities may have a lower chance of triggering adverse behavioral impacts to birds.

FINDINGS OF DISPLACEMENT

For grassland birds, seven of eight species (Upland Sandpiper [*Bartramia longicauda*], Savannah Sparrow [*Passerculus sandwichensis*], Grasshopper Sparrow [*Ammodramus savannarum*], Clay-colored Sparrow [*Spizella pallida*], Chestnut-collared Longspur [*Calcarius ornatus*], Western Meadowlark [*Sturnella neglecta*], and Bobolink [*Dolichonyx oryzivorus*]) showed displacement within 300 meters of wind turbines. Another grassland bird species, Vesper Sparrow (*Pooecetes gramineus*), was unaffected by wind facilities, and one generalist species, Killdeer (*Charadrius vociferous*), exhibited attraction. Although level of statistical significance varied across wind facilities, species, distances, and time period, effects were consistently negative for seven of the species. Displacement was detected one-year post-treatment, and this displacement effect persisted at least five years. No statement of effect can be made beyond this time period, as the evaluation was conducted only out to five years post-treatment. Displacement was more prevalent near turbines than further away, with the majority of displacement occurring within 300 m. Statistically significant (p-value <0.05) displacement was detected at all three wind facilities, within all distance categories, and for seven of nine species evaluated.[1] The calculation of displacement rate for grassland birds will be presented in a forthcoming journal article upon acceptance and publication.

For the five species of waterfowl (Mallard [*Anas platyrhynchos*], Northern Pintail [*A. acuta*], Blue-winged Teal [*Spatula discors*], Northern Shoveler [*S. clypeata*] and Gadwall [*Mareca strepera*]), the estimated densities of duck pairs on wetlands at wind facilities were lower for 26 of 30 sites, species, and year combinations, and of these 16 had 95% credible intervals that did not overlap zero and resulted in displacement rates ranging from 0 to 58%, with an average rate of 20%.[2]

CONCLUSIONS / APPLICATIONS

Avian displacement rates can be used as a foundation for calculating how much habitat is

needed to support displaced breeding pairs. In other words, the quantification of offset measures can be computed.

A manuscript explaining the quantification through real-world examples and calculations has been submitted to a journal.

Landscape-level conservation-delivery tools can prioritize grassland bird and waterfowl habitat conservation areas to help guide placement of offset areas likely to be of equivalent biological value to impact sites. These tools also can guide the siting of wind facilities in lower-value habitat, such as already-fragmented grassland landscapes with few seasonal wetlands, where the level of impact of behavioral displacement may not require offsetting measures.

Questions & Discussion

Q: *In your research, have you identified any large gaps?* [Chad and Jill]

A (Chad): There are quite a few gaps with regard to grouse and wind energy: lesser prairie chickens and sharp-tails, also cumulative impacts. Studies we evaluated showed evidence of displacement, but we need to look at size of project and surrounding landscape and connectivity questions. Are they traveling around or through to get to their breeding area?

A (Jill): The science that we presented can be used immediately to start informing decisions. No science is ever perfect, but as Tom Vinson, AWEA Vice President of Policy and Regulatory Affairs, alluded to during the "Conversation with Leaders," we can't wait years for research. We must work with the best available science that we have now, although we can work on bettering that science when allowed. With regard to the science of behavioral impacts, there are a number of ways to improve future research:

- Only a few species have been evaluated: nine in my research and a handful in other studies.
- My research occurred in grazed mixed-grass prairie, but impacts on birds in other ecosystems are largely unknown, such as the playa landscape that Anne [Bartuszevige, the moderator] works in.
- Few BACI studies have been conducted and one reason is that obtaining the years of pre-treatment information is difficult. However, it is important to have that information to develop a baseline for normal levels of population fluctuation in the avian numbers and distribution due to normally occurring variation from such things as precipitation. In order to get this pre-treatment information, the wind industry would have to work closely with biologists. Other well-designed studies utilizing nearby comparable paired sites also provide useful information.
- As wind facilities get built closer to one another on the same landscape, the issue of cumulative impacts should be tackled.

Q: *Is the offset a tract or tracts of land already providing habitat? If so, isn't there a net loss in*

bird abundance?

A: Yes, there is a net loss. For simplification purposes, we presented an example in which the amount of impacted habitat is offset by the protection (through a perpetual conservation easement, for example) of a comparable amount of existing grassland habitat; but to truly replace the lost habitat, and not just to protect habitat from future development, a developer would need to create new grassland habitat through restoration. There are logistical constraints to that option, namely that creating a biologically complex grassland can take years, one cannot be sure that the bird community will be the same or that the avian density will be the same as the impacted habitat, restored grasslands have special management needs, and willing landowners from which to acquire land have to be found. Restoring a grassland and then maintaining it afterwards can be very expensive. However, there are many examples, including the US Department of Agriculture's Conservation Reserve Program, that have very clearly proven successful in providing avian habitat. And, in the face of doing nothing, at least the protection of already existing patches of prairie ecosystem through mechanisms like perpetual easements protects those patches from future destruction and means that more habitat loss is stemmed.

Q: *Don't you need to know the species already on the mitigation site?*

A: Yes, for the method to be applied, you need to know avian density on the mitigation site – which means you need to know the species. If the species composition on the impacted site and the mitigation site aren't similar, then it would not be an appropriate mitigation site.

Q: *Was percentage displacement correlated to pre-treatment density?*

A: Statistically, percentage displacement was not correlated to pre-treatment density. Percentage displacement was calculated using pre-treatment density. Specifically, percentage displacement was based on the change in density from the pre-treatment density to the post-treatment density.

Q: *Any sense of habitats with greater resilience to turbine placement?* *[Chad & Jill]*

A (Chad): I would like to explore that more. What is the surrounding habitat like? How fragmented? Are there other nearby areas for the birds to utilize?

A (Jill): My research looks at avian response to turbines, not to habitat response, so I'm assuming this question might relate to greater resilience of birds depending on the habitat that they occupy. I have no direct data to answer this question. One might surmise based on issues of area sensitivity that grassland bird populations would be less affected by wind facilities in landscapes in which individual bird pairs have alternate grasslands to occupy once being displaced by a wind facility. However, the placement of a wind facility in a landscape fragments that landscape, thus lessening the overall integrity of that landscape for bird populations. From a grassland bird perspective, it is better to place wind facilities in already altered landscapes, such as cropland. However, from a waterfowl perspective, wetlands in cropland also provide breeding habitat for pairs. Consequently, in the Prairie Pothole Region, a cropland landscape with low wetland density might be the best option.

Q: *What mitigation measures should be taken in similar quality habitat to compensate for impact of wind farm construction?*

A: True mitigation would involve creating new grassland habitat to replace habitat lost by the wind farm, but see the response to the above related question on net loss.

Not asked during Session

Q: *How many years of pre-treatment were surveyed to inform the baseline birds/hectare?*

A: One year. Because of the confidential and competitive nature of wind development, most studies on turbine effects do not have pre-treatment data. The wind developers agreed to allow us one year before construction began; ideally, we would have had multiple years.

Q: *Your sample sizes are so small. How can you be certain you are observing displacement as opposed to variation or insignificant differences?*

A: In wind/wildlife BACI designs, sample sizes are typically small due to the aforementioned difficulty in obtaining from wind developers the exact locations of turbines prior to turbine construction, but because pre-treatment data are available and used in the analyses, these analyses are generally more powerful than other designs without any pre-treatment data. With small sample sizes, low power reduces the chances of detecting significant differences. Generally, only very large differences can be detected. But even with small sample sizes, we were able to detect a number of significant differences.

Improving Impact Assessments for Birds and Bats

Moderator: Eva Schuster
Kompetenzzentrum Naturschutz und Energiewende

Assessing Standardization in Studies of Wind Energy Impacts on Birds and Bats

Presenter: Todd Katzner, *US Geological Survey (USGS)*

Authors: Todd Katzner, Tara Conkling, James Diffendorfer (*US Geological Survey*), Adam Duerr (*Bloom Biological*), Scott Loss (*Oklahoma State University*), Taber Allison (*American Wind Wildlife Institute*)

PROBLEM / RESEARCH NEED

Increasing global energy production along with the need for climate change and air pollution mitigation is fostering development of renewable energy as an alternative to fossil fuels. Wind energy facilities are known to affect wildlife, with fatalities caused by collisions the primary focus of research. To predict and estimate these impacts, pre- and post-construction evaluations of wildlife habitat use, abundance, and mortality are often conducted. However, neither the degree to which these surveys are standardized within and across facilities nor the degree to which limitations exist in the collective body of wildlife impacts reports and publications generated to date have been explicitly quantified.

Objectives

We conducted a systematic literature search to identify peer-reviewed publications and unpublished reports on wildlife impacts from wind facilities in the US and Canada to determine:

1. the frequency of both *pre-* and *post*-construction survey implementation and how survey methodologies have evolved over time;

2. how frequently explicit experimental designs are implemented to allow for before-after analyses or impact-control analyses implemented; and

3. the degree of data standardization across pre- and post-construction surveys and among facilities to assess effects of renewable energy facilities on wildlife populations.

APPROACH

We compiled 548 reports and citations and analyzed 479 reports from 194 wind facilities.

FINDINGS

Preliminary analysis of our dataset suggests that post-construction monitoring for direct wildlife mortality from wind energy infrastructure has been a standard practice (n = 416 reports), but pre-construction monitoring to determine baseline wildlife abundance, habitat use, or mortality rate has been limited (n = 68). Notably, only 19.6% of facilities (n = 38) had data collected both pre- and post- construction, and only 56 facilities (28.9%) followed an experimental study design that included pre- and post-construction analyses or reference or control sites. Among wildlife habitat use surveys, very few (4 of 109 facilities) included detection probability estimation, a factor which limits comparisons of biological information between pre- and post-construction periods and among facilities. Moreover, the likelihood that a project will incorporate experimental design has not increased over time.

CONCLUSIONS / APPLICATIONS

Given these limitations across the collective body of research, we identify best practices that can improve the utility of future habitat use and mortality surveys to accurately predict and quantify impacts of wind energy facilities on wildlife.

An article detailing these findings has been submitted to Conservation Biology, and is in review.

Questions & Discussion

Q: *Did you find studies looking at raptor (non-eagle) nest occupancy pre- and post-construction? There is a need to understand what lower nest occupancy post-construction means.*

A: There is a need to understand the response of nest occupancy, but we did not look specifically at that. I'm not sure we could use our dataset to answer that.

Q: *Do you know of any efforts underway to standardize the types of data collected (or collection methods) across stages of project development (or across projects)? Will your research be used to begin these standardization conversations as they relate to relevant policy and required data collection/sampling campaigns?*

A: I know of no efforts to standardize data collected across stages of project or projects. What data is collected depends on the agencies, consultants, operators, etc. Stakeholders (agency managers, developers and operators) need to push each other to come up with a scheme that lets you do repeatable controlled experiments. There is the potential without greater cost to do things in a way that would add not just to conservation at projects but also to our ecological understanding.

Q: *Industry likely spends hundreds of millions on impact assessment. Assuming we all want to shift costs to conservation, what is the one thing each of you would recommend to maximize the efficiency (not the amount) of impact assessment dollars spent?*

A (Manuela): There is a lot of resistance to continuous monitoring for extended periods. I am working to develop a protocol that could be applied everywhere (every turbine, continuously) but at a very low rate (e.g., road and pad surveys). Having those data made publicly available, and the gain of having data from the entire world rather than just individual projects, would allow us to see patterns that we can't see now. For example, right now we have almost no publicly available information from Texas. The idea is to do something very low key, not expensive, but do it consistently everywhere!

A (Todd): What would be helpful is coordination and standardization among facilities. Doing that would increase your sample size dramatically, which means not having to dive in as deeply at any one site. If everybody does the same thing, we can pool data and begin to understand what's going on. Spread the effort around at a lower level. (To illustrate the point: if you want to estimate the height of men attending this conference, don't measure one individual ten times; rather, measure ten different men once and take an average.)

Carcass Age and Searcher Identity Affect
Morphological Assessment of Sex of Bats

Presenter: David Nelson, *University of Maryland Center for Environmental Science*

[slide presentation]

Authors: David Nelson, Juliet Nagel, Regina Trott, Caitlin Campbell (*University of Maryland Center for Environmental Science*), Lori Pruitt (*US Fish and Wildlife Service*), Rhett Good, Goniela Iskali (*Western EcoSystems Technology, Inc.*), Paul Gugger (*University of Maryland Center for Environmental Science*)

PROBLEM/ RESEARCH NEED

Understanding the ecology and conservation/management status of species requires knowledge of their distributions, including differences between sexes. Range maps do not tell us anything about abundance, how it varies with season, or about difference of distributions by sex. Females tend to occur in regions with warmer summer temperatures, but getting a more accurate picture of the sex ratios of turbine-killed bats would help us in assessing the impact of wind energy-related mortality on bat populations.

There is some morphological evidence that more male than female tree-roosting bats are killed at wind-energy facilities, but while carcasses provide an important resource for assessing the vulnerability of bat species to threats, the reliability of sex data derived from the external morphology of bat carcasses remains uncertain. DNA testing provides a more accurate method of carcass sex identification, but it is not as easy or quick to obtain.

Objective

The objective of this work was to better understand what factors influence the accuracy of morphology-based sex identifications of carcasses of tree-roosting bats? Candidate factors included:

- Carcass age - older carcasses more likely classified as unknown or misidentified
- Time of year - reproductive organs are more visible at different times of year; scavenger activity or decomposition may also vary seasonally
- Searcher identity – skill, experience, commitment

APPROACH

We used genetic-based assessment of sex to evaluate the effect of carcass age and searcher identity on morphology-based sex assessments of Eastern red (*Lasiurus borealis*) and hoary (*Lasiurus cinereus*) bat carcasses identified by 15 different searchers at a wind-energy facility in Indiana. A total of 103 Eastern red and 117 hoary bat carcasses were identified between from July through October over a three-year period (2010-2012). Carcass age was estimated from search frequency and carcass condition, and sex was identified using both external morphology and DNA.

Fisher's exact test was applied to determine the influence of time of year or searcher identity on the number of incorrect sex-morphology identifications of fresh (< 1 day old) carcasses.

FINDINGS

As had been observed in an earlier comparison done at a large Texas facility, fewer carcasses were identified as male using DNA identification. At the Indiana site, males were overrepresented by 9-10% in morphology-based sex identification.

Older carcasses are more likely classified as unknown, and more likely to be females. The proportion of carcasses for which morphology-based sex was unknown increased from 0.11 for those recovered within a day of death, to 0.56 within 2–3 days of death, and to ≥ 0.82 at ≥ 4 days of death. The proportion of carcasses for which sex was correctly identified based on morphology decreased from 0.9 for those recovered within a day of death, to 0.65 within 2–3 days of death, and to 0.25 at ≥ 4 days of death. Therefore, to look at the effect of other factors, we limited the assessment to fresh carcasses.

We did not find a strong correlation between accuracy of morphology-based identification and

time of year.

Searchers differed in their ability to identify sex. The proportion of morphology-based sex misidentifications of the 108 fresh carcasses (collected within 24 hours of death) varied (0.0–0.43) among searchers. However, there was no relation between a searcher's ability to find bats and the proportion of bats identified as sex "unknown". In other words, people who found more carcasses were no more accurate at identifying sex. Nor were more conservative searchers (those more likely to identify a carcass as "unknown" if uncertain) any more accurate.

<u>CONCLUSIONS / APPLICATIONS</u>

These results suggest that morphology-based assessments should be limited to fresh carcasses. Furthermore, additional training of people who collect and identify bat carcasses from renewable-energy facilities may improve the accuracy of morphology-based sex identification data obtained from carcasses.

These results also suggest that there may be overrepresentation of males in existing morphology-based sex identification of bat fatalities – at least for Eastern red and hoary bats – and it may be premature to say that relatively more male Lasiurine tree-roosting bats are being killed at wind-energy facilities.

Potential next steps include the following:
- Determine if results are applicable in other settings and bat species.
- Assess if additional training/oversight of searchers improves accuracy of sex-morphology data.
- Use DNA analysis of carcasses from range-wide sampling to assess potential bias toward fatalities of male tree-roosting bats at wind-energy facilities.

Questions & Discussion

Q: *How much training on sex ID did your searchers have before beginning?*

A: Searchers were shown how to ID sex based on external morphology. However, consistent protocols and training were not in place at the time of our study. Going forward, I would like to have more information about searcher background and the specific training that each searcher received.

Where Carcasses Land – and Why It Matters

Presenter: Manuela Huso, *United States Geological Survey (USGS)*

ABSTRACT

It has long been recognized that the turbine-caused carcass density beneath turbines is not constant but tapers out to zero at some unknown distance from the turbine. Estimates of total mortality at a site are dependent on accurate estimation of the density distribution of carcasses to appropriately account for those areas that were unsearched or unsearchable. Recent work has identified algorithms that can provide unbiased estimates even under anisotropic conditions. While exploring the properties of these algorithms we discovered a strong, but not surprising pattern: the spatial distribution of bat carcasses depends on wind speed during the night of their demise. At a site in the Midwestern US, all vegetation was cleared within 90 m of 16 turbines that were fully operational, i.e., not curtailed. Searches for bat carcasses were conducted daily and only "fresh" carcasses (<24 hours since arrival) were included in the analysis to relate fall distance to average wind speeds of the prior night. We found that the proportion of carcasses landing beyond 60 m of the turbine increased consistently with increasing wind speed. This has strong implications for interpretation of results of curtailment experiments where search radii are relatively small. No published curtailment experiment to date has been conducted using search plots with substantial amount of searched area > 60 m from the turbine and all have assumed equal detectability among treatments. If not properly accounted for, reduced detectability of fatalities occurring during higher wind speed conditions may bias results in favor of the curtailment treatment. We discuss the implications of these preliminary findings and propose alternative interpretations and suggestions for future studies.

[Editor's Note: *Neither the slides nor a summary of this presentation was available at the time of publication. Contact Manuela Huso (mhuso@usgs.gov) for more information.*]

Leveraging Artificial Intelligence for Wildlife Mitigation, Wind Energy and Conservation

Keynote Speaker: John Yarbrough, *National Renewable Energy Laboratory*

[slide presentation]

PROBLEM / RESEARCH NEED

As development of wind energy increases, so does concern for impact on bats and other wildlife. Impacts to wildlife can inhibit or prevent wind energy development as well as impose significant fiscal impacts on the industry. Unfortunately, there are no easy answers to these problems. We are faced with a twofold challenge: lack of unified data sources and the complex nature of the data itself. Over 900 bird and 47 bat species are potentially affected, each species having its own morphology, sensorial characteristics, phenology, behaviors, abundance and distribution. Wind farms differ in terms of size and configuration, types of equipment and location. Bird or bat interactions with wind energy projects vary regionally, and depend on landscape features, flight paths, foraging and breeding opportunities, and weather variables. The inner workings of wildlife interaction in and around wind farms is complex and data-intensive, and this has resulted in a lack of consensus on best strategies for minimizing the impact of wildlife and wind energy, especially bat-turbine interactions.

Currently, industry either uses a blanket curtailment strategy or is exploring some sort of "smart" curtailment strategies that depend on detection or risk profiling of conditions – or deterrent technologies, or a combination of approaches. Smart curtailment and deterrence are still in the experimental stages, and their refinement and implementation is inhibited by uncertainties and the difficulty of pinning down the conditions at the time fatalities occur. We have seen presentations on the use of automated data collection, but most of the data we gather is still being analyzed manually by graduate students. To deal with complex, data-intensive questions in real time, we need to leverage advances in data science and artificial intelligence (AI).

Objectives
Given advances in computer technology, decreasing data storage costs, and the exponential development and implementation of AI, can we leverage AI and computer vision to:

1. Develop and implement smart curtailment strategies based upon wildlife activity patterns?

2. Use real-time wildlife activity monitoring to inform curtailment decisions?

<u>APPROACH</u>

Introduced by William S. Cleveland in 2001 as an independent discipline that extended the field of statistics to incorporate "advances in computing with data," data science is the intersection of domain expertise, computer science, and mathematics (slide #10). Concentrations within data science include advanced visualization tools, data management and processing, and deep analytics. Within the category of deep analytics, AI leverages statistical analysis and machine learning to make a computer think "intelligently" as humans do, by iteratively acquiring information (data), using rules to reach approximate or definite conclusions, and self-correcting conclusions with additional data. AI is used in many fields from marketing to medicine (slide #12). One AI application, "Watson" is able to detect cancer much more accurately than human radiologists – even cancer that doesn't show up in radiology test results – using predictive analytics, a subset of machine learning.

For understanding and minimizing wind-wildlife interactions, AI offers two types of relevant applications: machine learning and computer vision. Computers can "see" better than human eyes, analyzing visual images collected automatically at the pixel density level. We have seen some examples of this with technologies that use thermal imagery to detect birds and bats offshore, and classify tracks as bats, swallows, gulls or terns based on flight pattern and shapes.

<u>FINDINGS</u>

The use of machine learning to learn about wildlife began around the year 2005, and took off exponentially around 2012. Examples of deep learning and computer vision in the scientific literature include:

- Bird movements at rotor heights measured continuously with vertical radar at a Dutch offshore wind farm (Ruben C. Fijn)

- Two-dimensional thermal video analysis of offshore bird and bat flight (Shari Matzner)

- Automatic identification of bird targets with radar via patterns produced by wing flapping (Serge Zaugg)

- Automatic classification of flying bird species using computer vision techniques (John Atanbor)

- The first artificial intelligence algorithm for identification of bat species in Uruguay with 93% accuracy in identification of species using acoustic variables (G. Botto Nunez)

- Classification success of six machine learning algorithms in radar ornithology: 80% accuracy in discriminating between birds and non-biological targets; did not perform as well when discriminating between bird functional groups (Isabel M. D. Rosa)

AI is changing the way we visualize wildlife data. Dashboards are designed to incorporate and visualize vast amounts and types of data. Computer technology is now allowing us to visualize data in three dimensions.

The National Renewable Energy Laboratory (NREL) and other organizations are beefing up their computational abilities. Located in NREL's Energy Systems Integration Facilities, the Insight Center combines state-of-the-art visualization and collaboration tools, allowing researchers and engineers not just to look at, but to rotate, enter, and walk through the wake pattern to understand what turbulence means for the wind farm (slides #20-21).

NREL is moving away from proprietary to open source software, such as OpenCV and TensorFlow (slide #22) – designed to make AI available to more people. This will revolutionize the use of these libraries of data we've been collecting. AI has the potential to help us develop curtailment strategies modeled after wildlife activity patterns using real-time detection and existing data sets and machine learning-based forecasting systems, improving our predictive capacity.

We *can* reduce wind turbine downtime and decrease wildlife facilities. Why aren't we?

Questions & Discussion

Q: *What do you need from us to provide you with the data you need to build an algorithm that can operate and hopefully fine-tune a smart curtailment strategy?*

A: For machine learning to work, we need vast data sets to train the computers. What data are out there, what questions are we trying to answer? What variables do you want to incorporate? AI is well-suited to working with many variables. (For example, in the policing model, they identified 1,400 variables that affect crime, and were able to determine 30 variables that were particularly useful for the model.) So, we need to identify those variables and find the data sets. You need a training set to build your model, then a test set to see how well the machine learning did.

Q: *So far, we have found many more carcasses below turbines that are simultaneously being monitored by video than we have observed being struck. How should we change the way we're monitoring, and what information we're collecting, to be able to answer the key question: What are the conditions when a fatality occurs?*

A: You need to expand your detection systems: broader video area, more kinds of detection systems. One idea is – if it is not possible to detect visually, can we, say, use seismological data to detect when a carcass hits the ground? AI gives us the capacity to process a lot of data and to look at a much larger number of variables – so think outside the box.

Q: *What is USFWS' position on AI? Taber Allison found they were very receptive to AI in the IdentiFlight technology.*

A: We have had conversations with people outside NREL who say, "We have all this data but we

don't know what to do with it." For example, drones collect a lot of data on animal tracks – what can we do with that? We should be able to determine what species of animal came through based on those tracks, provided you have a training set.

Predicting Risk to Bats: State of the Science

Moderator: Ryan Zimmerling,
Environment Canada and Climate Change - Canadian Wildlife Service

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Does Bat Activity Predict Bat Fatality at Wind Energy Facilities?

Presenter: Donald Solick, *Western Eco-Systems Technology (WEST), Inc.*

Authors: Donald Solick, Shay Howlin (*WEST, Inc.*)

PROBLEM / RESEARCH NEED

Bat activity studies using ultrasonic detectors have been a routine component of pre-construction wildlife surveys at wind energy facilities for over a decade. These surveys incur substantial costs to industry, but it is unknown whether they provide any real value in terms of identifying risk and minimizing impact to bat populations. The assumption has been that a positive, predictive relationship exists between bat activity and fatality, although this has never been empirically demonstrated. Hein et al. (2013) examined this relationship, but results were inconclusive possibly due to a low sample size (12 studies), wide geographic differences among studies, and variability in the methods of the studies that were available.

Objectives

Determine whether studies that measured pre-construction bat activity can truly predict post-construction bat fatality.

APPROACH

We analyzed 44 paired studies completed by WEST, Inc. that measured pre-construction bat activity and post-construction bat fatality.

We examined the activity data in terms of geographic region, ground versus raised detectors, detector type (Anabat vs SMx), a standardized fall migration period versus other measures of activity, and whether detectors placed at features attractive to bats are better predictors of mortality than detectors placed in habitat representative of turbine locations. Fatality studies used standardized carcass surveys, with a subset of turbines searched at 1- to 14-day search intervals, including both road & pad and cleared plot searches. Studies included in the analysis included searcher efficiency and carcass removal trials and used Huso or Schoenfeld estimators

to estimate bat fatalities/MW/year.

We paired pre-construction and post-construction surveys, averaging multi-year estimates. We used linear regressions to predict fatalities from bat activity, looking at season, detector height, and region.

<u>FINDINGS</u>

Bat passes/detector-night ranged from 0.07 to 20.14. Bat fatalities/MW/year ranged from 0 to 20.05.

We plotted ground-level activity (x axis) against fatality levels (y axis) during multiple seasons. These acoustic data do not predict fatality. We tried honing in on a high fatality season (Fall) – but again, bat activity was a poor predictor of fatality levels. We examined the results of 20 paired studies where activity was recorded at raised acoustic stations (45 m), but this also did not prove a good predictor of fatalities.

We also looked to see whether activity was a better predictor for each of the USFWS regions of the country. The Pacific region has the lowest rate of bat fatalities and bat activity. The Pacific SW results are somewhat confounded by one study which had high activity but low fatality. Again for the most part (except for the Pacific NW), bat activity does not seem to be a good predictor of bat fatality, period.

<u>CONCLUSIONS / APPLICATIONS</u>

Bat activity does not predict bat fatality – not by season, detector height, or region. Our sample size was approximately four times greater than Hein et al. 2013, with standardized methods – yet the relationship was weaker.

What might explain this weak relationship? It may be that the main species killed are not the main species detected. For example, at the Foote Creek Rim Wind Farm, hoary bats made up 88% of fatalities, but only 8% of acoustic detections (Gruver 2002). Hoary bats may not echolocate 50% of the time, and may be detectable only 10% of the time (Corcoran & Weller 2018). Some species may be attracted to turbines, so that activity patterns may change once turbines are built.

Adding more studies is unlikely to change this relationship between measured pre-construction activity and post-construction fatality rates. Therefore, the wind industry should seek alternative methods for assessing risk to bats.

This is not to suggest that acoustic surveys have *no* value. Acoustic survey techniques may be refined to provide information on timing, species identification, and relative abundance of protected/impacted species. They can be used to study behavior or migratory bats in Canada, and might help us learn more about Mexican free-tail bats and other molossids throughout

Central and South America. Acoustic transects may be helpful, using drones, to look at abundance of different species at prospective sites.

Questions & Discussion

Q: *Given that there is inter-annual variation in bat activity, do you think you would come to different conclusions depending on the timing of the studies?*

A: I don't know, but agree there is inter-annual variation in both bat activity and bat fatality. For this we were averaging data across studies, but given that we really found nothing, I am not sure that variation in timing would change the essential conclusions.

Q: *Not all species are vulnerable to turbine strikes to the same degree; do you think species-specific activity rates might reveal a relationship with fatalities for those species?*

A: There is some potential for that. Not with hoary bats, which are not that detectable with acoustic devices, but for Mexican free-tail bats, which are more susceptible to random collisions with turbines, we may be able to find more correlation there.

Q: *Could any inconsistencies in research methods (search method, plot radius, etc.) improve the correlation between bat activity and bat fatalities in future analyses?*

A: No. We've been using pretty consistent methodologies, standardized across studies, and we are still not seeing a correlation.

Q: *While detection methods may not have changed, did you consider improvements in the acoustic detection technology, and the influence of microphone sensitivity on your results?*

A: Acoustic detectors have improved, and are more likely to detect bats, but they are not sophisticated enough to pick up the micro-pulse sounds hoary bats are apparently emitting much of the time, based on Weller & Corcoran 2018. I don't think that we'd see a major change in the relationship between pre-construction activity and post-construction fatalities.

Related question, not asked: *As microphones deteriorate with exposure to moisture, volume sampled declines exponentially. Have you considered taking detector volume vs. detector night into account as the appropriate metric?*

A: I am not aware of research that has demonstrated an exponential decrease in detection volume with exposure to moisture. I would want to know how quickly that happens. If true, I assume it would vary greatly across different habitat types (arid vs. humid). So it is not something we have taken into the account. At the same time, I am not concerned because most of our studies run from April to October, and nearly all projects record the highest bat activity during the fall, at the end of the season. It does not appear that exposure has affected their ability to record bats. Even if it does, and late-season microphones are under-sampling the bats actually flying around, this effect would be equal across projects and therefore not an issue for our studies.

Q: *Based on your research, what are the most efficient mitigation measures for reducing risks to bats?*

A: Curtailment seems to be the most effective method so far, but could be smarter to be more efficient.

Not Asked during Session

Q: *Don't bat activity and bat fatalities consistently spike during the fall? Wouldn't that be evidence of some correlation?*

A: They do! Bat acoustics are very good at telling us *when* to expect highest mortality, and for most projects this appears to be during the fall migration period. However, this is different than conveying the magnitude of bat fatalities. For example, we may find that Project A has a bat activity rate of two passes/night during pre-construction, and then have a fatality rate of 15 bats/MW/year during post-construction; meanwhile, Project B may have a pre-construction bat activity rate of 20 passes/night and a post-construction fatality rate of just five bats/MW/year. Both projects had their highest activity and fatality during the fall, but the relationship between activity and fatality rates was reversed: Project A had less activity but killed more bats, while Project B had more activity and killed fewer bats. What we found in our work was that there is *not* a positive, linear relationship between activity levels and fatality levels.

Habitat Covariates to Predict Bat Mortality
at Iowa Wind Farms

Presenter: Elizabeth Baumgartner, *Western EcoSystems Technology (WEST), Inc.*

[slide presentation]

Authors: Elizabeth Baumgartner, Jared Studyvin, Jeff Fruhwirth, Jason Mitchell, and Melissa Welsch (*WEST, Inc.*)

PROBLEM / RESEARCH NEED

In the course of conducting post-construction monitoring for MidAmerican Energy's fleet of wind facilities in Iowa since 2015, WEST, Inc. investigated the relationship between the location of bat fatalities and the proximity and abundance of bat habitat features to potentially predict areas of higher risk of impact to bats. Anecdotal observations from technicians suggested a potential relationship; understanding this relationship could improve take predictions and improve the accuracy and efficiency of Incidental Take Permit compliance monitoring, and could provide data to inform siting as risk management of future wind project development.

Research conducted to date suggests some spatial patterns in bat fatality or activity associated with wind facilities: Thompson et al. suggested bat fatalities had an inverse relationship with distance to grassland cover, possibly indicating higher mortality in forested landscapes. Barre et al. and Millon et al. suggest that bats may avoid turbines when compared with nearby habitat, while Cryan's 2014 work suggests bats may be attracted to turbines. Our understanding of what environmental factors may increase bat mortality at wind farms continues to be incomplete, despite concerted efforts by leading experts.

Objectives

The objective of our analysis was to evaluate whether the habitat surrounding turbines and/or facilities is related to bat fatalities. Through this research, we hope to:

1. predict turbines or areas within a facility with higher risk of impact to bats;
2. inform future turbine siting decisions to reduce risk; and
3. focus management decisions on turbines with highest risk – for example, increasing cut-in speed for turbines near roosting habitat.

APPROACH

We compiled habitat information in and surrounding 21 of MidAmerican Energy's wind energy facilities in Iowa, relating habitat types to either turbine- or facility-level bat fatalities found during surveys conducted between 2015 and 2017. Fatality surveys were completed using a combination of road-and-pad and cleared plot surveys (slide #5 summarizes survey methods).

We compiled habitat polygons surrounding turbines in Iowa and related presence of habitat types to bat fatalities in a generalized linear model. Habitat variables were measured on buffers (e.g., 100 or 200 meter) surrounding turbines, as well as summarized over facility polygons. Covariates measured on these polygons included, but were not limited to, percentage of each crop type, distance to river, distance to certain crop types, and distance to nearest trees. After compiling covariates, we fit a generalized linear model relating the estimated annual number of fatalities observed to habitat variables.

FINDINGS

Species composition of fatalities was as expected. In total, 3,900 bat carcasses were included in our analysis; just over 70% were Eastern red bat and hoary bat (long-distance migratory bat species).

We used a generalized linear model to fit a line to our data, selecting Negative Binomial Distribution as the best fit. Marginal effects plots (slides #13-17) illustrate the relationships between our data and the following covariates.

- *Distance to Water Flow* - For every 1 km increase, fatalities decreased, on average, by approximately 7%.

- *Distance to Open Water* – For every 1 km increase, fatalities increased on average, by 8.8%. This may be an artifact relationship, given that turbines are typically built further away from open water, or it may be that this covariate is less important in irrigated fields, where water availability is higher than, say, in an arid or semi-arid landscape.

- *Distance to Large Forest Patch* – For every 1 km increase, fatalities decreased, on average, by approximately 3%. This is as we would expect biologically, based on bats' typical habitat preferences.

- *Proportion of Grains/Hay/Seed* – For every 10% increase in coverage, fatalities increased, on average, by 12%. We are uncertain if there is a biological significance to this relationship; perhaps this relationship indicates increased prey abundance. This suggestion is purely speculation; the data collected were not intended to address causality. Additional data are needed to further elucidate the potential connection.

- *Monitoring Year* – For every one year additional duration, fatalities decreased, on average, by 10%. There is not enough data here to support a long term trend. (In addition, not all turbines/facilities were monitored in every year.)

To summarize, we found a positive relationship between fatalities and distance from the turbine to open water and the proportion of grains/hay/seed cover, and negative relationships between distance to water flow, distance to large forest patch, and monitoring year.

We have begun modeling at larger radial extents, and while some patterns are indicated, our model breaks down as we increase radial distance from the turbine and increase the number of

turbines in each sample unit (thereby decreasing our sample size). At the facility scale, we have too much variability to develop a predictive model. There are fewer covariates in the top model as our buffer size increases, but the results we have do suggest potential relationships:

- 500-m Radial Extent:
    - Distance to Hay/Grain/Seed – fatality counts decrease as distance increases
    - Distance to Water Flow – fatality counts decrease as distance increases

- 1000 and 2000-m Radial Extent:
    - Distance to Water Flow – fatality counts decrease as distance increases

CONCLUSIONS / APPLICATIONS

On the micro-scale, we see several relationships that are interesting, in particular: distance to water flow; distance to large forest patches; and monitoring year. On the macro-scale, we see a negative relationship with distance to water flow. There is, then, a consistent negative relationship between bat fatalities at turbines and distance to flowing water.

We have several options to decrease the variability, and are continuing the work to fit predictive models.

- ***Refine our covariates –*** Split up water flow by size: do streams matter, or maybe just larger rivers? Somewhere in between? Define a minimum patch size for the grassland/ hay pasture. Test for attraction at facilities – what activity levels do we see at wind projects relative to the surrounding landscape?

- ***Increase Carcass Dataset –*** Add more facilities in similar environments. Add more years of study to the existing dataset.

- ***Increase Radial Extent –*** Make the facility level buffer larger, more relevant to flying species. Doing so may bring to light important relationships. This would require additional facilities in a similar (Midwestern) landscape, and would shift the objectives from management at existing facilities (micro-siting, spatial curtailment) to Tier 1 analyses (facility siting).

- ***Examine by Species –*** Do all bat fatality models fit the same patterns as target species, such as Indiana bat, Northern long-eared bat, or little brown bat? This is something we plan explore.

In conclusion, we are making headway in understanding what factors might increase risk of bat mortality at wind farms, but we need more data to enable to picture to come into focus.

Questions & Discussion

Q: *The magnitude of influence of monitoring year was much larger than those associated with habitat variables. Why do you think that fatality rates typically decline over time?*

A: It's an interesting question. We try not to speculate outside the time frame here, particularly

given that the specific turbines and facilities surveyed in each year varied.

Q: *Why did you choose a buffer of 500 m?*

A: We looked at 100m, 500m, 1km, and 2km. Showed stepwise progression out for compactness of presentation.

Q: *Did you consider the operational status of project when evaluating the observed decrease in bat fatality year over year? Namely, was gross generation/run time/maintenance down time normalized for each year? Was curtailment applied? These factors can vary year over year.*

A: Facilities were operating consistently throughout the study period. We did not consider downtime, but if there were to have been a turbine that was out of operation for a long period of time it would have been excluded. (This was not the case.)

Not Asked during Session

Q: *Year was the most important variable. What explains annual decreases?*

A: While it is, of course, of interest to the wind-wildlife community, the study design was not intended to answer this question. The relationship between habitat, time, and the location where bat carcasses are found is undeniably complex, and we are in the infancy of exploring these relationships.

Q: *Were surrogate (non-bat) carcasses used for searcher efficiency trials? If so, do you think this affected efficiency rates?*

A: We used bat carcasses for searcher efficiency once bats were obtained. Collection of bat carcasses occurred immediately and continued through the duration of the study.

Comment: *Suggest further model testing by examining whether predictiveness increases when considering less "habitat generalist" species. Also, consider using a scale that matches known daily mobility per species.*

Response: The comment is appreciated, thank you.

Q: *Habitat alone may not be magic bullet, but have you considered looking at habitat in coordination with weather variables – e.g., the prevalence of high-risk warm, calm nights among sites?*

A: This work is ongoing, but outside of scope of this presentation.

Landscape Features Associated with Hoary Bat Fatalities at Wind Energy Facilities

Presenter: Erin Baerwald, *University of Regina*

Author: Erin Baerwald (*University of Regina*)

PROBLEM / RESEARCH NEED

Currently, fatalities at wind energy facilities are one of the greatest known sources of mortality for migratory bats. Between 840,000 and 1.7 million bats are estimated to have been killed by wind turbines in the US and Canada from 2000-2011, and several hundred thousand fatalities are estimated to occur annually. Of these fatalities, approximately 72% are of three species of migratory tree-roosting bats: hoary bats, eastern red bats, and silver-haired bats. Recent analyses suggest that fatalities at wind energy facilities are negatively affecting populations of hoary bat, which are thought to make up about 32% of wind energy-related bat fatalities. Turbines take breeding individuals out of the population, which matters because bats are long-lived, low-reproduction species. Hoary bats come from large catchment areas, so fatalities at a given facility could have continental consequences.

To reduce the impacts of wind energy on bat populations, developers and operators can locate projects in "low fatality risk" areas, but this is challenging because habitat use by migratory tree-roosting species of bat is not well-understood. Intuitively, high-risk areas are within spaces that provide high quality habitat for bats (i.e., places with lots of trees and water) and/or concentrate migrating bats (e.g. riparian corridors or ridgelines), but these spaces are not well-defined.

Within regions, there is variability in fatality rates. In the Midwestern Deciduous-Agricultural Region, for example, a survey of 24 studies at 14 sites produced an average fatality rate of 7.94 fatalities/MW/year, but mortality ranged from 0.76 to 31.1 fatalities/MW/year. Candidate factors that may influence fatality rates include abundance, turbine height, site design, and location (topography, etc.). These studies do not show a consistent relationship between fatality rates and topography or habitat features, but they did not look at species-specific responses, and may have looked at too small a spatial scale for such far-ranging animals.

Objectives

The objective of this project was to model landscape variables relevant to hoary bats. Our hypothesis was that fatality rates are influenced by topography and habitat. We predicted that:

- shorelines and ridgelines would concentrate fatalities because of abundance;
- bat migration routes may align with some of the known bird migratory paths;

- fatalities would be greater at sites within a matrix of high-quality habitat (i.e. lots of trees and water); and that
- habitat within a site influences fatality rates less than landscape attributes around the site.

APPROACH

The wind energy facilities in Ontario make up 76% of the wind projects in Canada's Wind Energy Bird & Bat Monitoring Database. Hoary bats make up 30.8% of bat fatalities in Ontario. We looked at 131 studies from 51 wind projects in southern Ontario, excluding projects that curtailed operations during the period (2009-2016). Studies per site ranged from 1 to 6 years, with fatality rates ranging from 0.0 to 14.02 bats/turbine/year. The average adjusted fatality rate for hoary bats was 3.31 bats/turbine/year (± 3.06 SD), for an estimated total of 8,530 hoary bat fatalities per year.

We analyzed the data from these studies using adjusted fatalities/turbine/year as our response variable (Huso 2011). We used bootstrap forest partitioning to screen 25 predictor variables based on their predicted effect size, reducing the list to seven variables and seven interactions. We then removed non-significant interactions via backward stepwise selection. The final model used:
- Year
- Proportion of roads and urban areas within 1km
- Proportion of trees within 1km, 5km, 25km
- Proportion of water within 25km
- Proportion of cropland within 25km
- Water within 25km X Trees within 25km

Southern Ontario has a lot of trees, water, and cropland. Thirty-five percent of the population of Canada lives there, so there is high road density.

FINDINGS

Results of the generalized linear model were as follows:
- Year = negative relationship ($P < 0.001$)
- Proportion of cropland within 25 km = positive relationship ($P = 0.001$)
- Proportion of water within 25 km = negative relationship ($P = 0.003$)
- Proportion of trees within 25 km = negative relationship ($P = 0.04$)

Our analysis suggests that fatality risk for hoary bats is correlated with habitat features such as distance to forest and proportion of water and cropland. The data also suggest that fatality rates are correlated more with habitat surrounding a facility (i.e., within a 25 km radius) than within a facility (i.e., within a 1 km or 5 km radius). This knowledge can be used in siting future developments.

Fatalities did not concentrate along shorelines or ridges, nor at areas of high-quality habitat. It may be that the topography and habitat are not variable enough across this region for terrain/topography to be an influential factor in fatality rate variability.

CONCLUSIONS / APPLICATIONS

The fact that fatality rates are influenced more by the habitat surrounding the site (within 25 km) than by the habitat within or immediately around the site (1-5 km) raises the question of whether turbines are more attractive as tree mimics when there aren't actual trees nearby.

We need to consider these questions on a broader scale, given the great distances bats travel. It may also be that we need to look at sites closest to where bats are departing or completing their nights' journeys.

Questions & Discussion

Q: *What about the rest of the migratory tree bats?*

A: We have a very robust dataset for hoary bats, so that was a great place to start. It will be interesting to compare and contrast with other species; we hope to be able to answer these questions with the next part of the study.

Q: *Could an increase in insect abundance in agricultural areas contribute to what you observed?*

A: We actually detect fewer insects in agricultural areas. Also a lower diversity of types of insects, given limited plant diversity.

Q: *Would you expect results to change is you used a per MW or per RSA basis for your fatality metric?*

A: We modeled both per MW and per turbine, and it doesn't make any difference.

Q: *One hypothesis for decreasing fatalities with increasing distance from trees could be that, when trees are limited in a particular landscape, bats are more likely to be attracted to turbines. Do these studies address this hypothesis (or could they)?*

A: We did not include distance to any variable, because I had a single centering point, did not have level of data to address that hypothesis.

Q: *Based on your research, what are the most efficient mitigation measures for reducing risks to bats?*

A: I don't know for sure. Curtailment is effective, but not necessarily most "efficient". I think we need to be looking at a broader scale when it comes to siting.

Risk and Impact Assessment at Offshore Wind Facilities

Moderator: Kate Williams, *Biodiversity Research Institute*

How do Bats Utilize Offshore Areas of Lake Erie?

Presenter: Ashley Matteson, *Western EcoSystems Technology (WEST), Inc.*

Authors: Rhett Good, Ashley Matteson (*WEST, Inc.*); Ed Verhamme (*LimnoTech*)

PROBLEM / RESEARCH NEED

The development of on-shore wind projects has resulted in extensive monitoring of bat ecology, resulting in a significant amount of information regarding the timing and levels of bat activity. However, much less is known about the activity patterns of bats off-shore.

Objectives

WEST, Inc. completed a study of bat activity in Lake Erie for the proposed Icebreaker Wind Project, located 8-10 miles from the shoreline near Cleveland. There are nine bat species with ranges in the region, including listed species (Indiana bat, northern long-eared bat) and long-distance migrants (hoary, eastern red, and silver-haired bats). The purpose of the monitoring was to assess the level of bat activity and species composition during the spring, summer and fall seasons at the proposed project location and other nearby offshore locations.

APPROACH

Each of five stations were equipped with two Song Meter full-spectrum ultrasonic detectors (SM3 and SM4; Wildlife Acoustics, Inc.) at each station. Detectors were turned turn on 30 minutes before sunset and turned off 30 minutes after sunrise from March 21 through November 14, 2017.

- Two stations were deployed on LimnoTech buoys nine miles offshore, at the proposed project area: one with two microphone detectors approximately 1 m above the water level (9-mile lower), and an experimental model with two detectors mounted on a pole approximately 10 m above water level (9-mile elevated). (The 9-mile elevated station was deployed in July and collected data for about six weeks, when the pole collapsed.)

- Another pair of stations were located two miles offshore at the Cleveland water intake facility referred to as "the Crib": one with two microphones deployed approximately 3 m above water level (Crib lower), and the other deployed approximately 50 m above water level (Crib elevated).

- A fifth station was deployed on a LimnoTech buoy located three miles offshore, with two microphones deployed approximately 1 m above water level (3-mile lower).

Enclosed in weatherproof casing, the SM3 and SM4 detectors were modified by LimnoTech to enable them to be powered externally, which allowed units to be deployed for longer periods of time. Redundant detectors were deployed at each station to increase data collection in the event that a detector malfunctioned.

Calls were sorted first into low- and high-frequency calls. Species identifications were made using Kaleidoscope, with some calls reviewed.

Monitoring will be repeated for two years after project construction to better understand potential impacts of the project on bats.

FINDINGS

A total of 10,114 bat passes were recorded over the course of 939 successful detector-nights, including passes recorded by redundant detectors at each recording location. The same bat could be recorded echo-locating during multiple passes at a given station; therefore, bat pass rates do not necessarily represent numbers of individuals at each recording location, but rather, represent an index of bat activity.

The overall average bat pass rate documented during this effort for all stations combined was 6.8 ± 0.7 bat passes per detector night, with single station averages ranging from 0.8 to 16.2 bat passes per detector night. Bat activity was highest at the Crib lower detectors (28.7±4.5 and 20.9±3.5 bat passes per detector-night), and lowest at the Crib elevated detectors (2.4±0.5 and 1.0±0.2 bat passes per detector-night). Comparable levels of bat activity were recorded at the nine-mile elevated, nine-mile lower, and three-mile lower stations, falling within the bootstrapped standard error of mean bat passes per detector-night.

Bat activity was lowest in spring. Peak bat activity was recorded during the late summer/early fall period (roughly mid-July through early October), consistent with a well-documented pattern at terrestrial sites. We were surprised to see more activity over the summer months than for the fall, but a more fine-grained analysis of timing shows there was a drop off from mid-August to mid-September followed by a sharp peak in activity during the third week of September (probably associated with migration), followed by a sharp drop off for the remainder of the study period (negligible activity mid-October to mid-November). The higher than expected levels of activity over the summer may have been associated with a Mayfly hatch-out along the Lake Erie shore; bats may have been foraging during that time.

Four common and widespread bat species (Eastern red, hoary, silver-haired, and big brown) accounted for the vast majority (<99.9%) of identified calls documented during this effort. Species composition varied seasonally. None of the calls recorded during this effort was classified as potentially belonging to a federally listed species. Three long-distance migratory

species accounted for 80% of all bat activity:

- Eastern red bats - 40.5% of all bat passes recorded across all stations
- Hoary bats - 24.3% of all bat passes recorded across all stations
- Silver-haired bats - 15.3% of all bat passes recorded across all stations

CONCLUSIONS / APPLICATIONS

It is difficult to compare results from this site to other sites because SM3 and SM4 units have more sensitive microphones than do Anabat units and record more bat passes than do Anabat units under conditions of identical bat activity. Therefore, bat pass rates collected with SM3 and SM4 detectors cannot be directly compared with data collected at on-shore projects that used Anabat detectors to assess if rates of activity were low or high relative to other projects.

Questions & Discussion

Q: *Are there lights on the Crib? If so, could they be attracting insects and in turn bats?*

A: The Crib does have lights turned on during a period, may have been reason for higher activity.

Q: *Was there any difference in species composition relative to distance from shore?*

A: We saw a similar composition of species at different distances.

Q: *Was there evidence of foraging offshore (e.g. feeding buzzes)? If so, did you see a decrease in feeding activity further from shore?*

A: We did not look at foraging activity as a part of the study. However, it would be possible to go back and look at the full spectrum sound files to determine the number of feeding buzzes recorded.

Potential Interaction Analysis of Offshore Wind Energy Areas and Breeding Avian Species on the US Atlantic Coast

Presenter: Jeri Wisman, *Bureau of Ocean Energy Management*

Authors: Jeri Wisman (*Bureau of Ocean Management*), Sara Maxwell (*Old Dominion University*)

PROBLEM / RESEARCH NEED

Given increasing US interest in developing wind energy sites in offshore waters, efforts are underway to evaluate the threat to seabird populations with the potential risk of interacting with wind energy development lease areas in the mid-Atlantic. Previous efforts by the Bureau of Ocean Management (BOEM) and the National Oceanic and Atmospheric Administration (NOAA) have predicted avian density using at-sea survey data, and have done a good job of identifying low to moderate risk areas. But these assessments are missing information about overlap of breeding areas and wind energy lease areas.

Objectives

We seek to complement earlier survey-based avian density predictions by focusing specifically on birds during the critical and energetically demanding breeding stage of their life history. The specific objectives of this project were as follows.

1. Analyze overlap of breeding colonies for six seabird species and wind energy lease areas in the mid-Atlantic.

2. Analyze spatially-explicit animal movement and behavior of common terns breeding in coastal Virginia in relation to offshore wind sites in the US.

APPROACH

We combined colony size and location data via US Geological Survey's Colonial Waterbird Database on six at-risk seabird species with breeding ranges in the mid-Atlantic and foraging ranges greater than 10 km. Breeding season foraging ranges were determined for each species – brown pelican, common tern, great black-backed gull, gull-billed tern, herring gull, laughing gull – through the scientific literature. For each colony, we mapped buffer areas correlated with the species' inner "common" foraging zone and a limit or outer "uncommon" foraging range. (No data were available for Rhode Island, Maryland and Delaware.)

We integrated population size, vulnerability to offshore wind, and foraging areas, and overlaid this model onto current BOEM lease areas, assigning each species a vulnerability score based on a 2013 report (Wilmott et al. 2013, BOEM) which gave a value to different categories of risk for each species. Individual species vulnerability scores were combined with colony and

population sizes to produce colony vulnerability scores.

To address the issue of overestimated foraging areas, we collected GPS location data on common terns (*Sterna hirundo*) at a colony on the Eastern Shore of Virginia during their 2017 and 2018 nesting seasons. We collected 8,400 data points, and used these data to analyze spatially-explicit movement and behavior of common terns breeding in coastal Virginia in relation to offshore wind sites in the US. Of the several spatial use analyses considered, we discuss:

1. Residence time analysis
2. Kernel utilization distribution

FINDINGS

Laughing gulls ranged the furthest (45 km), but the common foraging range for all species was about 10 km from their breeding areas.

In a 2013 survey of colony sizes, a total of 62,000 breeding pairs were observed, with the greatest density found off the mid-New Jersey coast. Laughing gulls made up 81.3% of this area's population. Great black-billed gull ranked most vulnerable.

Species and colony vulnerability scores were used to calculate multi-species vulnerability, which in turn was used to map areas of high-predicted vulnerability in several areas along the mid-Atlantic. These include the northern and southern ends of the Eastern Shore of Virginia, southern to mid-areas of the New Jersey coastline, and western Long Island, New York. Out of the total study area, 31.73% of the high-predicted vulnerable areas overlapped with currently leased areas for offshore wind energy development. If these areas are completely developed, a combination of highly vulnerable seabird species, common foraging areas, and/or larger populations could be at risk of impacts from offshore wind.

We also compared our multi-species vulnerability model to the predicted density models produced by NOAA. We found that these models could be used together as tools to identify areas with both high predicted density as well as high vulnerability as they overlapped 38.54% in our study area.

For the GPS tracking, we applied a 1-km buffer around the tagging site to remove location points at the nest or small foraging trips around the island because we were more interested in other habitat usage. We used kernel utilization distribution (KUD) to show where birds spent more time at rest vs. where birds spent time foraging at greater distances from the nest.

A key finding of the tracking data is that breeding common terns most often utilized an area (7.25 sq. km) roughly half the size of the suggested foraging range found in the literature, and that some traditional risk-models may be overestimating the potential impacts of offshore wind development on seabirds. Other key points:

- Nearby north and south islands are important to this colony.

- We found no overlap between this breeding colony's activity with VA or MD offshore lease areas.

Tracking is critical; it shows that there is less impact than previously thought. Unlike the breeding colony surveys, GPS tracking begins to give us some of the directionality that can then be applied to the multi-species vulnerability study.

CONCLUSIONS / APPLICATIONS

The differences between our multi-species vulnerability (MSV) model and the NOAA predicted density model suggests that simply relying on predicted density as a metric for determining impacts may miss areas that are critical for breeding birds. MSV shows more variation in vulnerability along the coast. Areas of overlap (38.54%) between the two models indicate both high predicted density AND high vulnerability. The MSV model also yields a conservative take on foraging ranges and could be overestimating common foraging areas, thus overestimating vulnerability.

The MSV model allows us to see finer scale of vulnerability than in previous studies, and demonstrates the importance of considering specific species during breeding. Common foraging areas may have less risk than the "uncommon" foraging areas, which are more likely to overlap proposed wind project sites. We believe this is an important management tool as it fills gap in knowledge about risk to breeding seabirds. The MSV model is fairly simple and can be used to assess other species' risk provided you have their colony data.

Future Directions:

- 2018 was another tracking year; we will add this data to the MSV model when collected, and will be able to add data for Maryland and Delaware also.

- We will be tagging more common terns as well as black skimmers; we hope to collect migration data from these birds

- We'll run a similar spatial analysis with our 2018-2019 data once it's collected and are also using data from Virginia Tech for another colony.

- We want to investigate influences of weather and also look at nocturnal vs. diurnal travel patterns, and whether these might affect their interactions with offshore wind.

Questions & Discussion

Q: *Have you tried to run the (KUD) model of kernel analysis only on high-residence time points? Would that make a difference?*

A: We have not tried that, so I'm not sure whether it would make a difference, but that is a good suggestion.

Q: *How did you identify the "common" foraging range for the common tern?*

A: Conclusions from characteristics of foraging behaviors, e.g., common terns range up to 20 km, but more commonly found within 10 km. We found information in the literature. We are doing an updated literature search to make sure our information is up to date.

The Fate of Displaced Birds

Presenter: Jared Wilson, *Marine Scotland (Scottish Government)*

Authors: Kate Searle, Deena Mobbs (*Centre for Ecology and Hydrology*), Adam Butler (*Biomathematics and Statistics Scotland*), Bob Furness, Mark Trinder (*MacArthur Green Ltd.*), Jared Wilson (*Marine Scotland*), Francis Daunt (*Centre for Ecology and Hydrology*)

PROBLEM / RESEARCH NEED

Offshore renewable developments (ORDs) may result in collision mortality to seabirds, which has obvious demographic impacts. ORDs may also affect seabirds by displacement to less favorable habitats or via barrier effects to the movement of birds. These can take place at any season or life stage, but are thought to be most impactful during breeding season. These potential effects have been identified as a key ecological constraint for offshore wind farm development in Europe. Scotland in particular has a large number of breeding seabirds and breeding colonies. Our understanding of how displacement effects may impact individuals and populations is limited.

A simple approach to the quantification of displacement/barrier effects uses a matrix approach. Given the estimated number of seabirds in the windfarm area, the matrix allows us to determine displacement mortality based on what we believe will be (a) the percentage of birds displaced, and (b) the percentage of displaced birds that will die. While some empirical data on displacement rates are available for some seabird species, data are lacking on mortality level: that is, the percentage of displaced birds that die. Whilst simple to use, the matrix approach makes a number of assumptions.

Objectives

We developed a simulation model to estimate the time/energy budgets of breeding seabirds during the chick-rearing period, and translated these into projections of adult annual survival and productivity.

<u>APPROACH</u>

A tool (SeabORD) was produced to estimate the cost to individual seabirds, in terms of changes in adult survival and productivity, of displacement and barrier effects resulting from ORDs. Inputs included GPS tracking data or density decay functions on bird locations and distribution without the wind farm for the following species: northern gannet, black-legged kittiwake, Atlantic puffin, common guillemot (Murre), and razorbill.

The model simulates foraging decisions of individual seabirds under the assumption that they are acting in accordance with optimal foraging theory. In the model, foraging behavior of individual seabirds is driven by prey availability, travel costs, provisioning requirements for offspring, and behavior of conspecifics. We start by outlining the location of the proposed wind farm and considering possible responses to it. We then model effects on body mass with and without the wind farm. These effects in turn are used in a decision tree to determine adult or chick mortality, also behavior and impact on chick mortality if the foraging adult spends less time at the nest.

The model estimates productivity and adult survival, the latter resulting from estimates of adult mass at the end of the breeding season, which affects over-wintering survival probability. The model is run for the "no wind farm" scenario and "tuned" using long-term data collected at the Isle of May in eastern Scotland. Only once the model has been validated against these data is the model run for the wind farm scenarios.

<u>FINDINGS</u>

Outputs include time spent flying and foraging, body mass for adults and chicks, and the number of flights to and from the nest and foraging grounds. Outputs from the model can be used to estimate the population level change in adult mortality and breeding success. It can also estimate the change to demographic rates of those individuals that interact with the wind farm (of relevance to the matrix approach).

The estimated effects on demographic rates can then be used to in Population Viability Analysis to compare population change between wind farm and no wind farm scenarios to assess the population level consequences of the wind farm.

<u>CONCLUSIONS / APPLICATIONS</u>

SeaBORD is, to our knowledge, the first analytical tool for estimating the consequences of barrier and displacement effects upon demographic rates of seabirds. The tool was developed for common guillemot, razorbill, Atlantic puffin, and black-legged kittiwake during the chick-rearing period, but it can readily be adapted to estimate these effects on any seabird species in any part of the UK during chick-rearing – or other periods of the annual cycle – if empirical data are available.

Right now we are limited empirical data; this study has helped highlight data gaps. While there are no operational wind farms near breeding colonies of the seabirds we're studying, several projects are in planning stages or under construction, providing the opportunity to gather these data. We will continue to monitor to increase our understanding of displacement impacts.

Questions & Discussion

Q: *Could you specify the key knowledge gaps currently constraining the effectiveness of the SeabORD tool?*

A: One key evidence gap is the relationship between body mass and adult survival. There are limited data available, though a project has just started that will be analyzing existing monitoring data that will increase the empirical information available.

Not Asked during Session

Q: *How may model assumption of optimal foraging theory have affected the results?*

A: The model reflected as closely as possible the behaviors and responses to prey availability observed from long-term seabird studies.

Thermal Stereo-vision Technology for Assessing the Effects of Offshore Wind on Birds and Bats

Presenter: Shari Matzner, *Pacific Northwest Energy Laboratory*

[slide presentation]

Authors: Shari Matzner, Ryan Hull, Thomas Warfel (*Pacific Northwest National Laboratory*)

PROBLEM / RESEARCH NEED

Assessing the effects of offshore wind on birds and bats is challenging due to limited access to offshore wind sites. Periodic ship-based and aerial surveys are useful for taking population census, but long-term, continuous monitoring of the rotor-swept zone is needed to characterize avoidance and collision risk as we develop actual projects.

To make continuous observations – including in low visibility conditions – over extended periods of time at an offshore location requires technology that can record bird and bat activity

both night and day, and in low visibility conditions. Data processing must be automated to generate results in a timely, cost-effective manner. In previous work, we developed a method for generating a two-dimensional image of an animal's motion using thermal video and combining a sequence of video frames into a single composite image that shows a complete flight trajectory (slide #4). This approach reduces the volume of data significantly and generates passage rate data in near real-time.

Objectives

We sought to demonstrate that the composite motion track images from a stereo pair of thermal cameras could be used directly to generate three-dimensional tracks. A new, efficient system for obtaining three-dimensional flight trajectories using thermal stereo video – ThermalTracker2 –operates in real-time and significantly reduces the volume of data from the raw stereo video stream while providing essential data on flight patterns in the rotor-swept zone. Our objective was to validate that the ThermalTracker2 video can be used to monitor effects of offshore wind on birds and bats and give us more site-specific, continuous, and timely data.

APPROACH

How it works

We used open source processing software to develop an offline tool, then applied that processing software for use in real-time analysis.

Thermal video, like any video, is a sequence of two-dimensional images. Slide #7 shows a composite image using 300 frames of video to create a flight track. Blobs – groups of connected pixels-- are connected to create a track; a dot at the end of the track indicates direction of travel. Thermal imagery is easy to use for tracking, but produces a low resolution image; indistinct shape and lack of color information makes it difficult to identify species. However, thermal stereo video does provide information that can be extracted and processed to identify species, information such as the size of the animal, the shape of the flight trajectory and wing beat frequency.

The software also outputs a csv file with time, direction of travel, and other characteristics of flight path, such as sinuosity. By adding a second camera for stereo vision, the system can generate 3-dimensional tracks. This means we can tell where exactly in space the target was moving – whether the target was in the rotor-swept zone, its flight height – and something about flight behavior. Slide #8 diagrams stereo processing. It includes a calibration step, which calculates the parameters needed to do point triangulation in 3D space, and a stereo-matching step, which determines the relative positions of objects in the images from the two cameras. In slide #9, a red dot is the point used to locate the same object in the two images. Both of these critical steps (calibration and stereo-matching) are more challenging with thermal video.

System validation

We put together a prototype system, using off-the-shelf equipment (slide #11). The most expensive piece was a high-end scientific thermal camera – two Flir A655sc thermal cameras with field of view of 15 degrees horizontal and 11 degrees vertical, and 640 x 480 resolution. Other components of the system (laptop, external hard drive) were fairly inexpensive. In a first test of the system's real-time operation, we left it running unattended for a couple of 24-hour periods. The software was able to keep up with livestream thermal video from a single camera.

We then added a second camera. The wider apart the cameras are spaced, the better you can estimate the distance of an object. However, there's a trade-off involved, because the wider the spacing, the more unwieldy and more difficult it is to keep the cameras in fixed relationship to each other. We settled on a 1-m distance between cameras, which should keep the distance measurement accurate to within about 10 m for objects that are up to 100 m distant.

To validate the accuracy of the stereo processing, controlled target tests were conducted at the Pacific Northwest National Laboratory's Marine Sciences Laboratory in Sequim, WA. For the first controlled target test, an electric heating element approximately 8 in. x 8 in. was mounted on a pole carried by a person. In a second controlled target test, a pair of air-activated hand warmers was suspended from a line and pulled along through the field of view to simulate a small bird or bat in flight. The hand warmers were first fixed to a line about 30 m from camera (short-range) and again in a long-range test with the line 60-80 m from the camera. A grid pattern was used to calibrate the cameras.

As a further test of the prototype, Biodiversity Research Institute (BRI) used the prototype system to record thermal stereo video of wild birds (multiple species of gulls, terns, cormorants and shore birds) near Portland, Maine, comparing system tracking results with BRI observers' field observations. The expert observers' notes provided ground truth in the form of species and estimated distance from the camera, with observations spanning distances from 20 to 100 meters.

<u>FINDINGS</u>

Slide #15 shows the thermal flight track images from each of the two cameras. For the short-range test we first manually matched the points from each image to calculate the distance of the objects from the cameras, and then used that as the standard for comparing the automated calibration processing. For the long-distance test (slide #16, top table) the results were fairly mixed. Most of the results were within 10 m of the measured distances, but there was a lot of variation, and we concluded that the calibration process did not provide a very accurate set of parameters to do that triangulation. Results of the short-range test, which effectively takes the calibration step out of the equation, were within centimeters of the manually matched points; this validated that the automated stereo-matching worked as expected.

Slide #18 shows that the system tracking results on the wild bird data corresponded well with observers' field notes. The results of the wild bird data processing showed a detection rate greater than 90% on a selected set of the videos, and very few false positives.

We have determined that we can use the flight path to extract wingbeat frequency and use stereo processing to estimate additional parameters (body length, wingspan, flight speed, flight height) that will enable us to build species identification algorithms.

Next steps are to improve species classification capability and to produce a more rugged instrument package with a much smaller, less expensive camera that we can test in more challenging locations. In spring 2019, we will test a more rugged, lightweight, compact version of this system at a working wind turbine at the National Renewable Energy Laboratory's National Wind Technology Center. This testing will allow us to experiment with camera positioning at an operating wind turbine, using drones as controlled targets, and will also allow us to evaluate the system during extended operations in various weather conditions.

Thermal stereo vision is a practical technology for monitoring offshore wind energy sites, capable of providing:
- continuous observations
- flight height
- avoidance behavior
- taxonomic identification
- timely information
- low cost/complexity

Questions & Discussion

Q: *What is the range and field of view of the camera system? Why would you not use radar? (Are there advantages to using thermal camera over radar?)*

A: Detection range depends on the camera and size of the bird. If the bird occupies at least six pixels we can detect it. For very small bird, the current camera can detect it at 200 m. For the newer smaller camera, which has wider field of view, it's about 150 m. Radar covers a wider area, but it's harder to identify species using radar, and also more expensive and complicated to use. Thermal imaging can be a good complement to radar.

Q: *Is it a good idea to go to a cheaper camera? Don't you need a higher resolution?*

A: No; cheaper camera is still a resolution of 640 x 480 is the highest resolution you can get with a thermal camera. (See slide #24 for comparison of camera specifications.)

Q: *Have you estimated the thermal camera's probability of detection for small birds and bats?*

A: No, but as stated previously, it depends on camera resolution and size of the bird. We did do some tests with the ThermalTracker software that we developed initially. We had a test dataset that contained a total of 184 different tracks. Those tracks were identified by humans looking at

the video. Software detected 84% of human detected tracks, and detected three tracks that humans did not. Tracks that were not detected was due to insufficient contrast because the bird was too distant.

Developing an Ecological Risk-Based Management Framework for Wind Energy Development

Presenter: Alicia Gorton, *Pacific Northwest National Laboratory*

[slide presentation]

Authors: Andrea Copping, Alicia Gorton (*Pacific Northwest National Laboratory*), Elise DeGeorge (*National Renewable Energy Laboratory*)

PROBLEM / RESEARCH NEED

Risk-based management (RBM) is broadly defined as a method for identifying, assessing, and prioritizing risks, so the appropriate level of resources can be applied to minimize, monitor, and control unwanted outcomes. It is important to understanding wind-wildlife interactions because it takes into account inherent uncertainties in the system.

Existing approaches to risk assessment for wind turbines (both land-based and offshore) are based on traditional risk assessment methods that rely on a chain of linear cause-and-effect analysis which focus on technical risk and reliability analysis and do not address human, organizational, and environmental factors. Uncertainty due to lack of data can lead to misconceptions about short-lived but potentially high-impact activities, like pile-driving, and can result in conservative approaches – e.g., proceed with extreme caution or not at all. These challenges may result in a shift of focus and investments away from interactions that place wildlife at higher levels of risk, potentially resulting in greater losses to wildlife populations already under stress from climate change and other anthropogenic activities.

Especially in marine and coastal environments, there has been a recent shift toward ecosystem-based management (EBM), a more expansive holistic method that includes humans in an integrated view of managing resources while sustaining ecological integrity. In the US, marine EBM incorporates integrated ecosystem assessments (IEAs) that set goals and targets, define indicators, analyze status, trends, and risk, and evaluate potential future management and environmental scenarios. Marine EBM and IEAs have been implemented on the US Northeast Shelf for wind energy development. EBM approaches for land-based wind are in the early stages of implementation internationally; however, the literature suggests integrated risk

(RBM) or EBM approaches have not been fully developed or implemented in the US for land-based wind.

Objectives

The international collaboration Working Together to Resolve Environmental Effects of Wind Energy (WREN) has as its primary objective to facilitate international collaboration and advance global understanding of potential environmental effects of wind energy. To address the apparent lack of an integrated EBM framework for wind development (both land-based and offshore), WREN proposes a framework that uses the principles and experience gained from EBM in the marine environment to:

1. help inform permitting and assist with operational decisions under significant levels of uncertainty;
2. investigate the effects of data quality and access on other types of risk, such as financial and reputational risk; and
3. ensure that management decisions, monitoring program foci, and mitigation measures are proportional to the risk that wind energy farms pose to wildlife and habitats on land and at sea.

The goal of this approach is to help direct monitoring and evaluation resources toward the highest risks that need to be addressed to minimize effects on wildlife and habitats, while maximizing energy production.

APPROACH

The management framework consists of four parts:

1. Identify risks posed by wind farms for all phases of development
2. Set goals to evaluate the acceptability of those risks
3. Test those goals and associated management actions through a set of case studies that represent wind energy development in multiple nations on land and at sea
4. Develop a set of recommendations for implementing risk-based management for wind energy development

Arkema et al. 2006 investigated criteria and related requirements of ecosystem based management. Here, we adapted their criteria into ecological objectives (slide #20) needed to meet ecosystem RBM goals and help evaluate the acceptability of the identified risks.

To test the framework, we review three example international case studies chosen from WREN nations. The two offshore and one land-based project cover the range of development phases: planning, permitting/consenting, installation, operation, maintenance, repowering, and decommissioning.

1. Block Island is the first offshore wind farm in North America. Deployed in 2016, it consists of five seabed-mounted 6-MW turbines generating to the grid. We looked at the following phases:
   - Siting and planning: sited in a planned area
   - Habitat protection: horizontal directional drilling through shallow water and intertidal zone
   - Construction: mitigation for sound of piling at sea and additional vessel traffic
   - Operation: turbines curtailed during fog

2. Moray Firth (UK) involves three separate offshore development areas – Beatrice (84 7-MW turbines under construction, fully operational in 2019); Moray East (950 MW installed capacity – scheduled to begin construction in 2019); Moray West (under initial consultation, EIA scheduled to be submitted for 2018). We look at:
   - Siting and planning: area identified to exclude seabird and marine mammal areas; worst case scenario cumulative impacts at the population level.
   - Mitigation measures: incorporated through Environmental Impact Assessment.
   - Post-installation monitoring: stakeholders (Regional Advisory Group) agreed on question-based monitoring.

3. Jura Mountains, Switzerland – 145 wind turbines, spread over 2,000 square km, producing 22 million kWh of electricity a year to power 6,000 homes. Studies are underway to support consenting and development. We look at:
   - Siting and planning: landscape-level siting criteria for birds and bats, using vulnerability mapping; population-level cumulative impacts assessment, with and without mitigation, based on collision risk modeling and population models.
   - Mitigation: definition of potential addition mitigation measures, based on expert knowledge and negotiations.
   - Stakeholders: steering committee monitors projects and wildlife impacts during operations; adaptive management approach to guide future monitoring and mitigation.

FINDINGS

We evaluated different key management actions with ecological objectives in mind. The focus is on having a semi-qualitative assessment of how well management actions meet different ecological objectives. It is a very adaptive process. The matrix in slide #14 gives a high-level overview, showing which ecological objectives were met or favored (more or less) for different projects at different stages of development for these three projects.

No project will be perfect across the board, but this gives us a basis for determining which projects or project phases meet various objectives, whether certain objectives are more or less favored than others, etc. These are just three examples, and we are looking to add more. If you

have any thoughts or know of any projects that we could include, please contact the authors.

CONCLUSIONS / APPLICATIONS

Based on the objectives and goals for RBM for wind energy and an assessment of multiple development phases from the case studies, we propose six recommendations to support and facilitate RBM for wind energy development. For both land based and offshore wind, these recommendations are directed at robust assessments of populations and habitats that have reasonable likelihood of being effected by development and operation; a hypothesis-based program of post-installation monitoring of interactions and population health; and mitigation for any potential adverse effects.

- **Science-based Data Collection.** Baseline and post-installation monitoring data collection should be based on questions of scientific importance (such as population-level effects, changes in critical habitat for species under stress, etc.), using the same collection methods to the greatest extent possible for pre- and post-installation studies.

- **Complexity of Ecological Interactions.** Data collection and analysis must acknowledge and incorporate complexities of spatial and temporal changes in populations and habitats, as well as ecological interactions between predators/prey and competitors.

- **Mitigation Measures.** Mitigation actions (including curtailment, slow starts, seasonal changes in operations, and changes in monitoring efforts) must be guided by the outcome of post-installation monitoring results and be proportionate to the risk to target wildlife populations and habitats.

- **Integration of Adaptive Principles.** Post-installation data should be used to determine appropriate outcomes, be able to adjust monitoring (increase effort, decrease effort, or change effort), as well as pursue mitigation if needed.

- **Inclusion of Stakeholders.** Including stakeholder is necessary above and beyond what laws or regulations require. Stakeholders can help get subsequent projects going, can provide local knowledge, and even community involvement in financing.

- **Focus on Social and Economic Outcomes.** It is important to consider social and economic risks to local communities and region as well as to the business and society at large.

By evaluating the relative risks that define major ecological challenges of wind farms, this framework will provide improved risk estimates that will inform and accelerate future wind farm development and provide consistent and accessible methods for data collection and analysis. We are looking for more case studies to flesh out this framework. We will develop guidelines and finalize a white paper for review by March or April 2019.

Questions & Discussion

Q: What ecological goals are linked to the "economical", "technical" and "stakeholder"

objectives you mentioned?

A: Definitions of all of these were outlined in a 2006 study that scoured the literature for definitions of eco-system based management, producing a list of 17 criteria. We narrowed it down to criteria mostly applicable to wind energy, both on and offshore [see slide #20]. Definitions came from that 2006 study. For example, the economics objective is defined as: "operational constraints for ecological conservation allows for operation to be profitable." Science-based: "management criteria are science-based monitoring with hypothesis-based post-installation monitoring plans."

Not Asked during Session

Q: What is the difference between adaptive management and EBM?

A: Adaptive management is a flexible, "learning by doing" decision-making process. It is an iterative process that reduces uncertainty over time by adapting monitoring and mitigation practices based on previous outcomes. Ecosystem-based management (EBM) emphasizes the importance of ecosystems and the interactions/interconnectedness between systems (ecosystems, air, land, sea) within the decision making process. EBM practices may or may not be present within adaptive management approaches.

Assessing Risk to Eagles

Moderator: Taber Allison, *American Wind-Wildlife Institute (AWWI)*

Computational Fluid Dynamics:
A New Frontier in Eagle Risk Prediction

Presenter: Chris Farmer, *DNV-GL*

[slide presentation]

Authors: Chris Farmer, Dnyanesh Digraskar, Jessica Brownlee (*DNV GL*), Dave Brandes (*Lafayette University*), Greg Aldrich (*Duke Energy Renewables*), Tom Hiester (*IdentiFlight International*)

PROBLEM / RESEARCH NEED

Pre-construction measures of avian use have relatively low value as predictors of operational impacts because simple use measures do not account for flight behaviors and site-specific factors that influence behavior. We examined the relationship of collision risk to terrain at the Top of the World wind energy facility, where eagle fatalities are widely distributed, ranging from zero to three fatalities per turbine since operations began. When we look at a map of fatalities across the Top of the World wind energy facility, there does not appear to be a pattern linked to what we traditionally consider risk factors: ridge lines, slopes, saddles, notches, benches, nests. We have to look more deeply into the relationship between terrain and flight behavior to understand the pattern of fatalities.

Principles of flight dynamics suggest updrafts derived from terrain influence collision risk for soaring raptors within wind farms. Updraft velocities near or below the threshold necessary to sustain flight cause soaring raptors such as eagles and vultures to engage in high-risk flight behaviors near the ground. There are two major sources of updraft: thermal and orographic. Orographic updrafts result from deflection by terrain; these tend to be weaker and to weaken more quickly above the terrain than thermal updrafts. However, at times of year when thermal energy is insufficient to generate above-threshold updrafts, orographic lift becomes more important. (Slide #5 includes a graph of direct normalized solar irradiance, showing that fatalities at Top of the World peak during seasons with low thermal energy available, making orographic updrafts more important.)

<u>Objectives</u>

Our objective was to determine whether we can objectively predict, based on landscape and wind flow modelling using computational fluid dynamics, how collision risk is distributed at a project site.

<u>APPROACH</u>

Using standard hydrologic modeling techniques, it is possible to predict horizontal wind velocities given simple inputs such as a project area's wind rose and digital terrain model. We previously examined the ability of hydrologic modeling to predict the number and duration of high-risk flights by soaring birds within a wind farm; however, the predictions were limited to upwind areas around turbines.

Newer, more sophisticated techniques use computational fluid dynamics (CFD) codes to iteratively solve the Reynolds-Averaged Navier-Stokes (RANS) equations to produce highly detailed wind flow predictions. Wind flow modeling using CFD has become an important industry tool for bankable pre-construction energy assessments. Because CFD modeling allows us to examine all directions around a turbine and assess the vertical as well as the horizontal components of air flow, it can be used to predict updraft and downdraft distribution at a proposed or existing wind energy project site.

We used a steady-state RANS model, extensively validated for global wind energy assessments, to predict updraft and downdraft distribution at the Top of the World Wind Farm in Wyoming.

We provide a direct comparison of this landscape risk prediction to results of modeling derived from the simplified approach that was previously used at the site, and compare the predictions to high-frequency flight data containing information on approximately 40,000 eagle flights recorded by IdentiFlight, a machine vision system deployed to monitor golden eagle flights for approximately one year at Top of the World. IdentiFlight recorded a total of about 36,000 eagle flights within about a half-mile of turbines during that year; we defined high-risk flights as those within 100 m of turbines and below 200 m elevation. In the absence of eagle fatalities as a definitive measure of risk, we examine the influence of updraft velocities on flight time near the turbines.

<u>FINDINGS</u>

The test location is dominated by updraft velocities below the threshold for golden eagles. We looked at lift patterns related to wind direction (slide #8) at 12 turbines with day-of-death information for eagle fatalities. A total of six eagle fatalities at a cluster of three turbines were associated with SE winds. We are consistently seeing downdrafts around these turbines. Could it be that the interaction between updrafts and downdrafts increases risk?

IdentiFlight recorded 2,199 flights (297.5 minutes total flight time) that met our "high-risk" criteria (within 100 m of turbines and below 200 m elevation).

At the subset of turbines monitored by IdentiFlight, we see persistently low updrafts. The table on slide #12 shows that wind speeds associated with high-risk passes tend to be lower (4-8 m/s) and that wind direction associated with high-risk passes tends to be southerly to southwesterly. But when we look at fatalities associated with those same turbines, five of seven fatalities are associated with N to NW winds, and only two are associated with southerly winds (slide #13). This suggests that prevailing winds may be more predictive of eagle activity than of collision risk.

Another way to look at this is to try to come up with a quantitative risk index. Slide #14 shows how use or fatality distribution mapping can be combined with updraft distribution to produce a model-based index of risk on the landscape. If we split the area around the turbine into updraft and downdraft portions, we tend to find updrafts on the up-wind side and downdrafts on the down-wind side (slide #15). Testing this, the main result was that the mean updraft velocity on the up-wind side of turbines was significantly lower on NW winds than on SW winds. This could explain why five of seven fatalities were associated with N to NW winds.

The total number of high-risk flights increased as NW updraft velocity increased, and the number of high-risk flights decreased as SW updraft velocity decreased (slide #16). We are not yet sure what this means. Collisions appear to be associated with uncommon wind scenarios, which may explain why pre-construction use assessments are not necessarily predictive.

CONCLUSIONS / APPLICATIONS

Our preliminary results suggest that extraction of updraft velocities as a routine component of wind resource modeling will facilitate improved siting and micro-siting of wind energy infrastructure by allowing developers to identify and avoid areas of high inherent risk to soaring birds. Furthermore, because wind resource modeling occurs early in the development process, small investments in CFD modeling have the potential to produce large savings in expenditures on post-construction avoidance and minimization measures.

We need to know where eagles are on the landscape, or in this case a utilization distribution based on fatality mapping, as well as the wind direction. If prevailing winds predict activity but not risk, the path to risk prediction appears to go through fatality monitoring coupled with high-frequency surveillance monitoring to identify patterns of eagle use on the landscape. IdentiFlight monitoring is being conducted at other turbines at Top of World, so we are hoping to get a more detailed map of how risk is distributed across the wind farm as the data accumulate.

Refining this approach requires:
- additional testing against use and fatality data
- determination of correct inlet height (one of the CFD inputs)
- Combined irradiance and wind modelling for siting

This is a work in progress; we are interested in people's thoughts about what else we should look at. Slide #18 suggests how a tool like this might be used to identify areas of landscape that could be risky in terms of micro-siting and permitting, and also to help with smart curtailment during post-construction operation.

Questions & Discussion

Q: *Have you thought about how you might incorporate prey distribution into your evaluation equations?*

A: In looking at spatial overlays, prey distribution would be a logical overlay to use. But with some caution, because from what we're seeing at Top of the World, prey distribution changes a lot from year to year, and may already be incorporated in eagle use patterns.

Q: *Is it reasonable to assume that migrating eagles use or respond to wind uplift conditions in the same way as resident eagles?*

A: It depends on what they're doing at that location. At Top of the World, a lot of birds are hunting and foraging; they are mostly residents, but there are some floaters and migrants as well. In the east, where we see very concentrated eagle migration, we're seeing the birds using a lot of orographic lift during migration, and we are not seeing so many fatalities, because birds are passing through, whereas at Top of the World those birds are spending a lot of time within the wind farm, among the turbines. Near-threshold updrafts are more of a problem for foraging birds because it requires them to use wing-powered flight – during which activity they are probably less vigilant or aware of a potential obstacle – and because their exposure time is greater than birds that are just passing through.

Not Asked during Session

Q: *Can you elaborate on how CFD can be used for pre-construction risk assessment when fatalities appear to be associated with unusual winds?*

A: In a pre-construction context, there are several potential uses for this kind of modeling.

1. It may be possible to map updraft velocities for a larger area of interest using synoptic wind data; this may prove helpful in identifying avoidance areas dominated by near-threshold updraft velocities.

2. Within a project area, before turbines are on the landscape, examining updraft velocities for common and uncommon wind conditions can be used to identify locations with persistently low updrafts; I envision this as essentially a vote-counting exercise using the rationale that locations that have low updrafts the most often are likely the most dangerous places to put turbines.

3. A CFD updraft model could be used in combination with other data streams such as prey distribution, nest locations, and flight path maps to develop an understanding of how eagles use the project area, and drivers of that use. This approach will provide a great

deal of information for predicting future use of the landscape and micro-siting turbines to avoid areas of high risk.

4. Post-construction monitoring is typically planned prior to construction, and using a CFD updraft model as an information input will help target monitoring in large wind farms where decisions must be made about how to allocate monitoring effort spatially and temporally.

Assessment of Golden Eagle Mortality from Wind Energy and Associated Implications for Defining Project Risk

Presenter: Wallace Erickson, *Western EcoSystems Technology (WEST), Inc.*

Authors: Wallace Erickson, Kristen Nasman, Shay Howlin, and Kimberly Bay (*WEST, Inc.*)

PROBLEM / RESEARCH NEED

The US Fish and Wildlife Service (USFWS) 2016 status report estimated that approximately 40,000 golden eagles reside in the United States in August each year, with approximately 31,000 in the Pacific and Central migratory flyways (USFWS management units for eagle take from wind). Currently there are approximately 90,000 MW of wind energy capacity in the United States, with two-thirds of that being generated in states that make up the Pacific and Central golden eagle flyways.

There is a fairly robust data set on golden eagle mortality, based on 386 telemetered birds from 1997-2013 (USFWS). From these data, the USFWS estimated that approximately 6,000 golden eagles perish each year, with about half of those attributed to anthropogenic and the rest to natural causes. Starvation was estimated to be the number one cause, especially for young birds, followed by poisoning, illegal shooting, and fighting. Collision from various sources including vehicles, wires/fences, and wind turbines was ranked fourth overall and third among anthropogenic causes. These USFWFS data have been useful, among other things, in helping guide opportunities for mitigation for eagle mortality. Our research looks more closely at the wind turbine collision source based on fatality study data at wind energy facilities.

The scientific literature lacks defensible published estimates of golden eagle from wind energy projects. Pagel et al. (2016) reported known eagle fatality incidents, but not extrapolated estimates. Bay et al. (2017) presented annual total raptor mortality estimates as well as mortality for individual raptor species. However obtaining valid estimates for both bald and golden eagles has been a challenge for several reasons – including, but not limited to, uncertainty in how representative the studies available were of projects that were not studied,

and uncertainty in how the use of mostly non-raptor trial carcasses in searcher efficiency trials and carcass persistence trials affects mortality estimates, as well as variability in the field sampling methods (e.g. plot size).

Objectives

In this paper, we provide results of an eagle mortality assessment to evaluate the impacts of wind energy on golden eagles across the US, and include eagle mortality estimates in eagle flyway. Our objectives are as follows.

1. Provide an estimate of the percentage of the golden eagle population in the Pacific and Central Flyways of the Western US impacted by wind energy.

2. Describe assumptions, limitations, and future improvements to this and similar meta-analyses.

Approach

In this meta-analysis, we reviewed publicly available and other post-construction monitoring studies from the past two decades that we have been granted permission to use, and extracted raptor fatality estimates and species composition information for raptors as well as other relevant data, including study periods, MW of projects, plot size etc. Most studies are designed for consistency with the land-based wind energy guidelines; for example, typical monitoring consists of 30% of turbines sampled for a year.

In terms of available monitoring data, the best representation of projects within states comes from California, Oregon, Washington and Wyoming. There is lower representation in the Central plains states such as Kansas, Oklahoma, and Texas – which accounts for over half of the installed wind energy project capacity in the central flyway, but has limited monitoring data available.

We made adjustments to fatality rates and species composition based on plot size, period of study, species composition for detection differences of eagles compared to small raptors, and considered further corrections for carcass persistence differences between raptors and non-raptors. Regarding the later correction, based on 12 studies that conducted concurrent trials with both large raptors and surrogates such as pheasants and ducks, the large raptors consistently lasted longer than the surrogates. Most of the studies include surrogate carcasses to estimate raptor fatality rates, so the bias correction for carcass persistence in those studies is likely an overestimate. We are considering using a scalar to adjust for this potential bias, but ultimately decided to not adjust for that factor, given there are also other factors (e.g. plot size) that can affect the estimates in opposite directions.

For this presentation, we did not stratify the data by correlates of eagle abundance or other factors, but believe that will be necessary to strengthen the validity of the results.

Golden eagle carcasses were found throughout the year, with slightly higher fatality occurring in the early spring period. This is similar to the pattern observed by Pagel et al. (2013), but small sample sizes do not allow for statistical tests of differences.

After adjustments, the average overall raptor fatality in the Pacific and Central Flyways was 0.144 raptors per MW per year, with a standard deviation of 0.19. Red tail hawks and kestrels tend to make up the majority (over 70%) of raw raptor species (adjusted for persistence rates – shorter for small raptors compared to larger raptors), followed by Swainson's hawk. Golden eagles comprised approximately 2% of the raptor carcass detections.

Based on our analysis we estimated that approximately 0.5% of the golden eagle population (31,257 golden eagles) is impacted by wind energy on an annual basis within the Pacific and Central Flyways.

CONCLUSIONS / APPLICATIONS

Some of the challenges and limitations in this analysis and potential source of biases arise from considering how representative the available studies are of the universe of all projects to which we are extrapolating. The studies included in this meta-analysis are not a random sample of wind projects, they are wind projects that had publicly available data collected during a post-construction monitoring study. One way to reduce that bias is to stratify the data into eagle use and risk categories of higher and lower intensity. Not having that information for the entire area of the flyways was a limitation. For example, we do not have much data for Central Plains area; while these are areas with generally lower eagle density, there may be some areas in there with higher eagle density.

The western-wide eagle survey can serve as a tool for stratification, and should reduce bias and uncertainty in understanding cumulative impacts of wind on golden eagles. Other site-specific data such as the eagle use surveys can further help stratify the data. For example, areas in the central flyway but outside the eagle survey area are likely lower density areas. That said, we need to come up with a surrogate for large-scale density stratification. While we have micro-level siting differences for some of these strata, we need to look at the broad-scale and to incorporate uncertainty parameters for high-level analysis.

Going forward, the new GenEst software will help us standardize for this kind of meta-analysis and make results more comparable. In the past three years we are seeing more studies designed specifically for eagles and other large raptors as opposed to trying to measure general bird mortality; this should provide better and more precise information on raptor and eagle mortality. Using raptors (rather than surrogates) to estimate carcass persistence rates will yield more representative carcass persistence rates for eagles.

This analysis is focused on using data from systematic searches with bias correction and from quite a few projects studied for short time periods. Eagle carcasses are occasionally reported

incidentally. These data can provide information on presence of eagle finds, but not much information can be obtained from those data relevant to fatality rates unless quantification of detection probability is made. This is a needed area of research.

We have a good data set for conducting meta-analyses, and these prove useful in understanding overall current expected impacts of wind on golden eagles. While we need improvements to better account for potential biases and sources of variation in the estimates, we can conclude that:

- Golden eagle mortality due to wind is estimated to be approximately 0.5% of population estimate per year.

- Wind energy is responsible for one out of every 20 to 30 human-caused golden eagle fatalities.

Questions & Discussion

Q: *Bringing it down to project level, is there other information like nest location or prey availability that could be brought in?*

A (Wally): We did not; this was a large-scale look. We are planning on looking at eagle use, which has been serving as the metric for prediction in the Bayesian model, as a stratification variable. There are several projects – Top of the World is one, Foote Creek Rim is another, where it may be helpful to look at project-level stratification. The Western Golden Eagle Team product will include some nesting and habitat pieces as stratification variables that can help.

A (Chris): Yes, it's project-specific. I'm trying to get away from being captive of history on the landscape. Animal movements on the landscape are artifacts of history of individuals, not predictive of future animals. We need historical information, but to predict we need to get to something more basic about the landscape than just basing our predictions of use on history.

Q: *Do you think you would find similar results if this study was replicated in the Eastern US flyways?*

A: We focused on the two regions with most of the eagles, where we have the most information. In addition, our database doesn't include golden eagle fatalities in the central and Eastern Flyways, so we decided to not attempt to quantify an estimate.

Risk Validation Analysis: USFWS Pacific Southwest Region Example of Eagle Take Permit Renewal/5-year Review Process Considerations

Presenter: Heather Beeler, *US Fish and Wildlife Service*

[slide presentation]

Author: Heather Beeler (*US Fish and Wildlife Service*)

PROBLEM / RESEARCH NEED

The Shiloh IV Wind Project, LLC, located 30 miles from California's Altamont wind resource area in Solano County's Montezuma Hills WRA, was the first wind project to obtain an eagle take permit. Golden eagle use, abundance, behavior, and collision risk in the Montezuma Hills WRA and the Shiloh IV project area are well documented. Issued in July 2014 under the Bald and Golden Eagle Protection Act, the eagle permit authorized the take of five golden eagles over the five-year permit term, expiring in July 2019. The US Fish and Wildlife Service (USFWS) will be looking at compliance with the conditions of this take permit in considering the permit renewal request. The process is similar to what would be required under the revised 2016 Eagle Rule (81 FR 91551, Dec. 16, 2016) for long-term eagle incidental take permits.

Objectives

Discuss the available data and data decision options for this permit renewal, and for other projects located in the same wind resource area.

APPROACH

The permit renewal process is comprised of three steps.

1. Permit compliance risk validation - was eagle take within authorized limits?

2. Update risk prediction for next permit term.

3. Compensatory mitigation - mitigation credits or mitigation owed?

Step 1: Post-construction fatality monitoring. The Eagle Permit required searching 100% of turbines monthly for eagle fatalities over a two-year period. An overlapping bird and bat study required by the county involved searching 50% of turbines weekly for bird & bat fatalities over three years, beginning six months before the eagle study period and continuing for another six months afterward. If we relied only on the bird and bat study, only 44% of the total project area where eagles might be expected to fall would be searched.

Our evaluation used mortality monitoring data from both studies along with Evidence of

Absence (EoA) software (Dalthorp et al. 2017) to evaluate whether the number of fatalities had exceeded the expected threshold – that is, the permitted take level. While zero eagles were found in either study, the probability of detection factor is different for the two studies, given their different designs, resulting in different mean mortality estimates. (See slide #11.)

Step 2: Update risk prediction. Next, we reevaluated our predicted take estimate by updating the Shiloh IV risk prediction as calculated using our eagle Collision Risk Model (CRM) (USFWS 2013) with the EoA outputs, using Program R code script written by J.L. Simonis (DAPPER Stats 2017). The updated CRM used both the pre-construction eagle use data and data from the project's mortality study to update the project's CRM priors and refine the risk prediction.

Step 3: Compensatory mitigation status. Finally, we developed a simple tool to calculate how many eagles were compensated for by the project's electric utility pole compensatory mitigation package, and determined how much mitigation could be credited to the next permit term.

FINDINGS

Our results validated that take did not exceed the authorized take of five eagles over the five-year permit period. Using the two years of eagle study data and the one year (six months prior and six months following the two-year eagle study) of bird and bat study data, our EoA analysis concluded that there is an 80% probability that the true number of fatalities was less than or equal to two eagles, well within the authorized take limits.

Based on the pre-construction eagle use data, the original Shiloh IV Eagle Permit predicted take of 0.89 eagles/year, or 4.5 (rounded up to five) eagles over the five-year permit period. The updated risk prediction, based on pre-construction use and post-construction mortality, predicts a take of 0.80 eagles/year, or four eagles over five years.

The original eagle take permit required retrofit of 133 power poles; facility operator PG&E actually retrofit 140 power poles. However, all pole retrofits are not of equal value. Slide #23 shows two basic types of pole retrofits. Those on the left involve re-framing so that wires are not as close together; this is good for 30 years. Those shown on the right involve covering a portion of the wires with plastic, but this is not as durable a retrofit and is good for only 10 years. New regulations will require not a 1:1 mitigation but 1:2. Nevertheless, the project has 46 pole retrofit credits going forward, equivalent to at least one eagle.

In total, the Service would transfer 4 or more eagle "credits" of compensatory mitigation to the next permit obtained for Shiloh IV. Three eagle credits could be granted from the EoA analysis in Step 1 (Slide 13), and at least one eagle credit is granted because the project retrofit more than the required number of power poles (Slide 22). Therefore, Shiloh IV is not expected to owe any compensatory mitigation for the first five year permit term of a renewal/new long term incidental eagle take permit under the 2016 Eagle Rule.

Given that Shiloh IV was the first project to obtain an eagle take permit under the Bald and Golden Eagle Protection Act, there has been a great deal of interest in how the USFWS would use Evidence of Absence. This is an adaptive process. Although this permit review process is not definitive for the Service as a whole, it is an example of the USFWS Region 8's thinking about this.

Questions & Discussion

Q: *What "G-value" for Evidence of Absence did you assume for non-monitored years?*

A: "G" value is overall detectability – carcass persistence, observer efficiency, how much of the project area was searched. I used 0.000999 G value for non-monitored years. The overall G value was 0.3 for the analysis that indicated there were only two eagles likely taken over the 5-year permit period. That value was updated to 0.33"expected value" in the updated collision risk model. We used 80% rather than 50% because we wanted more confidence, but 50% is used elsewhere.

Q: *Did you combine the eagle with the bird/bat study results for the overlapping two-year period, or did you consider them separately?*

A: We used two years of eagle data, and one year of bird and bat data, including the 6-month period before and the 6-month period after the year-and-a-half period for which we have the overlapping eagle data. We looked at it a number of ways, but when you have eagle data, it makes sense to use the eagle data, so we just supplemented that with bird and bat data that did not overlap with the eagle monitoring study.

Q: *Of the searcher efficiency and carcass persistence rates that you used to calculate G values, is there a difference you see using raptors or surrogates for those persistence trials?*

A: We have Curry & Kerlinger reports for both the bird & bat and the eagle studies. I used their summaries but then went back and recalculated the persistence and searcher efficiency rates using the raw data. They did use raptor carcasses. There was some difference of detectability based on grass heights during the summer versus other seasons, but I did not dig deep into that. There was a large sample size of raptor carcasses in the bird and bat study and an adequate sample size for the eagle study.

Q: *Given the assumptions you put into the model, and that zero eagles were observed, you got a take estimate within permit compliance. What's the weight of evidence for when we'd say permit conditions had been exceeded?*

A: It's a good question. This is the first attempt to try to use Evidence of Absence. There is no guidance from the Service on this, this is just me in Region 8 working through the process. The Service has not made a final decision on how to use this. When we think about eagle use minutes, we still want to keep in mind inter-annual variation of eagle use. We don't want to set

the permit take level so low that we wind up running into compliance issues if there is an unusual year. The chart showing "what if you had only done the bird study, what if you had only done the eagle study – both of those indicate that there is a chance that your confidence levels exceed the "eagle per year" threshold in year 4 or year 5. The predictions of annual take under both those scenarios was higher than the one where I use the two years of eagle study and 1 year of bird and bat data. The technically correct way to use Evidence of Absence is to use the two years of eagle monitoring to project what is the chance of eagles taken that you did not find.

Q: *How was the 10-year/30-year credit determined for the power pole retrofitting offset mitigation?*

A: We have a spreadsheet analysis. If an eagle/year taken, how many retrofits required? In 2014 when the permit was issued, only the 10-year retrofits were available in our Resource Equivalency Analysis spreadsheet. A ratio of 2.3 short-term retrofits (plastic covers) are required per 1 long-term retrofit (reframed pole).

Q: *Could repowering of existing facilities be considered as an offset mitigation measure? What if permit holder wanted to consider additional or alternative measures? Or if an ECP proposed repowering or lead abatement, vehicle collision reduction measure, etc?*

A: We have thought about repowering, for example, and carcass removals from roads. We would be willing to implement that and other measures, we just need to be able to quantify the value in terms of eagle take offset by the mitigation effort. In California, we are thinking about land bank mitigation: if we're losing breeding habitat at a certain rate, can we quantify how much acquisition offsets would compensate for a territory or young eagles produced annually?

Improving Estimates of Collision Impacts to Birds and Bats

Moderator: Jenny Taylor, *Tetra Tech*

Turning Data into Insights: a Summary of Bird and Bat Collisions in the American Wind Wildlife Information Center

Presenter: Ryan Butryn, *American Wind-Wildlife Institute (AWWI)*

[slide presentation]

Authors: Ryan Butryn (*AWWI*), Brian Beckage (*University of Vermont*), Taber Allison (*AWWI*)

PROBLEM / RESEARCH NEED

Post-construction fatality monitoring (PCM) studies are the most widely available source of information about wildlife collision risk at wind energy facilities. Meta-analysis of these studies can offer insights about collision risk at a regional scale better suited for understanding population-level impacts to species. Refining our understanding of variability in collision risk would support an informed approach to predicting and mitigating wildlife risk at wind energy facilities.

The American Wind-Wildlife Information Center (AWWIC) program has three main components.

1. ***Data storage:*** wildlife activity and monitoring data; submissions from industry cooperators; publicly available reports

2. ***AWWI-led research:*** reviewed technical reports (awwi.org/results-catalog); peer-reviewed publications; topics solicited from stakeholders

3. ***Analysis tools:*** ability for stakeholders to interact with data aggregations; help inform siting and permitting decisions

Objectives

Currently a large amount of resources go into fatality monitoring and less into risk reduction and conservation efforts. The AWWIC's goal is to improve understanding of collision risk so that investments into conservation can be increased.

APPROACH

The American Wind Wildlife Institute (AWWI) has compiled a database of post-construction

monitoring (PCM) studies and has improved the data representation in regions where publicly available studies are not as numerous. Currently, the AWWIC database includes 243 PCM studies from 157 US projects, representing 18 GW, or 22% of US onshore wind energy installed capacity. AWWI has started producing technical reports summarizing data. This presentation highlights some interesting things we are seeing in the data, and we hope that it will encourage stakeholders to suggest ideas for future analyses.

<u>FINDINGS</u>

For both birds and bats, collision risk appears to be concentrated in relatively few species: eight bat species account accounted for 96% of all recorded bat fatalities; 10 bird species account for 42% of all recorded bird fatalities. Fatality estimates take incidents and adjust for area searched, searcher efficiency, and scavenger removal. Nationally, median take is 1.8 birds and 2.6 bats per MW per year. Fatality timing is very useful information for curtailment and other minimization efforts. Bat fatalities are concentrated in August and September. Passerine fatalities peak in late spring and again in early fall (side #9); raptor fatalities are more evenly distributed.

Understanding where collision fatalities land is useful for PCM study design, and also for comparing studies. We looked at a subset of 48 studies that had a search radius of 100 m or more, and found that bat carcasses tend to be found closer to the turbine (peaking at 26-50 m from turbine base), than bird carcasses were. There was little difference between small and large birds (slide #10) in terms of where their carcasses land.

Slides #11-13 illustrate how we can use the AWWIC data to learn more about occurrences for species. Tri-colored bat, for example, makes up 1.7% of all bat fatality incidents recorded in the US, but it comprises 5.2% of fatalities in USFWS Region 5 (Northeast and Mid-Atlantic states). Drilling further down within Region 5, we can see that there is substantial variation within eco-regions, with risk heavily concentrated in the Ridge and Valley and Central Appalachian eco-regions (slide #13). This kind of understanding can help bring risk analysis and potential mitigation into sharper focus. This is just one example; we can do the same analysis for other species of concern.

<u>CONCLUSIONS / APPLICATIONS</u>

We need sufficient regional representation of PCM studies so that conservation priorities can be informed. A key question is, how much monitoring effort is needed to understand wind-wildlife risk? What is our uncertainty, how much more monitoring needed? When we plot the relationship between search effort (total number of searches) and the proportion of all bird species found in a bird conservation region that are being found in PCM studies, beyond 20,000 searches, there is a diminishing level of returns in terms of finding additional species.

Key insights from our review of the AWWIC data:
- Findings support previous nationwide assessments of bird and bat collisions.

- Most bird and bat species appear to be at little or no risk of collision at wind energy facilities at current installed capacity.
- Some species appear to have higher collision risk than others.
- Distribution of fatality estimates suggests that most sites have low fatality rates.
- Birds and bats have different timing patterns and fall distances.
- Increased investment in fatality monitoring leads to diminishing returns in finding new species.

There is a lot of variability in the AWWIC data. Next steps in our meta-analysis include the following.

- Further evaluate AWWIC data to understand factors that underlie the patterns seen in the data, including possible field trials to refine our understanding of:
  - Variation in detection and carcass persistence
  - Species specific variation in curtailment effectiveness
- Develop a Bayesian model to determine the number of studies needed to reliably estimate bird and bat collision fatalities within a region.
- Recalculate fatality estimates in AWWIC using the new generalized fatality estimator (GenEst – released fall 2018).

Questions & Discussion

Q: *What do patterns of fatalities for Mexican Free-tailed bats look like in terms of timing?*

A: There are more into September, early October timeframe – see report: https://awwi.org/resources/awwic-bat-technical-report/

Q: *Why is finding a new species relevant?*

A: Rare species or endangered species may not be found no matter how much monitoring you do.

Q: *How likely is the pattern with low rates to be influenced by "submission bias"? (That is, companies do not want to share studies that show high fatalities.)*

A: The companies that are participating are giving us all their data.

Q: *Which 10 species made up the majority of bird carcasses, and are there common factors for the 10 bird species that are killed the most? For example, are they occurring in high density where killed, are they migrants, or…?*

A: Horned lark – inhabit the habitat around most wind facilities, especially in the prairies. Some migrants are in the list of top species. See poster for list of species.

Q: *Fatality information is valuable, but only one piece of the puzzle. Is there an effort to collect information on turbine operation or other environmental conditions (e.g., rotor RPM, wind speed and direction) along with fatality information?*

A: We do not currently have that information, but it would be great to get it. We can adjust the database to start collecting specific details that would be useful.

Q: *For AWWIC and Canadian databases, is there information available related to collection methods, calibration info (if applicable), data analysis techniques, quality assurance, assumptions, etc.? Are data sets linked to associated reports, studies, and peer-reviewed literature?*

A (Catherine): Alongside the raw data, we also get environmental assessment reports and methodologies. We also calculate results based on the raw data, so that helps with standardization.

A (Ryan): The AWWIC database has information about each of the studies, including what approach was used for determining bias, etc.

Q: *Any discussion around merging the databases?*

A (Ryan): We are aware of each other.

A (Catherine): It's a discussion we've started. We each have commitments to our data contributors, so would need to resolve those pieces before anything could be merged, but we are talking about this.

Not Asked during Session

Q: *What recommendations would you give to a country looking at developing a database from scratch? (We've heard a lot about standardization and being able to compare apples to apples; are there any other key things that you would recommend?)*

A: I would recommend collecting as much of the raw data as possible so that estimates can be recalculated as methods advance. For example the carcass persistence trials and searcher efficiency trials have data that are not often presented in reports, so it would be good to try and get those data from the authors.

Q: *Regarding the percentage of bats found within 50 m of a turbine, is there a correlation with hub height and blade length, or have these factors been teased apart?*

A: Most of the turbines are 80 m so in that reduced dataset of studies that searched beyond 100 m, there's not enough variation in turbines to notice trends, but we do hope to add that level of resolution to the analysis in the future.

Q: *Does AWWI solicit post-construction monitoring results from developers/industry, or is there coordination with state agencies to obtain data submitted to them? Is there a way for states, NGOs or others who have publicly available reports to submit to AWWI for inclusion in*

A: Yes, we would be happy to coordinate with states that have public, yet not readily accessible, data.

The Canadian Wind Energy Bird and Bat Monitoring Database: Overview, Results, and Opportunities

Presenter: Catherine Jardine, *Bird Studies Canada*

[slide presentation]

Author: Catherine Jardine (*Bird Studies Canada*)

PROBLEM / RESEARCH NEED

The Canadian Wind Energy Bird and Bat Monitoring Database (WEBBMD) is an initiative hosted and maintained by Bird Studies Canada (BSC), established in collaboration with the Canadian Wind Energy Association, Environment Canada and the Ontario Ministry of Natural Resources and Forestry. Similar to the American Wind-Wildlife Information Center (AWWIC), this database has been created to allow for the capture, storage and analysis of post-construction bird and bat mortality monitoring data collected at wind power projects through environmental approval processes. The database aims to facilitate an improved understanding of the impacts of wind turbines on birds and bats, improve consistency in the assessment of wind turbine impacts across the country, and inform guidelines and approvals processes.

Objectives

This presentation will provide an overview of the database, available resources, recent analyses and results, including a forward look at potential initiatives and collaborative opportunities.

APPROACH

Canada's WEBBMD was launched in 2008. The first step was developing standardized templates for data collection in environmental assessments. From the outset, there was a participation requirement for projects from Ontario, the province with the highest proportion of Canada's wind energy projects. This requirement has been extended to Saskatchewan; participation is voluntary for other provinces. The database currently contains data from 91 projects and 213 datasets, and continues to grow annually.

Analyses facilitated by the database have included an investigation of the effectiveness of

curtailment mitigation, an analysis of the impact of landscape level features on bat mortality, a comparison of multiple estimator equations as well as annual public summary reports.

<u>FINDINGS</u>

Slide #6 compares the AWWIC and WEBBMD databases. Canada's database has less variation in landscape level features and a patchier geographic distribution. However, WEBBMD does use a standardized template for monitoring data. There is less voluntary reporting in Canada (AWWIC participation is entirely voluntary), but in some jurisdictions the data submission is mandatory, so we are getting all the data from those areas. Studies in the WEBBMD average 2.4 years of monitoring/study, vs. 1.5 years for studies in the AWWIC database.

We have published annual database reports since 2012, including regional species composition and mortality estimates. Slides #8-9 give an example of species composition breakdown for birds and bats. Slides #10-12 give mortality estimates using different estimators. We will also run these through the new GenEst.

<u>CONCLUSIONS / APPLICATIONS</u>

Having a standardized template for data reporting expands and streamlines possibilities for collaborative and landscape level studies. For example, we evaluated the impact of mitigation on the proportion of bat carcasses observed at turbines throughout 12 wind farms in southern Ontario as a function of species.

- The AWWIC and BSC datasets represent valuable large amalgamations of wind wildlife data.

- The varying properties of these datasets make each better suited to answering different questions, but the option remains open to synthesize them and ultimately we do hope to do that.

- The annual reports provide good general summary information on a broad scale.

- The WEBBMD dataset can now be leveraged for more targeted and detailed studies through research partnerships.

Future directions include:

- Expanding on Erin Baerwald's pilot project (modeling landscape variables relevant to hoary bats)
- Examining mortality trends over time and how these are influenced by turbine design
- Developing range-wide species-specific mortality estimates (cumulative/annual)
- Gaining a better understanding of migratory movements (using the Motus tracking system) and they relate to mortality
- Evaluating predictive models (BirdCast)
- Analyzing database data using the GenEst estimator

Questions & Discussion

Q: *Standardization and metrics – why does Canada use per turbine metric?*

A: We do both, can analyze both per turbine and per MW mortality.

Q: *How does the Motus tracking system work? Which species were tagged?*

A: Motus uses automated radio telemetry stations. It has a global scope, with stations set up in US and Canada, Australia. This is one of a few studies using Motus to track bats in Southern Ontario. Specifically, we are looking at bats crossing Lake Erie here, using small radio frequency tags ($200-300 each). Silver-haired, hoary and Eastern red, but the system has been used to track up to 12 species so far.

Q: *How likely is the pattern with low rates to be influenced by "submission bias"? (That is, companies do not want to share studies that show high fatalities.)*

A (Catherine): We don't have that bias in jurisdictions where submission is mandatory, so we can use those areas to estimate the bias in other areas.

A (Ryan): The companies that are participating are giving us all their data.

Q: *Which 10 species made up the majority of bird carcasses, and are there common factors for the 10 bird species that are killed the most? For example, are they occurring in high density where killed, are they migrants, or…?*

A (Ryan): Horned lark – inhabit the habitat around most wind facilities, especially in the prairies. Some migrants are in the list of top species. See poster for list of species.

A (Catherine): Aerial singers and insectivores are the species we would expect to find in the RSAs of turbines.

Q: *Are you aware of any plans by the Ministry to use the BSC dataset to adjust monitoring protocols or fatality thresholds in Ontario?*

A: We are providing that data to the ministry to make those kinds of decisions, but we do not make those decisions, so I am not aware of any specific plans.

Q: *Fatality information is valuable, but only one piece of the puzzle. Is there an effort to collect information on turbine operation or other environmental conditions (e.g., rotor RPM, wind speed and direction) along with fatality information?*

A (Ryan): We do not currently have that information, but it would be great to get it. We can adjust the database to start collecting specific details that would be useful.

Q: *For AWWIC and Canadian databases, is there information available related to collection methods, calibration info (if applicable), data analysis techniques, quality assurance, assumptions, etc? Are data sets linked to associated reports, studies, and peer-reviewed*

literature?

A (Catherine): Alongside the raw data, we also get environmental assessment reports and methodologies. We also calculate results based on the raw data, so that helps with standardization.

A (Ryan): The AWWIC database has information about each of the studies, including what approach was used for determining bias, etc.

Q: *Any discussion around merging the databases?*

A: It's a discussion we've started. We each have commitments to our data contributors, so would need to resolve those pieces before anything could be merged, but we are talking about this.

Demography of Birds Killed at Wind Facilities

Presenter: Tara Conkling, *United States Geological Survey (USGS)*

Authors: Tara Conkling (*USGS*), Hannah Vander Zanden (*University of Florida*), James Diffendorfer (*USGS*), Adam Duerr (*Bloom Biological*), Scott Loss (*Oklahoma State University*), David Nelson (*University of Maryland Center for Environmental Science*), Julie Yee (*USGS*), Todd Katzner (*USGS*)

PROBLEM / RESEARCH NEED

Growing interest in wind energy development has led to increased concerns regarding the potential environmental impacts of these facilities, including adverse effects to wildlife populations. However, there is limited research examining the effects of wind-energy derived wildlife fatalities on the demography of affected avian and bat species.

<u>Objectives</u>

Our objective was to estimate demographic parameters and population growth rates for multiple avian and bat species. By looking at many species, we also sought to:

1. make rough relative rankings/prioritizations of the risks of renewable effects across species; and

2. possibly identify species traits associated with risk (e.g., r- vs. k-selected species, migrants vs. non-migrants, species with and without large proportion of immigrants, etc.).

<u>APPROACH</u>

We elicited expert opinion to develop a list of 34 priority species that may be affected within California. We then developed matrix models within a Bayesian framework for each species included in this list. We derived model priors with data from expert opinion, literature reviews, and broad-scale population monitoring programs including Breeding Bird Survey (BBS) and Monitoring Avian Productivity and Survivorship (MAPS). Additionally, we estimated immigration rates by incorporating the likely origin (local vs. migratory) of individuals killed at California wind energy facilities, based on quantifying hydrogen stable isotope ratios from bird and bat carcasses.

Using demographic rates derived from literature as prior information, we developed an Integrated Population Model (IPM) to estimate temporal variability in demographic rates and test the effects of a simulated decrease in survival on population dynamics.

<u>FINDINGS</u>

We detected substantial among-species variability in the proportion of migrant individuals killed at wind facilities, demonstrating the highly species-specific nature of the geographic and thus demographic impact of fatalities to these populations. Likewise, preliminary analyses for several species including American kestrels, red-tailed hawks, horned larks, and western meadowlarks highlighted potential discontinuities between model outputs (e.g., survival rates) and demographic estimates derived from existing monitoring programs.

We were able to develop models for 29 of the 34 species; based on our models, 20 of the 29 species have declining populations (λ <1); the others have stable or increasing populations. Lacking current population data, we were unable to develop models for five of the species: red-necked phalarope, ruddy duck, black rail, hoary bat, and Mexican free-tailed bat.

<u>CONCLUSIONS / APPLICATIONS</u>

How to interpret these demographic models in terms of species conservation and renewable energy impacts? It would be helpful to know how many of the individuals killed at a given facility are local. If a species' range is large but the catchment area is small, then additional fatalities likely are not highly influential on population size. However, if a species' range is large

but the catchment area also is large, for small populations additional fatalities may matter a lot, especially when λ <1. If both range and catchment area are small, then additional fatalities may matter a lot regardless of population size and regardless of λ.

These preliminary results illustrate the importance of obtaining baseline demographic data for species that occur near renewable energy facilities to better inform model priors, to increase identifiability of model parameters, and to improve fit of demographic models.

We also demonstrate the ease and utility of incorporating sample collection methodologies into existing fatality monitoring programs (i.e., feather and fur samples from found carcasses) to obtain stable hydrogen isotope measurements from additional facilities and locations. By increasing the size and quality of the overall dataset, we can more accurately incorporate immigration and emigration data into demographic models and improve our understanding of assessment and consequences of renewable energy effects to wildlife populations.

Questions & Discussion

Q: *Do you see synergies with the data you're collecting and the results of the large-scale databases? Is there overlap and could they be used together?*

A: Yes. We're all collecting data towards same goals of reducing impacts. Without that info, we don't know which species we need to consider. All are useful pieces of the puzzle. Renewable energy is a small part of the total picture of what's affecting these species.

A Wildlife Forensics Approach to Characterizing the Geographic Footprint of California Wind Energy Effects on Avian Populations

Presenter: Hannah Vander Zanden, *University of Florida*

Authors: Hannah Vander Zanden (*University of Florida*), David Nelson (*University of Maryland Center for Environmental Science*), Tara Conkling, Todd Katzner (*US Geological Survey*)

PROBLEM/ RESEARCH NEED

One of the recognized environmental impacts of wind energy generation is the fatality of avian wildlife that accompanies the operation of such facilities. A central challenge to mitigating this impact requires an understanding of the demographic mechanisms and geographic scope of these effects on avian populations. Beyond counting the number of fatalities, we need other approaches to determine scope and demographic outcomes for the species that are killed.

Wildlife forensics approaches may be helpful. Hydrogen isotopes (δ^2H) are an intrinsic marker that are commonly used to trace the geographic origins of migratory species. Precipitation δ^2H isoscapes show variation across continental gradients, and this local environmental signal is incorporated through the food web into animal tissues at the time of growth. The δ^2H composition of feathers from carcasses found at wind energy facilities in or near California reflect the location feathers were grown. For example, a recently-published study used stable isotope data to determine that 25% of golden eagles at Altamont are recent immigrants, suggesting that stable population numbers are supported by immigration from outside the Altamont.

Objectives

Analyze the hydrogen stable isotope composition (δ^2H) of feathers from carcasses of priority species found at wind energy facilities in or near California to assess the likely region of geographic origin.

APPROACH

Using input from policy-makers and stakeholders, we identified a group of 32 priority species for study. These are species with different life history strategies of varying conservation concern that are often found at either solar or wind facilities in the state. We analyzed feather samples from 423 individuals of 17 of the priority species killed at four wind facilities and modeled the likely origin of these individuals to characterize their local or migratory status.

We started with a precipitation isoscape and relied on regressions from the literature to match species as closely as possible, using species range maps obtained from BirdLife International to compute probability of origin. For each individual, we used a mean δ^2H value. We included

multiple levels of variance, and for each individual produced a posterior probability surface.

Finally, we used post-processing to designate individuals as local or nonlocal and make summary maps, with a color gradient indicating more likely areas of origin. To determine the local or non-local status, we looked at the probability of origin at the site where the sample was collected, setting a threshold probability for determining whether the feather was grown within the region that includes the collection site. (How this threshold setting changes the outcomes is something we still have to explore.)

FINDINGS

We had a total of 772 feather samples, including multiple samples from the same individual in many cases. The overwhelming majority of samples from 12 of our priority species with two or more individuals sampled came from the Altamont. Overall, we found a lot of variation in δ^2H values within and among species.

Preliminary results indicate that the geographic extent of impact extends far beyond the state of California, and we highlight the patterns for several species for which this is the case. For example, migrants composed 24% of the American kestrel samples, 62% of the red-tailed hawks, and 82% of the western meadowlark samples.

We are doing the same type of analyses for all the species, but this presentation focuses on examples from two species that represent ecologically distinct groups: horned lark (passerine), and red-tailed hawk (raptor).

- Horned Lark (HOLA) – 76% of fatalities appear to be local, vs. 24% non-local; some of these non-local individuals may be from not too far away from Altamont.

- Red-tailed hawk – Only 38% of fatalities appear to be local, vs. 62% non-local; some of these may be migrating from farther away but not very far away.

We generated local and non-local summary maps for horned lark and red-tailed hawk respectively, along with histograms showing the month and facilities at which the samples were collected. Maps showing the species' year-round range were compared with the local vs. non-local summary maps.

Overall, among all 12 of the species we analyzed, non-local individuals make up 51% of the samples. The non-local percentage ranged from zero for mourning doves and white-tailed kite to 100% for house finches and over 80% for the barn owl and western meadowlark.

CONCLUSIONS / APPLICATIONS

We can obtain information from carcasses which tells about their geographic footprint. We plan to contrast this with similar data from solar facilities, and will combine the geographic footprint analysis with demographic models to identify the demographic consequences for avian species that are affected by wind energy operations.

Q: *What is the typical per unit cost for hydrogen isotope analysis? How many labs can do this analysis?*

A: Hydrogen is $15-20 per sample (a little more expensive than carbon and nitrogen). There are a number of labs around the US.

Q: *How is the interpretation of isotope signatures affected if an individual that is growing tissue during migration eats other migrants?*

A: An organism's hydrogen values are influenced both by drinking water and diet. If an individual is feeding on other migrants, it might still be possible to determine their origin using stable isotope signatures if a lot of the assimilated hydrogen is from drinking water. Then again, the signal could be biased by the diet of migratory individuals. It would be interesting to investigate this with birds whose diets we know more about. For individuals that grow their feathers during migration, this will definitely influence the signal. Therefore, it is important to know the molting patterns of the species of interest and what period of the year would be represented in the collected feathers.

Q: *Any there any stable isotope data from birds that collided with buildings or towers? How do you think those local/non-local patterns would compare with wind and solar?*

A: I am not aware of any stable isotope studies for other anthropogenic collision or fatality causes. I am not sure of reasons to expect differences. It may be that local individuals habituate and are less likely to collide, but we don't know.

Q: *Is it fair to conclude that resident or local birds are learning to avoid turbines?*

A: It may depend on the species, but we don't have any evidence to suggest that this is the case.

Reducing Impacts to Eagles and Other Raptors

Moderated by Bob Murphy, *Eagle Environmental*

Research into the Auditory Attributes, Vocal Characteristics, and Behavioral Response of Eagles to Acoustic Stimuli

Presenter: Jeffrey Marr, *University of Minnesota*

[slide presentation]

Authors: Jeffrey Marr, Edward Walsh, Joann McGee, Peggy Nelson, Julia Ponder, Christopher Milliren, Christopher Feist, Patrick Redig (*University of Minnesota*)

PROBLEM / RESEARCH NEED

The development of acoustic deterrent technologies to mitigate raptor fatalities at wind farms requires fundamental research into the sensory capabilities of bald and golden eagles.

Objectives

This research had three goals.

1. Assess the frequency range of hearing and auditory sensitivities of bald eagles and golden eagles, as well as the auditory sensitivities of a surrogate species, red-tailed hawk.

2. Identify salient features of eagle calls that may be used in the development of acoustic deterrence protocols.

3. Complete pilot work on behavioral responses to auditory stimuli.

APPROACH

We assembled a project team with expertise in wind energy engineering, avian/raptor medicine and surgery, auditory neurobiology, bioacoustics, and audiology.

Part 1: For each species, both auditory brainstem response (ABR) and auditory steady-state response (ASSR) tests were conducted to evaluate threshold and suprathreshold responses: that is, what can eagles hear? Auditory brainstem response was measured by anesthetizing a

bird, placing a small auditory speaker above the bird's head, and measuring responses in the brain. Slide #5 illustrates the avian auditory pathway, which is very similar to that of mammals; successive waves reflect the sequential activation of increasingly rostral auditory nuclei. Wave I is produced by the auditory nerve. An ABR example is shown on the lower right. The response waveform consists of 4-5 highly replicable peaks/waves identified here with arrows. Wave I is generally largest and is the response element that we used in this study. The work also includes an assessment of red-tailed hawks as a potential surrogate species for future technology validation. Slide #6 compares the subjects (18 eagles and seven red-tailed hawks) in terms of sex, age, and other characteristics.

Threshold is defined as the lowest stimulus level at which a response peak is reliably detectable, and is determined by methodically reducing stimulus level in 10 dB steps until near threshold, at which point stimulus level is decreased in 5 dB steps to provide a more accurate estimate of threshold. Threshold value for the red-tailed hawk is indicated by an arrow in the figure on slide #8.

Part 2: To identify salient features of eagle calls that may be used in the development of acoustic deterrence protocols, we used high fidelity recordings of eagle calls collected under controlled conditions at the University of Minnesota Raptor Center. A subset of birds was recorded outdoors, approximately 3 m (10 ft) from the microphone, and a subset of birds was recorded indoors, approximately 4.6 m (15 ft) from the microphone, some up to 18 m (~60 ft). Slide #12 details the equipment and specifications used. Measurements were made on 362 artifact-free calls.

Part 3: The third part of our study tested the behavioral response of bald eagles to various auditory stimuli that included natural sounds such as eagle and other bird calls, as well as "non-natural" stimuli. We used three adult bald eagles as subjects (two education birds, one wild/clinic bird).

- 10-12 stimuli for each bird (signal sets)
- 10 reps for each signal set (tests)
- Sounds emitted from either left or right speaker
- Video recorded responses (head turn, body movement, activity level, etc.)

For this we used the Mobile Evoked Auditory Response Laboratory (MEARL) at Cyril, Oklahoma. Nine veterinary and audiology judges reviewed the video data and scored responses to signal sets and tests. Judge scoring was aggregated to determine behavior response to auditory stimuli.

FINDINGS

Part 1: Slide #8 compares findings for bald and golden eagles and red-tailed hawks of the ABR testing. Waveforms are produced from stimulation with clicks; these are highly replicable and response amplitudes increase directly as stimulus level increases. Response latencies also increase in an orderly manner as stimulus level is decreased – another standard characteristic

of sound-elicited auditory responses.

Results were as expected, although we noted that red-tailed hawk response amplitudes were always greater than those observed in either eagle species. Slide #11 shows response amplitudes increasing in an orderly manner as stimulus levels were raised. While amplitude growth is remarkably similar in the two eagle species studied here, these plots make clear that red-tailed hawk response amplitudes were always larger than those observed in either eagle species regardless of stimulation level, even though the same essential growth pattern was observed. This is likely due to differences in morphology.

Slide #9 compares ABR thresholds for the three species. Threshold-frequency curves, or audiograms, are generated by plotting threshold values versus stimulus frequency, and, as you can see in this plot, the shapes of threshold frequency curves are highly similar across species, although red-tailed hawk thresholds were, on average, 5-15 dB lower than that observed in eagles. Greatest sensitivity, known as the best frequency, was observed at 2 kHz for each species studied. All three of these species are auditory generalists, rather than specialists.

Part 2: Calls/songs were separated into 5 categories:

- Cackle (175) – sequence of brief elements (syllables) exhibiting harmonic structure that are repeated rapidly; some frequency modulation
- Chirp (88) – similar but more tonal in character, also exhibiting some frequency modulation and less nonlinear character than the cackle.
- Grunt (16)
- Scream (41) – higher fundamental frequency, highly harmonic and exhibiting a diversity of frequency modulation patterns within a call.
- Squeal (42) – most complex, with a lot of frequency modulation and nonlinearity.

Calls exhibit substantial non-linear elements (e.g., deterministic chaos, subharmonics, etc.), especially associated with screams and squeals. A subset of calls is clearly social, based on a recent encounter with a large group of bald eagles in British Columbia.

Part 3: Preliminary findings from the behavioral response tests were that more complex stimuli elicited the strongest responses. Grunts elicited the strongest response. Of the synthetic sounds, FM complex stimuli elicited the strongest response.

Habituation (reduced responsivity to stimuli) was observed across repeated trials. Slide #20 shows how relative habituation was estimated in this individual bird by averaging the numeric values representing the strength of the response (0 = no response, 1 = weak response, 2 = intermediate response and 3 = strong response) that were assigned by all judges across each stimulus trial. We expect to see differences in habituation with call type.

Although these findings are preliminary, eagles (bald and golden) and red-tailed hawks appear to function as auditory generalists based on audiogram comparisons. The red-tailed hawk is an appropriate surrogate for bald and golden eagles.

We identified five vocalization categories on the basis of spectro-temporal properties; there is substantial diversity within call types, most prominently screams. Bald eagles responded to spectrally complex acoustic signals more consistently than simple acoustic signals.

Habituation was generally observed following stimulus trial repetitions.

Questions & Discussion

Q: *What is the application of your findings?*

A: We were charged with doing basic physiological research, going into the peer-reviewed literature. In terms of wind energy, this information can be used by people developing audio deterrent technologies. I showed the simplest threshold, but more sophisticated analyses can also be found in our reports.

Q: *In the comparison of response amplitudes (slide #11), the error bars were pretty tight. Were the two eagle species closer to each other in terms of their response thresholds than the red-tail?*

A: The eagle species were quite close to each other in response; the red-tail hawk was more sensitive to thresholds. Technology developers have to make assumptions – do eagles have a special adaptation that we can take advantage of? The purpose of this research is to help us with making decisions about where to focus when developing technology.

Pilot Study to Evaluate the Effectiveness of DTBird in Reducing Risk of Golden Eagles and Other Raptors Colliding with Operational Wind Turbines

Presenter: Jeff P. Smith, *H. T. Harvey and Associates*

[slide presentation]

Authors: Jeff Smith, Jeff Zirpoli, Judd Howell, Kristina Wolf, Scott Terrill (*H. T. Harvey & Associates*)

<u>PROBLEM / RESEARCH NEED</u>

DTBird® is an automated detection and deterrent system designed to minimize the risk of birds colliding with operating wind turbines. We conducted a 10-month pilot study (December 2016 through August 2017) to develop an initial quantification of DTBird's ability to detect and deter golden eagles (*Aquila chrysaetos*) and other medium/large raptors (e.g., red-tailed hawks [*Buteo jamaicensis*] and other buteos) at an operational wind facility.

<u>Objectives</u>

1. Evaluate detection module using eagle-like UAVs (drones).

   - Evaluate detection and deterrent-triggering response envelopes and influence of flight and visibility factors.
   - Estimate probability of detection.

2. Evaluate deterrence module by assessing behavioral responses of *in situ* golden eagles and other raptors revealed in DTBird videos.

   - Estimate probability of deterrence.

3. Estimate potential for reducing risk of eagles and other raptors entering the rotor-swept zone (probability of detection times probability of deterrence).

4. Evaluate false-positive rates and system performance reliability.

<u>APPROACH</u>

We installed DTBird systems on seven turbines at the Manzana Wind Power Project in southern California (slide #9). The project consists of 126 1.5-MW turbines in the foothills of the Mojave Desert. Turbines were selected strategically, not randomly, to meet criteria that included: known eagle activity, habitat diversity, efficient network integration, and flight-trial logistics.

The system deployed for this pilot study included four cameras mounted in cardinal directions on each of the seven turbines, a video-based detection module that tracked objects based on

settings calibrated for birds with wingspans equivalent to those of golden eagles, and a deterrence module with speakers that emitted sounds to discourage birds from entering the rotor swept zone (RSZ) of turbines. The system produces a time-stamped record of detection and deterrent events and associated video clips. Analysts use an on-line digital analysis platform to classify and evaluate detected objects and export data and video clips for further analysis.

We used eagle-like, fixed-wing unmanned aerial vehicles (UAVs), equipped with high temporal and spatial resolution GPS tracking devices and flight data recording systems, as surrogates to evaluate performance of the detection and deterrence-triggering functions in relation to a variety of landscape, flight characteristics, and visibility parameters. The sampling unit consisted of randomly-generated transect flights, stratified by distance, altitude, orientation, and trajectory. To achieve independent transect samples, UAVs went out to predetermined loiter points and circled there for 30 seconds before starting a new transect. (See slides #10-11.)

The deterrent system also is based on calibrated bird sizes. The system calibrates perceived risk based on a bird's flight height and proximity to the RSZ, emitting first a warning signal and then – for birds that get closer to the RSZ – a stronger dissuasion signal. We evaluated DTBird's ability to deter eagles and other raptors from approaching turbines by assessing the behavioral responses of *in situ* raptors exposed to the deterrent signals, as depicted in a randomized sampling of approximately 5,000 of 16,000 DTBird event video records from January through August. Raptor flight diversions >15° away from risk and attendant changes in flight style were considered indicative of successful deterrence. We used a logistic regression to evaluate the influence of wind speed and month on the probability of deterrence.

FINDINGS

Slides #14 and 15 show the results for probability of detection.

- Response distances are highly variable – higher than expected. The detection envelope angles up, so one contributor to variability is birds flying in low and then popping up into the RSZ close to the turbine (See slide #12).

- Generalized Linear Mixed-effects Models (GLMM): Cloud cover was an important factor; mostly cloudy, whitish skies yielded best detection, dynamic bright blue skies with bright clouds yielded poorest detection. In general, detectability was best in the middle of the camera viewsheds. Detectability also improved as the profile exposure of the UAV increased as a result of increased rolling and pitching, steep descending flights, and bouncing around in the wind. Detectability declined with greater sun exposure (glare factor) behind the UAV. (GLMM for response distance ≈ Turbine ID [random effect] + Event Type + UAV ID + visibility factors + flight/position variables + selected 2-way interactions)

- The overall probability of detecting an eagle-like UAV that passed within the expected 240-meter maximum detection range for a golden eagle was 63%. There is a lower

probability of detection when targets come in low and pop up into the RSZ. Probability of detection is routinely lower for south-facing cameras with sun-glare, especially for targets southeast of the turbine in the direction of the morning sun.

- Species identification was difficult. The DTBird system does not distinguish birds from other airborne objects, but filtering can reduce false positives (detections of non-target objects).

Slide #17 shows the results of the deterrent response evaluation. Based on flight diversion angles and other changes in behavior in response to warning and dissuasion signals (*in situ* raptors), we classified the deterrence responses of 255 individual raptors, including 42 confirmed golden eagles and 46 confirmed buteos. Focusing only on cases that we classified as unequivocally successful deterrence events, the overall deterrence rate for all raptors was 36%, for buteos 39%, and for golden eagles 52%. Including potential successes increased the deterrence rate for all raptors to 76%, for buteos to 78%, and for golden eagles to 83%.

We estimated the probability of collision-risk reduction from deploying DTBird as the cross-product of the estimated probability of detection derived from the UAV flight trials and the estimated probability of deterrence derived from the *in situ* behavior studies. The minimum reduction in risk is the estimated probability of detection times the "successful" probability of deterrence. The maximum reduction in risk is the estimated probability of detection times the sum of the "successful" and "possible" probabilities of deterrence. These results are summarized in slide #18:

- Golden eagles: 33 to 53% reduction in collision risk
- All raptors: 24 to 62% reduction in collision risk

CONCLUSIONS / APPLICATIONS

Our results demonstrated that deployment of the DTBird systems had the potential to reduce the risk of golden eagles entering the RSZ of the seven study turbines by an estimated 33 to 53%. This suggests that deployment of DTBird may reduce collision risk for golden eagles at operational wind facilities. However, several factors will influence the actual risk reduction at a given facility:

1. the spacing and location of DTBird-equipped turbines relative to eagle/raptor activity;

2. the relative abundance of resident versus transient/migratory birds and variable tendencies to habituate to the deterrents;

3. the prevalence of false-positive detections (i.e., detections of inanimate objects and non-target birds);

4. site-specific landscape conditions that influence DTBird's ability to reliably detect and track target birds (e.g., sun glare, variable cloud cover, other sources of visual clutter, and wind dynamics); and

5. site-specific variation in technology reliability and maintenance needs.

Caveats: This study looked at risk reduction at the turbine, not facility, level. The technology shows good potential, but we need to evaluate habituation potential and look at nuances as well as test at other locations.

We will expand this research in 2018–2020 to include a second wind facility in a distinctly different landscape, conduct additional experimental investigations, evaluate certain refinements to the DTBird system, and develop multi-site inference about DTBird's ability to reduce collision risk for golden eagles and other raptors exposed to operational wind facilities.

Questions & Discussion

Q: *Could DTBird system be combined with radar for use with nocturnal migrating song birds? Could such a combination be effective in preventing catastrophic mortality events?*

A: DT Bat is available for nocturnal detection and deterrence of bat and potentially could be adapted for birds.

Not Asked during Session

Q: *Why use the average detectability across turbines (63%) instead of detectability in the distance band >230 to < 80 m? Which is the cumulative detectability up to 80 m and up to the blades?*

A: Evaluating the probability of detection within the overall 240-meter expected detection envelope is more consistent with how the USFWS incorporates eagle activity rates in their Bayesian model estimates of collision risk (i.e., activity rates estimated based on eagle activity detected within 800-m radius, 200-m tall cylinders around count sites (or prospective turbine locations). We will further evaluate such nuances in our expanded study.

Q: *How fast do the eagles respond to the acoustic deterrent? Will this be effective under most/all conditions (wind speed, flight line) or limited to birds moving slowly, for example?*

A: We evaluated behavioral responses to deterrents within 5 seconds of emittance. Responses are often immediate, but that is not the same as assessing how quickly they are able to effectively divert away from risk – we did not specifically evaluate this question in this pilot study, but it is of course an important one.

Q: *Did you notice whether eagle activity was different during UAV flight trials?*

A: There was very little eagle activity during the flight trials and we did not have a reliable means of comparing activity during and outside of the flight trials.

Q: *What were the challenges with installation and integration of DTBird units at the host site?*

A: Please read the technical report for a preliminary assessment of such matters.

Q: *Noise is a sensitive issue for wind farms. How loud is the dissuasion sound? Would it be audible to humans, and at what distance from the turbines?*

A: It is very loud at the turbines and readily detectable by humans as much as a kilometer away, but this varies a lot depending on wind and weather conditions.

Eagle Detection, Identification and Deterrent, with Blade Collision Detection for Wind Turbines

Presenter: Roberto Albertani, *Oregon State University*

[slide presentation]

Authors: Roberto Albertani, Kyle Clocker, Congcong Hu, Matthew Johnston, Will Maurer, Lei Peng, Sinisa Todorovic (*Oregon State University*); Manuela Huso, Todd Katzner (*US Geological Survey*)

PROBLEM / RESEARCH NEED

Supporting and improving the coexistence of wildlife with onshore and offshore wind turbines is a major conservation interest. Wildlife interaction monitoring and deterrent systems, coupled with detection of blade strike events, can support turbine installation decisions and effective siting verification. Moreover, an autonomous monitoring system for blade strike detection and taxonomic verification can inform wildlife deterrent validation and potential siting permission processes.

Objectives

We present the design of a novel multi-sensor, multi-component system applicable to any type of wind turbine, along with the results of partial testing of the system's ability to meet three fundamental objectives:

1. Detect and identify eagles flying in proximity of wind turbines including flight trajectory prediction

2. Deter eagles using kinetic ground devices

3. Detect blade collision using continuous vibration sensing and automatic video capture

APPROACH

Slide #5 gives a schematic overview of a turbine with its three sub-systems: (1) automated

visual detection; (2) Eagle deterrent; and (3) on-blade event (strike) detection and image capture.

1. Eagle detection is achieved by processing video streamed by a single miniature, 360^0 vision smart camera mounted on top of the turbine (slide #6). Eagle detection and trajectory estimation in 360-degree video consists of detecting moving objects in the video, (foreground), and then applying a deep convolutional neural network on the foreground to detect the target, determine if it is a golden eagle, and if so predict its direction of motion. We tested this using an eagle from the High Desert Museum in Bend, Oregon (slides #8-10).

2. The deterrent system is based on eagles' natural aversion to anthropomorphic figures – in this case, a colorful commercial inflatable "air dancer", which deploys automatically when an inbound eagle is detected. Deterrent units are triggered by a central computer and operated in random order to minimize habituation. We tested this in a wind tunnel and on a pick-up truck to assess when and how it operates, then tested it in the field at the Bear Valley Wildlife Refuge near Klamath Falls to see how it affected wild eagles.

3. The blade-event detection employs a custom, low-power wireless sensor module installed on each blade (slides #17-18). Continuous sensing includes vibration, motion, and image monitoring while data storage is only triggered by the detection of an abnormal event on any blade, including wildlife or lighting strike. We have tested this part of the system using tennis balls and small potatoes, reviewing video clips saved when a vibration occurs.

FINDINGS

Eagle detection. Slide #11 highlights results of the detection testing. We reviewed 34 video clips, each 10-20 seconds, consisting of 24 frames per second. An annotation of frames with birds 150-30 feet from the camera resulted in 2,030 video frames with eagles, and 630 with other raptors. Detection results showed high true positive (eagle detections when eagle was present) and true negative rates, as well as relatively high false positive (21%) and low false negative rates. There is an average start-time delay of about six frames before the system recognizes the bird as an eagle, and a corresponding stop-time delay of the same length.

Deterrent. The inflatable figure starts to "dance" at 3 mps, and ceases to dance at about 13 mps. However, even if it is horizontal (parallel to the ground), it is still visible to eagle from above (slides #13-14). During testing, of a total of 27 wild eagle sightings, the visual deterrent was deployed with 11 eagles. There was only one instance of an eagle changing its flight pattern at deployment. These results are as yet inconclusive, due to a low number of events.

Blade strike detection. This component of the system seems to work well. Slide #19 shows an example of an image captured by the video during a strike event from a water-filled tennis ball. Slide #20 shows examples of detection of anomalous blade vibrations that triggered the storage of images for event identification.

CONCLUSIONS / APPLICATIONS

The system, as designed, will effectively detect approaching eagles and potentially deter them from flying in close proximity to wind turbines. It represents an important improvement in eagle-wind energy interactions minimization technology, easing a current barrier to full development of the wind energy market.

Questions & Discussion

Q: *What is the minimum weight tested for impact detection?*

A: Kinetic energy, not weight, triggers the detection system, so it depends where on the blade the object strikes. We will implement a machine learning algorithm to recognize targets weighing 10-12 grams (using potatoes).

Q: *Can you see if strike tests caused any micro-fractures of the turbine blades?*

A: No damage whatsoever.

Q: *Cost – do you need detection units on each turbine?*

A: The deterrent can be located at any location within the wind farm. For detection, we can have one detection unit per turbine rotor, rather than per blade.

Effectiveness of Radar Assisted Shutdown on Demand of Turbines as a Mitigation Tool to Avoid Soaring Bird Mortality in Wind Farms

Presenter: Ricardo Tomé, *STRIX, Lda.*

[slide presentation]

Authors: Ricardo Tomé, Alexandre Leitão, Filipe Canário, Nadine Pires, Nuno Vieira, Marta Sampaio (*STRIX, Lda.*); Mahmoud Eisa (*NREA*)

PROBLEM / RESEARCH NEED

Wind farms may cause adverse effects on birds, especially mortality resulting from collisions with turbines. Although negative impacts are markedly site- and project-specific, several studies have shown that soaring birds such as raptors are particularly vulnerable to collisions. Such risk increases when wind energy projects are installed along main migratory flyways or commuting or foraging areas, where the number and frequency of birds is higher. The fact that some of the most wind productive areas worldwide overlap with these areas represents a major challenge and an opportunity to develop innovative and effective mitigation measures to reconcile wind energy production with important conservation aspects.

The map (slide #7) shows migratory flyways between Europe, Asia and Africa. Two areas where wind energy projects and migratory flyways overlap are the BSJ wind farm, in Portugal, near the crossing between Spain/Portugal and Africa, and the GeZ wind farm, in Egypt. Both areas have a high number of bird movements and a variety of species at risk. Despite differences in size and location, both projects are installed in migratory corridors of international importance for soaring birds: the 50 MW BSJ wind farm (Portugal) is crossed by nearly 5,000 individuals every autumn, whereas almost 400,000 birds occur in the 200 MW GeZ wind farm during spring. Nearly three-quarters (73%) of the movements in Portugal are within collision risk height (35-125 m). In Egypt the birds tend to be flying at higher altitudes, so that only 15% of movements are within risk height (20-100 m), but there are more birds at this site, so there are a lot of birds at risk (slides #8-11).

Objectives

Following a thorough evaluation process engaging interested stakeholders, Radar Assisted Shutdown on Demand (RASOD) was selected as the most appropriate minimization measure to be implemented. The goal of this presentation is to summarize and evaluate the performance of such method in the BSJ and GeZ wind farms.

A schematic in slide #15 illustrates the RASOD process. A flock of soaring birds is first detected by radar. If shutdown criteria are met, the shutdown order is given by phone call or accessing remotely the wind farm's control system (SCADA), followed by a re-start order after the birds have passed. Shutdown criteria are as follows:

- Intensity of migratory flow
- Flocks
- Globally threatened species
- Imminent collision risk
- Sand storms (in Egypt)

Video (slides #16-18) show: (1) a flock of Gryphon vultures flying around moving blades in Southwest Portugal, with one being struck; (2) flock of vultures over BSJ wind farm with blades shut down during passage; (3) a flock of white storks flying above the GeZ wind farm during a shutdown event. Slide #20 shows a radar image (radius 8 km range), with software tracking a flock of vultures as it approaches the wind farm, and the point at which shutdown was triggered.

FINDINGS

The temporary shutdown of turbines has proved extremely successful, rendering nearly zero or very low mortality of soaring birds in both wind farms since the beginning of their operational phase (2010 for BSJ and 2016 for GEZ). In Portugal, the BSJ facility has had only two fatalities of soaring birds in eight years, based on systematic bi-weekly extensive carcass searches. In Egypt, carcass surveys are limited and not conducted systematically. Nevertheless, records indicate that approximately 5-10 soaring bird fatalities have occurred per year over the past three years.

The operational results of RASOD in Portugal and Egypt were compared with previously established shutdown scenarios based on the information collected during the pre-construction monitoring of birds. In both cases, real equivalent shutdown periods were markedly lower than anticipated due to optimization over time as result of cumulative experience and adaptive management.

Graphs in slides #23-25 show that the number of shutdowns has trended downward over the years (2010-2017) that RASOD has been implemented in Portugal, with a corresponding decrease in the total equivalent period of shutdown hours: 7.25 hours in 2017, or 0.28% of the available production hours during migration season, and 0.08% of available annual production hours. Slide #26-28 shows the equivalent data for the GeZ wind facility in Egypt for the years 2016-2017: shut-down production loss is 0.03% of actual annual energy production, 0.15% of actual energy production during the spring migration season. By comparison, shutting down for maintenance and other reasons cost 3.5% of energy production during spring.

CONCLUSIONS / APPLICATIONS

In the light of these results, we also analyzed the implementation of RASOD in a 168 MW proposed wind farm project in Israel, where a conflict with foraging and breeding vultures is likely to emerge. We looked at high resolution GPS location data to estimate the total time Griffon vultures spend inside the project area, visual surveys to estimate the relative proportion of different sized flocks, and GPS data from vultures originating from different Israeli colonies to estimate the total number of vultures occurring in the area. Based on these estimates, we anticipate 35 hours of shutdown, or 0.4% of the available energy production hours (slide #32).

We conclude that radar-assisted turbine shutdown on demand can be extremely efficient in avoiding collision mortality in areas where such a conflict may emerge, effectively reducing soaring bird mortality rates while incurring negligible production losses. The combination of radar and human observer vantage points contribute decisively to bird detection, tracking and identification. Performance is enhanced by direct access to SCADA (turbine operation control system) and by adaptive management as the team gains experience, and radar position and monitoring period are optimized.

As with any technological solution, this approach requires site-specific adaptations to wind farm layout, topography, and especially differences in bird communities, abundance and behavior.

Questions & Discussion

Q: *Have you observed birds colliding with towers or moving blades?*

A: In the GeZ wind farm we have witnessed soaring bird collisions on two occasions. Both involved small raptors (Eurasian and Lesser Kestrels) that were only detected already very close to the rotating blades, with no time to order a shutdown. In Portugal collisions at BSJ are quite low; we found only two in eight years. We did not see the first one, but the second involved a honey buzzard that emerged very suddenly from a valley, and we could not stop the blades in time. However, on several occasions we have seen the same birds we have just saved colliding at neighboring wind farms that are not operating with shutdowns.

Q: *Are there any existing radar systems that could be used to assist automatically with turbine shut-down (e.g., weather or military radar or Birdcast)? If not, why not?*

A: In the case of BSJ (Portugal) there are a lot of people surveilling the wind farm plus the radar for 25 turbines. But the developers are happy because the percentage of operational time lost for the shutdown was so significantly narrowed compared to if they had to shut down during the entire spring migration. In Egypt and Portugal, we still need people to detect birds because we are concerned for particular species. Radar still is not good at distinguishing species of concern from common species that do not meet the shutdown criteria. Therefore, in such areas with a high diversity of bird species and where species-specific shutdown criteria have been set, a fully automated radar system could trigger frequently unnecessary shutdowns for birds that do not meet the criteria.

Q: *What is the range time for the shut-downs (min, max, average, median)?*

A: In the BSJ wind farm the equivalent shutdown periods decreased a lot between the first year of operation (2010) and 2017 due to the optimization of the RASOD system, cumulative experience by the monitoring team and adaptive management. In 2010 (75 shutdowns) the equivalent shutdown time statistics were as follows: min: 0.033 h (1 turbine shutdown for 56 min); max: 8,833 h (the whole 25 turbines shutdown for 8 h 50 min); average: 1,433 h; median: 0.95 h. In 2017 (33 shutdowns): min: 0.005 (1 turbine shutdown for 8 min); max: 2,233 h (16 turbines shutdown for 49 min); average: 0.221 h; median: 0.075 h.

In Egypt the equivalent shutdown time statistics are as follows (n=3 years, 177 shutdowns in total): min: 0.0002 h (2 turbines shutdown for 1 min); max: 5,067 h (the whole 100 turbines shutdown for 5 h 04 min); average: 0.096 h; median: 0.010 h.

Q: *How many human observers are at each site, and how long each day/week/month are they looking for birds?*

A: In the BSJ wind farm (Portugal) there are seven human observers/vantage points throughout the whole autumn migratory season (September 1 to December 15 = 106 days). In the GeZ wind farm (Egypt) there are six human observers during the whole spring season (February 20 to May 20 = 90 days). In both cases observers start monitoring early in the morning (8:30-9:00) and finish late in the afternoon (16:00-17:30), with some variation throughout the periods associated with the change in sun rise and sun set times.

Q: *What were the fatality numbers like before the shut-down study? (Or, what is the efficiency of this mitigation measure?)*

A: We do not have fatality numbers before the application of the shutdown mitigation measure because this started in the same year the wind farms started operating. However in the Portuguese case, and despite the lack of systematic monitoring or studies on fatalities, at least 50 fatalities were registered during the past 10 years in the neighboring wind farms to the BSJ wind farm that are not applying any turbine shutdown. This involved mostly vultures (Griffon, Cinereous and Egyptian vultures). Our data from the BSJ wind farm also shows that every autumn an average of 698 soaring birds crosses the rotor swept area of the turbines (slide #11). It is reasonable to assume that at least a big proportion of these would die if the turbines had not been shut down during their crossing.

Q: *How many RASOD (radar) units are installed at the Portugal wind farm? How many per turbine?*

A: A single X-band radar unit is installed to support the surveillance of the BSJ wind farm in Portugal (slides #19-20). This corresponds to 1 radar per 25 turbines or 50 MW. In the GeZ wind farm (Egypt), 2 radars were installed, corresponding to 1 radar per 50 turbines or 100 MW.

Q: *How many birds are needed for the radar to be able to detect them? Is there a target size or density limitation on the system?*

A: Bird detection by radars typically varies with size/mass and distance. Generally, the larger the bird or the flock of birds, and the shorter the distance, the higher the detectability. Marine radars such as the ones we have been using in wind farms can detect an individual passerine up to 700 m, a small flock of starlings up to 1.2 km, a pigeon or gull up to 2.5 km, a medium-sized raptor up to 4 km, and a large-sized raptor (such as a vulture or stork) up to 7 km. Big flocks (dozens or hundreds) of waders or ducks can be detected up to 7 km whereas a big flock (hundreds) of vultures can be detected up to nearly 20 km distance!

Facilitating Evaluation of Impact Minimization Technologies:
Objectives and Challenges of Technology Integration

Presenter: Stu S. Webster, *American Wind-Wildlife Institute*

[slide presentation]

Author: Stu Webster (*American Wind-Wildlife Institute*)

<u>PROBLEM / RESEARCH NEED</u>

American Wind-Wildlife Institute (AWWI)'s Technology Innovation and Research Program (Program) seeks to build a body of evidence around technologies and strategies to minimize wildlife collisions. Stakeholders and consumers of technology evaluation studies include: the wind industry, vendors and innovators, regulatory agencies, science and wildlife conservation interests, and the general public. This presentation focuses on the objectives and challenges of integrating wildlife impact reduction technologies with operational wind energy facilities.

Objectives

The Program evaluates impact reduction technologies with the following objectives in mind:

1. Reduce/remove market barriers for late-stage technologies

2. Realize multiple impact reduction strategies

3. Provide evidence of efficacy for market and regulatory acceptance

4. Replicate studies under diverse locations/conditions

5. Ensure the credibility and independence of research by pursuing:
   o Independent, 3rd party evaluation and/or partnerships
   o Peer-review of study design and final report
   o Published in scientific journals whenever possible
   o Diverse funding sources ($200k – $2M+ per field evaluation)

<u>APPROACH</u>

Technology evaluations include three key elements:
- Biological objective;
- Installation, integration, operations & maintenance; and
- Performance reliability and limitations.

Most of the presentations related to the Program we are hearing at this meeting focus on the biological objectives, but here we highlight the second element: installation and integration of systems as part of sophisticated wind energy facility systems.

The question of a given technology's suitability for application is explored in an AWWI White Paper recently produced by Kaj Skov Nielsen for AWWI.[5] There are a number of crucial questions about how impact reduction technologies themselves impact and integrate with the systems that make up a wind energy facility. Physical installation – mounting detectors and other equipment on the turbines themselves – can raise questions of warranty on turbines, requiring coordination with turbine manufacturers as well as operators. How will the technology interact with the system? We have to consider network and power needs, cyber-security, engineering, newer vs older turbines, and of course coordination with the onsite operator and support team.

Summary of "pre-Installation" Issues:
- Nature and assessment of baseline impact risks
- Determination of site and application suitability
- Network, physical, and power needs of a technology
- Physical installation of equipment, on or off turbine
- Costs and coordination with turbine manufacturer
- Costs and coordination with operator onsite and support team
- Compatibility of technology across turbine platforms and eras
- Warranty risks and uncertainties

Summary of Technology Integration Issues:
- Configuration with turbine, plant, and/or central Supervisory Control and Data Acquisition (SCADA) systems, which monitors wind plant status and performance as well as collect data and issue commands to the turbines
- Network, remote access, and cybersecurity
- Signal types, pathways, and destinations in compatible language
- Development of efficient human machine interfaces (HMI) – e.g., override of curtailment/release orders
- Data storage, transfer, and bandwidth requirements
- Remote access for real-time and diagnostic interactions

Summary of Performance Reliability and limitations:
- Effectiveness of reducing baseline impact risks
- Lifespan of hardware and software

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[5] American Wind Wildlife Institute (AWWI). 2018. AWWI White Paper: Integration of Wildlife Detection and Deterrent Systems in Wind Power Plants. Washington, DC. Available at www.awwi.org. AWWI acknowledges Siemens Gamesa Renewable Energy for contributing Kaj Skov Nielsen's time to AWWI for this paper.

- Maintenance requirements and operational logistics
- Service contract, warranty, and supply chain assurances
- Maintenance, troubleshooting, and malfunctions
- Durability – temperature, precipitation, ice, noise, vibration, dirt
- Collateral impacts (e.g., noise/visual complaints)

CONCLUSIONS / APPLICATIONS

A third element, performance reliability over time, also presents a challenge, given that studies typically run for one to two years. We try to design studies to help us evaluate performance reliability to the extent possible, and provide feedback to vendors and developers. Other questions that the Program tries to address include the challenges inherent in trouble-shooting systems in isolated and often hostile environments, and comprehensive system cost analyses.

Just as we seek to synthesize and share the latest information on risk minimization technologies, this presentation and the December 2018 White Paper are part of our effort to share with this community of stakeholders the importance of this work, which we hope to enhance and expand going forward.

Technologies for Reducing Impacts to Bats

Moderated by Christine Sutter, *Natural Power*

Testing Ultrasonic Acoustic Deterrents for Reducing Bat Fatalities at Wind Turbines in South Texas

Presenter: Sara Weaver, *Texas State University*

[slide presentation]

Authors: Sara Weaver, Ivan Castro-Arellano, Thomas Simpson (*Texas State University*); Cris Hein (*Bat Conservation International*)

PROBLEM / RESEARCH NEED

Wind energy development has long been known to directly impact bats by causing fatalities at wind turbines. Ultrasonic acoustic deterrent technology, as a bat impact reduction strategy at wind turbines, is in early phases of research, with few published field studies. In addition, current and previous studies have been confined primarily to northeastern United States and Canada, and have not been tested on the suite of species in south Texas, an area of high bat diversity and increasing wind energy development.

The inception of this project is a good example of multiple stakeholder collaboration. We started with BCI and NRG Systems to develop an acoustic deterrent. Duke Energy agreed to testing at a site in Starr County (South Texas – see slide #4) in an area of expanding wind development. The project consists of 255 Vestas 2 MW turbines with a 95-m hub height, feathered to the manufacturer's cut-in speed (3.5 m/s). There has not been much research on wind-wildlife interactions in this location.

Objectives

Our objective was to assess effectiveness of a newly developed ultrasonic acoustic deterrent for reducing bat fatalities at the Duke Energy wind facility in Starr County, Texas.

1. Can NRG System's deterrent effectively reduce bat fatalities at Duke Energy's wind energy facility in south Texas?

2. In particular, how is it effective at reducing species-specific fatalities?

The NRG ultrasonic acoustic deterrent unit consists of six sub-arrays programmed to produce continuous high-frequency sound at predetermined frequencies from 20 to 50 kHz (slide #4). The technology trials ran during late summer to fall of 2017 and 2018. We randomly selected 16 turbines, and retrofitted them all with units. We randomly assigned eight turbines as controls and eight turbines as treatments, with these assignments rotating nightly from 31 July through 30 October during both seasons.

After reassessing the original placement of the deterrents, we elected to reconfigure their position on the nacelle for the second year. Thus in 2018 we installed five rather than six arrays on the same 16 turbines. Based on behavioral studies, we had initially placed the deterrent units on the leeward side of the nacelle, where activity is highest. In 2018, we focused deterrents more on the danger zone, giving bats freedom to use the leeward area. (Slides #7 and 8 show the re-orientation and reconfiguration of the units on the turbine nacelle from 2017 to 2018.)

We established carcass-search transects, and searched all turbines daily within established circular plots for bat carcasses. Plots were cleared and maintained out to 100 m for the duration of the project. The response variable was the total number of fresh bat carcasses per turbine per night. We assessed effectiveness of deterrents with generalized linear mixed models in R version 3.4.3.

FINDINGS

In 2017, we completed a total of 1,388 searches (697 for control turbines and 691 for treatment turbines) and recovered a total of 434 bat carcasses comprised of 7 different species. Of these, 303 were determined as fatalities occurring the previous night that could be assigned to a treatment or control turbine and used in statistical analyses.

In 2018, we completed a total of 1,172 searches (584 for control turbines and 588 for treatment turbines) and recovered a total of 325 bat carcasses comprised of five species that could be used in statistical analyses. Fewer searches in year 2 were due primarily to weather events.

Looking at the combined results for both years (slide #12), we found:
- Fatalities at control were twice as high as at the treatment turbines (n=628)

- Deterrents had a significant effect on bat fatalities (β= -0.6, SE= 0.14, z= -4.1)
  - $p < 0.001$
  - There was a 50% reduction in overall fatalities (95% CI)

- Configuration of the deterrent units did not result in a significant difference

Species-specific results were less conclusive. Of the three species we were able to assess, we found an effect for Brazilian free-tailed (54% reduction, 95% CI 41-67%) and hoary bats (78%

reduction, 95% CI 62-95%), but not for Northern yellow bats (26% increase, 95% CI -79-21% [slide #13]). We were unable to statistically assess the remaining species due to small sample size.

<u>CONCLUSIONS / APPLICATIONS</u>

Our results support our prediction that deterrents would reduce bat fatalities. The overall effect that we saw can be attributed to the fact that there are a high number of Brazilian free-tailed at the project site. It is possible that the deterrent was less effective for Northern yellow bats because of a difference in call frequencies, but we don't know enough about this species to be sure. Likewise for Southern yellow bats. For some species, there were too few carcasses to make inferences.

Results from 2017 and 2018 are final and indicate ultrasonic acoustic deterrents are a promising strategy for reducing Brazilian free-tailed and hoary bat fatalities in this region, over and above feathering at manufacturer's cut-in speed.

Overall, we have been hearing that tree-roosting species incur the highest fatalities from collision with wind turbines, but that may be because we just are not getting studies in areas where there are a lot of Brazilian free-tailed bats. Some further areas for analysis include sex ratios and weather covariates, as well as further testing of various configurations in a controlled setting. We also would like to increase species-specific effectiveness (particularly for Northern and Southern yellow bats). While there is no one-size fits all solution, the more tools we have for industry the better.

Questions & Discussion

Q: *What other species might be negatively affected by frequencies used in your tests?*

A: I am not certain if this question means the sound negatively affected approaching bats by deterring them and thereby decreasing fatalities at turbines, or if it is referencing that we found more northern yellow bats at treatments than controls as a negative effect. In either case, our sample size was too small for other species to draw conclusions.

Q: *Do you think that moving the transducers to the rotor swept side of the turbine had an effect on the hoary bat fatality increase the second year?*

A: Based on our statistics, placement did not significantly affect fatalities. Additionally, we found more than twice as many hoary bats the second year, giving us a combined sample size large enough for statistical analysis, which we could not do in the first year, so it is difficult to say anything regarding placement for this species. However, I think it is unrealistic to assume 100% reduction in the first year, as bats may have been missed or scavenged. Regardless, I think an overall reduction of 78% is very encouraging.

Q: *Do hoary bats in the US and Canada move to or from Central and South America? If so,*

how is this additional "sink" considered in the estimates and projections of US and Canadian wind energy development's impacts to hoary bats?

A: Hoary bats are long distance migrants and do migrate into Mexico, but I am not aware of any transcontinental movements for this species.

<u>Not Asked during Session</u>

Q: *Does humidity have an effect on the lower frequency transduction?*

A: At the time of the meeting we had not had an opportunity to look at this for the combined data, and plan to do so in the future. However, we did assess for an interaction between treatment and weather covariates in year 1. No such interaction existed, indicating weather covariates, including humidity, did not significantly influence treatment effectiveness. In addition, average relative humidity in year 1 was 74%, and reductions were still significant despite high relative humidity for the duration of the project. We also plan to assess absolute humidity in the future, due to relative humidity's dependence on temperature.

Assessing Changes in Bat Activity in Response to an Acoustic Deterrent – Implications for Decreasing Bat Fatalities at Wind Energy Facilities

Presenter: Amanda Hale, *Texas Christian University*

[slide presentation]

Authors: Cole Lindsey, Amanda Hale, Tory Bennett (*Texas Christian University*); Kevin Kinzie (*General Electric Company*)

<u>PROBLEM / RESEARCH NEED</u>

Although wind power is a renewable energy resource with many environmental benefits, there are increasing concerns about negative impacts to bats. Across North America, large numbers of tree bats, in particular, are killed by wind turbines on an annual basis and there is a pressing need to develop effective impact mitigation strategies. One emerging technological solution is to deploy acoustic deterrents on wind turbines to disrupt bat echolocation, thereby preventing bats from entering the rotor swept zone. Although initial results from field tests of deterrent technology have shown promise, much remains unknown about how effectively acoustic signals deter bats from entering the rotor swept zone, and how bat species may vary in their responses to these acoustic signals over space and time.

Objectives

This project builds on previous research by General Electric on an acoustic deterrent device, and specifically seeks to:

1. improve our understanding of how bats respond to various ultrasonic stimuli;
2. test the efficacy of a redesigned GE deterrent system based on new findings.

APPROACH

We conducted ground tests of the GE acoustic deterrent at an operational wind facility (Wolf Ridge Wind) in north-central Texas over two field seasons. Post-construction fatality monitoring has been conducted at this site (2009-2014), and six bat species are known to be present, including eastern red bats. Results from the ground tests would be used to inform the deterrent redesign for further testing at another facility. Variables of particular interest were: location, habitat type, acoustic signal type, distance from emitter, and bat behavior.

The GE deterrent is an air-powered device, reliable and robust, and easy to maintain. The acoustic signal is a broadband high-frequency sound. The GE device sends a multi-directional signal, as contrasted with the directional signal sent by a typical transducer-based system (slide #7). The idea behind the technology is to interfere with bat echolocation so that bats avoid the area. While initial tests had showed promise, the desired outcome (reduction in fatalities) was not achieved, at least not for all species.

We used a pair of video cameras (night vision in 2015 and thermal in 2016) with overlapping fields to observe bats, and also used a bat detector to record bat activity within the focal area (slide #8). In 2015, we evaluated bat activity and behavior in response to continuous and pulsed ultrasonic signals emitted from deterrent devices placed 10, 20, and 30 m from three paired wind turbines and cattle ponds over 33 paired survey nights from August 17 to September 28, 2015. In 2016 the surveys included a modified pulse signal and we evaluated bat activity and behavior only at the cattle ponds, where we would see more bats. This testing took place over 81 pond nights from April 1 to September 17, 2016, allowing us to look for seasonal variability in response.

Testing was conducted in 10-minute intervals, rotating among four treatments: three different deterrent signals (continuous on, and a couple of different pulsing signals) and one silent control. Because the current GE device is limited by the number of air compressors that can be accommodated within a turbine tower, we wanted to see if a pulsing signal would work, allowing deployment of more emitters from the same number of air compressors. Each test interval was followed by 10 minutes with the deterrent off. Each signal was tested two times per night at each of three locations: 10, 20, and 30 m from the paired wind turbines and cattle ponds.

Video was reviewed and bat behaviors categorized: passing, foraging, reversal, pursuit (rare), contact (with ponds to drink).

<u>FINDINGS</u>

Bat activity was highly variable within and between survey nights in both years. We detected from zero to 69 bats in our nightly video surveys, with more bats observed at ponds compared to turbines. Bat activity was lower during the deterrent trials compared to the silent control periods, although the difference was significant only in 2016.

We found no difference in bat activity between the continuous and pulsed acoustic signals, suggesting that pulsed signals may be as effective at reducing bat activity as continuous signals. The deterrent was significantly more effective at 10 m than 30 m at the ponds (P = 0.003). The deterrent also changed bat flight behavior, with bats exhibiting significantly fewer complex foraging flight paths and significantly more simple straight-line flight paths during deterrent tests compared to control periods.

We identified a zone of low amplitude sound in the deterrent signal around 40 kHz, coinciding with the fundamental echolocation range of eastern red bats (*Lasiurus borealis*). (See spectrogram in slide #11, with black arrow indicating a higher amplitude tone above this frequency range, at about 48 kHz.) In 2016, GE changed the pressure in the manifold, shifting the frequency and amplitude of the high-amplitude tone so that it spanned 40-60 kHz (slide #14), with the goal of improving performance with eastern red bats. We have seen some evidence that eastern red bats (*Lasiurus borealis*) can shift echolocation call characteristics, including fundamental frequency, in response to sounds produced by an acoustic deterrent (slide #17). What we don't know is how much bats may shift the frequency of their calls, which is something we need to take into account in refining this deterrent technology.

With the 2016 data a larger sample size allowed us to show a consistent reduction in bat activity with the acoustic signals, and again no significant difference in response to the continuous vs. the pulsed signals. Looking at bat behavior in the video, we did see a greater proportion of passing with the acoustic deterrent on, and a greater proportion of foraging during the silent periods (slide #13).

<u>CONCLUSIONS / APPLICATIONS</u>

Overall, the results from the ground test indicated that the GE acoustic deterrent can reduce bat activity and alter bat behavior.

- The effectiveness of the deterrent was not influenced by signal type (continuous, pulsing). For the GE device, this means that an increased number of emitters could operate with pulsed signals for the same number of air compressors.

- The reduction in effectiveness with distance that we observed continues to be a challenge with current technology (i.e., emitters placed on the turbine nacelle or monopole).

- The shift in the frequency of the high-amplitude tone in the 2016 deterrent signals likely provided more effective interference with eastern red bat (*Lasiurus borealis*) echolocation calls.

Acoustic deterrents show promise as an effective impact mitigation strategy and warrant further development and testing on operational wind turbines. Of particular interest:

- Determining the optimal number, placement, and orientation of deterrent emitters along the turbine tower, nacelle, and possibly even the turbine blades to ensure adequate coverage of the rotor swept zone

- The extent to which bats may be able to shift the frequency of their calls to avoid the sound of the deterrent, and the possibility of generating an acoustic signal that covers a broad frequency range – particularly, for the bat community of interest.

Questions & Discussion

Q: *What level of mortality would result in population-level impact, and if it's not, should we adjust priorities?*

A: Given mortality we see from turbines, following the precautionary principle is a good idea at least in the short-term. Smarter curtailment. Need to learn more about population sizes.

Q: *We heard earlier about testing eagle reactions to various auditory stimuli. Have there been comparable studies of bat audiology to assess what acoustic frequencies elicit the strongest neurological and behavioral responses?*

A: It's a great idea, but we would have to look into that body of literature to know what has been done.

Q: *If acoustic deterrents work by jamming or masking echolocation of foraging bats, is there reason to think it also would work with non-echolocating or non-foraging bats?*

A: We don't know. An increase in straight-line passes through the deterrent zone (animals dissuaded from foraging because of acoustic deterrent) could still leave animals at some risk as they pass through.

Q: *Do you think there might be an opportunity to deter bats through some sort of constant modulation that would further complicate the bats' ability to compensate by changing echo-location frequencies?*

A: It's worth thinking about and testing whether a variable deterrent signal might be more effective; bats do shift their frequencies in a cluttered acoustic environment.

Not Asked during Session

Q: *In 2016, you had significantly lower bat activity in spring and fall. At what distance? 10 m?*

30 m? 45 m?

A: In 2016, overall bat activity was lower in the summer than in spring and fall over all distances combined (10-30m; Slide #12). Higher activity in spring and fall is likely due in part to migratory activity.

Q: *Did you account for the amount of ambient light during your trials to check whether deterrent was more effective on darker nights?*

A: We didn't directly measure light levels, but we have looked at the percentage of moon illumination and found no relationship with variation in bat activity.

The Potential Population-level Benefit of Turbine Fatality Reduction Measures for Hoary Bats

Presenter: Nicholas Friedenberg, *Applied Biomathematics*

[slide presentation]

Authors: Nicholas Friedenberg (*Applied Biomathematics*), Winifred Frick (*Bat Conservation International*)

PROBLEM / RESEARCH NEED

Hoary bats, *Lasiurus cinereus*, with their broad and well-mixed North American distribution, are an umbrella species for studying the interaction of bats with wind turbines. Large numbers of hoary bat fatalities occur at wind energy facilities in the United States every year. A previous modeling study suggested that the level of fatality from wind turbine collisions in 2014 may be sufficient to imperil the hoary bat population, particularly if the population was initially small (e.g., less than about 3 million bats). While large uncertainties exist in its parameters, including vital rates, population size, and the actual level of fatality, the model can serve as a tool for exploring additional aspects of bat management and wind development.

Objectives

The goal of this modeling exercise is to extend the original investigation to include projected increases in land-based wind energy capacity and use Monte Carlo simulations to find what level of fatality reduction (per MW) would be necessary to reduce or eliminate the risk of hoary bat decline or extinction.

APPROACH

In the original (Frick et al. 2017) model, a population starting at less than three million individuals would have to have a population growth rate greater than one to sustain itself over a 100-year period, given 2014 levels of installed capacity and no reduction in wind energy-related mortality. An expert elicitation for opinions of low, likely and high estimates of hoary bat population size revealed high uncertainty, spanning four orders of magnitude from 10,000 to 100 million hoary bats. Given previous estimates of annual wind fatalities in the range of about 75,000 to 150,000, it is likely there are substantially more than 100,000 hoary bats; for purposes of this modelling exercise, we focused on the experts' "most likely" abundance range of one to ten million and took it to represent the state of the population in 2012.

We extended Frick et al.'s model based on installed capacity growth in the US and Canada from 2012 to 2018, along with optimistic projections of wind build-out to 2050. If, as in Frick et al.'s model, we assume mortality is proportional to installed capacity, we will eventually run into the problem of there being enough capacity to kill more than 100% of the population in a single year.

A similar (but probably more realistic) approach is to assume fatalities per small unit of time are proportional to capacity, but annual fatality is the integral of this continuous process. (This is similar to prey death in a Nicholson-Bailey population model.) The wind mortality rate (proportion of population killed) never reaches 100%. In our model, a population of 1 million hoary bats is expected to experience 11% wind mortality in 2012 and 47% in 2050. A population of 10 million of would experience 5.8% annual mortality in 2050.

We are assuming simple exponential growth, with no compensatory increase in growth rate at low population size. The only complication we add is some stochasticity. The growth rate and wind mortality vary independently. Altering the variability of these two rates, within reason, makes little difference to our results. If wind mortality is greater than the amount by which the population can increase each year, the population will decline. Factors not in the model include: learning, local depletion, habitat preference, and migration routes.

We then introduce into the model the adoption of a technology or strategy that would reduce the hoary bat fatality rate per MW of installed capacity beginning with new construction in 2020, and reaching full adoption at all wind facilities by 2029. This schedule of adoption is used to modify the projected future wind mortality through 2050. We score the impact of wind mortality, and the benefit of mitigation, by measuring the probability of a 50% decline in the population as well as the probability of extinction. We compare outcomes given different starting population sizes and different levels of mortality rate reduction. Our baseline model assumes hoary bat abundance has no trend in the absence of wind mortality, but we also examine cases of increasing or decreasing trends.

FINDINGS

Given the optimistic wind energy capacity build-out and no fatality reduction measures, the

model shows a 100% probability of a 50% decline by 2050 in populations of 1 or 2.25 million hoary bats, and a 91% probability of decline in a population of 10 million. The bigger the current actual population size, the slower the decline and the more opportunity to mitigate the population-level impact. For example, the median year of decline is unchanged by a 50% fatality reduction in populations of 1 or 2.25 million but is delayed nine years in a population of 10 million. Extinction is delayed eight years in a population of 1 million and beyond 2050 in a population of 2.25 million. The largest abundance we investigated, 10 million, has no risk of extinction even without fatality reduction.

The model shows us how much fatality reduction we need, depending on the current population size and growth rate, to bring the probability of extinction by 2050 to less than 1%. So for example, if abundance is 2.25 million bats, and there is no inherent population trend, then a 22% reduction in fatalities brings the probability of extinction by 2050 to under 1%. Given the same starting population size and an inherent trend of 5% annual decline in abundance (from factors other than wind), 57% fatality reduction is needed to manage extinction risk; whereas with an increasing trend of 5% per year, no fatality reduction is needed.

CONCLUSIONS / APPLICATIONS

Comparison of results with reductions in fatality that appear possible using existing and emerging approaches, including seasonal and smart curtailment as well as deterrence measures, will improve our understanding of the potential to protect the long-term viability of the hoary bat population and provide decision support in the absence of complete biological knowledge.

More research is needed, but the clock may be ticking. Efforts are underway to learn more about abundance, but we need to think carefully about what we really need to know. We don't need a strong central estimate of population size, but we do need a reasonable *lower bound*. Models like this one give us benchmarks; if we know there are at least about four million hoary bats, we have some assurance we can avoid extinction by 2050. Likewise, it's more important to get a handle on minimum baseline population levels and to reduce the mortality rate as we build out than it is to focus on demography.

Understanding how fatalities scale with build-out is important; we want to consider regional factors and surrounding habitat, and also whether the appropriate scalar unit for build-out is MW or turbines or the land area of wind farms. In any case, it clearly appears possible that the hoary bat population is already declining in response to wind turbine fatalities, suggesting mitigation efforts should be expanded as soon as possible.

Questions & Discussion

Q: *Are your models based on females only? Did you consider sex ratio in the model based on possible sex ratio in collision mortality?*

A: Our model includes both sexes and assumes collision mortality is random with respect to sex. A male bias in fatalities has been observed at some sites, though the talk on sex identification today indicates some potential bias toward males in those numbers. Were we to make the model female-only and incorporate disproportionate male fatality, then collision mortality would decrease somewhat from where we are currently setting it. I suspect that the difference in results would be small and that there would be no change in the qualitative message that understanding hoary bat population size is key to assessing the risk posed by wind energy development.

Q: ***What level of mortality would result in population-level impact, and if it's not, should we adjust priorities?***

A: Unfortunately, we cannot answer that question with any certainty. We don't know, for instance, whether the hoary bat population has any capacity for compensatory growth, as might occur if reproduction or survival are currently suppressed by crowding. However, we can generate a conservative answer by assuming, as we have in our model, that the population is currently neither growing nor declining in the long term. Births and deaths, on average, balance each other out. Under this assumption, random annual environmental variation alone can cause the population to trend upward or downward.

That is to say, the model parameters are balanced on a knife's edge to maximize the model's sensitivity to both impacts and mitigation. *Any* additional mortality in our model causes the expected population size to decrease over time. Any other assumption would, in the absence of supporting evidence, be merely wishful thinking. To buffer our results somewhat, we look at the risk of declines that were improbable in the absence of wind mortality. However, even with that view, I cannot give a clear answer to this question because it depends fundamentally on the size of the population, which we do not currently know.

<u>Not Asked during Session</u>

Q: ***The extinction scenarios you present coincide with recent IPCC risk timelines. Do you have a sense for how hoary bat populations may respond to climate change impacts?***

A: This is a very interesting question. At a course level, it seems likely that changes in precipitation patterns, habitat availability, and the abundance and phenology of flying insects may all result from changes in climate this century and would directly affect hoary bat populations. I am particularly interested in the impact of insect prey availability, as it combines questions about climate change with the impact of large-scale patterns of land use and management.

Q: ***Given the Baerwald 2013 paper, why even include the low (10,000) population estimate from the expert elicitation?***

A: I showed a figure depicting the full range of expert opinions about the total abundance of hoary bats in the U.S. and Canada. That figure included values the experts considered low and high as well as "most likely". The lowest of the low estimates (10,000) falls below the range of

annual fatalities estimated in Arnett and Baerwald (2013). Our modeling was restricted to the range of "most likely" estimates, which was 1-10 million.

Using Thermal Videography to Compare Bat Activity and Behavior at Turbines Equipped with Ultrasonic Acoustic Deterrents

Presenter: Michael Schirmacher, *Bat Conservation International*

Authors: Michael Schirmacher, Cris Hein (*Bat Conservation International*); Manuela Huso (*US Geological Survey*)

This information is preliminary and is subject to revision. It is being provided to meet the need for timely best science. The information is provided on the condition that neither the U.S. Geological Survey nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the information.

PROBLEM / RESEARCH NEED

Wind turbine-caused bat fatalities are estimated in the hundreds of thousands per year (US and Canada). The majority of fatalities are migratory tree-roosting bats, though in some areas fatalities are dominated by Brazilian free-tailed bats. To date, the only scientifically proven strategy for reducing these impacts is curtailment: feathering turbine blades below a cut-in speed of 5 m/s for example. "Smart" curtailments designed to minimize production loss are in different phases of development or testing. However, given the current estimated impact of wind turbines on bats, the rapid expansion of wind energy development, and the loss of power production resulting from operational minimization, it is important to investigate alternative impact reduction strategies, including ultrasonic acoustic deterrents (UADs).

Objectives

In 2015, the U.S. Department of Energy funded five research projects to assess the effectiveness of deterrent technologies. In one of these projects, Bat Conservation International (BCI) used fatality surveys and 3D thermal videography to assess the effectiveness of UAD. For comparison, we also tested curtailment and a combination of curtailment and UAD treatments. In addition to evaluating the potential reduction in fatality from deterrents, our objective was to determine if three-dimensional (3D) thermal videography could enhance our understanding of how bats interact with wind turbines, and provide useful information on how best to place and orient UADs to maximize their effectiveness.

From June 14 through October 3, 2017, at the Blue Creek Wind Energy Facility in Ohio, we compared treatments:

- Control (Cut-in speed 3.5 m/s)
- Ultrasonic Acoustic Deterrents (UAD)
- Curtailment (5 m/s)
- Curtailment + UAD

Turbines with UAD treatment were fitted with four deterrent units on top of the nacelle, and two on the bottom.

Testing minimization strategies is extremely costly, and fatality surveys alone provide limited information on *why* a strategy is or is not effective. (For example, looking at fatality data alone, the combination of curtailment and UAD was effective at reducing fatalities for silver-haired and low-frequency bats, but the UAD treatment by itself had a negative impact – increasing fatalities – for Eastern red bats.) To supplement the fatality data, we recorded 3D thermal video at four turbines (Pair on two turbines at a time) to enhance our understanding of how bats interact with wind turbines and to glean insights about the optimal placement and orientation of UADs.

We used multiple synced thermal video cameras to provide multiple views of the targets, and used newly developed BatVis 3D software to filter and summarize the video data in three dimensions (X, Y, and Z meters relative to turbine hub), and export raw data of the active tracks (Fig. 1). An example of the metrics captured for a single bat track, with Y and Z dimensions shown in Fig. 2.
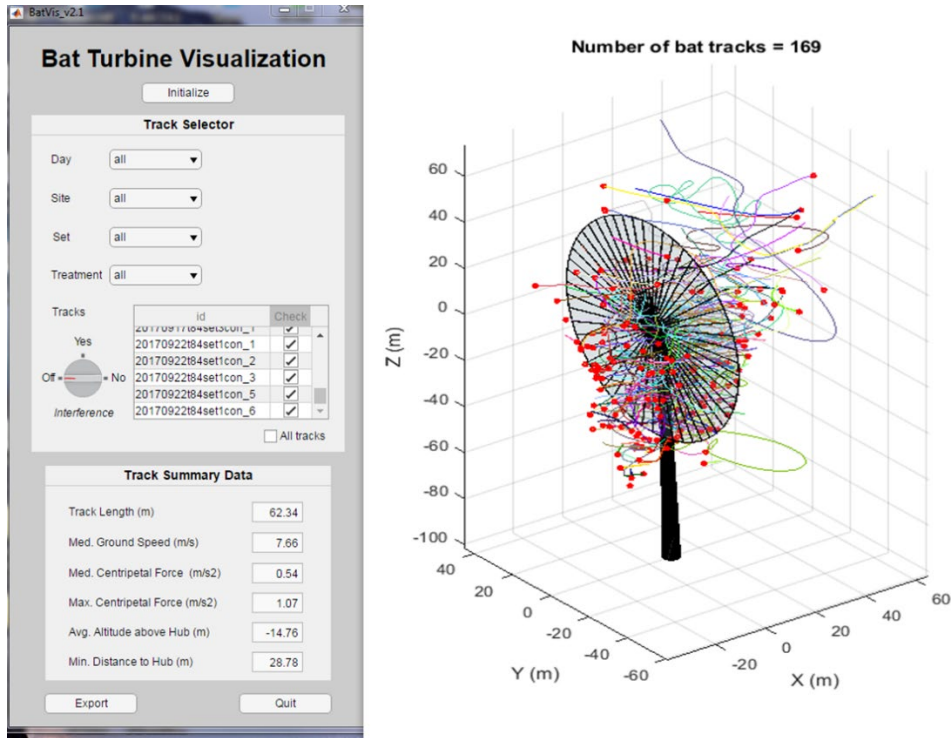
Figure 1. BatVis 3D software summarizes video data in three dimensions, and exports raw data of active tracks.
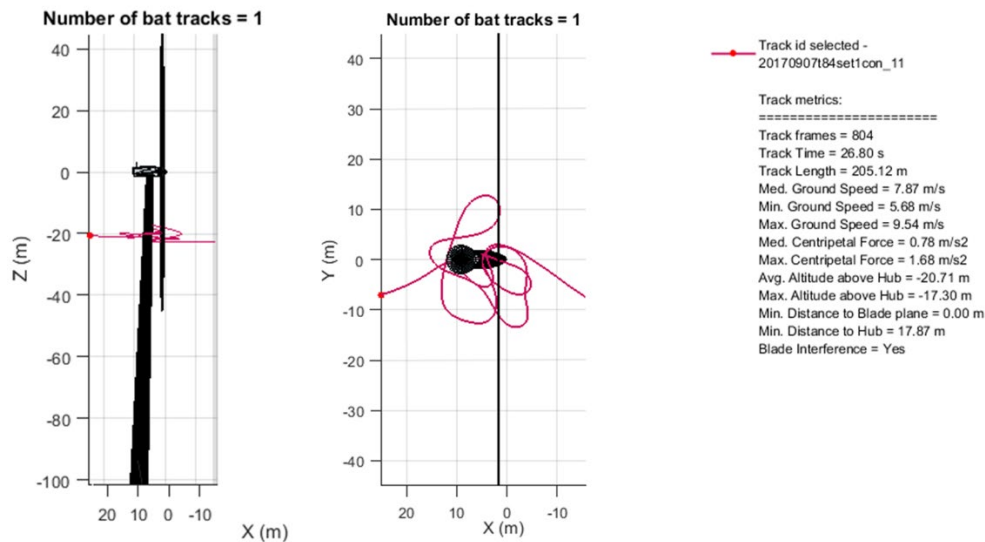
Figure 2. Example of the metrics captured for a single bat track.

FINDINGS

Preliminary results provide insight on improving the performance of UADs for future studies. Over 17 nights at one turbine we had a total of 169 bat tracks. On the nine control nights, we recorded a total of 82 bat tracks, and on the eight UAD nights, we recorded a total of 87 bat tracks. We compared control vs. UAD bat tracks by turbine operation status, which correlated

with wind speed. During times when the turbines were off (wind speed < 3.5 m/s), there were 21 bat tracks around the turbine with no treatment, and 17 bat tracks around the same turbine with the UAD. During times when the turbines were on (wind speed > 3.5 m/s), there were 61 bat tracks under control conditions and 70 bat tracks with UAD.

Under control conditions with the turbine off, individual bat tracks were longer, and more bats crossed the rotor-swept zone (RSZ) than with the acoustic deterrent operating.

When the turbine was on, bat tracks were similar for control vs. UAD nights, and more tracks crossed the RSZ under UAD treatments, but this was not significantly different from control. We also looked at the proportion of time bats spent within 5 m of the RSZ as an indicator of risk. On UAD nights a significantly higher proportion of time was spent within 5 m of the RSZ, compared to control nights. Of the bat tracks that crossed the RSZ when the turbine was operating, most of them originated windward of the RSZ, and this was similar for UAD and control nights.

CONCLUSIONS / APPLICATIONS

Thermal video results did enhance our understanding of control vs. UAD, though our current understanding is limited by small sample size (169 tracks from only one turbine).

These preliminary results suggest that some of the issues could be related to placement and orientation of UAD rather than effectives of the device. We will determine if these results are representative once we add data from the other turbines.

Our BatVis 3D software was effective in providing supplement information on the effectiveness of UAD but likely has other applications. Thermal videography provides specific timing of bat and wind turbine interactions, which can allow us to determine conditions correlated with bat fatalities and may be useful in enhancing existing impact reduction strategies (e.g., operational minimization) or possibly developing new strategies.

Next Steps:

- Process remaining video data and verify that relationships are representative.

- Publish results and BatVis 3D software code.

- Improve functionality of code.

- Test feasibility of technology software for other applications, such as modeling real-time risk to inform minimization, quantifying species-specific behavior, and offshore wind applications.

Questions & Discussion

Q: *It appears that most bats were clustering around the tower and nacelle; is that*

phenomenon unique to your study, or has it been observed in other studies?

A: Some of this could be sampling bias, as our cameras field of view was concentrated on the nacelle, where the deterrents were mounted. We hope to use this technology to better understand how bats approach turbines and if there are areas with higher bat use. Such information would be valuable to determine areas of highest risk, which could help inform UAD placement, but might also help us understand factors related to the potential attraction of bats to turbines.

Q: *For the single turbine with videography, were there were fewer fatalities when the turbine was operating under UAD treatment?*

A: I do not recall.

Q: *How can people access the BatVis 3D software?*

A: The plan is to publish it and make it available to the public. It's currently in Matlab which requires a license, but we are looking into the potential of converting to opensource.

Q: *What species were present at your site?*

A: Testing deterrents impacts our ability to record calls, limiting our ability to identify species. The majority of the fatalities were eastern red bats, hoary bats, and silver-haired bats.

A Comprehensive Approach to Evaluating & Mitigating Risk: the MidAmerican Energy HCP

Moderated by Jenny McIvor, *Berkshire Hathaway Energy*

This panel presented different aspects of the development and implementation of a single Habitat Conservation Plan project. Slide references are to a single powerpoint presentation.

The MidAmerican Energy Multi-Project, Multi-Species Wind HCP: A Collaborative, Data-Driven Approach to Habitat Conservation Planning under ESA

Presenter: Jenny McIvor, *Berkshire Hathaway Energy*

Authors: Jenny McIvor (*Berkshire Hathaway Energy*); Amber Schorg (*US Fish & Wildlife Service*)

PROBLEM / RESEARCH NEED

MidAmerican Energy began building wind energy in Iowa in 2004. From 2004 to 2009, the first four projects were built in Iowa, to the east and north of the Indiana bat range. There had been no bald eagle observations in Iowa at that time, and so Endangered Species Act (ESA) and National Environmental Protection Act (NEPA) review were not required. From 2010 to 2013, additional projects were built in counties at the eastern and northern edges of Indiana bat range, and there were beginning to be sitings of bald eagles during the winter months along the Iowa "coasts" (Mississippi and Missouri Rivers). In 2014, with the listing of the Northern long-eared bat, the wildlife risk profile changed dramatically and MidAmerican's energy wind energy portfolio was in the range of a protected species.

Objectives

Rather than tackle permitting on a project-by-project basis, we decided to take a comprehensive approach to a conservation plan.

We partnered with the US Fish & Wildlife Service (USFWS) and the Iowa Department of Natural Resources (DNR) to study impacts across the MidAmerican fleet. Research included post-construction monitoring for bats and for large and small birds as well as eagle use studies at project sites and reference areas; we agreed to make data available to the public and to use that data to inform the development of a habitat conservation plan (HCP). We agreed to do one NEPA process covering all 22 wind projects that would be operational as of year-end 2016. Collectively known as "Wind 1-10," these projects include 2,020 turbines and approximately 4,050 megawatts (MW) of capacity. (A second HCP is anticipated for the next phase of projects, Wind 11 and Wind 12.)

We executed Memorandum of Understanding documents at the outset of HCP development to facilitate collaborative planning and open communication between parties. There were a few unique aspects to this collaboration. For example, we knew there was a risk of finding covered species. With a Section 6 habitat conservation planning grant, we were able to use Section 7 consultation to obtain incidental take coverage for three years that protected us while we developed the HCP. This was a novel approach from the USFWS.

The plan area covers the entire state of Iowa. (Slide #7 - teal areas on map are project areas.) Covered species include Indiana bat, northern long-eared bat, little brown bat, tri-colored bat and bald eagles (slide #8 shows requested permit authorizations). Implementation take for bats is the mean or most likely scenario, authorized take is slightly higher (90% confidence interval for bats, 80% for eagles). We did not request an implementation take level for bald eagles, only an authorized take level.

FINDINGS

Key minimization and conservation components of our HCP are as follows:

- For bats, we will feather all turbines below manufacturers' cut-in speeds for all wind farms March 15-Nov 1. For the four highest risk profile projects, we will feather all turbines at wind speeds below 5.0 m/s when ambient temperatures are above 50˚ F, from July 15 through September 30.

- For eagles, we will remove carcasses and conduct landowner education programs.

MidAmerican will fund two mitigation accounts:

- $4.4m bat conservation fund, corresponding to the Implementation Take level
- $1.6m eagle conservation fund

Mitigation projects will be selected annually by a steering committee consisting of MidAmerican, a mitigation entity, Iowa DNR, and USFWS, with final approval by MidAmerican and USFWS. The bat mitigation fund will be adaptively managed between Implementation and Authorized Take levels; mitigation true-ups may take place in years 15 and/or 25, or sooner if

triggered by adaptive management. These decisions and other actions will take place at decision meetings scheduled every five years, so that we are not making decisions based on a single year of data.

Questions and Answers / Discussion

Q: *Given that golden eagles are not included as a covered species in the HCP, what happens if a golden eagle is taken at one of the facilities?*

A: We recognize that there is the potential for them to occur in Iowa, even though we have not seen any at our projects. There is a provision for a "changed circumstance" – that is, we can add golden eagles as a covered species if warranted in the future.

Q: *How many bald eagle fatalities were found incidentally, not in surveys?*

A: Overall number included in the HCP study was eight.

Q: *Why did you decide to pursue eagle take within the ESA framework?*

A: I wanted to do NEPA only once! We thought there would be efficiencies in combining permitting efforts across facilities, and we had seen changes in activity and risk over the past 10-15 years. Our feeling was that the risk was fairly ubiquitous across the state, and we wanted to cover all five species (four bat species and bald eagles) within one permit.

Q: *How much time do you have once the incidental take permit is approved until the first set of mitigation projects are in place? Is it important that mitigation stay "ahead" of authorized take?*

A (Quintana): Yes. The first set of mitigation projects are due to be completed within one year. Will then check in at five year intervals to see how mitigation aligns with actual take.

A (Jenny): MidAmerican will deliver a total of 1,309 acres over ten years, and that is funded up-front.

Q: *Regarding eagles, were per-year estimates pooled for the full project area, or per project or per MW?*

A: The estimates were pooled across all facilities. We actually did this for eagles and for each of the four bat species, producing one number for each of the covered species that we'll need to manage. That is an advantage for us with the various operating projects covered by the permit. All of the data and the technical reports are publicly available on the USFWS website.

From Concept to Action: Filling in Essential Live-Bat Data Gaps to Support the Development of the MidAmerican HCP

Presenter: Amber Schorg, *United States Fish & Wildlife Service (USFWS)*

Authors: Kelly Poole (*Iowa Department of Natural Resource*); Amber Schorg (*US Fish & Wildlife Service*)

PROBLEM/ RESEARCH NEED

As of 2015, most of the available data on bat locations were limited to the southeastern corner of Iowa, whereas most of MidAmerican's wind projects were outside that area. We needed to gather data where turbines actually were. The Iowa Department of Natural Resources' (DNR) approach involved an innovative use of an Endangered Species Act Section 6 planning assistance grant that helped make this collaboration work. The US Fish & Wildlife Service (USFWS) worked to understand the constraints and interests of MidAmerican Energy so that we could provide technical support for the development of the conservation measures in the habitat conservation plan (HCP).

The USFWS committed to three core principles:

1. Partnership approach – unlike compromise, which involves a series of trade-offs, we identified mutual goals that parties shared: reducing impacts to listed species; generating renewable energy.

2. Data driven decisions – where data gaps existed, we worked together to design studies to gather the most important information, creating an atmosphere of collaborative problem-solving.

3. Take a landscape-level perspective – the planning process had to be appropriate to a state- rather than project-level scale.

Objectives

The goal of the Section 6 planning assistance grant was to conduct baseline studies that would enable us to develop conservation measures commensurate with relative risk and impact for focal species, including the northern long-eared bat. In particular, we needed to know where long-eared bats are in both summer and winter and how they used the landscape during migration.

APPROACH

Part A: Identify occupied summer bat habitat across the permit area (the entire state of Iowa) through bat surveys. Anabat SD2 units were deployed by Iowa State University and Iowa-Minnesota Conservation Corps staff at a stratified random selection of sites on public lands (for

access reasons): two sites for each of 60 counties, with two nights of standardized acoustic survey data from two detectors at each site. Detectors were placed randomly in "suitable habitat" according to DNR's draft Niche Model. Map (slide #19) shows all of the study sites.

Part B: Discover and map occupied and potential hibernacula through acoustics and active surveys. Second piece of puzzle was to figure out where they were hibernating. There are not many caves in Iowa; most are on the east "coast" along the Mississippi River. We hypothesized that hibernacula would be found in rock outcrops along NW- to SE-flowing rivers in the state (slide #21). We surveyed potential hibernacula early in the spring and late into the fall of 2016, 2017, and 2018 (slide #22) to identify the beginning and end of active bat season in Iowa and the logical beginning and endpoints for migration studies. To further confirm whether these hibernacula were being used through the winter, we looked at rock faces to see where bats are going in and used Working Dogs for Conservation to help us discover where to look closer.

We also wanted to model what hibernacula might look like to guide mitigation. Over 45 days from mid-September through the end of October, we used a combination of acoustic, video, and thermal detectors at four sites determined by DNR (two hibernacula locations per site) to analyze what makes for optimal hibernation habitat. This information has been put together to guide further surveys, start to define characteristics for northern long-eared bat hibernacula in Iowa and target conservation (mitigation) efforts.

Part C: Determine timing, trajectory, and landscape use of fall migrating bats through telemetry. The third piece of the puzzle was figuring out the migration piece. Where are the corridors, and what does that show us about where risk is on the landscape? We put out an array of passive transmitter detectors across SW Iowa and tagged northern long-eared bats and a few little brown bats in a core maternity area. Transmitters were not available in 2017, so we shifted to aerial tracking along watersheds, where we found similar movement.

Part D: Fleet-wide fatality monitoring – see next part of presentation

<u>FINDINGS</u>

The Iowa DNR, USFWS, and MEC now have a good understanding of how bat resources are distributed across the state, including areas of relative importance for northern long-eared bats.

- Summer distribution is uneven, focused in the north-central, mid-central and southwest parts of the state (slide #20).

- Over 25 points of interest were surveyed for hibernacula, and over 10 new bat hibernacula confirmed. We found that sandstone and limestone outcrops of all sizes were used, that northern long-eared bats are likely to hibernate diffusely, and that slope and rock-type are important predictors of potential hibernacula.

- Northern long-eared bats make migratory movements throughout September, including back and forth and single direction movements. River corridors and forested habitat were primarily used for travel and foraging, but some time was spent over open lands.

<u>CONCLUSIONS / APPLICATIONS</u>

These data are being used to guide us in selecting focus areas for migration studies and mitigation measures, including which projects to curtail for listed species, and will be useful when it comes to choosing areas for mitigation lands.

Next steps are to: vet acoustic data, refine the hibernacula model, and produce an exposure model (risk mapping for the state of Iowa).

Questions and Answers / Discussion

Q: *How are dogs trained to find live bats?*

A: Dogs are trained primarily on scent swabs that are hidden in various configurations. Swabs were taken from *Myotis* bats during annual surveys that were already being done.

Q: *Boomerang effect – is it possible that this type of behavior could be a response to traumatic experience of capture – animal flees capture site, then returns?*

A: We don't know. We did see it several times, but we don't have any theories about that currently.

Q: *What is FWS response to priors developed by MidAmerican?*

A: For this HCP, we want to use the best available science, and our office believes that this is the best available for this fleet of projects.

Q: *Any advice on how to start slow to go fast – examples or lessons for other HCPs?*

A: This was too big a project to guess at. It was mutually beneficial to USFWS and MidAmerican to take the time up front to get the data to inform the HCP. Also, as a regulated utility, MidAmerican needs to meet not only the permit issuance criteria, but also has to demonstrate to economic regulators that the associated costs can be recovered from rates. Again, it was very important to take the time to get it right.

Q: *When do you anticipate having the exposure model completed, and do you plan to provide this publicly as GIS data?*

A: Everything produced as part of Sec. 6 grant is public, and will be made public. We intend that the grant will be completed within next couple of years.

Making the Best Available Science Better: Pre-Permit Fatality Monitoring to Improve Impact Prediction and Develop a Tailored Conservation Program for the MidAmerican HCP

Presenters:
Jesse Leckband (MidAmerican Energy) & Quintana Hayden (*WEST, Inc.*)

Authors: Jesse Leckband (*MidAmerican Energy*); Quintana Hayden (*Western EcoSystems Technology, Inc.*)

PROBLEM / RESEARCH NEED

During planning, MidAmerican and the US Fish and Wildlife Service (USFWS) determined that the habitat conservation plan (HCP) would cover 22 facilities across the state of Iowa, some of which were already operating, but none of which had standardized post-construction mortality data available. Planning requires baseline data – either surrogate data from other wind facilities to predict impacts and develop the conservation plan, or site-specific data collected at the covered facilities to support development of a tailored HCP. The latter option was recognized to provide MidAmerican and the USFWS with greater certainty in the resulting plan, and we came to a joint agreement and commitment to invest in the data collection effort and develop a tailored plan.

Objectives

Conduct site-specific pre-incidental take permit (ITP) fatality monitoring to support development of a tailored HCP.

APPROACH

From December 2014 through March 2018 searches were conducted of all turbines at all 21 MidAmerican wind energy facilities. Road and pad searches were conducted at the majority of turbines, and cleared plots were searched at 20% of the turbines at a subset of the facilities, for a total of 186,311 searches.

FINDINGS

A total of 4,900 carcasses (1,114 birds and 3,786 bats) were found, including one Indiana bat (*Myotis sodalis*; covered by the incidental take statement in USFWS's August 2015 Biological Opinion), and no northern long-eared bats (*Myotis septentrionalis*). Monitoring results provided four key points of information for the HCP:

1. Patterns in all-bat mortality across the fleet – seasonal patterns, variation by facility, annual patterns

2. Estimated take of (and hence impact to) the covered bat species

3. Variability in take of the covered bat species across facilities and across years

4. Information on the bias factors (such as searcher efficiency and carcass persistence rates) influencing monitoring outcomes

The fact that no northern long-eared bat fatalities were found during these monitoring surveys helped inform our understanding of the impacts occurring, but did not necessarily indicate that the take estimate should be zero. To evaluate the occurrence of rare events, such as take of covered bat species for an HCP, we use a sophisticated statistical tool, Evidence of Absence (EoA).

As with any statistical estimator, the quality of results depends on the quality of the assumptions and inputs used. In this case, we enhanced EoA's performance for the HCP by using the fatality data collected at the 22 facilities to inform the model. We developed take estimates for each of the covered bat species based on the fatality data, and used these take estimates to inform the EoA prior. The informed prior enabled the EoA model to yield estimates of biologically reasonable take levels, even when counts are zero. By informing the model with a dataset specific to the projects covered under the HCP, and providing multiple years of data to capture inter-annual variation, MidAmerican thus greatly reduced the uncertainty in the expected take of the covered species under the HCP. The informed EoA model will also be used to estimate take of covered bat species during the HCP's monitoring to evaluate compliance with the Incidental Take Permit (ITP). MidAmerican's take request (slide #42) was based on take predictions calculated directly from data collected at the covered projects.

The seasonality of bat fatality at the covered projects was assessed based on the timing of bat carcasses found at the projects between the all-facility minimization dates of March 1 and November 15. Slides #44 and 45 show a peak in both all-bat carcasses (in blue) and covered species carcasses (tri-colored bats in green and little brown bats in yellow) between the higher-take minimization dates of July 15 and September 30 (red dashed lines), for both 2015 and 2016.

CONCLUSIONS / APPLICATIONS

The greater level of certainty in the expected impacts enabled MidAmerican to tailor its conservation program for the HCP. This included a minimization plan designed specifically for the varying levels of take across the covered facilities:

1. The determination of relative expected take at the projects was made based on the observed covered species fatalities (higher weight) and the observed all-bat mortality rates (lower weight)

2. The HCP includes a higher level of impact minimization for facilities with higher expected take, and lower level of minimization for those with lower expected take. (Standard minimization measures will be implemented at all 22 facilities.)

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3. The seasonal dates of the minimization measures were based on the timing of the all-bat carcasses and covered species carcasses found at the facilities.

Beyond take predictions and the minimization measures, pre-ITP data also informed the MidAmerican HCP's monitoring program. The application of the informed EoA model to analyze monitoring data and the pre-ITP data collected on bias factors such as searcher efficiency and carcass persistence assures a high level of confidence in the robust performance of the monitoring program. This high level of confidence in the monitoring enabled MidAmerican and the USFWS to develop a mitigation structure that adapts the level of mitigation implemented under the HCP to the impacts that are actually occurring under the plan. MidAmerican will initially provide mitigation for the Implementation Level of take under the HCP – that is, the amount of take expected actually to occur based on the pre-ITP data. If necessary, based on monitoring results, MidAmerican will increase the level of mitigation up to the Authorized Level of take for the HCP – that is, the amount of take requested to be authorized in the ITP, which is a conservative estimate of the take that could occur, based on the variance measured in the pre-ITP data.

The use of site-specific data to improve the "best available science" for an HCP, enabling development of a tailored rather than a generic plan, has application beyond MidAmerican's HCP. This approach to conservation planning requires flexibility from the USFWS, first to allow pre-ITP data collection and then to consider and work with the applicant to develop a tailored plan. Collaboration with USFWS on pre-ITP data collection can be valuable for HCPs of any scale, given a couple of considerations:

- Early coordination with the Service regarding study design and objectives helps to ensure that the data are well-received by the agency.

- Establishment of the process for collecting, analyzing, and managing based on the pre-ITP data, before implementation of the study, helps to ensure consistent expectations for application of the study results between the applicant and the Service.

This approach aligns with the HCP Handbook's theme of "starting slow to go fast" – that is, it may require additional time upfront, but can reduce review time on the back end of the process because of the greater certainty in the plan. The relationship-building required to enable collection of pre-ITP data, and the support that investment in pre-ITP data provides to a collaborative relationship can also contribute to a faster process. Moreover, the benefits and requirements of this approach are not scale-dependent; they are just as applicable to a single-project HCP as to a fleet-wide plan.

Questions and Answers / Discussion

Q: *What is the manufacturer cut-in speed? Does it vary among sites? What is the decision framework to recommence normal operations following curtailment?*

A (Jesse): Cut-in speeds do vary – GE, Siemens, etc. – from 3 to 4 m/s. Return to operations following curtailment is based on what fatality monitoring tells us about average wind speed, which is determined on basis of a ten-minute average; also temperature is a factor.

Q: *What are Wind 11 & 12? Are they covered by this plan?*

A (Jesse): No, this HCP only covers projects that were in commercial operation as of the end of 2016. Wind XI will be a 50% increase over current fleet. Wind XII, is a proposed additional 591 MW, mostly Vesta 2.0s. Wind XI was contemplated as build out in phase 3 of the section 6 grant.

Q: *How much time do you have once the incidental take permit is approved until the first set of mitigation projects are in place? Is it important that mitigation stay "ahead" of authorized take?*

A (Quintana): Yes. The first set of mitigation projects are due to be completed within one year. We will then check in at five year intervals to see how mitigation aligns with actual take.

A (Jenny): The mitigation program will deliver a total of 1,309 acres.

Q: *Any advice on how to start slow to go fast – examples or lessons for other HCPs?*

A (Quintana): The main thing is to start the process intentionally, collaborating on mutual expectations before getting too far into specific details. This might be best example of taking time upfront to get data that can inform HCP. I have also seen at least one other example that was on a smaller (single-project) HCP. A lot of this preliminary communication can be handled through memos and white papers prior to starting work on an actual plan.

Not Asked during Session

Q: *If you find one Indiana Bat and zero Northern Long-eared bats, what kind of information can possibly inform you of what correlates with take of your protected species?*

A (Quintana): We were not looking for factors correlated with take of Indiana bats or northern long-eared bats for this HCP. Our take predictions for all of the covered bat species were based on estimates produced by the informed EoA model using the site-specific data as inputs.

Predicting Take of Bald Eagles at Wind Energy Facilities in Iowa Using Site and Species-Specific Data

Presenter: Todd Mattson, *WEST, Inc.*

Author: Todd Mattson (*Western EcoSystems Technology, Inc.*)

PROBLEM / RESEARCH NEED

What we know about the risk to bald eagles at wind farms is largely driven by data on golden eagles: 93% of eagle fatalities at wind farms have been golden eagles, only 7% have been bald eagles, which have a much broader distribution and may be less vulnerable to collisions. On the other hand, it is possible bald eagles are less likely to be discovered incidentally (i.e., outside of standardized post-construction monitoring).

Objectives

Wildlife studies at MidAmerican's wind facilities provided an opportunity to explore some of these questions on bald eagle risk.

APPROACH

Eagle use and fatality monitoring studies were conducted at 18 wind facilities in Iowa (slide #53). Eagle Use studies ran 16 months (2014-16), using fixed point-count locations.

Eagle fatality monitoring was completed (December 2014 - March 2017) at 18 wind facilities, with each facility monitored over at least two "high use" seasons (November-March). Monitoring included a visual scan approach from the base of the turbine in cardinal directions and standardized carcass searches using transects in 200 m x 200 m plots. Visibility was good: there was a 0.75 to 0.95 average probability that an eagle carcass was located within the area visible to searchers during a visual scan. Carcass persistence and searcher efficiency trials indicated an overall probability of detection ('*g'*) between 0.42 and 0.78.

Three Modeling Approaches were used:
1. Method 1:
   (a) Eagle Conservation Plan Guidance (ECPG) Collision Risk Model (CRM) USFWS 2013 – using site-specific eagle exposure/use data
   (b) ECPG CRM – using both site-specific eagle exposure/use and fatality data
2. Method 2: MidAmerican (MEC) Iowa/bald eagle prior distributions in CRM
3. Method 3: Evidence of Absence (EoA) Dalthorp et al. 2017

Over 1,000 bald eagle risk minutes within 800 m of the observer and below 200 m height were recorded, showing distinct use patterns in Iowa: high winter use with a big drop-off in summer. Given very low levels of use in summer months, we focused on collecting data over two winter seasons during the 16 month-study period. Fatality monitoring yielded three bald eagle fatalities found within search plots during the study period, plus some incidental finds. Slide #65 shows the variability among the four methods of estimating take (slide #65 shows the difference in take estimates calculated using these different methods, and highlights the substantial difference between the first method (1a) and the other three). The potential issue with the first method is that it uses a prior distribution developed for golden eagle collision rate, which is likely not predictive of bald eagle collision risk.

CONCLUSIONS / APPLICATIONS

MidAmerican plan to use the same methodology for its Wind XI & XII HCP. As shown in slide #66, predictions using the MidAmerican prior distributions, while not perfect, are more precise than those produced with the USFWS golden eagle prior distributions. We believe the process of collecting site-specific and species-specific data to determine risk and inform a permit can be employed at other wind facilities, as well.

Prior distributions presented in the ECPG CRM produce take predictions that appear to be extremely conservative for assessing bald eagle risk in Iowa. This analysis supports the hypothesis that bald eagles are less vulnerable to turbine collision than golden eagles. MidAmerican data could be used to create new or updated prior distributions for use in CRMs at other facilities in *similar habitats*, which is to say, in highly cultivated landscape.

Limited bald eagle fatality data suggest general use alone may not be a good predictor of eagle risk. There is an overall question of whether use is predictive of fatalities. An important factor for future consideration may be the type of eagle use (e.g., general soaring vs. active hunting).

Questions & Discussion

Q: *How many bald eagle fatalities were found incidentally, not in surveys?*

A (Jenny): The overall number included in the HCP study was eight.

Q: *Why did you decide to pursue eagle take within the ESA framework?*

A (Jenny): I wanted to do NEPA only once. We thought there would be efficiencies in combining permitting efforts across facilities, and we had seen changes in activity and risk over the past 10-15 years. Our feeling was that the risk was fairly ubiquitous across the state, and we wanted to cover all five species (four bat species and bald eagles) within one permit.

Q: *Can you speak to the potential effects of using eagle use data collected after the facilities became operational vs. following the FWS recommendation to collect use data prior to construction?*

A (Todd): USFWS thought collection of operational data would be helpful. As part of original study at 18 facilities, we established not only use studies within the project itself, but also reference points where we collected use data in similar habitat but away from wind turbines, thinking was that would help us understand how presence of turbines may affect eagle use. It appears that use is about 40% lower within the wind farm than in reference areas. If we are reducing use once operational, that would tend to make the predicted risk estimates even more conservative. Part of the challenge is that the operational data include use from high, medium and low-use sites. It's something for USFWS to think about.

Not Asked during Session

Q: *Is the bald eagle per year take estimate for the full ECP area, or per project (or per MW)?*

A (Todd): MidAmerican has applied for an eagle take permit for 22 of its operating facilities. The take prediction was calculated across all of these facilities.

Q: *Why would bald eagles be more difficult to find (compared with golden eagles)?*

A (Todd): Bald eagle carcasses may be more difficult to find in the Midwest and Eastern states, where vegetation cover may be denser (e.g., crops or forests), compared to the western US. Golden eagles generally occur in the more open habitats of the western U.S.

Q: *What percentage of eagles may fall outside the 100 m scan radius?*

A (Todd): Very few. We estimate that around 95% of eagles that collide with turbines will fall within 100 meters of those turbines (Hallingstand et al. 2018).

Technology-based Risk Assessment

Moderated by Tom Heister, *IdentiFlight*

Using Dedicated Full 3D Bird Radar to Assess Bird Flight Behavior and Collision Risk at Wind Farms in the Netherlands

Presenter: Hein Prinsen, *Bureau Waardenburg Ecological Consultancy*

[slide presentation]

Authors: Hein Prinsen, Jonne Kleyheeg-Hartman, Abel Gyimesi, Camiel Heunks
(*Bureau Waardenburg Ecological Consultancy*)

PROBLEM / RESEARCH NEED

The European Union's ambitious target of 27% renewable energy in 2030 means that the Netherlands will have to develop several thousands of wind turbines on land in the coming decade, on top of the existing 3,350 MW already installed on land. The relatively small size of the Netherlands (about one third of New York State) along with its intensive spatial planning means that most of these future wind farms on land will be located nearby or even within important bird areas (IBAs).

The port of Eemshaven in the northeast of the Netherlands currently accommodates almost one hundred wind turbines and installation of another hundred is planned in the coming years. This area borders the Wadden Sea, an internationally renowned IBA, and is located on a major migratory route between Scandinavia and Western Europe. Large concentrations of birds use sites within the area for migratory stopover and refueling. Of an estimated 5,000 avian collision victims each year, about 2,250 are passerines, including 16 species (totaling 1,500 fatalities per year) with declining populations.

Objectives

We discuss initial findings from a major research program started in August 2018 at the Eemshaven wind farm. The objective of this research is to develop predictive models and protocols for shutdown-on-demand during periods with high bird traffic at rotor height.

Data are collected 24/7 using a three-dimensional bird radar during periods of intense migration when passerine mortality is known to be much higher than average. The 3D radar MAX® is a full 3D scanning radar with a phased-array antenna and 17 stacked beams. It draws an average of 20 W, operates at 60 RPM, weighs 280 kg, and measures 1,237 mm x 654 mm x 1,660 mm. It uses an X-band frequency, has a small cone of silence, and covers a 15-km radius up to 1-km altitude. It can track passerine targets within at least 3 km. The unit comes with tracking software and automatic classification of bird and flock size. (Although radar does not allow for species identification, it is hoped that we will be able to use field data to train the software for species group identification.)

Typically, horizontal radar is used to capture routes and direction, while vertical radar is used to measure fluxes/intensity and height. Although the two types of antenna can be used simultaneously, it is difficult to match the two data outputs. The 3D radar MAX® allows us to capture both types of information and use it to create 3-dimensional profiles – essentially providing us with an animated "bird's eye" view of bird behavior within the wind farm – including avoidance in 3D, flight height profiles, and spatial and temporal density patterns, at high spatial and temporal resolution.

This information on the dynamics of bird movements will be linked to collision mortality within the wind farm, collected during twice weekly carcass searches. More importantly, the 3D radar data will be linked with larger scale migration and weather data (captured using meteorological radar), with the aim of developing a predictive model for temporary shutdown-on-demand during periods of high risk.

FINDINGS

Birds start the night's migration around 6:00 pm, arriving at Eemshaven from Denmark and North Germany four to five hours later, and from Sweden and Southern Norway after eight or nine hours; slides #16 & 17 graph these arrival pulses when different groups of birds starting from different points are passing the wind farm.

The distribution of flight altitudes over different time periods indicates that the majority of birds are approaching the wind farm at rotor height (slide #22 – blue bar chart). We used vertical radar to check flight heights in and outside the windfarm, up to two hours after sunset. The blue and green bar charts in slide #22 show that birds are flying at a higher altitude over the wind farm, which may suggest active macro-avoidance of the turbines.

Preliminary results show that:
- There is strong nocturnal autumn migration in Eemshaven (>5K birds/km/h)
- Peak migration is predictable and weather-related
- Important numbers of passerine migrants fly at rotor height…
- …but further analysis is needed to determine possible macro-avoidance

CONCLUSIONS / APPLICATIONS

Although there are a few start-up bugs and a lot yet to learn about this new system, the ROBIN radar 3D MAX® does offer:

- High spatial / temporal resolution of 3D data on behavior / intensity
- Self-learning system (i.e. clutter filtering)
- No species identification, but easily tagged tracks, using a flexible classification algorithm

The instrument is sensitive to rain and waves as well as metal objects in field of view.

This study demonstrates the possibility of linking local bird radar data with large-scale migration data from weather radar to develop predictive models and protocols for shutdown-on-demand during periods with high bird traffic at rotor height. With over 35 million records, we plan to do further analysis for spatial and temporal patterns. The final results will be presented at the Conference on Wind energy and Wildlife impacts in Scotland, August 2019.

Questions & Discussion

Q: *What's lowest altitude radar can reliably pick up targets?*

A: When we started field tests, we found targets that turned out to be sheep! So, we are able to pick up targets from ground level upwards.

Q: *What are the costs of setting up radar to monitor? Daily operational costs?*

A: The daily operational costs are not that much, but there are analysis costs. Radar does need some maintenance, especially if you are out in rough terrain.

Q: *Has 3D radar been implemented offshore? If so, how has it performed?*

A: No. This is new. The Dutch government, however, is planning to install 3D MAX® in one or more offshore wind farms in the coming year(s).

Q: *Have you detected any collisions with the radar system? Can you provide any information?*

A: No, we get back-radiation from the turbines themselves. Radar can be used to track targets outside and through wind farms, and can should be combined with a camera system to look at interaction with turbines.

Q: *Do you anticipate that these radar units would be used for the life of a given site, or would they be used to establish patterns in a project area and then moved on to a different site?*

A: Radar can be set up either in or outside the windfarm, and could signal the wind farm's SCADA to curtail operations. But it's a mobile system, we can set it up anywhere.

Q: *How much more expensive is the 3D radar to implement than either the horizontal or vertical radar, or combination of the two?*

A: I could not tell you how they compare; the 3D system costs roughly €700-€800,000.

Q: *In the West Atlantic Flyway, most migration occurs well above the rotor-swept zone, according to radar data. Any thoughts on why the difference?*

A: We were focused on what was flying at the altitudes nearer the rotor-swept zone, particularly nocturnal migrating passerines. It may be that more migrants are passing at higher altitudes as well.

Q: *Was any post-construction monitoring done while the radar was operating, and if so, was there any relationship between the number of carcasses and radar detections?*

A: There is fatality monitoring twice per week. There have been some turbine shut-downs to see if there is any impact on fatalities, but there are so many migrants passing through that it is hard to tell. We will have more to report next August at the meeting in Scotland.

Flight Patterns Analysis of the Golden Eagle in a Mexican Wind Farm Using Marine Radar and Direct Observation

Presenter: Rafael Villegas-Patraca, *Instituto de Ecología*

Authors: Rafael Villegas, Oscar Muñoz-Jiménez, Eduardo Ramírez Alamanza (*Instituto de Ecología*)

PROBLEM / RESEARCH NEED

Wind farm development is accelerating in Mexico. As in the United States, there is overlap between wind resource areas and distribution areas for the golden eagle (*Aquila chrysaetos*), which has important symbolic as well as ecological value. Mexican government agencies are concerned that the establishment of wind energy projects may threaten golden eagles in the mid-Mexican states of Aguascalientes and Jalisco.

Objectives

Our goal in describing the baseline patterns of movement traced by the golden eagle in a wind farm located in Jalisco includes these specific objectives.

1. Determine the flight behavior of the golden eagle in the study area using ornithological radar and monitoring station.

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2. Describe the use of the airspace of the golden eagle in the study area, including the identification of the main routes of displacement.

3. Analyze the possible effects that the operation of the wind farm causes on the golden eagle.

4. Issue impact mitigation recommendations based on the results obtained with the implementation of the monitoring protocol.

APPROACH

Although it is common to monitor large birds (such as condors) using radio telemetry, the marine radar has proved to be an effective tool because it:

1. avoids the direct manipulation of individuals and does not put their physical integrity at risk;

2. provides accurate data on the wide-range flight patterns; and

3. allows descriptions of trajectories of more than one individual at the same time (spatial and temporal flight pattern).

For this study, we used a combination of a truck-mounted ornithological marine radar and human observers at hawk-watch monitoring stations to collect data from a single wind farm in Jalisco State during four observation periods: August-September 2017, November-December 2017, January-February 2018 and June-July 2018. Slide #10 shows the location of the three human observer monitoring stations within the wind project. (Green points are eagle monitoring stations with human observers; the shaded circle shows the 6 km-radius area tracked by the radar unit.) The observation sites were established in high areas, each staffed by two specialists, one of whom tracked birds, while the other registered the weather conditions (wind direction and speed), percentage of the sky covered by clouds, type of clouds (cirrus, cumulus, strata and nimbus), environmental temperature and visibility in kilometers.

The radar tracks targets within an observation range of 6 km horizontal and 1.5 km vertical, but human monitors are needed to confirm species. Observations were made 8:00 AM to 5:00 PM during the study periods, recording all the flights. The radar operators had constant communication with the monitoring stations, to corroborate raptor trajectories. (Slide #9 gives a schematic description of radar operator and observer protocols.) The flight path data was collected by polar coordinates and the flight directions were reported by average angle (μ) and main vector length (r).

FINDINGS

We have over 4,000 records with different species, including many turkey vultures (*Cathartes aura*). For each 10-hour period, an average of 45.4 eagle flights were registered, with the peak hours of flight from 11 am to 12 pm and from 17 to 18 pm. In slides #12-14, blue lines show tracks of male eagles, red lines show female tracks. Clearly there is a lot of activity close to some turbines in the eastern part of the wind farm, and indeed there is a nest 200 m from one of the turbines (slide #15).

Sixty percent of the records were detected in potential risk heights (0-150 m) and about 65% were located within the wind farm polygon area. Additionally, two raptor nests were identified in the same gully over which eagles fly. The high frequency of individuals (slide #16) is associated with nesting areas, and there appears to be at least one resident eagle couple present within the wind farm area. Higher golden eagle activity was recorded during the months of September, November, December and February.

CONCLUSIONS / APPLICATIONS

Over the next five years, we anticipate 3,000 additional turbines being sited in northern Mexico. Marine radar combined with direct observation has proven to be a good tool for describing avian movement within a proposed wind energy project area, and can contribute to environmental assessment of wind farm development as well as ideas on how to reduce the impacts that can be identified at the planning stage.

At this wind farm, it was possible to identify the area where the golden eagles forage, which can be useful in designing a contingency plan to reduce the risk of collision.

We offer the following recommendations.

- Continue monitoring *Aquila chrysaetos* with both ornithological radar and monitoring stations.

- Design a protocol for a contingency plan to mitigate the impact of the wind farm where golden eagles are frequently observed.

- Frequently and permanently remove the carrion (or any other attractant) from inside the project area to prevent the golden eagle from entering the wind farm.

- Conduct focused monitoring of the identified nests and take protective actions to ensure the survival of the eagle chicks.

- Support the conservation of the nesting site "*Royal Eagle Protection Area of the Serranía de Juan Grande*" which is less than 8 km northwest of the wind farm.

Questions & Discussion

Q: *From your maps, it seems a majority of the golden eagle movements occur outside the wind farm area. Do you think they are actively avoiding the wind farm? Do you have pre-construction data to compare/evaluate this possibility?*

A: The majority of targets and flight routes are not really outside the windfarm. There is a lot of activity on the east side of the project area, about 8 km from the site. There was an EIA, but no pre-construction use surveys. At the moment we are seeing eagles flying at higher altitudes, above the rotor-swept zone, but definitely within the wind farm. Our concern is that juveniles will be at risk.

Q: *Are pre-construction wildlife/habitat surveys required for wind farm development in Mexico?*

A: Yes, there is a one-year pre-construction survey requirement. However, the EIA for this project did not find that nest. The developer obtained the permit, built the windfarm, and then "found" the nest during post-construction studies. If that nest had been identified in the EIA, they would not have built those turbines in that location. But now that the wind farm is there, we have to try to mitigate.

Q: *Were you aware of the nest prior to starting your study, and was the study designed around the nesting eagles?*

A: We knew there was the nest in the area, but it was only once we began this study that we found the specific site. For the next year we will catch the juveniles to put a radio tracking unit on them.

Q: *What is the added benefit of radar, why not just use human observers?*

A: Even if you put more people in the field, you may miss flight routes. We would need 20 people to cover the flight routes – it's a huge area.

Radar Quantifies Migrant Concentration and Dawn Reorientation at a Great Lakes Shoreline: Considerations for Wind Energy Development

Presenter: Kevin Heist, *US Fish & Wildlife Service (USFWS)*

[slide presentation]

Authors: Kevin Heist (*US Fish & Wildlife Service*), Tim Bowden (*Bureau of Land Management*), Jake Ferguson (*University of Minnesota*), Nathan Rathbun, Erik Olson, Dan Nolfi (*US Fish & Wildlife Service*), Rebecca Horton (*Minnesota Department of Natural Resources*), Jeffrey Gosse (*US Fish & Wildlife Service*), Douglas Johnson (*University of Minnesota*), Michael Wells (*US Fish & Wildlife Service*)

PROBLEM / RESEARCH NEED

Millions of migrating birds and bats encounter the Great Lakes on long-distance flights each spring and fall, but quantitative data regarding how they traverse this region are limited. Coastal areas can be attractive for onshore and offshore wind energy development; however, shorelines are known areas of migrant concentration due to the ecological barrier effect of large lakes. Details on the magnitude, timing, and behavior associated with migrant concentration are largely unknown and difficult to quantify.

Objectives

Our goal is to understand and document how aerial vertebrate migrants (birds and bats) move through the Great Lakes region, for the purpose of improving conservation outcomes for migratory species.

APPROACH

During the spring of 2014 we used two avian radar units to compare migration patterns at four paired shoreline (1.5 km from the shore) and inland (20 km from the shore) sites along the eastern shore of Lake Michigan in the north-central US. The mobile radar units were used to track thousands of individuals flying through horizontal and vertical sample volumes that extend multiple kilometers, providing a unique view of migrants moving across landscapes during both day and night.

Each radar unit included a horizontal and a vertical antenna. The horizontal antenna tracks the direction of flight, while the vertical antenna allows us to quantify activity, using a "target passage rate" per hour. The vertical antenna also measures target flight altitudes. Slide #4 provides an example of horizontal and vertical track plots.

We alternated the units between sites over four trials, comparing shoreline with inland activity.

(Before the trials, both units were placed at similar locations to see how well they compared at measuring target passage rates, and were found to compare closely.) We looked at four biological periods: dawn, dusk (one hour each), day and night. Differences in mean direction of flight were compared using circular statistics.

FINDINGS

Using a regression slope analysis, we found shoreline activity to be 27% greater than inland activity overall, and 132% greater during the hour surrounding dawn.

In general, migration is a nocturnal activity. Looking at the one-hour horizontal track plots, we see migration beginning around sunset. An analysis of flight directions found that migrants lift off in a uniform direction, flying to the north and northwest during dusk and night at both inland and shoreline sites, with many migrants at the shoreline heading out over the lake.

Approaching sunrise, we see a distinct change in activity. Flight directions shifted clockwise (to the north or east) at all locations except one inland site where no shift was detected. Migrants at shoreline sites, and especially those flying over water, exhibited a large shift eastward, indicating reorientation toward land. The difference in mean direction of flight between night and dawn, indicated by Watson-Williams tests, was 11 degrees at inland sites, 30 degrees at the shoreline sites, and 52 degrees (from north-northwest to northeast) for animals flying over open water.

These findings confirm shoreline observations in this study and others, that coastlines host high concentrations of migrant activity. Dawn appears to be a particularly risky period along shoreline, so curtailment might be appropriate, as migrants are needing to get off the open water and onto land. Throughout the day, there appears to be movement inland, but we're not detecting these movements, probably because targets are flying at lower altitudes.

CONCLUSIONS / APPLICATIONS

Our findings help confirm and quantify the phenomenon of migrant reorientation at dawn, and also stress the functional importance of coastal regions as landing zones for nocturnal migrants, and the importance of conserving shoreline stopover habitat.

This study also identifies daily and seasonal variation in use of coastal regions, and demonstrates the capabilities of mobile radar to quantify airspace use by migrants, including activity within the rotor-swept zone. Implications of this research include the following.

1. Mobile radar provides a unique view of airspace use for purposes of wind energy site assessment.

2. A high degree of caution should be taken when considering installation of vertical structures near shorelines.

3. Operational mitigation strategies should account for nocturnal migrants turning toward shore and accumulating in near-shore areas at dawn.

These findings were published as an open-access article in *Movement Ecology* (August 2018), including additional details on methods, analysis, and conclusions.[6]

Questions & Discussion

Q: *How small an animal can be detected by radar? How do you remove insects from vertical radar without speed of target?*

A: We use s-band (longer frequency) to try to avoid insects and precipitation. Bats and small passerines are the lower limit of target size.

Q: *Do you have data from vertical radar on flight heights inland versus shoreline?*

A: Our dataset would allow for that analysis but we have not done it yet.

Q: *How far offshore have you tracked nocturnal migrants? (Did you track migrants flying over the lakes? If not, could you have done so?)*

A: We use a 3.7 km range on the horizontal radar, and the shoreline units are positioned 1.5 km from shoreline, so we can see about 2.2 km out over the water.

Q: *Can you describe any patterns in flight altitudes of migrants among time periods and how they might relate to collision risk? For example, lower flight altitudes during dawn?*

A: I don't know of any systematic patterns at our 2014 sites.

Q: *What's the lowest altitude radar can reliably pick up targets?*

A: Usually at about 100 m. It varies from site to site.

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[6] Heist *et al. Movement Ecology* (2018) 6:15 https://doi.org/10.1186/s40462-018-0135-3

Balancing Risk and Uncertainty for
Greatest Advancement of Conservation

Moderated by Taber Allison and Abby Arnold, *American Wind Wildlife Institute*

The closing panel included five special presentations and a facilitated audience discussion moderated by Abby Arnold.

<u>INTRODUCTION</u>

Abby: At our 2016 meeting, Taber Allison presented a paper on relative risk and uncertainty; now it's time to bring this conversation back. National Audubon has made addressing Climate Change its number one priority. All the NGOs are telling us the same thing. We know that agencies have a mandate to protect species, and that wind companies have to limit risk in order to finance projects and get them built. How do we balance risk and uncertainty with the actions needed to address the greatest conservation challenge of all?

Our expert panel will get us started. Please note that panelists are speaking as individuals, not representatives of their organizations, so do not quote them.

Panelists:

- **Terry Root**, *Stanford University, Woods Institute for the Environment, Stanford University*
- **Taber Allison**, *Director of Research, American Wind Wildlife Institute (AWWI)*
- **Cris Hein**, *Senior Project Leader for the Wind Energy and Wildlife Portfolio, National Renewable Energy Laboratory (NREL)*
- **Dave Young**, *Western EcoSystem Technologies (WEST), Inc.*
- **Doug Johnson**, *Emeritus Research Statistician and Senior Scientist, USGS Northern Prairie Wildlife Research Center; Adjunct Professor, University of Minnesota*

<u>OPENING PRESENTATIONS</u>

Terry L. Root, *Stanford University* –

Facts matter. I worked with the International Panel for Climate Change (IPCC) for 21 years, and on climate change for over 30 years. We need to limit the average global temperature increase to between 1.5 and 2 degrees C (2.7 to 3.6 degrees F). If we get above 2 degrees C, scientists understand that a lot of methane frozen in the ocean along the continental shelves will be released into the atmosphere, and if that happens, the Earth's temperature could spike 4-6 degrees C (7.2 to 10.8 degrees F) in 20-25 years. That is very scary to contemplate.

When we go up 1.5 degrees C, our best guess is that we will have locked in 9.4 ft of sea level

rise and at 2 degrees C the locked-in rise will likely be 15 ft. We MUST keep the increase in the global average temperature as low as possible to avoid horrendous suffering by all species: we do not have a choice!

We need to make big changes, quickly. By the year 2030, we must decrease CO_2 emissions to be equal to 45 percent of global emission in 2010; to basically zero-percent by the year 2050. Methane stays in the atmosphere for 10 years, nitrous oxide ten times as long; CO_2 mostly stays in the atmosphere for more than a thousand years. Because the CO_2 lingers so long, a recent IPCC report explains we must also remove CO_2 from our atmosphere starting no later than 2050 to ensure the planet does not get much warmer than 1.5 degrees C. Even if we stop all greenhouse gas emissions now, temperatures would continue to rise for a while before they take time to come back down.

Currently the US gets 15 percent of its energy from renewables, with 5.6 percent from wind. Globally, 24 percent of electricity comes from renewables. One of the biggest changes we must make is to significantly increase renewable energy sources. By 2030, we need globally to get 48-60 percent of our electrical energy from renewables, and by 2050 the percentages need to increase to 63-81 percent renewables.

In 2007, the IPCC estimated species extinctions due to climate change. Warming by 4 degrees C could mean we lose half the species on the planet, many of which we – humans – will need to survive, such as pollinators or species to help clean our water. So when we talk about trying to stop climate change, what we are also talking about is trying to stop extinction. With turbines, we're less worried about extinction for the vast number of birds and bats, because turbines mainly affect populations for birds and bats near the turbines, not entire species. Develop wind energy responsibly, yes – but stop working on the third digit beyond the decimal point! If we don't get many more turbines deployed responsibly very soon, then the globe will warm to such an extent that we will experience extensive extinctions of birds, bats and all other species on our planet.

Taber Allison, *American Wind-Wildlife Institute* –

The Department of Energy's Wind Vision projected 2.5 times current installed wind capacity by 2030 to get us to 20 percent renewables, and as Terry has just pointed out, we need to be even more aggressive.

After 25 years, we have learned a tremendous amount, increasing our ability to predict risks and consequences and mitigate those risks. Additional research is needed. But the essential point is that we cannot pause in developing the wind energy resource while we do this research. Given how fast the Climate Change clock is ticking, we need to face, and decide upon, how much uncertainty we're willing to accept with regard to wildlife impacts in order to continue to develop wind in a timely and responsible manner.

Where do we think the risks are greatest? What results do we want scientists to present to us

in 2020, 2022, and 2024, to reduce risks to wildlife as we work toward emissions reduction targets and wind capacity increase that will keep our planet under the 2 degree C temperature increase ceiling? These are the questions I've asked our panelists to address, focusing on land-based wind energy development.

Cris Hein, *National Renewable Energy Laboratory –*

One way to think about complex issues is to identify what we know (known knowns) and what gaps exist (known unknowns). It also is important to recognize there are aspects that we are unaware of (unknown unknowns) and opportunities that may exist, but we have not approached the issue from the right perspective (unknown knowns).

Known knowns
- Changing climate conditions are impacting certain species of bats (e.g., large numbers of flying foxes are dying in Australia from heat exhaustion; fecundity is dropping in parts of the Southwestern US because of diminishing water resources).
- Wind energy development is impacting certain species of bats with estimates ranging in the hundreds of thousands/year: with the weight of evidence suggesting population-level impact for hoary bats are possible.
- Current minimization strategies varying in effectiveness and can be cost-prohibitive.

Known unknowns
- How many bats are out there?
- How do bats interact with landscape at different scales?
- What is the optimal impact reduction strategy – no such thing as one size fits all.
- How do we quantify the potential impact of offshore wind energy development?

Unknown knowns
- We may have already collected data that could answer some questions, but we need to consolidate these data and find better ways to process it: artificial intelligence?

Unknown unknowns
- ???

Collaborations are essential because they incorporate a variety of stakeholder input and can leverage funding from numerous sources. The Department of Energy has funded several studies bringing partners together to evaluate the effectiveness of technologies. The creation of the Wind-Wildlife Research Fund also show promise as a funding mechanism.

One such collaborative, the Bats and Wind Energy Cooperative (BWEC), held its fifth science meeting in June 2018, identifying population analyses, fatality estimation, and bat behavior at turbine and landscape scales as research priorities. Given the urgency of the situation, the two

critical goals are to:

- Determine population level and trends, which can place fatalities into context and inform the level of minimization that is necessary; and to
- Optimize impact reduction strategies that allow turbine to operate normally or as near normal as possible to maximize energy production.

Flexibility and creativity are crucial: the MidAmerican Habitat Conservation Plan is a good example. We need financial incentives or regulatory frameworks that encourage action prior to listing; a "research as mitigation" approach.

This is a solvable problem; we are on the brink of several breakthroughs aimed at meeting our collective conservation and renewable energy generation objectives.

Dave Young, *WEST, Inc.* – [slide presentation]

I am going to talk about eagles, though much of what I have to say relates to raptors generally: what do we already know, and what don't we know, and what do we do about it?

What do we know? Unlike bats, we do have decent eagle population estimates: bald eagle populations are growing; golden eagles appear to be stable. We know that both are susceptible to collision with turbines, but particularly golden eagles. We have good means of estimating fatality rates, and we know of effective detection and deterrent strategies. We also have a fair amount of information on other sources of eagle mortality which can be the basis for mitigation opportunities.

What don't we know? We don't know much about the population metrics of dead eagles and raptors. We don't know what constitutes a high risk site or what is the difference in pre- vs. post-construction use: for example, do eagles avoid wind projects? We don't know what covariates may contribute to collision or whether impacts from wind are causing population level effects. This question becomes more important as build-out continues.

What can we do? There is a lot of data out there. We can use fatality rate data to predict fatality rates at nearby or similar sites. We can ask more questions, and we can learn more from the dead birds and bats: for example, taking DNA, stable isotope samples, even stomach contents to learn more about the impacts of the take. We can use existing data to refine take estimation models. We need to continue to push technology, and to monitor populations. Fatality is an event, it helps us address "take". But mortality is a rate, a measure of deaths within a population; this is what helps us to get at impacts.

What is the goal? We want to still have viable, vibrant eagle and raptor populations for a long time going forward. The key questions to answer to support achieving this goal are: Defining population trajectories – are they stable, increasing, decreasing? Are impacts causing changes to stability? Can we effectively offset the impacts? And we must continue to use sound science and collaborate to answer these questions.

In the end, diverting monitoring funds to research that answers questions, and investing in conservation and protecting strongholds is a stronger approach than answering the same impact questions over and over.

Doug Johnson, *University of Minnesota* –

The goal for addressing climate change was to keep average temperatures from rising no more than 2 degrees Celsius. The most recent report from the IPCC, however, describes problems already witnessed, and advocates for an increase of no more than 1.5 degrees. This means we have even less time to act than we had thought. For wind energy to contribute to reducing the emissions of greenhouse gases, we need to drastically reverse our thinking. Instead of spending several years deciding if a site is suitable for wind development, we should proceed with development, assess the consequences to wildlife, and mitigate any damages.

We have made good progress in understanding detrimental effects of wind farms on wildlife. Bird strikes appear not to be a huge problem, except perhaps for golden eagles. Bat strikes are more of a concern. But for those species seriously affected, efforts to reduce strikes are under development and evaluation.

For indirect effects, such as avoidance of wind farms by wildlife, we can treat wind development as a hypothesis, estimate the impacts, and compensate for them. Habitat protection and restoration can compensate for indirect effects. Many stakeholders – the US Fish and Wildlife Service, Ducks Unlimited, Pheasants Forever, The Nature Conservancy, land trusts, private land owners, and others – have goals that include habitat protection and restoration. These and the US Department of Agriculture could be major land management partners. We need to cut the red tape to expedite wind energy development, not hinder it. The consequences of *not* developing wind energy are too severe to risk.

DISCUSSION

Abby: It had felt a little risky to bring this conversation to this group, but I think we are ready. We ask you to reflect on what we've heard from our panelists and over the past couple of days. Discuss with at your tables and then we'll have each table report out to the group:

1. ***What information do we need from the scientific community by 2020 and 2022?***
2. ***For your organization or agency, where would you like to invest your energy and resources?***

[*Attendees participated in discussions at the tables where they were seated, and then reported out to the plenary. Priorities reported out are grouped here by common theme or focus, not by table.* - Editor]

Invest in Solutions, not Monitoring

- Make a list of all the things causing those species to be in trouble, such as white-nose syndrome. Money spent monitoring fatalities at a wind energy project would be better invested toward solving the WNS problem.

- Use artificial intelligence to put the wealth of data sources we have towards informing risk and invest more of our limited resources towards solutions.

- Use all the data we've collected to develop standardized mitigation ratios for birds and bats on a per MW basis (based on type of project, type of habitat, etc.) that then could be applied to proposed projects. In lieu of pre- and post-construction monitoring, funding should go to conservation groups for research efforts based on mitigation ratios generated from a larger data pool.

Offshore

- Would like to see AWWI give greater consideration to offshore wind development.

- Offshore effects – push it forward – there could be large turbines with fewer effects and large energy contribution.

Refining High-Potential Strategies

- Improve curtailment to limit loss of energy production.

- Focus on groundwork for looking at population level effects (by 2022); by 2024 we could have more comprehensive answers on population levels.

- Identify/agree upon usable and acceptable deterrents that focus on minimization (e.g., use of UV light to make bats avoid wind farms); let's streamline the process for permitting deployable solutions.

- Develop blade types and turbine technology so that new wind development has less impact on birds and bats.

Policy & Regulation

- Let's hear from policymakers and regulators to tell us whether we have what we need to move forward with getting wind built.

- The conversation needs to shift toward cutting red tape; let's do the right thing for developers, and get regulators on board to talk about what is acceptable (with proposed mitigation).

- We should ask ourselves: what trade-offs are we willing to accept? Do we really want to see tens of thousands of species going extinct for the sake of four bat and two eagle species?

- Can we have a standardized sustainable mitigation/curtailment program based on wind projects categorized as low-, medium-, or high-impact?

- Move from avoidance to minimization.

- Need to develop a streamlined regulatory process to consider cumulative, population level impacts from wind energy development and move forward with projects. Change the focus from individual animals to populations.

- We have learned a lot about pre-assessment tools, and they don't match what we're seeing post-construction. How can we adapt the tools and data and focus on compensating for wind impacts rather than pre-/post-monitoring? (We need statistically rigorous, open-source monitoring of impacts on the national or continental-scale, rather than project by project. At site level we can focus on indirect effects and how to compensate for them.)

Science Questions

- We need to think more comprehensively about habitat loss – not just for individual species, but more comprehensively for multiple species and on a continental scale (e.g., monarch butterflies).

- Better quantification of compensatory mitigation and effectiveness for a suite of species, not just hoary bats.

- In the next two years, let's get a handle on tree bat population size and structure to understand context of impacts. (Use DNA tools to get at "effective" population size.)

- Let's improve risk modeling to understand how to retire risk for listed species.

- Develop a framework for species prioritization on a continent-wide scale. (Resiliency: r-selection, for those species that produce many "cheap" offspring and live in unstable environments vs. K-selection for those species that produce few "expensive" offspring and live in stable environments.)

- Western Governors Association (with NREL) developed "Western Renewable Energy Zones" initiative, identifying areas throughout the region that have potential for large-scale renewable energy development with low environmental impacts. It would be great to develop a continent-wide risk assessment tool that looks at those species that are

most at risk from wind. We should be able to look at siting in a larger context, across state lines.

Public Education

- Public education is key – get out in front of project planning. NIMBY comes from a lack of energy literacy. Not do you want a wind farm, but where do you want to get your energy?

WRAP-UP

Taber: I am particularly intrigued by the idea of a mitigation ratio concept; would like to hear from people about what information we have or would need to accomplish that.

We appreciate your engagement. As Abby mentioned earlier, we were a little nervous about being this explicit about this topic, but I think we are ready to move this conversation forward in the way that we were not a few years ago. AWWI will take this input into consideration as we move this conversation and these ideas forward in 2019.

Abby: If you want to continue in this dialogue, we will be convening a group to refine these ideas into a more specific vision and set of tasks. Let's give policymakers the science they need to be visionaries.