Wind Wildlife RESEARCH MEETING

NOVEMBER 12–15, 2024 | CORPUS CHRISTI, TEXAS

REWI Renewable Energy Wildlife Institute

Meeting Proceedings

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About REWI

The Renewable Energy Wildlife Institute (REWI, formerly the American Wind Wildlife Institute, AWWI) is an independent 501(c)3 organization that develops and leverages scientific research around renewable energy interactions with wildlife, habitats, and ecosystems. Built on a partnership of renewable energy companies, conservation and science organizations, and public agencies, REWI develops innovative approaches and independent results that advance renewable energy expansion while meeting conservation goals. REWI plans to continue hosting biennial Wind Wildlife Research Meetings.

Abstract

These proceedings document the 15th Wind Wildlife Research Meeting (WWRM), which was held on November 12-15, 2024, in Corpus Christi, Texas. The meeting covered current research pertaining to wind energy-related wildlife impacts from collision and displacement; the cumulative and potential population-level effects from both climate change and wind energy development; technological advances to avoid, minimize, and offset these impacts; and socioeconomic issues surrounding wind energy development. These proceedings reflect the core sessions of the meeting held November 13-14, including presentations and discussions among stakeholders – scientists, state and federal agencies, wind energy developers, and conservation organizations – who are working to understand challenges and develop solutions to mitigate risk to wildlife from wind, on and offshore, as we work to meet renewable energy targets to mitigate climate change. Summaries of the live presentations and discussions were compiled using the submitted abstracts, notes taken during the meeting, and recordings of the live sessions. Abstracts of the in-person posters and on-demand presentations are presented as submitted by the authors.

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These Proceedings and those from prior Wind Wildlife Research Meetings are available in PDF format with accompanying presentations available via links. Proceedings may be downloaded from the REWI website: https://rewi.org/news-events/wind-wildlife-research-meeting-past/.

Disclaimer

Some of the presentations described in the Proceedings of the 15th Wind Wildlife Research Meeting may have been peer-reviewed independent of this meeting, but results should be considered preliminary. This document may be cited, although communication with the author before doing so is highly recommended to ensure that the information cited is current.

These proceedings do not necessarily reflect the views of the REWI or those noted above. REWI expressly disclaims any warranties or guarantees, expressed or implied, and shall not be liable for damages of any kind in connection with the material, information, techniques, or procedures set forth in this publication.

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Abbreviations

Acoustic-activated Deterrent or Curtailment (AAC)
American Wind Energy Association (AWEA)
American Wind Wildlife Information Center (AWWIC)
Annual Energy Production (AEP)
Association of Fish and Wildlife Agencies (AFWA)
Bald and Golden Eagle Protection Act (BGEPA)
Bird Protection System (BPS)
Climate and Economic Justice Screening Tool (CEJST)
Collision Risk Model (CRM)
Commercial Operations Date (COD)
Community Benefits Plan (CBP)
Confidence Interval (CI)
Direct Collision Risk Sphere (DCRS)
Diversity, Equity, Inclusion, and Accessibility (DEIA)
Eagle Vehicle Strikes (EVS)
Endangered Species Act (ESA)
Environmental Protection Agency (EPA)
Facility-specific Fatality Rate (FSFR)
Federal Advisory Committee (FAC)
Geographic Information System (GIS)
Gigawatt (GW)
Habitat Conservation Plan (HCP)
Incidental Take Permit (ITP)
Inflation Reduction Act (IRA)
Local Area Population (LAP)
Megawatt (MW)
Megawatt Hours (MWh)
Motus Wildlife Tracking System (Motus)
National Eagle Support Team (NEST)
National Renewable Energy Laboratory (NREL)
National Wind Coordinating Collaborative (NWCC)
Natural Resource Defense Council (NRDC)
Net Negative Present Value (NPV)
Non-governmental Organization (NGO)
Not in My Backyard (NIMBY)
Office of Energy Efficiency and Renewable Energy (EERE)
Offshore Wind (OSW)
Post-construction fatality monitoring (PCM)
Potential Collision Risk Sphere (PCRS)
Probability of Detection (PD)
Probability of Effective Deterrence (PED)
Renewable Energy Potential Model (reV)
Resource Equivalency Analysis (REA)
Rotor-swept zone or area (RSZ)
Special Purpose Utility (SPUT) permit
Theodore Roosevelt Conservation Partnership (TRCP)
Turbine Integrated Mortality System (TIMR)
United States (US)
United States Department of Energy (DOE)
United States Department of Fish and Wildlife Service (USFWS)
United States Geological Survey (USGS)
Unmanned Aerial Vehicle (UAV) – aka, drone
Vestas Bat Protection System (VBPS)
Western Ecosystems Technology, Inc. (WEST)
Wind Energy Guidelines (WEGs)
Wind Energy Technology Office (WETO)\
Wind Wildlife Research Meeting (WWRM)

Welcome and Keynote
15th Wind Wildlife Research Meeting
Confronting the Climate and Biodiversity Crises with a Responsible Transition to Wind Energy.

Speakers:

- **Eric Schauber –** Director of Research and Programs, Renewable Energy Wildlife Institute
- **Shilo Felton –** Senior Scientist, Wind Program Lead, Renewable Energy Wildlife Institute
- **Tony Reames –** Tishman Professor of Environmental Justice, Director of the School for Environment and Sustainability Detroit Sustainability Clinic, University of Michigan

Eric Schauber – Renewable Energy Wildlife Institute: Welcome address

It is my honor to welcome you to the Renewable Energy Wildlife Institute's (REWI's) 15th biennial Wind Wildlife Research Meeting (WWRM). I'm Eric Schauber, REWI's Director of Research and Programs, and I joined REWI in February 2024. Before that, I was Director of the Illinois Natural History Survey and prior to that I was on faculty at Illinois University—Carbondale in the Zoology Department. I'm passionate about the outdoors and I love to share this passion with my family, and it's the need to make a better future for them all that led me to REWI. Our mission is to employ science and collaboration to accelerate the development and deployment of renewable energy to mitigate climate change and protect wildlife and ecosystems. We conduct trusted, rigorous science and support science to better understand the risks of renewable energy to wildlife and related natural resources, and to develop solutions to avoid, minimize and mitigate those impacts. We also operate as aggregators and communicators of information. We disseminate the results of our own work and those of others to stakeholders and decision makers through databases, publications, webinars, trainings, workshops, and our online research hub. Finally, we operate as conveners, a role which originated from the partnership of forward-thinking leaders from the renewable energy industry and the conservation science community. REWI staff manage the Renewable Energy Wildlife Research Fund (REWRF, the Fund), an industry-led initiative advancing scientific research on solutions to mitigate solar and wind, wildlife impacts and accelerating renewable energy to meet clean energy demand.

We also convene the Wind Wildlife Research Meeting to share knowledge and perspectives that are needed for sound decision making. In the 30 years since this meeting was established, there have been huge leaps in the amount of renewable energy in operation, the policy and regulatory environments, and our understanding about how wind energy affects wildlife. The Wind Wildlife Research Meeting provides an internationally recognized venue to share and engage with the latest science, focused on developing solutions. This meeting also brings together thought leaders to discuss priority topics and themes in the wind wildlife arena. Academics, researchers, conservation scientists, consultants, federal and state agency personnel, NGO representatives and industry professionals come together every other year for this unique opportunity.

Research is about taking a hard look at reality and trying to figure out how the world is working and how we might be able to change it. Reality stubbornly exists and has consequences, no matter which way political winds are blowing. The reality we are facing is multifaceted and has unprecedented challenges as well as unprecedented opportunities. Climate change is reality, and combined with the biodiversity crisis, is one of humanity's greatest challenges. At the same time, humanity has developed renewable energy technologies to power our industries, homes, and transportation, while greatly reducing greenhouse gases emissions. Renewable energy technologies also help with energy independence, improve public health, and provide well-paying jobs. However, renewable energy development, like everything else that people do, has unintended consequences and impacts, including adverse effects on wildlife. We can only succeed in responding to this reality and changing its trajectory if we understand it and identify workable solutions to avoid, minimize and mitigate negative impacts while amplifying the benefits and making sure those benefits are shared by all. Our goal at this meeting is to come together and share what we have learned through rigorous science and collaboration toward the shared goal of having real world impacts in navigating these entwined crises. Organizing such a momentous meeting is no small feat, and so I'm pleased to introduce the chair for the scientific program of this year's Wind Wildlife Research Meeting and REWI's leader of the wind program, Dr. Shilo Felton.

Shilo Felton – Renewable Energy Wildlife Institute: Welcome address

I'm looking forward to spending this week with all of you working on solutions to mitigate climate and biodiversity crises through a responsible transition to wind energy. I'd like to thank those who hosted yesterday's workshops, which were a great success. This meeting has been a year in the making, and I want to thank the REWI staff for pulling this together. I also want to thank our planning committee, who were essential in helping us to determine the theme and scope of the meeting, and to identify panelists and our keynote speaker. We also recruited over 60 volunteers to review abstracts, thanks to all of you who participated. If you'd like to support the development of future meetings, please reach out to info@rewi.org. This meeting would not have been possible without the support of our sponsors, and we're very excited to welcome several folks whose attendance was made possible by these sponsorships. We have a lot of presentations by folks who could not make the meeting in person, so I encourage you to peruse the on-demand content for this meeting, which are summarized in the last section of these Proceedings. I encourage you to sign up for REWI's mailing list on rewi.org for updates on REWI's workshops, webinars, future meetings, and any updates on our research activities.

We're living through unprecedented global change where greenhouse gas emissions and land use change are rapidly changing our Earth's climate and reducing global biodiversity. Land-use change comes in many forms, including agriculture, forest management, housing, commercial development, and energy production. Wind energy is an essential tool in our fight to minimize the catastrophic impacts of global warming. The unfortunate reality is that rising temperatures and sea level are part of our future. Renewable energy is not going to remove the carbon already in our atmosphere, and it will take nearly 20 years for the carbon emitted today to dissipate. In the meantime, we are living in a positive feedback loop. Greenhouse gases trap radiant energy, increasing global temperatures. This leads to melting ice caps, raises sea level, and lowers the reflectivity of the Earth's surface, causing it to absorb more heat, further releasing carbon trapped in the ice caps and glaciers. Warming temperatures increase evaporation rates, which increases the frequency and intensity of storms – we nearly had to cancel this meeting due to multiple hurricanes headed for Corpus Christi. These hurricanes diverged from Corpus Christi but were hugely impactful to the communities in their paths. No matter how successful we are at reducing carbon emissions, we must use our skills to support affected wildlife and ecosystems. The purpose of renewable energy is to make that climate change scenario as livable as possible.

As scientists and practitioners, we have a responsibility to figure out how to do this in a way that is efficient, environmentally friendly, and socially just. One person who knows well the challenges we are facing as a global community under climate change is Dr. Tony Reames, who has built his career at the intersection of energy and environmental justice and policy. He served as the presidential appointee from 2021 to 2023 at the U.S. Department of Energy (DOE), where he established and led the Office of Energy Justice Policy and Analysis to advance racial and socioeconomic equality. As Principal Deputy Director for the Office of State and Community Energy Programs, Dr. Reames worked with state and local organizations to accelerate clean energy deployment strategies involving a wide range of stakeholders. Now, as Tishman Professor of Environmental Justice at the University of Michigan School for Environment and Sustainability (SEAS), Dr. Reames has founded the Urban Energy Justice Lab and the Energy Equity Project and serves as the Director of the University of Michigan's SEAS Detroit Sustainability Clinic. His research focuses on investigating fair and equitable access to affordable, reliable and clean energy production. I would also be remiss if I didn't honor Dr Reames' service in the U.S. Army as a Captain serving a tour of duty in Iraq. Dr. Reames, thank you for your service and I am honored to welcome you to REWI's 15th Wind Wildlife Research Meeting.

Tony Reames – University of Michigan: Keynote: Reconciling conservation, environmental justice, and energy justice in the pursuit of a renewable energy transition

I grew up in the small town of Bishopville, in Lee County, South Carolina, which has a strong tie to cotton. The only person ever elected to Congress from Bishopville was nicknamed Cotton Ed, who was known to be a racist, a segregationist. And his goal in Congress was to keep the Black community down and the price of cotton up. I focus on that because my work lies at the intersection between race, class, and place of our energy system. I have been doing some deep analysis on my hometown. Lee County was home to a cotton-picking festival and is also home to the South Carolina Cotton Museum. Many of my ancestors were sharecroppers. Bishopville was the largest growing cotton producer in the state and became a major hub for the textile industry. Eventually many of my relatives worked in the textile mills. In the 1990's, manufacturing plants left the southern U.S. and moved to other parts of the globe, causing major economic upheaval. To replace the tax base, Bishopville became home to two things that are unwelcome in most communities: the state's largest landfill and maximum-security prison. A landfill and prison cannot completely replace the tax base vacated by the textile industry, but the landfill did generate some gas energy. Tennessee tried to send their coal ash to Lee County, and it took community action to stop it.

This brings me to a quote from Martin Luther King Jr. to frame this talk: "The arc of the moral universe is long, but it bends towards justice." This quote was added to by Barack Obama, to end with "... but it does not bend on its own." Think about our role in justice in this moment, it takes urgency and intention. Most communities will not accept these locally unwanted land uses.

I learned about the environmental justice movement at North Carolina A&T State University, a Historically Black College in Greensboro, North Carolina, the home of the modern environmental justice movement. According to the U.S. Department of Energy (DOE), environmental justice is the "fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies."

I wanted to frame just how long it has taken to get where we are today:

- 1982: In Warren County, North Carolina a predominantly African American community laid their bodies on the line to stop a landfill. This action was unsuccessful but launched the environmental justice movement.
- 1990: University of Michigan held the first research symposium on race and pollution, and the U.S. Environmental Protection Agency created an environmental equity working group.
- 1991: First National People of Color Environmental Leadership Summit
- 1994: President Clinton signed an executive order on Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations
- 2022: U.S. Environmental Protection Agency launched the Office of Environmental Justice and External Civil Rights
- 2023: President Biden signed an executive order on Revitalizing Our Nation's Commitment to Environmental Justice for All

"Energy Justice" refers to the goal of achieving equity in both the social and economic participation in the energy system, while also remediating social, economic and health burdens on those historically harmed by the energy system. There are interrelated energy justice tenets to achieve energy justice, and you must first identify the injustices that exist:

- Distribution: disparities in income, energy prices, and energy efficiency
- Recognition: Identify vulnerabilities, needs, and respect

- Procedure: Information access, decision making, legal rights
- Restorative: Moves toward solutions

The “Energy Justice Conceptual Framework” (Sovacool & Dworkin 2014) outlines principles to deploy a more just and equitable energy system. These principles are presented from easier to harder to implement and understand:

- Availability: People deserve sufficient energy resources of high quality.
- Affordability: The provision of energy services should not become a financial burden for consumers, especially the poor.
- Due Process: Countries should respect due process and human rights in their production and use of energy. People should be at the table when decisions are made about energy infrastructure impacts on their communities.
- Transparency and accountability: All people should have access to high-quality information about energy and the environment, and fair, transparent, and accountable forms of energy decision-making.
- Sustainability: Energy resources should not be depleted too quickly.
- Intragenerational equity: All people have a right to fairly access energy services.
- Intergenerational equity: Future generations have a right to enjoy a good life undisturbed by the damage that our energy systems inflict on the world today.
- Responsibility: All nations have a responsibility to protect the natural environment.
- Resistance: Energy injustices must be actively, deliberately opposed.
- Intersectionality: Acknowledging how the realization of energy justice is linked to other forms of justice (e.g., socio-economic, political, and environmental).

We are running out of time to limit global temperature rise to 1.5°C. This moment in history demands urgency and a focus on justice. We are making progress on energy justice, but there are still millions of people without basic access to energy. As of 2022, 60% of energy in the United States came from fossil fuels. President Biden set ambitious goals to reduce greenhouse gas emissions by 50% by 2030, to reach 100% carbon-free energy by 2035, and achieving net zero energy economy by 2050. Though we have made historic investments in renewable energy, we must accelerate our progress if we want to meet these goals. REWI’s mission reads: “through science and collaboration, accelerate responsible deployment of renewable energy to mitigate climate change and protect wildlife and ecosystems.” Humans are a part of that ecosystem, and everybody here is a part of the fight for justice and climate efforts. Energy justice lies at the intersection of climate justice and environmental justice, but all of this is encompassed within the broader scope of conservation including all species and ecosystems.

I have seen wind turbines all over the world, from Greenland to Aruba. I met a farmer in Kansas in 2012 who leased some of his land to a wind company. He appreciated the opportunity to participate in the renewable energy transition, and it also supported his ability to continue farming.

I had a group of students working on a project to understand opportunities and barriers to city-level commitments to 100% renewable energy. The students were interested in how communities were engaged in decisions about renewable energy. Community involvement is important to decision-making for siting and placement of renewable energy. Access to volunteers, social networks, and outreach are important tools to ensure people's voices are heard. A community-based approach supports equity, justice and democracy, empowering self-determination for communities. They allow us to acknowledge that decision-making processes are complex and cannot be based solely on an economic model. This approach also fosters social connectedness and collective action. Finally, community-based energy projects create institutional capabilities to be more effective in the delivery of services.

I was excited to join the Biden Administration in 2021 to find solutions that support our climate goals. We need a government wide approach to address climate change. The Justice40 Initiative was launched to make investments in our clean energy future more equitable and just for communities across the country. Justice40 says that 40% of federal investments in clean energy should flow to disadvantaged communities that face economic, environmental, or social challenges, communities struggling to transition from a coal or fossil fuel economy, or other communities suffering from economic loss. To identify disadvantaged communities, the White House launched the "Climate and Economic Justice Screening Tool" (CEJST) in November 2022. This tool identified 37% of census tracts, representing 28% of the U.S. population, as disadvantaged. We established the White House Environmental Justice Advisory Council and an inter-agency environmental justice council with representatives from twenty-four agencies. I created the Office of Energy Justice Policy and Analysis in the Office of Energy Justice and Equity. These initiatives bring people together to talk about equity and justice through working groups and stakeholder engagement practices.

Former Secretary of Energy (served 2021 – 2025) Jennifer Granholm was incredibly supportive of energy justice. We needed to articulate policy priorities to help people at the Department of Energy connect Energy Justice to their work. We created a goal to decrease the energy burden and environmental exposure for disadvantaged communities, and to increase other opportunities such as parity in clean energy access and adoption, access to low-cost capital, and contracting opportunities for minority and diverse-owned clean energy businesses, job training, energy resiliency, and energy democracy.

The U.S. Department of Energy (DOE) was created in 1977, and in 1978 it established the Office of Minority Economic Impact. The office had an outstanding mandate to create a research arm, and I was asked to set it up, which was my dream job. The idea was to support the Department of Energy in the adoption of Energy Justice throughout its programs. We launched Justice Week to help the agency address justice in their work. We modeled the Office of Energy Justice Policy and Analysis after a framework developed by former Congressman Bobby Rush of Illinois, who advocated for its creation for decades.

We went on an “Energy Justice to the People” road show, visiting communities like Corpus Christi, TX to learn how they envisioned the Inflation Reduction Act might benefit their communities.

Executive orders live with the executive who passed it, so Justice40 lives with President Biden, though some executive orders such as Clinton’s environmental justice order from 1994 have persisted. The only way to integrate this into what DOE does is to put a requirement in funding opportunities for applicants to focus on the communities where they plan to build projects. Community Benefits Plans (CBPs) cover four areas including labor, the workforce, DEIA (Diversity, Equity, Inclusion, and Accessibility), and a plan to accomplish Justice40. Over time, anybody receiving DOE funding will be working to achieve these goals, and it allows communities to come to the table. The Community Benefits Plan changes the game, making it an integral part of the planning process. We have developed a decision-support tool to help communities determine the capacity of the community to integrate renewable energy projects, and the benefits those projects could provide. Data justice and transparency is another big component, so we also created a dashboard that shows how money is invested in disadvantaged communities. We have also developed an environmental justice score card, which provides information on how every federal agency is making progress on environmental justice.

This moment requires a layered, collaborative approach, because no single entity can achieve our climate and energy justice goals alone. We need research, state and local partners, philanthropy, and the private sector. I want to leave you with a quote that sets us up to move forward with this work by agricultural scientist, inventor, and educator Professor George Washington Carver, who taught at Tuskegee University for 47 years: “When you can do the common things of life in an uncommon way, you will command the attention of the world.” Everyone here today is in the right line of work, at the right time, to do the common thing in an uncommon way. If we share our methods and perspectives with others, it can lead to transformative change.

Audience Questions & Keynote Speaker Response/Discussion

Can you please define self-determination in the context of your work?

Dr. Reames: Within the energy democracy framework, part of it is decision-making or providing economic resources in your community. Community-owned solar provides an opportunity to think about self-determination. How do communities have the opportunity to make decisions that impact them and to deploy that technology or that resource themselves? In contrast, a corporation could come in and make those decisions for them. Much of the self-determination literature is related to communities being able to use their culture to make decisions, and to self-govern, including tribal communities.

Where do you think environmental justice initiatives and Community Benefits Programs (CBPs) will go from here, and will they continue through the new administration?

Dr. Reames: That is the million-dollar question. There are a couple of things that give me joy. CBPs are currently engrained into the Department of Energy and all the applications that have been released, so projects that have been selected or are in negotiations already have that in the contract with the government with money that has been appropriated. For programs that have not yet been funded, it is unknown. The beauty of the Justice40 initiative is that it already lives outside of the federal government, and similar initiatives exist in state and local governments from California, to New Mexico, to Michigan, to New York. The philanthropic community has already caught onto Justice40, so even if it is not implemented in future federal projects, we will still see it in other areas.

Warren, North Carolina is a rural area, and we know that toxic release inventory sites and landfills frequently impact both rural and urban areas. Is your work more focused on rural or urban communities, and where do you see the greatest impact?

Dr. Reames: My research lab is called the Urban Energy Justice Lab. I started this work collecting data in Kansas City, Missouri, and then I moved to Detroit, Michigan, so most of my work has been in urban communities. There are a lot of similarities with rural communities. There are unique characteristics between rural and urban communities, but the principles of energy justice can and should be applied to both. I have colleagues that do most of their work in rural communities, which is where most of the renewable energy projects are being built. There are siting issues, such as whether a community with a renewable energy project will get to use that resource. The University of Michigan has committed to being net zero from renewable energy, but most of that will be sited hundreds of miles away, so there is no opportunity for students to engage with it, and the rural communities may not want this infrastructure, which can lead to tension. Some people say this is a shift toward environmental justice because urban communities were the primary host of dirty coal plants, and these renewable projects are being shifted to rural communities. There are interesting debates along the urban/rural divide, but this allows us to apply the principles of energy justice in new ways.

When you identified disadvantaged communities for the Justice40 initiative, what was the reaction from members of those communities? When you interact with them, do they accept or push back on those designations?

Dr. Reames: The map of disadvantaged communities was built before President Biden took office and was published in August 2022. It is challenging to identify a place as something, define it with the right set of characteristics, and there is disagreement about how to define "disadvantaged," such as whether race should be a factor. We consulted with communities before the map was released. We could not mandate 40% of dollars would flow to disadvantaged communities, so we adopted the concept of 40% of benefits, because benefits encompass more than just money. Simultaneously, some states were putting out their own maps, so we allowed people to use those maps if they justified its use for an individual project. We also allowed communities to self-identify if they felt they should be represented on the map. Few, if any, communities decided to de-identify.

Audience Question: I have experienced opportunities where these processes were set up for communities to participate in that are dominated by NIMBY-ism (not in my back yard), causing the burdens to get placed on communities with less capacity to voice their opinions. Do you have any advice to navigate this type of scenario, opening people's minds, and leveling the playing field?

Dr. Reames: Community engagement is difficult! NIMBY-ism may bring to mind a group of people with higher socio-economic status who do not want new energy infrastructure but can also be a group with lower socio-economic status who has been overburdened by the energy system. We brought our road tour to Corpus Christi because a lot of the federal funding would support projects in places like here, to decarbonize places with a lot of carbon emissions. There were a lot of hydrogen and carbon capture projects planned for the Gulf of Mexico, but the communities felt like those projects would instead prolong the fossil fuel industry and pollution near their homes contributing to asthma, cancer, etc. Engaging with communities about projects they do not want can toughen you up. Energy efficiency is not usually a hard sell, but hydrogen, carbon, or direct air capture projects can lead to difficult conversations. Making space for everybody is critical, and the development of a CBP brings stakeholders together. We implement a CBP game where people take on the role of other stakeholder groups to understand other perspectives. Finding creative ways to get people to think about others can push people to a happy medium.

Many energy projects are funded and designed by private organizations that work with a few landowners. Do you have any advice on how to encourage developers to think more about the communities they are working in?

Dr. Reames: What is community? Is it a set of people, or a place? What is our responsibility to a landowner who wants to develop their land for renewable energy versus the people that live around them? Nothing I talked about today is easy, but early, often engagement is critical. We were on the road before the infrastructure law passed, although details of the IRA were not yet finalized, but we started mapping assets and figuring out the types of projects and places that were suitable. The Community benefits plan allows for benefits to spread beyond just the renewable energy company or the landowner(s) holding the leases. If the perception is that only one person will benefit from the project, it is harder to get buy-in, so the opportunity to plan and articulate the benefits to the broader community is key.

Recommended Resources

- Sovacool and Dworkin 2014. Global Energy Justice: Problems, Principles, and Practices. https://doi.org/10.1017/CBO9781107323605

Session 1: Risky Behavior – Assessing and Moderating Risk for Birds and Bats

While risk to bats from collisions with wind turbines is a significant conservation concern, there remains much to be learned about bat behavior near wind turbines. This session provided an update on the state of the science in research to better understand and minimize risk factors for bats at wind energy facilities.

Moderator: Amanda Hale – Principal Biologist, Western EcoSystems Technology, Inc.

Speakers:

- **Seta Aghababian –** Data Scientist, Stantec Consulting Services
- **Aaron Corcoran –** Assistant Professor, University of Colorado, Colorado Springs
- **Måns Karlsson –** Analytic Lead, DHI A/S
- **Jenny Taylor –** Senior Biologist, PCM Program Manager, Tetra Tech
- **Dorian Pomezanski –** Project Manager and Terrestrial/Wetland Ecologist, Natural Resource Solutions, Inc.
- **Isabel Gottlieb –** Senior Research Manager, Renewable Energy Wildlife Institute

Link to Recording: https://vimeo.com/1031565071/c4e210e0a0

Seta Aghababian – Stantec Consulting Services: Assessing bat spatial activity and detection likelihood near wind turbines

Wind turbine-related mortality poses a significant threat to bat populations and effective monitoring at wind turbines is crucial for developing fatality minimization strategies. Acoustic detectors are the most widespread and practical tool for assessing species-specific bat activity patterns and exposure to turbine operation. However, acoustic monitoring can only detect bats while they are echolocating, so some species may be under sampled, and bats may go undetected in certain environmental conditions or when engaging in flight without echolocation. Evaluating minimization strategies, such as curtailment, could be improved by understanding where bats fly in the rotor-swept zone and what factors, such as species-specific echolocation behavior, affect our ability to detect bats near wind turbines. Though thermal cameras are more challenging to deploy and do not enable species identifications, they capture a larger sampling area near wind turbines and provide insights into bat behaviors that acoustic detectors may miss, specifically flights without echolocation. In our study, we integrate these two technologies by deploying paired acoustic detectors and thermal video cameras at wind energy facilities in Maine and Missouri to assess where bats fly near wind turbines, and identify factors that may affect bat detection for each method. We deployed thermal cameras at ground level (1.5 meters) and acoustic detectors at nacelle-height (94 meters in Maine and 120 meters above ground level in Missouri) and mid-tower (20 meters up the turbine monopole) at 10 wind turbines per site throughout spring, summer, and fall of 2023. We measure spatial activity by comparing how often bats are detected by thermal cameras within and outside range of nacelle-height and ground level acoustic detectors. To determine how species or environmental conditions may affect our ability to detect bats, we correlate acoustic species identifications, wind speed, and turbine operation with detected camera passes and compare the influence of each factor. We found that nacelle-height acoustics and thermal camera data strongly aligned across the season, though the cameras were able to more accurately capture larger peaks in activity. There was bat activity picked up by the cameras that did not have corresponding acoustic data at either height, which could indicate some spatial influence on bat activity. Nacelle height acoustics correlated more strongly with camera data than mid-tower acoustics, possibly due to periods of high bat activity near the ground. Temperature and turbine operation did not influence acoustic detection, though high wind speed may reduce acoustic detection at nacelle height. This may be explained by bat behavioral responses or aerodynamics in high wind speeds. A common question we receive about acoustics is whether multiple bat calls typically represent individual bats making multiple passes, or presence of additional bats. We have observed individual bats making several bat calls recorded in the acoustic data, periods with more acoustic passes usually occur when more bats are present. Our acoustic data demonstrates that multiple species, individuals, and behaviors (feeding buzzes, approach phases, social calls) can be confirmed. Pairing acoustics and cameras can be used to address hypotheses about bat attraction to turbines, and to help refine minimization strategies. Nacelle height acoustics are an effective tool for capturing bat activity trends in the rotor swept area, and are not heavily influenced by environmental conditions. Better understanding of bat flight height could improve minimization strategies such as deterrent placement.

Aaron Corcoran – University of Colorado, Colorado Springs: No evidence that bats are attracted to the wakes of wind turbines at an Iowa wind facility

Wind turbines create wakes behind them with lower wind speeds which may create more favorable flight conditions or increased prey availability or social opportunities for bats. Tall structures may also indicate potential roost sites for tree bats, which are the main species killed at wind facilities. We hypothesized that bats are attracted to turbine wakes and predicted that bats would approach turbines from and be most active in the wake. To test this hypothesis, we used 3-D thermal videography and acoustic recording equipment to document bat activity patterns and behavior at two wind turbines on a wind farm in central Iowa, in August and September 2022. Cameras were positioned to capture the wake regions north of the turbines during prevailing winds coming out of the South-Southeast. We also monitored bat activity at three study trees and modeled the wakes of both turbines and trees. We used through-tracker open-source software enhanced with machine learning to detect and track targets in the videos. Note that at the distances in these videos (50-200m) it is impossible to confidently distinguish between birds and bats. We used weather data collected at the turbines to develop an analytical wake model, which was subsequently validated and calibrated. Contrary to our predictions, target activity in the turbine wake regions was low, with only 3% of 13,298 detections occurring there, with the bulk of target activity occurring in front of the turbine. If targets were using the wake to assist in migration or approaching turbines, we would expect to see southeast trajectories moving toward the turbine. Also contrary to our predictions, of the 385 targets that were detected in the turbine wake, most involved targets flying straight and perpendicular to the airflow. Our study found no evidence to support the hypothesis of bat attraction to turbine wakes. This may indicate that turbine wakes do not provide significant aerodynamic benefits to bats.

We were happy and impressed by the ability of our thermal cameras to detect and track targets in 3D at distances of 50 – 200m. Thermal cameras have great potential for use in refinement of curtailment and other risk minimization strategies, optimizing and evaluating effectiveness of deterrents, quantifying exposure risk, and detecting fatalities.

Måns Karlsson – DHI A/S: Radar-based monitoring of bird avoidance behavior at Block Island Wind Farm 2018-2021

DHI and Stantec monitored post-construction bird and bat activity at the Block Island Wind Farm off the coast of Rhode Island from 2018 through 2021. Block Island is a birding hot spot with 312 bird species reported on eBird. A prototype of DHI's multi-sensor system MUSE was applied using integrated solid-state S-band radar and long-range PTZ camera mounted on turbine 2 and monitoring flying birds and bats around turbines one and three. The production version of MUSE that is deployed today at 10 projects uses updated camera and radar systems. I will focus today on the avoidance behavior of birds documented by the radar of the MUSE system during a 28-month period from January 1, 2019 to May 13, 2021. The system was configured to only track bird targets when they were detected within 1,500 m of the radar, and to a height of 800 m. The MUSE software controlled the automated tracking and geo-referencing of track data and controlled the filtering of static and dynamic noise. The radar data was further processed under a caution principle by filtering tracks with unreasonable or doubtful values. From August 1, 2018, to May 13, 2021, the radar operated during 20,184 hours of the 24,072 total hours during this timeframe. Track length densities, defined as track length per area unit, were computed based on the filtered set of tracks, and plotted in a grid where each pixel corresponds to an area of 3.75 m x 3.75 m. The phenology of the radar tracks showed peak densities during the morning hours, declining over the course of the day. There is relatively high activity during the night. We observed the lowest bird activity in the winter months. Seasonal flight directions aligned with migratory movements along the coast. Movements during winter and summer months were less directional than during the periods of seasonal migration. Cumulatively, these findings are consistent with established daily and seasonal movements of birds in the area, giving us confidence that the system provides accurate information on bird activity.

The recorded patterns of track density distributions during both daylight and night hours in all months clearly indicated avoidance of the turbines. This was so, even if the radar was shaded within the nearest 75 m from the turbine tower due to the static clutter induced by the turbine and rotor blades. The zone of avoidance seemed to stretch at least to 1/3 of the inter-turbine distance equivalent to 275 m. The general avoidance behavior also clearly translated into a zone of higher densities located between the turbines and at 300-400 m distance along the array; that is, close to the mid-point between adjacent pairs of turbines. Fine-scale flight distributions of tracks displayed more linear patterns along the side of the array during the night than during daytime, possibly associated with nighttime migration along the eastern coastline of Rhode Island. During daylight hours, radar tracks showed more of a tendency to circular patterns around turbines 1 and 3, possibly associated with birds moving offshore and onshore during breeding season and winter foraging activities.

We have shown that the MUSE prototype can detect and track birds, with data that reflects expected phenology and behavior. The production version of MUSE has improved capabilities including advanced radars and cameras with longer detection range, camera tracking and species identification using AI, and the ability to predict simple flight paths and suggest curtailment events to the SCADA system.

Jenny Taylor – Tetra Tech: Does size matter? Investigation of the effects of wind turbine size on bird and bat mortality

Advancements in wind turbine technology have led to larger, more energy productive turbines. However, the degree to which increases in turbine size may affect wildlife mortality is not yet fully understood. Our research objective was to determine the effect of different turbine size parameters on collision-based bird and bat mortality; our ultimate research goals were to 1) enhance the ability to predict and avoid bird and bat collision-based risk as understood from existing data, and 2) expand available information on species fall distributions.

We developed a hierarchical model, based on a Bayesian framework, to investigate the potential influence of three turbine size parameters: ground clearance, rotor diameter, and power rating on fatality rates and fall distances.

We selected the turbine size parameters (covariates) using correlation matrix to determine which parameters were the least correlated. To isolate the effects of turbine size and remove the effects of environmental conditions, we created a paired study design using "mosaic" wind projects, selecting projects that incorporated at least two different turbine sizes with a difference in rotor length of at least 10 m. Mosaics were either in-project (more than one turbine type within the project) or neighbor mosaics (projects that met the turbine difference criteria within the same county, and with the Commercial Operations Date (COD) and then post-construction monitoring within the same year). We used data from the American Wind Wildlife Information Center (AWWIC) database, the Canadian Wind Energy Bird and Bat Monitoring Database, and fatality data from Tetra Tech's own database for which we had client permission to use. Our data comprised 44 projects and 24 mosaics spanning 12 Bird Conservation Regions which were used to represent distinct ecological units. For the three turbine size parameters of interest, the turbines in our study ranged from 20-54 m in ground clearance, 1 – 3.6 MW in power rating, and 61-136 m in rotor diameter. We used three representative species that are widely distributed and commonly found as fatalities at wind farms: hoary bat (*Lasiurus cinereus*), horned lark (*Eremophila* *alpestris*), and red-tailed hawk (*Buteo jamaicensis*). Further, these species are representative of taxa of conservation concern: migratory tree roosting bats, grassland birds, and raptors.

Our hierarchical model used a Bayesian framework using priors from publicly available studies to build out posterior distributions to which we could compare our focal dataset. All of the levels of our hierarchy can influence fatality rates, so with the hierarchical model, we could isolate and control for effects and create turbine-specific fatality estimates that then we could relate back to the specific metrics of a specific turbine.

Our results show that turbine size does influence fatality rates, however the effects vary by turbine size parameter and by taxon. Organized by turbine size parameter, our results indicate the following effects on fatality rates: 1) decreasing ground clearance leads to increased fatality rates for all three species and was most pronounced for hoary bats; 2) increased rotor diameter leads to increased fatality rates for red-tailed hawks and to a lesser extent, horned larks but was negligible for hoary bat; and 3) increasing power capacity leads to increased horned lark fatality rates, with a weaker influence on red-tailed hawks and was also negligible for hoary bats. Additionally, our turbine size parameters were inconsistent in their fall distribution effect; carcasses of a given species were sometimes thrown farther by a shorter turbine and sometimes farther by a taller turbine suggesting there are other species-specific factors that may be involved in determining carcass fall distances such as flight height and flight behavior. Our model suggests that a substantial proportion of the horned lark and red-tailed hawk carcasses land in areas where less than 10 percent of the area is commonly searched. As such, our results have implications for selecting search plot dimensions in future studies. To our knowledge, this is the first investigation of ground-clearance effects on mortality.

Our study shows that in addition to turbine size, regional and local factors strongly influence fatality rates. It also provided further evidence that hoary bats may fly lower within the rotor swept area than previously thought. If wind projects repower with longer blades but keep the same hub height (i.e. increase rotor diameter/decrease ground clearance), there is potential for increased risk to hoary bats and red-tailed hawks.

Dorian Pomezanski – Natural Resource Solutions, Inc.: Comparison of bat activity and fatality data at operational wind facilities in Ontario and Alberta, Canada

Migratory bats are common fatalities at wind turbines, and hoary bats were recently listed as endangered in Canada. The assumed relationship between bat acoustic activity and wind turbine fatality risk has been a long-standing question within the wind energy industry. Currently, the scientific understanding of this relationship is limited by contrasting results and a continued lack of consensus. Acoustic data collected at operational turbines can be a reliable indicator of bat risk, but pre-construction acoustic data is not successful at predicting post-construction fatalities. However, bat acoustic activity continues to be the primary basis on which bat fatality risks are assessed prior to wind turbine construction, including specific reference to acoustic thresholds for determining risk in regulatory guidelines in the province of Alberta. A further complication is that current bat acoustic monitoring techniques cannot confidently determine how many recorded calls are attributable to an individual bat. The objective of this study was to explore the relationship between bat acoustic activity and wind turbine fatality risk using NRSI's internal database of acoustic and fatality data collected at wind energy facilities across Canada, and focused on silver-haired, hoary, and eastern red bats.

This study used an extensive internal data set of both acoustic and fatality data from 12 wind energy facilities in the provinces of Ontario and Alberta from 2007 to 2023, including over 50,000 hours of acoustic data and 6,000 bat fatalities. Our acoustic data was generally collected from the ground level, between May and October. Where possible, bat acoustic and fatality data was categorized to species level. Fatality rates were estimated using Ontario's regulatory formula, which incorporates searcher efficiency, carcass persistence, and proportion of area searched. Linear regression analyses were used to determine the strength and significance of the relationships between acoustic and fatality data exploring relationships including 1. Operational acoustics vs corrected fatality rates; 2. Pre-construction acoustics vs corrected fatality rates; and 3. Pre-construction vs operational acoustics. Species-specific results were only possible for the first analysis.

Preliminary results show a moderate correlation between operational acoustics and fatality rates with a $R^2 = 0.33$. Sites in Ontario had higher bat acoustic activity and higher fatality rates compared to Alberta. Silver-haired bats had the highest acoustic activity and fatality rates, eastern red bats the lowest, and hoary bats were in the middle. For the relationship between pre-construction acoustics and fatalities, we found a mixed bag in the distribution, resulting in a non-significant, weak relationship between these two variables. Finally in the relationship between pre-construction and operational acoustics, we found a strong relationship with an $R^2 = 0.85$.

Ground-mounted acoustics show promise as a tool for predicting fatalities of migratory bats at wind energy facilities. The strong relationship between pre-construction and operational acoustics suggests there may in fact be utility in pre-construction acoustics if it is identified to species. With the ongoing status considerations of several long-distance migratory bat species (eastern red bat, hoary bat, and silver-haired bat) at the federal and provincial levels, as well as the current review of the provincial regulatory framework relating to assessment of risk and application of mitigation in Alberta, this research has management implications for the continued build-out of wind facilities within Canada and their potential interactions with migratory bats.

Isabel Gottlieb – Renewable Energy Wildlife Institute: Developing and evaluating a smart curtailment strategy for bats integrated with a wind turbine manufacturer platform

Cumulative impacts of bat fatalities at wind energy facilities are a major conservation concern in North America. A leading strategy to minimize bat fatalities is to curtail turbines when bats are at the highest risk of collision: often during the fall migration season (approximately July through October), at night, and in low wind speeds (e.g., below 5.0 m/s;

commonly referred to as “blanket curtailment”). We developed a bat fatality risk model using empirical bat fatality, bat activity, temporal, and environmental data, which then informed curtailment rules for the Vestas Bat Protection System (VBPS): a novel “smart” curtailment strategy with the goal of reducing bat fatalities without further increasing the loss of power production compared to blanket curtailment. The model selected varied its parameters by month, including the curtailment window (portion of the night), cut-in speed, and wind direction. We evaluated the performance of the VBPS smart curtailment in comparison to blanket curtailment and control turbines by comparing observed bat fatality rates and power production data between treatments using generalized linear and additive mixed models. Implementation of the model was partially automated (time and wind speed), and partially manually (wind direction) due to delays in the finalization of capabilities of the curtailment software, which led to the refinement of the model to VBPS-surrogate rules which were implemented based on nightly forecasted wind directions. Both curtailment treatments resulted in fewer bat fatalities and less power production compared to control turbines, but there was not a significant difference in performance between VBPS-surrogate and blanket curtailment treatments. The VBPS-surrogate treatment resulted in a 36.3% reduction in bat fatalities compared to control turbines, and a 7.1% reduction in power production during the curtailment periods (i.e. nighttime hours during the study period), or an estimated 0.75% reduction in Annual Energy Production. VBPS-implemented smart curtailment shows promise as a conservation tool; future studies should evaluate VBPS using fully automated curtailment based on wind direction and should include precipitation as an added covariate to potentially improve VBPS’s value as a conservation tool.

Audience Questions & Speaker Response/Discussion

(for Seta Aghababian) An R^2 of 0.7 is good in ecology, but risk is not uniform over the course of a season. How strong is this relationship during peak migration?

Seta Aghababian: We did not separate the analysis by peak season vs not peak season, but in the regression, having variability on a nightly basis throughout the season helps to see that. Earlier graphs depict a lesser relationship at one site on a seasonal basis. When looking at the global model for determining detection likelihood with presence/absence based on the number of units that we were detecting in either method, whether that was integer-based acoustic passes or number of seconds containing bat calls, it did not vary as much and followed similar seasonal patterns. Risk probably varies similarly for each method.

(for Aaron Corcoran) If the direction of flight is driven by migratory movements would you expect a different relationship in summer (outside of migration)?

Aaron Corcoran: Migratory movement patterns are interesting; in the study they could not differentiate between bats and birds in thermal videos. The research team is using acoustics, video, and radar to attempt to figure this out. One of the commonalities of studies in this field is the difficulty in studying these animals and figuring out how to solve these problems.

(for Måns Karlsson) The radar can see anything. Is this system appropriate for tracking offshore insect migrations and plumes and bats? What are the biggest challenges in using the tech for this application?

Måns Karlsson: Yes, the radar can see anything and much of the data contains things we are not interested in such as waves and turbine blades. The challenge with detecting targets such as bats and insects is that the smaller the target, the greater the limitations on detection range. It could be easier to use radar to detect insects or bats on a macro level such as detecting a swarm of insects, but if you want to detect individual bats, you need very good radar.

(for Måns Karlsson) You said that one of your plots seemed to show avoidance. Is that real, or is this a resolve of clutter near turbines showing fewer birds?

Måns Karlsson: We believe we saw true avoidance in these plots. In our last figure there was a blue line representing the smoothing of the track density as a function of the distance from a turbine. There was also a black vertical bar which represents the detection limit. Within that detection limit, we cannot detect birds without the use of advanced radar, which was not used in this study, so it could not detect birds in the rotor-swept zone. However, before birds get that close to the turbine, we observed a decrease in track density, and we filter out the clutter from the turbine. I do believe that we see true avoidance, but do not want to claim that we only see true avoidance.

(for Jenny Taylor) Did you analyze fatality rates relative to operational status or power produced to account for how much time the turbines were spinning? And did you account for wind speed in your fall distance and distribution models?

Jenny Taylor: We did not, for both questions.

(for Jenny Taylor) What considerations do you have for variation in the fatality data related to the quality/effort that might be available in the AWWIC for studies to use?

Jenny Taylor: The AWWIC is a thorough source of information, in order to enhance the information that is available, consider contributing power production information along with the fatalities to better contextualize the information.

(for Dorian Pomezanski) Have you looked at correcting raw bat activity rates by relevant risk parameters such as wind speed?

Dorian Pomezanski: We did not correct bat activity rates based on wind speed, we used searcher efficiency, scavenger removal, and proportion of area searched.

(for Isabel Gottlieb) Cut in speed of 10 m/s is very high. How often, or what proportion of nights, was this implemented? Was this a major contributor to production loss?

Isabel Gottlieb: 10 m/s is a very high cut in speed, though it applied only to the month of July and a small slice of wind directions (originating from the North). I don't have the numbers in front of me, but I believe that it was realized a small proportion of the time, so in this instance it isn't likely that it had a huge impact. But the specifics of how this strategy could be applied to any given site could be very different because you would want to develop a site-specific model.

(for Aaron Corcoran) How did you account for bats nearest the turbine that would be outside the field of view of the cameras?

Aaron Corcoran: In this study the cameras were pointed adjacent to the turbines because our research question was related to what was happening in the wake, which is very large. Close to 50 meters is almost very small versus the wake itself, not something they were looking at in this particular study.

(for Seta Aghababian) What's considered "high" wind speed affecting nacelle height acoustics? How does this relate to wind speed at which bats stop flying or foraging?

Seta Aghababian: Each site has different wind speed characteristics. At our main there was a steeper drop off in bat activity above 5 m/s with the nacelle acoustic detectors.

(for Seta Aghababian) With the stratification of your detectors were you able to determine if the bats were within the rotor-swept zone (RSZ)?

Seta Aghababian: We were not comfortable asserting any spatial inference from the cameras based on the error range. Broadly you might assume they are near the nacelle based on the acoustics, but I cannot say whether they are within the rotor-swept zone.

(for Jenny Taylor) In your study design how did you account for interannual availability?

Jenny Taylor: For an end of project mosaic the post-construction fatality monitoring (PCM) data was from one project, for a neighbor mosaic they used PCM from the same year, which served as a control for inter-annual variability.

(for Jenny Taylor) Does a smaller ground clearance mean the entire rotor-swept zone is lower or does it mean it is higher? How can we think of different metrics of turbine size independently?

Jenny Taylor: Ground clearance and the maximum height are not independent of each other. The correlation matrix showed which were least correlated, but they are still correlated. The biggest implications are if the RSZ during the repower is getting larger but the tower height is not changing, that usually means the ground clearance is getting lower and maximum height increases, and they are interdependent.

(for whole panel) Do any of your datasets provide insights into where bats might be colliding with turbines along the blades? When the blade sweep has low ground clearance, do you think bats are colliding in that lower portion?

Seta Aghababian: We present research suggesting where bats might collide with turbines in our poster, abstract #91. Broadly, we are coming together on where bats are likely to cocur in the airspace, which might be related to where the magnitude of fatalities occur. For example, as we see mid tower acoustic detectors picking up more activity compared to nacelle-height detectors, so the decline of bat activity from lower to higher height suggests that the lower rotor sweep is an area of interest. I am not saying that is where bats are hitting the turbine, but it is something we should explore.

Aaron Corcoran: We have 3D data on the altitude of bat detections showing a strong peak in the lower reaches of the rotor-swept zone, though the study was not set up to test that specifically.

Recommended Resources

- Garvin et al 2024. Does size matter? Investigation of the effect of wind turbine size on bird and bat mortality. https://doi.org/10.1016/j.biocon.2024.110474
- Peterson et al 2021. Acoustic Exposure to Turbine Operation Quantifies Risk to Bats at Commercial Wind Energy Facilities. https://doi.org/10.1002/wsb.1236

Session 2: Creative Avian Mitigation Solutions

This session reviewed recent science on risk minimization strategies for avian species at renewable energy infrastructure. It also explored developing approaches to expand compensatory mitigation for eagles

Moderator: Chris Farmer – Principal Onshore Biologist, Ørsted

Speakers:

- **Hein Prinsen –** Senior Consultant, Wildlife-friendly Energy Transition, Waardenburg Ecology
- **Jeff Smith –** Associate Wildlife Ecologist, H.T. Harvey & Associates
- **Geoffrey Palmer –** Senior Biologist, Western Ecosystems Technology, Inc.
- **Julie Heath –** Professor and Interim Director of the Raptor Research Center, Boise State University
- **Steve Slater –** Conservation Science Director, HawkWatch International
- **Vince Slabe –** Energy Scientist, The Peregrine Fund

Link to Recording: https://vimeo.com/1031616313/2944b88bc4

Hein Prinsen – Waardenburg Ecology: Paint it black!? Does a single black rotor blade reduce bird mortality?

A previous study in Norway, published in 2020, indicated that painting one blade of a wind turbine black may largely reduce the number of bird collisions. However, the sample size of that study was relatively small and the study location on a small island contained relatively few bird species, making it difficult to extrapolate the results. Therefore, there is need for a more elaborate study, on other sites, in a more species-rich environment and preferably with more treated turbines. In September 2021 we started a three-year study in windfarm Eemshaven in the Netherlands. On this hotspot for bird migration and local bird movements bordering the Wadden Sea, a much broader set of species is present and collision rates among birds are known to be relatively high. The study consists of 14 turbines in a BACI setup (*Before–After–Control–Impact*). After one year of null monitoring, during which all turbines had white blades, half of the turbines received one black blade (seven pairs of impact and control turbines).

The monitoring results of the first two project years show that collision rates are highest among gulls, waders and songbirds (passerines). Both in the year *before* and in the first year *after* painting the blades, a comparable number of collision victims was found (177 and 145 victims respectively, before correction for search area). Species richness was also comparable. In total 45 bird species were found as collision victim *before* painting and 39 species in the first year *after* painting. The number of fatalities is highly variable, however, both in time (seasons) and space (different turbines), but also in terms of species composition. Overall, considering all species and turbines, the results thus far do not show a statistically significant effect of the black blade. Diurnal species do show a reduction in collision rates after painting the blades, but the reduction is weak. The high variability in collision rates makes it difficult (at this point) to draw conclusions about the effectiveness of the black blade for the different species (groups) involved. Currently, we are carrying out the third and final year of monitoring. Hopefully, the results of this last year of monitoring will allow a more solid statistical test of the effectiveness of the black blade.

Jeff Smith – H.T. Harvey & Associates: Automated detection and audio deterrence system reduces collision risk for eagles at two commercial wind energy facilities

Automated detection and deterrence/curtailment technologies can reduce the risk of birds colliding with wind turbines. We conducted multi-faceted research to evaluate the detection and audio-deterrence performance of DTBird® at two commercial wind facilities in the western U.S.: the Manzana Wind Power Project in a desert foothills environment of southern California (7 turbine-specific DTBird installations) and the Goodnoe Hills Wind Farm on a grassland/temperate scrub ridgeline above the Columbia River in southern Washington (11 functional installations). This was the first study of DTBird in North America. We evaluated DTBird's effectiveness in detecting and discouraging Golden Eagles (*Aquila chrysaetos*) and other large soaring raptors from approaching the rotor-swept zone (RSZ) of spinning turbines. Here we present an overarching assessment of DTBird's ability to reduce collision risk for Golden Eagles, including quantitative indices that can be incorporated as risk-reduction parameters in models used to estimate eagle fatalities at wind facilities. The research included (a) using eagle-like unmanned aerial vehicles (UAVs) to estimate the probability of detection (PD) and evaluate detection and deterrent-triggering performance; (b) classifying behaviors of *in situ* eagles recorded in DTBird videos to estimate the probability of effective deterrence (PED) and evaluate the influence of environmental variables; and (c) conducting a two-year randomized control-treatment experiment using 14 turbines outfitted with DTBird systems at the Goodnoe Hills to provide independent estimates of eagle dwell times and deterrent-triggering rates at installations operating with audio deterrents broadcasting normally (treatment) or muted (control). The probability of detection was 65% (±1% CI) and was similar at both sites. Detection was highest (65-75%) when the eagle-surrogate UAV passed through low/mid viewshed at relatively close distances (up to ~150 m) and improved with afternoon light. Focused on eagles/surrogates that were at moderate to high risk before being exposed to a deterrent signal, across the two study sites DTBird combined with spinning turbines reduced the risk of entering the RSZ by an estimated 54% (PD x PED). Response distances (the distances at which the DTBird system initially detected and then triggered a deterrent signal in response) showed improved performance under overcast skies, with faster UAV flight speeds, and with greater UAV pitching and rolling in the wind. Additional multi-faceted comparisons enabled by the 2-year Goodnoe Hills experiment revealed the audio deterrents themselves reduced overall collision risk for Golden Eagles by ~30%, elevated by another ~11% for eagles at moderate/high preexposure risk of collision. Eagles spent 27% less time dwelling near turbines when deterrence signals were broadcast compared to when signals were muted. Overall, three different estimates indicated that deployment of DTBird reduced the probability of a Golden Eagle entering the RSZ by 27–30% beyond the influence of spinning turbines alone. Performance could be improved by providing higher resolution videos for species identification, improvement of false-positive filtering, and ensuring stable and reliable performance. Reducing Golden Eagle fatalities by applying viable and affordable technological solutions is important to mitigate concerns for a species whose populations may be relatively stable overall, but have declined in several areas of the U.S.

Geoffrey Palmer –Western Ecosystems Technology, Inc.: Whooping cranes and predicting power line collision risk: habitat, relative risk, absolute risk

The whooping crane population declined to 15-21 individuals in the wild before its listing as endangered species in 1967 and has since increased to over 500 birds in the self-sustaining Aransas-Wood Buffalo population, plus smaller experimental populations. Migration is a challenging time for whooping cranes, and wind resources and transmission overlap heavily with their migration corridor. Nearly half of mortalities occur during migration, and power line collisions are a known source of mortality.

Western Ecosystems Technology, Inc. (WEST) uses a unique three-tiered approach to assess potential collision risk of the federally listed whooping crane with overhead power lines. The first tier can be used for siting and avoidance and is based on a general landscape-based stopover habitat assessment commonly used for wind energy development that has been modified to more comprehensively incorporate potential attraction and avoidance factors. During migration, whooping cranes stop to rest in shallow, open water wetlands. This assessment includes wetland data from the National Wetlands Inventory and the Watershed Institute's 2012 model to score models on a scale of 3 (low) to 20 (high) based on water regime, distance to forage, size, type, and mosaic. This analysis is then incorporated into a line marking analysis, which is the minimization phase of the project. This second tier utilizes a data-driven weighted landscape model to assess relative collision risk to cranes along the length of a power line. The goal of this tier is to develop potential minimization measures to reduce potential collision risk. It is a data-driven landscape model done using GIS (Geographic Information Systems) software, broken into three categories: attraction (wetlands, forage), avoidance (forests, anthropogenic features), and bird presence (avian use data on three scales). Each pole in the segment receives a risk score relative to the other poles in the segment. Segments of the power line that are identified as high risk can be modified with line markers to be made more visible to whooping cranes and other birds. Lastly, results from the first two tiers are incorporated into a quantitative model to assess absolute risk to this species during line operation for regulatory compliance. We are able to calculate project specific take estimates and can revise these estimates based on the implementation of a line marking strategy.

Julie Heath – Boise State University: Disease and ectoparasite management improve nestling golden eagle health and survival: an effective mitigation strategy

Managing emerging pathogen and parasite threats could provide cost-effective compensatory mitigation options for protected species affected by renewable energy production, such as golden eagles (*Aquila chrysaetos*). We used nest camera data to assess the cause of death for golden eagle nestlings in southern Idaho. Together, poultry bugs (*Haematosiphon inodorus*), a blood-sucking ectoparasite that lives in golden eagle nests, and trichomonosis, a fatal disease that is transmitted through the consumption of rock pigeons (*Columba livia*) caused ~27% of nestlings to die each year. From 2022-2023, we treated trichomonosis-infected nestlings with an anti-protozoan drug and developed a protocol for reducing poultry bug densities in eagle nests; then, we projected the effects of treatments on population growth using simulation models. We applied 1 of 3 experimental parasite treatments to eagle nests in late summer months: permethrin and diatomaceous earth, diatomaceous earth only, or water – a control, and measured effects on eagles the following year. Twelve eagle nestlings that would have died from trichomonosis lived to fledge from the nest after successful treatment. The permethrin and diatomaceous earth treatment to nests significantly reduced poultry bug densities in the subsequent breeding season and improved nestling health and survival. Nestlings had significantly higher hematocrit, female nestlings had higher mass, and, on average, more nestlings (0.70) successfully survived to fledge compared with control- and diatomaceous earth-treated nests. Further, we projected that the treatment of disease and parasites would increase population growth rates by 4% and 8%, respectively. In total, we estimated that 17.5 nestlings (equating to, 10.2 adult eagles, using published age specific survival rates) were saved through disease and parasite treatments in two years. We have developed a successful method for treating pathogens and parasites in nestling eagles which improves their health and survival. In areas with dense concentrations of poultry bugs or where eagles consume rock pigeons, disease and parasite treatments could be an effective compensatory mitigation option or management tool with population-level impacts on eagle populations.

Steve Slater – HawkWatch International: Quantifying golden eagle-vehicle strike risk and mitigation in the western U.S.

Golden eagles (*Aquila chrysaetos*) in the western U.S. are experiencing unsustainable levels of anthropogenic mortality ("take") from electrocution, collisions, etc. Any permitted golden eagle take must be offset. Power pole retrofits are currently the primary method of compensatory mitigation, due to an existing Resource Equivalency Analysis (REA). Golden eagles are also vulnerable to vehicle strikes, which occur most commonly in winter when live prey is less available and eagles scavenge on roadkill. We studied "eagle-vehicle strikes" (EVS) at eagle and roadkill hotspots in Oregon, Utah, and Wyoming in three phases. During phase I, we collected data on baseline (unmanipulated) conditions including densities of roadkill and eagle carcasses, and we placed cameras on carcasses to observe eagle behavior. We found that moving roadkill 12 m from the road increased eagle use and decreased flushing four-fold, relative to the road edge. We also found that eagle mortalities occurred most commonly where mammal roadkill and live eagle densities overlapped. During Phase II, we selected four study areas in Wyoming for more intensive surveys. In addition to repeating the methodologies used in Phase 1, we tracked eagle carcass persistence intensively and used a BACI design to move a subset of mammal roadkill "eagle safe" distances (i.e., at least 12m) from the roadway. Overall, 86% of dead eagles disappeared within 7 days of discovery due to legal and illegal collection, suggesting eagle-vehicle collisions regularly go undetected by wildlife managers. During the first two phases combined, we collected 6.15 million photos at roadkill using motion-sensitive cameras, including 7,249 eagle-vehicle interactions, and found 65 dead golden eagles and 14 bald eagles. Camera data was used to improve published model estimates of the number of eagles that can be saved each year via targeted roadkill management in Wyoming, and to support the creation of an associated carcass Resource Equivalency Analysis (REA) tool. We suggest that ~40 big game carcasses moved during weekly winter surveys equals one golden eagle saved, in areas meeting certain live eagle density, roadkill density, and traffic volume criteria. During Phase III, we demonstrated the feasibility of weekly roadkill relocation in central Utah and southwestern Wyoming, moving 450 carcasses including 299 big game carcasses at least 12 m. Most recently, we performed a west-wide gather of eagle mortality and big game roadkill data covering the past 10 years to identify areas to target in future mitigation efforts. This data will be used to create a predictive model of eagle mortality hotspots based on roadkill densities, eagle winter distributions, and traffic volume. The data is also being used to carry out roadkill relocation in 5 sites this winter in Idaho, Utah, Wyoming, and Colorado, with the goal of offsetting 10 eagles this winter. Overall, during 8 winters of research, we have found that roadkill represents a critical, but risky winter food source for golden eagles. That risk can be drastically reduced with regular patrols of hotspots and proper roadkill management.

Vince Slabe – The Peregrine Fund: Efficacy of non-lead ammunition distribution programs to offset fatalities of golden eagles in southeast Wyoming

Golden eagles face many anthropogenic risks including illegal shooting, electrocution, collision with wind turbines and vehicles, and lead poisoning. Minimizing or offsetting eagle deaths caused by human-caused sources including wind energy development is often viewed as an important management objective. Despite understanding the leading anthropogenic sources of eagle fatalities, existing scientific research supports few practical solutions for mitigating these causes of death. All big game carcasses shot with lead ammunition and 90% of their gut piles contain lead fragments that become available to scavengers such as eagles for consumption. Up to 50% of both bald and golden eagles show signs of chronic lead poisoning, which results in a ~1% reduction of the golden eagle population growth rate. When a hunter switches from using lead ammunition to copper, it directly reduces the availability of lead fragments available to eagles for consumption, and turns hunted carcasses and gut piles into a safe food source.

We implemented a 2-year non-lead ammunition distribution program in southeast Wyoming and evaluated its effectiveness as a compensatory mitigation action to offset incidental take (i.e., fatalities) of golden eagles at wind energy facilities. Research questions included:

1. How many hunters will participate in the program?
2. How many will use their copper ammo to harvest game?
3. What is the estimated reduction in eagle fatalities?

Our research was based on the Cochrane et al. model (2015) to estimate the effect of lead abatement. The study area was in the Shirley Basin in southeast Wyoming, which was selected because this area has a lot of wind development, high or moderately high lead poisoning risk, and high golden eagle abundance. We identified hunters who had big game tags in the Shirley Basin and sent them a postcard to inform them they were eligible to receive two free boxes of copper ammunition through a website called Hunters for Eagle Conservation. All recipients agreed to participate in a short post-hunt survey to indicate whether they used the ammunition, and how many gut piles they left on the landscape. Preliminary data suggests that in 2020 and 2022, we distributed non-lead ammunition at no cost to 699 hunters with big-game tags specific to our > 400,000 ha study area. These hunters harvested 296 pronghorn, 14 deer, and 33 elk in the study area which accounted for 6.9% of the total harvest in 2020 and 6.5% of the total harvest in 2022. 88 additional animals were harvested using the free copper ammunition outside of the Shirley Basin. We used road surveys in 2020 to estimate a density of 0.036 (95% CI = 0.018 – 0.058) golden eagles per km2 during the big game hunting season in our study area. Established mitigation calculations suggest that our non-lead ammunition distribution program offset the fatality of 3.84 (95% CI = 1.06 – 23.72) eagles over the course of these two hunting seasons. Our work suggests that the use of non-lead ammunition is successful at reducing eagle fatalities, and that this data could provide a useful framework to expand compensatory mitigation options for wind facilities or other anthropogenic causes of death.

Audience Questions & Speaker Response/Discussion

(for whole panel) Please share your thoughts on where you are with regard to having everything needed for Resource Equivalency Analysis (REA) for the compensatory mitigation strategy you are working on, and if one is already underway with the U.S. Fish and Wildlife Service (USFWS), what is the status?

Vince Slabe: I have been working with the USFWS on an REA for the lead abatement model. I have answered questions for them and provided my understanding of the model, and hopefully it will be finalized very soon.

Steve Slater: We are in a similar place with the carcass relocation model, and there was an REA produced from the model in the 2023 publication. The USFWS has asked a round of questions and I believe we are close to approval for that REA for Wyoming specifically where our data was collected, though it is less certain for other areas where we have less certainty on eagle abundance, roadkill density, etc.

Julie Heath: Compensatory mitigation using parasites and pathogen treatment is still very much in the nestling phase. We are far from developing an REA, but we have lots of great data and the concept is fairly simple: if you put a pill in an eagle that has trichomoniasis, you have saved one eagle. It's very easy to count and doesn't require complex modeling of probabilities. We just need to get to the next stage of working with the USFWS.

(for whole panel) What are the expected costs for compensatory mitigation using these different methods?

Steve Slater: For road kill relocation, the cost is about $20-25,000 per eagle per year. It can be less expensive in areas with high eagle and/or roadkill density. If you are only looking to achieve compensation for one eagle, there are start up costs that get diluted if you increase the number of eagles you are compensating for, if you have an area that can support that amount of mitigation. This includes all the permitting with the U.S. Department of Transportation, training, mileage, insurance, and everything.

Vince Slabe: For lead mitigation we don't have a number yet, but the price will vary based on abundance of eagles and gut piles. For lead mitigation, it is beneficial to target areas with high density of eagles and a lot of hunting. Stay tuned for prices.

Julie Heath: We have not calculated prices yet for parasite/pathogen treatment, stay tuned.

(for Jeff Smith) Are there any concerns with the use of an audio deterrent for eagles constituting "disturbance" or "harassment" under the Bald and Golden Eagle Protection Act (BGEPA)?

Jeff Smith: We initially planned to conduct the Washington portion of the study in an area with a lot more eagles but were prevented from doing so not because of disturbance from the audio deterrent, but from the unmanned aerial vehicles (UAVs) that were a part of the study. But specifically, regarding the deterrent being a disturbance, it hasn't come up because the idea is that we're trying to prevent them from being killed.

(for Jeff Smith) Your studies took place in the West in wide open areas, but there are a lot of eagles in areas of the country that are more densely populated with humans. How loud is the deterrent signal to humans and is there concern about deploying the system in areas where it could disturb human neighbors?

Jeff Smith: At the Washington site, there were not residents near enough to be bothered by the deterrent. We did have a situation at the California pilot study where we moved an installation in response to a complaint from a neighbor whose residence was a half mile from the turbine. The degree to which the deterrence broadcast caries with climatic conditions, winds, but they do broadcast a fair distance and can disturb nearby neighbors.

(for Hein Prinsen) Do you think there would be a greater reduction in the collisions of birds measured if you had a larger sample size or longer study duration, or do you feel quite confident in the power of your analysis thus far?

Hein Prinsen: We have already started to look at the second year of data with the black blades so we have a larger sample size already but we are not seeing a significant change. If you look longer maybe you will find something, but the bottom line is that the 70% reduction in fatalities that everybody is talking about using the black painted blades, is not being reached.

(for Hein Prinsen) There are turbine blades painted with patterns in South Africa, what are your thoughts on the potential effectiveness of that approach?

Hein Prinsen: In the South Africa study, they painted two red bands on the turbine blades. The study has a small sample size with just a few turbines over a short period and they also found rather good results for raptors. There are a number of studies emerging with related ideas- paint the blades like zebra, etc. There are challenges with NIMBYs complaining about painted turbines, maybe this approach would meet less resistance in an offshore environment.

(for Geoffrey Palmer) Were you able to go back to areas where whooping cranes had been observed to validate the predictions of the model, or do you think there would be value in such an exercise if you have not?

Geoffrey Palmer: I certainly think there is value, we have not run that analysis on whooping cranes, but we have validated models for other species.

(for Hein Prinsen) Have you encountered any issues with different coatings on different turbine blades regarding the reliability or operations? There is speculation that the black paint could heat up the blade or cause differential weight of the turbine.

Hein Prinsen: I don't know the results of those analyses, but RWE is working on it because it's an important question for wind developers. Heating in a temperate area is probably not going to be a major issue, but perhaps in other climates. They will likely publish the results of those tests within a year.

(for whole panel) Can we overlay mitigation options and prioritize areas in it? Could we have a national-scale, spatially referenced scheme where you could identify what would be the most fruitful mitigation option for your area, or a set of mitigation options?

Julie Heath: That is a super cool concept to overlay the lead, vehicle collision, and pathogen maps and get a feel for what might be most effective where, that might be a good next step.

Steve Slater: A next step for the vehicle collision model is to have a prioritization map similar to what they've done for electrocution risk, overlaying where densities of eagles are greatest in the winter and roadkill to prioritize where to do carcass removals. One of the advantages of getting this option added to in lieu fee programs is to increase the options for those paying into the system, so there are a mix of solutions to achieve the eagle credits.

Vince Slabe: I like Steve's map that shoes areas where we need to focus on carcass removal. If we had a map combining all these compensatory mitigation options into one map and let that drive the conversation instead of cost.

Recommended Resources

- Slabe et al., 2024. Efficacy of non-lead ammunition distribution programs to offset fatalities of golden eagles in southeast Wyoming. https://doi.org/10.1002/jwmg.22647

- Lonsdorf et al., 2023. Assessing carcass relocation for offsetting golden eagle mortality at wind energy facilities. https://doi.org/10.1002/jwmg.22478

- Heath et al., 2024. Disease and ectoparasite management improve nestling golden eagle health and survival: An effective mitigation strategy. https://doi.org/10.1101/2024.08.14.607861

Session 3: Eagle Permits, Monitoring, and Population Modeling in a Changing Regulatory Landscape

Management of eagle take at wind energy facilities has evolved since the publication of the Eagle Conservation Plan Guidance in 2013. Eagle rule updates in 2016 and 2024 have created data standards, established general permits, and provided permit conditions for compliance monitoring. This session brought together experts to discuss several aspects of eagle management and permitting including how eagle take permits can be adapted to information collected during monitoring, fatality monitoring approaches in the context of permit compliance, and implications of eagle mortality at wind turbines for population dynamics.

Moderator: Shawn Childs – Environmental Program Manager, PacifiCorp

Speakers:

- **Matt Stuber –** Raptor and Energy Lead, U.S. Fish and Wildlife Service
- **Eric Hallingstad –** Senior Biologist, Western EcoSystems Technology, Inc.
- **Simon Weller –** Associate Statistician, Western EcoSystems Technology, Inc.
- **Tara Conkling –** Biologist, U.S. Geological Survey

Link to Recording: https://vimeo.com/1032031247/d96afc74bb

Matt Stuber – U.S. Fish and Wildlife Service: Adapting eagle take permits to best available information

The U.S. Fish and Wildlife Service (USFWS) published their first eagle take permit regulation, which was subsequently revised in 2016 to introduce long term (30-year) permits and to define a preservation standard, which requires that the issuance of an eagle permit is consistent with the goal of stable or increasing breeding populations of eagles at two geographic scales (Eagle Management Unit, and Local Area Population: LAP). The eagle rule was revised again in February 2024, which introduces two permit types. The general permit is an automated permit issuance framework where a wind company can confirm that they meet eligibility requirements, register, and print out a permit in one day for projects in areas with low risk to eagles. Specific permits can last up to 30 years, and can be amended over time. They are similar to the former long-term permits, with some important updates. Under the previous regulation, long-term permits required mandatory check ins every 5 years. These check-ins were an opportunity for USFWS to review the best available information, including and especially site-specific fatality monitoring, and re-assess estimated fatality rates, effectiveness of fatality reduction measures, appropriateness of compensatory mitigation requirements, and estimated project impacts to eagle populations. Based on these check-ins, permit amendments, particularly amendments to compensatory mitigation requirements, could be performed.

If the permittee and the Service feel that permit conditions are appropriate, it is possible that no amendments are necessary for the life of a permit. The new specific permits do not require regular check ins, but the conditions (avoidance, minimization, adaptive management, compensatory mitigation) are set until either the permittee or USFWS requests that the permit be amended. The USFWS encourages permittees to review their data and conditions and apply for an amendment on an as-needed basis. Permittees can submit a request for an amendment online, along with justification for the amendment and supporting data. The USFWS reviews the request, conducts new analyses (Collision Risk Model: CRM, REA) if necessary, and will approve the request or propose changes. Amendments that do not require new analysis incur a $500 amendment fee; amendments that do require new analyses (i.e. new fatality estimation or mitigation method) incur an additional $10,000 administration fee. For the Service to conduct re-analysis of permit conditions and consider permit amendment requests by permittees, the permittee must have provided new and reliable information (e.g., site-specific fatality monitoring) that can be utilized in a re-analysis. Typically, this information will be post-construction fatality monitoring data, which must have been collected for at least two full years, achieved the required average site-wide g-value of 0.35, be accompanied by appropriate bias trial data, and representative of the project. However, such information could also be in the form of things such as updated operational daylight hours or updated project size and extent. The Service will utilize the best available tools for determining updated compensatory mitigation rates. All permits have monitoring and reporting requirements which are submitted for USFWS review to update fatality estimates and assess consistency with the preservation standard. If a permit is inconsistent with the preservation standard, the USFWS will alert the permittee and propose new terms. The permittee may accept the proposed terms (no fee) or negotiate new terms, which incur the $500 amendment fee and if necessary, the $10,000 administration fee if new analyses are required. Permittees may choose to implement minimization measures or conduct compensatory mitigation to bring the permit back into consistency with the preservation standard.

Limitations on Amendments: For Tier 1 permits, only minor amendments are allowed unless the permittee pays the Tier 2 application fee, with the exception of amendments to mitigation requirements. These amendments can be substantial, but will require two years of supporting data to justify.

Eric Hallingstad – Western EcoSystems Technology, Inc.: Strategies for efficient eagle fatality monitoring under the 2024 eagle rule

The U.S. Fish and Wildlife Service (USFWS) revised the eagle incidental take permit regulations (Permits for Incidental Take of Eagles and Eagle Nests; 2024 Eagle Rule) in April 2024. The revised regulations created General Permit and Specific Permit options for authorizing eagle take at wind energy facilities. Regardless of permit type, the USFWS requires wind energy facilities holding incidental eagle take permits to document permit compliance through fatality monitoring. For General Permits, the USFWS requires minimal fatality monitoring effort—quarterly visits to each turbine, scanning visible areas out to at least 40 meters from turbine bases (referred to as "concurrent monitoring" by USFWS, as these searches are meant to be readily conducted by Operations and Maintenance personnel during their normal day-to-day activities). However, in the recently released *Specific Permit Conditions – Incidental Take of Eagles by Wind Energy Projects - Tier 1*, the USFWS requires the implementation of Standard Monitoring for all Specific Permits authorizing the take of eagles. The USFWS defines Standard Monitoring as eagle fatality monitoring that achieves an average annual site-wide probability of detection, or *g*, of greater than 35% (0.35) over a five-year period. This level of monitoring will have substantial cost implications over a permit term, particularly for long-term permits lasting up to 30 years. Challenging site characteristics—such as topography, dense vegetation, and agricultural activities—can limit a permittee's options for attaining the minimum *g* tied to Standard Monitoring. Furthermore, the USFWS's Specific Permit conditions also require five years of Enhanced Monitoring, defined as monitoring that achieves an average annual *g* of >50% (0.50) over a five-year period, to assess the efficacy of any adaptive management response triggered during the permit term or if the 0.35 average annual *g* is not met during Standard Monitoring. To decrease monitoring costs, a permittee will need to develop an efficient eagle fatality monitoring protocol that provides a quantifiable detection probability. Permittees can then demonstrate eagle take permit compliance by using optimized search protocols that balance detection probability with monitoring effort and costs.

The g-value is a product of searcher efficiency, carcass persistence, and an area adjustment, so maximizing these values will result in a robust g. In landscapes with low viewshed complexity, scan-based searches from the base of each turbine can be an efficient alternative to labor intensive fatality searches (e.g., transect-based). If searcher efficiency is a challenge, the use of drones or dog teams can increase detection rates, though these searches may be costly and more research is needed on these methods. Game bird carcasses have traditionally been used in lieu of raptor carcasses for persistence trials, but the comparatively short persistence times for game bird carcasses results in higher and less accurate eagle take estimates. It is important to move away from the use of game birds for these trials in an eagle fatality estimation scenario. The model used by the USFWS's National Eagle Support Team (NEST) to estimate the area adjustment shows a relatively uniform carcass distribution from the base of the turbine out to about 100 meters, and then the distribution drops sharply. If search plots only extend to 80 meters from each turbine, that could result in a 20% drop in the predicted carcass availability in your search plots--substantially lowering the resulting g-value. Not only can a low g-value result in additional fatality monitoring requirements, but greater uncertainty leads to higher fatality estimates and may require adaptive management responses and an increased compensatory mitigation burden.

When designing your monitoring methodology, it is important to consider your site conditions and to choose the most efficient and appropriate monitoring methods to ensure that you achieve an average annual g-value of >0.35 over each 5-year period. Permittees should consider mapping the viewshed complexity at their site, utilizing site-specific or regional data for bias trials, and running simulations to predict g-values for a variety of search methods to assist in developing an efficient monitoring plan.

Simon Weller – Western EcoSystems Technology, Inc.: Permitted take implications associated with the 2024 eagle rule

The U.S. Fish and Wildlife Service (USFWS) revised the eagle incidental take permit regulations (Permits for Incidental Take of Eagles and Eagle Nests; 2024 Eagle Rule), which were published in the Federal Register in February 2024. The USFWS stated the purposes of the revisions are to "increase the efficiency and effectiveness of permitting, improve clarity for the regulated community, and increase the conservation benefit for eagles." The 2024 Eagle Rule included the creation of the general permit option for wind energy facilities that meet eligibility criteria based on eagle abundance and eagle nest proximity. To determine which areas would be eligible for specific permits, the USFWS created a map based on eBird data showing the 50th quantile of relative abundance for golden eagles, and the 95th quantile of relative abundance for bald eagles. The 2024 Eagle Rule also added a tiered system for specific permits, designed to improve permitting process efficiency. In the Final Environmental Assessment supporting the rulemaking, the USFWS presented compensatory mitigation rates and requirements for bald and golden eagles.

The USFWS uses a Collision Risk Model (CRM) to predict eagle fatalities at a given wind site, based on the exposure rate, collision probability, and an expansion factor. In the revised eagle rule, the USFWS has developed four new exposure prior distributions for the CRM based on field data, with variations for each eagle species and for the general and specific permit zones. The exposure prior distributions are used in combination with available eagle minute data (if available) to quantify the level of eagle exposure to turbines at a project for calculating take predictions. The bald eagle exposure prior-only prediction is much higher than its golden eagle counterpart when no post-construction monitoring (PCM) data is incorporated. When PCM data are incorporated (g – 0.35, no fatalities found), an increase in observed eagle use results in a marginal increase in the fatality prediction. Both pre- and post- construction eagle use and/or fatality data are important for improving eagle take predictions.

There is a potential pathway for a wind project in the specific permit zone to pursue a general permit if the developer can demonstrate that the eagle collision risk is low enough to be comparable to projects in the general permit zone, though it is uncertain how the USFWS might evaluate such projects. To pursue this option, the developer would apply for a specific permit, but request general permit consideration, along with site-specific data justifying the low take prediction. The service may grant general permit eligibility if the data indicate sufficiently low risk to eagles. Take thresholds for consistency with general permit standards are 1.01 bald eagles, or 0.07 golden eagles, per 100 turbines, per year. Pre-construction eagle use data will be important in updating take estimates for general permit eligibility.

Tara Conkling – U.S. Geological Survey: Regional vulnerability of golden eagles to renewable energy production

As renewable energy production expands across North America, regulatory guidelines often call for estimates of population level impacts of renewable energy-derived fatalities on wildlife. We developed a framework to define the geographic origin of individuals killed at renewable facilities and then to use demographic models to estimate consequences of renewable energy development for those origin populations. Previous studies have used stable hydrogen isotope values (δ^2H) to define the geographic origin, but there is substantial uncertainty associated with hydrogen-based origin assignment. To overcome these challenges, we used a multi-isotope approach to geolocation, considering isotopes of sulfur ($\delta^{34}S$) in addition to δ^2H values to evaluate the subpopulation of origin for Golden Eagles found dead at wind energy facilities and from other sources of anthropogenic-based fatalities in Wyoming. We then used a Bayesian integrated population model to identify vulnerability of these subpopulations to fatalities from wind energy development.

Preliminary data suggest that the multi-isotope assignment process using δ^2H and $\delta^{34}S$ values resulted in improved estimates of population of origin compared to those derived from a single isotope alone. Demographic models identified widely varying levels of vulnerability among subpopulations, with notable differences between migratory and resident populations. Our approach illustrates the relevance of multi-element isoscapes to further identify subpopulations of interest and assess vulnerability of species potentially affected by wind energy development for multiple distinct breeding and wintering subpopulations.

Audience Questions & Speaker Response/Discussion

(for Simon Weller) Should development sites in the general permit area collect pre-construction eagle use data? And, is there a more efficient way to predict whether a project will likely comply with the general permit requirements over the five year permit term?

Simon Weller: I never want to advise against collecting data or information about your site, but it may not be necessary if you meet all of the general permit requirements set by the USFWS. I don't know of a more efficient way to predict compliance.

(for Matt Stuber) Availability of raptor carcasses is a limiting factor for bias trials for post-construction fatality monitoring. Is there any plan for the U.S. Fish and Wildlife Service (USFWS) to develop a conversion or framework for carcass persistence using game birds?

Matt Stuber: The USFWS is aware and recognizes that it's hard to obtain raptor carcasses to estimate carcass persistence. We have compiled data from sites we have access to and are working on a solution which is forthcoming. It is on the way, we are hopeful to have a value that is a little conservative that a developer can use if they don't have site specific data.

Eric Hallingstad: Western EcoSystems Technology, Inc. (WEST) has developed a model to scale up game bird persistence data to reflect raptor persistence that has gone through the peer review process and was published recently. It is available as a tool, but we have not heard the USFWS provide support for the use of our model.

(for Tara Conkling) What was the primary source of mortality for the 172 golden eagles in Wyoming?

Tara Conkling: I don't remember off the top of my head, but if you contact me later I can give you that breakdown.

(for whole panel) Is it reasonable to expect that if a project cannot achieve a 0.35 g-value will be able to then achieve a 0.5 g value?

Matt Stuber: That depends on the reason you didn't achieve a 0.35 g-value. If it is because it was impossible, or because you made a decision not to monitor rigorously enough? We do recognize there are situations where achieving a 0.35 g-value will require more work and that's just a function of the site.

Eric Hallingstad: There are some things within the g-value that you can control, like your detection, to some extent, and your area adjustment. If carcass persistence is your issue, you may not be able to achieve a 0.5 g-value no matter how hard you look, but you can increase your search effort and area.

Matt Stuber: The USFWS strongly recommends that if you're trying to meet a 0.35 g-value, you should aim a little high, that way if year 5 comes and carcass persistence is a problem or there are other reasons your g-value is lower than expected, you have a buffer.

Eric Hallingstad: However, adaptive management triggers are based off of carcasses found and assume a g-value of 0.35, so if you search more efficiently, you are likely to find more carcasses and trigger adaptive management, which would require going to the USFWS to prove that your g-value is high and that your adaptive management triggers should be adjusted.

(for Matt Stuber) How do you envision estimating Local Area Population (LAP) for new permits going forward?

Matt Stuber: Estimating LAP for specific permits will be similar to how it's always been, the U.S. Fish and Wildlife Service (USFWS) will run a site-specific analysis and determine consistency with the preservation standard at that scale for every permit application. For general permits, there will be a post-hoc LAP analysis. The USFWS has mitigation rates we are requiring in each Eagle Management Unit for general permits, and built into that rate is a small amount of mitigation that can be banked and used in case the USFWS finds out down the line that we are at risk of not being consistent with the preservation standard in a particular LAP. So if the USFWS issues 50 permits and 40 of them are in the same LAP, we have a way to go and put mitigation on the ground to ensure the take authorized is consistent with the preservation standard.

(for Matt Stuber) Looking into your crystal ball, do you see any possible changes to implementation of the 2024 Eagle Rule with the change in the administration?

Matt Stuber: I unfortunately do not have an answer about what the new administrations priorities will be. I can say that we worked hard to get the rule finalized in a timely manner, far ahead of the Congressional Review Act deadline under which a new administration can reach back and nullify a rule without explanation. Beyond that, I cannot say. Stay tuned.

Recommended Resources

- Millsap et al., 2022. Age-specific survival rates, causes of death, and allowable take of golden eagles in the western United States. https://doi.org/10.1002/eap.2544

- Hallingstad et al., 2018. Developing an efficient protocol for monitoring eagle fatalities at wind energy facilities. https://doi.org/10.1371/journal.pone.0208700

- Hallingstad et al., 2023. Game bird carcasses are less persistent than raptor carcasses, but can predict raptor persistence dynamics. https://doi.org/10.1371/journal.pone.0279997

Special Session: A Celebration of 30+ Years of Cross-Sector Collaboration on Wind and Wildlife

Moderator: Abby Arnold – Executive Director, Renewable Energy Wildlife Institute

Honorees:

- Robert Thresher, National Renewable Energy Laboratory (NREL)
- Jan Beyea, formerly with the National Audubon Society
- Eric Lantz, U.S. Department of Energy (DOE) Wind Energy Technologies Office (WETO)
- Tom Vinson, American Clean Power Association (ACP)
- Jerome Ford, U.S. Fish and Wildlife Service (USFWS)
- Jon Belak, National Audubon Society
- Christy Johnson-Hughes, U.S. Fish and Wildlife Service (USFWS)
- Rachel London, U.S. Fish and Wildlife Service (USFWS)
- Cris Hein, National Renewable Energy Laboratory (NREL)
- Sam Enfield, Former President of the American Wind Energy Association (AWEA)
- Rene Braud, formerly with Pattern Energy
- Meaghan Gade, Association of Fish and Wildlife Agencies (AFWA)
- Aimee Delach, Defenders of Wildlife, REWI Board Chair
- Katie Umekubo, Natural Resources Defense Council (NRDC)
- Clay Crowder, Arizona Game and Fish Department, Association of Fish and Wildlife Agencies (AFWA), REWI Board Member
- Tim Hayes, Natural Resource Solutions, LLC, formerly with Duke Energy Renewables
- Christina Calabrese, EDP Renewables, REWI Board Member
- Misti Sporer, Deriva Energy, REWI Board Vice Chair

The Renewable Energy Wildlife Institute (REWI) was thrilled to highlight decades of cross-sector collaboration around wind energy and wildlife with a special session at the 15th biennial Wind Wildlife Research Meeting (WWRM). REWI gathered representatives from the renewable energy industry, conservation science nonprofits and public agencies to celebrate all who have collaborated on wind and wildlife research and policy over the last 30 years. Seventeen individuals were honored not just for their role, but for the commitment of their respective organizations to support extraordinary collaboration on the key questions and paths forward for renewable energy.

The special session was led by REWI Executive Director Abby Arnold, with Honorees Eric Lantz (DOE), Jerome Ford (USFWS), Jon Belak on behalf of Garry George (National Audubon Society), Sam Enfield (former AWEA President), and Christina Calabrese (EDP Renewables, REWI Board) all sharing statements on the value of collaboration to their respective organizations, and the critical role REWI plays in facilitating those needed ties.

Three Decades of Collaboration: This collaboration began in 1994, when the U.S. Department of Energy (DOE) and the National Renewable Energy Laboratory (NREL) joined with the renewable energy industry, conservationists, and public agencies to form the National Wind Coordinating Collaborative (NWCC). This cross-sector convening of stakeholders provided the foundation to advance progress in understanding the risk for wind energy on wildlife, and support research that has provided solutions to minimize and mitigate wind energy development impacts on wildlife.

Recognizing the value of collaboration, the U.S. Fish and Wildlife Service (USFWS) created a Wind Turbine Guidelines Federal Advisory Committee (FAC) which ultimately resulted in a consensus agreement. This collaboration and research informed the USFWS Land-Based Wind Energy Guidelines (WEGs) published as final in 2012. REWI (then the American Wind Wildlife Institute, AWWI) was founded in 2008 from the successes of this history of collaboration, at the end of the FAC process. REWI's partners and collaborators have demonstrated the value of working together to advance responsible clean energy development – and continue to do so. Even with some of the most challenging wind and wildlife issues – including the impact of wind on bald and golden eagles – collaboration has led to breakthroughs. Just this year, the USFWS published an updated Eagle Rule in early 2024 based on 12 years of research and input from key stakeholders.

REWI and its collaborators are looking forward to continuing this positive action in 2025 and beyond, to continue facilitating renewable energy development that conserves and mitigates impacts on wildlife. Honorees and WWRM attendees also took this session to thank REWI's Abby Arnold for her decades of tireless work facilitating these processes, with REWI Board Vice-Chair Misti Sporer (Deriva Energy) dedicating a reading of Louis L'Amour's "Embers in the Dark" in her honor. Abby concluded the session by calling on those in the room to carry these efforts forward. The session ended with attendees on their feet, looking forward to continuing this collaboration over the years to come.

For biographies of each honorees and additional quotes from the session, please visit the corresponding news article on REWI's website titled "REWI Celebrates 30+ Years of Cross-Sector Collaboration on Wind and Wildlife."

Recommended Resources

- There are no recommended resources for the special session.

Session 4: Confronting the Climate and Biodiversity Crises with a Responsible Transition to Wind Energy

This session delved into big-scale questions about the relationships between renewable energy development and species extinction rates, and the costs and trade-offs related to curtailment, mitigation, and siting. The session also discussed the dynamics and importance of cross-sector relationship building and collaborations between developers, agencies, and conservation organizations.

Moderator: Eric Schauber – Director of Research and Programs, Renewable Energy Wildlife Institute

Speakers:

- **Paul Rabie –** Principal Statistician, Western Ecosystems Technology, Inc.
- **Christian Newman –** Technical Executive – Endangered and Protected Species Research Program, Electric Power Research Institute
- **Cris Hein –** Senior Project Leader, National Renewable Energy Laboratory
- **Claire Burch –** Ph.D. Candidate, University of Oklahoma
- **Jamelle Ellis –** Senior Scientist, Theodore Roosevelt Conservation Partnership
- **Christi Calabrese –** Senior Director, Permitting and Environmental Affairs, EDP Renewables
- **Ben Thatcher** – Chief, Branch of Environmental Review, U.S. Fish and Wildlife Service

Link to Recording: No recording is available for Session 4.

Paul Rabie – Western Ecosystems Technology, Inc.: Renewable energy's potential to reduce global climate-mediated extinction risk

Decarbonizing electricity production underpins every scenario in which humanity avoids causing catastrophic levels of global warming. How the pace and scale of the energy transition will shape biodiversity outcomes, however, remains to be described quantitatively. To help answer this question, we predicted extinction rates of terrestrial plants and animals as a function of the rate at which renewables–specifically, wind and photovoltaic solar–replace fossil fuels as a source of electricity.

We looked at 5 build out scenarios to model global surface temperatures and wildlife extinction risk (for all taxa, Australian rainforest vertebrates, and land birds) in response to each scenario. "Business as usual" and an "Instant" transition to renewable energy were used as bookend scenarios to compare "slow", "linear", and "rapid" renewable energy build out. Under the "business as usual" scenario, global temperatures were modeled to rise to 4° C above historic average by the 2100, and 17-22% of taxa are at risk of extinction. Under the "instant" scenario, both temperature and extinction risk remain fairly stable.

Using these three estimates of the relationship between surface temperature increases and extinction risk for terrestrial plants and animals, we show that delaying the adoption of renewables and the elimination of fossil fuels substantially increased the number of species committed to extinction by 2100. Slowly replacing fossil fuels with renewable energy such that they did not come to dominate electricity generation until late in the 21st century yielded extinction rates only modestly lower than a business-as-usual approach in which unabated fossil fuels remained a large part of the energy mix. In contrast, a rapid energy transition with a rapid phase-down of fossil fuels yielded much lower predicted extinction rates that were not substantially different from a counterfactual scenario in which wind and solar energy instantly and immediately replaced all fossil-fuel-generated electricity. While the model cannot incorporate all the nuances of the real world, these estimates show that any policies slowing capacity growth of renewable energy will increase the number of species driven to extinction by human-caused climate change.

Christian Newman – Electric Power Research Institute: Financial implications of existing U.S. wind facilities from turbine curtailment for bats

Wind energy is responsible for hundreds of thousands of bat deaths annually from collisions with wind turbines. White nose syndrome has decimated many species of cave roosting bats, causing their take by the wind industry to be regulated. Hoary bat populations are likely declining due to wind energy development and may pose a future regulatory risk. To minimize bat deaths, many wind facilities use turbine curtailment during periods of expected bat activity–mainly at night during the summer and early fall when wind speeds are low. Turbine curtailment is currently the most effective tool for reducing bat fatalities, though there are a few deterrent systems in development and testing. Though curtailment is effective, it also has economic and renewable energy/carbon impacts.

This study simulated wind energy production at 18 existing wind facilities across the contiguous United States (US) under varying curtailment scenarios covering the period of April 1 – October 31. The curtailment scenarios included both “smart” and “blanket” curtailment approaches with cut in speeds of 5.0 m/s and 6.9 m/s. We evaluated annual energy production (AEP) under each scenario and analyzed the impact financially of each wind facility. We found a national median 0.12% to 1.91% AEP loss with our low and high curtailment scenarios from curtailment across the U.S. For many wind facilities, this AEP loss could affect their financial viability, as under high scenarios, curtailment resulted in a negative net present value (NPV) for over 13% of wind facilities. The study also analyzed the regional differences, divided by U.S. Fish and Wildlife Service (USFWS) Regions. Our findings suggest that curtailment with low cut-in speeds may not alter AEP significantly, but more stringent curtailment could negatively affect wind facility financials. The cumulative impact of curtailment could exceed $100 million in costs for the wind industry in some USFWS Regions. Estimating precise financial losses from modeled curtailment scenarios is extremely complicated and nuanced, but this model is a good start to discuss the potential magnitude of the costs of curtailment. Future directions for this research may focus on other financial metrics for the viability of wind facilities. They could examine AEP loss from different smart curtailment technologies to better understand how wind facilities can pursue cost-effective curtailment to reduce bat fatalities.

Cris Hein – National Renewable Energy Laboratory: Using the Renewable Energy Potential model (reV) as a framework to evaluate wildlife considerations on renewable energy production, siting, transmission and deployment

Current decarbonization modeling often employs techno-economic and capacity expansion tools that have limited ability to represent wildlife considerations related to wind energy. Doing so can be challenging in national models for many reasons, including a lack of data, variation in type of interaction across species, as well as varying behavioral responses in space and time.

We present the Renewable Energy Potential model (reV) as a framework to account for wildlife interactions with wind energy systems. reV is a hierarchical geospatially explicit model that couples highly efficient power system generation modeling with high resolution siting and transmission data to create supply curves. The model incorporates databases on the built environment (buildings, roads, energy infrastructure, etc), landscape features (topography, hydrography, habitat types, protected lands, etc.), regulatory landscape (renewable energy ordinances, setbacks, limits on sound, hub height, shadow flicker, etc), and renewable energy resource availability (wind speed, solar irradiance, climate projections). We summarize three studies that demonstrate how reV incorporates wildlife considerations ranging from energy production curtailment; implications of ecological mitigation costs on transmission interconnection lines; and the incorporation of wildlife siting constraints to evaluate impacts to future RE deployment, electricity prices, and emissions.

We briefly discussed "National-scale impacts on wind energy production under curtailment scenarios to reduce bat fatalities" (Maclaurin et al 2022), in which we analyzed the economic viability of wind plants across the country under a range of curtailment strategies meant to minimize risk to bats. We then discussed how reV incorporates impacts to wildlife in its turbine and transmission siting.

Finally, we presented on "How ecological restrictions combine with social factors to impact national wind energy potential and deployment" (Lopez et al in review). In this project, we found that increased ecological siting constraints for key wildlife considerations and habitat could reduce available technical potential for wind energy from a baseline of 15.43 TW to 7.57 TW. When coupled with high social constraints, technical potential could be further reduced to 1.88 TW. We used the Regional Energy Deployment System (ReEDS) model to estimate future buildout to meet national decarbonization goals under these siting regimes. If wind energy development avoids both areas of high social and high ecological stress, there could be a shortfall in the amount of wind energy, which will likely need to be offset primarily through additional solar energy development. However, solar and other renewable energy sources all have their own social and ecological constraints. We also found that the increased constraints on wind energy could lead to higher electricity prices as well as higher emissions, demonstrating that more work is needed to understand the tradeoffs between decarbonization goals and wildlife considerations.

Claire Burch – University of Oklahoma: We're all in this together: building better relationships in the environmental planning of wind energy

Planning and successfully deploying land-based utility-scale wind energy is not a task that can be taken on by wind energy developers in isolation but requires a collaborative governance approach including diverse perspectives at the table. Loveless et al. (2021) called for, in The Wildlife Professional, "Increase[d] collaboration between state agencies, industry and conservation organizations... Reduced conflict regarding wind energy development and wildlife impacts requires increased collaboration and good faith participation by all stakeholders." Complex problems like building large wind farms in more ecologically sensitive habitats will require more innovative and pragmatic planning.

This research explored the perspective of renewable energy developers, state and federal regulators, and environmental non-profits on the environmental permitting and planning of utility-scale wind and solar development in the Great Plains region of the U.S. The study focused on the feedback all three groups provided as to their relationships with each other, to share honest insight into feelings left unsaid at the table and provide suggestions of what might be next in building better relationships to continue deployment of wind energy across the region.

We focused on the Great Plains region for this research – North Dakota, South Dakota, Iowa, Nebraska, Kansas, Oklahoma, and Texas – because this is a region with a similar level of regulatory oversight and associated guidance in place. We conducted 56 hour-long interviews via Zoom with our three groups of interest from March to October 2023. Our final participant group included 19 developer staff members representing 15 development firms, 18 regulatory staff members from state and federal agencies, and 19 environmental non-profit staff members representing 13 organizations. We used a snowball sampling approach to recruit participants, starting with individuals that we knew and then asking for recommendations upon completion of the interview. All interviews were transcribed from recordings; for any participant that declined to be recorded, detailed notes were taken and used alongside the transcripts. We utilized a qualitative analysis approach, coding all transcripts in NVivo.

A key theme shared by all three groups regarding their relationships with one another was the importance of relationship building, collaboration, and respect. They recognized that relationships were often contingent on individual personalities and biases, and that the best conversations were the ones where it felt like everyone was participating and there were tangible outcomes. All three groups shared both positive and negative perceptions associated with previous interactions, which is important feedback to help improve future interactions. Participants often brought up unprompted the dichotomy they experience in the industry between deployment of renewable energy and protection of local biodiversity.

In discussing the relationship between developers and agency staff members, developers noted that some of the challenges in consultation with agencies arose from turnover in agency staff, and variable application of the same guidelines between agencies. Developers, however, discussed a number of positive experiences in working with regulators, an important perspective to highlight. Agency staff noted that after the conclusion of consultation, follow-up communication was rare and it was, therefore, difficult to know if there was implementation of recommended conservation practices. Further, there exists a stigma that regulators are against renewable energy development, which does not appear to often be the case Staffing capacity was also a consistent topic of discussion, with an emphasis on the often limited capacity and concerns that capacity will present challenges as the workload for permitting renewable energy projects increases. Overall, developers and regulators should consider increasing their collaboration and creating consistency in the permitting processes.

While some non-profit organizations have a relationship with developers, a number of non-profit organizations do not engage with developers at all, due to the lack of opportunity or bandwidth. Non-profit organizations are also not a monolith, and do not always coordinate closely or have the same priorities. Some non-profits engage with regulatory agencies, often through working groups or advisory communication, but this engagement is currently limited. Agency staff members noted that guidelines developed by non-profit organizations do not always align well with the regulatory landscape, which emphasizes the potential benefit of non-profit organizations communicating more consistently with agencies

Ultimately, successful build out of renewable energy development will require increased collaboration between these three stakeholder groups, including building and maintaining relationships between individual people in each group.

Jamelle Ellis – Theodore Roosevelt Conservation Partnership: Untitled remarks

The Theodore Roosevelt Conservation Partnership (TRCP) has a mission to ensure that all Americans have quality places to hunt and fish. We engage with policy and advocacy, including responsible renewable energy development focused on migratory big game species. TRCP collaborates with policymakers at the federal and state levels to integrate renewable energy policies as demand increases. While recognizing the importance of renewable energy development for conservation, TRCP emphasizes that such development can have significant consequences for wildlife and habitat. Policymakers, non-governmental organizations, and the renewable energy industry must work together to minimize impacts on wildlife, including siting renewables to avoid sensitive ecosystems. For example, wind turbines can disrupt sage-grouse leks, contributing to population declines. Other species, such as mule deer, may also experience displacement due to wind infrastructure. Big game species require large, contiguous areas of land and habitat, but wind energy development can result in permanent changes in land cover or habitat fragmentation. Land disturbances, including fencing, can be further compounded by the spread of invasive plants, which create highly flammable fuel loads and increase the frequency and intensity of wildfires. Post-fire, landscapes often become dominated by low-nutrition invasive plants, triggering a snowball effect that leads to malnutrition, reduced reproductive success or survival rates, and further population declines. TRCP is involved in assessing solar projects focused on responsible siting that limit adverse impacts on wildlife habitats. The Big Game Guidelines for Utility-scale Photovoltaic Solar Development were released in August 2024. The purpose of this document is to supplement state-specific guidelines and best management practices to provide state wildlife agencies as well as industry, non-governmental organizations, and members of the public who engage in solar development projects, with additional science-based recommendations specifically for western big game species for example ungulates including mule deer, elk, and pronghorn, many of which migrate long distances between seasonal ranges.

Christi Calabrese – EDP Renewables: Untitled remarks

Christi Calabrese oversees environmental permitting and permit compliance for EDP Renewables North America's (EDPR NA's) projects in the U.S., Canada, and Mexico. Her team gets involved in the development process early on, during the prospecting stage. There are many considerations when developing a project such as access to transmission and community-scale concerns. Environmental considerations, although important, are not always the top consideration when deciding if a project should move forward. When a project is far along in development, the environmental team will conduct field studies to understand the resources on site and how best to reduce impacts. Engaging with stakeholders early on in the development process is key to make the best decisions for the project. The end goal is to have the most environmentally responsible project, for the life of the project. Adaptive management is important because some projects have unexpected impacts. Fatality monitoring is currently a hot topic, and the industry would like to move away from project-by-project monitoring. How can we leverage the wealth of existing data and potentially divert those funds from monitoring to conservation? Time and resources are limited for industry as well as wildlife agencies, so we need to concentrate on wildlife issues with the greatest impact. We particularly need to put our resources towards bat conservation. We have made some headway with risk minimization technologies for bats, but the development and testing for these technologies is extremely expensive. Collaboration and communication within the various stakeholders are key in making progress on all these issues. A good example of collaboration is the communication framework that the American Clean Power Association (ACP), the wind industry, and the Association of Fish and Wildlife Agencies (AFWA) developed, and the first section of this Framework focuses on relationship building.

Ben Thatcher – U.S. Fish and Wildlife Service: Untitled remarks

The U.S. Fish and Wildlife Service (USFWS) is currently focused on ecological services, and recently created new position for offshore wind. We also have counterparts in the national migratory bird program, and regional offices. Our staff have expertise in each field office. Partnerships are key, including our formal liaison relationship with the Renewable Energy Wildlife Institute (REWI). Our goal is to deploy 25 GW of wind by 2025. We are working with industry groups, the Association of Fish and Wildlife Agencies (AFWA), and other federal agencies such as the U.S. Department of Energy (DOE), U.S. Geological Survey (USGS), and the National Renewable Energy Laboratory (NREL) to achieve this goal. We are working to streamline Endangered Species Act (ESA) compliance. Early engagement is important. We have published mitigation policies and are working on regulation for compensatory mitigation review and implementation to ensure consistency.

Audience Questions & Speaker Response/Discussion

(for whole panel) How do you handle the mismatch of the level of detail and scale we have for different pieces of information? For example, spot prices for electricity, viewsheds at specific turbines, vs. what we know or don't know about the hoary bat population, or how a certain species might be affected by climate change?

Paul Rabie: We need to act based on what we do know. Every new project can be a hypothesis on the landscape. There is a great deal of variation in the precision with which we know things, but what happens when we talk too much about uncertainty is that we delay and fall behind on our renewable goals – and that is a choice.

Christian Newman: We need to come to a consensus about what we know and when it's good enough. Collecting data delays decisions; we have to understand that there will be uncertainty and consequences, but that we're also running out of time.

Cris Hein: There are two kinds of data: precise engineering data, and messy biological data. We don't have the best tools or methodologies to get a precise population size for bats, there will always be huge error bars. Hopefully development of technologies will help.

Claire Burch: I agree that we need consensus surrounding what uncertainty we can live with. People get caught up in the big picture, but the reality is that the local environmental conversation are becoming a pinch point in development. We need to get better at taking big picture concepts and translating them to the local scale. We need folks who are good at communication to do this work; you can do more harm than good for renewable energy development if you are not skilled at navigating these challenges.

Jamelle Ellis: TRCP is a policy and advocacy organization, and we participate in the Association of Fish and Wildlfie Agencies (AFWA) energy committee and other groups. In August 2024, we contributed to Hall Sawyer (Western Ecosystems Technology)'s solar/big game siting guidelines. It is important to provide recommendations based on science and data.

Christi Calabrese: We have to look at the information that we have, make a decision, and move forward. The amount of data that we currently gather project-by-project is unsustainable.

Ben Thatcher: Our ability to engage in clean energy project review and planning is hindered by the volume and demand for all projects coming through our offices, not just renewables.

(for Christian Newman) When converting power loss data into revenue loss, did you include time of day and pricing into your comparison of different curtailment scenarios?

Christian Newman: Our current analysis is more of a back-of-the-napkin estimate, but we plan to a more detailed analysis later. It is difficult to decide what is the right cost data to use for such an analysis, because there are lots of different options. But it is important to do these analyses in terms of dollars because you have to make an economic case to move the conversation forward.

(for Christian Newman) There is a huge spread of responses across facilities regarding the cost of curtailment. Do you have any insights related to what caused your high curtailment costs?

Christian Newman: One major factor is project size, a big project will incur bigger curtailment losses.

Christi Calabrese: Cut in speed also makes a huge difference in the cost of curtailment, especially when going from a 5.0 m/s curtailment to 6.9 m/s.

(for Claire Burch) Is there any evidence that a developer's focus on climate change can reduce trust in a community? If so, how do you manage it?

Claire Burch: The climate change vs biodiversity dichotomy can be divisive, and we've spent a lot of time talking about how discrediting that dichotomy is, particularly when the community is focused about protecting their local biodiversity while developers are more passionate about climate change. It could be better to deemphasize climate change in these conversations and focus on the values of the people you are talking to.

(for whole panel) How big are aggregate costs of conservation? Christian congregated costs by region; are there strategies to deal with these costs, and can they be passed onto consumers?

Christian: That is a hard question to answer. There are curtailment costs, compensatory mitigation, and monitoring. If you curtail your turbines, where is that energy then going to be produced? If all the wind turbines in the Midwest curtail at the same time, can the grid handle that variability? Are you burning fossils fuels instead? Biodiversity loss has value.

Power purchase agreements must be met; for future wind farms, could curtailment losses be built into the power purchasing agreement/ We need large scale, collective action, which is challenging because each company needs to make sound financial decisions for each project.

Christi Calabrese: Companies have different business plans and decision making. EDP Renewables will seek a permit if they have a bat problem at their wind facility, but their neighbor might not, and their project and pricing might be more competitive as a result. There is a trade off, and it can hurt the project's ability to be built if not everybody is participating in conservation measures.

Recommended Resources

- There are no recommended resources for session 4.

Session 5: Leveraging Existing Data Towards Proactive Conservation

This session summarized what we have learned from fatality monitoring at wind facilities over the past 20 years, including insights into large-scale estimates of fatality rates and population trends for birds and bats in North America and the presentation of new modeling approaches to improve estimates of fatality rates at both large and small scales.

Moderator: Meaghan Gade – Energy and Wildlife Program Manager, Association of Fish and Wildlife Agencies

Speakers:

- **Andrew Wilk –** Data Manager, Renewable Energy Wildlife Institute
- **Rhett Good –** Principal Biologist, Bat Practice Group, Western EcoSystems Technology, Inc.
- **Teresa Bohner –** Biologist, U.S. Geological Survey
- **Ashton Wiens –** Mathematical Statistician, U.S. Geological Survey
- **Faith Kulzer –** Associate Statistician, Western EcoSystems Technology, Inc.
- **Michael Sullivan –** Fisheries Scientist, Alberta Fish and Wildlife
- **Quintana Hayden –** Senior Director, Wildlife & Federal Lands, American Clean Power Association
- **Karen Herrington –** Midwest Region Ecological Services Program Leader, U.S. Fish and Wildlife Service

Link to Recording: https://vimeo.com/1032035372/1aa1b114f9

Andrew Wilk – Renewable Energy Wildlife Institute: Bird and Bat Fatality - Insights from combined efforts and an integrated model

Accurate estimates of cumulative bird and bat collision fatalities at wind facilities on regional or national scales are critical to understand the impacts on their populations. Some facilities have post-construction fatality monitoring data which are used to estimate a facility-specific fatality rate estimate (FSFR) but many facilities are unstudied or their data are not available. Therefore, characterizing cumulative fatality across regions requires predictive modeling using known FSFR rates to estimate collision fatality at unstudied sites. However, post-construction monitoring data are not always collected in the same way and FSFR can be estimated using different analyses. To build predictive models, it is necessary to either ignore the variability in methods used to generate FSFRs or develop an approach which can accommodate the differences while accurately characterizing error.

We estimated cumulative fatality for the Great Plains ecoregion by using known FSFR estimates and predicting to facilities without available data. Our modeling approaches included bootstrapped averaging, a simple linear model, and a hierarchical model. The bootstrapping approach uses a known set of estimates to generate a sample mean, resamples the set many times to generate a distribution of means, and uses the mean and error of the resulting distribution to extrapolate across all facilities in a region. This approach cannot accommodate any variability in site specific fatality due to the landscape context of individual facilities or variation in survey and analysis methods. The linear modeling approach predicts FSFR using facility characteristics and landscape context as covariates. This approach allows fatality rates to be estimated using environmental relationships that may drive the estimates but still ignores the variability in how the mortality studies were conducted and analyzed.

Previously, we developed a hierarchical model to accommodate the variation in post-construction methodology and make data from these different efforts comparable. We have extended this model by incorporating facility, landscape, and seasonal effects to predict daily mortality, searcher efficiency, and carcass persistence for multiple facilities concurrently. By enhancing the model in these ways, we can account for the effects that local landscapes and time of year might have on mortality, carcass persistence, and searcher efficiency and incorporate that variance when extrapolating to data-deficient facilities. Use of the hierarchical model requires a higher standard of data compared to the bootstrap and linear model approaches. We fit the model for all non-raptor bird species, and a subset of 4 migratory bat species. We found that the three methods of predictions had similar cumulative fatality estimates, but we are more confident in the uncertainty estimates provided by the hierarchical model.

By predicting mortality at a daily rate we were able to model the annual peaks in avian mortality that coincide with migrations. By expanding our model to include variance in carcass persistence, searcher efficiency, and daily mortality rates, we have developed a way to leverage data from broad spatial extents and multiple study types. Next steps to further develop this approach are to incorporate additional data to broaden spatial extent of our predictions, incorporate the effects latitudinal gradient on the timing of fatalities, and to assess the influence of covariates on ecological and observation processes.

Rhett Good – Western EcoSystems Technology, Inc.: Twenty years and 600 post-construction monitoring studies – what have we learned? An overview of the results of the USFWS and ACP meta-analysis, and how the information can be used to inform monitoring strategies

Beginning in the late 1990s, many wind energy companies commissioned voluntary studies of bird and bat mortality to better understand impacts from wind energy development. The U.S. Fish and Wildlife Service (USFWS) Land-based Wind Energy Guidelines (2012) recommended post-construction monitoring studies designed to estimate bird and bat mortality at most wind energy facilities, and companies responded by commissioning hundreds of post-construction monitoring studies based on the guidance provided. Many state agencies that regulate the development of wind energy also require post-construction monitoring studies of bird and bat mortality. USFWS (2012) and Strickland et al. (2011) provided recommendations for estimating bird and bat mortality at wind energy facilities, which many studies followed, allowing for comparisons between projects and among regions.

The USFWS also requires compliance monitoring, which typically entails post-construction monitoring studies, at wind energy facilities that receive an incidental take permit (ITP) for bat species protected under the Endangered Species Act (ESA). The USFWS is developing a post-construction monitoring framework for bat-wind incidental take permits (ITPs), with the intent of utilizing existing post-construction monitoring to inform the duration and intensity of future monitoring recommendations.

We conducted a meta-analysis of post-construction monitoring projects to inform a new monitoring framework using questions defined by the USFWS and American Clean Power Association (ACP). The meta-analysis used 609 post construction monitoring studies from 327 wind facilities, containing a total of 62,147 bat carcasses and 917,262 individual turbine searches. Across USFWS Regions, these studies covered 8.5% (Southwest, Region 2) to 57% (Northeast, Region 5) of the operating wind energy facilities on the landscape. Even in regions with a lower proportion of wind projects included in the study, about 40 studies were available per region.

Does the type of risk (migration risk only vs summer/maternity colony risk) at a site influence the number of listed species found? We used projects with ITPs for Indiana bats and classified them by risk type, and found there were larger numbers of carcasses of listed species at projects with summer/maternity colonies on site, although many of these fatalities still occurred in the fall. We found similar results for tricolored and little brown bats, though we had less data on those species. This suggests that there are many wind projects in open landscapes with no bat habitat, which are lower-risk projects that may be good candidates for less monitoring, particularly in regions with lots of data.

The next question is: Do bat fatality rates show trends over time? For most projects with multiple years of monitoring, subsequent years showed similar or lower estimates compared to the initial, baseline estimate. Sites where fatality estimates increased in subsequent years were likely due to a greater search effort rather than increased risk.

We also examined ITPs that reported take estimates using Evidence of Absence. We found that although there have been no recovered carcasses of Northern long-eared bats for the last six years, the ITP studies were estimating take rates above anticipated levels, which suggests that we shouldn’t be looking at these studies in isolation, but also at the broader picture. It is unlikely that all of these studies are taking Northern long-eared bats when none have been reported across the whole country. We also looked at the fatality rates during spring migration and found that for the majority of projects, spring fatality rates were low. It is likely that in regions or habitat types where spring fatalities are low, reducing or eliminating spring monitoring would be reasonable.

In summary, in locations or seasons with low risk, we can likely justify reducing or eliminating fatality monitoring and diverting those funds to other conservation efforts.

Teresa Bohner – U.S. Geological Survey: A hierarchical estimation of turbine-level multi-species bat fatality accounting for heterogeneous search efforts

Over half of bat species in North America have declining populations, due to white nose syndrome, wind energy, and other threats. Substantial growth in U.S. onshore wind energy sector has been occurring over the last decades and will continue to expand owing to advancements in technology, declining costs, and U.S. clean energy goals to permit at least 25 gigawatts of onshore renewable energy by 2025. This growth, however, poses potential impacts on wildlife, including bats, through fatality from collisions. Bat fatalities are relatively rare events, detection is challenging, and there are lots of zeros in the data. Understanding the collision risk profiles of different wind energy projects and the individual turbines within them can help to inform the location, design, and operations of future projects with an aim towards minimizing and mitigating wildlife interactions. Currently, the vast portion of collision-related research focuses on producing accurate and unbiased estimates of total numbers of fatalities at a facility and/or how broad-scale factors like land cover or seasonality relate to facility-level differences in fatality rates. Variability in bat fatality rates across facilities and through time is imperative to predicting wind energy development impacts on populations, however understanding if and how fatality rates vary at finer (turbine-level) scales can deepen our understanding of overall facility and within-facility risk profiles of wind projects.

We incorporated facility- and turbine-level covariates as a part of the total fatality estimation process on a weekly interval with a Bayesian hierarchical n-mixture model at 13 wind facilities across Iowa in 2016. This allowed us to produce estimates of fatality rates while accounting for heterogeneous search efforts and imperfect detection and understand important facility and turbine level covariates related to fatality rates. This research was possible due to a high-resolution bat carcass data set collected by Western Ecosystems Technology (WEST), Inc. and their wind energy facility partners. Bat fatalities were monitored across all 13 wind facilities from March 16 to November 16, 2016, and all turbines at each facility were searched twice per week. 80% of the searches were road and pad searches, while the remaining 20% were full plot searches. The model produced estimates of weekly turbine-level fatality rates. The timing and magnitude of fatalities also varied across species. We found fatality rates varied both across and within facilities and we related that variability to a suite of facility-level (i.e. nighttime brightness, facility age, land cover metrics) and turbine-level (i.e. turbine capacity, metrics of turbine placement on the landscape) characteristics. Turbines closer to the edge of the facility have higher fatality rates compared to interior turbines. These results highlight the importance of analyzing turbine-level fatality data when possible as it can deepen our understanding of important drivers of bat fatalities at current and future wind energy projects. The code for this study will be published as a software release.

Ashton Wiens – U.S. Geological Survey: National analysis of bat fatalities at wind energy facilities

To meet decarbonization goals, wind energy development is expected to increase in the coming decades. Wind turbines are a concern for ecosystems globally by causing fatalities among many bat species. Research is being undertaken to find ways to mitigate wind energy-related fatality, but bats are already facing environmental stressors such as white-nose syndrome and resulting population declines. White nose syndrome has driven several bat species to be listed under the Endangered Species Act, leading to consultation between developers and the U.S. Fish and Wildlife Service (USFWS) for permitting. Currently a widely accepted methodology for quantifying bat fatality is to use megawatt capacity as the primary predictor of bat fatality risk. This proxy is limited in its ability to accurately capture fatality risk to bats because it fails to characterize other aspects of wind turbine technology, such as the physical area of risk to bats, and ecological bat characteristics, such as seasonal patterns in abundance and habitat use, and their interactions.

One goal of this analysis is to provide data products to assist in the permitting process. We seek to explain and predict fatalities and variation among wind facilities in the U.S. related to landscape and ecological covariates, explore whether we can replace bats/MW with a better predictor of fatalities, and determine whether we can forecast fatalities to aid in siting, permitting, and mitigation.

Here we quantify bat fatality at wind facilities over time throughout the United States, using a dataset comprising of 511 post-construction monitoring reports from 277 wind facilities. We use a Bayesian hierarchical n-mixture model to relate bat fatality to characteristics of wind energy facilities, land cover composition, and bat ecology. Our models identify which covariates have significant relationships with bat fatality, and model fit is assessed by comparing model predictions to observed fatalities. We explore hypothesis-driven models, comparing pairs of models addressing key groups of covariates (such as turbine characteristics vs landscape characteristics), as well as predictive models. At the model selection phase, we found that models using the size of the rotor swept area to predict bat fatalities performed better than models using MW/generation capacity of the turbine. There were many potential covariates available for this modeling effort covering detection adjustments, wind facility characteristics, and ecological or habitat features. While model selection and validation are ongoing, these covariates help explain the observed fatality counts, with fatality estimators (corrected for unsearched area and portion of year) serving as prior information on detection probabilities. Total rotor swept area, bat species richness, and curtailment regimes appear to be important covariates in preliminary modeling efforts. The importance of these covariates corroborates our hypotheses and gives us confidence in the model performance. Ecoregion and landcover data provide insights on the large- and small-scale spatial variability in fatality data.

We demonstrate improved predictive performance by incorporating high-resolution compositional land cover data, which requires utilizes a log-ratio transformation based on principal balances of landscapes across the U.S. We can use the model to retrospectively predict how many fatalities may have happened at facilities for which we have no fatality monitoring data. The model can be used to estimate cumulative bat fatality estimates on a regional or national scale. Finally, we can make predictions of potential fatality rates and potential wind energy sites based on site characteristics. Lack of standardization between datasets has been a substantial challenge. The current model uses fatality data for all bat species, but species-specific models will be an important next step. More future work includes a population viability analysis based on our risk maps and energy forecasts, and multi-scale inference comparing predictions from this model to fine-scale spatial predictions from Teresa Bohner's work.

With a diverse set of covariates, the fitted model importantly moves beyond the current practice of using only megawatts to predict bat fatality risk and can be used to assess risk with more accuracy. To help policy and decision makers, the model can provide risk maps illustrating predicted fatalities over space and across seasons for a variety of wind turbine characteristics such as size and curtailment. These risk surfaces provide insight into the geographic and temporal variation in bat fatality related to wind energy.

Faith Kulzer – Western EcoSystems Technology, Inc.: Trends in tree bat abundance using post-construction monitoring fatality rates as a proxy

There is increasing concern that some bat species' populations are declining due to collision mortality with wind energy facilities, but this impact is largely unquantified because of a lack of available population estimates. To gain insights into population trends, we examined fatality rates for hoary, eastern red, silver-haired, and big brown bats: the four bat species most commonly found as fatalities at wind turbines. Fatality estimates were used as a proxy for population size under the assumption that the probability of a bat colliding with a turbine has remained constant over time, and thus temporal trends in fatality rates could serve as an approximation of temporal trends in abundance. We collected data from 85 publicly available post-construction fatality monitoring studies from 55 wind facilities, conducted from 2003 to 2022 in 13 states across the Midwest and Northeast U.S. Fish and Wildlife Service (USFWS) Regions. We analyzed changes in species-specific bat fatality rates (calculated as the product of the study's all-bat fatality rate and proportion of fatalities attributed to that species) over time using generalized linear mixed models. We included fatality estimator and facility as random effects and study year, facility age, turbine operation, and region as fixed effects. We found no significant trends in fatality rates through time for hoary, eastern red, or silver-haired bat and a significant positive trend in fatality rates for big brown bat. Fatality rates in Midwestern states were higher than Northeastern states. Sites with curtailment regimes in place did not have overall lower bat fatality rates, though curtailment regimes are likely to be put in place at projects that have higher bat fatality risk. Different covariates explained patterns of observation for each species, suggesting that species-specific models may be more useful than combining all bats. These results suggest that population sizes have been relatively stable over the past 20 years for tree bats and are likely increasing for big brown bats, although temporal trends in fatality rates are not a direct measure of trends in abundance. Though other recent studies in Ontario and the Pacific Northwest observed declines in hoary bat populations, this study suggests that declines may be regional in nature rather than continent-wide. These results may prove useful in assessing the status of tree bat populations, an important step in the USFWS's process to propose listing a species as endangered or threatened.

Michael Sullivan – Alberta Fish and Wildlife: Let's make green MW's and hoary bats co-exist

Hoary bats were recently classified as endangered in Canada, primarily because of losses from wind energy turbines. We want bats and wind energy to coexist. I learned from one of my Ojibwe teachers that while Western science tends to separate systems into parts, indigenous communities look at everything as a system and we are bringing that systems view to the world of bat/wind work. In Alberta, a collaborative project between biologists and industry created a "what-if" family of systems models linking bat population and turbine operations. Their function is to help policy makers reduce regulatory risk, while conserving Alberta's bats. The key value of the models is their simplicity, their ability to immediately simulate and compare wide-ranging options of turbine operations (numbers, sizes, locations, deterrence, cut-in speed), and thereby help understand trade-offs between bat population trends and energy economics.

Most of Alberta's 1,500 (and rapidly increasing) wind turbines are in the open plains in Southern Alberta and together incur over 6,000 bat fatalities per year. We created two streams of models. The first are bat/turbine systems models, to examine what might happen to bats over the next 80 years under mitigation scenarios. These models use population dynamics and wind facility characteristics and mitigation/operations practices to project bat populations. The second set of models uses historic wind and price data to predict the cost of implementing the associated mitigation/operation practices. We built stock and flow models to take components of existing Western science and combine them into a system view. Under a business-as-usual model, we found that hoary bats in Alberta would be at risk of extinction within 15-20 years. A 6 m/s curtailment regime during August and September would buy us a few years, but an 8m/s cut in speed buys us 60 years. This isn't a solution on its own, but gives the community time to invent better solutions. Given the huge amount of uncertainty in bat population and demographic data, it is important to ensure that the resulting conservation actions/solutions are robust to the uncertainty in the population and demographic data (population size, birth rate, etc).

These mitigation efforts are expensive. While uncertain about future wind energy prices, we have high quality data on historic wind resources and prices for the past decade. Combining these data with calculations of wind shear, power curves, surface roughness, etc., we can make a pretty good projection of future costs. While the model suggests that implementation of curtailment at 8 m/s during August and September would incur approximately 5-6% financial losses over the course of a year, losses from bat mitigation are a tiny portion of the natural variation in wind pricing.

Immediate implementation of 8 m/s cut-in speed has been proposed (but not mandated) by the provincial government wildlife agency. This “harsh medicine” of high cut-in speeds, as proposed by Alberta government policy, might be mitigated by “spoonfuls of sugar” including:

- Economic thresholds for avoiding cut-ins (if $$/MWh value is very high, cut-in speeds lowered or removed),
- No mitigation when bats not flying (cold and wet dividend)
- Public relation credits for participation in bat conservation (Green Bat Stamp)
- Government promotion of increased turbine efficiency at high wind speed (compensating for losses at lower cut-in speeds)
- relaxation of widespread and potentially less-effective monitoring.

Audience Questions & Speaker Response/Discussion

(for Quintana Hayden) From industry’s perspective, what kind of conservation actions can industry take based on the data that is available to us today? And what are some additional data that we might need, and what are some of the challenges that industry faces related to data?

Quintana Hayden: Bats are currently the American Clean Power Association’s (ACP’s) top wildlife priority, because we need both bats and wind. We know climate change negatively impacts biodiversity and is the top concern for bats as a whole. Wind energy must make up a substantial part of our electrical grid if we are to achieve our climate goals. If we curtail turbines for bats, that power is usually generated by fossil fuels, and so curtailment has a climate impact and carbon cost as well. We need a clear, achievable path to long-term coexistence with bat populations. We need to start turning data into action. We know there are impacts to bats ,we have tools to start addressing that. There are challenges and disincentives for voluntary conservation actions. Many of our members take conservation actions anyways because of their values and commitments to conservation, but we need to reduce barriers and disincentives to conservation actions. Data can drive development of incentives, lower operational uncertainty, and facilitate the acceptance and adoption of workable conservation measures. What data do we need? We need to prioritize our efforts to improve the efficiency and effectiveness of conservation tools.

Karen Herrington: The U.S. Fish and Wildlife Service (USFWS) uses data in so many ways. One of the most important factors is that we use best available data, including several great and robust datasets presented today that we can use to make decisions at the USFWS. Rhett Good talked about our collaborative effort with ACP to develop a lower monitoring level for our habitat conservation plans (HCPs). The USFWS has looked at meta-analysis to extract the take home points, and determine what we really need to get out of a lower monitoring context. USFWS will be putting out bat fatality framework in the next couple of months. The second thing to highlight is the decisions that USFWS makes for Endangered Species Act (ESA) listings. What do we need to make good decisions? We are working closely with USGS to evaluate status of bat species including tricolored, northern long-eared, little brown bats, including the impacts of wind energy. We've used fatality data to draft guidance in areas where take in uncertain for for northern long-eared bats and tricolored bats. But the biggest point is hoary bats, which have been added to our national listing work plan. We've made this announcement far in advance because we believe that we can preclude the need to list hoary bat. We need to stop approaching bat conservation in a piecemeal fashion with different bat species and listing decisions and work towards an all-bat solution. This is a call to action! You need to know the timing of the process. USFWS will use the best available data to make a listing decision for 2028. We have some time to do real conservation actions. Typically start species status assessments 2 years before the date on the plan. We'll start for the hoary bat in 2026. The time is now to take conservation actions to prevent the listing of the hoary bat.

(for Rhett Good) Regarding your recommendation to reduce or eliminate monitoring for bats in the spring; are you seeing a high proportion of female bats, including pregnant females in spring fatalities, and if so, would that change your recommendation?

Rhett Good: We didn't summarize the sex data of the fatalities, as that data is often unreliable. There are projects where we would want to continue to monitor, for example if there are maternity colonies on site and you are worried about fatalities of pregnant females. However, most projects have low risk during spring.

(for Teresa Bohner) Could you define how you use the term edge effects and expand on why you concluded that you are seeing edge effects? Is it due to habitat differences, bats being intercepted at the edge of the facility, or something else?

Teresa Bohner: We do use distinctions between habitat types to define edge effects, for example being close to a forest edge or a water source, and those covariates are included in our model. We are examining the partial effect of turbine arrangement (i.e., how close is the turbine to the edge of the minimum convex polygon of the facility). There is also the "core" so a more circular facility will have different edge effects than an oblong facility. At the moment, it is just a hypothesis that bats might be killed at turbines around the edge of a facility before making it to the core, but we don't have the data to answer that question yet.

(for whole panel) A number of speakers discussed a future with less monitoring or no monitoring. How do we know when we're "there" from a modeling, regulatory, or industry perspective?

Andrew Wilk: My biggest concern is over extrapolating. We have great data in some areas, but you don't want to extrapolate into regions where you don't have any data. We are doing highly dimensional, multi-variate statistical models, it is challenging to predict onto a facility for which we have no analogs in the data. When a new facility is proposed for monitoring, we need to is if are there analogs with similar characteristics for both the facility and landscape for which data is available.

Rhett Good: I agree with Andre's sentiments, and there are certain types of projects in certain regions that are well studied, so for a new facility in a prairie landscape with similar landscape and turbine size, we can probably make good predictions. Recent research on lower blade tip height suggests that you need to also include turbine characteristics in these decisions.

Ashton Wiens: As a statistician, I would approach this with model validation to determine whether we replace monitoring with predictions. To achieve that, we do need good spatial coverage and covariates that capture spatial heterogeneity at small scales to be confident in our assignment of analogs. That's the next step in study so that we can be more confident in our predictions.

Michael Sullivan: As a manager, I would say that monitoring without some threshold is pointless. For example, if we have 4-5 fatalities per megawatt, the model says we need to get that down to 1. We don't need really precise monitoring to differentiate between 1 fatality per megawatt and 5. It's critical not only to get good precision, but to design your monitoring to determine whether you're above or below an actionable threshold. Industry likes that because it gives them regulatory assurance.

Quintana Hayden: It is important to know what is the management question, and how will the data influence management or conservation measures? Realistically, landscape level monitoring is going to continue to be important to ensure the viability of future bat populations, but I am not sure that monitoring with precision at specific projects is necessary to achieve the common goal of coexistence of bats and wind, and at this point may be counter-productive.

Karen Herrington: the Wind Energy Guidelines (WEGs) include some baseline monitoring, and a low level of baseline monitoring at each project will continue to be important, but I do think we're at a place where the level of monitoring USFWS has required at least in the Midwest is probably not necessary anymore. That will be reflected in the bat fatality framework that is coming out soon. We have learned a lot over the past 20 years doing "evidence of absence" level monitoring, and we can start to look more holistically at fatalities at a larger scale.

(for whole panel) A lot of the models presented today were made using databases that are proprietary and not shared widely. If it is indeed time for collaborative action, how can we increase data availability to do these large-scale assessments?

Faith Kulzer: All of you [owner/operators] can play a big part by contributing data to the American Wind Wildlife Information Center (AWWIC) and Renew databases. Both databases contain a lot of publicly available information. A lot of the analyses we do use data that is not publicly available but that the industry is willing to share while maintaining some level of confidentiality in the data. I encourage all owner/operators to contribute fatality data to these databases.

Andrew Wilk: There is a real benefit in the methods we are all employing, in that we can create informed priors in this statistical framework so we don't have to ignore the information that is already out there. With parallel development of these models, we can share some level of information about effect sizes and use those to improve each other's models.

Recommended Resources

- There are no recommended resources for session 5.

Session 6: Smart curtailment in Action: Results from Real World Implementation on Wind Farms

Until recently, smart curtailment has been discussed mostly in a theoretical capacity. Implementation has now begun at several wind farm sites. Binding together knowledge, innovation and technology, the speakers present results from real projects in minimizing the impact of wind energy via wildlife monitoring, deterrence and curtailment. Discussion focuses on bird and bat monitoring programs for renewable energy projects in the operational phase in both the United States and Europe.

The scientific literature is inconsistent in its use of terminology surrounding curtailment, so here we propose some definitions for the purposes of clarity in this session.

- *Environmental curtailment* – Any curtailment (feathering/angling the blades parallel to the wind to slow/stop them from turning) implemented for the protection of birds and bats.
    - *Operational or blanket curtailment* – The most common form of operational curtailment for bats, where turbines are curtailed based on a certain wind speed threshold, and sometimes also a temperature threshold. A common example of blanket curtailment is for turbines to be curtailed at night, when wind speeds are below 5 m/s and when temperatures are above 40 degrees Fahrenheit, during the fall bat migration season.
    - *Smart curtailment* – Curtailment regimes where the species activity or other environmental variables are used to refine curtailment to periods of higher fatality risk.
        - *Algorithmic curtailment* – Site-specific bat risk model using environmental conditions to predict bat risk
        - *Acoustically-triggered curtailment* – Curtailment triggered based on real-time acoustic bat call detection and activity levels
        - *Informed curtailment* – Curtailment based on real-time detection of raptor species, via automated technologies or human observers.

Moderator: Mona Doss – Vice President of Business Development, Wildlife Acoustics, Inc.

Speakers:

- **Roger Rodriguez –** Bat Biologist/Principal Consultant, EchoSense LLC (Natural Power)
- **Michael Whitby –** Director of Bats and Wind Program, Bat Conservation International
- **Eran Amichai –** Principal Scientist, Normandeau Associates, Inc.
- **Paul Howden-Leach –** Director, Automated Bioacoustics
- **Aleksandra Szurlej Kielańska –** Research Biologist, Bioseco SA

Link to recording: https://vimeo.com/1032035680/bfb5cb79f2

Roger Rodriguez – EchoSense LLC (Natural Power): Making smart curtailment smarter: improving wind energy production while mitigating bat risk with alternative operational strategies

Smart curtailment methodologies have been implemented as alternatives to blanket curtailment to reduce bat fatalities at wind energy facilities while also recovering lost energy associated with blanket curtailment strategies. Studies have shown that typical operation of the acoustic-activated curtailment system, EchoSense, has led to comparable results in bat fatality reduction as blanket curtailment while leading to considerable reduction in energy loss (~41% to 56%) associated with blanket curtailment. In light of these results, it may be possible to recover additional lost energy while maintaining minimal risk to bats with different operational modes. We conducted analyses to assess turbine operational time and bat risk under different system configurations. The first analysis consisted of comparing typical EchoSense operation where turbines are curtailed based on detections at any deployed acoustic detector (i.e., site-wide; this is how EchoSense has been operated in the field to date) versus operating the windfarm in subsets where turbines respond to detections from a limited number of corresponding detectors (zone-based). We hypothesized that by dividing the facility into curtailment zones, there would be an increase in energy production; but how will bat risk change? Another operational strategy under consideration is the acoustic trigger threshold; under current operation, curtailment commands are issued with the detection of at least a single bat call. Single bat calls may be indicative of low-risk behavior such as a bat passing through the airspace but not in direct conflict with the turbine. It may be possible to increase the threshold (require multiple bat calls within a certain time period) to initiate curtailment without substantial increase in risk to bats.

To test these operational modifications and understand bat risk at turbines without detectors, we used our existing data to model bat risk at turbines that were not outfitted with acoustic detectors using existing data and environmental covariates at 10-minute increments, using the threshold $p \geq 0.5$ to infer bat presence. Our data indicate that shifting from a site-wide to an approach with one detector per zones would result in a 10% increase in operational time, with a 20% increase in potential bat risk; however adding an additional detector (two detectors per zone) to each zone reduces bat risk by 20-25% (equivalent to site-wide operation) while maintaining similar operating time compared to site-wide curtailment. When the threshold for the number of bat calls necessary to trigger curtailment was raised, we found a straightforward tradeoff between operational time and exposed bat risk when doing site-wide curtailment. However, when you switch to a zoned approach, we found improved operational time and lowered bat risk for a given curtailment threshold. Additionally, switching to a zoned approach with a raised threshold decreases the number of curtailment events by approximately 30% in contrast to a sitewide approach with a ≥ 1 bat call trigger.

This desktop analysis suggests that these alternative operational strategies can increase operational efficiency while mitigating bat risk. For future work, we will explore creative dynamic zones and trigger thresholds that can change along with bat risk across the seasons and time of night. In light of the recent curtailment guidance for the tricolored bat provided by the USFWS, these curtailment strategies could be implemented in cooperation with the field office in the event of a tricolored bat fatality at a wind facility. If the facility is divided into zones, the zone where the fatality occurred may be put into blanket curtailment, while allowing the remainder of the facility to use acoustic-activated smart curtailment.

Michael Whitby – Bat Conservation International: Comparing costs and benefits of discordant bat minimization efforts: a case study with TIMR

Bat fatality minimization studies are difficult to conduct and often experience low statistical power to detect differences. Proper study design and analysis methods can greatly increase the ability to detect differences between treatments. Nonetheless, the end results can be difficult to compare for minimization efforts that are discordant. When comparing options for potential curtailment regimes, tradeoffs between bat conservation and power generation are highly subjective. The cost/benefit comparison becomes even more difficult when treatments are increasingly discordant – such as curtailment based on wind-speed only vs algorithm-based curtailment. Power is generated at a higher rate in higher wind speeds, so the cost of curtailment increases non-linearly with increased cut-in speeds, making comparisons across windspeeds difficult. A paper published by Huso et al in 2020 showed that energy production can help to “levelize” bat fatality rates and that bat fatality rates are not correlated with the turbine’s nameplate capacity, but with the actual energy production. Likely because this help account for multiple other turbine differences such as the rotor swept area and rotational speed of the blades. We utilized two metrics combining bat fatality information with power generation to access the differences between normally operating turbines (feathered below the manufacturer’s cut-in speed), turbines curtailed below 5.0 m/s, and turbines operated under turbine integrated mortality system (TIMR) (an acoustic-based curtailment system) up to 6.9 m/s. Our field study took place in Iowa using a randomized block design and daily fatality monitoring using dog teams. We built a model to measure the effect of the curtailment strategy on the daily bat mortality at each turbine. We used real energy production values to model energy curves for each treatment at each turbine and accurately predict energy production of the turbines based on nightly wind speed. We ran 1000 simulations to estimate the fatalities and energy production over the course of the season for each curtailment method. These combined the two predictions into two metrics, bat fatalities per MWh produced and fatality reduction per MWh lost production. These metrics allow us to evaluate differences in impacts on both bats and energy production across the treatments that operated at different wind speeds. Bat fatalities per MWh was calculated by dividing the simulated fatality prediction by the energy produced, a lower value indicates that more conservation minded energy production. We found that the TIMR system (operated to 6.9 m/s) results in less bats killed per MWh produced than 5.0 m/s wind speed only curtailment. Acoustic activated curtailment (AAC) operating below 6.9 m/s had nominally smaller fatality reduction per MWh lost production – however, it also had more predictable results (less variation). These metrics helped to contextualize the lack of strong statistical evidence that TIMR reduced fatalities more than curtailment and that TIMR operated up to 6.9m/s but also resulted in statistically less power than 5.0 m/s wind speed only curtailment. This type of analysis could help to make informed decisions in selecting curtailment systems for wind facilities but was only doable because of the availability of detailed energy production values.

Eran Amichai – Normandeau Associates, Inc.: TIMR: acoustically activated smart curtailment to reduce bat fatalities

Normandeau's turbine-integrated mortality reduction (TIMR) system is an acoustically activated smart curtailment system that integrates real-time bat activity and environmental conditions (typically wind speed) to predict high or low risk conditions and curtail turbines accordingly. TIMR has now been evaluated in two separate studies in Wisconsin and Iowa and was shown to be an effective method for reducing bat fatalities as well as reducing energy production losses.

The Wisconsin study took place in 2015 and found that TIMR reduced bat fatalities by 84.% compared to control turbines, with a corresponding reduction in power generation of <3.2%, and a 48% reduction in curtailment time compared to blanket curtailment. The Iowa study took place in 2021 and 2022, and found that TIMR reduced bat fatalities by 48.6% compared to control turbines, with a 1.0-1.2% reduction in power generation. We are beginning to explore refinement of TIMR's curtailment orders using a zoned approach. Zones are determined using site specific knowledge, terrain, bat behavior and ecology. This reduces curtailment by monitoring for bat activity at a higher resolution and only curtailing turbines that have higher risk, rather than curtailing site wide.

We are testing the zoned approach at a large wind farm in the Midwest, using TIMR as an alternative to blanket curtailment in wind speeds from 3.0 m/s to 5.9 m/s. 23 turbines (~15% of the facility) were selected based on fatality data, terrain, and biology, and were outfitted with TIMR systems. In summer/fall of 2024, the first year of operation, we used a site-wide curtailment approach as a direct comparison to blanket curtailment at 5.9 m/s. In future years, we hope to operate TIMR using a zoned approach. We have designed six zones, each with multiple TIMR units. I cannot share data from this study yet, but preliminary results largely echo prior studies. In a desktop analysis using wind speed and bat call data from a single night where the wind speed was primarily between 3.0 and 5.9 m/s (i.e., the turbines would be curtailed all night under the blanket curtailment strategy), we would see a 29.3% reduction in curtailment using the site-wide TIMR approach, and a 47.7% reduction in curtailment using the zoned approach.

TIMR reduces bat fatalities comparably with blanket curtailment, but reduces energy production losses, particularly in high wind speeds. If designed thoughtfully, the zoned approach can save a lot of energy production while also protecting the bats. TIMR is especially advantageous when bat activity is unpredictable, in higher wind speeds, or under uncertain regulatory policies. Acoustically activated smart curtailment is a promising approach that, combined with informed siting decisions will help reduce bat fatalities at wind facilities while minimizing energy production loss.

Paul Howden-Leach – Automated Bioacoustics: Acoustic-triggered curtailment for bats with the SMART System – a case study from the U.K.

Wind farm operators are subject to evolving challenges regarding the need to balance bat conservation with wind energy production and economics. At the moment blanket curtailment is the current leading global solution for reduction of bat fatalities at wind farms. We present a case study for a single 500 kW wind turbine with a 40m hub height and 52m rotor diameter in Southern England trialing a new Acoustic-Triggered Curtailment approach.

In the U.K., we apply the definitions of curtailment differently compared to the U.S. For this study, we use the following definitions:

- *Blanket curtailment*: Curtail the turbines when bats are *possibly present*: dusk to dawn, from April through October.
- *Operational curtailment*: curtail the turbines when bats are *likely present*, based on environmental thresholds such as temperature (> 10° C), and wind speed (< 6.0 m/s) from dusk to dawn from April through October
- *Acoustically-triggered Curtailment:* Feather turbines when bats *are present*, as indicated by the Wildlife Acoustics SMART system.

When the turbine was installed 9 years ago, acoustic surveys and bat carcass searches concluded bat activity levels were 'moderate' compared to elsewhere. In July 2023 a Wildlife Acoustics SMART real-time bat detection system with Acoustic-Triggered Curtailment capabilities was deployed at the turbine. Though data collection is ongoing, here we present data collected with that system between July 2023 and July 2024.

Seven species of bats were detected, with varying levels of nightly activity throughout the summer period. *Nyctalus noctula*, a high-flying bat that commonly collides with turbines, made up 25% of the 2,195 bat passes recorded. *Pipistrellus pipistrellus* made up 50% of the recorded bat passes. Bat activity was highest between July and September.

Under blanket curtailment in the U.K., where the turbines are curtailed all night from April – October, each turbine loses 105.5 days of operational time over the course of the year. The temperature at the study site was always above the 10° C threshold, so operational curtailment was based only on a wind speed threshold of < 6.0 m/s. Six percent of activity (measured as 15s recordings) occurred in wind speeds over 5m/s, but no bats flew at wind speeds above 11.5m/s. Operational curtailment at 5.0 m/s resulted in an average of 30 hours of curtailment per month. If the cut-in speed is raised to 11.5 m/s, it results in 130 hours of curtailment/month. Operational curtailment reduces risk to bats, but it may curtail turbines when bats are not present, and may let turbines run even when bats are present.

The SMART system uses microphones to detect sounds and issue curtailment orders when bat calls are detected. The Acoustic-Triggered Curtailment modelled at our site accurately signaled the turbine in the presence of bats, with a 4.4% false positive rate and a 2.8% false negative rate. The monthly average was 9 hours of curtailment/month.

Comparison of modelled and implemented Acoustic-Triggered Curtailment at our site from July through September showed that modelling accurately represented what happened in the field.

We modelled operational losses (in hours) at the site under blanket curtailment (dusk to dawn) and operational curtailment (dusk to dawn at wind speeds <=5m/s), and compared these strategies with Acoustic-Triggered Curtailment with a cut in speed of 4.0 m/s. Operational curtailment at 5m/s resulted in over 10 times more hours of lost generation time (30.3 hours/month) than Acoustic-Triggered Curtailment (2.8 hours/month).

The SMART system issues a curtailment order within 2-3 seconds of the appearance of a bat, and for this turbine, it slows to a rate with significantly reduced risk within 5 seconds of the curtailment order, and the turbine is risk free within 15 seconds. The system continues to monitor for bats, and will restart the turbine after 10 minutes with no bat activity.

These findings suggest that Acoustic-Triggered Curtailment, using systems such as the SMART System, will be a valuable addition to the options available to wind turbine operators balancing energy production with bat conservation. This approach is adaptable and can be used in combination with other conservation measures. It is also valuable for gathering data and gain insights on the seasonality, species composition, and behavior of bat activity at the wind facility.

Aleksandra Szurlej Kielańska – Bioseco SA: Effectiveness of bird protection against collisions on wind farms thanks to on-demand shutdowns: case study from wind farms with BPS system installed

The urgent need to carry out the energy transformation resulted in many countries developing wind energy, and with this a lot of opposition due to the negative impact of turbines on avifauna. Is it possible to balance the rapid increase of wind energy capacity with protection of biodiversity? The solution can be provided by technological innovation in the form of detection-reaction systems. However, there are few data published on the operation of such systems, casting doubt on their actual efficiency. The most common questions we field regarding the performance of these detection-reaction systems are about the number of turbine stops and the number of false positive detections.

We have analyzed the data from three Bird Protection Systems (BPS) installed on a wind farm in central Spain. This system uses cameras in stereoscopic set up, enabling 3d location of bird, distance, altitude estimation and size classification. The system triggers curtailment if a target bird crosses into the "risk sphere", which is defined based on the turbine size and rotor diameter. In this case, the risk sphere was defined by a 300 m diameter from the turbine.

We used data recorded by the system and data from on-site ornithological monitoring. The data for the analysis were detection data plus videos and photos recorded by systems in the period from July 2021 to June 2022. All birds recorded by the systems have been tagged to species/group of species by qualified ornithologists. The system detected over 16,800 birds during the study period. The majority of detections (~ 10,300) were small birds (wingspan < 1.1 m). Of the remaining ~6,000 bird detections, over 5,100 were large raptors (vultures, kites, eagles) which are the greatest concern due to collision risk. Over 3,000 of these large raptors crossed into the "risk sphere", triggering a turbine stop signal. Approximately 650 of those stop signals occurred when the wind speeds were below 2.0 m/s and there was no energy production. This resulted in ~2,350 actual curtailment events triggered by large raptors.

We further divided the risk sphere into two sections based on the blade length, plus a 20 m buffer. The Direct Collision Risk Sphere (DCRS) was defined as within 61 m of the turbine, and the Potential Collision Risk Sphere (PCRS) was defined as 61 – 300 m. Of the ~2,350 raptors that triggered curtailment events, 572 of them approached within the DCRS and flew safely past the turbine. The majority of raptors that triggered curtailment events were vultures and kites, followed by eagles, buteos, and harriers. No raptor collisions were detected during the study.

These curtailment events averaged about 1.5 stops per turbine per day, for approximately 5 minutes per day. Each curtailment event was reviewed in search of potential false positives. The false positive rate was ~0.7 false positives per turbine per day.

The BPS's ability to accurately estimate bird distance from the turbine and classify bird size allows for protecting big raptors from collision while keeping the actual losses of energy production below 1% of annual energy production (AEP).

Audience Questions & Speaker Response/Discussion

(for whole panel) In light of the USFWS tricolored bat guidance, how will the data you presented today be affected by the new guidance?

Roger Rodriguez: You can operate smart curtailment in zones and adjust them to your spatial and temporal scale/risk level of interest. You can also adjust the acoustic trigger threshold. If implementing acoustic-triggered smart curtailment, you may want to have a conversation with your local field office if you can demonstrate no increased risk to tricolored bats.

Michael Whitby: All of these studies have shown that acoustic-triggered curtailment is an effective minimization measure. We can reduce bat fatalities, and we can increase energy production by operating in zones. We're just beginning to understand how altering the settings of curtailment triggering impact efficacy. We all demonstrate that fatalities still do occur. It's an excellent minimization measure but there will always be fatalities. This is not a criticism, just a fact. We can achieve greater fatality reduction with additional detectors, lower thresholds for curtailment, but that will also result in more energy loss. Finding the balance is difficult, but fatalities will still occur. It's a difficult thing to work into ESA protections.

Eran Amichai: Related to the tricolored bat guidelines, in some times and locations, the guidelines call for blanket curtailment at an increased cut in speed. This is where acoustic-triggered curtailment really excels, because even a small reduction in curtailment time results in a lot more power generation. In a previous session, it was said that we need all bat solution, and this approach could be a great candidate. Hoary bats are flying above 5.0 m/s, so acoustic activated curtailment in high wind speed helps to address that and could be part of the solution to prevent them from becoming listed.

(for whole panel) How should smart curtailment evolve to address the growing risk to the hoary bat population? A lot of the solutions presented have site specific implementation. Could these solutions develop to a place where they are more plug and play on a grander scale?

Michael Whitby: Acoustic activated curtailment can be extremely beneficial. It's not exactly plug and play, but it's fairly easy to implement. You don't need certainty in bat ID because it is an all-bat solution. There are some barriers with maintenance and integration, but those are being reduced.

Eran Amichai: I don't share your fear of site-specific solutions. It will be slightly different in every application. It is easy to play with parameters, close enough to plug and play.

Roger Rodriguez: Also, since you are collecting data in real time, you can adapt the system to the site. As far as plug and play, getting the right people in the room and making it happen is all it takes.

(for Paul Howden-Leach and Aleksanda Szurlej Kielańska) Are there any lessons learned from your work in Europe that could apply to the U.S. or North America?

Paul Howden-Leach: You have to work on a site-by site basis, and bats behave differently everywhere. If you have access to the right people at the right time, you can get a lot done. That micro level data is so important, and turbines are all different.

Aleksanda Szurlej Kielańska: When we are talking about bird fatalities, we have different problems and seasonal patterns. Shutting down turbines on demand could be a good solution for bird fatalities. We have seen systems that are installed and do not work or the operators do not use them. We have wind farms with no raptor mortality, and not all turbines are problematic, so solutions must be site specific.

(for whole panel) What are the pros and cons of the approaches you took, or of pairing different types of curtailment methodologies, for example acoustic triggered curtailment with some type of blanket curtailment?

Paul Howden-Leach: You can use operational or acoustic triggered curtailment together, where you implement curtailment based on wind speeds up to a certain cut in speed, and then above that, you use acoustic-triggered curtailment. In low wind speeds, you don't want a lot of start and stopping of the turbine blades due to wear and tear on the turbine, so you might as well just shut them down.

Roger Rodriguez: We have stacked blanket curtailment up to a certain speed and then applied acoustic curtailment above that. We have also considered incorporating some algorithm-based curtailment.

(for Michael Whitby and Eran Amichai) Your studies indicated different levels of success, can you comment on where the discrepancy might be in terms of how you are viewing data and results?

Eran Amichai: Michael and I are in agreement about the efficacy and results, though there was a difference between the first and second validation tests at different sites.

Michael Whitby: I don't think the numbers changed, if there were any discrepancies, it was a mistake. For the Wisconsin 2015 study, there were two different analyses.

Recommended Resources

- Vallejo et al 2023. Bat Smart Curtailment: Efficacy and Operational Testing https://doi.org/10.2172/2212448

- Huso et al 2020. Relative energy production determines effect of repowering on wildlife mortality at wind energy facilities. https://doi.org/10.1111/1365-2664.13853

Session 7: Integrating Wildlife Monitoring and Minimization Technologies into Wind Energy Development Processes

Technological solutions are needed to monitor and minimize the effects of wind energy development on the environment. This session will focus on identifying strategies to better facilitate integration of wildlife monitoring and minimization technologies into the design, planning, and permitting of wind energy facilities, both onshore and offshore. Speakers 1) briefly reviewed key limitations to this type of integration, 2) presented research and coordination efforts focused on developing strategies to improve integration, and 3) discussed key approaches for improved integration, including potential lessons learned for offshore wind energy development from processes in terrestrial systems (and vice versa). The discussion included topics such as the early identification of resources (power, physical space, internet, etc.) that can be designed into wind turbines to facilitate wildlife monitoring and minimization efforts once a project is built, as well as approaches for incorporating technology deployment into regulatory and permitting processes.

Moderator: Cris Hein – Senior Project Leader, National Renewable Energy Laboratory

Speakers:

- **Kate Williams –** Director, Center for Research on Offshore Wind and the Environment, Biodiversity Research Institute
- **Julia Robinson Willmont –** Vice President, Normandeau Associates, Inc.
- **Debby Barbé –** Marine Ecologist, Project Lead/Consultant, Waardenburg Ecology
- **Misti Sporer –** Environmental Director, Deriva Energy
- **Brogan Morton –** Founder & CEO, Wildlife Imaging Systems

Link to Recording: https://vimeo.com/1032035832/ee285306ba

Cris Hein – National Renewable Energy Laboratory: Opening remarks

Technology is great, until it is not. When it is not functioning like we want it to, we find ourselves yelling at and pleading with an inanimate object. To help us facilitate technology integration so that it works properly during monitoring and minimization studies, we've assembled a panel of experts who will share their wisdom, expertise, and lessons learned about funding, developing, applying, and integrating monitoring and minimization technology with land-based and offshore wind turbines.

Kate Williams – Biodiversity Research Institute: Constraints and opportunities for deployment of bird and bat monitoring technologies on offshore wind turbines

With increased focus on offshore wind (OSW) as a renewable energy resource in the U.S. and elsewhere, there are concerns about OSW impacts to wildlife, including birds and bats. A recent study, funded by the National Offshore Wind Research and Development Consortium (Courbis et al. 2024) identified technology gaps and technological research and development priorities for monitoring marine mammals and birds for OSW. A synthesis of current monitoring technologies was conducted, focusing specifically on bird monitoring technologies designed to be deployed on offshore structures. Many of these technologies were also highly relevant to bats. Priorities to advance wildlife monitoring that were identified in this study included improved integration of wildlife monitoring systems into OSW infrastructure and operations, as well as remote access mechanisms for data collection, system maintenance, and data transfer, and advancements in automated collection and analysis of data. Addressing these needs would allow for more cost-effective, safe, scalable OSW wildlife monitoring that could produce more statistically robust datasets. Improved integration of monitoring technologies into OSW systems (e.g., to ensure that turbines or other platforms are appropriately designed to house monitoring technologies) will require early communication on the timeline of OSW project engineering, which is often well before wildlife monitoring plans are discussed. Thus, harmonization of data collection goals and approaches for monitoring systems on OSW structures – whether determined via industry coordination, regulatory guidance/requirements, or both – would be very beneficial for this emerging industry. Development of a standard “plug-and-play” space for technology deployment on OSW platforms was particularly recommended, but in general, more collaborative development of monitoring plans could help to optimize monitoring so data are collected in a manner that can answer key science questions, reduce uncertainty, and support regulatory compliance. In the absence of such coordination, deployment of monitoring systems is *post hoc* and requires considering a range of challenging issues.

We have an ongoing deployment of bat detectors for Project WOW which serves as a case study. It is a large, federally funded study ending in 2027, focused on assessing the effects of wildlife from the first commercial scale offshore wind farms in the U.S. We are trying to understand patterns of bat presence and species composition and activity levels offshore, and the covariates that may help us to understand drivers of those patterns. We are deploying acoustic detectors at multiple locations at different distances from shore. One major focus is placing detectors on wind turbines at Vineyard Wind 1 off the southeastern coast of Massachusetts. We installed four detectors on wind turbine nacelles before they were moved offshore, because we would not have access once the wind turbines were in place. Some challenges encountered to date include sharing technical specifications, scheduling work, data transfer, planning and completing work offshore, and communication between engineers and biologists.

Julia Robinson Willmont – Normandeau Associates, Inc.: Lessons learned from the CVOW pilot project on deployment of offshore wildlife monitoring systems

ATOM is a multi-sensor system that monitors airspace to record bird and bat activity. When first designed, it was tested on the Frying Pan Shoals offshore platform from where, for just over a year, it recorded novel information on migrating birds. Comprising stereo thermal cameras, ambient light camera, bird and bat acoustic sensors, and Motus receivers, a deployment on the two Dominion demonstration turbines was the first time the ATOM system was mounted on offshore wind turbines. Two ATOM systems were initially deployed and at least one system has remained deployed for three years.

Deployment and maintenance of systems offshore comes with inherent logistical and technical challenges. Managing, calibrating, and analyzing data streams, from five different sensor types, also requires careful planning and coordination. Considerations for the installation of the system include the location of the unit relative to the boom, and interactions between different metals present in the attachment bracket and rails which can cause corrosion. It is best to avoid direct connections into the SCADA system’s fiber network for cybersecurity reasons, but satellite modem connections can be unreliable.

Sensor calibration is difficult in the offshore environment. Motus sensors were calibrated using drones piloted from a boat, which entailed significant challenges related to health, safety, and logistics. Maintenance is particularly difficult in an offshore environment because gaining access to the site is limited. Microphones for acoustic detectors were swapped and brought back in for maintenance at every check. Lightning strikes are common and may impact acoustic detectors; two units each for birds and bats are placed on the turbine for redundancy.

The taxonomic groups most commonly detected by the ATOM systems were (in order) bats, passerines, unidentified birds, gulls, raptors, and shorebirds. Approximately 63% of the detections were from video sensors (81% birds), and 37% from acoustic detectors (81% bats). Our data shows that bird detections reduce significantly when wind speed exceeds 5 m/s, and 57% of all bird activity occurred when the turbine blades were not moving. 90% of passerine activity occurred during the day, but acoustic activity indicated the presence of migrants flying at night, thus showing the importance of this sensor type for nighttime species identification. Over 7,000 insects were detected at the wind turbines per year including at least 7 species of lepidoptera.

Debby Barbé – Waardenburg Ecology: Integration of wildlife monitoring requirements into power purchase agreements and project planning

The case study presented is the Ecowende offshore wind farm, which is committed to implement an extensive ecological program resulting from the first ever ecological non-priced criteria of Hollandse Kust West VI (HKW^) in the Netherlands. The Netherlands has a distinct approach to permitting for offshore wind energy. The government organizes the development permit, which includes background surveys, environmental impact reports, etc. which were made available to the developers and prospective bidders including specific technical and environmental requirements for the site. Non-priced criteria focus on system integration and ecology and promote multi-party collaborations from early in the process. Environmental commitments made by the winning bidder are integrated into the permit and become mandatory. This encourages developers to set ambitious environmental goals that exceed legal requirements.

Waardenburg supported the developers to design the ecological measures for the KHW6 project. The site has 52 wind turbines totaling 760 MW located 53 km off the coast in the North Sea and is scheduled to go online in 2026. The ecological program includes 19 research and monitoring plans, including both above and below water measures covering multiple species. The measures are mostly focused on minimizing impacts and restoration. Effectiveness must be monitored, and they seek to fill some knowledge gaps.

Underwater measures include use of a vibro hammer and other noise minimization measures, and measures to minimize habitat disturbance and restoration, such as eco-scour protection. Above water, they are implementing a corridor, increased air gap, variable hub heights, coated blades, and curtailment for wildlife. They will conduct research to determine the effect of including a corridor in the facility for the habitat use of birds. They will install blade sensors, video and thermal cameras, radar, microphones, and other sensors to collect biological data. Early coordination facilitates a more streamlined process. They began planning in 2021, producing a Nature Inclusive Design. They are currently conducting baseline monitoring and technology testing and will reassess the plan before monitoring and research begins in 2026.

The following are the benefits and challenges of integrating ecological research and monitoring into offshore wind development and permits:

Benefits:

- Enhances biodiversity and ecosystem health.
- Provides a framework for adaptive management based on monitoring data.
- Drives innovation and best practices.
- Involves natural resource experts from the beginning of project development.
- Includes long-term commitments to ecological monitoring programs.
- Includes knowledge sharing as a requirement.

Challenges:

- Knowledge sharing during the tender phase
- High complexity of conservation measures
- Project planning and interface management
- Translating ideas from paper into practice
- Time pressure for innovations
- Knowledge sharing timeline

- Additional permits for implementation still must be applied for

Non-priced tender criteria facilitate innovation, best practices, and multi-party collaboration. It provides insights for minimization and restoration and informs future offshore development with data-driven decision making.

Misti Sporer – Deriva Energy: An industry perspective on how to successfully integrate technologies with land-based wind turbines

"Problems, problems, problems… people have problems" – the root of every problem in integrating technology, dealing with statistics, or communicating policy is people. You must get at the people to solve the problem. Solving problems is about figuring out how to get the industry, the bird, whale, or bat nerd, the engineer nerds, and the finance people to all understand each other. Where do the problems exist in our conversations?

Why: Why are we making a certain choice? Why did you select a certain conservation measure? Is it voluntary or required? Does it occur during development, construction, or operations? You need to adjust your language depending on your audience and relate to specific people.

Who: Who is responsible for the operation/maintenance of the site, and who will be burdened by the choices you have made? Who needs to be at the table to help figure out how to implement it? What engineering controls need to be in place? Will the turbine manufacturer allow you to integrate software into their system?

When: When does it take place? Does it begin on day one? How does it integrate into the workday of staff and the operation/maintenance cycle?

Where: Where do the data go? How do we get them to the right people, at the right time, with the right permission? Is it proprietary? How do we share SCADA/operations information with companies? If they do not have proper cyber security measures in place, she cannot share data.

What: What is the underlying land ownership? Can researchers place tools/technologies outside of the leased land parcel? Do you need additional permissions from the landowner?

How: How do we communicate these things in a constructive way? You cannot walk into an engineer's office and tell him how to do their job that day. You have to share information in a way that encourages cooperation and teamwork.

Communications: You need to adjust your messaging and language to meet the needs of the team members you are working with. You can explain to the financial people why the integration of a certain technology makes financial sense; or tell the marketing folks how these conservation measures will benefit our brand. Developers are looking for available land and good points of interconnection. How do you communicate what you care about in a way that gets these other team members to care about it too and make decisions together? Decisions made in development have 30-year repercussions and have to be communicated to the construction team to ensure that those decisions are implemented at the right time.

Permit Compliance: There is a lot that goes into permit compliance (e.g., achieving a specific g-value [i.e. searcher efficiency rate] in post-construction fatality monitoring). How do you communicate the importance of searcher efficiency to your field technicians? If you do not communicate well, you create problems that make it harder to implement your solutions.

Power purchase agreements are legally binding contracts that outline how power is bought. If the wind developer doesn't meet the terms of the contract, there are legal consequences. There are very real implications of curtailment regimes that reduce power production, and you have to be very clear about the costs (both financial and power production) to avoid violating the power purchase agreement. The cost of power and curtailment varies across the day and is most expensive during peak hours (around 6 PM). It can be very difficult to estimate the cost of curtailment because it is complicated. You need to understand wind patterns to determine proper placement of cameras and other sensors and communicate that clearly to the people responsible for placing those on site.

Things that keep Misti up at night:

- Curtailment impacts business so it must be done in a way that allows wind energy to remain a viable source of electricity.
- How can we implement minimization measures that are effective?
- How do we ensure our data are meaningful and useful?
- How do we bring about informed policy changes?

Brogan Morton – Wildlife Imaging Systems: Lessons learned from integrating camera systems and ultrasonic deterrents at wind energy facilities

Big lessons learned from technology integrations:

Identify the right stakeholders early: When does the technology need to be integrated? Who are the relevant people at the wind company who are the decision makers? Wind companies are made up of a bunch of different groups of people. Identify the right people in each stakeholder group (development, operations, permitting, original equipment manufacturer, etc.), and identify a "wrangler" for each stakeholder group – a person who can help to navigate systems within their company and tap into necessary expertise (IT person, lawyers, etc.).

Figure out who incurs the risk related to integration: I will provide several miniature case studies from the perspective of a technology developer. There are several major considerations when attempting to integrate a technology into a wind turbine including access to wind turbines and platforms, physical mounting and installation methods, power supply, data storage, and transmission. Logistics of installation need to be well planned out: how much manpower and time (and turbine down time) is required, and is the timing compatible with the wind facility's needs? If you want to install equipment on the wind turbine, you may be asking to drill holes in the nacelle or tower of the wind turbine. There are major considerations regarding warranties and structural integrity, serviceability, turbine damage, wind loading, corrosion, that must be discussed. For example, if a bat deterrent is bolted to the underside of a nacelle and a bolt comes loose, and it falls off and hits a wind turbine blade, who is responsible for that damage? If the equipment is attached using magnets, are they strong enough? If you install equipment on the tower, it must withstand tower icing and be accessible using a ladder or lift equipment (which may not be easily accessible). For ground installations, try to keep equipment within the footprint of the right of way, and be wary of theft. Neighbors may be concerned about privacy related to camera equipment. Data transmission is extremely challenging due to cybersecurity, data bandwidth, and limited IT resources. One potential (but expensive) solution for cybersecurity and bandwidth issues is to install a separate set of fiberoptics.

Your perspective does not include all of the relevant information; seek out those who can fill those gaps. What you think may be easy to accomplish may have many other challenges and considerations that you did not know about. Everything at a wind energy facility is highly engineered, so making even small changes can require substantial discussion and problem solving.

Audience Questions & Speaker Response/Discussion

(for Kate Williams and Julia Robinson Willmont) Did you make use of or learn from experience from Europe, related to deploying equipment in an offshore wind farm?

Kate Williams: We spoke to some scientists at the Royal Belgian Institute of Natural Scientists and used some photographs of their deployment setup to help guide our installation. We also worked closely with Wildlife Acoustics to implement some of their lessons learned.

Julia Robinson Willmont: We did not coordinate directly with anyone from Europe, but we did update our weatherization and placement details based on our own lessons learned.

(for Debby Barbé) Can you share your experience regarding the level of involvement and collaboration with regulators in your project?

Debby Barbé: Waardenburg is the main contractor for ecological monitoring for the developer, and we are supporting them, but they are the party who is interfacing directly with the regulators. The information and data that come from this project will be important for informing future policy measures.

(for Brogan Morton and Misti Sporer) Are there roles, benefits, pains of different tech implementation of deterrents vs monitoring equipment?

Misti Sporer: It matters who is paying for it, and whether it comes out of the development, construction, or operations budget. Some money is easier to access than others, it can be easier to get a loan and wrap a minimization measure into financing. It can be much harder to pay cash out of an operations budget, because that money is fixed, so it is less likely that something big can be paid for at the operations phase.

Brogan Morton: There are two ways to think about these things. If you are asking to put equipment on a turbine that must help meet permit requirements for the life of the project, the tech developer will get scrutinized because they need to be available to support the operation and maintenance of their risk minimization technology for 25-30 years. Will the company be around that long? For a monitoring technology, it likely only needs support for a few years, it is not a piece of hardware that needs to last forever.

(for Brogan Morton and Misti Sporer) What can we do to provide an Environmental/Wildlife 101 style overview to other people at these companies who don't think about these issues all the time, like engineers or IT? Or do they get that sort of education already?

Misti Sporer: All of our new hires go through a 10-minute computer-based training that reviews the relevant environmental laws. It is an incredibly light introduction that is only meant to inform these employees that there are laws we need to abide by. If there are materials such as short educational videos from a state division of natural resources about a certain issue, I will share it with my company-wide team. I try to share and make it real to the team why we care about wildlife. Engineers and other team members often show interest in these videos and webinars. You have to navigate conversations with finesse. If you are not equipped to have a conversation, don't do it; find the person who is prepared and ask them for support.

Brogan Morton: Engineers are problem solvers, so you can create buy-in to help solve a problem just by drawing them into the conversation to start generating ideas, even if they don't know the difference between a pronghorn and a mule deer. If you approach them saying here's a problem and some context, what is the best way to accomplish this?

Recommended Resources

- Courbis et al, 2024. Technology Gaps for Monitoring Birds and Marine Mammals at Offshore Wind Facilities. https://doi.org/10.4031/MTSJ.58.3.1

In-Person Posters

Abstract Number 10. Navigating USFWS survey guidance for listed bat on wind energy industry projects

Presenter: Buck Ray
Session/Format: In-Person Poster Presentation
Authors: Buck Ray, Olsson; Jeff Williams, Olsson

Abstract: With the proposed listing of the tricolored bat (Perimyotis subflavus) as endangered in 2022 in addition to the currently listed Indiana bat (IBAT) (Myotis sodalis) and northern long-eared bat (NLEB) (Myotis septentrionalis), potential impacts if renewable projects on bats have become more important. Following the expiration of the Land Based Wind Energy Guidance in 2021, the USFWS has provided updates to the Range Wide Indiana Bat and Northern long-eared Bat Survey Guidelines and has provided multiple additional voluntary guidance documents. As understanding and implementing USFWS guidance and protocols for assessing impacts to bat from renewable projects becomes increasingly challenging, we will discuss strategies to navigate survey methods and requirements streamlines project coordination with USFWS to meet ESA compliance within Section 7 or 10 contexts.

Abstract Number 12. Why not drones? UAVs for added safety, efficiency, and accuracy in wind-wildlife research.

Presenter: Nathan Jones
Session/Format: In-Person Poster Presentation
Authors: Nathan Jones, HDR

Abstract: The possible uses of unmanned aerial vehicles (UAVs), or drones, for wildlife surveys and other environmental compliance is expanding rapidly. Drones can facilitate improvements in accuracy, cost and time efficiencies, and an increase in safety over traditional environmental data collection. In this talk, we will learn about proven uses of drones for wildlife surveys from two case studies. The first case study evaluated the use of drones for raptor nest surveys in extreme terrain. In comparison to traditional methods of survey, drones proved more efficient, safer, and more accurate. The second case study will describe the use of fixed-wing drones, automated flights, and artificial intelligence to survey for Florida sandhill crane nests. This case study also proved efficiencies over traditional survey methods. In addition, we will explore the endless opportunities for innovative applications of drone technology in the wind-wildlife research space, both onshore and offshore. Finally, we will discuss the origins and implications of the current regulatory restrictions on using drones for wildlife surveys and how to navigate these hurdles in the short-term while efforts to change policy are taking shape.

Abstract Number 17. whooping crane habitats and wind turbine siting—a balancing act in the migration corridor

Presenter: Chris Jorgensen
Session/Format: In-Person Poster Presentation
Authors: Chris Jorgensen, Olsson; Morgan Starr, Olsson

Abstract: Whooping cranes (Grus americana) are critically endangered, with an estimated population of around 800 individuals. Effective conservation strategies are essential to support their recovery, particularly during migration when they traverse vast distances between breeding and wintering grounds. This analysis focuses on evaluating stopover habitat density within the whooping crane migration corridor, considering recent findings from Pearse et al. (2021) that indicate these birds avoid wind turbines out to 5 kilometers. To assess suitable stopover habitats, we utilized spatial data from multiple sources, including land cover data, and locations of wind turbines across the migration corridor. The corridor, extending from northern Canada to the Texas Gulf Coast, encompasses a diverse range of landscapes, including wetlands, agricultural fields, and prairies, which are critical for resting and foraging during migration. Due to the size of the corridor, we limited our evaluation to one state and used the migration corridor through Kansas as our area of interest.

We analyzed habitat density throughout our area of interest. First, we categorized land cover types within the corridor using the National Land Cover Database (NLCD) and other relevant datasets. We then evaluated these habitats based on their suitability for whooping cranes, considering factors such as proximity to water sources, vegetation types, and human disturbance levels. Using focal statistics, we quantified the available stopover habitat within our area of interest to determine where the highest density of suitable habitat exists, and where within the corridor siting wind energy would have the least impact based on recent research findings.

In conclusion, our preliminary findings demonstrate how simple tools that are available in common Geographic Information System (GIS) software can help inform wind turbine siting decisions early on in project planning. By identifying stopover habitat and protecting critical stopover habitats within the whooping crane migration corridor, we can drive responsible sighting while enhancing the conservation efforts for this iconic species.

Abstract Number 21. Improved definitions of tricolored bat habitat will facilitate siting/permitting throughout the species' range

Presenter: Timothy Sichmeller
Session/Format: In-Person Poster Presentation
Authors: Timothy Sichmeller, Western EcoSystems Technology, Inc. (WEST); Larisa Bishop-Boros, Western EcoSystems Technology, Inc. (WEST)

Abstract: The tricolored bat (Perimyotis subflavus), once common and widespread across the eastern U.S., has suffered severe population declines due to white-nose syndrome. Because of these declines, the U.S. Fish and Wildlife Service has proposed listing the species as endangered under the Endangered Species Act. With the listing decision imminent in 2024, an improved understanding and characterization of suitable habitat for this species across its range is essential for siting and permitting renewable energy facilities. Although the tricolored bat is often found in forested habitats, it exhibits flexibility in habitat use in spring, summer, and fall across its range. For example, this species is also found in areas with little tree cover dominated by open grassland, prairies, and agricultural fields. The species is also flexible during the winter; tricolored bats hibernate in caves and mines in the north and frequently hibernate in culverts in the south. In this presentation, we will provide an updated review of research and publicly available data to show how suitable foraging, roosting, and over-wintering habitat varies for tricolored bats across their range. Improved definitions of suitable habitat will facilitate timely and efficient siting and permitting decisions for renewable energy projects.

Abstract Number 22. Seasonal and species-specific efficacy of curtailment for minimizing bat fatalities

Presenter: Victoria Zero
Session/Format: In-Person Poster Presentation
Authors: Victoria Zero, Western EcoSystems Technology, Inc. (WEST); Christopher Murray, Western EcoSystems Technology, Inc. (WEST); Daniel Riser-Espinoza, Western EcoSystems Technology, Inc. (WEST)

Abstract: Turbine curtailment is effective at reducing bat fatalities. However, most of our knowledge of curtailment efficacy comes from metrics of overall fatality rates without regard to species. Furthermore, most studies take place in the fall even though many wind facilities pose a risk to bats throughout the active season. There are morphological and behavioral reasons to believe that the efficacy of curtailment may vary amongst species and between seasons. With more wind facilities implementing curtailment each year, and with additional species of bats being considered for listing, it is important to empirically test the assumption that curtailment is equally effective for all species and seasons. The goal of this study was to investigate ways to minimize impacts to bats from wind operations at a commercial-scale facility in the Midwest. We estimated the fatality rate of turbines curtailing at wind speeds up to 5.0 meters per second (m/s) only when bats are present (acoustic-activated curtailment) and compared that to turbines operating under blanket 5.0 m/s (blanket) curtailment and to turbines operating at a manufacturer's cut-in speed of 3.0 m/s (control). Twenty turbines were assigned to each of the three curtailment groups in the summer and fall of 2021. For the acoustic-activated curtailment treatment, the wind operator installed Natural Power's smart curtailment system (EchoSense [formerly Detection and Active Response Curtailment]) for bats at five turbines and curtailed all turbines operating under that treatment when the call of any bat species was detected at any of the units. We first determined that curtailment reduced bat fatalities by approximately 42 to 45%, and there was no statistical difference in fatality rates between

the blanket and acoustic-activated curtailment treatments. To test whether curtailment efficacy varied by season or species, we modeled carcass counts corrected for detection probability by species using generalized linear mixed models. For big brown bats, the most common species at this site, both curtailment treatments resulted in lower fatality rates than the control. Overall fatality rates were similar in the summer and fall and both curtailment treatments were equally effective in both seasons for this species. For hoary bats, both curtailment treatments resulted in lower fatality rates than the control treatment. Fatality rates were lower in the summer than in the fall, and there was a significant interaction between season and the blanket curtailment treatment; blanket curtailment was more effective in the fall than the summer for this species. For eastern red bats and silver-haired bats, there was no effect of curtailment or of the interaction of curtailment and season. We will discuss the implications of these findings for bat conservation and regulation.

Abstract Number 24. Migrating bats harness the power of the nocturnal jet

Presenter: Kristin Jonasson
Session/Format: In-Person Poster Presentation
Authors: Kristin Jonasson, Western University; Christopher Guglielmo, Western University

Abstract: As wind energy continues to expand, the need for enhanced strategies to mitigate bat mortality at wind farms becomes even more pronounced. Effective management hinges on a robust comprehension of animal movement ecology, currently absent for migratory tree-bats often affected by wind farm fatalities. Using the Motus Wildlife tracking system, we obtained unprecedented insights into the of in-flight behaviors of migrating bats (L. noctivagans, L borealis, L. cinereus). Using a subset of flights with impressive distances (mean: 83 ± 44 km, max: 181 km) and extended durations (mean: 2.3 ± 1.8 hours, max: 8.4 hours), we modeled ground speed in relation to wind conditions at various altitudes. The average ground speed of bats was 12.2 ± 4.6 m/s (43.8 km/h), was best explained by tailwind support at 950 mb, which provided bats with 6.8 ± 1.8 m/s of wind assistance at altitudes of 288 ± 90 m above ground level. Our study unveils the impressive capability of migrating bats to reach substantial groundspeeds by harnessing the power of the nocturnal jet. This discovery represents a paradigm shift that demands a re-evaluation of wind as a primary driving factor in the conflict between bats and wind energy development. Understanding bats' attraction to wind resources allows for the strategic placement of wind turbines, mitigating conflicts and accurately assessing population-level impacts of wind energy on bats.

Abstract Number 25. Resource selection and survival of plains sharp-tailed grouse at a wind energy facility

Presenter: Carly Kelly
Session/Format: In-Person Poster Presentation
Authors: Carly Kelly, Western EcoSystems Technology, Inc. (WEST); Chad LeBeau, Western EcoSystems Technology, Inc. (WEST); Jeffrey Beck, University of Wyoming; Alex

Solem, South Dakota Game, Fish, and Parks; Kurt Smith, Western EcoSystems Technology, Inc. (WEST)

Abstract: As the demand for wind energy development increases across much of the Great Plains region, there is a need to understand how wind energy generation may impact wildlife. Due to their extensive range across areas with high quality wind resources, plains sharp-tailed grouse (Tympanuchus phasianellus jamesi) represent a valuable species to evaluate responses associated with wind energy development. We used spatial and demographic data from 130 radio-marked female sharp-tailed grouse to evaluate the effects of a wind energy development on resource selection (nest, brood-rearing, and breeding season) and survival (nest and female) during the April to August breeding season over a 3-year period from 2020–2022 in northeastern South Dakota, U.S. We did not find evidence that females selected nest sites in relation to wind energy infrastructure but found that females with broods and during the breeding season avoided areas near high densities of wind turbines within their home ranges. We found consistent avoidance of transmission lines across all life stages at the home range scale. We did not detect an effect of wind energy infrastructure on nest or female survival; however, we caution that the effect on female survival may be biologically meaningful. Our results have implications for siting future wind energy development in ways that can minimize impacts to breeding sharp-tailed grouse.

Abstract Number 27. Trends in greater sage-grouse lek counts relative to existing wind energy development in Wyoming

Presenter: Chad LeBeau
Session/Format: In-Person Poster Presentation
Authors: Chad LeBeau, Western EcoSystems Technology, Inc. (WEST); Kurt Smith, Western EcoSystems Technology, Inc. (WEST); Lauren Hoskovec, Western EcoSystems Technology, Inc. (WEST); Jeffrey Beck, University of Wyoming

Abstract: Rapid increases in wind energy development globally highlight the need to evaluate how electricity generation may impact wildlife. The greater sage-grouse (Centrocercus urophasianus) has experienced range-wide population declines, primarily due to habitat loss and degradation. Studies have documented a negative association between oil and gas development and sage-grouse populations. However, potential sage-grouse population declines associated with wind energy development have not been adequately addressed. We investigated the relationship between wind energy infrastructure and changes in male sage-grouse counted on leks from 2000–2020 in Wyoming. Our study was conducted in central and southwest Wyoming in the vicinity of 10 wind energy facilities in proximity to sage-grouse leks occurring outside of Wyoming's Core Areas and dominated by big sagebrush (Artemisia spp.) communities. We considered several covariates describing wind energy infrastructure and explored whether males attending leks exhibited lagged responses of 1–7 years following development. We failed to detect a relationship between male sage-grouse lek attendance and proximity to, density of, or distribution of wind turbines following development in all models. Our findings were

based on the average lek in our analysis being 6.5 kilometers from a wind turbine and most turbines were clustered such that undisturbed habitat surrounding leks remained. Therefore, interpretation of our results should be restricted to siting practices of the facilities that we evaluated because direct habitat removal and fragmentation resulting from any form of energy development is unlikely to benefit sage-grouse populations. Our study evaluated the response of low-density, peripheral populations of sage-grouse to wind energy development outside or near the edge of Core Areas. As such, our results should not be extrapolated to higher density sage-grouse populations occurring in Core Areas.

Abstract Number 28. Synthesizing the environmental effects of offshore wind energy development in the Gulf of Mexico

Presenter: Hayley Farr
Session/Format: In-Person Poster Presentation
Authors: Hayley Farr, Pacific Northwest National Laboratory; Mark Severy, Pacific Northwest National Laboratory; Michael Richlen, Pacific Northwest National Laboratory; Lenaig Hemery, Pacific Northwest National Laboratory; Marg Daly, Pacific Northwest National Laboratory; Cris Hein, National Renewable Energy Laboratory; Jeff Clerc, National Renewable Energy Laboratory; Frank Oteri, National Renewable Energy Laboratory; Laura Dempsey, National Renewable Energy Laboratory

Abstract: With support from the U.S. Department of Energy's Wind Energy Technologies Office, the National Renewable Energy Laboratory (NREL) and the Pacific Northwest National Laboratory (PNNL) are jointly leading the U.S. Offshore Wind Synthesis of Environmental Effects Research (SEER) project to synthesize and share the best available science on offshore wind energy's potential environmental effects. In its first phase, the SEER project published a set of educational research briefs, hosted a public webinar series and workshops, and compiled research recommendations focused on the U.S. Atlantic and Pacific Coasts. More recently, the SEER team expanded its focus to the U.S. Gulf of Mexico and began engaging with a variety of offshore wind stakeholders to determine their information needs and develop a collaborative outreach, engagement, and dissemination strategy. After working with subject matter experts to compile available information, the SEER team has now published a new educational research brief focused specifically on the Gulf of Mexico, the potential environmental effects relevant to that region, and their associated monitoring and mitigation approaches. The new research brief is openly available on Tethys (https://tethys.pnnl.gov/seer), along with all past SEER products and a suite of other resources intended to support the international wind-wildlife community (e.g., documents library, archived webinars, online tools). In addition to publishing the new brief, the SEER team also hosted public webinars featuring panel discussions with subject matter experts from the Gulf of Mexico region to further share the state of the science with stakeholders. Leveraging support from its regional advisory committee and partners, the SEER team is now working to further disseminate its educational research briefs, webinar recordings, and other resources to relevant audiences in the Gulf of Mexico and throughout the United States. As offshore wind

development expands into new regions, clear, concise, and easily digestible information and resources, such as those developed by the SEER project, can help stakeholders and communities make informed decisions about responsible offshore wind energy.

Abstract Number 35. Development and use of a custom-built drone for bat population surveys at wind farms

Presenter: Jonathan Rogers
Session/Format: In-Person Poster Presentation
Authors: Jonathan Rogers, Persimia, LLC; Ashwin Krishnan, Persimia, LLC; Arjun Krishnan, Persimia, LLC; Michael Gerringer, Western EcoSystems Technology, Inc. (WEST); Kimberly Bay, Western EcoSystems Technology, Inc. (WEST)

Abstract: Drones have recently been shown to be a valuable platform from which to conduct bat population surveys. Unlike static detectors or cameras, drones can detect bats over wide areas and at a range of altitudes. They can also be flown faster than bat flight speeds, reducing the possibility of double counting as multiple bat calls are detected. Historically, several challenges have arisen when using drones for bat detection. These include the need to mount an acoustic detector to the vehicle, and noise emissions from the drone that interfere with the ability to detect bat calls. A more recent issue has been so-called "NDAA-compliance" requirements which stipulate that federal agencies and programs that are federally funded may not operate drones manufactured in certain countries. This has severely limited the set of commercially-available drones that may be used for population surveys at energy facilities.

Over the past year, Persimia, LLC and Western EcoSystems Technology (WEST) partnered to develop a custom-built NDAA-compliant drone for bat surveys at wind farms. The design integrates an acoustic monitor and infrared camera into the aircraft. The vehicle also includes a suspended microphone that hangs 30 ft below the aircraft to reduce the amount of background noise detected from the drone. The vehicle has an endurance of approximately 25 min and range of 5 km. A key feature of the drone design is a reduced noise signature – the rotor system is specifically tailored to reduce noise emissions in the range of bat echolocation frequencies. This is achieved through careful propeller selection, increased separation distance between the rotors, and tuning of the electronic speed controller commands to the motors. Furthermore, LIDAR sensors are used instead of traditional ultrasonic sensors for above-ground altitude sensing, which furthermore limits acoustic emissions in the ultrasonic range. As a result, noise emissions from the drone are limited to around 5 kHz, which is well outside the frequency range of the bat species that are of interest in planned survey activities. The drones were used for extensive bat population surveys at several midwestern wind farms in summer of 2024.

This poster will present an overview of the drone design and specific features intended to reduce noise emissions. The noise emission spectrum will be presented and compared to that of a standard commercial drone. The poster will present plans for further optimization

of the drone acoustic signature and discussion of the potential to extend or alter the design of the vehicle for other types of wildlife population surveys.

Abstract Number 37. Best practices in searcher efficiency trials for conservation detection dogs

Presenter: Anna Ciecka
Session/Format: In-Person Poster Presentation
Authors: Anna Ciecka, Western EcoSystems Technology, Inc. (WEST); Sally Yannuzzi, Western EcoSystems Technology, Inc. (WEST); Laura Martinez-Steele, Western EcoSystems Technology, Inc. (WEST); Daniel Riser-Espinoza, Western EcoSystems Technology, Inc. (WEST); Rachel Katz, Western EcoSystems Technology, Inc. (WEST)

Abstract: Conservation detection dogs (CDDs) are being deployed more frequently at renewable energy sites to assist with avian and bat fatality monitoring because they can achieve higher searcher efficiencies than humans searching alone. Searcher efficiency trials estimate the probability of search teams finding a carcass. While human searchers rely on visual detection of carcasses, dogs rely primarily on olfaction, making carcass odor an important consideration when designing trials for CDDs. Volatile organic compounds (VOCs) are released from carcasses during decomposition, which change over time and are subject to additional modification through carcass storage methods. We investigated the effect of bat carcass storage on CDD searcher efficiency using both lab-based mass spectrometry analysis and field-based trials. Analyses of the VOCs captured from polymer tubes paired with bat carcasses stored four ways illustrated shared VOCs but distinct odor profiles by storage condition. We tested the effect of carcass storage condition on the searcher efficiency of similarly trained CDDs in the field as part of ongoing monitoring in Missouri. The best-supported model did not include carcass storage nor CDD as explanatory variables for searcher efficiency. Our results provide evidence that any carcass storage condition evaluated here is appropriate to use for bat searcher efficiency trials due to a dog's ability to generalize across similar odors with appropriate training. Although CDDs can generalize odor profiles across carcass storage conditions, we also discuss other factors that may affect detection of bat carcasses by CDDs and therefore impact fatality monitoring results.

Abstract Number 39. The advantages of digital aerial surveys: lessons learned from the European offshore wind industry

Presenter: Zack Johnson
Session/Format: In-Person Poster Presentation
Authors: Zack Johnson, HiDef Aerial Surveying; Kelly Macleod, HiDef Aerial Surveying

Abstract: Digital aerial surveys (DAS) have long replaced visual aerial surveys within several European countries for offshore wind baseline and pre/post construction monitoring. Traditional visual aerial survey methods require a relatively low flight height to ensure the accurate identification of observed species. The HiDef method of DAS was developed over a decade ago to collect accurate ecological data at a flight height high

enough to safely clear ever-growing modern wind turbine generators. Using the HiDef method, our aircraft survey from an altitude of 1800ft, approximately three times that of visual surveys. The replacement of visual observers by digital cameras has proved to be more effective for ornithology studies than visual aerial surveys. Detection and species identification rates tend to be higher with DAS compared to visual aerial surveys, with cetacean identification rates greater than 90% as indicated by a collation of our U.K. data. This surpasses identification rates reported from visual aerial and / or shipboard surveys. This advantage is due to the ability to review – and re-review- objects detected in multiple video frames and augmenting the images with specialized software, much of which is developed in house. All data are processed in-house through a combination of AI identification and manual review and is randomly audited for accuracy. Additionally, the exceptionally high resolution of our digital video camera system allows surveys to take place at higher windspeeds than visual surveys, which provides an advantage for ornithology surveys given known relationships between seabird flight height and wind speed. We will present evidence from Europe of the success of digital aerial surveys, and comment on future challenges in the context of efficient, timely offshore wind consenting.

Abstract Number 40. How power line and substation design, construction, and operation are integral to wind energy reliability

Presenter: Geoffrey Palmer
Session/Format: In-Person Poster Presentation
Authors: Geoffrey Palmer, Western EcoSystems Technology, Inc. (WEST); Lori Nielsen, Western EcoSystems Technology, Inc. (WEST); Meggin Weinandt, Western EcoSystems Technology, Inc. (WEST)

Abstract: Power lines and project substations are common denominators for renewable energy generation. Planning is integral to avoiding potential issues during project design, construction, and operation of project collection systems, substations, and transmission interconnections. By bridging wildlife biology and electric infrastructure, the presentation will outline common challenges encountered in the U.S. and Canada and describe opportunities to address these challenges. The Avian Power Line Interaction Committee (APLIC) and the organization's suggested practices are a keystone for this overview. The project planning and design phase provides a critical juncture to meld overall project needs with design elements that can keep electric equipment and power lines isolated or insulated from wildlife contacts and a suite of options are available to make this possible for every project. Implementation of best practices when building to specific design elements and installing retrofit materials to ensure design meets reality is a key element during construction. Lastly, power line and substation operations are integral to a renewable energy facility's operations and reliability. Wildlife contacts with electric infrastructure and animal-caused outages create a different suite of challenges, and this presentation will cover a range of considerations, approaches, and solutions to meet these challenges. Ultimately, planning, design, construction, and operations of electric infrastructure to reduce wildlife interactions should be structured to meet regulatory

requirements with the added benefit of enhancing facility reliability and ultimately overall system stability.

Abstract Number 42. Revised marine bird collision and displacement vulnerability index for Pacific outer continental shelf offshore wind energy development

Presenter: Emma Kelsey
Session/Format: In-Person Poster Presentation
Authors: Emma Kelsey, USGS Western Ecological Research Center; Josh Adams, USGS Western Ecological Research Center; Jonathan Felis, USGS Western Ecological Research Center; David Pereksta, Bureau of Ocean Energy Management Pacific Region

Abstract: The installation of offshore wind energy infrastructure (OWEI) at sea may affect marine birds by increasing the risk of mortality from collision with OWEI (Collision Vulnerability) and disturbance and displacement from important habitats (Displacement Vulnerability). In 2017, we published the first comprehensive database quantifying marine bird Collision Vulnerability and Displacement Vulnerability to potential OWEI in the U.S. Pacific Outer Continental Shelf region (waters within the Exclusive Economic Zone off California, Oregon, and Washington; Adams et al. 2017, Kelsey et al. 2018). To better inform continued offshore wind energy planning in the region, we have updated this vulnerability index with new research and data, additional species present in the POCS, and an evolved understanding of the application and utility of the index (hereafter Version 2). Phalaropes and Red-billed Tropicbird have the highest Collision Vulnerability scores, while gulls, terns, jaegers, South Polar Skuas, and pelicans have moderately high Collision Vulnerability. Boobies, sea ducks and pelicans have the greatest Displacement Vulnerability. Overall trends in ranked scores among marine birds in the POCS were consistent between Version 2 and Version 1, although the addition of new data and updated calculations shifted some relative vulnerability scores among species. Alcids, loons, storm-petrels, Black Brant, and phalaropes ranked higher for Collision Vulnerability in Version 2 compared with Version 1; sea ducks, cormorants, South Polar Skua and jaegers ranked lower. Displacement vulnerability ranks were higher in Version 2 for gulls, pelicans, sea ducks, and alcids and lower for albatrosses, terns, and loons. Our Vulnerability Index Version 2 is an up-to-date, representative, and transparent assessment of marine bird vulnerability to potential offshore wind energy development. This updated index can assist resource managers and others in understanding, and addressing, potential interactions between OWEI and marine bird species that inhabit the Pacific Outer Continental Shelf Region.

Abstract Number 43. Reviewing 15 years of wind-wildlife research through the lens of Tethys

Presenter: Jonathan Whiting
Session/Format: In-Person Poster Presentation
Authors: Jonathan Whiting, Pacific Northwest National Laboratory; Hayley Farr, Pacific Northwest National Laboratory; Mark Severy, Pacific Northwest National Laboratory

Abstract: Tethys (https://tethys.pnnl.gov) is a repository of documents and resources focused on wind and wildlife concerns, which is trusted around the world in support of understanding and mitigating environmental effects. Funded by the U.S. Department of Energy, Tethys has been operational for 15 years and highlights almost 7,000 documents that represent the most comprehensive collection of literature on this topic in the world. A team of content curators actively seek out new content to make sure the collection captures new research. Grey literature is also included in the collection, resulting in hundreds of reports that are no longer available online. Tethys is a resource to support collaboration and advancement in research, encourage proactive environmentally friendly wind energy development, and communicate wind and wildlife concerns to the public. Anyone can access the information on Tethys, and it has supported many literature reviews and syntheses over the years. But there is a wealth of information contained in the aggregate website tracking information that is collected behind the scenes. This includes information about what documents are seeing the most traffic and how those trends have changed over the years. With the addition of environmental stressor-receptor tags on all documents in Tethys, this can give a rare glimpse into environmental concerns from the global community. Tethys is a technical resource, so the usage data are likely not representative of the general public, but might represent interests from the community (researchers, developers, regulators, stakeholders) with some public interest in the mix. An analysis of Tethys usage statistics, as collected across the last decade over Google Analytics, is being compared with categorized document counts on Tethys. This presents a unique time-series analysis of community interests in various wind energy environmental stressors and receptors. Use of Tethys has increased from 30,000 visitors in 2013 to over 440,000 visitors in 2023, so the resolution of community interests has increased. This analysis highlights how wind wildlife research interests have evolved over 15 years of information collection and synthesis, and how those interests compare with document topics.

Abstract Number 45. Bird and bat abundance and activity vary within and among years at offshore wind turbines

Presenter: Greg Forcey
Session/Format: In-Person Poster Presentation
Authors: Greg Forcey, Normandeau Associates, Inc.; Julia Robinson-Willmott, Normandeau Associates, Inc.; Eran Amichai, Normandeau Associates, Inc.

Abstract: Numerous bird and bat species-specific traits such as [JW1] abundance, patterns of activity, and avoidance behavior can influence exposure to turbine blades, collision risk, and displacement risk. To date, information on offshore bird and bat interactions with wind turbines is limited, and few studies examine interannual variation. The paucity of knowledge restricts informed decision-making and hampers effective development of suitable mitigation strategies. To help fill knowledge gaps, we were initially commissioned by Dominion Energy to conduct an 8-month study at the Coastal Virginia Offshore Wind (CVOW) Pilot Project in Virginia, collecting data on bird and bat interactions with wind turbines. The CVOW Pilot Project is a two-turbine, 12-megawatt demonstration

project approximately 27 nautical miles from the Virginia Coast, designed to test wind turbine infrastructure and conduct research to inform decisions for a future, larger commercial project. At both wind turbines, we installed thermal cameras, a visible-light camera, two acoustic detectors for birds and bats, and a VHF receiver for detecting Motus-tagged birds. At the conclusion of the first period of study, Dominion extended the study for a further 2 full years at one turbine, decommissioning the system at the other. Data were collected for three years at Turbine A01, allowing for observations of interannual variation. Across years and turbines, bird and bat species composition, abundance, temporal variation, and behavior were evaluated and compared among years. Peaks in activity during fall migration varied among years, and we observed variations in the number of behaviors among different species. Foraging behaviors were most common with passerines, while non-foraging behaviors were most common with other non-passerine species groups. These results suggest that exposure, collision, and displacement risks vary among years for birds and bats in the offshore environment, and additional years of offshore bird and bat data allowed us to quantify this variability. These data are useful for understanding potential exposure, collisions, and displacement risks with wind turbines in the mid-Atlantic offshore areas. Conducting similar research at other wind facilities would provide insights into the spatial variation in bird and bat behavior with wind turbines, as this study only examined temporal variation at one wind facility. Regardless, future risk assessments should consider the impacts of abundance and behavioral interannual variation when predicting the impacts of collisions and displacement from offshore wind turbines and making minimization and mitigation decisions.

Abstract Number 46. 3-Dimensional geo-tracking of bats in support of flight behavior analysis

Presenter: Marcus Chevitarese
Session/Format: In-Person Poster Presentation
Authors: Marcus Chevitarese, Sightir Inc; Dave Johnston, H. T. Harvey & Associates; Brandon Lee, Sightir Inc; Ryan Devitt, Sightir Inc

Abstract: Bats play a pivotal role in various ecosystems, contributing to insect control, pollination, and seed dispersal. However, the expansion of wind energy infrastructure has been detrimental to bat populations, primarily through collision mortality and habitat disruption. This study leverages advanced 3-Dimensional Geo-Tracking technology to provide a deeper understanding of bat flight behaviors, particularly in proximity to wind energy developments. Using the Thermal Tracker 3D system developed by Pacific Northwest National Laboratory (PNNL) and commercialized by Sightir, our research captures precise flight data across different species during active periods.
We deployed the Thermal Track 3D (TT3D) to passively track bats with thermal stereoscopic imaging. The TT3D system relays real-time positional data of tracked bats by recording multiple parameters of bat flight, including altitude, speed, and trajectory. These data are then analyzed using sophisticated algorithms to interpret flight patterns and identify potential risk areas around wind turbines.

Our study enables insights into bat flight dynamics, emphasizing the importance of altitude in determining collision risks with wind turbines. This study also explores the utility of virtual geo-fencing—a technique that can be utilized to establish temporary risk zones around turbines when bats are detected. Furthermore, the results underscore the potential of 3D tracking in enhancing our understanding of bat spatial use and interactions with wind farms. By providing precise altitude and behavioral data, we expect to enable the tailoring of turbine operational protocols to align with bat activity patterns, thereby minimizing negative interactions. The implementation of virtual geo-fencing, enabled by real-time tracking, offers a novel tool to manage turbine developments and operations, reducing impacts to bat populations and enhancing the sustainability of wind energy projects. A feature that will be augmented by future and ongoing projects integrating TT3D with Radar and Acoustic systems.

In addition to advancing our scientific knowledge of the aerial ecology of bats, this ongoing research also provides practical applications for the integration of renewable energy solutions with bat conservation. By improving our capability to monitor and predict bat activity, we can optimize wind farm designs and operational strategies to safeguard bat biodiversity, illustrating a successful merger of technology and environmental stewardship.

Abstract Number 50. Substation design and operation: how to plan for wildlife contacts and enhance system reliability

Presenter: Lori Nielsen
Session/Format: In-Person Poster Presentation
Authors: Geoffrey Palmer, Western EcoSystems Technology, Inc. (WEST); Andrew Metzger, EDF Renewables North America; Elise Anderson, EDF Renewables North America; Lori Nielsen, Western EcoSystems Technology, Inc. (WEST)

Abstract: Substation design and operation optimization can be critical to maintaining renewable energy planning for facility reliability, depending on certain variables. These variables include a facility's interconnection to the grid, voltages within the project substation, wildlife species most likely to occur in substations, and how wildlife ingress (e.g., birds, mammals, reptiles) can result in significant safety and reliability issues within a substation. This presentation will illustrate the risk assessment approach developed by WEST, working with engineering and operations for both new substation design and existing substation retrofit options to reduce potential animal-caused outages and enhance facility reliability. The core approach is applying risk zones within a substation, prioritizing the analysis based on the repercussions of equipment loss or damage on the low-voltage side of the substation. Identifying trends and patterns of wildlife use and reducing potential wildlife contacts within each risk zone aid in incrementally and cost-effectively reducing outage risk over the long term. EDF is a co-author on this presentation, providing the renewable energy perspective on applying this risk assessment approach on a fleet-wide basis, ranking risk to operations balanced with retrofit costing and schedules.

Abstract Number 55. The costs of wind energy permitting compliance actions for regulated bats in the U.S.

Presenter: Christian Newman
Session/Format: In-Person Poster Presentation
Authors: Katie Surrey, Electric Power Research Institute; Christian Newman, Electric Power Research Institute

Abstract: The rapid expansion of the wind industry to meet the demand for sustainable energy has increased concerns about the impact on wildlife, particularly bats. Wind turbines pose fatality risks for bats, and the projected growth of installed wind capacity overlaps extensively with the ranges of several endangered and at-risk bat species that are already threatened by white-nose syndrome. To comply with the Endangered Species Act, wind energy operators can submit a Habitat Conservation Plan (HCP) and Incidental Take Permit (ITP) to the U.S. Fish and Wildlife Service. These documents include estimates of incidental take (e.g., unavoidable fatality after avoidance and minimization) and identify compensatory mitigation measures to offset potential adverse effects on species. They also contain some cost information associated with the implementation of the HCP/ITP. Our study analyzed 25 publicly available project-specific HCPs up through 2022 to provide a range of bat-related costs for wind facilities in the U.S. and created a general linear model to estimate potential project-specific costs. The results found the median reported total cost of an HCP was approximately $4,680,000. Total HCP cost appeared to correlate highly with Mitigation Costs and Total Bat Take. The median cost for compensatory mitigation was $1,640,000, and monitoring activities was approximately $3,150,000. As bat populations continue to decline, the need for HCP/ITPs will likely increase, adding further compliance requirements for companies. This analysis provides insight into the costs of complying with the Endangered Species Act, to help identify variables that might affect the costs of compliance and estimate future costs for the wind industry.

Abstract Number 58. Development of an offshore micro-activity, micro-avoidance and mortality detection system using thermal cameras

Presenter: Jon Ritter
Session/Format: In-Person Poster Presentation
Authors: Jon Ritter, Wildlife Imaging Systems; Brogan Morton, Wildlife Imaging Systems

Abstract: Wildlife Imaging Systems has announced a project with Vattenfall and Wageningen Environmental Research to study the use of thermal cameras in the offshore environment. The intent of the project is to study the efficacy of using thermal cameras around an offshore wind turbine to monitor wildlife micro-activity, micro-avoidance and collisions with the turbine blades in the rotor swept zone, as well as direct mortality occurring in the offshore environment. Without a system to currently detect direct mortality caused by offshore wind turbines, there is a dearth of data that can be used to inform a collision risk model. While others have used cameras to monitor micro-activity

and -avoidance in the offshore environment, more work needs to be done on this topic, especially at night for bats and night migrating birds.

The project is taking place at the Hollandse Kust Zuid (HKZ) Offshore Wind Farm in the North Sea off the coast of the Netherlands. This pilot study is deploying sixteen thermal cameras. Twelve of sixteen will be used to measure direct mortality caused by the wind turbine. They will be mounted on the railing of the transition platform and their field of view will be directed radially outward away from the turbine tower, with the focal length of the camera chosen to see a 10 cm object up to 115 m away, covering the whole area below the rotor swept zone for all wildlife of interest. They will cover the full 360° around the base of the tower and operate for 24 hours a day. The goal of these cameras is to detect a falling object after a direct fatality. The technology used to detect and track mortalities has been validated in the onshore environment, with this deployment being used to validate it offshore.

The additional four cameras will be mounted to the railing of the transition platform, but will be looking up toward the nacelle, monitoring the rotor swept zone. The four cameras will be positioned such that they will each be monitoring a side of the turbine, resulting in 360° coverage of the rotor swept zone. All camera data will be processed using state-of-the-art machine vision and AI to automatically detect, track, and classify each detection. The tracks will then be used to analyze the behavior of wildlife near the turbine and will be able to document any micro-avoidance seen and any specific behavior that may lead to a fatality. This camera data will be accompanied by radar and acoustic data so that macro- and meso-level activity and avoidance can be observed as well as the ability to speciate vocal wildlife.

The study is beginning in 2024 and is planned to cover the autumn migration season of 2024 and the spring migration season of 2025. We will present lessons learned from equipment deployment and initial data processing.

Abstract Number 60. Analysis of effectiveness of acoustic bat deterrents at operational wind facilities in Ontario, Canada

Presenter: Charlotte Teat
Session/Format: In-Person Poster Presentation
Authors: Charlotte Teat, Natural Resource Solutions Inc.; Andrew Ryckman, Natural Resource Solutions Inc.; Kayla Mimms, Natural Resource Solutions Inc.

Abstract: Reducing bat mortality at operational wind facilities remains an important topic, particularly in light of several bat species being considered for regulatory protection at federal, state, and provincial levels in Canada and the United States. One such minimization tool are turbine-mounted acoustic deterrents to reduce the interactions between bats and wind turbines. The objective of this study is to evaluate the effectiveness of acoustic deterrents in reducing bat mortalities at two operational wind facilities in Ontario, Canada.

This study used bat mortality data collected in southern Ontario, with 10 treatment turbines, across two facilities, included in the sample size. At each of the two facilities (10 turbines), one year of baseline fatality data was collected during normal operations. Two subsequent years of fatality data was then collected with blanket curtailment in place (5.5m/s; July 15 to September 30), followed by three years of mortality data with operational curtailment and acoustic deterrents installed. Across the six monitoring years, 293 bat mortalities were collected. This long-term study includes data from 2017-2022 and totals 60 turbine-years of data. The number of bat mortalities per turbine was compared during each treatment at the facilities, including baseline (normal operations), blanket curtailment, and blanket curtailment with an acoustic deterrent.

The analysis compares the number of bat mortalities per turbine at the same 10 turbines across each year of the study. This allowed for a direct comparison of data at the same geographic location and within the same landscape from year to year, as opposed to using control turbines with a different surrounding landscape, differing nearby habitat features, etc. Preliminary analysis of the combined mortality data indicates an overall reduction of 33.1% in bat mortalities from baseline data (normal operations) to blanket curtailment. The data suggests a further 40.5% reduction in overall bat mortalities following the addition of an acoustic deterrent, relative to blanket curtailment. Reductions in mortalities of individual species was also observed, with the largest overall reduction as a result of acoustic deterrent installation observed with Big Brown Bat (Eptesicus fuscus; 71%), and with species-specific reductions being noted in each of the three migratory bats, ranging from 13% to 36% reduction, observed following the installation of an acoustic deterrent. This presentation will summarize the findings of the bat mortality analysis completed in this study, including overall reductions and species-specific results to inform the overall effectiveness of acoustic bat deterrents. The results of this study will further contribute to the knowledge surrounding efficacy of acoustic deterrents and their use in reducing bat mortalities at operational wind facilities, particularly in combination with a low-level blanket curtailment strategy. Furthermore, this study has management implications for the continued operation of wind facilities across North America as several bat species are considered for regulatory protection and state, provincial, and federal jurisdictions are tasked with defining minimization strategies.

Abstract Number 62. Simulating acoustic exposure reduces timeframe and cost of curtailment evaluation and adaptive management

Presenter: Trevor Peterson
Session/Format: In-Person Poster Presentation
Authors: Trevor Peterson, Stantec Consulting; Caroline Byrne, Stantec Consulting; Seta Aghababian, Stantec Consulting

Abstract: Evaluating curtailment effectiveness is a critical aspect of monitoring frameworks for commercial wind energy facilities seeking to minimize or avoid risk to bats. Carcass studies are the standard method used to assess bat fatality rates at wind facilities but are not well suited for evaluating curtailment as they lack both the temporal resolution to define conditions when bats are at risk and the precision to detect differences among curtailment strategies. Carcass data must be aggregated among turbines and across relatively long time periods to generate accurate fatality estimates; comparing curtailment strategies therefore requires surveys to occur at multiple turbines and treatment groups, which translates to an immense survey effort and associated cost. Importantly, studies that rely on carcass searches cannot measure reductions in risk from curtailment without incorporating normally operating control turbines; doing so increases the potential for impacts to rare species and contributes to cumulative mortality for collision-prone species like hoary bats (Lasiurus cinereus). Turbine-mounted acoustic detectors provide finer resolution data to compare exposure of bats to risk of turbine-related impacts among species and curtailment strategies at substantially lower cost. Acoustic detectors also record bats regardless of turbine operational status, enabling reliable simulation of acoustic exposure for any curtailment strategy. A single season of acoustic data can therefore be used to simulate multiple curtailment alternatives, dramatically reducing the time and effort required to explore options to reduce risk to bats. We aggregate data from turbine-mounted acoustic detectors collected at over 25 wind energy facilities across five states from 2011–2023 and demonstrate how acoustic data enabled precise and consistent evaluation of curtailment strategies. We also demonstrate the ability to verify proper implementation of curtailment using acoustic exposure and explore how acoustic monitoring could be incorporated into rare bat take permits and associated minimization and adaptive management frameworks. This analysis contributes to a growing body of evidence that acoustic exposure is positively correlated with fatality risk and can supplement or even replace more costly carcass monitoring.

Abstract Number 63. Integrating acoustics into an Incidental Take Permit compliance monitoring framework: a case study at an Illinois wind energy facility

Presenter: Sydney Edwards
Session/Format: In-Person Poster Presentation
Authors: Sydney Edwards, Stantec Consulting; Trevor Peterson, Stantec Consulting; Terry VanDeWalle, Stantec Consulting; Jenny Monson-Miller, National Grid Renewables

Abstract: Traditionally, Incidental Take Permit (ITP) compliance monitoring consists of standardized carcass searches at a predetermined level of effort designed to document rare events. Often, doing so necessitates clearing vegetation beneath turbines to create large searchable areas; this process results in burdensome compliance monitoring costs over the permit term and requires compensating landowners for lost production. The resulting fatality estimates often provide no direct measure of the effectiveness of minimization measures incorporated into an ITP, limiting management options for rare species such as the tricolored bat (Perimyotis subflavus). Acoustic bat detectors offer an alternative solution for compliance monitoring over long permit terms at reduced cost and effort. Acoustic bat detectors placed on turbine nacelles can be used to record acoustic bat calls and calculate acoustic exposure to turbine operation and associated risk on an overall or species-specific basis. Acoustic exposure measured at turbine nacelles has

been positively correlated with bat mortality rates at multiple temporal scales and subsequent studies in progress have documented strong positive correlations between the rate of exposed bat passes pooled among detectors and the number of carcasses found per turbine search when summarized on a biweekly basis. Turbine-related bat fatalities result from exposure to turbine operation, and if calculated over a consistent seasonal extent among years, cumulative biweekly exposure, representing the accumulation of fatality risk over time, should track changes in the bat fatality rate closely. We used a large dataset of turbine-based acoustic monitoring conducted at commercial wind energy facilities across multiple states from 2012 – 2022 to evaluate inter-site and inter-annual variation in acoustic exposure and to determine appropriate threshold levels of change in acoustic exposure beyond which curtailment protocols may need to be adjusted. We applied this information to develop a post-construction monitoring and adaptive management framework that substitutes turbine-based acoustic check-in monitoring in place of regular check-in carcass monitoring to track ITP compliance. We walk through this process using an existing Illinois wind energy facility as a case study to show a specific example of how acoustics can be used in compliance monitoring in a real-world situation.

Abstract Number 67. Evaluating Maximum Likelihood Estimators for acoustic presence of bats at wind energy facilities

Presenter: Donald Solick
Session/Format: In-Person Poster Presentation
Authors: Donald Solick, Electric Power Research Institute; Bradley Hopp, Electric Power Research Institute; John Chenger, Bat Conservation and Management; Christian Newman, Electric Power Research Institute

Abstract: Acoustic monitoring of bat echolocation calls is an important tool for determining presence of threatened and endangered bat species prior to construction of a wind energy facility. The U.S. Fish and Wildlife Service considers a species to be present if automated bat echolocation classification software (‘autoclassifiers’) calculates a significant Maximum Likelihood Estimate (MLE) from a night of recorded files. MLE calculation is influenced by the accuracy of an autoclassifier and by the relative abundance of other species recorded during a night, which suggests accurately determining acoustic presence might be challenging for rare species. We used known reference calls for nine northeastern U.S. species to simulate survey nights that varied in absolute counts of target species and relative abundance of other recorded species to estimate the number of correctly classified files required by Kaleidoscope Pro and SonoBat software to establish acoustic presence for each species. We found that, in general, Kaleidoscope Pro required fewer files than SonoBat to establish presence for most species, and that the number of files required by both programs increased dramatically at lower relative abundance of the target species and when accuracy of the program was taken into account. For example, both programs likely require >25 high-quality calls of Indiana bats (a federally endangered species) or up to 75 low-quality calls to establish statistical acoustic presence of this species when it comprises 10% of the

recordings, illustrating the challenge of acoustically detecting rare, acoustically ambiguous species at wind energy facilities.

Abstract Number 68. Buffalo Quarry Conservation Bank and gray bat resource equivalency model

Presenter: David Bender
Session/Format: In-Person Poster Presentation
Authors: David Bender, Stantec Consulting Services, Inc.; Kasandra Wasinger, Stantec Consulting Services, Inc.; Jason (J.T.) Layne, Stantec Consulting Services, Inc.

Abstract: The Empire District Electric Company d/b/a Liberty Utilities (Empire), in coordination with USFWS, purchased an abandoned rock quarry known to be used by gray bats as a summer maternity colony in southern Missouri. The quarry, now known as the Buffalo Quarry Conservation Bank (Buffalo Quarry), will serve as a conservation bank for the endangered gray bat, the first of its kind in Missouri. The Gray Bat Service Area for Buffalo Quarry includes a portion of the gray bat's western range, from northeast Arkansas into north-central Missouri.

The total colony population size was determined using the most recent June (2022) emergence count data. Emergence count data from June was used because adult female bats are more likely to be occupying the cave and it is before juvenile bats start flying. Based on the most recent emergence count, the total colony population estimate for Buffalo Quarry was 77,214 individuals. It is common for both sexes to use the same summer roosting site; however, the sexes tend to segregate based on microclimatic conditions within the site (Elder and Gunier 1978). Results from netting surveys in July 2021 and May 2022 indicate that gray bats use Buffalo Quarry as both a maternity colony and a bachelor colony. Credits for conservation banks are determined based on the total number of adult females due to their ability to produce offspring and contribute to the species' population growth. Based on emergence count and netting survey data, the female population for the Buffalo Quarry gray bat maternity colony was conservatively estimated as 38,607 individuals by using an assumed 1:1 sex ratio of females to males.

The Credit Evaluation Case Study: Buffalo Quarry Conservation Bank follows the process for calculating gray bat credits in the Maternity Colony Protection Model of the Gray Bat Resource Equivalency Model (REA model) for Buffalo Quarry. The REA model was modified from the Indiana Bat REA – Winter Habitat Protection module but was tailored using gray bat-specific biological information and demographics. The gray bat REA model is intended to provide a suitable framework for evaluating the amount of mitigation that may be required to offset the expected take of the species from wind energy projects by calculating debits of bats authorized for take and offsetting it with credits gained from Buffalo Quarry.

Abstract Number 69. Gray bat emergence surveys – comparison of visual and infrared techniques

Presenter: Jason (J.T.) Layne
Session/Format: In-Person Poster Presentation
Authors: Jason (J.T.) Layne, Stantec Consulting Services, Inc.; Derek Scholes, Stantec Consulting Services, Inc.; David Bender, Stantec Consulting Services, Inc.

Abstract: The gray bat (Myotis grisescens) maternity colony at Buffalo Quarry Conservation Bank (Buffalo Quarry) was first identified in 2013, when a meteorologist in Springfield, Missouri, contacted the Missouri Department of Conservation (MDC) to inform them of possible bat activity observed on weather radar in the vicinity of Buffalo Quarry. The same year, MDC and the U. S. Fish and Wildlife Service (USFWS), in coordination with Missouri State University (MSU), conducted an informal, visual emergence count and estimated nearly 50,000 bats emerging from the mine identifying this as an important gray bat resource in the region.

From 2019 - 2023, Stantec conducted visual emergence counts adapted from the stopwatch bat counting method described by Elliott et al. (2005). In addition to visual count estimations, video-aided estimation techniques were added to the surveys to help assess colony size. Stantec biologists used Thermal Infrared (TIR) cameras (FLIR T1020) to observe bats emerging from the mine exits and recorded the emergence. Unlike the visual estimate method which ended one hour after sunset/after lighting limitations, video monitoring continued until the biologists observed bats returning in greater numbers than exiting/emerging at <1 individual/minute as viewed by the TIR imagery in the field. Videos were used to make refined estimates using similar calculations as used for visual estimations.

The number of bats exiting the Buffalo Quarry mine during the visual emergence counts was between 19,709 individuals in June and 36,985 individuals in July. During the video emergence counts, the number of bats exiting the mine were between 42,780 individuals in June and 57,808 individuals in July. In 2021 video-aided estimation emergence counts yielded an average population estimate of 67,052 individuals and 77,214 bats emerged from the two primary exits during this 2022. The highest rate of emerging bats calculated over a one-minute period at both exits was 6,498 individuals. The video-aided counts were more reliable in getting accurate counts than visual counts due to the versatility after dark and were able to document the annual variation across years.

In addition to the emergence counts, Stantec worked with the USFWS to capture bats emerging from the mine to determine the sex ratio of the gray bat population and to verify that Buffalo Quarry was functioning as a maternity colony. Bats were captured by using both mist-nets and harp traps. All bats observed during netting surveys were gray bats, and the composition of captures included post-lactating females, juveniles of both sexes, and adult males. The results of the netting and trapping indicates that the Buffalo Quarry is

being used as a maternity colony and as a bachelor colony. The results of these surveys were used to determine the resource value of the Buffalo Quarry and used to help establish the site as a Mitigation Bank.

Abstract Number 70. Pre-construction acoustic data accurately predicts curtailment effectiveness

Presenter: Josh Flinn
Session/Format: In-Person Poster Presentation
Authors: Josh Flinn, Stantec Consulting; Trevor Peterson, Stantec Consulting; Caroline Byrne, Stantec Consulting; Seta Aghababian, Stantec Consulting

Abstract: Bat acoustic activity rates measured during pre-construction surveys have shown little if any correlation to fatality estimates once wind energy projects are operational. Many factors could explain why the rate of bat passes measured pre-construction could be a poor predictor of fatality rates including behavioral attraction to turbines, confounding effects of detector placement and microhabitat, or limited spatial coverage of pre-construction surveys. Additionally, an important consideration is whether previous attempts to link pre-construction bat activity with post-construction fatalities have asked the right questions. The overall rate of bat passes recorded is only one metric that could be derived from pre-construction acoustic surveys. Seasonal patterns in bat activity measured pre-construction, for example, have been closely aligned with seasonal distribution of fatalities, and species composition measured at detectors deployed near the height of the rotor-swept zone in meteorological towers has been similar to species composition of fatalities. The seasonal and temporal distribution of pre-construction bat activity and relationships with temperature and wind speed can also be used to predict how effectively curtailment strategies would reduce risk to bats. The ability to accurately forecast curtailment effectiveness will be of increasing importance as the wind energy industry explores solutions to manage risk to rare bat species such as the tricolored bat (Perimyotis subflavus), which is expected to be listed as federally endangered in 2024. We present data from a multi-year study at two Missouri wind energy facilities in which we compared predictions of curtailment effectiveness based on pre-construction acoustic data to measured reductions in acoustic exposure once the facilities were operating and the curtailment strategies were implemented. We found that estimations of curtailment effectiveness based on pre-construction acoustic data, measured in terms of the percent of bat passes exposed to turbine operation and reductions in the cumulative biweekly rate of exposure, were comparable to measurements post-construction. Our analysis suggested that extrapolation of wind speed data recorded pre-construction at 60-meter meteorological towers to nacelle-height (120 meters) may overestimate the wind speeds at which bat activity is expected to occur, thereby underestimating the effectiveness of curtailment at reducing risk to bats. Acoustic monitoring once turbines are operational is critical for evaluating curtailment effectiveness, but our analysis suggests that pre-construction data could provide a basis on which to design strategies that target certain levels of risk reduction.

Abstract Number 71. 3D bat tracking system using multi-thermal video cameras

Presenter: Sora Ryu
Session/Format: In-Person Poster Presentation
Authors: Sora Ryu, National Renewable Energy Laboratory; John Yarbrough, National Renewable Energy Laboratory; Cris Hein, National Renewable Energy Laboratory

Abstract: Wind power technology has advanced rapidly in recent decades, leading to the deployment of a great number of large wind turbines across diverse natural landscapes, which can result in adverse wildlife interactions. Studies of bat behavior and interactions with turbines have occurred for nearly two decades and yet, little is still known about their behavior and interactions with turbines during their active period, limiting the research community's understanding of the risk.

Prior efforts have been made by John Yarbrough and Paul Cryan towards building a 2D machine learning algorithm which filters the movement of the blade and focuses on tracking movements of biological objects in the field of view. To go beyond 2D tracking system and build a more sophisticated 3D bat tracking system, we have pioneered 3D computer vision techniques within a deep learning framework. Our software allows for the calibration of the cameras to extract the 3D information of biological objects, in this case our primary interests being bats.

We utilized three thermal cameras in this study, spaced 37.5 inches apart and directed upwards towards the Gamesa and GE Wind turbine situated at NREL's Flatirons Campus. The dataset is generated from thermal camera videos, collected from June to December 2021 and 2023, where it was originally purposed for classifying biological objects such as bats, birds, and insects. The dataset has over 870,000 thermal images, and training, validation and test sets are generated via splitting the dataset with 80:10:10 ratio. All training and testing experiments are conducted under GPU setting with libraries such as CUDA and cuDNN. The improved machine learning models are defined, trained and tested via TensorFlow library.

Our system consists of three parts – bat detection, bat tracking, and stereo vision. The improved multiclass classification model has been used for the bat detection, where the transfer learning technique has been leveraged to overcome the limited amount of data. The Euclidean Distance-based tracking algorithm shows the tracking results, informing when, where, and how long the bat has been within the field of view. We lastly leverage stereo vision to gain 3D information of bats, estimating the height and size of the bat based on the disparity between two frames and allowing to obtain 3D bat tracking paths from a pair of stereo thermal videos.

Our final model performance achieved over 0.92 on averaged test accuracy, increased by 5.5% compared to the baseline model. The increment ratios for each category are 3.44% for bat, 13.6% for bird, 7.74% for insect and 0.41% for non-biological objects. We also

validated our depth estimation formula with the wind turbine's actual nacelle height and width. From the stereo vision system, nacelle width was estimated as 4.15m while the actual width was 3.81m, and the nacelle height was estimated as 259.6ft while the actual height was 254ft.

Introducing this technology to the market will facilitate efficient and accurate data retrieval, providing valuable insights to enhance our understanding of the factors driving risks to bats from wind energy.

Abstract Number 72. Lessons learnt from monitoring the effects of operational offshore wind farms in Europe - a large-scale synthesis and comparison

Presenter: Florian Lecorps
Session/Format: In-Person Poster Presentation
Authors: Florian Lecorps, Biotope; Pauline de Rock, Biotope; Magali Sabino, Biotope; Josef Haisch, Biotope

Abstract: The expansion of offshore wind power is currently gathering pace worldwide. The increase in the number and size of turbines is accompanied by potential environmental impacts that are not yet fully understood. The impacts of operational offshore wind farms (OWFs) are being studied in different countries through various monitoring programs. However, the exchange of knowledge between countries is not always assured.
The aim of this study was to provide a comprehensive comparison of the environmental effects and mitigation measures of operational European OWFs. To achieve this, a systematic review of monitoring reports from operational OWFs has been carried out (excluding peer-reviewed articles).

The study, carried out over a one-year period, was commissioned by the French Ministry of Energy, Ecology and the Sea (National Observatory for Offshore Wind Farms), with the support of the French Office for Biodiversity (OFB) and IFREMER. The consortium in charge of this study is made up of Biotope and its partners
BioConsult SH, HiDef Aerial Surveying, BRL Ingénierie and the Royal Belgian Institute of Natural Sciences (RBINS).
The first step was to draw up a complete inventory of operational OWFs and their main characteristics. For each country, the regulatory framework was examined and the lead authorities / regulators and dedicated observatories were listed.

A large number of biological monitoring documents were analyzed. In all, 514 monitoring documents were analyzed. They cover the pre-construction, construction and operation phases. They concern 72 offshore wind farms in operation in Europe, notably in the U.K., Belgium, the Netherlands, Germany and Denmark. Biological groups monitored include birds, fish, benthos and marine mammals. Very little data has been compiled for chiropterans.

Following a general analysis of all the documents compiled, an in-depth analysis of 288 documents was carried out for the main biological groups (on the basis of 15 different wind

farms for most biological groups) as well as for mitigation measures. In total, reports from 35 different wind farms were used in this detailed analysis. The targeted wind farms were selected on the basis of the quality and quantity of data available, and the representativeness of the technical or biographical characteristics of the offshore wind farms.

The methodologies used to monitor the environmental effects of OWFs were identified, and the effects observed on marine ecosystems reviewed. On one hand, these effects were examined as pressure/receptor pairs, and on the other, possible ecosystemic and cumulative impacts were investigated. In addition, the measures used to avoid, reduce and mitigate impacts were identified and their effectiveness assessed when possible. Finally, the applicability of the results to the French context was assessed, with the aim of obtaining important information for future environmental impact studies and impact management in France. A meta-analysis of European OWFs, their impacts and mitigation measures has never been carried out at this scale before, and provides valuable information to the public and decision-makers.

Abstract Number 73. The potential of turbine shut-down approaches to minimize impacts on seabirds

Presenter: David Wilson
Session/Format: In-Person Poster Presentation
Authors: David Wilson, The Biodiversity Consultancy; Ricardo Tomé, The Biodiversity Consultancy; Aonghais Cook, The Biodiversity Consultancy; Claire Fletcher, The Biodiversity Consultancy

Abstract: The offshore wind industry is likely to expand rapidly over the next decade, with much of that growth in emerging markets, where, typically, seabird communities are less well understood than in established markets. Onshore, once impacts have been avoided as far as practicable, then the shut down turbines to prevent fatalities from collision with turbine blades remains the primary approach to reduce impacts and has proven extremely successful where it has been well implemented. There are now increasing examples of shut-down approaches being implemented or required at offshore facilities, although almost always for terrestrial or migratory species rather than seabirds.

This talk will provide a future-oriented review of shut-down approaches and how they may be applied to, or modified for, the unique characteristics of seabirds and the marine environment. Issues discussed will include how and why shut-down is currently applied offshore, and which seabird species or marine locations are likely to require shut-down in the future as offshore wind expands into new geographies. We will then consider which onshore approaches to shut-down might be transferable to the offshore environment. Finally, we will identify some key gaps for future research and highlight scenarios for discussion where shut-down may not be appropriate or is not likely to achieve the desired outcomes.

Abstract Number 74. Navigating the impact of turbine scale on bat detection and deterrence

Presenter: Kaj Nielsen
Session/Format: In-Person Poster Presentation
Authors: Kaj Nielsen, SKOV

Abstract: Wind turbines deployed in offshore projects are significantly larger than what has ever been deployed onshore, and even bigger turbines are expected to enter commercial sales for offshore in coming years. As regulators, researchers and operators, it is critical that we understand to what extent research results from smaller turbine models apply to these very large turbines and to what extent we need to consider how such a large change in scale may result in new and possibly surprising results. This presentation will provide examples with a focus on the mechanics and physics of the turbines, explore possible models for understanding growth of turbines at this scale, and provide biologists additional background to consider when designing new studies or meta-studies based on past research.

A specific area of focus is the placement of monitoring and deterrence with respect to the tip height and speed of the blade tip. The preferred placement of bat detection and bat deterrent devices for smaller turbines has been at the nacelle, but it is time to question this approach and ensure sure that science supports decisions regarding where to place these devices on very large turbines. The likely outcome is that it may be preferential to place bat detection and bat deterrent devices in the region of lower tip height on the turbine tower both for research and operational purposes. If there is a significant difference in what part of the rotor sees more bat collisions for larger rotors, it would be valuable to focus deterrence and environmental monitoring on the particular area of the rotor that impacts more bats. It is also very likely that performing bat curtailment based on the nacelle wind speed is no longer optimal. Curtailment based on an estimated lower tip height wind speed may offer a more accurate risk reduction, and it would be advantageous if a scientific study could document and quantify the impact of such a change. If the lower swept area of the rotor poses a bigger risk than the upper swept area of the rotor, how do we need to differentiate the treatment?

In conclusion stakeholders would benefit from a collaborative effort to harmonize requirements for mounting devices mid-tower, especially as this is a sensitive subject for tower manufacturers. With multiple individual requirements it will be much more difficult to get cost effective mounting options in future towers, potentially slowing down deployment of already available technology, and hampering the benefit of all the good research already done.

Abstract Number 75. Preliminary pond tests of an ultrasonic bat deterrent: implications for wind energy

Presenter: Cerise Mensah
Session/Format: In-Person Poster Presentation

Authors: Cerise Mensah, Texas State University; Carly Naundorff, Texas State University; Sarah Fritts, Texas State University; Shilo K. Felton, Renewable Energy Wildlife Institute

Abstract: An unintended consequence of wind energy is bat collisions with wind turbines, which result in hundreds of thousands of fatalities annually in North America. Minimization strategies to reduce bat fatalities would likely be more widely implemented if effectiveness was demonstrated consistently. Ultrasonic bat deterrents are designed to emit sounds that create an unattractive airspace around the dangerous rotor-swept area of a wind turbine, minimizing bat fatality reduction strategies that decrease wind energy, such as curtailment. However, previous field testing has suggested species-specific responses to various frequency emissions. Moreover, many frequency sounds would attenuate before reaching the turbine blade tips, which may decrease effectiveness of the ultrasonic deterrent. We will test a new ultrasonic deterrent manufactured by MIDE. The MIDE deterrent is designed for deployment on a wind turbine blade. The ability to deploy the deterrent on a blade may increase effectiveness as the deterrent can cover a wider area within the airspace. This is particularly important as wind turbine blades are increasing in length. We plan to test the effectiveness of the deterrent at three to four ponds in Hays County, Texas from July-October 2024. We will monitor bats acoustically using Wildlife Acoustics SM4-BAT detectors during the entire duration of the study. We will select three nights at each pond with favorable environmental conditions for bat activity to test effectiveness of the deterrent. On these nights, we will power the deterrent for at least one hour, depending on bat activity, and track bat flight behavior with a thermal camera (Axis 1942-E). We will identify nights with similar environmental conditions to track bat flight behavior as control periods. We will compare the number of bat echolocation calls as well as the number of bat thermal detections between times when the deterrent is powered on and control periods. We will strive to identify to species bats using the acoustic data using Sonobat. If this blade-mounted deterrent reduces bat activity at ponds, we will conduct further testing in a controlled environment. Results herein will be preliminary, but will compare the frequency and rate of echolocation callas and thermal detections between treatment and control periods for each pond.

Abstract Number 79. Validating a 3D wildlife tracking system

Presenter: Brogan Morton
Session/Format: In-Person Poster Presentation
Authors: Brogan Morton, Wildlife Imaging Systems; Jon Ritter, Wildlife Imaging Systems

Abstract: There are many issues that a wind developer must consider when siting a wind project, but one that has become increasingly pressing in the U.S. is the effect of turbines on local wildlife. New onshore wind development is occurring across the entire the U.S. and has brought wind plants into greater conflict with wildlife, especially bats. The burgeoning U.S. offshore wind industry is also contending with these wildlife conflict issues as well, with a focus on migratory and marine birds.

While the timing and relative wildlife activity can be gleaned from acoustic and 2D thermal data, three-dimensional monitoring and tracking methods must be used to better quantify wildlife interactions with wind turbines. For onshore turbines, understanding how bats use the vertical aero-environment around turbines and if there are specific risky behaviors associated with mortality is critical. For offshore turbines, informing the model input parameters as well as validating models to predict avian distributions, calculate mortality, and estimate individual and population level impacts is also needed. For both onshore and offshore turbines, monitoring can inform adaptive management by quantifying the efficacy of mitigation.

The technology innovation we have developed is a cost-effective 3D wildlife tracking system based on stereo security cameras and advanced processing software. Using security cameras improves the reliability of the system by eliminating the need for a field-computer to acquire synchronized video from both cameras. This also significantly reduces the cost of the system by replacing expensive synchronized cameras with less expensive security cameras and eliminates the need for a power-hungry computer in the field. Switching to these cameras is enabled by the advanced software that time synchronizes the data in software as well as automates the in-situ camera-to-camera (extrinsic) calibration that is required.

We designed and fabricated a prototype 3D camera hardware kit used for testing and validating the algorithms we created. For initial testing we used Axis Q1952-E thermal cameras, although the software can use visible light camera footage as well. We captured validation data by flying a drone with GPS logging capabilities through the field of view of our stereo cameras and compared the reconstructed path to the actual path. The drone was flown at distances of 25 meters, 50 meters, and 75 meters to assess the system's performance across different distances. The reconstructed drone tracks remained within 2 meters from the corresponding measured GPS positions.

After the success of the validation testing with the drones, we plan to deploy two prototypes to turbines at an operational wind facility in the U.S. Midwest during the peak bat season in 2024. In our presentation, we will discuss the benefits of 3D wildlife tracking for both the onshore and offshore turbines, we will present the results of the validation testing conducted with the drone, as well as present the initial result of our 2024 field testing.

Abstract Number 80. Experimental evaluation of an automated detection and audio deterrence system for reducing the risk of collision for eagles at a commercial wind energy facility

Presenter: Jeff Smith
Session/Format: In-Person Poster Presentation
Authors: Jeff Smith, H. T. Harvey & Associates; John Romansic, H. T. Harvey & Associates; Stephanie Schneider, H. T. Harvey & Associates; Scott Terrill, H. T. Harvey & Associates;

Taber Allison, Renewable Energy Wildlife Institute; Shilo K. Felton, Renewable Energy Wildlife Institute

Abstract: DTBird® is an automated detection and audio deterrent system designed to discourage birds from approaching spinning wind turbines. We conducted multi-faceted research in the western U.S. to evaluate its effectiveness in detecting and deterring Golden Eagles (Aquila chrysaetos) and other large soaring raptors. Here we report the results of a 2-year (September 2021–September 2023) control-treatment experiment implemented at a commercial wind facility in Washington where 14 DTBird systems were spaced around the perimeter of a 48-turbine array. The experiment involved randomized daily operation of turbine-specific DTBird systems with (treatment) and without (control) the audio deterrents broadcasting. We addressed two research hypotheses with different dependent variables: a) probability of triggering a dissuasion

signal (i.e., the more raucous of two deterrent signals, triggered to indicate incursion into a high-risk zone); and b) dwell time (i.e., tracking period) per detection event. We developed generalized linear mixed models (GLMMs) for Golden Eagles alone and all eagles combined (including Bald Eagles [Haliaetus leucocephalus] and unidentified eagles) to evaluate the effect of Treatment Group in conjunction with other predictors. Treatment Group did not significantly influence the probability of dissuasion triggers, but the indications were consistent with our hypothesis that dissuasion-triggers should be less common at installations operating in treatment mode. The dwell-time models indicated stronger Treatment Group effects consistent with our hypothesis that eagles should dwell less around treatment turbines. Broadcasted deterrents had a modest (24–27%) overall positive effect in reducing eagle activity at DTBird-equipped turbines. That apparent avoidance effect was heightened on turbine-specific days when the overall deterrent-triggering rate was elevated due to the involvement of high numbers of false positives (FPs; i.e., detections of various inanimate objects and non-target flying animals, and caused by various software glitches). Though generally not a desired feature, atypically high and sustained FP deterrent-triggering activity likely contributed to temporal declines in both dependent variables, reflecting an overall pattern of enhanced positive habituation (i.e., avoidance of broadcasted deterrents) among eagles across the study.

Abstract Number 82. Insights from avian collision and avoidance data from on and offshore facilities to inform future collision risk assessments and identify research priorities

Presenter: Sally Yannuzzi
Session/Format: In-Person Poster Presentation
Authors: Sally Yannuzzi, Western EcoSystems Technology, Inc. (WEST); Todd Mabee, Western EcoSystems Technology, Inc. (WEST); Jennifer Stucker, Western EcoSystems Technology, Inc. (WEST); Peter Kappes, Western EcoSystems Technology, Inc. (WEST); Tracy Brunner, Western EcoSystems Technology, Inc. (WEST); Melinda Conners, Western EcoSystems Technology, Inc. (WEST)

Abstract: Three decades of post-construction fatality monitoring at land-based wind energy facilities in the U.S. have yielded valuable insights into the species composition of avian collisions. As offshore wind energy rapidly develops globally, leveraging existing data is crucial for informing future avian collision risk and implementing effective minimization and mitigation strategies to reduce impacts to birds. Collisions of birds with wind turbines at offshore wind facilities (OWF) have rarely been documented and, therefore, collision risk is poorly understood.

We conducted a literature review of offshore collisions and avoidance data from resources published within the last 15 years to review the current state of knowledge of avian collisions and avoidance rates in both the offshore and onshore environments. This compiled literature was considered in combination with onshore avian fatality data from Renew (WEST's database with over 600 post-construction fatality monitoring studies) to provide insight into the overall collision vulnerability of avian guilds that occur in the nearshore and offshore environments (offshore guilds).

Globally, 478 collisions from five avian guilds containing 20 species were recorded at OWF. Terns and gulls were the dominant guilds (46.9% and 27.0%, respectively) followed by waterfowl, pigeon/doves, and fulmars. Fatality data from Renew at onshore facilities included 344 bird species from 50 guilds totaling 16,845 fatalities across the U.S. and Canada. Of the 50 guilds, 10 were offshore guilds including shorebirds, waterfowl, gulls, pelicans, tropicbirds/frigatebirds, cormorants, petrels, terns, loons, and shearwaters, totaling 1,205 fatalities. Although shorebirds comprised the majority (53.3%) of fatalities of offshore wind guilds, killdeer (a common onshore species) accounted for 85.0% of shorebird fatalities.

The waterfowl guild comprised 33.0% of the offshore guild's fatalities from Renew, with dabbling ducks and geese (more commonly in onshore environments) comprising 91.7% of waterfowl fatalities. The remaining fatalities from offshore guilds included gulls (7.5%), pelicans (3.2%), tropicbirds/frigatebirds (1.2%), and cormorants (0.8%). After removing more land-dominant shorebirds and waterfowl from the list, shorebird fatalities (94) were still only slightly higher than gull (90), and waterfowl fatalities (33) were fewer than pelican (39).

Avoidance rates were also summarized to supplement our knowledge of offshore guilds. Avoidance data at the meso- and micro-scale were generally lacking, with most studies focused on gulls. Two other offshore guilds (waterfowl and gannets/boobies) had avoidance data at these scales, but with low sample sizes. While avoidance was generally high for these three guilds, waterfowl and gull collisions at both offshore and onshore wind facilities were common.

Collision and avoidance data are generally lacking in offshore environments, specifically at the meso- and micro-avoidance scales, and transferrable data may be gleaned from onshore wind facilities to inform collision vulnerability at OWFs. Additional research

collecting collision and avoidance data in the offshore environment would help inform robust risk assessments and collision risk modeling.

Abstract Number 84. Echolocation and rotation: comparing bat activity patterns in relation to wind turbine rotor speed

Presenter: Caroline Byrne
Session/Format: In-Person Poster Presentation
Authors: Caroline Byrne, Stantec Consulting; Trevor Peterson, Stantec Consulting; Seta Aghababian, Stantec Consulting

Abstract: Acoustic data from turbine-mounted detectors has shown great promise to design, evaluate, and even trigger curtailment strategies. Pairing acoustic bat passes with turbine rotor speed measurements enables calculation of the amount and proportion of bat activity exposed to turbine operation and the associated risk of turbine-related impacts. By aligning acoustic data with time-stamped wind speed and temperature recordings, acoustic exposure can be simulated for different turbine operational strategies even before they have been implemented. This enables testing potential strategies with varying degrees of protectiveness and comparing them to uncurtailed turbine operation without the associated risk to bats of operating uncurtailed control treatments. Acoustic detectors can record bats regardless of whether turbines are operating, but simulating exposure for different curtailment alternatives assumes that turbine motion does not have a pronounced effect on the spatial, temporal, or seasonal distribution of bats near the turbine nacelles. The importance of this assumption depends considerably on how different a simulated curtailment strategy is from what was implemented when acoustic data were collected, but it is important to investigate how turbine motion may affect bat presence and acoustic activity in the rotor swept zone when simulating exposure across strategies. We deployed acoustic detectors (nacelle and 20 meters above ground level) at two wind projects in Missouri that were part of a curtailment study funded by the Renewable Energy Wildlife Research Fund to evaluate how acoustic activity varied according to turbine operation under a range of weather conditions. We aligned bat acoustic data with 10-minute binned weather and turbine rotor speed measurements. Study turbines were separated into operational treatments with cut-in speeds from 3 to 8 m/s . Comparing acoustic bat activity patterns recorded between these operational treatments provided an opportunity to investigate the relationship between turbine movement and bat activity under the same weather conditions. Overall bat activity patterns did not differ substantially between operational treatments, although acoustic bat activity appeared slightly higher at idle versus operating turbines under some conditions, suggesting the need for further study and the importance of articulating assumptions when simulating acoustic exposure. These research questions underlie an important practical goal of determining how best to use acoustic detectors to design and evaluate curtailment strategies and other measures to reduce risk to bats. Such questions become more important as the wind energy industry expands into new regions and explores options for managing risk to species listed under the Endangered Species Act.

Abstract Number 86. Accelerating technology solutions to minimize effects on birds and bats from land-based wind energy

Presenter: Isabel Gottlieb
Session/Format: In-Person Poster Presentation
Authors: Isabel Gottlieb, Renewable Energy Wildlife Institute; Cris Hein, National Renewable Energy Laboratory; Patrick Field, Consensus Building Institute; Taber Allison, none

Abstract: There is an urgent need to produce renewable energy to stave off the worst effects of climate change and to meet national and state decarbonization goals. Wind energy is a key sector in the transition to renewable energy, yet the operation of wind turbines directly and indirectly affects certain species of birds and bats. The cumulative effect of wind turbine strikes can have both biological and regulatory consequences, and, in some cases, delay permitting and construction or affect ongoing operations. Technology can help quantify and minimize these effects, but the pace of development, acceptance, and adoption of technological solutions is slow. While adopting cost-effective technologies may reduce negative effects on wildlife and help achieve both energy production and conservation goals, consensus is lacking among developers, regulators, and the conservation community regarding how to define technology effectiveness and acceptance and how to develop a standardized process for doing so. In this paper, we provide a brief overview of the state of the science of technologies for monitoring or minimizing negative effects to wildlife from wind energy deployment. We also outline major barriers to technology acceptance and deployment. We then propose recommendations to facilitate the development, acceptance, and adoption of cost-effective technologies.

Abstract Number 88. Compensatory mitigation solutions for sage grouse in southeastern Colorado

Presenter: Alexis Echols
Session/Format: In-Person Poster Presentation
Authors: Alexis Echols, Burns & McDonnell; Paul Sherman, Burns & McDonnell

Abstract: The State of Colorado is in the process of approving significant renewable energy resources which must balance near term impacts to threatened and endangered species with long term goals of energy decarbonization. Burns & McDonnell is working with energy developers to provide near term timely and economical mitigation solutions to species protections.

Since 1998, the United States Fish and Wildlife Service (USFWS) has considered the lesser prairie chicken as a species of concern and a candidate for Threatened or Endangered listing pursuant to the Federal Endangered Species Act (ESA). Over that time, lesser prairie chicken populations have remained unstable, resulting in its ESA listing as Threatened and Endangered by the USFWS across various ecoregions in March of 2023. Lesser prairie chicken habitat exists in the shortgrass prairies of the southern Great Plains. This includes

portions of Kansas, Oklahoma, Colorado, New Mexico, and Texas, and spans three distinct ecoregions. Though there are conservation efforts for the lesser prairie chicken in portions of their range, no conservation banks exist within the most arid of the ecoregions they inhabit, the Sand Sagebrush Ecoregion, which crosses the entire LPC range in Colorado. Previous conservation efforts have focused on New Mexico, Texas and Kansas, however with no lesser prairie chicken conservation banks in the state of the Colorado, infrastructure developers in the region face limited mitigation options for the newly listed species.

Wind and related infrastructure being proposed in southeastern Colorado now must contend with regulatory oversight and approvals which aim to provide species protection while enabling the development of renewable energy. State agencies would prefer for mitigation efforts to remain within state boundaries.

In an effort to provide high quality mitigation options in the Sand Sagebrush Ecoregion, Burns & McDonnell set out to identify large, contiguous land areas for conservation of the species in southeast Colorado. This presentation will walk through the land identification process, which was dependent on publicly available habitat information and species data from both public and private lands. We also discuss project coordination with Colorado Parks and Wildlife and the USFWS who are seeking an increase in habitat quality over time as opposed to a conservation only approach. Early and often communication with both state and federal agencies was key to identifying the right parcels, and to determining how to conserve and restore them. Habitat on potential parcels was examined to determine a baseline quality and inform conservation or restoration actions needed for each area. We will discuss planned restoration and long-term management activities such as the removal of internal fences, trees, and other structures, and grassland management to improve species composition and diversity. Restoration actions will be driven by baseline habitat data and agency feedback. Once implemented, restoration efforts will be monitored and may be adjusted over time.

Burns & McDonnell plans to have credits available in 2025 to provide offsets for projects impacting lesser prairie chicken habitat in the Sand Sagebrush Ecoregion.

Abstract Number 90. Seabird and bat behavior at an offshore wind energy site

Presenter: Jennifer Wehof
Session/Format: In-Person Poster Presentation
Authors: Shari Matzner, Pacific Northwest National Laboratory; Evan Adams, Biodiversity Research Institute; Andrew Gilbert, Biodiversity Research Institute; Kate Williams, Biodiversity Research Institute

Abstract: Offshore wind energy is needed to transition away from fossil fuels and to meet clean energy goals. The impacts of offshore wind energy development on seabird and bat populations are not yet well understood for waters of the United States. To advance our

understanding, several technologies for recording the presence and behavior of aerofauna were deployed on an anchored barge approximately 45 km (27 mi) south of Martha's Vineyard in Massachusetts from June to September of 2024. The barge was equipped with wind-profiling lidars and other atmospheric and meteorological instruments. It also hosted several systems focused on monitoring wildlife in the offshore environment, including acoustic bat detectors and a ThermalTracker-3D, a novel thermal camera system that records the three-dimensional flight tracks of aerofauna. The ThermalTracker-3D system includes stereo-optic thermal cameras, a visual spectrum camera, and a software program that locates, tracks, and supports identification of flying animals in the video footage. The system provides three-dimensional flight tracks and related behavioral data for observed aerofauna. The system was recently deployed on a buoy offshore of California (Schneider et al. 2024; https://www.frontiersin.org/articles/10.3389/fmars.2024.1346758/full), and provided high resolution (within ±5 m on average) flight tracks for birds moving 100-500m from the system. The 2024 barge deployment is the first offshore deployment for this system in eastern North America, and is providing essential data on offshore flight heights of aerofauna (24 hours a day and in all weather conditions) that are not obtainable via more traditional means such as observational surveys. These data can be used to understand collision risk with offshore wind energy development via such uses as incorporation into collision risk models. We will present preliminary results from the barge and validation survey observations in 2024. Human surveys were paired with the camera systems detections to evaluate the efficacy of the system and support software development focused on automation of species identification. Together, these data provide insight into flight behavior of fauna in an area of planned offshore wind energy development south of Massachusetts/Rhode Island and can inform decisions around the design and operation of planned wind turbines in the region.

Abstract Number 91. Bat and bird behavior at commercial wind turbines as revealed by 3-D thermal videography

Presenter: Aaron Corcoran
Session/Format: In-Person Poster Presentation
Authors: Seta Aghababian, Stantec Consulting; Michael Whitby, Bat Conservation International; Aaron Corcoran, University of Colorado--Colorado Springs

Abstract: The wind industry is experiencing rapid growth, yet lethal interactions between bats and birds with industrial-scale wind turbines pose significant ecological challenges. While previous studies have used two-dimensional video to observe bat behavior, this method has limited ability to provide precise, quantifiable spatial metrics essential for understanding collision causes and developing mitigation systems. We applied three-dimensional thermal videography to measure bat and bird activity at commercial wind turbines, accurately capturing the spatial positions of these animals.

We reconstructed 22,479 flight paths of nocturnal aerial animals over 89 recording nights at two wind turbines in an Iowa wind energy facility between August and October 2021. Our

observations revealed that 68% of vertebrate animal flights occurred within the rotor-swept zone, putting them at risk of blade collisions. Activity in the lower half of the rotor-swept zone (below the turbine nacelle) was 300% higher compared to the upper half. We found that activity within and above the rotor-swept area peaked in late August, during early evening hours, and under wind conditions blowing to the south at speeds between 3 and 6 meters per second.

For a subset of 23 nights throughout the sampling period, we manually classified the behavior of 4,252 flight paths. Linear flight behaviors were more common above the turbine, while non-linear behaviors were more frequent at altitudes within the lower rotor-swept zone. Additionally, we documented two collisions, both of which had flight patterns indicating that wind turbulence near turbine blades (5-10 m) might be a proximate cause of fatality events.

Our findings indicate that although three-dimensional video may not be essential for general activity studies, it is a valuable tool for improving targeted mitigation systems, such as acoustic deterrents, and for providing detailed characterizations of bat and bird behavior near turbines to better understand collision causes. We suggest researchers and managers consider placing acoustic deterrents and monitoring equipment in the lower rotor-swept zone, such as on the monopole, to optimize for the greatest concentration of flying vertebrates at risk of collision with turbine blades.We note that this research is ongoing, particularly in distinguishing between bats and birds in videos using video pattern recognition and correlating video detections with concurrent bat echolocation and radar data.

Abstract Number 93. Hoary bat ecology and conservation in a renewable energy future

Presenter: Amanda Hale
Session/Format: In-Person Poster Presentation
Authors: Shilo K. Felton, Renewable Energy Wildlife Institute; Erin Baerwald, University of Northern British Columbia; Jeff Clerc, National Renewable Energy Laboratory; Winifred F. Frick, Bat Conservation International; Amanda Hale, West, Inc.; Cris Hein, National Renewable Energy Laboratory; Eric Schauber, Renewable Energy Wildlife Institute; Theodore J. Weller, United States Department of Agriculture

Abstract: Hoary bats are the widest-ranging bat species in North America and constitute the greatest number of bat carcasses found at wind energy facilities on the continent. Hoary bat fatalities have been found in nearly all PCM studies conducted in the U.S. to date. According to the American Wind Wildlife Information Center (AWWIC), the species makes up 27% of reported bat fatalities across facilities in the country. Collision risk for hoary bats increases during fall migration, particularly between July and October. Although knowledge gaps remain regarding population size and vital rates of hoary bats, models indicate that current levels of wind turbine mortality may result in a severe population decline for the species unless minimization strategies are implemented. High rates of

collision fatalities of hoary bats have led USFWS to initiate a status review of the species to inform a planned 2028 listing decision for this species under the Endangered Species Act. Being listed as Threatened or Endangered would likely have serious impacts on wind energy production. Given the large potential for impacts on both hoary bat populations and renewable energy development, it is timely to rigorously characterize and improve the state of knowledge of this species' autecology and interactions with wind turbines and other stressors. We conducted a literature review to provide an overview of the state of the science on hoary bat ecology and conservation challenges related to wind energy and other stressors. This comprehensive review addresses what is currently known in publicly available literature about population status, habitat requirements, migration ecology, echolocation and social calls, as well as impacts of wind energy development, habitat loss, and climate change. As a result of this overview, we will identify critical questions and tools necessary to inform future management decisions for hoary bat conservation.

Abstract Number 95. Optimized Smart Curtailment: achieving bat risk reduction targets while minimizing power loss from curtailment

Presenter: Michael True
Session/Format: In-Person Poster Presentation
Authors: Michael True, Western EcoSystems Technology, Inc. (WEST); Paul Rabie, Western EcoSystems Technology, Inc. (WEST); Amanda Hale, Western EcoSystems Technology, Inc. (WEST); Rhett Good, CWB®, Western EcoSystems Technology, Inc. (WEST)

Abstract: Wind turbine curtailment (i.e., feathering turbine blades below a certain wind speed [cut-in speed]) is the primary strategy to minimize bat mortality at wind energy facilities. However, curtailment can be costly depending on both the length of the curtailment period and the cut-in speed applied. Bat activity (and presumed risk when the rotor is moving) is not constant. Rather, it varies with calendar date, time of night, temperature, and other atmospheric conditions linked to bat biology. Therefore, curtailment all night for extended periods of time (i.e., "blanket curtailment") leads to little conservation value and excessive losses during periods of low risk such as cold temperatures late in the season. One form of "smart curtailment" is algorithm-based—the setting of curtailment schedules based on periods predicted to have high collision risk. Implementing these algorithms produces conservation benefits while reducing turbine downtime and lost power production. To date, most algorithm-based smart curtailment strategies are based only on bat risk. We introduce WEST's Optimized Smart Curtailment (OSC) model which creates curtailment algorithms informed by the variables associated with both bat risk and power production potential. We showcase OSC trained on real data from a wind facility to demonstrate its use in certain contexts related to unique conservation and energy loss reduction goals. In 2024, WEST applied for and was awarded REWRF funding to test the effectiveness of OSC versus blanket curtailment treatments at three separate wind facilities in the U.S. Here, we introduce the study, which will advance in multiple phases: acoustic and thermal camera data collection, development of OSC algorithms, implementation of OSC algorithms and blanket curtailment treatments at each

facility, and carcass monitoring. The study aims to demonstrate the effectiveness of OSC in terms of minimizing risk to the extent of blanket curtailment while being less costly.

Abstract Number 96. Predicting hoary bat fatalities using the passage of regional weather systems

Presenter: Rhett Good, CWB®
Session/Format: In-Person Poster Presentation
Authors: Rhett Good, CWB®, WEST; Paul Rabie, West, Inc.; Simon Weller, Western EcoSystems Technology, Inc. (WEST); Kristen Nasman, Western EcoSystems Technology, Inc. (WEST)

Abstract: Hoary bats are the bat species most frequently found as fatalities at wind energy facilities in the U.S., and there is increasing concern over the potential of wind energy to impact hoary bat populations. Many wind energy companies utilize a simple and effective strategy called blanket curtailment to reduce collision mortality over a predetermined time frame (typically the late summer and fall) when most bat fatalities occur. Because hoary bat fatalities do not occur every night, tools that predict nightly risk to hoary bats may allow wind energy facilities to regain lost energy production on nights where curtailment is not necessary to minimize collisions with hoary bats. Many wind energy facilities in the Midwest lack significant forest cover near turbines, and most bats must fly long distances after leaving their roosts before they encounter turbines. Past efforts to predict hoary bat fatalities using on-site weather variables showed inconsistent results. One potential cause for inconsistency is that hoary bats in the Midwest may initiate flight or migration based on cues occurring several kilometers from wind turbines. We utilized fatality data from three wind energy facilities, spanning two or three years at each site, to determine if hoary bat fatalities could be predicted by covariates related to the passage of regional weather systems. We developed models to predict bat fatalities based on weather variables measured at airports within 240 kilometers (km) of two wind energy facilities, one in northeast Illinois (Pilot Hill) and one in northwest Indiana (Fowler Ridge). The efficacy of the models was tested at a third, anonymous wind energy facility located in northeast Illinois. All three facilities are located within approximately 21–64 km of each other, have little forest cover (i.e., <0.5% of land cover near turbines), and collected post-construction monitoring data from turbines that operated at manufacturer's cut-in speed during the late summer and fall. We used regularized logistic regression to predict the probability of a hoary bat fatality night with models that were trained using either hoary bat fatality data or all bat fatality data. The optimal model and classification threshold predicted that curtailment could be eliminated on 39% of nights during the late summer and fall, while still maintaining 79% of the conservation benefit to hoary bat fatalities, compared to curtailment every night. Hoary bat fatalities in Illinois and Indiana were correlated with the passage of regional weather systems, and these could be used to improve predictions of hoary bat fatalities. Funds for this study are provided by the Renewable Energy Wildlife Research Fund (REWRF), administrated by the Renewable Energy Wildlife Institute (REWI). Future research can build upon these results by expanding these methods at other facilities and in other regions.

Abstract Number 100. Progress towards mitigating wind energy risks to bats: A tool for evaluating attraction hypotheses

Presenter: Jeff Clerc
Session/Format: In-Person Poster Presentation
Authors: Michael Sinner, National Renewable Energy Laboratory; Jeff Clerc, National Renewable Energy Laboratory; Sora Ryu, National Renewable Energy Laboratory; Eliot Quon, National Renewable Energy Laboratory

Abstract: Observational studies have shown that bats are often found flying in the vicinity of land-based and offshore wind turbines, and some species may even be attracted to wind turbines and their wakes. Various attraction hypotheses exist and may differ between species: increased concentration of prey; lower speed, more turbulent air in the wind turbine wake; and heat and auditory emissions from the turbines. Regardless of the exact reason for the attraction, methods for understanding bat flight paths in and around wind turbines and wind farms are needed to intelligently control and curtail wind turbines to mitigate bat takes.

To this end, we have developed a methodology and tool for simulating bat flight paths in computer simulations. The approach can be used to generate individual flight paths but more importantly, to understand the probability distributions of bat flight paths. While the tool is currently in development, we intend to adjust parameters of the model to match characteristics from actual flight paths taken from cameras and radars near wind turbines and present the results of this work.

The simulation methodology adopts an engineering approach, treating bats as a “bluff bodies” that are transported through the air by a combination of the propulsive force exerted to move towards an objective, the propulsive or drag force contributions coming from the air flow in the main wind direction, and perturbations caused by atmospheric turbulence. These forces and associated accelerations are integrated in time to produce a representative bat flight path through wind environments produced by a stochastic turbulence generator (TurbSim) often used in wind turbine dynamics modeling. At the time of writing of this abstract, we have the capability of simulating bat flight paths with different orientation strategies in undisturbed “free stream” airflow without wind turbines. We can also make simplified corrections for the presence of wind turbine wakes, which are characterized by a lower wind speed zone downstream of the wind turbine. The wakes are represented using a well-established turbine wake model (FLORIS) that has been applied to wind-plant design and controls optimization. We are now in the process of incorporating models for how bats may be attracted to wind turbine rotors, nacelles, and towers; how the additional turbulence generated in a wind turbine wake changes the bat flight paths; and how an energy budget may modify bat behaviors.

Abstract Number 103. Comparing algorithm-based informed versus acoustic-activated smart curtailment methods for balancing bat conservation and energy production at wind energy facilities

Presenter: Roger Rodriguez
Session/Format: In-Person Poster Presentation
Authors: Roger Rodriguez, Natural Power; Virginia Iorio-Merlo, Natural Power; James Robbins, Natural Power; Gillian Vallejo, Natural Power

Abstract: Curtailment strategies that utilize bat presence data have been developed as alternatives to blanket curtailment to reduce bat fatalities at wind energy facilities while also recovering lost energy associated with blanket curtailment. One method, referred to as algorithm-based informed curtailment (ABIC), involves employing non-probabilistic or probabilistic modeling using pre-existing bat presence data, typically acoustic data, with environmental data, particularly wind speed and temperature, and sometimes data on power production. ABIC methods use such data to predict and prescribe periods when risk to bats is low and energy production is maximized indicating when turbines may reasonably operate. Another method is acoustic-activated smart curtailment (AASC), which combines real-time data on bat presence, typically acoustic data, with wind speed and temperature data to curtail instantly based on pre-determined rulesets. While both methods have demonstrated success in achieving bat fatality reduction and simultaneously increasing energy generation compared to blanket curtailment, advantages and disadvantages are often discussed but no quantitative comparison of the methods has been conducted yet. For example, one contrasting point has been the ability to account for variation in bat activity on a fine temporal scale. That is, while ABIC methods estimate a period of likely bat presence, these methods may still result in curtailing during periods when bats may not occur in the rotor swept area and/or are at low risk, because these methods are only predictive. Alternatively, AASC methods are able to respond to real-time bat activity immediately but represent a more reactive approach which lacks predictive power. To compare ABIC and AASC methods, we assessed these methods for their ability to reduce bat risk and maximize energy production based on simulating curtailment scenarios using bat acoustic data collected from an existing wind energy facility. Bat risk was defined as the number of exposed bat calls, i.e., those recorded when turbines would be operational under each of the simulated curtailment scenarios. Analyses were conducted on the same dataset, including bat acoustic detections, wind speed, temperature, and power. Based on this analysis, we discuss the advantages and disadvantages of the two strategies and suggest that use of real-time data, compared to predictive algorithms, may result in increased efficiencies in energy production, especially given temporal variation in bat activity. Both informed and smart curtailment methods provide advantages over traditional blanket curtailment approaches, because they lead to comparable, if not better, reduction in bat risk while enabling increased renewable energy production which will be advantageous in addressing climate change and its impacts on bat populations. We will discuss the benefits of using both methods, as well as avenues for

further research, such as developing “intelligent curtailment” by combining algorithm-based and acoustic-activated methods.

Abstract Number 108. Can renewable energy development benefit from the lessons learned in the conservation world? Energy focal areas as a strategy to focus development while minimizing impacts.

Presenter: Mike Houts
Session/Format: In-Person Poster Presentation
Authors: Mike Houts, Kansas Biological Survey, University of Kansas. Enel Green Power; Natalie Rodriguez, ENEL Green Power North America

Abstract: Goals are useful, but they are generally more achievable and effective when they are guided by a strategy. Conservation efforts have learned this and adopted conservation targeting strategies to guide their efforts for maximum effectiveness. While every acre counts, the mantra of avoiding “random acts of conservation” and instead concentrating efforts in priority areas has helped the conservation community make significant progress towards numerous goals. Plans and strategies help turn goals into efficient realities. America’s goal of having 80% of its energy derived from renewable energy will require a substantial increase in the number of industrial wind and solar facilities, however, where this power generation will occur is largely undefined. Most of the United States is suitable for either wind or solar development with some calculations indicating the U.S. landscape could theoretically produce six to seven times the amount of electricity we consume as a country. While the financial limitations related to the proximity of transmission lines, and avoidance of environmental constraints somewhat guide where wind and solar are developed, willing landowners are potentially the biggest factor in deciding where a facility will be built. So, while the energy goal is 80% of demand, the strategy is effectively “wherever companies can find a place to put it”.

What if there was a strategy to guide development into certain areas using incentives to boost landowner participation and reduce development costs in key areas? What if there was a way to minimize the random acts of renewable energy development impacting species, habitats, and communities across the landscape. The creation of energy focal areas that concentrate energy generation in areas with good wind or solar potential, near transmission lines, and in areas with lower environmental/habitat risk could help the U.S. achieve its goal. This GIS (Geographic Information System) exercise uses the 7 sq. km cogs of the nested hexagon framework to analyze energy and environmental data to explore the areas available if most new energy development were focused along highways and existing transmission corridors, and away from cities and protected conservation areas. Energy focal areas can then be further refined to minimize impacts to migration routes, flyways, and other wildlife/habitat priority areas. By developing a renewable energy siting strategy to guide responsible progress to the 80% goal, the U.S. has a better chance of achieving that goal while also preserving its vast natural landscapes and the many species and communities that rely on them.

Abstract Number 112. Spatial econometric analysis of impacts of wind turbine-related bat mortality on agricultural pest control as an ecosystem service

Presenter: Nihar Chhatiawala
Session/Format: In-Person Poster Presentation
Authors: Nihar Chhatiawala, Pardee RAND Graduate School

Abstract: The effectiveness of wind energy as a means of reducing dependence on fossil fuels is highly influenced by the selection of project sites with desirable wind conditions. Such conditions have allowed Texas – particularly in some of its historically agricultural regions – to lead the adoption of wind energy in the United States. Concerns that wind energy leads to localized environmental impacts, albeit less severe than the globalized impacts of fossil fuels, continue to influence the debate as to where turbines should be sited, how they should operate, and the extent to which hesitation is valid amid the urgency of climate change mitigation. In this paper, we attempt to test the claim that bat mortality due to wind turbines could increase vulnerability of crops to pests by weakening bat-derived agricultural pest control as an ecosystem service. Using publicly available data from the USGS and USDA, we sought diff-in-diff specifications to model the implementation of wind energy over time with relation to the yield of upland cotton across Texas counties between 2000 and 2022, finding mixed evidence for the causal effect of an interaction term between agricultural volume and wind energy implementation on per-acre yields (i.e. an effect of wind energy implementation that depends on the acreage of upland cotton crops in a given county) and weak evidence for the causal effects of wind energy implementation alone. We approach these results with caution, noting limitations in the data and specification as well as inconsistent findings across geographical data slices. We will refine our analysis (incorporating discussions of how such insights can influence ecosystem service pricing and decision-making under uncertainty) and share initial results leading up to WWRM 2024.

Abstract Number 115. Eagle incidental take general permit eligibility for wind energy projects

Presenter: Kylan Frye
Session/Format: In-Person Poster Presentation
Authors: Kylan Frye, U.S. Fish and Wildlife Service; Matt Stuber, U.S. Fish and Wildlife Service

Abstract: The U.S. Fish and Wildlife Service (Service) has developed a new permitting approach for incidental take of eagles and wind energy generation facilities. For wind projects that are located in areas pre-determined to have relatively low risk to eagles, and that have no turbines that are located within 660ft from the nearest known bald eagle nest and within 2mi from the nearest golden eagle nest, applicants may be eligible to receive a general permit. General permits are automatically issued permits designed to expedite permit issuance for eligible projects. These permits all have the same standard conditions, require use of an in-lieu fee program for compensatory mitigation, are non-amendable, and have a 5-year maximum tenure. We present an overview of the general permitting approach, focusing on eligibility criteria, how we arrived at the criteria, why the criteria are important, how to determine if your project is eligible, and recommendations for documenting eligibility during the application process. Further, we discuss how eligibility may change through time based on observed eagle take. Lastly, we will also discuss how some existing wind projects who do not meet eligibility criteria may request general permit eligibility through the specific permit application review process.

Abstract Number 119. Bat curtailment 101 – practical considerations crucial to the planning, design, and implementation of bat curtailment

Presenter: Quintana Hayden
Session/Format: In-Person Poster Presentation
Authors: Allison Poe, EDP Renewables; Andrew Pinger, Scout Clean Energy; Dave Phillips, Vestas/Steelhead; Jennifer Schroeder, Capital Power; Joe Gerland, RWE Clean Energy; Quintana Hayden, American Clean Power Association; Stu Webster, Triple Oak Power

Abstract: Numerous studies have shown that wind turbine generator (WTG) curtailment (aka curtailment) reduces bat fatalities at wind projects, with varying benefits depending on the curtailment cut-in speed, WTG type/size, habitat present, temperature, species characteristics, and various other potential factors. While curtailment has been shown to be an effective mitigation strategy, to be a <u>successful </u>mitigation strategy, curtailment must be optimized to balance bat conservation needs with energy production and other project factors. As regulatory agencies, developers/operators, and other stakeholders work to find the appropriate balance, this work requires an awareness of the numerous practical considerations affecting the planning, design, and implementation of curtailment. To increase the collective knowledge and understanding of the considerations crucial to successful bat mitigation strategies, ACP has prepared a primer on the technical logistics and resources relevant to WTG curtailment, packaged for presentation to non-engineers. This information was gathered from industry developers and operators with active wind farms in both Canada and the U.S., and includes operational considerations such as energy production modelling, financial and commercial agreements, curtailment loss scenarios and how these impacts various financial agreements; project siting and wind resource considerations; variation in market price; and grid stability/stranded resource/frequency impacts. How does broadscale wind energy curtailment affect grid stability as wind becomes a greater part of the energy mix? What replaces it? Can we quantify the loss of renewable energy electrons? In additional to operational considerations, there are additional logistic considerations including target bat species, data requirements, curtailment design (blanket, optimized smart/algorithm informed, activity/acoustic triggered) and technological limitations/requirements/costs. Information on these considerations has been gathered from industry researchers and operators who have been involved in the research and or implementation of curtailment. We conclude that the consideration of curtailment for the purpose of mitigating impacts of wind turbine operation on bat species is an important mitigation option, but one that comes with a wide range of factors that must be considered not only by the developer/operator communities but also the regulatory and conservation community partners with whom they engage.

On Demand Presentations

Abstract Number 11. Crouching tiger, hidden danger: patterned blades reduce avian fatalities at an African wind farm

Presenter: Rob Simmons
Session/Format: On-Demand Oral Presentation (virtual, pre-recorded)
Authors: Rob Simmons, FitzPatrick Institute, University of Cape Town; Marlei Martins Birds & Bats Unlimited, South Africa; Francisco Cervantes, Pyrenean Institute of Ecology, Spanish National Research Council

Abstract: We sought to test the blade-patterning mitigation technique at an African wind farm to explore its application in reducing avian mortality rates. Despite the success of the pilot project in Norway (May et al. 2020), no other published studies have field-tested this form of passive mitigation.

At a species-rich, 67 MW wind facility in Hopefield, South Africa, Umoya Energy patterned single blades at four high-fatality turbines, in 2023, with two broad "signal red" stripes, as dictated by the South African Civil Aviation Authority. Avian fatalities, surveyed weekly beneath the turbines, were then compared before and after painting using the Before-After-Control-Impact (BACI) approach. Seventy-five fatalities of 24 species of raptors, passerines and wetland species from two previous years were compared for the same (four) turbines after patterning with two sets of controls: (i) their four nearest neighbour controls (NNC) and (ii) all 16 controls (AC) over 16 months. A Bayesian GLM indicated a 52% - 100% (95% credible interval) mortality reduction in patterned turbines vs controls after painting for NNC comparisons, and a 55% - 100% reduction for the 16 AC comparisons. There was no clear indication that birds avoiding the patterned turbines veered into NNC turbines with a change in mortality between a 71% reduction and a 443% increase.Of 14 raptor species recorded on site, ten species (comprising 23% of all fatalities) have been killed by the wind farm. While this highly impacted group continues to occur at the wind farm and to be killed at the control turbines, fatalities at the patterned turbines dropped from seven individuals (in 24 months) to zero in 16 months following treatment. Expected (8.7) versus observed fatalities (0) for all species at the patterned blades indicated a 100% reduction over 16 months.

While further monitoring and experimentation in areas with other species is required, blade patterning holds great promise as a cost-effective mitigation in reducing fatalities at wind facilities in biologically diverse and raptor-rich areas of the world.

Abstract Number 33. Repowering in the East: exploring the potential impacts on wildlife

Presenter: Michael Morgante
Session/Format: On-Demand Oral Presentation (virtual, pre-recorded)
Authors: Michael Morgante, WSP

Abstract: With the initial buildout of land-based wind energy projects in North America occurring in the West, so too was the initial repowering of projects. We are now seeing repowering occur more in the East, and with increasing plans for more to come as turbines installed in the 2000s are reaching the end of their useful and permitted life spans. The repowering of land-based wind energy projects typically coincides with the now longstanding trend of deploying increasingly taller turbines. The latest generation of land-based turbines are often substantially taller than their predecessors, including some where the rotor diameter is greater than the previous maximum turbine height, and the height of the newer model nacelle may exceed the maximum height of the blade reach for turbines installed in the 2000s.

The potential impacts on birds and bats from these taller turbines can be different than those from prior turbine generations and include both positive and more adverse effects. Evaluations of repowering project impacts on wildlife in the West often focused on the changed conditions for Golden Eagle (Aquila chrysaetos), Burrowing Owl (Athene cunicularia), and other raptors. Repowering projects in the East will need to review a mostly different assemblage of bird and bat species. Potential impacts for eastern bird and bat species and species groups will be explored.

Reviewing the overall repowering project rotor sweep area (RSA) in comparison to the existing project's RSA is useful when considering the potential for bird and bat collisions, especially since the overall RSA could increase or decrease depending on the number of turbines and the dimensions of the blade sweep. Similarly, it is important to compare the difference in maximum blade height and the difference in minimum blade reach. Modern turbines now reach higher into the typical altitude range of nocturnal bird migration. Depending on the hub height and rotor size, the lowest blade reach of some repowered projects may be higher than the existing projects, which could benefit lower-flying bat species, such as the Northern Long-eared Bat (Myotis septentrionalis), and diurnal flying birds. In the East, where wind speeds are typically lower than wind projects in the West, cut-in speed limitations for bat protection will be even more important to consider for repowering project viability, especially considering most of the original projects were constructed prior to the advent of reduced cut-in speed requirements.

Some other factors to consider when working through repowering project siting and permitting will be discussed as well. One of these is to define the area to be evaluated for wildlife surveys and potential impacts. For example, in New York, the Office of Renewable Energy Siting requires pre-repowering avian surveys to be completed within 250 meters of proposed turbine locations beyond the footprint of the existing wind project.

Abstract Number 34. A rapid, inexpensive, biodiversity metric to assess ecological integrity at terrestrial wind energy sites

Presenter: Zoe Jewell
Session/Format: On-Demand Oral Presentation (virtual, pre-recorded)
Authors: Zoe Jewell, WildTrack

Abstract: While much research continues to be undertaken into the impact of wind installations on birds and flying mammals, there is less on the impact of ground-dwelling species in such ecosystems. There is some evidence that ground-nesting birds, terrestrial mammals and insects may be impacted, and/or avoid these sites.In this presentation, we argue a case for monitoring small mammals (mice and shrews) as indicators not only of environmental integrity at such sites, but also as attractants for other species that might be more drawn into collisions as a result.Small mammals represent up to 40% of mammalian species in ecosystems globally. Their ubiquity, species diversity and rapid breeding rates make them ideal indicators of environmental health. Their species richness and abundance inform on fine-scale responses to environmental change, making them ideal pre-, during, and after-development comparison indicators of impact at sustainable energy sites. However, monitoring this group currently requires intensive trapping and examination by expert mammalogists, at a high cost of both time and money. WildTrack (www.wildtrack.org) will present a new metric for assessing small mammal diversity, and hence ecosystem integrity, using an adaptation of its award-winning footprint identification technology, FIT. Trialled with small mammals in the U.S., Europe and South Africa to date, this new metric is based on an inexpensive, rapid assay of small mammal species using cheap locally-sourced materials to collect data, and a multi-modal analytical platform driven by AI with morphometrics, and founded on traditional ecological knowledge. The objective is that this could provide a transformative tool for environmental surveys where local operatives can collect data after just a short training, and analytics will return results in near real-time.This presentation will provide a broad overview of the technique and its potential application.

Abstract Number 52. Sight vs. scent: implications for using detection dogs on wind facility impact assessments

Presenter: Julia Nawrocki
Session/Format: On-Demand Oral Presentation (virtual, pre-recorded)
Authors: Michael Whitby, Bat Conservation International; Julia Nawrocki, Rouge Detection Teams

Abstract: Detection dogs are becoming an increasingly important tool for wildlife surveys. One area of rapid adoption is for assessment of wind energy impacts. However, the tools to assess wind energy impacts on wildlife were developed to be used with data collected by human searchers. The difference between human searchers and detection dog teams goes beyond increased searcher efficiency. Human searchers rely on vision to detect target. Detection dog teams have the additional means of using the dog's nose to detect a target via scent. The differences between vision and scent need to be accounted for in designing and analyzing assessments. We conducted daily searches at a wind facility in Iowa using detection dog teams as part of minimization studies. We discovered that the analysis assumption of decreasing searcher efficiency was violated and required careful analysis. Possible mechanisms include: 1) the scent of a 'fresh' bat has dissipated less and is not encountered at the same rate as older carcasses 2) training materials for

detection dog teams are older carcasses. Adjusting for these factors in the second year increased our searcher efficiency, especially for fresh carcasses. Detection dog teams are a powerful tool that can improve the precision of fatality estimation, however, their use is not a simple replacement for human searchers. This provides a case study of how integrating dog training, study design, and analysis is needed when using detection dogs in the field. When properly used, detection dog teams can lead to powerful results for wildlife impact studies.

Abstract Number 56. Proximity to wind turbines influenced insect pollinator assemblages and native plant pollination

Presenter: Michelle Weschler
Session/Format: On-Demand Oral Presentation (virtual, pre-recorded)
Authors: Lusha Tronstad, Wyoming Natural Diversity Database; Michelle Weschler Wyoming Natural Diversity Database; Amy-Marie Storey, University of Wyoming; Joy Handley, Wyoming Bureau of Land Management; Bryan Tronstad, Wyoming Natural Diversity Database

Abstract: The wind energy industry is growing rapidly, but little is known about interactions between land-based turbines, plants and insect pollinators despite turbines likely impacting these taxa throughout the world. Insects are killed in large numbers when they strike turbines and could be attracted to wind facilities due to turbine color, shape and temperature output, which could in turn attract insectivorous vertebrates. One of the myriad abiotic influences of turbine operation on the environment is the production of infrasound. Infrasound (≤20 Hz), produced by turbines, causes vibrations with unknown effects to biota <20 km from turbines. Plants may have higher self-pollination rates due to infrasound, and insects that nest underground may be negatively impacted by the vibrations. To determine if plant reproduction and insect assemblages were influenced by proximity to turbines and produced infrasound, we measured seed-set and pollinator activity within a wind facility, and at five sites located 4 to 28 km from turbines in southeastern Wyoming. We measured the number and mass of seeds produced by self-pollination, insect pollination and hand pollination for nine native plants in 2022. We counted butterflies and bees via timed transects, and we collected bees using blue vane traps deployed for <48 hours from May to August of 2022 and 2023. Our final results indicate the proportion of developed seeds and seed mass generally decreased with distance from turbines, suggesting vibrations from turbines may aid in pollination. We captured more bees and butterflies during transects at the wind facility compared to sites <13 km away ($p < 0.05$). Vane traps collected fewer insects at the wind facility despite fewer blooming plants occurring there ($p < 0.05$); vane traps tend to catch fewer insects when flowers are abundant on the landscape. These results support the hypotheses that insects are attracted to turbine bases and are more abundant at wind facilities. Non-metric multidimensional scaling showed that the pollinator assemblage at the wind facility was unique compared to the other sites, suggesting turbines may be attracting species that wouldn't normally be present in similar, undeveloped habitats. Our study suggested that turbines attracted pollinators. Energy companies and land managers may need to

consider the presence and activity of insects around turbines as the number of insect species protected by the Endangered Species Act rises. Furthermore, understanding the influence of turbines on plant-pollinator interactions is necessary for implementing effective, sustainable agroecosystems. Our results will help managers make informed decisions and promote new strategies as wind energy development grows.

Abstract Number 76. What's the difference between juvenile and adult white-tailed eagles in keeping their distance from the rotor swept zone? Preliminary results

Presenter: Dariusz Górecki
Session/Format: On-Demand Oral Presentation (virtual, pre-recorded)
Authors: Aleksandra Szurlej Kielańska, TACTUS, Bird-friendly Investment Support Association; Dariusz Górecki, TACTUS, Bird-friendly Investment Support Association

Abstract: The dynamic development of wind energy requires the simultaneous implementation of effective systems minimizing the risk of collisions between birds and wind turbines. Data on collision avoid ance behavior of big raptors with wind turbines is limited. Especially when it comes to the use of detection-reaction systems that enable taking actions to trigger a collision avoidance reaction, such as emitting sound or light signals.

We have analyzed the data from BPS detection–reaction systems installed on wind farms loceted in: Spain, Germany and Poland. BPS undertakes actions depending on distence from the turbines: strobo deterrent, audio deterrent, stopping the rotor. We used data recorded by the systems on the red kite Milvus milvus, white-tailed eagle Haaliaetus albicilla and griffon vulture Gyps fulvus. All birds recorded by the systems have been tagged to species by qualified ornithologists. We analyzed data of raptors moving near wind turbines to identify whether birds avoided the turbines as a result of the use of strobe and audio-based scarer mods.

Data from Germany showed that share of white tailed eagle whose movement did not activate the STOP signal after activating the strobe signal was 18.5%. In the case of a red kite it was only 4.5%. Data from Spain showed that 23% of griffon vulture flying near the turbines didn't activate the STOP signal after activating the audio signal. Data from Poland showed that only 2% of white tailed eagles were noted in a direct collision risc zone after emitting strobe signal. Moreover, only 30% of adult birds flow into the potential collision rosc sphere, while over 70% of juvenile were noted in this zone.

Our findings suggest that in the case of the white-tailed eagle, the use of strobe signals and in the case of the griffon vulture, the use of acoustic signals may be a way for these birds to avoid collisions, but the data available at present does not allow for the formulation of unequivocal parts indicating the level of effectiveness of using this type of solution in minimizing the risk of collision, but suggests the need for further research and testing, also due to the need to determine whether and after what time birds become accustomed to the emitted signals, so that it does not constitute a warning.

Further tests and analyzes are needed regarding the use of sound and light signals in different locations and for wind projects with different parameters of turbines.

Abstract Number 94. Adaptive management to reduce bat fatalities at Altamont Pass wind energy facilities

Presenter: Katrina Smith
Session/Format: On-Demand Oral Presentation (virtual, pre-recorded)
Authors: Katrina Smith, California Department of Fish and Wildlife; Bronwyn Hogan U.S. Fish and Wildlife Service; Doug Leslie, ICF; Tara Conkling, U.S. Geological Survey; Ricka Stoelting, California Department of Fish and Wildlife

Abstract: Hoary bats (Lasiurus cinereus) are at risk of severe population decline and face significant impacts from wind energy facilities (Friedenberg & Frick 2021; Rodhouse 2019). The first actions to reduce these impacts in California are being implemented at the Altamont Pass Wind Resource Area. An adaptive management strategy ensures that the best available science and emerging technologies are used to assess impacts on bats, and that those impacts are minimized to the extent possible while maximizing energy production. First, blanket curtailment stops turbines from spinning when wind speeds are low during the high-risk period from April to October. Second, acoustic monitoring at turbine height and ground level facilitates analysis of bat activity in relation to wind speeds and bat fatality patterns, which could inform smart curtailment. Third, submission of carcasses and tissue samples collected in the Resource Area supports genetic research to inform population-level impacts. Finally, installation of Motus towers near wind energy facilities and funding Motus tag deployment supports migration research, which could inform siting of future wind energy facilities. As wind energy scales up, collaboration and incentives to implement creative solutions are needed to mitigate adverse impacts to bat populations.

Abstract Number 104. Wind farms and bats in Mexico: emerging issues

Presenter: Minerva Angela Uribe Rivera
Session/Format: On-Demand Oral Presentation (virtual, pre-recorded)
Authors: Minerva Angela Uribe Rivera, Autonomous University of Baja California; Claudia Leyva Autonomous University of Baja California; Mariana Villada, Autonomous University of Baja California; Carlos Peynador, Autonomous University of Baja California; Miguel Briones, IPN; Cris Hein, National Renewable Energy Laboratory

Abstract: Mexico, the second largest producer of wind energy in Latin America with 71 wind farms in operation, faces uncertainties regarding the impact of these projects on bats. The lack of post-construction monitoring and public consultation on reported impacts hinders the assessment of bat impacts in the country. With limited information available, the evaluation of bat impacts in Mexico relies on studies from North America and Europe, where species richness and abundance differ. This gap in global and Mexican

data results in difficulty determining affected species, mortality risks, and cumulative collision impacts. Consequently, there is an inability to accurately assess or underestimate the magnitude of these impacts in Mexico, leading to the absence of specific mitigation measures despite regulatory instruments such as the Environmental Impact Assessment.

To address these issues, a diagnostic study was conducted to identify key challenges associated with the impact of wind farm operation on bats using the horizon scanning method. By exploring potential issues, threats, and opportunities related to evaluating, preventing, and mitigating wind farm impacts on bats, the study aimed to shed light on undocumented impacts. Through semi-structured interviews with key stakeholders such as bat experts, environmental consultants, and project developers, various issues were uncovered.

Preliminary results indicate that at least 39 bat species have mortality records in wind farms in Mexico, of which one is listed as Near Threatened on the International Union for Conservation of Nature Red List; the lesser long-nosed bat (Leptonycteris yerbabuenae) and the southern long-nosed bat (Leptonycteris curasoae), are included as vulnerable in the IUCN Red List (2024) and as threatened in Mexican legislation.

In the environmental impact assessment phase, concerns were raised regarding the lack of consideration for bats in the site selection process for wind farm construction and the insufficient protection of bats in Protected Natural Areas. The need for more trained professionals for bat monitoring, specific protection guidelines, and improved surveillance for compliance were highlighted. Additionally, the absence of data on mortality rates and affected bat species, as well as the unknown population-level impact of wind farms on these species, underscored the gaps in information.

By employing horizon scanning to reveal new challenges and confirm existing problems, the study intends to inform policy development and reevaluation surrounding wind farm operations and their impact on bats in Mexico. Through enhanced understanding and data collection, the hope is to foster more effective mitigation strategies and safeguard bat populations in the face of expanding wind energy projects in the country.