Solar Power and Wildlife/Natural Resources SYMPOSIUM

PROCEEDINGS

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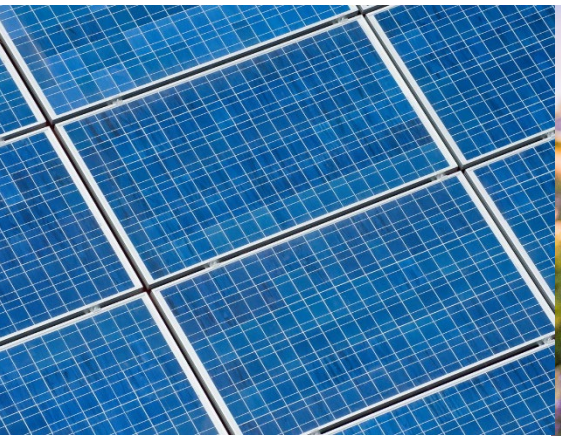

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About REWI

REWI (formerly the American Wind Wildlife Institute) is an independent non-profit 501(c)3 organization built on a strong partnership of leaders. REWI works collaboratively with the wind and solar power industries, conservation and science organizations, and wildlife management agencies on a shared mission: through science and collaboration, accelerate responsible deployment of renewable energy to mitigate climate change and protect wildlife and ecosystems.

REWI plans to continue hosting Wind Wildlife Research Meetings and Solar Symposia.

Abstract

The world is experiencing two entangled crises—climate change and biodiversity loss—that must be addressed simultaneously. Renewable energy, particularly large-scale photovoltaic (PV) solar energy development, is a key component in the fight against these crises. PV solar presents unique risks and challenges, including direct mortality and habitat loss (among others) to certain native biodiversity and other natural resources, while it also mitigates climate change and provides opportunities to enhance biodiversity and benefit ecosystem services under specific scenarios. Our current understanding of these risks, challenges, and benefits is low and limited geographically and taxonomically, but we gain valuable knowledge every year due to dedicated stakeholder groups including scientists, solar energy developers, the conservation sector, and government wildlife agencies.

These proceedings reflect current research and concepts around balancing conservation and the rapid build-out of solar energy, and they include sessions on communication among stakeholders, avian-solar interactions, wildlife habitat loss and fragmentation, vegetation management and biodiversity responses, data standards and sharing, and technological solutions to studying biodiversity responses. The 2nd Solar Symposium, November 14–16, 2023, convened leading scientists and other stakeholders to continue productive discussions and collaborations toward finding solutions and identifying opportunities to benefit biodiversity and ecosystem services.

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Disclaimer

Some of the presentations described in the Proceedings of the 2nd Solar Power and Wildlife/Natural Resource Symposium may have been peer-reviewed independent of this meeting, but results should be considered preliminary. This document may be cited, although communication with the speakers or presentation-on-demand author before doing so is highly recommended to ensure that the information cited is current.

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Abbreviations

AAM	Animal Activity Monitoring
ACP	American Clean Power Association
AFWA	Association of Fish and Wildlife Agencies
AI	Artificial intelligence
AGL	Above ground level
AWWIC	American Wind Wildlife Information Center
BBHF	Bee & Butterfly Habitat Fund
BGEPA	Bald and Golden Eagle Protection Act
BIL	Bipartisan Infrastructure Law
BLM	Bureau of Land Management
BMPs	Best Management Practices
CCRA	Climate Change Risk Assessment
CO_2	Carbon dioxide
CPA	Candidate Project Area
CRP	Conservation Reserve Program
CSP	Concentrating solar-thermal power
CV	Computer vision
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
DWR	Department of Wildlife Resources
ECP	Engineering, procurement, and construction
ECT	Environmental Consulting & Technology
eDNA	Environmental DNA
EIS	Environmental Impact Statement/Report
EPC	Engineering, procurement, and construction
EPRI	Electric Power Research Institute
ESA	Endangered Species Act
FPL	Florida Power & Light
FWC	Fish and Wildlife Commission
GPS	Global Positioning System
GPV	Ground-mounted PV solar power plant
GSM	Global System for Mobile Communication
GW	Gigawatt
IIJA	Infrastructure Investment and Jobs Act
IPaC	U.S. Fish and Wildlife Service Information for Planning and Consultation
IRA	Inflation Reduction Act
LiDAR	Light detection and ranging
LED	Light-emitting diode
MBTA	Migratory Bird Treaty Act
ML/DL	Machine/deep learning
MW	Megawatt
NEPA	National Environmental Policy Act
NGO	Non-governmental organization
NRCS	Natural Resources Conservation Service
NRDC	Natural Resource Defense Council
NREL	National Renewables Energy Laboratory
PHASE	Pollinator Habitat Aligned with Solar Energy
PV	Photovoltaic
RE	Renewable energy
REWI	Renewable Energy Wildlife Institute
RFP	Request for proposals
RGB	Red, green, and blue
SEIA	Solar Energy Industries Association
SETO	Solar Energy Technologies Office
SFWA	State Fish and Wildlife Agency
SWWG	Solar Wildlife Working Group
TB	Terabytes
TCFD	Task Force on Climate-Related Financial Disclosures
TNC	The Nature Conservancy
TW	Terawatt
UAS	Unmanned aircraft systems
UAV	Unmanned aerial vehicles
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USSE	Utility-Scale Solar Energy
UV	Ultraviolet
VDEQ	Virginia Department of Environmental Quality
VMP	Vegetation Management Plan
WEGs	Wind Energy Guidelines
WEST	Western EcoSystems Technology, Inc.

Welcome Address
2nd Solar Power and Wildlife/Natural Resources Symposium,
The Future is Bright for Solar Energy and Wildlife

Abby Arnold – Executive Director, Renewable Energy Wildlife Institute

Amy Martin – Non-Game and Endangered Species Program Manager, Virginia Department of Wildlife Resources

Abby Arnold

Over the next decade, the responsibility lies with us to make a significant impact on addressing climate change. Two years ago, REWI's board decided to expand our focus from wind, which we have been working on for over 30 years, to include solar. With support from Dr. Josh Ennen and Dr. Taber Allison, we published the first National Solar Wildlife Research Plan[1] based on an extensive literature review that highlights research priorities and solar's impact on wildlife and habitat. This plan encourages us to look at solar through an ecosystem lens, to think creatively about these facilities on the landscape, and to think about how we can set this up in a way that does what the state and federal agencies, our conservation communities, and our industry are interested in, which is to build out solar in a way that maximizes benefits and minimizes impacts. I want to remind you that REWI is here for you. REWI is dedicated to supporting the conservation community, industry, academia, and consulting by providing practical solutions through collaborative research efforts. Our goal is to provide practical solutions that can be applied on the ground. As we tackle these challenges, let us remember our common love for nature, the outdoors, and wildlife that unites us as a community.

The urgency of addressing climate change, the sixth mass extinction, and the need for a renewable energy (RE) transition are pressing issues that demand our collective efforts. The challenges we face require unprecedented collaboration and dedication from all of us. Our vision is to find a path forward that maximizes energy production while conserving wildlife, supporting ecological health, and minimizing climate change. It is crucial for the younger generation to continue working towards solutions that benefit our children and the natural world we cherish.

Amy Martin

Welcome to Virginia, where a commitment to leading wildlife conservation takes center stage, inspiring individuals to embrace the outdoors and recognize their integral roles in nature. Guided by the principles of conservation, connection, and protection, Virginia strives to manage and conserve wildlife populations and habitats for the well-being of both present and future generations. The state connects people to its diverse outdoors through various activities, including boating, education, fishing, hunting, trapping, and wildlife viewing, with a dedicated focus on ensuring safe outdoor experiences and managing human-wildlife conflicts.

Virginia showcases its abundant natural resources, stretching from the coast to the mountains. Renowned for its historical significance, the state beckons history lovers with landmarks such as Colonial

[1] National Solar Wildlife Research Plan 2023–2025; https://rewi.org/resources/national-solar-wildlife-research-plan-2023-2025/

Williamsburg, Jamestown, and sites associated with eight U.S. presidents. Outdoor enthusiasts are captivated by Virginia's extensive parks, the George Washington and Jefferson National Forests, 550 miles of the iconic Appalachian Trail, and the Blue Ridge Parkway nestled in the west. With 42 state parks managed by the Department of Conservation and Recreation and offering over 700 miles of trails, lodges, cabins, and conference centers, Virginia invites residents and visitors alike to experience the beauty and diversity that define the Commonwealth. In addition, the Virginia Department of Wildlife Resources (DWR) has 48 wildlife management areas, maintains the Virginia Birding and Wildlife Trail, and manages 883 designated species of greatest conservation need.

In the realm of solar development, Virginia demonstrates a forward-thinking approach to environmental stewardship. In 2022, Virginia's new governor unveiled a plan for the state's energy future, with a specific emphasis on supporting and promoting RE. The DWR plays a key role in reviewing and providing input on solar projects, using a permit-by-rule approach for smaller projects administered by the Virginia Department of Environmental Quality (VDEQ). What is unique is that solar developers must consider data on Virginia's wildlife and adhere to requirements for coastal avian protection zones and historic resource reviews.

Collaboration among natural resource, historic, and permitting agencies ensures a comprehensive review. If they find potential impacts on species of concern, developers may address the issue by providing additional information and a mitigation plan. Larger projects or projects selling directly to clients undergo permits through certification by the State Corporation Commission, allowing input from agencies like DWR to prioritize wildlife considerations. Key wildlife considerations include siting and habitat protection, wildlife passage, habitat fragmentation or loss, and stormwater management. The DWR actively engages with localities so they can make informed decisions regarding siting through presentations, comprehensive planning, and data sharing. The department's data is publicly available and accessible, they collaborate with partners to develop siting tools, and they participate in regulatory panels to provide a wildlife perspective on solar facility rules and regulations.

Two areas for industry innovation I am looking forward to are fencing strategies and compatible uses for solar sites. DWR seeks solutions for fencing that balance safety for the facility with wildlife conservation. Additionally, long-term management of solar sites is a priority for the department, and they encourage compatible uses in solar sites, such as the Pollinator Smart Program[2], invasive species control, and exploring dual usage opportunities. Decommissioning plans are under consideration, including the restoration of soils and habitats, recycling of panels, and collaborative decision-making on site appearance. Active RE permits in Virginia can be explored on the VDEQ website.

[2] Virginia Pollinator Smart Program; https://www.dcr.virginia.gov/natural-heritage/pollinator-smart

Keynote Address

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

Speaker:

- **Mackenzie Landa** – Senior Advisor to the Deputy Secretary, U.S. Department of the Interior

The keynote address was given by a senior-level staff member from the U.S. Department of the Interior (DOI), Mackenzie Landa, Senior Advisor to the Deputy Secretary, who shared how the DOI is working to help achieve goals set by the Biden-Harris Administration for RE. Prior to joining the Biden-Harris Administration, Mackenzie Landa served as counsel to Senator Cory Booker, working on environmental, animal, energy, natural resources, and agricultural issues. Prior to working in the Senate, she served as counsel to the U.S. House of Representatives Select Committee on the Climate Crisis, leading the committee's work on nature-based climate solutions. The speaker addressed the following: 1) how DOI plans to help achieve energy goals while minimizing impact of species and habitat, 2) challenges DOI faces when implementing policies, and 3) DOI's role as a partner.

The Biden-Harris Administration has set ambitious renewable energy goals to reduce U.S. greenhouse gas emissions. How does the DOI plan to help achieve those goals while minimizing the impacts on species and habitat?

Mackenzie Landa: The Biden-Harris Administration has outlined ambitious goals for RE development and greenhouse gas emissions reductions, aiming for emissions to be reduced by half by 2030 and achieve net zero emissions by 2050. The DOI is actively engaged in this climate solution, particularly in developing RE on public lands. At the same time, this effort emphasizes a thoughtful approach to minimize and mitigate impacts on wildlife, species, and habitats. Collaboration is critical to achieving these goals, and we rely on partnerships with industry, non-governmental organizations (NGOs), scientists, states, Tribes, and other groups and stakeholders.

The Bureau of Land Management (BLM) is updating its Western Solar Plan,[3] which was developed in 2012 as one of the first comprehensive efforts to identify lands with high potential for solar development while minimizing impacts on sensitive environmental resources. Their current goal is to implement knowledge learned over the past 10 years to achieve these ambitious targets while avoiding conflicts with natural resources and wildlife. The BLM is closely collaborating with the U.S. Fish and Wildlife Service (USFWS) to address conflicts with wildlife and habitats. The USFWS is developing a specialized workforce to guide responsible RE development without compromising biodiversity goals or impacting threatened and endangered species, while leveraging knowledge and tools from existing programs such as the Endangered Species Act (ESA), the Migratory Bird Treaty Act (MBTA), and the Bald and Golden Eagle Protection Act (BGEPA). In addition, the U.S. Geological Survey (USGS) plays a crucial role in providing scientific guidance, particularly in understanding and mitigating impacts on wildlife migration and habitats associated with utility-scale solar projects.

Overall, the administration emphasizes a science-based approach to policymaking, ensuring that RE development aligns with environmental conservation objectives, and that could not be done without our partners on the ground doing the science.

[3] Draft Utility-Scale Solar Energy Development Programmatic Environmental Impact Statement; https://blmsolar.anl.gov/solar-peis-2023/

What are some challenges that the DOI is running into in an effort to implement policies that balance the needs for renewable energy deployment and wildlife conservation?

Mackenzie Landa: We face intertwined crises—the worsening climate and biodiversity crises. Protecting our national parks, wildlife, and waterways is crucial for community, ecosystem, and economic health. To address these crises, actions at the local level are just as important as actions taken from top-down approaches. Collaboration is key. We must collaborate from every angle and across every level. Despite these challenges, the collective effort I see is promising.

How does the DOI weigh renewable energy land use needs with Biden's "America the Beautiful Initiative" (i.e., the 30x30 initiative)?

Mackenzie Landa: The America the Beautiful Initiative aims to protect, conserve, and restore 30% of the United States lands and waters by 2030. But it is more than just a number. It is guided by key principles: collaborative and inclusive conservation, Tribal sovereignty, and science. These are the same principles reflected in the Western Solar Plan as we look to expand RE development. The plan will focus on ensuring maximal solar potential while preserving protections for U.S. lands and waters. The BLM manages about 245 million acres, with 870,000 of those acres identified for solar, ensuring there is enough land to meet our RE targets while also improving conservation outcomes, restoring ecosystems, and making sure habitat and species are protected. In addition, wildlife corridors and habitat connectivity are key components of the America the Beautiful Initiative. The BLM has its own policies aimed at advancing, enhancing, and restoring ecological connectivity and migration corridors, which were used to guide the solar plan.

What is the DOI's role as a partner? How can REWI support you, your agency, and your responsibilities?

Mackenzie Landa: We are at a critical juncture. We have political support, unprecedented funding from the Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act (IRA), and scientific breakthroughs happening all the time. The DOI aims to be a supportive partner, by offering clear guidance and a framework for how we can move forward to responsibly develop RE on public lands all while participating in our shared responsibility to protect America's lands, waters, and wildlife. We seek communication from partners—what are your challenges and obstacles? Tell us your ideas and your successes. Our doors are open for collaboration. If we work together, we can tackle these issues effectively and in a durable way.

What is your hope for the future? What is your ideal and vision for all of us?

Mackenzie Landa: The problems we are working on are hard. Let us prioritize what is crucial for our planet and future generations: robust diversity, mitigating climate change, and sustainable RE development. Let us set aside disagreements and focus on shared goals. Together, we can create the future we desire. Our door is open—let us seize this opportunity.

The Future is Bright for Solar Energy and Wildlife

Moderator: Taber Allison – Director of Research, Renewable Energy Wildlife Institute

Speakers:

- **Josh Ennen** – Senior Scientist, Renewable Energy Wildlife Institute
- **Michele Boyd** – Program Manager, U.S. Department of Energy Solar Energy Technologies Office
- **Alyssa Edwards** – Senior Vice President, Environmental Affairs and Government Relations, Lightsource bp
- **Meaghan Gade** – Energy and Wildlife Program Manager, Association of Fish and Wildlife Agencies
- **Nathanael Greene** – Senior Renewable Energy Advocate, Natural Resources Defense Council
- **Thomas Wittig** – National Energy Coordinator, U.S. Fish and Wildlife Service

Moderator Dr. Allison introduced this session, noting that both the scale and pace of solar energy build-out are essential, and REWI has adjusted their mission statement to emphasize the necessary acceleration of RE development while still protecting wildlife and habitat: "Through science and collaboration, accelerate responsible deployment of RE to mitigate climate change and protect wildlife and ecosystems." During the session, the participants provided context and perspectives from multiple stakeholders on the projected rapid development of solar energy, the changing policy landscape, and addressing wildlife conservation needs. Further, participants discussed specific challenges each is facing surrounding decision-making on an accelerated timeline after the timely release of the Biden-Harris Administration's Fifth U.S. National Climate Assessment[4], and each expressed the need for discussions to broaden from risks, challenges, and mitigation to assessing potential benefits provided by PV solar facilities. Finally, participants discussed the need for collaboration amongst stakeholders—beyond sharing only ideas and experiences, but sharing data as well. Below, each presentation is summarized instead of providing abstracts.

National Solar Wildlife Research Plan 2023–2025, REWI

Presenter: Josh Ennen (Renewable Energy Wildlife Institute)

Summary: REWI published its National Solar Wildlife Research Plan (The Plan[5]) in May 2023. The Plan and its companion document, Solar Energy Interactions with Wildlife and Their Habitat[6], were informed by exhaustive literature reviews and an assessment phase. The assessment phase consisted of a third-party conducting surveys and interviews with more than 100 individuals and approximately 25 stakeholder groups. Our aim was to collect topics of interest across a wide range of perspectives, with the overarching goal of making these documents available as resources to the community. These documents will be updated every three to five years and exclude concentrating solar-thermal power (CSP) facilities.

REWI is establishing its solar program research priorities based on the Plan. Our challenge was navigating the complexity of topics related to solar energy and ecological systems. This required an understanding of the dynamics from the species level to the broader ecosystem level, encompassing the intricacies of biological hierarchy and the associated behaviors. When we began thinking about priorities, we started by looking at three decades of wind research and how that could be shifted into the solar domain. However, solar is more complex than just the connection between wildlife and infrastructure, so

[4] The Fifth U.S. National Climate Assessment; https://nca2023.globalchange.gov/
[5] National Solar Wildlife Research Plan 2023–2025; https://rewi.org/resources/national-solar-wildlife-research-plan-2023-2025/
[6] Solar Energy Interactions with Wildlife and Their Habitat; https://rewi.org/wp-content/uploads/2023/05/REWI-Solar-Energy-Wildlife-Interactions-Summary-2023.pdf

we knew we needed to expand our approach. Research is beginning to show that solar infrastructure interplays with the environment and ecological processes through complicated processes like plant-soil interactions. We will also have to consider how site and ecological systems interact with the landscape (e.g., movement, fragmentation, and other processes).

REWI has begun to think about how to make these complex interactions more tractable. One way is to think about PV solar as an "ecosystem." Think of ecosystems in their simplest definition: a dynamic system with biotic and abiotic conditions that are interacting within a defined area. Using this framework allows researchers to focus beyond species-level impacts as a sole feature of the solar infrastructure and in isolation from on-site and landscape contexts. It highlights the importance of on-site and landscape variables to include when building predictive models, which will help explain variation in ecological responses among sites. The ecosystem framework is a holistic approach that unites research and priorities, such as fatalities, habitat loss, and other species-level interactions, with the growing interest in ecosystem function and services around solar energy.

Solar Energy and Wildlife

Presenter: Michele Boyd (U.S. Department of Energy Solar Energy Technologies Office)

Summary: The Biden-Harris Administration set a goal of an equitable transition to a decarbonized power sector by 2035 and a decarbonized economy by 2050. What does this goal mean for solar deployment? What challenges need to be addressed in order to meet these important milestones? How does this impact wildlife? Our role at the U.S. Department of Energy (DOE) and within the Solar Energy Technologies Office (SETO) is to accelerate the advancement and deployment of solar energy in support of these goals. In September 2021, the DOE released the Solar Futures Study[7], which examined solar energy's role in transitioning to a carbon-free electric grid. The study found that with aggressive cost reduction, supportive policies, and large-scale electrification, solar could account for as much as 40% of U.S. electricity supply by 2035 (1000 gigawatts [GW] of solar deployment, about a 6.5 times increase from current solar capacity) and 45% by 2050. To hit these targets, we would need to double the current solar deployment rate to 60 GW per year by 2025. In addition, it was found that land availability does not constrain solar development. Ground-mount solar is projected to require 5.7 million acres by 2035 and 10 million acres by 2050 (0.3% and 0.5% of U.S. contiguous land area, respectively). Although these percentages are low at the scale of the contiguous United States, the impact that solar deployment is having at the local scale for communities and the resulting land use conflicts are high, particularly when it comes to concerns about wildlife and habitat use.

Last year, the IRA was passed into law, putting the United States on a path to meeting these goals. The IRA provides more than 10 years of support and tax incentives for equitable solar deployment. The IRA is expected to increase annual PV deployments by about 30%, with two-thirds being ground-mount PV, which will enable the United States to approach the levels needed to reach the 2035 goal.

However, a number of very important challenges need to be addressed: interconnection, cost and delays, permitting, equity in the energy transition, workforce development, and siting (which includes wildlife and habitat issues). The DOE does not have a regulatory role in determining where solar is deployed, but we have a very important role in addressing the barriers to large-scale deployment. We are 1) funding data collection and analysis to understand land conversion and use, 2) looking at the siting costs and timelines because we want to develop tools that enable better decision-making, and 3) investing in socioeconomic research to look at the costs and benefits of solar development. Additionally, we are interested in innovative siting solutions that reduce land use conflicts (e.g., agrivoltaics) and understanding environmental costs and benefits, which can be generalized into three research categories: 1) minimizing the impacts and maximizing the benefits of large-scale solar deployment on wildlife, 2) solar-wildlife interactions, and 3) quantifying and qualifying ecosystem services.

[7] Solar Futures Study; https://www.energy.gov/eere/solar/solar-futures-study

With this research, we are facilitating access to data through data-sharing infrastructure. To learn more about our events, funding, and presentations, sign up for our newsletter.

Lightsource bp's Focus on Enhancing Biodiversity, Environmental Benefits, and Solar Development

Presenter: Alyssa Edwards (Lightsource bp)

Summary: The Fifth U.S. National Climate Assessment[8] issued by the Biden-Harris Administration on November 14th, 2023 indicates time is running out. Even with the most progressive climate legislation ever passed in United States history, we are truly at a tipping point. It is up to us to make a difference moving forward. We are here because we are committed to advancing the energy transition in a sustainable and just way.

From an industry perspective, we are committed to doing exactly that. We are connected with our stakeholders, state agencies, federal agencies, the environmental NGO community, the Solar Guidelines, and Uncommon Dialogue[9]. We want to get this right. The challenge is understanding 1) what are the risks, 2) how do we innovate, and 3) what should we be spending our dollars on in terms of research? Time is not on our side. Lastly, I would challenge the notion that solar projects are just opportunities for the environment; they can do more than just deliver clean, RE. Environmental benefits can be layered with community benefits.

The States' Perspective of Energy Development and Wildlife

Presenter: Meaghan Gade (Association of Fish and Wildlife Agencies)

Summary: It is the statutory responsibility of state fish and wildlife agencies to manage wildlife and habitat within their borders. It is the job of the Association of Fish and Wildlife Agencies (AFWA) to help states do that job. As we start seeing massive increases in the number of proposed solar facilities, AFWA wanted to figure out how states can facilitate this growth while minimizing wildlife impact. Most states do not have regulatory teeth when it comes to providing input on solar development, so they rely on voluntary approaches to minimize wildlife impacts.

We sent the states a survey[10] at the end of 2021 to better understand their concerns, their priorities, and what they believe needed to happen for this to be successful. The results showed huge regional variation, which makes sense given the completely different ecosystems and species in each region. This means there cannot be a national "one-size-fits-all" approach, and we need to start thinking about this at the regional level.

Habitat fragmentation was state fish and wildlife agencies greatest concern, followed by permanent impacts, temporary impacts, migration barriers (particularly amongst western states), invasive species introduction, and a lack of overall research (particularly at the regional level). A common concern across states is that grasslands and prairies are believed to be most at risk. States want more research on what strategies to avoid, how to minimize and compensate for bird impacts, indirect and cumulative impacts, and Best Management Practices (BMPs). They request 1) national-level guidance for solar but at a regional scale, like the USFWS Land-Based Wind Energy Guidelines (WEGs), 2) early and frequent communication, and 3) opportunities to talk with developers at stages where they can make changes.

[8] Fifth U.S. National Climate Change Assessment: https://nca2023.globalchange.gov/
[9] Uncommon Dialogue; https://woods.stanford.edu/research/solar-landconservation
[10] Solar Siting Survey Final Report;
https://www.fishwildlife.org/application/files/7616/8053/3632/Solar_Siting_Survey_Summary_AFWA_FINAL.pdf

AFWA is working on facilitating those requests: providing state-level information, developing tools and maps, collecting and sharing data with relevant stakeholders, helping develop PV solar energy guidelines, and recommending interstate collaboration. Interstate collaboration will not only improve consistency in decision-making between states but also provide learning opportunities. For example, a state like Arizona, which has had solar development much longer than most states, can provide guidance to states with more recent solar development. Lastly, AFWA is working on developing a searchable, open-access database that will contain resources on BMPs for states. The goal is for stakeholders (e.g., researchers, state biologists, industry) interested in developing their BMPs to go and see what others have done.

I want to highlight that states are partners in solar development. They want to partner every step of the way. We ask that you continue to see states as partners in this energy transition.

Key Federal Updates and Emerging Topics in Permitting

Presenter: Thomas Wittig (U.S. Fish and Wildlife Service)

Summary: The USFWS manages wildlife as a trust resource. These wildlife do not belong to us but rather to the American people, and we manage them on behalf of the American people. As an agency, we recognize climate change will be a challenge, if not an existential threat, for many species we manage. There is a significant need to address climate change through clean energy development. However, USFWS wants to ensure this development occurs in a thoughtful and responsible way. We see ourselves as regulators, technical advisors, and, ultimately, partners throughout this transition.

Regulators: We use permitting as a conservation tool. An ESA permit can offer a route to recovery for listed species. Despite being constrained by the nature and design of the laws surrounding permitting (ESA, MBTA, BGEPA, etc.), the agency still has room for innovation, creative partnerships, and the ability to improve the efficiency and transparency of permitting tools. For example, we applied over a decade of knowledge and experience gained issuing eagle permits to revise our regulations, resulting in a more transparent process around the conservation and management of bald and golden eagles.

Technical Advisors: We offer many resources, including the Information for Planning and Consultation System[11] (IPaC)—a web-based software that provides lists of natural resources and species that might occur in project areas—to support accurate decision-making. We have our human resources: amazing staff based in headquarters, regional, and field offices that are available to clean energy developers to lend their knowledge, experience, and expertise to responsible energy development.

Partners: We hope to be partners with industry. We have a unique organizational structure based locally, regionally, and nationally, and have a long history that can be an asset to solar developers. We would like to leverage our partnership role to support responsible development. USFWS recognizes the challenges that come with the rapid build-out of solar energy development, like the significant increase in workload. USFWS is working to make sure our staff have the resources necessary to provide decisions and guidance within a reasonable timeline.

Feedback has shown that the USFWS's decision-support tools are helpful, but that their influence on macro-siting is often overridden by factors such as transmission line access. The agency wants to help mitigate landscape-scale impacts by being part of the conservation about siting of new and rebuilt transmission lines and encouraging development in less sensitive areas. USFWS is eager to learn and is hopeful that through partnerships, development can be done in positive ways.

We emphasize that we recognize solar development can have both positive and negative impacts on wildlife and their habitats. We need help understanding exactly what those impacts are and how best to

[11] Information for Planning and Consultation System: https://ipac.ecosphere.fws.gov/

quantify them. It is our responsibility to accurately account for both the positive and negative impacts of solar in managing wildlife for the benefit of the American people.

Natural Resource Defense Council's Work on the Nexus Between Energy, Technology, and Policy

Presenter: Nathanael Greene (Natural Resource Defense Council)

Summary: The nexus of climate, biodiversity, and equity with the passage of the IRA last year is hugely important. The Natural Resource Defense Council (NRDC) thinks a lot about the climate crisis and recognizes the biodiversity crisis. But over the last few years, we have started to participate in some broad conversations about equity and how our society has grown widely inequitable. Not just along income lines, but racial lines. At NRDC, these three crises (climate, biodiversity, and equity) are intertwined and inseparable, and we are attempting to solve them simultaneously. The scale of development that needs to occur is a huge financial opportunity for communities. This will change our energy infrastructure, which is currently widely inequitable. We dump a lot of our dirty infrastructure in communities deemed disposable. The change in our infrastructure is potentially a huge challenge, yet also a huge opportunity. We must ensure it is done right and done quickly. How do we do wildlife permitting and permitting for solar more quickly and effectively? In a way that no longer only recognizes mitigation, but is tangibly beneficial to wildlife and biodiversity? Coming from someone who is not a wildlife scientist, or a scientist at all, I believe that we can take seemingly irreconcilable differences and make them mutually supportive. We can bring together wildlife, ecosystem, economic, and equity benefits. Right now, the U.S. populace likes renewables. We need to keep it that way, and if anything, accelerate the processes so development occurs while the U.S. populace is on board.

Audience Questions and Speaker Response/Discussion

Speakers responded to questions broadly addressing the following topics:

- Net positive biodiversity
- Incorporating the counterfactual
- Fencing

What do we mean by "net positive"? How is it measured, achieved, and what are wildlife challenges we want to minimize to help achieve net positive, if possible?

Nathanael Greene: Our goal in the RE sector is to support the build-out of renewables in a way that provides a net benefit to the climate, which is relatively straightforward compared to biodiversity and equity. It is important to clarify when we say, "We are not just mitigating the harm." Words like avoid, minimize, and mitigate are ones we commonly use; however, they are not producing a net improvement. The challenge is determining a proper baseline. For example, when looking at biodiversity, we assume the alternative to development is some pristine natural state, which would be hard to measure as a net improvement. My hope is that we can collectively determine a baseline that we can use to assess net improvement that is more realistic than a pristine natural state.

Alyssa Edwards: At Lightsource bp, we have made a public commitment to reach a biodiversity net gain on all our operating projects within five years of commercial operation date. It has been a journey, as there are no real standards for this. We use two different methods to calculate biodiversity net gain. It requires baseline assessments and yearly monitoring. The biggest opportunity we have at solar facilities is the 90% of land underneath and around the solar arrays that have no infrastructure, which goes untouched. We have been establishing vegetation that provides habitat for pollinators and other wildlife, working with soil scientists and experts to develop curated seed mixes that grow in ways that do not interfere with the

compatibility of the solar facility. As we evolve as an industry, we are trying to innovate and find ways we can add environmental value within the facilities, such as agrivoltaics.

Michele Boyd: Beauty is in the eye of the beholder. Who gets to decide whether the benefits are net positive? We need to figure that out. In addition, we need to better engage with communities so we can bring them along. Stakeholders are going to want a say about their local community, and together they can help with better decision-making.

Thomas Wittig: Net positive is a relative term that could vary based on your perspective. The National Environmental Policy Act (NEPA) holds the Federal government accountable for accurately analyzing the impacts of our decisions. Our NEPA documents look not only at negative impacts, but also positive impacts. USFWS loves hearing about new approaches and technologies, but we are ultimately responsible for our decisions on these resources. We need to see data on the efficacy of new approaches and technology because we want to ensure we are not making inaccurate assumptions when deciding on permits and approvals. We are excited to see projects like those funded by the DOE's SETO because they will help inform our decision-making and figure out cases where a net positive may occur.

Meaghan Gade: The states are starting to see a paradigm shift from single-species conservation to a more holistic landscape approach, like the Midwest Landscape Initiative[12]. Thinking about this at the landscape scale is a great step in thinking about net positive impacts.

How do we incorporate the counterfactual into our evaluation of net positive (i.e., what if we do not build solar or wind)?

Josh Ennen: A paper we are working on with desert tortoises studied different climate scenarios to answer the question: what if we did not build out renewables? What we found was that there would only be small pockets of tortoise habitat left. Mitigation strategies may have to occur where tortoises are translocated to cooler environments because deserts are now too hot for survival. We are getting to the threshold where we are seeing massive biodiversity loss. We know that developing solar facilities will benefit wildlife by mitigating climate change, but we still need to be cognizant of the local impacts, as well.

How do we calculate net positive when we have fencing that effectively excludes wildlife, either through loss of habitat or changes in movement patterns across the landscape?

Michele Boyd: We have not been using the term "net positive," but we are very interested in understanding and quantifying the benefits that solar provides to wildlife. But it is extremely difficult. My concern is that we do not have the time to properly address this and find a formula everyone agrees on. We will need a judgment call based on the data and research available, and that concerns many. We need to make all data publicly available, including industry data. Work with us and others to try to answer these questions as fast as possible.

Josh Ennen: Can research keep pace with deployment? We need to speed up deployment, and hopefully research can track and provide the answers we need. We have come a long way in the last five years (around 40 publications to hundreds published in the United States), but we still need to expand our taxonomic and geographical interests so we can understand how biodiversity is responding regionally. Once we understand the biodiversity responses to on-site management and the surrounding landscape, we can answer questions more rapidly. But we do not have the data right now, and we need more research across the United States and in unique regions.

[12] Midwest Landscape Initiative; https://www.mlimidwest.org/

Alyssa Edwards: Fencing is one of the biggest struggles for Lightsource bp. We must innovate around it. It is tough. We understand issues with fencing and habitat fragmentation, but we also need to listen to our communities that engage in sheep grazing and agrivoltaics. It is a big topic, and we must make tradeoffs and innovate around it.

Meaghan Gade: We do not have a lot of information or research regarding solar. Especially for state agencies that are trying to make decisions based on the best available science. Oftentimes, that does not exist. We must make some type of tradeoff. We need to determine the amount of data and research that we are comfortable with to make management decisions, ensuring that we can implement them at the necessary rate we need.

Michele Boyd: Another barrier is that state agencies are asking for published papers, which take years. If there is a way to have a conversation around papers that are not yet published, that could help us progress faster.

Meaghan Gade: We should consider using information from those with on the ground knowledge, like state agencies.

What is something you would change regarding this process of incentivizing nature-based features?

Nathanael Greene: We need to think about projects at an individual level by getting to know the community surrounding the site. The site will be a huge change in their landscape, so we should consider what matters to them. Do they care about agrivoltaics? Are sheep more important than wildlife habitat? This net positive benefit needs to be informed heavily by what the community believes is a benefit. That is what is important.

Building Bridges among Stakeholders

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

Speakers:

- **Jeremy Thompson** – Energy Program Coordinator, Oregon Department of Fish and Wildlife
- **Deron Lawrence** – Senior Director, Natural Resources, Longroad Energy
- **Christina Calabrese** – Director, Permitting and Environmental Affairs, EDP Renewables
- **Meaghan Gade** – Energy and Wildlife Program Manager, Association of Fish and Wildlife Agencies
- **Tiffany Sprague** – Project Evaluation Specialist, Arizona Game and Fish Department
- **Amber Zuhlke** – Director, Environmental Affairs, Lightsource bp
- **Jason Hight** – Director, Office of Conservation Planning Services, Florida Fish and Wildlife Conservation Commission

Moderator Abby Arnold introduced this session, noting state fish and wildlife agencies' interest in increased communication and is being addressed through negotiations between state and wind energy stakeholders. Participants heard about similar discussions that were starting between solar and state agency leaders. Speakers featured nearly a year of conversations between state agencies and wind industry representatives to understand each other's perspectives, highlighting insights into what they learned in the wind/state communication discussions. Speakers noted the importance of building relationships and early and often communication between state agencies and developers/operators in addressing wildlife challenges and opportunities. The session featured state and industry representatives committed to a newly convened dialogue on navigating the rapid build-out of solar to help achieve net zero carbon goals while conserving wildlife and habitat. The session started with a presentation by Meaghan Gade, who introduced the newly formed interdisciplinary solar task force team working to create a communication framework, followed by a discussion and audience questions with all session participants.

Insights from State and Industry on the Power of Communicating

Presenter: Meaghan Gade (Association of Fish and Wildlife Agencies)

Summary: In 2019, AFWA conducted a survey addressing wildlife and wind-siting impacts. The findings unveiled concerns among state fish and wildlife agencies, particularly regarding bird and bat mortality, reliance on voluntary consultations, and inconsistent communication with developers. The survey emphasized the need for improved interstate coordination, consistent research interests, and enhanced collaboration between state agencies, industry, and stakeholders—areas that could equally benefit the solar sector.

One key finding highlighted by the survey was insufficient communication with developers, prompting a recommendation to improve engagement by prioritizing early and often communication. The goal was to provide an opportunity for agencies to offer feedback to developers during the planning and development phases. However, without consistent and iterative communication, the states are unaware of whether the developers implemented their feedback. To address this challenge, a communication framework was developed in collaboration with the American Clean Power Association (ACP). A dedicated team, comprised of industry and state fish and wildlife agency representatives, engaged in tough yet transparent conversations. Over seven months, discussions covered aspects such as defining effective communication for state agencies, outlining ideal communication practices, identifying barriers limiting

industry communication, and clarifying the concept of "early and often" communication. This collaborative effort resulted in successfully releasing the wind communication framework[13] in August 2023.

The communication framework, based on the WEGs, prioritized interactions between states and industry. It follows the same tiered structure of the WEGs, integrating communication elements into the preliminary site evaluation. The framework emphasizes flexible milestones, allowing for timely discussions triggered by specific developments during siting and developments. Recognizing the need to establish expectations early, a tier that was not present in the WEGs was established, called "Tier Zero–Relationship Building." This tier underscores developing trust and ongoing relationship building, acknowledging that effective communication is an iterative and continuous process.

Building on the success of the wind communication framework, a task team was formed in September 2023 to develop a similar framework for solar. This interdisciplinary team, comprised of members from the solar industries alongside state representatives, is actively collaborating on shaping a comprehensive solar communication framework.

Audience Questions and Speaker Response/Discussion

Speakers responded to questions broadly addressing the following topics:

- The importance of participating in this state/industry dialogue
- Principles learned from the wind dialogue
- Comparisons between the wind and solar dialogue
- Processes for conflict management and stage agencies with limited staff
- Increasing representation and public outreach
- Economic benefits of the solar communication framework

Why is participating in this task team to shape the solar communication framework important to you?

Jason Hight: We do not want to be seen as the regulatory fish and wildlife agency. We want to build relationships outside of the regulatory process. Good relationships make our jobs easier. As we continue to work with industry partners and strengthen these relationships, we will better understand the challenges they will face. This results in our recommendations going farther due to the trust that has been built over time. This process takes time, but the benefits are great.

Christina Calabrese: I think many of the issues highlighted by the AFWA survey could be resolved with better communication. I felt like a good way to start is through transparent communication and building relationships. We have a big interest as an industry in moving projects faster and removing any impediments. My company values transparency and stakeholder engagement, and we could lend our knowledge to this process.

Jeremy Thompson: Oregon is a non-regulatory agency, but we are called upon by our partners to work on these projects because they come through different permitting paths. We have seen the value of these relationships. Good partnerships lead to positive outcomes and easier permitting opportunities. Poor partnerships lead to conflict and possible litigation. If we build relationships earlier, we can hopefully decrease and avoid fights later down the line.

Tiffany Sprague: Collaboration is critical to making sure we are doing things right from the start. Arizona is a non-regulatory agency; therefore, in most cases, there are no requirements for developers to consult with us. We often find out about projects after they are complete. If we do find out before then, it is

[13] AFWA–ACP Communication Framework for Wind Energy; https://cleanpower.org/resources/communications-framework-for-wind-energy/

usually because the developers are required to check a box that says, “We coordinated with you,” but at that point, the project footprint and design are almost finalized and there is limited room for meaningful engagement or to provide beneficial recommendations. Communication here is very critical.

Deron Lawrence: The climate change crisis is here. Yet, it is something we think about in the background as we continue our daily lives. The challenge we face is tripling the deployment of RE development to reduce the amount of carbon dioxide (CO_2) in the atmosphere. The only way this can happen is with more transmission and removing permitting impediments. Developers want permits and approvals; we do not want something to pop up that will cost us more money. But these relationships are important, and more important are the difficult conversations we need to have about how we preserve the biodiversity of an area or mitigate that area for the losses we have, and how we build solar faster. It is important to have greater understanding between groups and ongoing conversations, which will lead to future success for both sides.

Amber Zuhlke: I do not like surprises, and when you are in the development of renewables, you know there is always a surprise. This framework can help eliminate that uncertainty. Being up front and communicating early on can help address and plan for issues that may arise. This communication lays the foundation for how to deal with problems no one predicted (e.g., a new species on site, etc.). With these relationships built early on, a quick phone call to a team member to address this new problem is much easier when that person is aware of the project. We need to lay the foundation of collaboration throughout the project’s life, from inception into operations.

What are the principles you learned from the wind dialogue, and can any be applied to solar?

Christina Calabrese: It seems the main concern for both wind and solar is that agencies do not want to be blindsided by industry. There are examples of agency folks being notified by upset land owners calling state staff about projects, yet this is the first time the agency has heard about the project. This leads to frustration. They cannot do their job properly because they were not informed about projects early on. They just want to be included in the process so that they can lend their expertise; they do not want to put roadblocks in the way of development.

Deron Lawrence: At the start of these conversations, it took a few meetings for us to get to know each other, develop that foundation of trust, and understand that ‘this does not have to be figured out in three meetings,’ which was very helpful. We were able to build respectful candor through sharing our nightmare scenarios, like a project being developed in sensitive sage grouse habitat, or developers reluctant to speak with agencies for fear of ending up with an extra million dollars of litigation. The stories shared were real and required vulnerability, which allowed the group to feel safe having these conversations. This allowed us to dive deep into trying to figure out how we can best communicate and try to avoid any surprises. This led to very constructive conversations that progressed relatively quickly.

Meaghan Gade: It came down to the principle of being honest and trying hard to understand other perspectives. During these conversations, we realized our goals are more or less aligned, and we are just approaching them from slightly different angles. If we can understand each other's angles, we can make progress. Having open and honest communication is what made this successful.

What protections did you provide individuals during these discussions to make everyone comfortable (i.e., can they be honest without feeling as though something would be held against them)? Were there confidentiality protocols in place?

Meaghan Gade: Not in a formal way. We just started with an understanding of the purpose of these conversations, and the only way they will be successful is if they remain confidential.

Can anyone speak to processes for late grievances or conflict management approaches?

Jeremy Thompson: One way to mitigate this is to build those relationships early on. When there are surprises or potential pitfalls, it is now easier to have conversations because you already have that trusted, respectful rapport between groups. State agencies need to do their best to provide all the information they can to developers, including being open and honest with the resources available to them. This includes being honest about confidential or sensitive data they are not allowed to share or just information that is unknown. Having that trust and open communication will help when any surprises pop up.

How can state agencies with limited staff correspond with all the developers given the pace of development?

Tiffany Sprague: You need to look at it from a more cumulative perspective. Developing more resources will help with effective communication and building relationships. Having that foundation is critical to easing that capacity workload. I personally coordinate more than 150 RE projects and I spend a lot of time tracking down contact information. If I hear about a project, I immediately reach out, try to coordinate, and build that communication pathway. It will eventually get easier as these relationships continue to develop and as we continue to work together to identify the best ways to move forward.

Jason Hight: We must remember that this goes both ways and we can learn from each other (industry and agencies). What has made an impression on me is how different the regulatory landscape can be. So groups like this, who can encapsulate this information and spread it out, will help mitigate this limited staff issue. Things like best practices, beneficial practices, the solar toolbox document, BMPs, etc. that are created by groups can be passed around, which will help with timeline and efficiency issues.

Amber Zuhlke: We thought about the communication framework to put in pieces where there are regular check-ins on projects. Historically, I have only reached out when I need something or the project is on fire, and I may be remiss in telling the agencies information that may be of lower priority. Having regular check-ins allows for discussions on topics that range from low to high priority.

Deron Lawrence: Everyone in the agencies is stretched thin and has too many projects. I do think the onus is on the developers to put together good applications, be really efficient and thorough, and have the information required for the agency to review. Wasting the agency's time with inadequate applications hurts both the industry and the agency, as well as the relationship we are trying to establish.

Christina Calabrese: Reaching out to state agencies via email early in the development process should not be viewed as a burden for industry. Just find the agency contact information, include them, and they will let you know if they can engage in that particular project. At least then you can say you established contact and this was the response the agency provided. That contact is enough to begin opening the lines of communication and building relationships. Do not let the fear of them not having enough staff stop you; everyone is understaffed and busy.

What are some pinch points in the solar dialogue relative to wind?

Christina Calabrese: For the wind conversations, we had the backbone of the WEGs. We do not have that for solar, so we started from square one, which was a little harder to navigate.

Tiffany Sprague: We have the same ultimate goal, but we have different priorities. One side wants to develop solar as quickly as possible and the other wants to conserve as much habitat as possible. You cannot accomplish one without sacrificing the other, but that is where this open and honest communication is critical.

Can you give examples of stages for solar, and how it is different than wind?

Christina Calabrese: The scope of site characterizations is quite different. There were a lot of discussions surrounding the design of solar. If the developer wants to start discussions after the design is complete, that removes a large chunk of where the agency can provide feedback.

From the states' perspective, what are the developmental stages for siting, and what questions come up in each stage that differs from wind?

Tiffany Sprague: Post-construction monitoring is different, and it is something that agencies would love to see. Understandably, solar is not quite there yet.

Has there been an effort or initiative to include representatives from major environmental consultants in these conversations? What about local organizations, conservation organizations, or public representatives?

Jason Hight: Consultants have made their opinions and feelings known to the RE companies, so I do not feel like they are being left out. Just because there is not a physical body in the room with us, does not mean their viewpoints have not been included. Florida is open to all players and it is unlikely that a group who wanted to be involved would be told no.

Meaghan Gade: We intentionally stay focused on state agencies and industry for this framework. We are starting to see more federal involvement within the states with solar energy development. These are the critical relationships right now. After all of that is done, we can expand to other groups.

Is there a common message that has worked or are agencies and industry working on messaging for public outreach (relating to the wind protocol)?

Meaghan Gade: We hosted a webinar that can be found on the AFWA website that went into detail about the wind protocol and its process (AFWA Webinars)[14]. We encouraged state agencies to use the protocol with their industry partners and then encourage the industry to get their companies to use the protocol. We are basically trying to do a roadshow.

Deron Lawrence: We are planning to have a presentation at an ACP siting conference in the spring. Sharing this document with other developers, the consultants, etc., I think it is going to work. We hope to see the same with the solar protocol.

Christina Calabrese: Now that everyone is aware of this protocol, you can take it to your partners and colleagues and get them on board using the framework. We are relying on everyone to spread the word.

Do any of you have ideas to help get this information to the community?

Tiffany Sprague: We need to get this information out to land managers because that is how we often find out about these projects. Some counties coordinate with us, but others do not. If this can get out to the managers, this can be beneficial so they can learn the value of engaging as early as possible.

How can developers invest more in community engagement?

Christina Calabrese: We are very intentional about going to the communities early. We have a community relations team and often hire people from the community in which we are developing projects to be a resource for the communities. In addition, we are present at fairs and other community events. It is important to start early on so we can think about community concerns and be mindful of them throughout

[14] AFWA Webinar Series; https://www.fishwildlife.org/afwa-inspires/mat-team/webinars

the development process. There is always room for improvement, but it is something that is a big priority for developers, especially establishing that engagement early on.

Amber Zuhlke: We have developed a toolkit that our developers can use within the community early in a project's inception. These toolkits help us be consistent and transparent with the communities, and have been very helpful.

Deron Lawrence: We start with the land owners who work with the neighbors. Our goal is to find out what the community needs, whether it is emergency services, broadband internet, or education. If we recognize what is important to the communities, we can look at ways to enhance their lives and discuss ways to minimize or mitigate their concerns.

Have there been studies to quantify the benefits of communication to a developer? Do studies show the economic/financial value as the project moves ahead?

Christina Calabrese: Project delays cost the most, so the goal of this communication framework is to set a foundation to remove impediments (e.g., schedule delays) that could cost money. How we quantify that is still being addressed.

Jeremy Thompson: One goal from the agency side is that if we have early engagement, we can help direct projects in a larger area into specific lands where we do not have wildlife concerns that may impact habitat. The goal is to minimize and avoid disturbances, right? Avoiding those issues would reduce the bottom-line cost for developers.

What are your hopes for solar?

Jason Hight: An outcome I would like to see is that if someone from Florida Fish and Wildlife Commission (FWC) walked into an industry office and told them their fencing requirements were incorrect and needed changing, we would not get laughed out of the office. With these communication protocols, there will be early coordination, so either they will have the correct fencing requirements to begin with or there will be respect and trust to have a productive conversation around an issue. This is a tool to deal with issues that will result in a beneficial outcome. We need a unified group to develop clear solutions to make this successful. In Florida, we have a landscape conservation strategic initiative. Informing the RE companies about this initiative and what it may mean to them would benefit FWC because it is an opening to start conversations. These initiatives already come with a whole collection of partners, so there is no reason RE companies cannot be a part of or at least know about these initiatives. Having this open communication will allow us to share our goals with others. We want them to know what we care about, and vice versa.

Tiffany Sprague: We need to move beyond project-by-project planning and move into the perspective of landscape-level planning. Engagement early on is important. In Arizona, we have a checkerboard landscape of ownership, where a project on state land is required to do one thing, while next door, a project on BLM land is required to do something different. These cases can lead to wildlife traps instead of benefiting wildlife if these requirements are different or if one developer is not interested in being on board with a certain initiative. Engaging before those decisions are finalized allows us to move forward with this landscape perspective. We have been trying to get these conversations started across different land managers and developers, attempting to plan cohesively instead of individually. The agency is trying to take on a leadership role. This is why the protocol is critical: we must work together.

Christina Calabrese: My hope is that once this conversation is finished and everyone is working together in good faith to implement the protocol, these conversations will be easier. Both parties can speak more transparently. Conflict will still occur because some issues are hard to work through and opinions may

differ widely between developers and the state agency, and it might be hard to accommodate that. But at least we are having those discussions, which is a step in the right direction.

Deron Lawrence: I would like to see real partnerships developed from this framework. I think the solar industry is facing withering criticism, and it is affecting our ability to continue this energy transition. If this communication succeeds and we can start building partnerships, maybe we can start being viewed in a more positive light because we are incorporating more ecological benefits into our projects. We recognize the direct impacts on habitats and we are not building parking lots or malls; most of these projects are vegetated sites that support wildlife. Hopefully we can begin to change how the industry is viewed across the country.

Meaghan Gade: Making this the new normal. Having open conversations with what we thought of previously as being competing interests, but now working together to find those commonalities, no matter how small. My hope is that we continue to really try and work together to build those partnerships that have open communication and trust.

Amber Zuhlke: Having a framework, a toolkit, or a roadmap to show what you are supposed to do is helpful. The people here have been doing this for a long time. But what about people new to this space? They do not know who fought the battles and they have not seen the pros and cons. Having tools to help point to certain topics that were vetted and agreed upon, providing guidance, will be valuable for the next generation of developers.

Crafting Solutions for Habitat Fragmentation and Connectivity Challenges

Moderator: Aaron Facka – Senior Wildlife Biologist, Wildlands Network

Speakers:

- **Todd Mattson** – Service Director, Principal Ecologist, Western EcoSystems Technology, Inc.
- **Michael Levin** – PhD Student, Columbia University
- **Kristin Eaton** – Wildlife Project Manager, Florida Power & Light Company
- **Todd Katzner** – Research Wildlife Biologist, U.S. Geological Survey
- **Quentin Hays** – Senior Wildlife Ecologist, Wildlife Program Director, GeoSystems Analysis, Inc.

This session featured research and expertise on wildlife habitat fragmentation and connectivity challenges associated with the solar build-out. Moderator Aaron Facka opened the session by introducing the Wildlands Network[15], a non-profit interested in landscapes and species connectivity. During the session, speakers discussed the possible relationships between PV solar build-out and mammals, the associated problems, and the potential solutions relating to habitat fragmentation and connectivity challenges. Speakers were given license to speculate to a degree about these challenges because there is a lack of evidence (both published and unpublished data) about these topics.

Habitat Connectivity for Big Game and Utility-Scale Solar Development—An Emerging Issue

Presenter: Todd Mattson (Western EcoSystems Technology, Inc.)

Authors: Todd Mattson (Western EcoSystems Technology, Inc.), Hall Sawyer (Western EcoSystems Technology, Inc.)

Abstract: The construction and operation of large-scale PV solar energy facilities are anticipated to undergo rapid expansion in coming years to address the growing demand for RE. However, the proliferation of PV facilities is sometimes occurring in areas of the western United States with high value to mule deer, elk, and pronghorn populations. This has raised concerns from the natural resource agencies and the conservation community about their potential impact on big game habitats and migratory movements. A better understanding of PV solar's direct and indirect impact on big game, as well as characteristics of corridors in and around facilities actively used by big game, will provide invaluable knowledge for design features that minimize the impact on migratory ungulate movements. We will review a case study that highlights the challenges that large-scale PV poses to pronghorn conservation, including the installation of impermeable security fencing that blocks access to and reduces connectivity between formerly available habitats, and discuss siting and ungulate-specific BMPs that will help to minimize habitat loss and retain landscape connectivity.

[15] Wildlands Network; https://wildlandsnetwork.org/

Walking on Sunshine: Projected Overlap between Solar Development and Land Important for Animal Movement in the United States

Presenter: Michael Levin (Columbia University)

Authors: Michael Levin (Columbia University), Liz Kalies (The Nature Conservancy), Emma Forester (University of California, Davis), Elizabeth Jackson (Columbia University), Andrew Levin (University of Rochester), Caitlin Markus (The Nature Conservancy), Patrick McKenzie (Columbia University), Jared Meek (Columbia University), Rebecca Hernandez (University of California, Davis)

Abstract: The United States may produce as much as 45% of its electricity using solar energy technology by 2050, which could require more than 40,000 km^2 of land to be converted to large-scale solar energy production facilities. Little is known about how such development may impact animal movement. Here, in an analysis relevant to the "Evaluating and Mitigating Solar-Wildlife Interactions including Wildlife Habitat" symposium topic, we use five spatially-explicit projections of solar energy development through 2050 to assess the extent to which ground-mounted PV solar energy expansion in the continental United States may impact land cover and alter areas important for animal movement. Our results suggest that there could be a substantial overlap between solar energy development and land important for animal movement: across projections, 7–17% of total solar development is anticipated on high-value corridors between large, protected areas, while 27–33% of total development is expected on The Nature Conservancy's (TNC) Resilient and Connected Landscapes. Furthermore, some land cover categories more likely to support animal movement may be converted by solar development across more than 1% of their total national area. We also found substantial variation in the potential overlap of development and land important for movement at the state level. These findings are final, peer reviewed, and have been published in Environmental Science and Technology[16]. These results indicate that careful solar facility siting based on local data and stakeholder engagement is likely the most important and effective means of avoiding the negative impacts of solar development on animal movement.

Florida Power & Light Company: Solar and Wildlife Movement

Presenter: Kristin Eaton (Florida Power & Light Company)

Abstract: The number of solar electric facilities in Florida has been increasing over the last decade to meet growing energy demands and mitigate climate change. Until recently, standard security practices included installing a 2.4 m high chain-link fence topped with three-strand barbed wire outriggers around the site perimeter. This type of fencing generally precludes the use of solar sites by most wildlife species except avifauna and small-bodied herpetofauna and mammals. Installation of new solar facilities in southwest Florida that are habitats for the endangered Florida panther (*Puma concolor coryi*) present additional challenges. Chain-link fencing eliminates the area within solar facilities as habitat for panthers and their prey. To address these concerns, Florida Power & Light (FPL) has installed 1.2 m and 1.8 m wide mesh farm field fencing supported by wooden posts around new solar sites, in panther habitats and other areas throughout Florida. Panthers and white-tailed deer (*Odocoileus virginianus*), the primary prey species of panthers, can leap over 1.2 m farm field fencing; panthers and some prey species (e.g., raccoon [*Procyon lotor*]) can access sites by scaling the wooden posts of 1.8 m farm field fences; and smaller prey species (e.g., rabbits [*Sylvilagus* spp.], armadillo [*Dasypus novemcinctus*]) can access sites by passing through wide-mesh fencing. FPL has installed wildlife cameras at two solar sites in panther habitats to assess the effectiveness of panther- and prey-friendly fencing. FPL has recorded most panther

[16] Levin et al. 2023; Solar Energy-driven Land-cover Change Could Alter Landscapes Critical to Animal Movement in the Continental United States. https://doi.org/10.1021/acs.est.3c00578

prey species mentioned in the literature within a few days of camera installation and recorded panthers on the most recent camera study at the Sawgrass Solar Energy Center. Camera studies have also shown use of solar sites by other listed species, such as the federally-listed threatened crested caracara (*Polyborus plancus*).

Effects of Solar Development on Desert Kit Fox Habitat Use

Presenter: Todd Katzner (U.S. Geological Survey)

Authors: Sharon Poessel (U.S. Geological Survey), Marie Hardouin (Cornell University), Steven Grodsky (U.S. Geological Survey, New York Cooperative Fish and Wildlife Research Unit, Department of Natural Resources and the Environment, Cornell University), Todd Katzner (U.S. Geological Survey)

Abstract: Increasing development of solar energy projects in the Mojave and Sonoran Deserts of California can lead to land use change and wildlife habitat loss. One species that may be affected by solar development is the desert kit fox (*Vulpes macrotis arsipus*). Such development can influence kit foxes via modification or destruction of habitat, creation of anthropogenically-induced disease risks, and enhancement of predation or competition from coyotes (*Canis latrans*). Better understanding of these threats and the possible negative or positive impacts of RE development on desert kit foxes will help to identify conservation goals for this species. Our primary objective for this project is to estimate home range size, home range overlap, and movements related to solar development areas by desert kit foxes. Additionally, fox movement and habitat use will be analyzed to understand the use of roads, urbanized areas, and other human-influenced components of the ecosystem. A secondary objective is to assess disease risks in desert kit foxes, particularly the prevalence of canine distemper virus. We captured 20 kit foxes (14 males, six females) from November 2022 to January 2023 near six solar facilities in varying stages of development in the Mojave and Sonoran Deserts, and we fitted them with Global Positioning System–Global System for Mobile Communication (GPS–GSM) collars to track their movements. We also tested each fox for the canine distemper virus, as well as for antibodies to the disease. Preliminary results suggest that foxes readily used the solar facilities during both development and operation. Individual or paired fox territories had minimal overlap, and one male fox moved 30 km within a day. In the first six months of the project, four foxes died, two of which were likely a result of coyote predation. None of the foxes tested positive for canine distemper, and only six (30%) had antibodies to the disease. We will continue to collect telemetry data until the end of 2023, then we will fully analyze the data in 2024. The results of our study will be useful in understanding how solar facilities affect the movements and habitat use of kit foxes in the deserts of southern California.

Utility Scale Solar Energy Development and Ungulate Movement in the Southwest: A Case Study in the Four Corners

Presenter: Quentin Hays (GeoSystems Analysis, Inc.)

Authors: Quentin Hays (GeoSystems Analysis, Inc.), Aaron Facka (Wildlands Network)

Abstract: As the United States transitions to renewables from carbon-intensive energy sources, Utility Scale Solar Energy (USSE) facilities are being planned and constructed across the country. In the arid southwestern United States, where abundant sunlight and large swaths of undeveloped public and private land combine to create ample opportunities for solar energy developers, the build-out of USSE has increased dramatically in recent years. The potential impacts of this build-out on wildlife remain poorly understood, particularly on large mammals that may undertake long-distance movements, such as pronghorn (*Antilocapra americana*). The results of studies elsewhere in the western United States suggest that USSE facilities may negatively impact pronghorn through direct habitat loss and by driving behavioral alterations. However, the movement ecology of pronghorn and other large mammals in the southwest is

understudied, including how environmental factors, such as the Southwest Monsoon, may influence movements. The Wildlands Network and a group of collaborators recently initiated a study investigating how USSE development in the Four Corners region of the southwestern United States may affect habitat use and movement of pronghorn and other wildlife. Using remotely piloted aircraft, visual and track-based surveys, remote cameras, and satellite telemetry, we aim to better understand the potential impacts of USSE build-out on wildlife in the arid southwest, with the ultimate goal of helping inform USSE site selection and post-construction monitoring processes.

Audience Questions and Speaker Response/Discussion

Speakers responded to questions broadly addressing the following topics:

- Wildlife passages and corridors
- Comparison of fence size and permeability
- Water in desert systems
- Gaps in movement data
- Importance of pre- and post-construction data

(for Todd Mattson) What were the dimensions of the fenced area at the Sweetwater Solar Facility? Did you record any direct observations of the animals using or interacting with the fences?

Todd Mattson: The facility was an 80-megawatt (MW) facility, around 640 acres in size (roughly the project size). We did not record any direct observations. We used telemetry and fitted GPS collars on pronghorns prior to construction. These data were used in our analysis.

(for Michael Levin) In your wildlife corridor analysis, was a component of field validation considered or did you feel like it was needed?

Michael Levin: That is one major issue with these types of studies. It is virtually impossible in broad national analysis to do ground truthing. The point of this analysis was to point out the potential areas that could be important for preserving connectivity between large, protected areas in a general sense. This type of analysis is good enough to provide evidence on the landscape characteristics within potential corridors that may be worthwhile when considering the conservation of connectivity.

Are there specific approvals you need for fencing? Are shorter or normal-size fences better? How do fences interact with animals?

Kristin Eaton: Fencing is very site-specific, whether it is 4 feet or 6 feet. We have not done a formal comparison between the two fencing heights. We monitor our sites 24/7, and in one camera study, we found a lot of movement through and over the four-foot fence. However, these were areas near wetlands or canals, and our six-foot fences were near more heavily trafficked areas. Comparing the two fence sizes is something we plan to do in the future.

(for Kristin Eaton) Was there any difference between the 4 feet and 6 feet that would minimize habitat fragmentation? Were there any specific security issues observed?

Kristin Eaton: On-site permeability helps with reducing fragmentation and having a fence that allows movement is beneficial, especially for mammals like the Florida panther. We have had some problems with hogs with both the wildlife-friendly fence and chain-link fencing.

(for Todd Katzner) What kind of fencing was in place at the different sites? Were there differences in fencing gap sizes or was it all straight fencing?

Todd Katzner: I do not have those details on the type of fencing, but I do know three sites had no fencing. For the other fenced sites, the pictures of the fencing look sturdy. One site has gaps for road runners and tortoises. Foxes may also use those gaps or go over the fence if there is no barbed wire on top.

(for Todd Katzner) What are killing foxes in those areas? Is it vehicles or a variety of mechanisms?

Todd Katzner: We did not get carcasses fast enough to discover the cause. We know interspecific competition is high between foxes, coyotes, eagles, and feral dogs.

(for Quentin Hays) What is the availability of water in desert systems and how is that different than other places relative to solar facilities?

Quentin Hays: The Middle Rio Grande in New Mexico is one of the largest ungulate movement corridors in that area. Essentially, you could look at a map of riparian systems and assume that there will be a movement corridor. Arroyos may or may not have running water, but they will often be vegetated and be the only cover on the landscape. These types of landscapes can be very challenging to traverse. Ungulates may have to travel longer distances to find forage because vegetation is so sparse. Oftentimes, the only water on the landscape is associated with ranching and we know wildlife use those. Water plays an essential role in the southwest. This is unlike areas such as the Northern Rockies, where ungulates can follow spring snowmelt, the so-called "Green Wave."

How do we improve or address those gaping holes in animal movement data, specifically around migration corridors?

Quentin Hays: It is really hard. Federal and state agencies are understaffed, and these studies are long-term. Agencies do not have infinite time to collect data, analyze it, inform siting guidelines, and then tell companies where they can or cannot build. We need to be more solution oriented.

Todd Katzner: There are opportunities for experiments with wildlife passages and wildlife-friendly fencing. We almost had one going in the Mojave Desert. We can take advantage of putting cameras on fences, aggregating data across sites, and sharing our data.

Todd Mattson: We are in a situation where we must use the data we have. It may not be as perfect as we would like, but we have information we can begin to work with. Whether it is specific to solar or information coming from roadway, ecology, or big game, we need to aggregate the data so we have enough data to understand the best practices we can start applying.

How important is pre-construction data compared post-construction data?

Kristin Eaton: Pre-construction data is extremely helpful. Knowing where the species may be and how we can move things or if there is a corridor is very helpful when designing a site.

Michael Levin: This would allow the possibility of creating a pipeline for solar development before construction begins. This pipeline could be stakeholders notifying scientists of what is to come so they can ground truth prior to construction if there is interest. Right now, it is really difficult to know when/where solar developments will occur in a publicly available way.

Todd Mattson: Pre-construction data and big game research are very expensive. There is a need for it. There are opportunities to collect it, it is useful. We are at the "learning by doing" phase and we need to start gathering post-construction data. How are animals adjusting to these facilities?

Quentin Hays: It depends on what type of pre-construction data is wanted. Site-specific data is really hard. Migration or seasonal movements are plastic and can change from year to year. You can have landscape-level alterations that throw wrenches into wildlife movements (e.g., drought, fire). These can be very different across systems (e.g., drought in the southwest versus the northwest), so it is important to be able to understand these differences at facilities on the landscape.

Todd Katzner: Pre-construction data has two values. One is for site-specific data, what is going to happen to these animals? I think that is even less important than the second value, which is just getting the before and after data. Having pre- and post-construction data is rare. Without this, you lose so much information. Having both allows for informed interpretation. If you aggregate them correctly, you are able to predict what is going to happen at new sites, and maybe you can do so without doing pre-construction analysis at these new sites.

Avian-Solar Interactions

Moderator: Garry George – Senior Director, Climate Strategy Clean Energy Initiative, National Audubon Society

Speakers:

- **Tara Conkling** – Wildlife Biologist, U.S. Geological Survey
- **Ryan Harrigan** – Associate Adjunct Professor, University of California, Los Angeles
- **Daniel Riser-Espinoza** – Consulting Statistician, Western EcoSystems Technology, Inc.
- **Amanda Klehr** – Project Biologist, Det Norske Veritas
- **Yuki Hamada** – Biophysical and Remote Sensing Scientist, Argonne National Laboratory

This session featured recent research on avian-solar interactions and highlighted current understanding of the risk to avian species associated with PV solar development and operation. Moderator Garry George introduced this session, stating his favorite subject—"birds, birds, birds, and solar, solar, solar"—and provided an update on The Audubon Society, who, like birds, are everywhere (27 regional offices with 465 chapters). During the session, speakers discussed the importance for stakeholders to understand the risks and challenges related to avian-solar interactions as PV solar build-out continues across the United States, and the importance of having access to published and unpublished preliminary data. Speakers covered a variety of topics, including on-site avian mortalities and breeding, avian community composition, and behavioral observations of avian species interacting with various solar-related infrastructure.

Isodemography Identifies Vulnerability of Nightjar Populations to Fatalities at Solar Energy Facilities

Presenter: Tara Conkling (U.S. Geological Survey)

Authors: Tara Conkling (U.S. Geological Survey), Hannah Vander Zanden (University of Florida), David Nelson (University of Maryland), Adam Duerr (Conservation Science Global), Todd Katzner (U.S. Geological Survey)

Abstract: As RE production expands across North America, regulatory guidelines often call on management for stable or increasing populations of wildlife species. To do this requires estimates of population-level impacts of fatalities from RE facilities. An integral part of this assessment is defining the geographic origin of highly motile species killed at solar facilities. Many previous studies have used stable hydrogen isotopes (δ2H) for this purpose. However, the uncertainty associated with δ2H-based estimates of geographic origin is typically large, making it difficult to use this approach to identify the origin of a given individual. One way to address this uncertainty is to simultaneously consider data from more than one stable isotope. We used a multi-isotope approach to geolocation, considering both d2H and carbon stable isotopes (δ13C) to evaluate population of origin for common nighthawks (*Chordeiles minor*), lesser nighthawks (*Chordeiles acutipennis*), and common poorwills (*Phalaenoptilus nuttallii*) found dead at solar energy facilities in California. Preliminary data suggest that the multi-isotope assignment process resulted in substantially improved estimates of population of origin than with either isotope alone. Data on population of origin were then used together with Bayesian demographic models to identify vulnerable subpopulations of nightjars to fatalities from solar energy development. Our approach illustrates how refinement of identification of origin can then be used to improve the assessment of vulnerability, or lack of vulnerability, of species potentially affected by solar energy development.

Building a Framework to Genetically Characterize "Feather Spots" and Understand Demographic Impacts of Solar Energy Sites on Avian Populations

Presenter: Ryan Harrigan (University of California, Los Angeles)

Authors: Cristian Gruppi (University of California, Los Angeles), Peter Sanzenbacher (U.S. Fish and Wildlife Service), Karina Balekjian (University of California, Los Angeles), Rachel Hager (University of California, Los Angeles), Sierra Hagen (University of California, Los Angeles), Christine Rayne (Colorado State University), Teia Schweizer (Colorado State University), Christen Bossu (Colorado State University), Daniel Cooper (Resource Conservation District), Thomas Dietsch (U.S. Fish and Wildlife Service), Thomas Smith (University of California, Los Angeles), Kristen Ruegg (Colorado State University), Ryan Harrigan (University of California, Los Angeles)

Abstract: Alternative energy production is expected to increase rapidly in the coming years, enabling us to meet global demands while at the same time helping to reduce the impact of climate change. A large proportion of this new energy will be provided by installations for solar energy production, yet more work is required to understand the potential impacts of current and future utility-scale infrastructures on wildlife, in particular on avian populations. A relatively easy way to investigate avian-solar interactions is to collect and identify remnants at energy facilities. Collected specimens include intact or partial carcasses that are readily identifiable, as well as those that appear as "feather spots", known to be of avian origin but not readily assignable to species through morphological analyses. These latter unidentified samples are typically excluded from further downstream analyses, leading to a loss of valuable data.

To address this limitation, we optimized a DNA barcoding approach to identify such samples (which may represent up to 32% of all samples collected at a facility) collected at facilities installed in Southern California. After DNA extraction, we amplified and sequenced target portions of mitochondrial CO1 gene using universal primers suitable for all avian taxa. We then leveraged the basic local alignment search tool (BLAST) as a computational tool to search for sequence similarity from an open-access database (GenBank) to identify samples to species, and in most cases, to individuals. Through these analyses, we could identify to species 93% of all samples previously listed as unidentified, leaving only 1% of the total left unidentified. Genetically identified specimens not only contributed to subsequent analyses but represented a different composition of the avian community compared to those derived solely from morphological identification. These new data, combined with our previous efforts to map genetic variation across species ranges (The Bird Genoscape Project[17]) allowed us to assign individuals to the distinct breeding populations they belong to, and to better understand the relative risk of both solar and wind facilities to these distinct populations.

Our results suggest that this genetic approach can be extremely useful to verify, correct, and complement morphological identifications, allowing for more accurate data to be used in investigations of avian interactions with RE installations across facilities, years, seasons, or technology types. Most importantly, these data can contribute to a better understanding of avian species and populations most at risk from anthropogenic development, and lead to more informed, science-based management and siting strategies in the future.

[17] The Bird Genoscape Project; https://www.birdgenoscape.org/

Emerging Trends in Bird Mortality at Photovoltaic Solar in the United States and Canada

Presenter: Daniel Riser-Espinoza (Western EcoSystems Technology, Inc.)

Authors: Daniel Riser-Espinoza (Western EcoSystems Technology, Inc.), Kent Russell (Western EcoSystems Technology, Inc.), Nick Bartok (Western EcoSystems Technology, Inc.), Josh Sullivan (Western EcoSystems Technology, Inc.), Karl Kosciuch[18] (Western EcoSystems Technology, Inc.)

Abstract: Understanding bird mortality at PV USSE projects is an important component of the topic "Evaluating and Mitigating Solar-Wildlife Interactions including Wildlife Habitat." The published studies use data from the southwestern United States where carcasses have represented a mixture of locally common ground-dwelling birds and birds that associate with aquatic habitat. How the patterns found in the United States compared to other regions of North America, especially in ecoregions distinct from the southwestern United States, is largely unknown, as fatality monitoring data has not been widely available. Fatality monitoring at PV solar facilities greater than 1 MW is required in Alberta and reports become public after submission to the Alberta Utilities Commission. We summarized fatality monitoring results from 24 studies at 12 distinct PV projects conducted in Alberta between July 2020 and November 2022, and compared the patterns to those from the United States. We categorized each fatality as either an aquatic habitat bird classification (water associate, water obligate), or an "other birds" category based on the life-history trait criteria used in Kosciuch et al. (2020)[19], and calculated species and group composition based on reported numbers of detections in each category. We also summarized each project-reported fatality estimate standardized by nameplate MW capacity. Species and group composition were variable by project, with most fatalities represented by feather spots, and gray partridge (n = 52) and mourning dove (n = 14) comprising 38.4% of fatalities. Mallard was the most highly-represented water associate (n = 9; 5.2% of all fatalities). There were no Alberta projects with water obligate fatalities included in the analysis. The adjusted fatality estimates at Alberta projects fell within the range reported in Kosciuch et al. (2020), ranging from 0 birds/MW to 5.25 birds/MW, and birds that associate with aquatic habitat comprised 19.8% of unadjusted detections. In summary, the most frequently-detected species were locally common and associated with the ground. Although species composition differed, the results in Canada were similar to the United States. Overall, the data suggest that bird mortality at PV solar is consistently lower than other anthropogenic structures (e.g., buildings) and aquatic habitat bird mortality was limited to several projects, similar to a finding in the United States. The results strengthen the inferences provided in Kosciuch et al. (2020), extending previously recorded patterns to new ecoregions and providing greater certainty that similar patterns may be present at future PV facilities in a variety of landscape contexts.

Avian Use of Operational Photovoltaic Solar Energy Facilities in the Northeastern United States

Presenter: Amanda Klehr (Det Norske Veritas)

Authors: Amanda Klehr (Det Norske Veritas), David King (United States Forest Service, Northern Research Station), Kimberly Peters (Ørsted North America)

Abstract: PV solar energy development in the northeastern United States is rapidly growing, dominated by the installation of ground-mounted projects. Most PV projects in the region are built on farmlands and in early successional and forested habitats, and there is increasing concern by regulatory agencies and other stakeholders about potential impacts to declining wildlife species associated with these habitats. Our understanding of PV effects on birds and other wildlife species in the northeastern United States is

[18] Current Affiliation; Tetra Tech
[19] Kosciuch et al. 2020; A Summary of Bird Mortality at Photovoltaic Utility Scale Solar Facilities in the Southwestern U.S. https://doi.org/10.1371/journal.pone.0232034

limited. Additionally, there are currently no published studies that examine habitat-related outcomes or breeding bird communities associated with solar facilities in the northeast. To address some of these knowledge gaps, we conducted breeding bird point count surveys in 2021 and 2022 to document avian species and communities at operational PV solar facilities and at paired reference sites in New York and western Massachusetts. The 2021 surveys were completed at nine operational PV solar sites and paired reference sites, and the 2022 surveys were completed at 13 operational PV solar sites and paired reference sites. Our surveys were limited to smaller, mostly community-scale facilities (e.g., ≤ 10 MW capacity) in both states, which are characteristic for the region; however, larger-scale sites (> 50 MW) are currently under development in New York. Vegetation characteristics were measured during each visit to account for short-term changes in habitat structure, including those resulting from vegetation management practices (e.g., mowing, cutting). Multiple modeling methods that explicitly accounted for detectability and other factors were used to assess abundance of 15 species that were detected during at least 10% of point count locations across the solar and reference sites. Models that examined associations among avian abundance, habitat, and PV design and management included covariates for point-level vegetation measurements, landscape characteristics, and PV solar facility characteristics (panel height, panel spacing, mowing or grazing practices). Preliminary findings indicate that species richness, and abundances of seven of the 15 species were generally higher in the solar facilities compared to the paired reference sites, particularly at facilities with higher vegetation, but patterns varied across species, land cover/habitat type, and region. The most common species observed across both solar and paired reference sites consisted of song sparrow, red-winged blackbird, American robin, and barn swallow. In addition, 90 active nests were located during the surveys, either on the racking structures beneath PV modules or within vegetation on site. Species observed nesting on PV solar structures included house finch, American robin, and eastern phoebe, while song sparrows and field sparrows were observed nesting within vegetation and on the ground in the facilities. At 63 nests for which success monitoring was logistically feasible, success rates were estimated to be approximately 55% which is comparable to regional estimates.

Preliminary findings may help to identify effective management practices that will improve benefits to birds, while reducing potential negative impacts from PV solar energy development in the northeastern United States. Ongoing research in the region will also be discussed.

Preserving Bird Behavior at Photovoltaic Solar Facilities Using Continual Video Monitoring

Presenter: Yuki Hamada (Argonne National Laboratory)

Authors: Yuki Hamada (Argonne National Laboratory), Adam Szymanski (Argonne National Laboratory), Paul Tarpey (Argonne National Laboratory), Leroy Walston (Argonne National Laboratory), Heidi Hartmann (Argonne National Laboratory), Andrew Ayers (Argonne National Laboratory)

Abstract: With support from DOE's SETO, we have been developing a camera system to continually monitor daytime bird interactions with PV solar facility infrastructure since 2021. During the period, we collected video of bird activities around PV facilities in the desert southwestern, midwestern, and northwestern regions of the United States. Portions of the recordings from the desert southwestern and midwestern regions were used to generate training data to develop and validate artificial intelligence (AI) models that detect birds and classify their activities. Training data consists of sequences of images clipped from the videos (known as "tracks") and information about the speed and trajectory of objects. Object types and bird activities in the tracks were labeled by humans.

Many bird tracks, when they are animated, tell us a story about each bird visiting PV facilities—how they approached, what they did inside, and how they left the facility. We have not confirmed that any birds collided with panels in these data to date. A large majority of birds flew high up in the sky, some of which later flew close to panels. They flew right above, between, and/or under panels. Some perched on a panel

or structure, some landed on the ground, and some flew away without touching down. In addition to these general movements, we saw other behaviors. Some birds appeared to carry a twig or other object, perched on a panel as a pair, or picked at something on the ground. Are these behaviors indicating nesting, mating, and/or foraging? Can we link these to PV facility benefits to birds? We need more studies to answer these questions, and continual video recordings would play an important role in understanding avian-solar interactions.

Audience Questions and Speaker Response/Discussion

Speakers responded to questions broadly addressing the following topics:

- The importance of background mortality
- Video verification with carcass searches
- DNA/stable isotopes
- Future of mortality monitoring
- Needs for future research

(for Daniel Riser-Espinoza) What about background mortality? How do you consider that? Is there some kind of mortality at the control site that you might see on the solar site?

Daniel Riser-Espinoza: Background mortality (i.e., mortality caused by natural processes) can be hard to distinguish from mortality caused by panel collisions or collisions with other solar infrastructure. Additionally, a high proportion of bird remains found during monitoring are partial carcasses or feather spots. This results in a lack of physical evidence that impedes researchers from determining the cause of mortality. With birds using solar sites in a variety of ways, it is reasonable to think some of the mortality is due to background causes. However, the difficulties lie in quantifying that information, which would require a lot of additional monitoring to measure in a statistically rigorous way. One way to understand these challenges is by using control sites. By simultaneously monitoring mortalities on a patch of land outside and within the solar site, researchers can begin to understand the relative impacts of the solar site and account for background mortalities in their estimates. For example, previous studies[20] have shown similar patterns of mortality for species (e.g., mourning dove) across both control and solar sites. This contributes to the evidence that background mortality could be an important proportion of the fatality estimates that are being measured at the site. However, to reiterate the previous point, measuring background mortality at the control site is not necessarily directly comparable to the mortality measured within the facility because cause is often not apparent and species composition may vary between the facility and control site, to name a couple of confounding factors.

(for Daniel Riser-Espinoza) Did Dr. Kosciuch do a study on background mortality in part of the lake effect study?

Daniel Riser-Espinoza: We did do control sites for that study[21]. We were interested in whether aquatic habitat birds were showing up in the control sites as an alternative hypothesis to the lake effect hypothesis. We thought maybe these birds are dying in the surrounding California desert in areas we were not searching, and therefore, not finding them. A little different context, but same idea.

[20] H.T. Harvey & Associates. 2015; California Valley Solar Ranch Project Avian and Bat Protection Plan Final Postconstruction Fatality Report. Report to HPR II, LLC, Santa Margarita, CA

[21] Kosciuch et al. 2021; Aquatic Habitat Bird Occurrences at Photovoltaic Solar Energy Development in Southern California, USA. https://www.mdpi.com/1424-2818/13/11/524

(for Daniel Riser-Espinoza and Tara Conklin) How do you know mortality is caused by the solar site?

Tara Conklin: Unless researchers observe a collision with infrastructure, it is hard to determine with confidence the cause of death. If the bird is found dead at the site, then it was caused by the site, and mortality is listed as an "anthropogenic source." Specific causes of mortality are not identified.

Daniel Riser-Espinoza: We are getting an overall estimate of mortality within the site. Whether they died because of a specific interaction with the facility is unclear.

(for Yuki Hamada) Were any carcass searches completed to verify the video?

Yuki Hamada: To date, not with our cameras. We have been busy developing the technology and now that it works, cameras need to be deployed into the field. A multiple method approach should be used (e.g., the camera system plus a field survey) to identify the relationship between the data. These camera systems can witness collisions but they cannot provide the outcome of that collision at this time. Using a multi-method approach will allow researchers to understand the mechanisms surrounding these bird fatalities. In addition, camera traps are cost-effective, can monitor larger areas, can capture additional data (e.g., observe predator behavior), and can be deployed with other instruments and sensing systems (e.g., acoustic sensors) that can provide a more comprehensive understanding of avian-solar interactions and the outcomes of these interactions at sites.

(for Yuki Hamada) Did you consider thermal imaging for nighttime video?

Yuki Hamada: That was our first idea, and we wanted to do both, but it came down to budget and timeline. We picked the (red, green, and blue) RGB camera because it was cost-effective and easy to interpret. We know the benefits of thermal imaging (e.g., temperature gradients at night and under shade) and plan to incorporate that technology into the camera systems at a later date.

(for Yuki Hamada) What is the viewscape of the camera in regard to detecting the birds (i.e., how many solar panels per se or the range of detection)?

Yuki Hamada: It depends on a few factors: bird size, the angle of solar panels, the height of the camera, and background conditions (e.g., lighting [time of day, cloud conditions], weather, etc.). Currently, our cameras can detect and record bird behaviors approximately 125–500 feet away, depending on the size of the bird (large-bodied birds are detected farther away relative to small-bodied birds) and the panel angle. If the panel is flat and the background conditions are good, the viewscape can be quite large.

(for Yuki Hamada) What is the cost of the AI video system and is it commercially available?

Yuki Hamada: The camera itself is about $3,500 plus the cost of software. There is a discount if you order a lot of units. Having partners willing to cost share would be helpful.

(for Ryan Harrigan and Tara Conkling) How important is feather condition when extracting DNA or stable isotopes? How long until they start to desiccate and how does that relate to the information that can be extracted?

Ryan Harrigan: The condition of the carcass plays a role in whether you can obtain DNA from a sample. If it has been sitting out in the elements for a long time and is highly desiccated, the chances of obtaining a clean DNA sample are reduced. Ultraviolet (UV) light is known to greatly reduce DNA quality. But because the DNA is extracted from areas not exposed to UV light, they can remain exposed or in the elements for extended periods. We have around 350,000 feathers at University of California, Los Angeles, and we keep the majority of those at room temperature.

Tara Conkling: Stable isotopes are relatively stable in the environment, so a reduction in quality is not of great concern. A lot of feathers come from systematic monitoring efforts, so they are usually not on the landscape long enough to be negatively influenced by the elements.

Does the future of solar research contain mortality monitoring or does the future go beyond collecting dead birds?

Tara Conkling: There is an important cost-benefit tradeoff that must be considered. Post-construction monitoring is expensive, but it provides valuable information that you cannot get with just remote sensing and cameras for detecting interactions with panels. Without the information from those carcasses, you cannot identify where these individuals came from, how populations are connected, or understand movement patterns, therefore impacting the ability to effectively manage these species. Collecting carcasses still has a place here and is integral to addressing questions we do not yet have answers to.

Ryan Harrigan: As a data scientist, one of the most valuable things is the time-series information we can use to assess the range and migratory route shifts that correspond to the shifting climate. This can only be done with baseline information, which is collected during the first couple of years.

Daniel Riser-Espinoza: There is value in baseline mortality monitoring data, as it can be used to help answer some of the questions posed during this session. In addition, it could be used to build models that may function at landscape scales, predicting what mortality may look like at a PV site in regions that have not been monitored. Then researchers could validate these models with additional targeted monitoring. But the need to collect carcasses may really depend on whether it is a specific research question (e.g., one that requires a specific spatial scope) or if it is just monitoring for a permit requirement. I think we need to start by identifying the most important question we are trying to answer with our monitoring effort.

Amanda Klehr: Scale is most important in my research as our sites are small, which may result in bird use and overall community dynamics differing from larger sites (e.g., ≥ 50 MW). It is important for us to consider wildlife permeable fencing and whether we will allow meso-predators onto our sites based on site-specific predator interactions.

Yuki Hamada: Adaptive monitoring needs to be considered. There is no superior method that can be used across all sites to answer all questions. Sites may need specific technologies and methodologies to answer questions of interest. It may also be different based on regions, time of year, and size of facilities. However, a collective collaboration to determine what research questions are most important, sharing the pros and cons of methodology, and sharing data will be key to determining the best path forward for future research.

What do you need to keep moving forward? More money, sites, visibility, partners, etc.?

Amanda Klehr: All of the above. Partnerships with solar facility operators, NGOs, statisticians, and universities. Having more open collaboration because we are all doing the same thing, we all care and want to see results.

Daniel Riser-Espinoza: Money, time, and partnerships are super valuable. Communication between private entities and government entities is helpful to ensure valuable questions are addressed. Expanding these partnerships and collaborations can maximize the effectiveness of research when dealing with limited resources (e.g., money and time).

Ryan Harrigan: There is some hesitancy from the industry to collaborate if there is not a requirement to partner with an agency or university. One mechanism known to bridge the hesitancy gap of industry working with agencies and universities is "buy-in." If agency and university scientists and researchers “buy in” to an industry program, whether through financial assistance, contributing data, or another form of

contribution, for a year or two, this provides a temporary partnership where the entities can work more collaboratively and could lead to long-term collaborations that benefit all entities involved.

Tara Conkling: More collaborations and more money to help answer questions. Being able to hire and pay researchers would lead to questions being answered faster and timelines being met. Data should be collected with a purpose. We could collectively address specific research questions, use a standardized collection method across sites, and pull the data together for analysis. This may be a more effective way to answer our key questions.

Is there a way to obtain the data before it is published?

Garry George: The hard part is waiting three to four years for a publication when the data and early analysis may be valuable. Solar development is moving quickly and we have the need to keep up. REWI wants to keep up with solar development and is creating a data-sharing infrastructure, SolSource Database[22], in which information can be pooled from numerous solar projects across regions for review and synthesis.

[22] SolSource Database; https://rewi.org/about-us/our-work/solsource/

Vegetation Management I. Key Considerations for Restoration and Management

Moderator: Lexie Hain – Director Agrivoltaics and Land Management, Lightsource bp

Speakers:

- **Peter Berthelsen** – President, Conservation Blueprint
- **Dan Salas** – Senior Ecologist, Certified Senior Ecologist, Stantec
- **Jordan "J" Martin** – Agrivoltaics Researcher, National Renewable Energy Laboratory
- **Jonathan Thompson** – Project Manager, Tetra Tech

This session featured research emphasizing key drivers, considerations, and lessons learned from vegetation establishment and management at PV solar facilities. Moderator Lexie Hain introduced the session by speaking about how her interest in sheep grazing led her down the path of vegetation management through building Agrivoltaics Solutions, LLC and founding the American Solar Grazing Association. During the session, the audience heard about the important decisions stakeholders make when selecting a generic or site-specific revegetation management plan and the many nuanced considerations that come with that process. Speakers noted that as the development of PV solar sites continues, more locations with unique vegetative challenges will arise; therefore, understanding the pros and cons of these considerations (e.g., cost differences between pre- and post-construction seeding, generic or site-specific noxious weed control) will play a pivotal role in making informed choices. The session covered a variety of topics, including tools for vegetation management, management challenges, considerations to ensure vegetative success, and information about the Pollinator Habitat Aligned with Solar Energy (PHASE)[23] and Innovative Solar Practices Integrated with Rural Economies and Ecosystems (InSPIRE)[24] projects.

Key Considerations to Ensuring Vegetative Success

Presenter/Author: Peter Berthelsen (Conservation Blueprint)

Abstract: There are several key considerations that often determine the final vegetative cover establishment success or failure on utility-scale solar projects. Whether or not and how these key considerations are applied include the following examples.

Seed mixtures must be designed considering all the project's different objectives. Those factors all influence the seed mixture design that should be used on the site. A final vegetative seed cover should be designed taking into consideration a wide range of factors that include things like 1) the maximum growth height of individual plant species, 2) the lower solar panel height above the ground, 3) the pollinator value of individual plant species, 4) the response of plant species to mowing activities, 5) the ease or speed of establishment, 6) the ability for a plant species to persist in the planting for 20 to 30 years, 7) plant species tolerance to partial shading, 8) adaptation to the geography and soil type, 9) commercial availability and cost of the seed sources, and 10) albedo effects of the plant species in the seed mixture.

Every project should go through the process of having a Vegetation Management Plan (VMP) created specifically for each project. Where possible, the VMP should be created early enough in the projects timeline that it can be included in the request for proposals (RFP) shared with engineering, procurement,

[23] Pollinator Habitat Aligned with Solar Energy; https://rightofway.erc.uic.edu/phase
[24] Innovative Solar Practices Integrated with Rural Economies and Ecosystems; https://openei.org/wiki/InSPIRE

and construction (EPC) bidding on the construction of the project. Some of the important considerations and detailed guidance that should be included in every VMP include 1) site preparation activities, 2) herbicide residual effect evaluation, 3) pre- vs. post-construction planting options, 4) planting timelines and dates, cover crop planting options and methods, 5) planting methods, 6) seed mixture design, 7) management plans for years one, two, and three-plus, 8) invasive plant species monitoring and control, 9) vegetative quality targets, and 10) seed mixture planting maps.

For sites that are being established on lands that were formerly in agricultural production, weed management during construction and in the first year of final vegetative cover establishment are critically important. If weed control timing and application are delayed, it can increase the costs and extend the time period required to achieve a fully established cover and/or lead to a failure to establish. If grazing activities are to be conducted as part of the project's future management plan, a Grazing Management Plan should be developed and guide the application and management of grazing activities for the project. The Grazing Management Plan should include specific detailed guidance and recommendations related to the following items: 1) stocking rates and frequency of grazing rotation, 2) number of grazing paddocks established on the site, 3) use of an annual grazing refugee area on the site, 4) monitoring activities of grazing impacts on vegetative growth and pollinator benefits, and 5) timing of grazing activities throughout the growing season.

Developing Tools to Aid Industry and Pollinators

Presenter: Dan Salas (Stantec)

Authors: Dan Salas (Stantec), Ben Campbell (University of Illinois, Chicago), Indraneel Bhandari (University of Illinois, Chicago), Iris Caldwell (University of Illinois, Chicago), Michael Fridman (Stantec), Adam Dolezal (University of Illinois, Urbana-Champaign), Tristan Barley (University of Illinois, Urbana-Champaign)

Abstract: Globally, biodiversity is declining. Pollinators such as native bees, which provide valuable ecosystem services, are facing significant losses due to a combination of habitat loss and other stressors. As solar energy production increases, there has been growing interest in pairing new RE infrastructure with habitat conservation for pollinators. While this is a unique opportunity to combine RE with conservation, industry and land managers are seeking answers to fundamental questions about the compatibility and effects of revegetation practices on utility-scale solar.

The PHASE project is funded through the DOE's SETO to investigate the economic, ecological, and panel performance impacts of co-locating pollinator habitat with large-scale (> 10 MW) solar energy infrastructure. Preliminary research results indicate that establishing pollinator habitat in solar facilities can have some benefits to pollinator communities. This project also includes developing tools to support solar industry decision-making regarding pollinator vegetation. Tools developed include a pollinator solar vegetation implementation manual to support vegetation planning and decision-making, a cost comparison calculator to help evaluate different vegetation approaches, a seed selection tool to identify species best suited to site conditions, and guidance for using a habitat assessment tool to evaluate vegetation outcomes. Tools developed by the PHASE project team are expected to be available in March 2024.

Vegetation Management Lessons Learned and Helpful Tools

Presenter: Jordan "J" Martin (Agrivoltaics Researcher, National Renewable Energy Laboratory)

Authors: James McCall (National Renewable Energy Laboratory), Jordan Macknick (National Renewable Energy Laboratory), Jordan "J" Martin (National Renewable Energy Laboratory)

Abstract: The InSPIRE Project is investigating questions around vegetation management and agrivoltaics at solar sites across the United States. Results from research at three Enel Green Power pollinator-friendly solar sites in Minnesota have shown that the success of different pollinator-friendly seed mixes depends on the ecoregion and can vary from site to site. Results from the Enel Green Power sites also showed that weed coverage decreases dramatically by three years post seeding. The InSPIRE project has also created resources like The 5 C's of Agrivoltaics[25] and an online agrivoltaics financial calculator to help farmers, land owners, developers, and facility operators with vegetation management at solar facilities. The PV-SMaRT calculator[26] was created by the University of Minnesota in partnership with the National Renewables Energy Laboratory (NREL) to help with questions surrounding stormwater runoff at PV sites.

Vegetation Management: Implementation Challenges

Presenter: Jonathan Thompson (Tetra Tech)

Abstract: This presentation focused on the challenges of revegetation on utility-scale solar sites, using examples from the intermountain west. The context of revegetation for utility-scale sites includes what can be a tension between short-term and long-term revegetation needs. In the short-term, sites need to meet revegetation criteria for site stabilization with perennial groundcover and closing out of stormwater permits. However, in the longer-term, sites may have revegetation goals such as biodiversity, habitat, pollinator species, native species, and site management concerns such as frequency of mowing, fire risk, and height of vegetation. Expectations of revegetation can be out of synch with the reality of revegetating sites, particularly in challenging ecological regions. Representations of revegetated sites in marketing and research are frequently drawn from smaller, intensively managed sites in wetter ecoregions and are unrepresentative of revegetation outcomes in much of the country. Examples of challenges to implementing successful revegetation presented included: ecological, environmental, and geographic and temporal scales.

Sites in the arid west receive limited precipitation that is typically concentrated during the winter months. Frequently, this results in a very narrow seeding window, and successful revegetation may require site-specific techniques such as seeding on snow. The limited precipitation may also affect the potential suitability of a site for agrivoltaics and grazing.

The geographic scale of utility-scale solar presents challenges to revegetation, particularly when extensive areas of a site are graded below the existing root structure. The temporal scale also presents challenges, as a typical construction schedule will span more than one growing season.

Contracting: Key tasks affecting site revegetation, including grading and seeding, are typically subcontracted. As a result, the developer may not have direct control over timing, means and methods, or the qualifications of the subcontractor performing the work.

[25] Macknick et al. 2022; The 5 Cs of Agrivoltaics Success Factors in the United States: Lessons from the InSPIRE Research Study. https://www.nrel.gov/docs/fy22osti/83566.pdf
[26] PV-SMaRT calculator; https://license.umn.edu/product/pv-smart-solar-runoff-calculator-version-30

Audience Questions and Speaker Response/Discussion

Speakers responded to questions broadly addressing the following topics:

- Recommendations for achieving seeding targets
- Thoughts on the perceived aesthetics and appearance of vegetation on sites
- Proper vegetation management assistance
- Capturing costs for the various vegetation management strategies
- Invasive, noxious weeds and habitat conditions
- Insurance and fire risk

(for Jonathan Thompson) Do you have any recommendations to help encourage firms and people running the EPC construction cycle to hit seeding targets?

Jonathan Thompson: There are two approaches here: 1) regulatory—EPCs are highly cost-motivated, and they do not want to end up in regulatory non-compliance and be at risk of fines, and 2) contracting—the developer ensures they have direct control and say over the qualifications of who is seeding, the timing and methods of seeding, and whether it is contracted through the EPC, directly to the developer, or subcontracted. The contracting approach is the best tool, particularly subcontracting, which is occurring more recently. Subcontracting allows our botanists and revegetation people to have direct control. No matter the approach, one issue that remains is that it is still the developer's responsibility to meet site and permit conditions, and these developers/EPCs do not have long-term stakes in the site.

Peter Berthelsen: That tool becomes more available to solar developers when a VMP is included in their EPC's RFP.

Jonathan Thompson: The difference between having a generic revegetation plan versus having a very site-specific plan is everything. Generic plans provide no real guidance to the EPC (i.e., seedings must be done at X time but does not specify by what method). Site-specific plans provide guidance and control that becomes something anyone can implement (i.e., seedings must be done at X time using method ABC).

What are your thoughts on how the public, owners, regulators perceive the aesthetics and appearance of vegetation over the operating phase of the project and how it is maturing over time? How would you guide people to think differently?

Dan Salas: A field full of black-eyed Susans, or *Coreopsis*, is great marketing material. It is aesthetically pleasing. However, it is misleading because not every site looks like that, and if it does, it is for a short period of time (e.g., maybe one week per year). As more sites are developed, people will begin to have a more realistic understanding of what vegetation looks like as it matures and throughout the course of the projects. One potential tool to aid this understanding is the use of realistic renderings or visualizations during community meetings and stakeholder engagement, rather than marketing photos.

Jordan "J" Martin: One expectation from the community is for immediate results. For instance, they expect to see results the year following construction if native pollinator habitat is added to a site. Native species require time, and in certain cases more than five years, to successfully germinate and begin growing. The community needs to be prepared for what will realistically occur.

Dan Salas: Aesthetics and what you can do in terms of vegetation management are scale dependent. At the community level, more intensive management can be achieved where you can have a more diverse seed mix, but at the utility level that may not be possible.

How can state agencies assist proper vegetation management for projects?

Peter Berthelsen: Do not let the pursuit of perfect become the enemy of doing something really good. Think about when you are providing guidance, determine what objectives are important, and which must happen. For example, just because you want prairie restoration, which a utility solar site will never be, this does not mean managing that site to the best of your abilities is not worth it.

Dan Salas: Listening to the developer and considering the project as a whole is important. Compatibility is important. An example is the roadside. One may think the roadside is a good place to build habitat, but there will be parts that require mowing, parts that require more frequent maintenance, and parts that may be more or less suitable for that habitat. Just because you want something does not mean it is the best choice. It also comes back to the logistics of what you can do. Find out what can work logistically for each specific site because there are many opportunities for habitat and ecosystem services aside from native pollinator habitats (e.g., reducing runoff).

Are you capturing the costs of all these different strategies, including pre-seeding?

Jordan "J" Martin: In the test plots, I believe they were broadcast seeded. But we have done some native seed drilling in different test plots. In general, we see better outcomes with native seed drilling. If the equipment and funds are available, we found better germination rates and fewer weeds using drilling.

Dan Salas: Seeding techniques can vary. Generally, drilling is best. If it is post-construction, a combination may be best where you broadcast in areas you cannot drill. In terms of cost, I do not believe I have seen a substantial difference on a large scale. We are developing a cost comparison calculator, so share your data because it will be helpful.

Jordan "J" Martin: Seeding pre-construction is ideal and minimizing grading (if grading is necessary) will help get your seed mixes established quickly and produce good ground cover.

Is anyone looking at quantifying costs around pre-seeding techniques versus others?

Dan Salas: We are trying to quantify this area with the cost comparison calculator. The way we have it built in gives you a default assumption and you can adjust it from there. From talking with contractors, the ability to pre-seed varies from site to site. Pre-seeding can cut costs roughly in half and is logistically easier as you do not have to work around pilings or panels.

Peter Berthelsen: Some of the costs you are saving with pre-seeding are that you no longer have to pay for a cover crop.

Jordan "J" Martin: NREL came out with a capital cost paper[27] that looked at the costs associated with different land uses and dual land uses at solar sites. This included some information about pre-construction versus post-construction seeding costs. NREL is currently in the development of a new capital cost model that should come out in 2024. We are in the data collection phase, so please send us your data.

Jonathan Thompson: If you are fortunate enough to pre-seed (which is dependent on many factors), costs become comparable to Conservation Reserve Program (CRP) lands. The Natural Resources Conservation Service (NRCS) publishes costs relating to CRP lands and the use of traditional agriculture equipment on larger scales. Pre-seeding is comparable to NRCS costs for establishing grasslands, but once the solar

[27] McCall et al. 2023; Vegetation Management Cost and Maintenance Implications of Different Ground Covers at Utility-Scale Solar Sites. https://www.mdpi.com/2071-1050/15/7/5895

infrastructure is in place, the costs become more comparable to their landscape costs. This information may be useful during discussions when other comparisons are not available.

(for Jonathan Thompson) How can we avoid cheatgrass and improve habitat conditions?

Jonathan Thompson: The expectation cannot be that it is going to be completely perfect. Sites we see with great success have to keep populations of cheatgrass low and likely have commonalities between them, such as 1) they were lucky, 2) their site was already really flat, or 3) they had a really good combination of ECP and direct moving contractor, which resulted in less vegetation being distributed and left more root structure and existing seed mix in the ground. If you blade everything to bare ground and it sits for eight months with the wind blowing seeds in, it becomes more challenging to manage. Site-specific plans can make all the difference, by hitting seeding windows using appropriate techniques or using a revegetation contractor that is local and experienced in the region. A generic plan or even a site-specific plan, that requires use by an extremely busy site manager or EPC construction manager who does not have the time to read a detailed plan, will never do as well.

Do you have any advice about best practices relating to invasive, noxious weed policies and targets to ensure contractors can achieve those goals, are interested in compliance, and can afford to comply?

Dan Salas: There are two aspects: 1) prevention—there are policies and procedures regarding species that require equipment to be clean, and 2) control—it is key to control noxious weeds during site establishment as the weeds are establishing. Experts are needed who know different stages of noxious weed growth to be able to monitor and remove noxious weeds across the life cycle. Do not wait until there is a phone call or notice of non-compliance. Invest in prevention and control early.

Jonathan Thompson: This is where site-specific management versus generic management plans are important. You can get through permitting with generic plans that state you will treat invasive, noxious weeds via hand pulling, chemicals, etc. However, specific techniques may not work for every species of weed, and do we expect a site manager to be able to identify grass species from each other and the best time of year for treatments to occur? We tend to see noxious weed plans that are approved that focus on what is legally required, which differs from what the state or county lists as noxious weeds. In addition, what might be prevalent at one site, like cheatgrass, may not be listed as a noxious weed you are mandated to control. However, it may be listed within the revegetation criteria. These generic plans can get confusing and we are grappling with creating usable documentation while keeping the viewpoints of the developers in mind (e.g., minimizing unwanted or additional tasks).

Peter Berthelsen: Here is a story that will paint a picture of how serious a situation can be when dealing with invasive, noxious weeds. In Michigan in the late 1890s, they collected weed seeds, put them into soil in glass jars, and buried the jars. Every 10, 15, and 20 years, they would dig up a jar to see if the seeds would germinate and grow. One hundred twenty-seven years later, the seeds still germinate and grow. Any kind of soil disturbance leads to a significant weed problem. You must have a plan in place to address this.

Jordan "J" Martin: You can control weeds by mowing. However, the more you mow, the more weed growth will happen because native plants take longer to seed and set seed, and you will mow them down before they get that chance. Yet weeds grow faster, will perk back up after they have been cut, and eventually outcompete native species.

Relating to insurance, we hear insurance brokerages are increasingly concerned about fire risk and vegetation heights. How can we speak to risk-adverse insurance brokerages and related parties on that subject?

Peter Berthelsen: How do we not eliminate but reduce the likelihood of fire? We do so by trying to design and establish vegetation that will stay green longer throughout the year.

Jordan "J" Martin: NREL is very much interested in this question, but we are coming at it from the other side: using our connections within the insurance world surrounding RE to begin discussions. Pollinator habitat and the education gap surrounding what we are planning do not line up with what the insurance agencies expect.

Dan Salas: We can take clues from other industries when it comes to managing risk. Fire risk depends on where you are located in the country and what time of year. That can be incorporated into the revegetation plans (e.g., having vegetation in less fire-prone areas, incorporating fire breaks, adding seasonal [dry or wet season] or mowing triggers, etc.). There are many ways to minimize risk while maintaining vegetation.

Jonathan Thompson: This is a topic of concern at the state level, especially with climate change and increases in brush fires, grass fires, and wildfires. In Oregon, projects go through the Oregon Energy Facility Siting Council state-level permitting processes, and one piece is fire analysis. It looks at pre- and post-project fire risks (e.g., flame height, how far flames will travel, how fast fire will spread, etc.). This focus on fire risk is expected to increase in the next five to 10 years, which is included in permitting and planning and will be included in site vegetation management.

Vegetation Management II. On-site Ecological Outcomes

Moderator: Ashley Bennett – Research Scientist, Electric Power Research Institute

Speakers:

- **Tristan Barley** – Graduate Research Assistant, University of Illinois, Urbana-Champaign
- **Claire Karban** – Postdoctoral Fellow/Research Ecologist, U.S. Geological Survey
- **Laura Fox** – Natural Resource Specialist, Argonne National Laboratory
- **Rhett Kerby** – Principal Soil Scientist, KerTec, LLC

This session featured data-driven discussions on the ecological responses (e.g., wildlife, their habitat, and ecosystem) associated with vegetation, restoration practices, and vegetation management. Moderator Ashley Bennett began the session by introducing her role as research scientist with the Electric Power Research Institute (EPRI), where she focuses on vegetation management, mostly on right of ways, but spends time focusing on solar sites, as well. The session focused on vegetation research in the midwestern and western United States. The speakers' research focused on vegetation responses at PV solar sites, studying the pollinating insects (e.g., bees) responses to native vegetation, and how solar construction impacts plant communities in arid ecosystems.

Lessons Learned from Integration: An Entomologist's Perspective on Habitat Challenges

Presenter: Tristan Barley (University of Illinois, Urbana-Champaign)

Authors: Tristan Barley (University of Illinois, Urbana-Champaign), Ben Campbell (University of Illinois, Chicago), Indraneel Bhandari (University of Illinois, Chicago), Leroy Walston (Argonne National Laboratory), Heidi Hartmann (Argonne National Laboratory), Laura Fox (Argonne National Laboratory), James McCall (National Renewable Energy Laboratory), Jordan "J" Martin (National Renewable Energy Laboratory), Adam G. Dolezal (University of Illinois, Urbana-Champaign)

Abstract: Globally, insects are declining at alarming rates, with groups such as native bees, which provide valuable ecosystem services, needing conservation efforts to mitigate these losses. One of the main causes of these native bee declines in the Midwest is habitat loss, with large areas that were historically prairie habitat now being utilized for agricultural production. As solar energy production has increased in this region, however, there has been growing interest in pairing new RE infrastructure with vital bee conservation habitat. While this is a unique opportunity to combine RE with conservation, most research efforts investigating insect communities in this new habitat system have occurred in smaller facilities (< 10 MW).

The PHASE project is funded through DOE's SETO to investigate the economic, ecological, and panel performance impacts of co-locating pollinator habitat with large-scale (> 10 MW) solar energy infrastructure. This research includes developing tools to support solar industry decision making regarding pollinator vegetation, assessing panel energy output when pollinator plantings are present, as well as community assessments for pollinator vegetation, birds, bats, and insects. Our preliminary results indicate that establishing pollinator habitat in solar facilities can have some benefits to bee communities. However, habitat establishment is difficult, and more thoughtful vegetation management is likely key to creating more meaningful conservation habitat.

The Ecological Impacts of Solar Energy Development in the Southwestern United States

Presenter: Claire Karban (U.S. Geological Survey)

Authors: Claire Karban (U.S. Geological Survey), Seth M. Munson (U.S. Geological Survey), Jeffrey E. Lovich (U.S. Geological Survey), Steven M. Grodsky (U.S. Geological Survey, Cornell University).

Abstract: To meet RE targets, solar energy development is expanding rapidly throughout the United States. In 2023, the United States plans to add nearly 30 GW of utility-scale solar energy capacity—the most of any year to date. Although solar energy can reduce carbon emissions relative to more traditional forms of energy, it has intensive land use, requiring approximately 1.8 times as much land as surface-mined coal and 15.8 times as much land as natural gas for the same energy generating capacity. Much of the solar energy capacity is being developed in the southwestern United States, where there is high solar irradiance across the Mojave, Sonoran, Chihuahuan, and Colorado Plateau deserts. However, these deserts are sensitive to land use disturbance and the environmental consequences associated with solar energy land conversion are predominantly unknown or only beginning to be understood.

To fill this knowledge gap, we present a novel framework for predicting the impacts of solar energy development to plants and wildlife by linking disturbance types associated with solar facility construction and operation to the morphological, physiological, life history, and behavioral traits of species and guilds. In the absence of empirical research on the impacts of solar development on the many organisms affected, this framework provides insights and suggests pathways for future research. Guided by this framework, we present the Gemini Solar Project[28] as a case study. The Gemini Solar Project is a utility-scale PV solar energy development located in the Mojave Desert northeast of Las Vegas, Nevada. Disturbance types during the construction phase of the project include driving over and crushing vegetation, soil destabilization, road traffic, and noise pollution. We quantify declines in native perennial plant cover, plant species richness, biocrust cover, and soil stability resulting from construction activities and compare these measured results to those predicted by the framework. We also demonstrate shifts in the plant community composition under and between PV panels. Our work highlights new insights to fill the current gap in our understanding of the impacts of rapidly expanding solar energy development and contributes a predictive framework for evaluating impacts to species and guilds.

Insect Response to Solar-Pollinator Habitat

Presenter: Laura Fox (Argonne National Laboratory)

Authors: Laura Fox (Argonne National Laboratory), Heidi Hartmann (Argonne National Laboratory), Leroy Walston (Argonne National Laboratory)

Abstract: The expansion of utility-scale solar development across the United States has increased the pressure on land resources for energy generation and other land uses (e.g., agriculture). To address this growing issue, greater emphasis has been placed on development strategies that maximize the benefits of energy generation and multiple ecosystem services, such as combining solar energy development with biodiversity conservation. Compared to other types of site management, the restoration of native grassland habitat at solar energy facilities ("solar-pollinator habitat") has the potential to improve habitat quality for pollinating insects and other native wildlife, while also providing other ecosystem service benefits. As more solar developments are being managed for solar-pollinator habitat, there is a need for monitoring projects to inform questions around ecological performance, scalability, and management considerations. In this presentation, we share our collaborative broad-scale ecological monitoring strategy for solar energy sites in the Midwest that have been planted with pollinator-friendly native

[28] Gemini Solar Project; https://www.primergygemini.com/

vegetation. Several of these solar facilities have been systematically monitored over the past five years to measure habitat and insect pollinator responses over time, whereas research is just beginning at the other sites. The primary ecological performance measures we are investigating include 1) vegetation establishment and habitat composition, 2) on-site insect pollinator abundance and diversity, and 3) off-site pollinator visitation to nearby agricultural areas. Findings from monitoring efforts show temporal increases in habitat diversity and on-site pollinator abundance and diversity. There are also some temporal trends in pollinator visitation to nearby agricultural fields. In addition to these findings, we will discuss designs for research at new large-scale facilities (> 10 MW) to monitor vegetation establishment and pollinator effects considering the scale and configuration of the plantings.

Accelerating Ecological Succession through Best Management Practices

Presenter/Author: Rhett Kerby (KerTec, LLC)

Abstract: KerTec was engaged to implement BMPs on a newly constructed solar site in west Texas to improve vegetation and ecological health. KerTec performed stabilization, decompaction, incorporated soil amendments, drill seeded, hydromulching, and vegetation management via chemical and mechanical methods. A vegetation monitoring survey was conducted by SWCA Environmental Consultants on the solar site to assess the success of the reclamation efforts and plant community succession over time. The survey compared eight locations in the solar panel areas and eight samples outside of the solar panels but inside the project footprint. Data collected compared overall site conditions, a list of all species present, estimated percent cover of vegetation, the presence/absence and quality of pollinator habitat, and the presence/absence of noxious or invasive weeds. The seeded species were identified as "target species." Within the panel areas, average vegetation cover was 60.6% with 55 identified plant species. Within the control areas, average vegetation cover was 56.3% with 63 identified plant species. No state- or federally-listed noxious weeds were detected in either area, but some invasive species were present. Seven target species were found in the panel areas and five target species were found outside the panel area. In summary, the results are as expected. Target species were identified along with numerous other species, which are expected by natural succession. A desirable plant community is created and influenced by strategic management over time.

Audience Questions and Speaker Response/Discussion

Speakers responded to questions broadly addressing the following topics:

- Relationships between bee diversity and plant diversity
- Challenges with managing pollinator habitats
- Commercial bee hives and solar facilities
- Soil horizon reconstruction
- How to mimic disturbances like fire
- Best management practices for arid habitats and incorporating potential impacts of climate change into management plans

(for Laura Fox) Why do you think you did not see as many wild bees compared to other taxa at the PHASE sites?

Laura Fox: The vegetation at the PHASE sites is newer when compared to the InSPIRE sites, which have been established for roughly five years. At the InSPIRE sites, the data shows a higher native bee abundance and greater diversity, but these increases have begun to level out. We expect a similar pattern as the vegetation continues to establish itself at the PHASE sites. One consideration is that the location

of the native pollinator habitat of interest at these PHASE sites was placed just along the perimeter and not between the panel arrays.

(for Laura Fox or Tristan Barley) Are you collecting data on other species like birds or bats?

Laura Fox: The Argonne National Laboratory Research Team does have acoustic monitors at all the sites, along with motion detector cameras. These are recording bird activity on-site and off-site, as well as ultrasonic bat activity at night. Leroy (Lee) Walston will be discussing this in greater detail in the session "Applying Technology to Answer Tough Questions."

Tristan Barley: We are collecting other insects that are natural enemies to crop pests (e.g., ground-active predaceous beetles) and pollinators that are not bees.

(for Tristan Barley) What year post-construction was your study done?

Tristan Barley: Each PHASE site is different. Most are two years post-construction but some are three. Unfortunately, we do not have controls or pre-construction data for these sites.

When considering installing pollinator habitat, are there any concerns that it will create sinks?

Tristan Barley: There was research done on installing prairie strips in agriculture land with the idea that these strips of pollinator habitat around the field margins would increase pollinators on the agriculture fields. They did not find an ecological sink and found benefits for pollinators. Although this is not an example of a solar-pollinator habitat, it may provide some suggestions that it would not be a sink.

(for Tristan Barley and Laura Fox) Do you believe the lack of bee diversity is related to plant species diversity and what are the main factors for low establishment of vegetation?

Laura Fox: The reason for the 20% forb diversity is because the sites are currently at year two post-seeding. We expect diversity to increase as time passes. Our dominant forbs, early in the season for PHASE, are clover (June/July). Later in the season (August/September) it becomes black-eyed Susan and goldenrod. We identify all forbs on site, even if it is just one cardinal flower.

Tristan Barley: Lack of plant species diversity is tied to bee diversity, specifically the lack of native vegetation, which attracts rare bee species. Anecdotally, we are seeing more generalist bees in our solar-pollinator habitats. Bumble bees can visit just about anything found at our prairie sites where the vegetation is more robust. Specialist bees may prefer a certain flower, resulting in those species being harder to find and harder to conserve. This must be considered when determining what type of habitat you plan to conserve and what species are important. Planting clover can support bumble bees, but maybe not the rare species that are important. Vegetation plays a role and is important; however, it is not the only important factor.

(for Laura Fox and Tristan Barley) Does it make sense to promote commercial hive co-location with pollinator-friendly solar panels?

Laura Fox: We see a lot of honey bees on the native grass and white clover vegetation that is planted between the arrays. Many of our sites have hives, which is why honey bees are separated in our studies. We see these species primarily on clover, where we do not see many native bees.

Tristan Barley: Having hives next to your site will give you more bees; however, that is not necessarily good for conservation efforts. Honey bees can be detrimental to native bee communities via pathogen exposure, microbiome exposure, or competition. Native bees use prairie plants throughout the season, but towards the end of the season, honey bees have switched from clover (which is now out of season) to

the same prairie plant species, increasing competition. If you are trying to install a solar-pollinator habitat with the idea of it being a good conservation habitat, adding hives is a bit contradictory.

What are some challenges that come with creating pollinator habitat? Are we increasing the risk of bringing in competitors? How do we address those challenges? Might it be preferable to invest in pollinator habitat restoration off-site?

Tristan Barley: Concerns may depend on what region you are in. For example, in Minnesota or Wisconsin, sites may see the rusty patch bumble bee, which is federally listed. Conversations need to be had about what steps to take if a federally-listed or state-listed species shows up. There are also discussions about whether the ESA should list insects, as they are everywhere and managing an endangered insect may not be as successful as a bald eagle. Conversations need to continue about how to encourage habitat creation while not punishing facilities when a federally-listed insect shows up, which the site is now in charge of managing.

There is value in keeping restoration off-site and apart from heavily-used areas. For example, instead of restoring a wetland next to a big box store, it was moved far away from the original location to mitigate heavy metal runoff that would have occurred if it were restored next to the store. Allowing it to be created as its own natural system that can be protected has value.

Laura Fox: Off-site restoration was a large part of solar regional mitigation plans with the BLM from my experiences years ago, particularly in a big southwest project. I am unsure if this occurs in the Midwest due to the private farmer-leased land. It would be difficult, but it is a good thought.

Claire Karban: The southwest has seen a lot of utility-scale solar because it is very sunny. The federally-listed desert tortoise habitat overlaps nicely with areas primed for utility-scale solar. In this case, there may not be alternative options, whether for construction or for habitat restoration off-site.

(for Rhett Kerby) Soil decompaction, how is that done? Are soil horizon reconstructions needed?

Rhett Kerby: Soil decompaction is done with a tillage implement, a rolling type of implement like a disc (e.g., a plow). As a rule of thumb, aim for less than 200 pounds per square inch in soil compaction, which is the point at which roots are not able to grow. If this is for seedbed preparation, compact down to four inches. Reconstructing soil horizons is a function of geological time. My perspective is to minimize the initial disturbance to prevent the deconstruction of the horizons. You may be able to reestablish horizons on the topsoil because you can remove and replace it. But that is the extent of reestablishing soil horizons.

What are ways to manage or anticipate the effects of climate change or drought within vegetation management approaches or restoration plans?

Claire Karban: The best thing is minimizing any level of disturbance from the beginning. This is typically more successful than any restoration.

Rhett Kerby: If there is a disturbance, the best strategy would be to stabilize the soil. If the soil is stabilized, any ecological processes that occur next will be more successful.

How can we mimic disturbances to maintain species diversity at solar sites?

Tristan Barley: Some prairies do not burn and are mowed. Mowing can mimic burns if done correctly and at the right time. Natural prairies do not burn annually, maybe every five to 10 years, and cannot be included in management plans. However, because mowing can mimic burning it is easier to incorporate

that strategy into management plans. You cannot mow sites like they are your front lawn, as that produces weeds. However, if mowing plans are done thoughtfully and strategically they can successfully replace the need for burning.

Rhett Kerby: Thoughtful, timely mowing can mimic fire. But it is important to keep in mind that vegetation reduction is an important component of ecological succession, amongst many other factors that help in these processes (e.g., inter-seedings and light disturbances).

For our more arid grasslands, what are some of the best management practices for maintaining diversity in those systems?

Rhett Kerby: According to the U.S. Department of Agriculture (USDA), there are methods to inter-seed species, or forbs and legumes, into grasses or into grass stands. Time, along with light disking as a form of light disturbance, can create additional vegetative responses.

What do you see as the next big gap research needs to address?

Tristan Barley: Research needs to be conducted in more ecoregions. PHASE is occurring in the Midwest and we are learning a lot of great things. But these results may not be applicable to the Pacific Northwest or southwest, as the plant communities and insect communities are completely different.

Laura Fox: The establishment question is important, especially on sites where pollinator habitat is on the perimeter. When you have these large sites with 800 acres of different vegetation types, but then a perimeter with pollinator habitat, what does that look like long-term? How is weed control managed and how do we manage mowing to allow perennials to be successful? Those are important questions.

Claire Karban: There are a lot of exciting innovations in mitigating the effects of solar development and co-locating things like native vegetation and habitats with solar. We just do not have enough data yet to understand how well it works. We need time to continue exploring how plants and wildlife respond to solar.

Rhett Kerby: There is a disconnect between the impacts from erosion and how that relates to long-term vegetation expression over time. In other words, what is erosion doing to our ability to express the desirable vegetation? More research needs to be done between erosion control and vegetation establishment.

Standardizing Data Collection to Maximize Learning

Moderator: Josh Ennen – Senior Scientist, Renewable Energy Wildlife Institute

Speakers:

- **Ryan Butryn** – Senior Information Science Manager, Renewable Energy Wildlife Institute
- **Michael Ricketts** – Soil Scientist, Argonne National Laboratory
- **Daniel Riser-Espinoza** – Consulting Statistician, Western EcoSystems Technology, Inc.
- **Tara Conkling** – Wildlife Biologist, U.S. Geological Survey

This session featured presentations on standardized methods and data collection on ecological responses (e.g., soils, wildlife, and ecosystem health) and highlighted the importance of standardization in maximizing data sharing and learning. Moderator Josh Ennen introduced this session, noting the need for more data and the collective research priority of standardizing protocols to compile data to answer broader landscape- and regional-level questions. Speakers discussed the need for standardized studies and methods to collect and compile ecological data to answer larger questions. Individual speakers focused on databases that organizations are compiling, examples of standardizing data, issues that come with collecting data differently, and the challenges faced in compiling data.

Introducing REWI's SolSource Database and the Importance of Data Standardization

Presenter: Ryan Butryn (Renewable Energy Wildlife Institute)

Authors: Ryan Butryn (Renewable Energy Wildlife Institute), Andrew Wilk (Renewable Energy Wildlife Institute), Taber Allison (Renewable Energy Wildlife Institute)

Abstract: The projected growth of solar energy developments requires responsible siting and might present permitting challenges owing to concerns about impacts on natural resources. Siting and permitting decision-makers can benefit from having access to the best available information related to risks to natural resources. REWI, using its extensive experience in managing sensitive data, is developing a data-sharing infrastructure called SolSource Database, which is a community resource to house solar-related data and information with the flexibility to adapt to emerging stakeholder needs. It will aggregate ecological and monitoring data related to wildlife interactions, vegetation, and ecosystem function. The goals of the data-sharing infrastructure are to connect stakeholders with information to inform decisions, compile data for synthesis and hypothesis testing, and encourage scientific collaborations that address solar-natural resources challenges. REWI is also compiling scientific literature related to solar-natural resources challenges and issues. This literature will be searchable using various filters and end users will be able to contribute pertinent resources to the library.

Standardizing Methods for Soil Collection and Analysis at Solar Facilities

Presenter: Michael Ricketts (Argonne National Laboratory)

Authors: Michael Ricketts (Argonne National Laboratory), Heidi Hartman (Argonne National Laboratory)

Abstract: Efforts to decarbonize the energy grid will require substantial development of utility-scale solar facilities which are expected to exceed 3 terawatts (TW) of power production in the United States by 2050. This presents an important opportunity for active land and vegetation management that can provide numerous ecological benefits and economic opportunities for solar developers while simultaneously removing atmospheric CO_2 via soil carbon sequestration. For example, proper vegetation

management can lead to increases in pollinator habitat/refugia from pesticides and promote increases in soil organic matter content leading to increased soil carbon storage and overall improved soil health. However, data evaluating the effects of utility-scale solar panel infrastructure on the soil environment are lacking.

To accurately and efficiently quantify changes in soil characteristics over large spatial and temporal scales, as well as monitor possible adverse impacts of solar facilities on the soil environment (e.g., heavy metal deposition and construction disturbance), will require standardized methods tailored to address considerations specific to solar industry developers. Our three-year project aims to develop standardized methods to collect, measure, and analyze soil health characteristics (including soil organic carbon, bulk density, nutrients, pesticides, and metal concentrations) to provide reliable data for national efforts to achieve net zero carbon goals while meeting social, ecological, and energy needs. This research appropriately fits in the "Solar Lifecycle and Natural Resource Considerations" topic of interest as it addresses both the "long-term effects of solar development on soils," and the "environmental costs/benefits and BMPs associated with land use conversion to solar." Because this project is still in its early phases, we intend to present an overview of the project and its goals, focusing on the development of the recommended field and analytical methods for measuring and mapping soil data in solar facilities.

Field sampling design and mapping methods are complex and vary widely depending on the project goals, acceptable level of uncertainty, and site characteristics (e.g., topography, soil type, land use history, and management). This is primarily due to the inherent heterogeneity of soil and hydrological regimes across the landscape at most solar sites. Extensive research exists on methods for measuring soil carbon stocks and this project will build upon that previous work. However, reviewing the large volume of literature on this topic and distilling it to find methods applicable to solar industry developments is not a trivial task. Methods vary regarding sampling design, depth of soil sampling, degree of sample homogenization (or compositing), and sample number/density needed to achieve reliable calculations of the mean within acceptable degrees of uncertainty. Recommendations regarding soil depth, arrangement, and density of soil sampling can have a large impact on the cost and feasibility of soil sampling protocols. All these factors point to a need for the development of consistent, reviewed, and agreed-upon methods that could be used across the solar industry to quantify soil-related ecosystem service for ground-mounted solar systems.

Western EcoSystems Technology's Renew Databases and Lessons in Data Standards for Solar

Presenter: Daniel Riser-Espinoza (Western EcoSystems Technology, Inc.)

Authors: Daniel Riser-Espinoza (Western EcoSystems Technology, Inc.), Arin Thacker (Western EcoSystems Technology, Inc.), Shay Howlin (Western EcoSystems Technology, Inc.)

Abstract: Western EcoSystems Technology, Inc. (WEST) has developed a database of wind monitoring data to facilitate meta-analyses and contextualize bird and bat fatality data at wind energy facilities. The Renew database also includes PV solar monitoring data collected over the last 10 years. We will discuss some of the lessons learned about data standardization from the collection of wind facility data over the last 25 years, how it applies to PV solar, and some of the potential benefits of data standards.

Limited Rigor in Studies of Wildlife Mortality at Renewable Energy Facilities

Presenter: Tara Conkling (U.S. Geological Survey)

Authors: Tara Conkling (U.S. Geological Survey), Todd Katzner (U.S. Geological Survey), Jay Diffendorfer (U.S. Geological Survey), Chris McClure (The Peregrine Fund), Sandra Cuadros (The Peregrine Fund), Scott Loss (Oklahoma State University), and Adam Duerr (Conservation Science Global)

Abstract: Lack of rigor and variation in study design together limit efforts to understand the broad-scale effects of wind power infrastructure on wildlife populations. We evaluated 753 peer-reviewed publications, unpublished reports, and citations, and we analyzed data from 592 of these sources (253 facilities: 243 wind and 10 solar) in 33 states and provinces in the United States and Canada, and five additional countries. This analysis determined the frequency of pre- and post-construction surveys and whether that frequency changed over time, the frequency of studies explicitly designed to allow before-after or impact-control analyses, and what types of survey data were collected during pre- and post-construction periods and how those data types were standardized across periods and among facilities. Within our dataset, post-construction monitoring for wildlife fatalities and habitat use was a standard practice (86%), but pre-construction estimation of baseline wildlife habitat use and mortality was less frequently reported. Only 22% of the facilities provided data from both pre- and post-construction and less than 30% had experimental study designs. Of the subset of facilities at which habitat-use surveys were conducted, less than 3% estimated detection probability. Thus, the available data generally preclude comparison of biological data across construction periods and among facilities. Use of experimental study designs and following similar field protocols would improve the knowledge of how RE affects wildlife.

Audience Questions and Speaker Response/Discussion

Speakers responded to questions broadly addressing the following topics:

- Challenges with standardizing data collection methods
- Lessons learned about large databases
- Interdisciplinary collaboration in data standardization
- Plans to improve soil health

What are the challenges of standardizing data collection methods?

Ryan Butryn: With SolSource Database, we are looking to narrow down research questions. We may not be able to do that across the whole country because there may be different questions that are region-specific. It is just going to be a matter of making sure that each region is getting its specific needs addressed and that those data are being collected consistently.

Daniel Riser-Espinoza: When thinking about post-construction monitoring for bird fatalities, the motivation for each particular study and the monitoring efforts required can vary quite a bit based on the conditions of a permit or other regulatory guidelines. So it can be challenging from a study design perspective to get full consistency or a complete study design that would be ideal for everyone to answer all the questions we might have. But, we can leverage things like GenEst[29] and the kind of data structures that are required for GenEst to at least get the bare minimum data to be able to pull different studies together. This is something we can do on an individual project basis or in the context of a particular permitting structure under state or federal guidelines.

Michael Ricketts: From a regional perspective, I think about how the climate, vegetation, and ecosystems are different in every region. This applies to revegetation, seed selection, and seed sourcing. Those decisions must be applicable to the region. Then, it is important to think about the differences between solar facilities within specific regions and whether they can be aggregated before we attempt to standardize.

Tara Conkling: Reporting requirements across regions may differ as well. There may be challenges in terms of not necessarily even making the data aggregate available, but whether or not that level of data

[29] A generalist estimator of mortality; https://www.usgs.gov/software/genest-a-generalized-estimator-mortality

collection is even occurring at these solar facilities. If we want to answer region-specific questions, one of the data gaps we need to address is ensuring consistent data collection is occurring across regions regardless of reporting requirements. Once these pieces are filled in and provide us with a bigger picture, we can lessen our intensive data efforts because we will have this information available.

How do we get more people on board with standardizing data collected at solar facilities?

Ryan Butryn: Technically, we can share data. We know how to standardize our protocols, but really, the social component of communication between groups is what is challenging. We need to make sure that we are communicating with state and federal regulators so they understand the standardized protocol approach.

Michael Ricketts: Two points: 1) we need to come together as a community and agree on a definition of what these standardization metrics are, and 2) we need to do something to increase incentives. What incentives might someone need to jump on board with this new standardized protocol approach? It is ultimately up to the individuals who know what the benefits are of having standardized data to communicate those with the wider community. If developers are informed of these benefits and can share them with their community, they may be more willing to be on board.

Daniel Riser-Espinoza: I think with some of the channels of communication that have been discussed during this conference, there is an opportunity to inform and motivate developers to monitor in a standardized way based on a particular permitting requirement or if they were just aware of an alternative approach that would be beneficial to their project and broader research goals but provide little to no additional costs. Maintaining those lines of communication between developers, industry, agencies, NGOs, research organizations, etc. may create the leverage needed to be more efficient about data collection. Again, we cannot let the perfect be the enemy of the good.

Tara Conkling: It is great to have the SolSource Database as a template coming out in terms of accessibility, making sure data is in the format it needs to be in. Having everyone on the same page and using the same formatting will help a lot and it will speed up this process.

Any lessons learned about databases you want to elaborate on?

Ryan Butryn: Think about the analysis up front. With American Wind Wildlife Information Center (AWWIC), a lesson learned would be that we focused really hard on getting the data and not losing it. We created almost a repository, not thinking of it as a research tool. Now we are trying to apply research questions and it is hard because the data is not standardized. Leading with the research question is something we are trying to do. What is the question we want answered, and what data do we need?

(for Daniel Riser-Espinoza) Is the Renew database propriety to WEST or is it something that others can access?

Daniel Riser-Espinoza: The Renew database is proprietary; you must be a WEST employee to access it. We do produce reports based on this database every couple of years, which can be accessed by the public. These reports summarize a lot of information based on questions that were confronted by our clients and stakeholders.

Can/will any of the bird data that may go into SolSource Database or are in the Renew Database be shared with larger bird databases (e.g., eBird or Avian Knowledge Network)? Are there plans to interact with other databases?

Ryan Butryn: I've thought about it a few times, where SolSource Database could publish databases of certain types. For example, one could be bird-related and then provide those published links to other repositories, so we could be a source of data rather than a sink.

Daniel Riser-Espinoza: I do not believe this is something we have thought about with Renew or have any distinct plans to do. But it is something we can think about.

Michael Ricketts: Some lessons learned from other fields of science, like microbial ecology, were that early in genomic analyses. There were problems being able to identify or have the databases available and standardized enough to be able to link your specific region of DNA to a taxonomy. Creating those databases took a lot of effort, but now there are bioinformatic tools that, as long as you have your comma-separated values or tab limited file in the correct format, you can collate all of those databases. I think if we could standardize across these databases and use the computing methods that exist for collation, that would be helpful.

(for Michael Ricketts) Do you see interdisciplinary collaboration in data standardization (e.g., collaborations between soil scientists, hydrologists, and vegetation ecologists)?

Michael Ricketts: Absolutely. I think it is important for us to have experts from different regions that address one specific question and concern of the solar industry. With experts from the specific region, they have the knowledge of what that specific site needs, especially because certain aspects of the site are linked together (e.g., soil and vegetation).

How do we identify standardized methods? How do we do so in a cost-effective way? Are there technologies we can use?

Michael Ricketts: This is kind of the larger problem we face. How do we implement these grandiose ideas we have of standardization? If we cannot all agree on what questions are important, then we may not get far. As far as new technologies, I mentioned those earlier in terms of computing tools that can coalesce databases together.

Ryan Butryn: Sharing raw data and properly attributing the raw data is very important. If you have summarized or analyzed the data but someone cannot recreate how you got your results, that is a problem. We also must consider our confounding variables: how efficient were our observers, what was the weather that day, etc. We need to note things that may have influenced our data collection because those are harder to anticipate.

Tara Conkling: We need to consider the quality of the study design. We need to ensure we are not just collecting data but also collecting quality data. The data we have currently is a matter of convenience sampling. We are only collecting data from facilities that allow us access. In a perfect world, we could use random sampling from all the facilities, but since we cannot do that, standardizing the data we collect will be beneficial.

Daniel Riser-Espinoza: There is value in some mutually agreed-upon data standards, at least for certain types of surveys. There are a lot of different reasons a facility will do monitoring, and each facility is unique. One facility may not provide the exact data we need but it may be able to contribute in a small way to the larger effort. It is important to keep in mind that, in an ideal world, every facility would provide all the data in a standardized way so we could answer every question. But most will probably be able to

provide some of the data, which will only answer a few questions. But as time goes on, I think having guidelines or recommendations for good data will certainly help bring together more disparate datasets.

(for Michael Ricketts) Can you comment on the ability to create a plan that can theoretically create an improvement in soil health? Is the idea of there being a theoretical way true or false?

Michael Ricketts: From my experience, I would say this idea is true for multiple reasons. There are a lot of soil health indicators that are well established (e.g., microbial activity, respiration). The general goal is to improve soil health over time. In an ideal scenario, native, deep-rooting vegetation will do this over two to three decades (e.g., soil carbon accrual). Organic carbon is one of the best indicators of soil health, but it takes a long time. Techniques used on shorter timescales are aeration and reduced compaction, but these may depend on how disturbed the soil was originally. If the soil is disturbed just one to two feet down, the deeper soil is now exposed to the atmosphere, which results in chemical reactions that severely affect the soil pH and inhibit plant growth. It is key to minimize soil disturbances for healthy soil. In addition, adding vegetation will increase soil health.

How do we get more people on board? Can we agree on rules and standards around how we handle data and how we lump technologies or regions?

Ryan Butryn: This is something we are keyed in on, particularly how we structure our data sharing agreements and access to the data. We want to ensure that REWI plays a role in what questions are being addressed with this data to ensure they are in line with REWI's national research plan or the particular interests of the solar community in general. We essentially want to play a gatekeeper for AWWIC and SolSource Database to ensure the data is used appropriately.

Daniel Riser-Espinoza: Once you have a database, you have to cultivate it, monitor it, and protect it. You have to ensure the data has proper attributes to know whether it can be included in some larger meta-analysis. We need to ensure the data being combined is appropriate, which will depend on the question we are interested in answering with those data. This is challenging and requires careful explanation and nuance to move forward appropriately with all stakeholders, but it is really important to make sure the data are being used properly.

Tara Conkling: It is also valuable to know what locations these data exist for. Due to confidentiality or data sharing agreements, I understand that the data may not be available. But knowing if the data is being collected at a location is helpful. Oftentimes, it is challenging to know what is being monitored or what information is available at many of the solar facilities. It is hard enough to find where solar facilities are located in this country. I think knowing this information will help us understand where gaps exist and how to improve them.

Michael Ricketts: With sensitive data, it might be hard to share it on a public repository, especially if it is connected to location data. I think we need to understand the need for some facilities to want a guarantee of anonymity for certain types of data per their request.

Applying Technology to Answer Tough Questions

Moderator: Karl Kosciuch – Wildlife Program Manager, Tetra Tech

Speakers:

- **Liz Kalies** – Lead Renewable Energy Scientist, North America Region, The Nature Conservancy
- **Mark Davis** – Conservation Biologist, Illinois Natural History Survey
- **Leroy (Lee) Walston** – Ecologist, Argonne National Laboratory
- **Christian Newman** – Technical Executive, Endangered and Protected Species Research Program, Electrical Power Research Institute
- **Riley Knoedler** – Associate Data Scientist, Western EcoSystems Technology, Inc.

This session featured technologies (e.g., camera trap arrays, passive acoustic recorders, remote sensing and drones, environmental DNA [eDNA], etc.) that facilitate the rapid and broad-scale data collection of solar-wildlife interactions. Moderator Karl Kosciuch began the session reminiscing on questions raised during the 1st Solar Power and Wildlife/Natural Resources Symposium and the lack of data to address those questions then. Now, as data has started coming in and questions are being addressed, a new set of questions are being generated. During this session, speakers focused on how technology (e.g., cameras, acoustic recorders, drones, etc.) could be applied to answer tough questions and/or easy questions that may be expensive to answer.

Passive Acoustic Monitoring Technologies to Understand Avian and Bat Occurrence at Solar Energy Facilities

Presenter: Leroy Walston (Argonne National Laboratory)

Authors: Leroy Walston (Argonne National Laboratory), Katherine Szoldatits (Argonne National Laboratory), Heidi Hartmann (Argonne National Laboratory), Laura Fox (Argonne National Laboratory), Yudi Li (University of California, Davis), Rebecca Hernandez (University of California, Davis)

Abstract: As more "habitat-friendly" solar facilities are being developed and managed, there is a need for monitoring projects to inform questions around ecological performance, scalability, and vegetation management. With the current pace of solar development, it is particularly important for these monitoring projects to utilize best available tools and technologies that provide timely results to inform science-based decisions on siting, permitting, and BMPs. In this presentation, we share interim results of ongoing DOE-funded studies to understand whether the construction of solar energy facilities and the vegetation managed at those facilities influence the occurrence and activity of bird and bat communities. We deployed several passive acoustic recorders (Wildlife Acoustics Song Meter Mini Bat recorders[30]) to detect the presence of vocalizing bird and bat species within the solar facilities and in adjacent reference areas in nearby agricultural fields. Our goal was to determine whether habitat plantings at solar facility test sites increase the diversity and abundance of wildlife over time as compared to reference sites without pollinator plantings.

This presentation will discuss the methods we utilized to analyze the large volume (> 2 terabytes [TB]) of acoustic and ultrasonic data collected from these recorder units. Advancements in automatic species classifiers that utilize machine learning and deep learning can expedite the processing of these

[30] Wildlife Acoustics Products: https://www.wildlifeacoustics.com/products

recordings and quickly generate species detections within the acoustic files. We used BirdNET[31], developed by the Cornell Lab of Ornithology, to automatically generate bird species detections from acoustic recordings; we used Kaleidoscope Pro software[32] by Wildlife Acoustics to automatically generate bat species detections from ultrasonic recordings. As emerging technologies, there is a need to validate these automatic classifiers. This presentation will discuss our validation methods and how we used the validation results to guide our interpretation of the output from the automatic classifiers. Integrating passive monitoring methods with advanced automatic species detection technologies can provide timely and scalable information on biodiversity at solar energy sites, which will facilitate the rapid science-based decision-making needed to commensurately support the nation's fast-evolving RE transition.

Unmanned Aircraft Systems and Light Detection and Ranging/Camera Technologies to Detect Avian Events and Other Environmental Measures at Utility-Scale Power Plants

Presenter: Christian Newman (Electrical Power Research Institute)

Authors: Christian Newman (Electrical Power Research Institute), Arun Pandey (EDM International, Inc.), Michael Gerringer (Western Ecosystems Technology, Inc.), Richard Tennis (Southwest Research Institute), Terry Jennings (Electrical Power Research Institute), Cara Libby (Electrical Power Research Institute)

Abstract: Monitoring and differentiating avian activity of concern at utility-scale solar facilities, such as collisions and associated fatalities, is challenging and costly because it relies on surveys of bird carcasses conducted by human observers. As the solar industry grows, technological solutions are a viable solution for long-term and short-term monitoring of avian interactions. The DOE's SETO funded a project to develop and validate two complementary, cost-effective remote sensing technologies to monitor avian interactions and fatalities at utility-scale solar facilities: fixed platform Animal Activity Monitoring (AAM) and unmanned aircraft systems (UAS). AAM was a two-dimensional (2D) camera-based monitoring system used for monitoring transmission lines for avian activity and recording video clips of the activity. This project integrated LiDAR enabled three-dimensional (3D) avian detection and recording to identify potential avian collision events at solar facilities. UAS included an unmanned aerial vehicle (e.g., UAV or drone), a sensor package (e.g., cameras), and software to fly the vehicles. This project developed and used these technologies integrated with machine learning to automate the detection of key avian events (e.g., collision, fatalities). Preliminary findings will be presented from Fall 2023 field demonstration trials where the two technologies were co-deployed with human observers searching for carcasses among solar PV modules at several large-scale PV solar facilities. Preliminary findings will include how the technologies worked, cost-effectiveness compared to human observers, and potential future applications.

Improving Solar Siting and Design through Technology

Presenter: Liz Kalies (The Nature Conservancy)

Authors: Dr. Liz Kalies (The Nature Conservancy), Grace Wu (University of California, Santa Barbara), Emily Leslie (Montara Mountain Energy), Ryan Jones (Evolved Energy), Nels Johnson (Renewable Energy Deployment), Joe Fargione (The Nature Conservancy), Chris Hise (The Nature Conservancy), Christel Hiltibran (The Nature Conservancy), Jessica Wilkinson (The Nature Conservancy)

Abstract: TNC is focused on the dual challenges of biodiversity loss and climate change, which means we must meet ambitious targets for greenhouse gas emission reductions that will require dramatically more RE. Our science projects that this deployment will be one of the major industrial drivers of impacts to

[31] BirdNET Sound ID: https://birdnet.cornell.edu/
[32] Kaleidoscope Pro Analysis Software; https://www.wildlifeacoustics.com/products/kaleidoscope-pro

natural areas globally over the next 10 to 20 years, which could exacerbate biodiversity loss. To help reduce conflict, we provide science to inform RE siting and design strategies that avoid development of natural areas and minimize impacts to wildlife. We also support and convene research on the landscape-scale impacts of solar energy development, and particularly the effects of fragmentation. We estimate that in the past four years, over 3,000 miles of new fence line have been constructed in the United States for solar development, creating barriers to wildlife movement. These barriers will be even more problematic as animals try to adapt to the effects of climate change by moving northward and uphill. Our research uses tools and technology to assess wildlife responses to solar development at large scales and determines how to reduce this impact (e.g., through the implementation of wildlife-friendly fencing and unfenced wildlife passageways).

Using Computer Vision to Monitor Wildlife Impacts at Renewable Energy Facilities

Presenter: Riley Knoedler (Western EcoSystems Technology, Inc.)

Authors: Riley Knoedler (Western EcoSystems Technology, Inc.), Kimberly J. Bay (Western EcoSystems Technology, Inc.), Michael B. Gerringer (Western EcoSystems Technology, Inc.), Larisa J. Bishop-Boros (Western EcoSystems Technology, Inc.), Leigh Ann Starcevich (Western EcoSystems Technology, Inc.), Andrew Telander (Western EcoSystems Technology, Inc.), Swapnali Patki (Western EcoSystems Technology, Inc.).

Abstract: UASs improve our ability to monitor large areas and challenging terrain; however, significant effort is required to manually review the vast quantity of images or videos collected by UAS. Computer vision (CV) is a field of machine learning focused on interpreting visual data, including data collected by UAS. We have developed CV methods to automate data processing and efficiently monitor bird and bat activity at RE facilities. We flew UAS equipped with thermal cameras and acoustic bat detectors along 0.5 to 1 km transects at 20 m and 40 m above ground level (AGL) at wind energy facilities in the Midwest, collecting a total of 2,214 videos. We combined data augmentation, CV, and tracking algorithms to identify portions of video that contained birds or bats. The time required for manual review fell by 92%, and we maintained a greater than 80% detection probability for the objects of interest, enabling estimation of trends in species composition and abundance at the facilities. While this method was developed and tested at wind energy facilities, it is transferable to other types of facilities and environments.

Beyond wildlife monitoring, UAS and CV have the potential to meet a variety of needs at solar facilities, including general vegetation monitoring, weed detection and mapping, and panel performance and contaminants surveys. This technology shows promise in enabling the industry to efficiently match the pace of demand for solar power.

Emerging Environmental DNA Technology for Rapid, Accurate, and Cost-Effective Biodiversity Assessment

Presenter Mark Davis (Illinois Natural History Survey)

Abstract: As species continue to be added to the register as threatened or endangered, and as RE development continues apace, the regulatory burden for measuring and monitoring imperiled biodiversity will only increase in the next century. The development of rapid, accurate, and cost-effective monitoring tools that can capture whole-community perspectives is, therefore, a conservation imperative. Environmental DNA (eDNA) technologies and methodologies are an exciting alternative to conventional monitoring. Here, I will describe eDNA, discuss its application with respect to RE, and articulate its potential in not only measuring and monitoring biodiversity at-scale, but also gleaning critical population-level information.

Audience Questions and Speaker Response/Discussion

Speakers responded to questions broadly addressing the following topics:

- Limitations and obstacles with these technologies and in a regulatory context
- Data analysis bottlenecks
- Challenges surrounding communication with non-technical crowds
- Comparing datasets using new technologies and traditional methods

What are some limitations and/or obstacles for using the data you collected with the technology in a regulatory context to support solar energy project development or solar energy project compliance monitoring?

Mark Davis: I think a lot about eDNA and acoustic monitoring with bat work. A question that is asked a lot is how we know if it was actually there if we did not have the physical animal in hand. There is a long history of state and federal wildlife agencies that base occurrence elements on "animals in hand." The challenge for me is how we demonstrate the burden of proof and our level of confidence when we say that using this technology, the animal is present. Then we can start accepting acoustic, environmental, and eDNA data.

Leroy Walston: No method solves everything. The most comparable method to acoustic is point-count surveys. However, there are pros and cons to fieldwork. I do not want to see a day where we remove people from the field because that data is invaluable, and it can tell us the information we cannot get from acoustic monitoring (e.g., how birds use sites, nest success, predator interactions, etc.). Acoustic data just tells us about presence and absence. There are other ways technology may address some of these questions, but having a combination of technology and people in the field will help.

Christian Newman: We must recognize that regulators are oftentimes conservative. They are in a position where they must be sure and feel confident that they will not get sued when signing off on something. That is a challenge. What can be frustrating is that we are used to certain traditional methods, yet we do not know how good or accurate those methods are. However, we accept the results because those are the ones we have historically used. With these newer technologies, we are tasked with showing how they compare to human observers, even when humans miss or have incorrect observations. We need the community to accept these technologies as an alternative. I understand that it can be hard to ask for point counts plus adding new technologies (which are additional costs), as it may result in different and potentially contradictory answers. As we move forward, we must realize that these technologies (including remote sensing) are collecting and seeing things humans are potentially missing or were not able to collect previously.

Riley Knoedler: AI will never be the solution to everything. However, as we expand into new dimensions (e.g., carcass persistence time under offshore wind turbines) we need to have new solutions. You cannot do on the ground point count monitoring in all situations. It is important to think about what situations AI will make the most sense to use, and it may not always be the best choice to use. What is beneficial is that it gives us a tool to do something we could not have done before.

With a future full of rich tech-driven data, do you foresee problems of data analysis bottlenecks or more difficulty in data presentations and communication? Especially with non-technical crowds?

Liz Kalies: Creating tools around siting is a huge challenge. There are a lot of data out there and because a lot of it is at the state level, we cannot make direct comparisons. We would need it on a national scale

so we could make comparisons across the country. Some states have more data and operational natural heritage programs, while others do not have the capacity to create good siting data. It can also be complicated to find the data you need even if it does exist. So improving data all around, alongside improving tools, is really important to better refine siting data.

Mark Davis: There are two different questions here: 1) the data bottleneck issue—we are running into that issue where I get my eDNA sample sequence. I used to spend $5,000 to have a company run seven billion reads. Now, I purchased my own sequencer, spent $2,000, and got 70 billion reads. So the volume of data is increasing, but we need the bioinformatics infrastructure (e.g., companies with sequencers for commercial applications) to move it forward. 2) How do we communicate this to decision-makers? When I say, "I got reads from *Bombus affinis*[33]," individuals will look at me and ask, "What do you mean, read?". We need to learn how to communicate this technology in ways that are accessible and available to the general public.

Christian Newman: I think this technology (i.e., UAS) is a real opportunity because if someone does not believe the results (i.e., the AI tool), you can show them the data and run another model. This provides an opportunity to validate models in real time, which cannot be done easily with traditional methods. It is exciting to have the tools we have today and they will get even better as the years progress. As models progress, we can rerun the data and answer new questions with previously collected data by applying different kinds of analysis tools. We will just need to focus on keeping data standardized so it can be easily applied to new tools. It is difficult to explain these tools, but we can do it.

Leroy Walston: This is an opportunity to look at the data and communicate science in a way we have not been able to in the past using more traditional methods. We can get more data in a shorter period of time. For instance, with acoustic data, we can look at temporal density on a fine scale, allowing us to answer very temporal questions that may not be able to be addressed by doing point count surveys every two weeks. All the data is valuable, no matter the methods; however, having continuous streams of data can help address really important questions.

Riley Knoedler: There is a social aspect to people being afraid of AI. It gets hyped in the media as something that will take all our jobs and there is an expectation that it is proficient and capable of doing everything. However, this is not true and we need to change that narrative.

(for Mark Davis) As far as the eDNA methods, is this something an operator can go out and do by hiring someone, or is this an academic endeavor? How does one get the samples to do the analysis?

Mark Davis: It is a non-academic approach and something I could train everyone here how to do. It is straightforward and has been used in community science initiatives. It started out with people using hand pumps to filter water and returning those filters in silica gel packs. There is a very low bar for entry, and it is accessible and easy to use. One thing to keep in mind, just like any other monitoring tool, is that there are false positives and false negatives. So even though it is easy to learn, there are a lot of nuances to be mindful of. The challenge we run into is that I am not a service lab and there is a lack of service labs out there, so the infrastructure is not there yet. Most of this work is being driven by research labs at universities because they have the infrastructure. Hopefully, as infrastructure improves, this can be more readily available as a monitoring tool.

[33] Rusty patched bumble bee

Christian Newman: One thing that is really critical when you are in the field collecting data is to ensure it is done properly so it is not contaminated. We have had a couple projects where our samples were contaminated, showing things that were not present.

(for Liz Kalies) You showed a picture of a fence that looked semi-permeable to wildlife, would that be considered satisfactory from a regulatory perspective?

Liz Kalies: Yes, the fence meets the National Electrical Code. There are at least two developers who use this fence as their common practice, and they are happy with it. They think it is comparable in terms of safety and sturdiness.

Mark Davis: That fence is probably an eDNA sampler.

(for Leroy Walston and Riley Knoedler) Do you think that we are now introducing new complications into data standardization? How do you compare acoustic recording birdsong data to point count data or carcass detection rate for drone with AI versus humans? Are we now introducing an entirely new set of data that needs/would limit the ability to make comparisons across methods used to answer the same questions?

Leroy Walston: Yes, this is comparable. Acoustic data can be used in the same way as point count data. In another study I am working on in Nebraska, we found a high degree of comparability, especially in the short term (e.g., a day in which someone was in the field collecting point count data and acoustic monitoring was occurring). The benefit of the acoustic recorder is that it is out 24/7 over a time period. If you look at the species accumulation curve, our study detected over 60 species during the summer and our point count surveys verified the presence of each species. Although the data is slightly different, the end results for your metric of interest after the analysis are the same.

Riley Knoedler: Regarding fatality monitoring, we are reporting the recall of the machine learning model, which is essentially the detection probability. When using a traditional monitoring approach, you must consider what amount of area was covered and the likelihood that the observer saw something. It is like comparing the success of a search done by humans versus dogs; dogs are better. Dogs and drones have a higher detection probability than humans. There may be challenges in comparisons without an understanding of detection probabilities, but I do not think it is prohibitive.

On-Demand Oral Presentations and Posters

Impacts of Photovoltaic Solar Energy on Soil Carbon: A Global Systematic Review and Framework

Presenter: Noah Krasner (University of California, Davis)

Format: In-Person Poster

Authors: Noah Z. Krasner (University of California, Davis), Jessica Fox (Electric Power Research Institute), Alona Armstrong (Lancaster University), Kathleen Ave (Sacramento Municipal Utility District), Fabio Carvalho (Lancaster University), Yudi Li (University of California, Davis), Leroy Walston (Argonne National Laboratory), Michael P. Ricketts (Argonne National Laboratory), Sarah M. Jordaan (McGill University), Majdi Abou Najm (University of California, Davis), Heidi M. Hartmann (Argonne National Laboratory), Rebecca Lybrand (University of California, Davis), Rebecca R. Hernandez (University of California, Davis)

Abstract: Solar energy is anticipated to be the primary source of energy as early as 2050 and the greatest additions in global capacity are currently in the form of ground-mounted solar energy. Increasing interest lies in understanding and anticipating opportunities to increase soil carbon sequestration across the footprint and perimeter of both conventional PV solar energy power plants and dual-use systems. However, to date, studies of the relationship between soils and solar energy are limited to unique, localized study sites. In this study, we employed a systematic review to 1) identify what soil and soil-related properties interacting with solar energy infrastructure have been studied globally, and 2) assess the frequency and trends of soil and soil-related properties studied within this corpus. We use these data to identify research priorities and knowledge gaps and provide a conceptual model for the study of soil and solar energy interactions that applies to multiple installation types and contexts where solar energy is deployed. In all, this study provides a baseline and framework for assessing the feasibility of combining nature-based climate solutions with the climate change mitigation potential of solar energy.

Nest Surveys and Guidance Relating to the Migratory Bird Treaty Act

Presenter/Author: Pamela Garrison (SWCA Environmental Consultants)

Format: In-Person Poster

Abstract: The MBTA, originally passed in 1918, implements four treaties that provide for federal protection of selected migratory birds. This list includes more than 1,000 species, including eagles and other raptors, waterfowl, shorebirds, seabirds, wading birds, and passerines. Under the MBTA, actions resulting in take or possession (permanent or temporary) of a protected species, in the absence of a USFWS permit or regulatory authorization are in violation of the statute. The MBTA states, “Unless and except as permitted by regulations…it shall be unlawful at any time, by any means or in any manner, to pursue, hunt, take, capture, kill…possess, offer for sale, sell…purchase…ship, export, import…transport or cause to be transported…any migratory bird, any part, nest, or eggs of any such bird” (16 U.S. Code § 703[34]). The word "take" is defined by this regulation as “to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect” (50 CFR § 10.12[35]). Destruction or alteration of bird habitat that does not result in the direct taking of birds, nests, or eggs is not prohibited by the MBTA. The current interpretation by the USFWS as of October 4, 2021, per the

[34] 16 U.S. Code § 703 – Taking, killing, or possessing migratory birds unlawful; https://uscode.house.gov/view.xhtml?path=/prelim@title16/chapter7/subchapter2&edition=prelim
[35] 50 CFR § 10.12; https://www.ecfr.gov/current/title-50/chapter-I/subchapter-B/part-10/subpart-B/section-10.12

revocation of a January 7, 2021 rule, is that the MBTA prohibits incidental take, with the agency indicating it will apply enforcement discretion consistent with judicial precedent and long-standing agency practice. Consequently, under current interpretation, avian mortalities that result from events such as collision with overhead power lines or destruction of nests during vegetation clearing activities could be considered violations of the MBTA and subject to enforcement discretion by the USFWS. If vegetation clearing activities are not able to take place outside of the nesting season (generally March through mid-September), nest searches in advance of clearing are recommended to maintain compliance with the MBTA. This poster will discuss the steps involved with nest searches and give guidance on timing and impacts to project schedule and cost.

Experts' Perceived Risks to Ecosystems and Species from Renewable Energy Expansion Across the United States

Presenter: Daphne Condon (University of California, Davis)

Format: On-Demand Oral Presentation

Authors: Daphne Condon (University of California, Davis), Tyler Scott (University of California, Davis), Toni Lyn Morelli (U.S. Geological Survey), Adam B. Smith (Missouri Botanical Garden), Uzma Ashraf (University of California, Davis), Rebecca R. Hernandez (University of California, Davis)

Abstract: Projections estimate that the United States must increase its RE generation by nearly 70% to achieve its goal of net zero carbon emissions by 2050. Large-scale (≥ 1 MW) RE technologies, namely wind and PV solar energy power plants, are necessary to achieve this goal. However, these facilities require large amounts of land and may subsequently impact ecosystems and biodiversity. Understanding the nexus of RE and biological conservation is critical for managing tradeoffs between carbon reduction and ecosystem protection, but perceptions about the direct impacts of RE sites vary widely. This study assesses how experts in RE development across the country perceive these trade-offs. Because RE development decisions are fragmented across a wide array of investors, regulators, and operators nationwide, how these perceptions vary across local contexts will shape how and where RE build-out occurs. We established a unique framework to document the structure of expert knowledge, known as a knowledge system. We first identified all entity types (n = 15) that comprise experts across the RE and conservation knowledge system in the United States. We categorized these 15 entities into the following six groups: federal and state agencies; universities and research institutes; utilities and utility-related entities; Tribal groups; firms in environmental and RE development affairs; and non-profit organizations. We used web-scraping snowball techniques to compile an entity-based email contacts list representing these six knowledge system groups across all 50 states. Experts from this list (n = 116) participated in a voluntary Qualtrics e-survey, which measured their perception of local- to national-scale impacts of RE siting and expansion on native ecosystems and species. Respondents identified and compared the net impacts from wind and PV energy siting to the physical footprint of other land use and land cover change drivers, including those associated with the fossil fuel and agriculture industries. We found that the greatest number of experts perceived the net impact of large-scale solar on native plants and animals as negative. However, our results also show that experts perceive the net impact of large-scale solar in 2023 to be less than all other given land uses but most comparable to the impact of industrial timber operations. Over 60% of expert respondents perceived urban growth to have a greater impact on plant and animal species than large-scale solar by 2050. Nearly half of all respondents also identified risks posed to artificial (farmland) and grassland ecosystems from the direct footprint of large-scale solar. Our Kruskal–Wallis test results showed statistical significance between respondents' geographical regions and their perceived impacts from large-scale solar on ecosystems in 2023 and 2050. Survey results allow us to identify research gaps within biodiversity-RE interactions and propose zones for targeted conservation decision-making.

Wings Over Sunlight: An Examination of Avian Diversity, Community Composition, and Conservation Significance at Operational Photovoltaic Solar Energy Facilities in New York and Western Massachusetts

Presenter: Amanda Klehr (Det Norske Veritas)

Format: In-Person Poster/On-Demand Presentation

Authors: Amanda Klehr (Det Norske Veritas), David King (U.S. Forest Service, Northern Research Station), Kimberly Peters (Ørsted North America)

Abstract: PV solar energy development in the northeastern United States is rapidly growing, dominated by the installation of ground-mounted projects. Most PV projects in the region are built on farmlands and in early successional and forested habitats, and there is increasing concern by regulatory agencies and other stakeholders about potential impacts to declining wildlife species associated with these habitats. Our understanding of PV effects on birds and other wildlife species in the northeastern United States is limited and most studies to-date have focused on potential negative impacts, such as bird fatalities at large-scale facilities (> 50 MW) in habitats and regions that may not be relevant to the northeastern United States. Additionally, there are currently no published studies that examine habitat-related outcomes or breeding bird communities associated with solar facilities in the northeast. To address some of these knowledge gaps, we conducted breeding bird point count surveys in 2021 and 2022 to document avian species and communities at operational PV solar facilities and at paired reference sites in New York and western Massachusetts. The 2021 surveys were completed at nine operational PV solar sites and paired reference sites, and the 2022 surveys were completed at 13 operational PV solar sites and paired reference sites. Our surveys were limited to smaller, mostly community-scale facilities (e.g., ≤ 10 MW capacity) in both states, which are characteristic for the region; however, larger-scale sites (> 50 MW) are currently under development in New York. Vegetation characteristics were measured during each visit to account for short-term changes in habitat structure, including those resulting from vegetation management practices (e.g., mowing and cutting). Multiple modeling methods that explicitly accounted for detectability and other factors were used to assess abundance of 15 species that were detected during at least 10% of point count locations across the solar and reference sites. Models that examined associations among avian abundance, habitat, and PV design and management included covariates for point-level vegetation measurements, landscape characteristics, and PV solar facility characteristics (panel height, panel spacing, mowing or grazing practices). Preliminary findings indicate that species richness, and abundances of seven of the 15 species were generally higher in the solar facilities compared to the paired reference sites, particularly at facilities with higher vegetation, but patterns varied across species, land cover/habitat type, and region. The most common species observed across both solar and paired reference sites consisted of song sparrow, red-winged blackbird, American robin, and barn swallow. In addition, 90 active nests were located during the surveys, either on the racking structures beneath PV modules or within vegetation on site. Species observed nesting on PV solar structures included house finch, American robin, and eastern phoebe, while song sparrows and field sparrows were observed nesting within vegetation and on the ground in the facilities. At 63 nests for which success monitoring was logistically feasible, success rates were estimated to be approximately 55% which is comparable to regional estimates. Preliminary findings may help to identify effective management practices that will improve benefits to birds, while reducing potential negative impacts from PV solar energy development in the northeastern United States.

Power of Place: A Nationwide Decarbonization and Land Use Study

Presenter/Author: Liz Kalies (The Nature Conservancy)

Format: In Person Poster/On-Demand Presentation

Abstract: Land management and wildlife compatibility: to reach the goal of net zero carbon emissions in the United States by 2050, we must transition to a clean and equitable energy economy. To do this, we need to increase our RE capacity almost four times and expand high-voltage transmission capacity by roughly 60%. As the RE build-out advances, this related infrastructure will touch down in landscapes and communities virtually everywhere. While there are numerous environmental and social benefits associated with this development, there are also tradeoffs for nature and people. If we do not account for these tradeoffs and plan accordingly, resulting conflict could substantially slow progress on the clean energy transition. We asked the question: "Can we meet our national climate change and decarbonization goals without compromising conservation and community values?" For the analysis, we first identified areas as suitable for solar and wind development and assigned environmental and social impact scores using multiple environmental and social datasets. We then identified Candidate Project Areas (CPAs), which are roughly one square mile areas suitable for project development and characterized the potential for types of technologies and/or siting strategies within each. Next, we modeled energy portfolios based on current and emerging technologies over a range of impact scenarios. Finally, we downscaled the energy portfolios to find locations within the CPAs most likely to be developed and quantified potential impacts to natural areas and working lands based on the location of energy infrastructure. We present impacts to land cover types (e.g., forests, wetlands, crops) as well as specific wildlife concerns (e.g., whooping cranes, tortoises, bats, grouse). The study demonstrates that with careful and coordinated planning and robust community engagement, the United States can build the clean energy infrastructure needed for economy-wide, net zero emissions by 2050 while avoiding most impacts to sensitive natural and working lands; and we can do it cost-effectively. We can also create new clean energy opportunities in areas that have historically been economically driven by the fossil fuel industry. The policy recommendations that stem from this study are designed to assist energy planners and decision-makers at all levels of government in identifying pathways to achieve net zero by 2050 while prioritizing people and nature.

Renewable Energy Siting: Anticipating Future Conservation Risks and Opportunities for Vulnerable Species

Presenter: Uzma Ashraf (University of California, Davis)

Format: In-Person Poster

Authors: Uzma Ashraf (University of California, Davis), Toni Lyn Morelli (U.S. Geological Survey), Adam B. Smith (Missouri Botanical Garden), Rebecca R. Hernandez (University of California, Davis)

Abstract: As anthropogenic climate change progresses, attention is increasing on climate change mitigation, including a dramatic increase in RE development. Simultaneously, the Biden-Harris Administration's 30x30/America the Beautiful vision sets ambitious targets for conservation. Despite the promise of these goals for addressing conservation issues, conflicts between wildlife conservation and RE are of increasing concern. In this research, we are identifying conflicts between wildlife conservation and solar and wind siting by intersecting models of species' climate-change-induced range shifts with maps of RE potential. We are developing an integrated methodology for reducing conflicts between RE installations and conservation, both now and in the future. We aim to enhance RE capacity while reducing biodiversity impacts and facilitating research-related activities that enhance equity and energy democracy without compromising wildlife conservation goals. To identify target species, we conducted a systematic

literature review. Additionally, we are considering costs and benefits to frontline communities and using a translational science approach to engage with and assess stakeholder attitudes, including semi-quantitative approaches to understand values and perceptions towards RE siting and its outcomes for wildlife towards identifying typologies of environmental injustice. Overall, we identify current and future impacts of RE siting scenarios on vulnerable wildlife populations towards a unified goal of climate-smart siting to achieve the best outcomes for climate mitigation, biodiversity, and local communities.

Wildlife-Friendly Fencing Reduces Impacts of Solar Farms in Central California

Presenter: Brian Cypher (California State University, Stanislaus)

Format: On-Demand Presentation

Authors: Brian Cypher (California State University, Stanislaus), Will Knowlton (Althouse & Meade, Inc.), Greg Salas (Althouse & Meade, Inc.), Emily Lund (Althouse & Meade, Inc.), Brian Boroski (H.T. Harvey & Associates), Erica Kelly (California State University, Stanislaus), Tory Westall (California State University, Stanislaus), Jason Dart (Althouse & Meade, Inc.)

Abstract: Solar farms are rapidly multiplying throughout the world, including in the United States. One environmental concern regarding solar farms is that they occupy extensive areas of land, much of which was habitat for various wildlife species. A number of strategies have been employed to mitigate this habitat loss and lessen impacts to wildlife. One strategy is the use of modified security fencing that facilitates continued use of the land by impacted wildlife species. Modified, wildlife-friendly fencing was installed at four large, recently constructed PV solar farms in the arid San Joaquin Desert region of central California. Fence designs included standard chain-link with a reinforced or unreinforced 13 cm gap at the bottom, and “hogwire” style fencing with the larger mesh openings (usually approximately 13 cm by 13 cm) at the bottom. In this bioregion, such permeable fencing was mandated by the USFWS and the California Department of Wildlife to allow continued use of the solar farms by endangered San Joaquin kit foxes. Indeed, kit foxes have continued to use all four solar farms and the demographic and ecological attributes of these foxes were similar to those of foxes using nearby natural lands. Other terrestrial vertebrate species also have continued using the facilities including red foxes, coyotes, bobcats, badgers, striped skunks, long-tailed weasels, jackrabbits, cottontails, California ground squirrels, threatened San Joaquin antelope squirrels, endangered giant kangaroo rats, Heermann’s kangaroo rats, San Joaquin pocket mice, western burrowing owls, greater roadrunners, western rattlesnakes, gopher snakes, California kingsnakes, and side-blotched lizards. Species primarily excluded include larger ones such as ungulates, bears, and mountain lions. However, wildlife corridors were incorporated into the design of all four facilities and are being used by larger species (e.g., pronghorn and elk), thus facilitating the maintenance of regional connectivity. Therefore, security fencing surrounding solar farms clearly can be designed to accommodate continued use by local wildlife, including rare species.

Global Adoption of Field Margins and Hedgerows at Photovoltaic Solar Farms

Presenter: Yudi Li (University of California, Davis)

Format: In Person Poster/On-Demand Presentation

Authors: Yudi Li (University of California, Davis), Rebecca R. Hernandez (University of California, Davis)

Abstract: Large ground-mounted PV solar power plants (GPVs) are rapidly deployed worldwide to drive the transition towards a low-carbon economy. The expansion of these solar plants often encounters local opposition due to their land-intensive nature and potential negative impacts on the environment and society. In response, post-construction vegetation restoration practices, including solar-pollinator habitats in the United States have gained popularity. In addition to creating grasslands within the array footprint,

we proposed to incorporate field margins and hedgerows along facility boundaries, including array perimeters and buffer zones. These linear semi-natural structures, consisting of herbaceous and woody plants, offer open spaces with fewer height limitations than underneath PV panels. This allows for more diverse botanical and structural features, leading to a broader range of ecological functions. Despite limited research and data on this topic, our study aims to address crucial questions by conducting a comprehensive review and analysis of literature, environmental impact report (EIS), and online sources from multiple countries. Specifically, we investigate 1) the causes of public opposition to GPVs and how field margin/hedgerow integration can help address these conflicts, 2) the current state of field margin/hedgerow applications and their associated ecosystem services on GPVs, 3) the full potential of GPV field margin/hedgerow in terms of area and length, and 4) the existing barriers and potential solutions for embedding field margin/hedgerow in GPVs. Preliminary findings from our analysis of 63 protested GPVs in the United States, the United Kingdom, and Australia between 2010 and 2022 reveal 26 drivers of opposition, with visual impact, farmland loss, and biodiversity decline among the top concerns. We identified that 23 of these opposition drivers could be mitigated by field margin/hedgerow establishment to varying extents. Additionally, among 116 GPVs in the same three nations, we found that 55% and 72% of projects involved field margin and hedgerow in their landscape planning, respectively, with a consistent emphasis on multi-functionality. However, mismatches between public interests and solar developers' priorities were observed. Furthermore, our mappings of field margin/hedgerows regarding three width scenarios (3 m, 5 m, and 10 m) around 664 community- and utility-scale PV metrics across five continents in the Northern Hemisphere demonstrated that narrower strips contribute more effectively to the total added length and are more practical for smaller facilities with limited open space. Drawing insights from agricultural systems, we identified finance and knowledge as the dominant barriers and proposed four primary solutions: information and support, legislation and permit, incentive and grant, and scientific research. To reinforce the evidence in this section, we may further conduct interviews or surveys with solar developers. This study holds significant importance in promoting the widespread adoption of field margin/hedgerow worldwide for co-benefits and multiple land uses and facilitating a more sustainable implementation of solar energy infrastructure.

Abiotic and Biotic Factors Affecting Pollinator Habitat Restoration in Solar Installations

Presenter/Author: Sarah Kania (ASA Analysis & Communication, Inc.)

Format: In Person Poster/On-Demand Presentation

Abstract: In the United States, land dedicated for solar energy installations is increasing rapidly to meet RE goals. However, multi-acre utility-scale solar energy projects have potential adverse effects caused by large-scale landscape transformation (Trainor et al. 2016[36]; Hoffacker et al. 2017[37]). An increasingly popular solution to mitigate negative environmental effects of solar sites involves using the space between panels as restored pollinator habitat. Planting and maintenance of pollinator-friendly plant communities in these spaces pose unique challenges that make consideration of both abiotic (e.g. soil type, nutrients, and climate) and biotic (e.g., local pollinator community, hardiness of plant species) factors for long-term success. We investigated the roles of soil nitrogen and plant species on pollinator preference. In one experiment, three cultivars of *Brassica rapa* (*Brassicaceae*) were grown under high and low nitrogen levels to determine the effects of soil conditions on pollen production and attractiveness to bumble bees (*Bombus impatiens*). A two-way, mixed model analysis of variance (ANOVA) was used to evaluate effects of nutrient level and plant type on plant biomass, pollen grain area, and number of pollen grains. When given 100% of recommended nitrogen, plants had a higher production of pollen grains than

[36] Trainor et al. 2016. Energy Sprawl is the Largest Driver of Land Use Change in United States. https://doi.org/10.1371/journal.pone.0162269

[37] Hoffacker et al. 2017. Land-sparing Opportunities for Solar Energy Development in Agricultural Landscapes: A Case Study of the Great Central Valley, CA, United States. http://dx.doi.org/10.1021/acs.est.7b05110

plants grown with low levels of nitrogen. The size of pollen grains was not affected by soil nitrogen, but rather by cultivar. These differences in size and number of pollen grains can be important for bee foraging preferences, although we found that genotype was only a marginally significant factor in bumble bee foraging preferences of these plants. In a second experiment we evaluated the relative attractiveness of 10 species and cultivars of mints from two plant genera, *Mentha* and *Pycnanthemum*, at two semi-natural study sites known to support diverse a pollinator community in central Pennsylvania (Russo et al. 2013)[38]. Linear mixed effects models were used to examine the fixed effects of selected factors on abundance of visitors within an insect order, total visitor abundance, and diversity of visitors. The native *M. arvensis* had the greatest abundance of pollinator visitors, but all species and cultivars showed similar diversity of pollinators. The two mint genera also served as generalist plants within this plant-pollinator network, attracting pollinators from the insect orders *Hymenoptera*, *Lepidoptera*, *Diptera*, and *Coleoptera*. Generalist plant species are important to pollinator communities as they can attract and provide resources for generalist pollinators (those that visit a variety of plant genera/families) as well as specialists (those that visit only a select number of plant genera/families) (Martín González et al. 2010[39]; Ollerton 2017[40]). Thus, native *Mentha* and *Pycnanthemum* may be good additions to restored pollinator habitat at solar sites, where attractive, low maintenance, fast growing, hardy, and short statured plants are preferred. The results from both studies revealed the importance of choosing the right plant species to support pollinator communities. Our results also provide better understanding into the importance of soil nutrition on pollen floral resources and, ultimately, the plant's attractiveness and utility to pollinator species. Ultimately, we hope these insights will help to improve the quality of restored pollinator habitat.

Improving the Potential for Reclamation/Restoration Success through Revegetation Monitoring

Presenter: Carla DeMasters (Western EcoSystems Technology, Inc.)

Format: In Person Poster/On-Demand Presentation

Authors: Carla DeMasters (Western EcoSystems Technology, Inc.), Michael Van Laeken (Western EcoSystems Technology, Inc.), Alisa Baadsgaard (Western EcoSystems Technology, Inc.)

Abstract: Revegetation monitoring is a critical step in understanding whether a reclaimed area is on track to support a diverse and sustainable plant community. Revegetation monitoring can lead to improved reclamation outcomes and decreased project costs. It can also inform adaptive land management decisions relating to erosion and weed control. Despite its importance in informing vegetation management decisions and the overall outcome of projects, revegetation monitoring is an often neglected or oversimplified step in the reclamation of highly disturbed sites. Here, we draw from experience conducting large-scale and long-term quantitative monitoring studies on native and reclaimed vegetation in a strict regulatory environment, namely coal mine reclamation projects in the western United States. We explore the feasibility of and potential for using some of the methods from these studies at solar energy facilities to help improve reclamation success at these sites. This presentation will focus on quantitative methods for assessing key measures of revegetation success, including seedling density, vegetation cover, species richness, herbaceous productivity, and plant density, all of which play into providing important wildlife habitat at solar energy facilities. Common methods for establishing revegetation performance standards will be discussed, as well as sampling design and analysis methods.

[38] Russo et al. 2013. Supporting Crop Pollinators with Floral Resources: Network-based Phenological Matching. https://onlinelibrary.wiley.com/doi/10.1002/ece3.703
[39] Martín González et al. 2010. Centrality Measures and the Importance of Generalist Species in Pollination Networks. https://doi.org/10.1016/j.ecocom.2009.03.008
[40] Ollerton 2017. Pollinator Diversity: Distribution, Ecological Function, and Conservation. https://www.annualreviews.org/doi/10.1146/annurev-ecolsys-110316-022919

Finally, revegetation monitoring will be discussed in relation to project timelines, including baseline, interim, and project close-out; how these project phases relate to important stages in plant community development; and reasonable expectations for plant community development over the life of a project.

Rapid Ecological Assessments: A Stepwise Strategy to Establish, Measure, and Report Metrics of Ecosystem Health at Solar Facilities

Presenter: Michael Van Laeken (Western EcoSystems Technology, Inc.)

Format: In Person Poster/On-Demand Presentation

Authors: Michael Van Laeken (Western EcoSystems Technology, Inc.), Alaini Schneider Cossette (Western EcoSystems Technology, Inc.), Carla DeMasters (Western EcoSystems Technology, Inc.), Alisa Baadsgaard (Western EcoSystems Technology, Inc), Andrew Telander (Western EcoSystems Technology, Inc.), Todd Mattson (Western EcoSystems Technology, Inc.)

Abstract: There is currently an industry-wide lack of empirical data to measure the environmental co-benefits provided by the restoration and maintenance of regionally appropriate sustainable vegetation within ground-mounted solar energy projects. To help address this data gap, WEST has developed rapid assessment methods that can be integrated into the Society for Ecological Restoration's Ecological Recovery Wheel[41] framework to measure and communicate changes in environmental co-benefits and monitor the progress of a project towards achieving restoration success. These assessment methods offer a simple, practical, inexpensive, and scientifically defensible approach to aid the solar industry in monitoring restoration success and understanding co-benefits. WEST is currently field testing and refining these methods, collecting data at a number of solar sites across the United States. These pilot studies are providing quantitative and qualitative data on baseline conditions and ecosystem health and functions. After restoration, we will compare baseline conditions to post-construction conditions to assess whether ecosystem health and function has been maintained or has improved as a result of the project and project restoration initiatives. Data collection for these metrics involves ecological assessments and surveys, including a combination of desktop analyses and rapid field surveys, to efficiently generate consistent data at a pre-determined frequency for each project. For easy communication with project stakeholders, data will also be reported using an interactive data visualization tool. The tool is designed to display project-specific metrics alongside environmental co-benefits for pre- and post-construction site conditions. Post-construction monitoring of a project's natural resources can provide empirical data which supports the use of certain sustainable restoration strategies. Continued monitoring offers environmental co-benefits to local ecosystems within and adjacent to solar projects, resulting from restoring and maintaining sustainable vegetation.

Science before Engineering: Preparing to Better Mitigate Wildlife Impacts and Habitat Loss while Advancing Development of Non-Residential Photovoltaic Systems (New Paltz, New York Landfill Solar Facility Project)

Presenter: Thomas Nitza (Walden Environmental Engineering, PLLC)

Format: In-Person Poster

Authors: Thomas Nitza (Walden Environmental Engineering, PLLC), Kara Belinsky (State University of New York, New Paltz), Shreyak Karkera (Walden Environmental Engineering, PLLC)

[41] Society for Ecological Restoration Recovery Wheel; https://www.ser.org/page/SERNews3113

Abstract: This project examines the measurable effects of development of non-residential solar on the habitat of wildlife. This project includes research and development funding from New York's State Energy Research and Development Authority and the Research Foundation of the State University of New York system. The most serious and widespread threats to birds and insects are climate change and habitat loss. Harnessing solar energy to generate electricity is one of the key methods to reducing the effects of climate change to wildlife and humans, but the construction of typical PV solar arrays may result in habitat impact or loss. This study presents empirical data from the advancement of the Town of New Paltz landfill solar facilities. The purpose of the study is to better understand impacts on wildlife and develop enhanced or alternate techniques to enable solar construction and nature/wildlife to be less impactful to the habitats involved. Some of the data-rich techniques used during the study were bird point counts conducted during peak bird migration and breeding in late April and mid-June. The study resulted in 1,295 observations of birds identified by sight and/or sound. The study detected 678 birds of 57 different species in the forest reference site and 617 birds of 39 species at the landfill solar array site. This study sampled insect pollinators biweekly from June through late August using a combination of aerial nets and soap bowl traps. The study used aerial zip-nets to sample larger insects. The specimens were then collected in plastic bags, fixed using ethyl-acetate, and saved for later identification in the lab. This wide variety and large abundance of bees indicates that the flowering plants on the landfill site provide good habitat for many native pollinators and European honey bees. Based on our observations of the conditions at the landfill site and our bird point counts and preliminary bee data, the study decided to add flowering plant sampling to explain and describe how our landfill site may differ from many more typical landfill cap sites and solar arrays and to inform our choice of mitigation techniques after the solar array is built. The study sampled three times—once at the beginning of July, once at the end of July, and once at the end of August—to capture pollen and nectar source diversity and abundance along with our insect pollinator sampling. Knowing the identity and abundance of floral resources supporting pollinators at our site will allow us to plan for plantings to replace these plants if they are disrupted during the construction of the solar array and to increase availability of these and similar floral resources, especially those found on native plants. The results of this study are leading the project to include several strategies to promote conservation and growth of bird and bee communities after construction and co-locating of the solar facilities—and the subsequent reexamination of the bird and bee populations both in numbers and diversity.

Designing Avian Vision Integrated Deterrents for Solar-Bird Interactions

Presenter: Patrice Baumhardt (Purdue University)

Format: On-Demand Presentation

Authors: Patrice Baumhardt (Purdue University), Benny Goller (Purdue University), Lance Kelly (Lynntech Inc.), Esteban Fernández-Juricic (Purdue University)

Abstract: One hypothesis behind avian mortalities in solar facilities is the lake effect hypothesis, which postulates that solar facilities and bodies of water have similar visual signatures from the perspective of birds. We hypothesized that modifying the visual signature of solar panels could modify the level of attraction to solar facilities, potentially helping to mitigate avian mortality. We tested the degree of attraction/avoidance to solar panels whose visual signature was modified with a light-emitting diode (LED) light veil under semi-controlled conditions using mallard ducks (*Anas platyrhynchos*). Visual modeling using an LED light veil to change the visual signature of the solar panels indicated that blue light (462 nm) increased the chromatic contrast of the solar panels. Behavioral experiments revealed that the presence of a bright blue light veil on a solar panel evoked an avoidance response in the ducks. Further testing in the use of blue light avian vision integrated deterrents is needed; however, our final results are a promising avenue of inquiry into this complex problem.

Emerging Trends in Bird Mortality at Photovoltaic Solar in the United States and Canada

Presenter: Daniel Riser-Espinoza (Western EcoSystems Technology, Inc.)

Format: In-Person Poster/On-Demand Presentation

Authors: Daniel Riser-Espinoza (Western EcoSystems Technology, Inc.), Kent Russell (Western EcoSystems Technology, Inc.), Nick Bartok (Western EcoSystems Technology, Inc), Josh Sullivan (Western EcoSystems Technology, Inc.), Karl Kosciuch[42] (Western EcoSystems Technology, Inc.)

Abstract: Understanding bird mortality at PV USSE projects is an important component of the topic "Evaluating and Mitigating Solar-Wildlife Interactions including Wildlife Habitat." The published studies use data from the southwestern United States where carcasses have represented a mixture of locally common ground-dwelling birds and birds that associate with aquatic habitat. How the patterns found in the United States compare to other regions of North America, especially in ecoregions distinct from the southwestern United States, is largely unknown, as fatality monitoring data has not been widely available. Fatality monitoring at PV solar facilities greater than 1 MW is required in Alberta and reports become public after submission to the Alberta Utilities Commission. We summarized fatality monitoring results from 24 studies at 12 distinct PV projects conducted in Alberta between July 2020 and November 2022, and compared the patterns to those from the United States. We categorized each fatality as either an aquatic habitat bird classification (water associate, water obligate), or an "other birds" category based on the life-history trait criteria used in Kosciuch et al. (2020), and calculated species and group composition based on reported numbers of detections in each category. We also summarized each project-reported fatality estimate standardized by nameplate MW capacity. Species and group composition were variable by project, with most fatalities represented by feather spots, and gray partridge (n = 52) and mourning dove (n = 14) comprising 38.4% of fatalities. Mallard was the most highly-represented water associate (n = 9; 5.2% of all fatalities). There were no Alberta projects with water obligate fatalities included in the analysis. The adjusted fatality estimates at Alberta projects fell within the range reported in Kosciuch et al. (2020), ranging from 0 birds/MW to 5.25 birds/MW, and birds that associate with aquatic habitat comprised 19.8% of unadjusted detections. In summary, the most frequently-detected species were locally common and associated with the ground. Although species composition differed, the results in Canada were similar to the United States. Overall, the data suggest that bird mortality at PV solar is consistently lower than other anthropogenic structures (e.g., buildings) and aquatic habitat bird mortality was limited to a several projects similar to a finding in the United States. The results strengthen the inferences provided in Kosciuch et al. (2020), extending previously recorded patterns to new ecoregions and providing greater certainty that similar patterns may be present at future PV facilities in a variety of landscape contexts.

Walking on Sunshine: Projected Overlap between Solar Development and Land Important for Animal Movement in the United States

Presenter/Author: Michael Levin (Columbia University)

Format: In-Person Poster

Authors: Michael Levin (Columbia University), Liz Kalies (The Nature Conservancy), Emma Forester (University of California, Davis), Elizabeth Jackson (Columbia University), Andrew Levin (University of Rochester), Caitlin Markus (The Nature Conservancy), Patrick McKenzie (Columbia University), Jared Meek (Columbia University), Rebecca Hernandez (University of California, Davis)

[42] Current Affiliation; Tetra Tech

Abstract: The United States may produce as much as 45% of its electricity using solar energy technology by 2050, which could require more than 40,000 km^2 of land to be converted to large-scale solar energy production facilities. Little is known about how such development may impact animal movement. Here, in an analysis relevant to the "Evaluating and Mitigating Solar-Wildlife Interactions including Wildlife Habitat" symposium topic, we use five spatially-explicit projections of solar energy development through 2050 to assess the extent to which GPV energy expansion in the continental United States may impact land cover and alter areas important for animal movement. Our results suggest that there could be a substantial overlap between solar energy development and land important for animal movement: across projections, seven to 17% of total solar development is anticipated on high-value corridors between large, protected areas, while 27 to 33% of total development is expected on TNC's Resilient and Connected Landscapes. Furthermore, some land cover categories more likely to support animal movement may be converted by solar development across more than 1% of their total national area. We also found substantial variation in the potential overlap of development and land important for movement at the state level. These findings are final, peer reviewed, and have been published in Environmental Science and Technology[43]. These results indicate that careful solar facility siting based on local data and stakeholder engagement is likely the most important and effective means of avoiding the negative impacts of solar development on animal movement.

Passive Acoustic Monitoring Technologies to Understand Patterns of Avian and Bat Occurrence at Solar Energy Facilities

Presenter: Leroy Walston (Argonne National Laboratory)

Format: On-Demand Presentation

Authors: Leroy Walston (Argonne National Laboratory), Katherine Szoldatits (Argonne National Laboratory), Heidi Hartmann (Argonne National Laboratory), Laura Fox (Argonne National Laboratory), Yudi Li (University of California, Davis), Rebecca Hernandez (University of California, Davis)

Abstract: As more "habitat-friendly" solar facilities are being developed and managed, there is a need for monitoring projects to inform questions around ecological performance, scalability, and vegetation management. With the current pace of solar development, it is particularly important for these monitoring projects to utilize best available tools and technologies that provide timely results to inform science-based decisions on siting, permitting, and BMPs. In this presentation, we share interim results of ongoing DOE-funded studies to understand whether the construction of solar energy facilities and the vegetation managed at those facilities influence the occurrence and activity of bird and bat communities. We deployed several passive acoustic recorders to detect the presence of vocalizing bird and bat species within the solar facilities and in adjacent reference areas in nearby agricultural fields. Our goal was to determine whether habitat plantings at solar facility test sites increase the diversity and abundance of wildlife over time as compared to reference sites without pollinator plantings. This presentation will discuss the methods we utilized to analyze the large volume (> 2 TB) of acoustic and ultrasonic data collected from these recorder units. Advancements in automatic species classifiers that utilize machine learning and deep learning can expedite the processing of these recordings and quickly generate species detections within the acoustic files. We used BirdNET, developed by the Cornell Lab of Ornithology, to automatically generate bird species detections from acoustic recordings; we used Kaleidoscope Pro software by Wildlife Acoustics to automatically generate bat species detections from ultrasonic recordings. As emerging technologies, there is a need to validate these automatic classifiers. This presentation will discuss our validation methods and how we used the validation results to guide our

[43] Levin et al. 2023; Solar Energy-Driven Land-Cover Change Could Alter Landscapes Critical to Animal Movement in the Continental United States. https://doi.org/10.1021/acs.est.3c00578

interpretation of the output from the automatic classifiers. Integrating passive monitoring methods with advanced automatic species detection technologies can provide timely and scalable information on biodiversity at solar energy sites, which will facilitate the rapid science-based decision-making needed to commensurately support the nation's fast-evolving RE transition.

Developing a Set of Wildlife-Focused Best Management Practices for Solar in Michigan

Presenter/Author: Christopher Hoving (Michigan Department of Natural Resources)

Format: In-Person Poster

Abstract: Utility-scale solar development in Michigan is expected to be one of the most extensive and rapid changes in land use in Michigan in the last 100 years. Like much of the Midwest, the primary anticipated land use change is from row-crop agriculture to fenced utility scale solar development. The Michigan Department of Natural Resources, in partnership with the East Lansing Field Office of the USFWS, convened a working group of agency staff to develop a set of voluntary BMPs. Our initial plan was to develop BMPs to encourage native biodiversity and pollinator habitat. However, as our agencies interacted with land managers, facility operators, and their neighbors, other problems and concerns became apparent. We received reports of wildlife damage to solar facilities and solar facility injury to wildlife, which was mostly attributed to white-tailed deer and fencing. There were also unexpected complications in how and when agencies were consulted, potential shortages of native wildflower seed, when to mow to minimize harm to wildlife, and how to decommission and restore sites. We used existing sets of BMPs from other states that had been compiled by the Midwest Landscape Initiative and the AFWA. Our BMPs build on those existing BMPs and extend them based on our agency's emerging experience with wildlife complaints from solar operators and their neighbors. We hope that our voluntary BMPs will help solar developers reduce their costs, impacts to wildlife, and provide conservation benefits to their human and non-human communities on and around their sites. We also hope that our set of voluntary BMPs are useful to other agencies as they develop or revise BMPs of their own.

Solar Energy for Climate and Nature: The Mockingbird Solar Center Biodiversity Initiative

Presenter: Daniel Willard (Ørsted Americas)

Format: On-Demand Presentation

Authors: Daniel Willard (Ørsted Americas), Chris Farmer (Ørsted Americas)

Abstract: The crises of climate change and biodiversity loss are closely connected. Climate change is accelerating the alarming trend of global biodiversity loss, and we need natural habitats protected and restored to meet global and national climate targets. Vast amounts of land already have been altered by human activity. Increasing pressure for development—including solar energy development—means natural habitats need to be protected explicitly. This presentation addresses the opportunity to create greater value from solar energy development by addressing these interrelated crises together. At its Mockingbird Solar Center (471 MW Alternating Current) in Texas, Ørsted is demonstrating that the build-out of RE is compatible with protection and restoration of important tallgrass prairie habitat. Tallgrass prairies are valuable ecosystems, hosting rich plant biodiversity, providing habitat for a wide range birds, pollinators and other species, and sequestering carbon in the soil; however, they are a scarce and threatened ecosystem, with less than 5% remaining in the United States and less than 1% remaining in Texas. At the Mockingbird solar project, Ørsted purchased nearly 1,000 acres of native prairie adjacent to the solar center and is donating it to TNC for permanent protection. The protected area was designed for maximum conservation impact based on analysis of native plant diversity and other sensitive habitat features, creating the largest protected area on record for this type of native prairie. On other prairie areas

where the solar center is being built, Ørsted is partnering with TNC to minimize construction impacts, restore habitat, and measure performance toward goals. This includes implementation of construction measures such as weed-wash stations to prevent invasive species encroachment and double-ditching collection lines to preserve natural soil structure. Prairie areas under solar arrays will be restored with a native seed mix collected from the adjacent protected area which can also serve as a seed bank for future restoration efforts. Additionally, Ørsted is testing restoration potential on degraded pasture areas dominated by non-native vegetation, with the goal of expanding the footprint of the prairie as part of the solar center. The Ørsted Mockingbird Solar Center biodiversity initiative is expanding the state of knowledge of how solar energy projects can simultaneously deliver positive and measurable contributions to climate and nature.

Solar Ecosystem Enhancement Planning

Presenter: Daniel Spethmann (Working Lands Investment Partners, LLC)

Format: In-Person Poster

Authors: Daniel Spethmann (Working Lands Investment Partners, LLC), Michael S. Fishman (Edgewood Environmental Consulting LLC)

Abstract: Solar energy development yields an important intrinsic environmental benefit in offsetting greenhouse gas emissions from fossil fuel energy generation, but it struggles with balancing its environmental impacts of habitat loss and alteration. A collaborative team of ecologists and ecological economists from Working Lands Investment Partners, State University of New York College of Environmental Science and Forestry's Restoration Science Center, and several consulting companies have developed an interactive tool that enables solar developers to assess their chosen development sites for ecosystem services and then select specific projects to enhance ecosystem services on finished solar parks to increase their environmental value and offset habitat impacts. Enhancement opportunities identified in the tool are supported by linked published literature that demonstrates proven ecosystem service benefits for each management option. This tool can be used to mitigate environmental impacts of solar development on greenfield sites, agricultural sites, and any site where habitat enhancement opportunities can be identified. The resulting management will significantly increase the ecological value and integration of solar sites into their surrounding landscapes.

Vulnerability of Caprimulgiformes Populations to Fatalities at Solar Energy Facilities

Presenter: Tara Conkling (U.S. Geological Survey)

Format: In-Person Poster/On-Demand Presentation

Authors: Tara Conkling (U.S. Geological Survey), Todd Katzner (U.S. Geological Survey), Hannah Vander Zanden (University of Florida), David Nelson (University of Maryland), Adam Duerr (Conservation Science Global)

Abstract: As RE production expands across North America, regulatory guidelines often call on management for stable or increasing populations of wildlife species. To do this requires estimates of population level impacts of fatalities from RE facilities. An integral part of this assessment is defining the geographic origin of highly motile species killed at solar facilities. Many previous studies have used stable hydrogen isotopes (δ^2H) for this purpose. However, the uncertainty associated with δ^2H-based estimates of geographic origin is typically large, making it difficult to use this approach to identify the origin of a given individual. One way to address this uncertainty is to simultaneously consider data from more than one stable isotope. We used a multi-isotope approach to geolocation, considering both d^2H

and carbon stable isotopes ($\delta^{13}C$) to evaluate population of origin for Common Nighthawks (*Chordeiles minor*), Lesser Nighthawks (*Chordeiles acutipennis*), and Common Poorwills (*Phalaenoptilus nuttallii*) found dead at solar energy facilities in California. Preliminary data suggest that the multi-isotope assignment process resulted in substantially improved estimates of population of origin than with either isotope alone. Data on population of origin were then used together with Bayesian demographic models to identify vulnerable subpopulations of nightjars to fatalities from solar energy development. Our approach illustrates how refinement of identification of origin can then be used to improve assessment of vulnerability, or lack of vulnerability, of species potentially affected by solar energy development.

Accounting for Potential Climate Change Impacts on Habitats in Renewable Energy Planning

Presenter/Author: Nihar Chhatiawala (Federick S. Pardee RAND Graduate School)

Format: In-Person Poster

Abstract: Consideration for the environmental impacts of RE projects enables policymakers, developers, and other stakeholders to select sites in a manner that minimizes harm as well as to employ appropriate conservation measures within existing project sites. By amending assessments of land use conflict to account for the projected effects of climate change on habitats, stakeholders can plan for longer term conservation in areas that are both highly suitable for solar development and of great ecological importance. This research contains pilot studies demonstrating the use of species distribution models, which predict the distribution of species based on indicators of habitat suitability, to generate plausible scenarios of habitat shifts for important species over decades. These scenarios reflect the broad range of plausible climate change impacts on habitats as well as the uncertainties faced when assuming the most important indicators of habitat suitability. The methods utilized in this research may assist stakeholders with siting decisions and with the development of longer-term conservation plans on developed lands where the increasing presence of species of interest could pose additional challenges for land owners. Though this work additionally uses case studies related to wind farms and lithium mines, the focus of this poster will be the initial results from a case study on the longleaf pine ecosystem in the southeastern United States, where solar planning is ongoing amid efforts to reverse habitat fragmentation that has imperiled keystone species, such as the gopher tortoise as well as the longleaf pine itself.

Development of State-Specific Best Management Practices for Photovoltaic Solar Installations in Georgia

Presenter: Amy Gutierrez (The Nature Conservancy)

Format: In-Person Poster/On-Demand Presentation

Authors: Amy Gutierrez (The Nature Conservancy), Eric Bauer (U.S. Fish and Wildlife Service), Matt Elliot (Georgia Department of Natural Resources), Michele Elmore (U.S. Fish and Wildlife Service)

Abstract: The rapid expansion of solar development in Georgia is both directly and indirectly contributing to increased severity and frequency of threats faced by many at-risk and listed species. Given the lack of a required review process for solar projects, a collaborative approach is critical to improving outcomes for state species and ecosystems of concern. To achieve this, the Georgia Utility Scale Solar Siting Initiative partnership was developed, which brings together federal and state natural resource agencies, conservation organizations, state and local utilities, and other experts interested in both clean energy and biodiversity. Based on feedback from partners and developers, as well as recommendations derived from the Solar Wildlife Working Group's "Solar Siting Survey," the partnership has prioritized the development of voluntary BMPs for the state of Georgia in the absence of existing BMPs. The Georgia BMPs are

intended to increase awareness and improve outcomes for at-risk and listed species impacted by solar development in Georgia (including gopher tortoise, gopher frog, eastern diamondback rattlesnake, Florida pine snake, eastern indigo snake, southeastern American kestrel, loggerhead shrike, hairy rattleweed, and pollinators including the monarch butterfly). The BMPs will provide a comprehensive summary of practices that can avoid or minimize impacts throughout the lifecycle of a solar project. They will include a summary of all recommended state-specific tools and resources currently available to responsibly guide solar development in Georgia. Early siting resources like the Georgia Low Impact Solar Siting Tool guide development away from sensitive habitats and ecosystems. Focal species profiles with streamlined survey and monitoring recommendations summarize seasonal restrictions or considerations that should be incorporated into early project planning. Identification of priority topics for Georgia, such as freshwater stream diversity or the importance of sandhill habitats, can improve awareness and guide developers toward avoidance or careful management of projects with potential to impact these resources directly or indirectly. The BMPs will also provide recommendations that can maximize potential co-benefits using site design elements such as wildlife friendly fencing, native and pollinator plantings, and co-location of agriculture. The Georgia BMPs will be finalized prior to the fall of 2023 and will be maintained by the Georgia Department of Natural Resources. As field research into wildlife interactions continues to progress and developers provide actionable feedback, the BMPs will be further refined to reflect the most impactful recommendations. To improve continuity across Georgia's 159 counties, the BMPs will be amplified through the established collaborative partnership of state and federal natural resource agencies, state utility partners, and conservation organizations. Additionally, regional partnerships such as the Southeast Regional Partnership for Planning and Sustainability will expand the impact of the BMPs by supplying this framework to neighboring states facing similar challenges that they can adapt to their own needs. The successful implementation of the Georgia BMPs is anticipated to improve species outcomes and community benefits without negatively impacting the acceleration of solar development.

Innovative Solar for Conservation and Agriculture

Presenter/Author: Elise Couillard (EcoBalance Technologies)

Format: On-Demand Presentation

Abstract: Delivery of meaningful on-site solar projects that power existing infrastructure and/or provide meaningful habitat-friendly effects should be showcased in their ability to improve water and air quality and preserving critical wildlife habitat. It is possible to develop projects focused on distributed generation and with strict parameters for dual land use. Conservation, environmental, and agricultural entities can and should be taking the lead on developing and integrating solar projects. Multiple case studies of successful integration of solar projects at conservation organizations are evidenced in Wisconsin and can be used as a roadmap for entities in other states. Conservation organizations should have more direct ownership of renewable technology assets, in addition to providing guidance on renewable technology placement and impact.

National Solar Siting Survey Assesses Impacts to Resources and Identifies Needs and Priorities for State Fish and Wildlife Agencies

Presenter/Author: Bob Sargent (Georgia Department of Natural Resource Division)

Format: On-Demand Presentation

Authors: Bob Sargent (Georgia Department of Natural Resource Division), Meaghan Gade (Association of Fish and Wildlife Agencies), Jessica Wilkinson (The Nature Conservancy),

Abstract: Solar Wildlife Working Group (SWWG) composed of State Fish and Wildlife Agency (SFWA) representatives, NGOs, and industry representatives was convened under AFWA's Energy and Wildlife Policy Group in 2021. In December 2021, the SWWG distributed a 40-question "Solar Siting Survey" to solar energy points of contact in SFWA in all states. Questions included open ended and multiple choice answer options; for some, respondents could select more than one answer. Responses were received from 41 SFWAs representing 92% of the total MW of solar capacity installed in the United States. Results were assessed at national and regional scales. Most (71%) respondents indicated that the potential risks to wildlife habitat posed by the development of solar PV can be substantial. Grasslands/prairies ranked most at risk nationally and regionally except in the southeast, which reported agriculture habitat at most risk. Habitat fragmentation (61%) and permanent direct impacts (56%) were the largest concerns nationally. Current state requirements for solar PV siting vary, with most states (80%) relying on voluntary approaches to minimize impacts to species and habitat. Sixty-three percent of respondents said that other than requirements for wetland, stream, or listed species, their state does not require developers to coordinate with wildlife agencies on potential resource impacts or require solar PV to avoid, minimize, or offset impacts. Only agencies in the western regions require early coordination with SFWA. Several respondents noted that by the time SFWA are contacted, developers have already invested time and resources into the project. When PV projects do go through early coordination with the SFWA, proponents most frequently request data about the presence of regulated species or their habitat, general requests for information about species or habitats, and presence of sensitive but unregulated species or their habitat. Pre-construction wildlife monitoring and data collection occur more frequently than post-construction, but both occur infrequently. More than 40% of respondents felt the available science on impacts of PV development on wildlife and habitat does not address their greatest information needs. Respondents identified a need for more region-specific research on impacts and for better accessibility to scientific findings. Nationally, respondents overwhelmingly (88%) indicated that PV energy guidelines should be developed similar to the USFWS's land-based WEGs and be regional in scope. Based on the results, the SWWG recommends that all parties should 1) identify ways for coordination between proponents and SFWA to occur more consistently and earlier, 2) develop tools, maps, and collect data to assist in identifying low-impact siting opportunities, 3) enhance interstate collaboration, which would lead to more consistency and enable SFWA to learn from each other—the creation of a resource library featuring BMPs, guidelines, and geospatial tools could assist in this endeavor, 4) develop standard monitoring protocols to gather pre-construction and post-construction wildlife data to assist in future siting decisions, 5) states coordinate with developers to identify and share research needs, and 6) develop nationwide utility-scale PV guidance with region-specific information that focuses on low impact siting.

Brightfields: Matching Redevelopment with Renewable Energy

Presenter/Author: Adam Flege (HDR)

Format: In-Person Poster/On-Demand Presentation

Abstract: The history of heavy industrial manufacturing in certain portions of the United States and the legacy of blighted and underutilized properties known as "brownfields" represent an opportunity for utilities and RE developers to utilize already developed land to increase RE production as the United States transitions from fossil fuels to renewables. The United States' inventory of underutilized brownfield properties represents a prime opportunity for redevelopment, especially with the influx of new state and federal dollars into brownfield redevelopment and infrastructure projects and the focus of economic development agencies on revitalizing their respective communities. Many states and the federal government through the Infrastructure Investment and Jobs Act (IIJA) have offered recent funding opportunities to communities for brownfield redevelopment projects, ultimately resulting in an increase in revitalized areas within communities, but also representing the potential for an increase in available

square footage for RE developments, particularly solar. In the state of Ohio, for example, RE sources represent only 3% of the energy Ohio produces, compared to 20% of the energy produced in the United States from renewable sources[44]. While utility-scale solar projects have already been built or are already underway, more are in the pipeline seeking regulatory approval by the Ohio Power Siting Board and the Public Utilities Commission. However, these projects mostly focus on greenfield redevelopment, utilizing agricultural land instead of already developed land, to build out the renewables fleet. Examples of renewable projects completed on greenfields will be compared to renewable projects completed on brownfields, with the pros and cons weighed for each.

Partnering with Utility-Scale Photovoltaic Solar/Wind/Storage Developers on Climate Change Risk Assessment to Optimize Siting and Facilitate Successful Long-Term Outcomes for Project Development.

Presenter: Susan Kemball-Cook (WSP)

Format: In-Person Poster/On-Demand Presentation

Authors: Sean Fox (WSP), Susan Kemball-Cook (WSP), Scott Cooper (WSP)

Abstract: WSP is working with RE market participants, including developers, constructors, and operators, of facilities utilizing solar, wind, energy storage and other technologies (e.g., green hydrogen) to assess actual and potential physical climate risks to proposed projects in the United States and Canada. Our clients include an industry leader in corporate climate action and climate-related disclosure, integrating climate change risk assessment and management into strategic and project-level decision making. This client's global Investment Committee has incorporated climate change in their decision-making and risk analysis. Climate change risk assessment is further optimized through a partnership across a range of environmental assessments for new energy projects during the early-stage siting phase. For at least 12 wind, PV solar, green hydrogen, and battery energy storage system projects to date, WSP has performed physical climate change risk assessments (CCRAs) that are aligned with the recommendations of the G20 Financial Stability Board's Task Force on Climate-Related Financial Disclosures (TCFD). Alignment with the TCFD recommendations is critical to our client's overall climate change strategy, risk management program, and European Union (EU) regulatory compliance. Consistent with the TCFD recommendations, WSP uses a forward-looking scenario analysis approach and leverages climate model projections developed for periodic assessment reports prepared by the Intergovernmental Panel on Climate Change. Present and future risks at each project location across the project's lifetime are evaluated based on materiality, frequency, duration, and severity. The CCRAs WSP is developing are industry-innovative in that they go beyond qualitative risk scoring to provide quantitative information on each generation asset/project's historic, present-day, and future exposure to acute and chronic climate hazards, including temperature and precipitation changes, severe storms, flooding, drought, and wildfire. Probabilistic framing of the climate change results is used where the available data support this approach. For example, extreme value analysis is performed to calculate changes in future temperature and precipitation, which are reported as changes to the intensity of the 20-year and 100-year event intensities. The quantitative climate projection information produced during the CCRA is utilized by our client for strategic siting, design engineering, development of permitting strategy, and financial due diligence decision-making. Based on the findings for each project, WSP prepares recommendations for enhancing the project's climate resilience. To facilitate use of the CCRA information in site planning/design, this past year WSP developed and presented a three-part training for our client's global technical staff on climate change science and climate modeling. The objective was to enable our client to

[44] Remaking Ohio: The New Power Play. https://spectrumnews1.com/oh/columbus/news/2022/06/02/ohio-s-role-in-the-race-for-renewable-energies

effectively use the quantitative climate projection data prepared by WSP during the CCRAs in their siting and design work. The CCRA program, which may be expanded to cover transition risk in addition to physical risk, is expected to serve as a model for WSP to utilize with other strategic clients developing RE generation infrastructure in a sustainable and cost-effective manner.

Standardizing Methods for Soil Collection and Analysis at Solar Facilities

Presenter: Michael Ricketts (Argonne National Laboratory)

Format: In-Person Poster

Authors: Michael Ricketts (Argonne National Laboratory), Heidi Hartman (Argonne National Laboratory)

Abstract: Efforts to decarbonize the energy grid will require substantial development of utility-scale solar facilities which are expected to exceed 3 TW of power production in the United States by 2050. This presents an important opportunity for active land and vegetation management that can provide numerous ecological benefits and economic opportunities for solar developers while simultaneously removing atmospheric CO_2 via soil carbon sequestration. For example, proper vegetation management can lead to increases in pollinator habitat/refugia from pesticides and promote increases in soil organic matter content leading to increased soil carbon storage and overall improved soil health. However, data evaluating the effects of utility-scale solar panel infrastructure on the soil environment are lacking.

To accurately and efficiently quantify changes in soil characteristics over large spatial and temporal scales, as well as monitor possible adverse impacts of solar facilities on the soil environment (e.g., heavy metal deposition and construction disturbance) will require standardized methods tailored to address considerations specific to solar industry developers. Our three-year project aims to develop standardized methods to collect, measure, and analyze soil health characteristics (including soil organic carbon, bulk density, nutrients, pesticides, and metal concentrations) to provide reliable data for national efforts to achieve net zero carbon goals while meeting social, ecological, and energy needs. This research appropriately fits in the "Solar Lifecycle and Natural Resource Considerations" topic of interest as it addresses both the long-term effects of solar development on soils and the environmental costs/benefits and BMPs associated with land use conversion to solar. Because this project is still in its early phases, we intend to present an overview of the project and its goals, focusing on the development of the recommended field and analytical methods for measuring and mapping soil data in solar facilities.

Field sampling design and mapping methods are complex and vary widely depending on the project goals, acceptable level of uncertainty, and site characteristics (e.g., topography, soil type, land use history, and management). This is primarily due to the inherent heterogeneity of soil and hydrological regimes across the landscape at most solar sites. Extensive research exists on methods for measuring soil carbon stocks and this project will build upon that previous work. However, reviewing the large volume of literature on this topic and distilling it to find methods applicable to solar industry developments is not a trivial task. Methods vary regarding sampling design, depth of soil sampling, degree of sample homogenization (or compositing), and sample number/density needed to achieve reliable calculations of the mean within acceptable degrees of uncertainty. Recommendations regarding soil depth, arrangement, and density of soil sampling can have a large impact on the cost and feasibility of soil sampling protocols. All these factors point to a need for the development of consistent, reviewed, and agreed-upon methods that could be used across the solar industry to quantify soil-related ecosystem service for ground-mounted solar systems.

Population-Level Identification and Risk Assessment of Avian Wildlife from Renewable Energy Installations

Presenter: Cristian Gruppi (University of California, Los Angeles)

Format: In-Person Poster

Authors: Cristian Gruppi (University of California, Los Angeles), Peter Sanzenbacher (U.S. Fish and Wildlife Service), Karina Balekjian (University of California, Los Angeles), Rachel Hagar (University of California, Los Angeles), Sierra Hagen (University of California, Los Angeles), Christine Rayne (Colorado State University), Teia M. Schweizer (Colorado State University), Christen M. Bossu (Colorado State University), Daniel Cooper (Resource Conservation District Santa Monica Mountains California), Thomas Dietsch (U.S. Fish and Wildlife Service), Thomas B. Smith (University of California, Los Angeles), Kristen Reugg (Colorado State University), Ryan J. Harrigan (University of California, Los Angeles)

Abstract: Alternative energy production is expected to increase rapidly in the coming years, enabling us to meet global demands while at the same time helping to reduce the impact of climate change. A large proportion of this new energy will be provided by installations for solar energy production, yet more work is required to understand the potential impacts of current and future utility-scale infrastructures on wildlife, in particular on avian populations. A relatively easy way to investigate avian-solar interactions is to collect and identify remnants at energy facilities. Collected specimens include intact or partial carcasses that are readily identifiable, as well as those that appear as “feather spots,” known to be of avian origin but not readily assignable to species through morphological analyses. These latter unidentified samples are typically excluded from further downstream analyses, leading a loss of valuable data. To address this limitation, we optimized a DNA barcoding approach to identify such samples (which may represent up to 32% of all samples collected at a facility) collected at facilities installed in Southern California. After DNA extraction, we amplified and sequenced target portions of several mitochondrial genes using universal primers suitable for all avian taxa. We then leveraged BLAST as a computational tool to search for sequence similarity from an open-access database (GenBank) to identify samples to species, and in most cases, to individual. Through these analyses, we could identify to species 93% of all samples previously listed as unidentified, leaving only 1% of the total left unidentified. Genetically-identified specimens not only contributed to subsequent analyses, but represented a different composition of the avian community as compared to those derived solely from morphological identification. These new data, combined with our previous efforts to map genetic variation across species ranges (The Bird Genoscape Project) allowed us to assign individuals to the distinct breeding populations they belong to and to better understand the relative risk of both solar and wind facilities to these distinct populations. Our results suggest that this genetic approach can be extremely useful to verify, correct, and complement morphological identifications, allowing for more accurate data to be used in investigations of avian interactions with RE installations across facilities, years, seasons, or technology types. Most importantly, these data can contribute to a better understanding of avian species and populations most at risk from anthropogenic development, and lead to more informed, science-based management and siting strategies in the future.

Solar Synergy: A Collaborative Approach to Delivering Pollinator Health and Environmental Benefits on Solar Projects

Presenter/Author: Peter Berthelsen (Conservation Blueprint)

Format: On-Demand Presentation

Abstract: The Bee & Butterfly Habitat Fund[45] (BBHF) is dedicated to the establishment and management of high-quality pollinator habitat through collaborative initiatives. In 2023, the BBHF announced an initiative called Solar Synergy that was developed collaboratively with solar developers. This program offers key incentives to include pollinator health and habitat benefits on utility-scale solar projects and to document those benefits. The Solar Synergy program offers four environmental benefits for solar developers and their projects.

Final Vegetative Cover with Pollinator Benefits: The program collaboratively designs two seed mixtures for use on the project that include a seed mixture designed for use within the array area and one for use on the buffer areas of the project that come without vegetative height restrictions. The array area seed mixture is designed to not grow taller than the lower panel height of the project and to meet as many as 14 other project objectives. The buffer area seed mixture is provided to the project by the BBHF at no cost, or at a significant cost-share, depending on the number of acres being established.

Soil Sequestration Monitoring: For the first six years of the project, the carbon sequestration changes in the soil will be monitored and documented using national standardized techniques and methodologies. Should carbon sequestration gains be able to be monetized, the BBHF will connect the project with entities interested in purchasing those carbon credits. This aspect of the program is offered at no cost to the solar developer or solar project.

Pollinator Habitat and Population Monitoring: With our partners at the Monarch Joint Venture, standardized monitoring programs will be conducted that document the pollinator habitat attributes and changes on the site as well as the pollinator populations on the site. These monitoring activities will be conducted during the first six years of the project. This aspect of the program is offered at no cost to the solar developer or solar project.

Commercial beekeeping connections: The solar project will be connected with a commercial beekeeper to establish a honey bee apiary associated with the project site. This effort is an effort to increase U.S.-sourced honey production and offer significant sustainability-messaging opportunities for the project and solar developer. This aspect of the program is offered at no cost to the solar developer or solar project.

The Solar Synergy program is offered to solar developers and their projects across the country. Since the program was announced in March 2023, projects have been enrolled with 15 different solar developers. There are still many solar developers that have not heard of this innovative, collaborative offering and we would like to introduce the program and its benefits to a broader audience. The overall goal of the program is documenting the environmental benefits that can be achieved through a thoughtful vegetative plan that is created working collaboratively with solar developers. A plan that ensures and delivers the project's primary objectives of generating clean energy with realistic future operations and management plans, and producing pollinator health and habitat benefits, can be achieved.

Avian Surveillance within Concentrating Solar Power Flux Hazard Volumes

Presenter: Maria Swartz (Sandia National Laboratories)

Format: In-Person Poster/On-Demand Presentation

Authors: Maria Swartz (Sandia National Laboratories), Jaclynn J. Stubbs (Sandia National Laboratories), Gabriel C. Birch (Sandia National Laboratories), Jason M. Toberman (Sandia National Laboratories), Daniel E. Small (Sandia National Laboratories)

[45] The Bee & Butterfly Habitat Fund; https://www.beeandbutterflyfund.org/

Abstract: CSP plants use large arrays of mirrors to concentrate sunlight to generate heat for clean electricity production and long-duration storage. However, concentrated sunlight can harm avian wildlife and has been reported to cause avian deaths at multiple CSP plants, creating a potential roadblock for future CSP development due to the legal protections for birds under the MBTA. We report on preliminary results of a state-of-the-art avian surveillance system by developing using an AI-based detection system capable of initiating mitigations to divert avian wildlife from high flux volumes around the CSP towers before they incur serious injury. This system is composed of a stereoscopic visible imaging system coupled with traditional CV and machine learning algorithms. This publication will cover the optical system design, CV and machine learning algorithm design and performance parameters, and initial results for the detection and classification prototype system deployed at a CSP facility. Imaging systems were selected such that small avian wildlife at 200 m from the sensing system is imaged with three pixels across target. By utilizing stereoscopic imaging this approach is able to accurately localize avian wildlife within a 3D world space, enabling rejection of common nuisance sources (e.g., airplanes, insects, etc.). By utilizing Nvidia Jetson computational modules[46], edge computation can be performed that limits the data throughput and allows for real-time activation of the mitigation techniques. A semi-automated labeling tool to process video data has been designed and implemented for use in machine learning algorithm development. This allows for improvements to the normally slow and cumbersome process of labeling large amounts of training data. The tool uses standard image processing techniques such as motion detection and thresholding, to process the collected data and automatically annotate individual birds. An avian-detection algorithm can be trained with the processed data which improves speed and robustness and allows for iterative refinement of the avian-detection machine learning model. Synthetic data was also utilized due to the complexity of capturing real wild avian life data. The Unreal Engine[47] was used to place synthetically generated birds into a scene with clouds and cameras that mimics the real-world detection system. This allows for the seamless generation of data that can be used to augment the training dataset. Additionally, the synthetic data gives absolute ground truth for objects which can be used to verify the backend stereoscopic calibration and position estimation algorithms. Approaches that evaluate the accuracy of the stereoscope position estimation are discussed and reported. The final bird detection algorithm is trained on data collected and labeled, as well as synthetically generated data. This avian-detection machine learning model leverages open-source deep learning models such as YOLO-NAS[48], and retrains with this new data. Results of this algorithm are reported and sensitivity analysis will be included.

Siting Smart Projects—How to Manage Project Cost and Schedule Uncertainty amidst a Shifting Regulatory Landscape

Presenter/Author: Troy Rahmig (Tetra Tech)

Format: On-Demand Presentation

Abstract: Existing environmental regulations are often one of the primary considerations when siting a new solar project. Project siting—especially relative to natural resources—influences everything from the studies required, permits needed, and regulatory agencies involved. All of those considerations affect the early-stage costs needed to verify a project is viable and understand schedule limitations. Recently, this has become even more challenging due to newly listed bat species and changes handed down by the U.S. Supreme Court to the Clean Water Act. Now projects that will remove trees in almost every state need to consider whether the loss of habitat will result in take of endangered bat species. Meanwhile, projects are less likely to need federal Clean Water Act permits from the U.S. Army Corps of Engineers (USACE) due to

[46] https://developer.nvidia.com/
[47] https://www.unrealengine.com/en-US
[48] https://deci.ai/blog/yolo-nas-object-detection-foundation-model/

new restrictions placed on where their jurisdiction applies. This potential reduction in jurisdiction seemingly expands the potential areas where projects could be sited. The downside of that change is most projects will not have a federal nexus that would require consultation between federal agencies for effects on endangered species, which is a routine and predictable process. Without that reliable federal nexus, projects that result in the removal of bat habitat face a more unpredictable permitting future, left to the discretion of the project proponent. This includes either constructing the project in a way that avoids take or pursuing an incidental take permit under Section 10 of the ESA. The Clean Water Act and ESA, including their interaction under Section 7 of the ESA, often have a considerable influence on where solar projects are sited and how they are built. The recent changes in species listings and in the Clean Water Act are creating some new uncertainties during siting and permitting. This presentation will outline key considerations for how to manage those uncertainties during the siting process and steps that can be taken early in the process to make the project timeline more predictable.

Northern Harriers (*Circus hudsonius*) Are Driving the Need for Habitat Mitigation for Proposed Solar Projects in New York State

Presenter: Michael Newhouse (WSP)

Format: In-Person Poster/On-Demand Presentation

Authors: Michael Newhouse (WSP), Kayleen Snyder (WSP), Michael Morgante (WSP)

Abstract: RE plays a vital role in mitigating climate change and reducing greenhouse gas emissions. In New York, RE, such as solar energy, is a target initiative, with the goal to be 70% renewable electricity by 2030. Agricultural lands, including hay/pasture and cultivated crops, are often suitable locations for solar development (Katkar et al. 2021)[49]. However, the nomadic northern harrier (*Circus hudsonius*) utilizes similar land cover types and is a regular occurrence in many parts of New York, which is at the southern end of its current breeding range. Northern harrier is currently listed as a "Threatened" species in New York (NYSDEC 2019a)[50], which can be problematic for proposed solar sites because it requires applicants to submit a robust assessment of the projected facility site's potential for habitat take as part of the permit application process (NYSERDA 2023)[51]. The presence of harriers often leads to an expansive "occupied habitat" determination and a corresponding requirement for extensive habitat mitigation. As of March 2023, there were 82 existing and potential future permit applications for solar, solar and energy storage, and onshore wind projects with the Office of Renewable Energy Siting in New York (ORES 2023)[52], many if not most of which had recent northern harrier sightings, especially in winter. The distribution and abundance of northern harriers were listed as "Stable" (McGowan and Corwin 2008[53]; NYSDEC 2014)[54] and they are frequently detected during wintering grassland raptor surveys and Christmas Bird Count data (NYSDEC 2014). Similarly, neighboring states, such as Vermont and Massachusetts, have seen a positive trend in winter surveys for the species (Renfrew 2013)[55]. This has led New York State Department Environmental Conservation to consider a status change from

[49] Katkar et al. 2021. Strategic Land Use Analysis for Solar Energy Development in New York State. Renewable Energy. https://www.sciencedirect.com/science/article/pii/S0960148121004900.
[50] NYSDEC 2019a. List of Endangered, Threatened and Special Concern Fish and Wildlife Species of New York State. https://dec.ny.gov/nature/animals-fish-plants/biodiversity-species-conservation/endangered-species/lists.
[51] NYSERDA 2023. Solar Installations on Agricultural Lands. Solar Guidebook for Local Governments, Albany, NY. https://www.nyserda.ny.gov/All-Programs/NY-Sun/Communities-and-Local-Governments/Solar-Guidebook-for-Local-Governments.
[52] ORES 2023; https://ores.ny.gov/permit-applications
[53] McGowan and Orwin (Eds.) 2008; The Second Atlas of Breeding Birds in New York State. Cornell University Press, Ithaca, NY. https://figshare.com/articles/book/The_Second_Atlas_of_Breeding_Birds_of_Vermont/11499330/1.
[54] NYSDEC 2014. Species Status Assessment: Northern Harrier. https://extapps.dec.ny.gov/docs/wildlife_pdf/sgcnnharrier.pdf.
[55] Renfrew 2013. The Second Atlas of Breeding Birds of Vermont (2nd ed.). University Press of New England. http://val.vtecostudies.org/projects/vermont-breeding-bird-atlas/.

"Threatened" to "Species of Special Concern" in New York (NYSDEC 2019b)[56], yet this species' presence continues to dominate the need for habitat mitigation of New York solar projects compared to other state-listed grassland species.

Pollinator Monitoring to Understand Effects of Vegetation Management at Solar Energy Facilities

Presenter: Laura Fox (Argonne National Laboratory)

Format: In-Person Poster

Authors: Laura Fox (Argonne National Laboratory), Heidi M. Hartmann (Argonne National Laboratory), Leroy Walston (Argonne National Laboratory), Irene Hogstrom (Argonne National Laboratory), Yudi Li (University of California, Davis), Tristan Barley (University of Illinois, Urbana-Champaign), Adam Dolezal (University of Illinois, Urbana-Champaign)

Abstract: With the increased land use associated with utility-scale solar development in recent years, considerable attention is being paid to increasing the environmental compatibility of these facilities. As a case in point, the Pollinator Power Act of 2023 was introduced in the U.S. Senate, which if passed would require at least 35% of pollinator habitat in new solar facilities and not less than 50% of that habitat to be comprised of only native plant species. At the time of presentation, our group will have completed six years of monitoring pollinator trends at three Minnesota solar facilities planted throughout with pollinator habitat, three years of monitoring at several solar facilities in other midwestern states with varying extents of pollinator habitat and native species plantings, and three years of monitoring at a solar facility near University of California, Davis. This presentation will summarize the results of these ongoing monitoring efforts with a focus on correlations between pollinator abundance and diversity in relation to vegetation plantings deployed at the solar facilities. While summer 2023 data are not yet available, results to date for the Minnesota solar facilities indicate increases in pollinator numbers and types between 2018 (the year the pollinator habitat was planted) and 2022. The trends for the other Midwest solar facilities that have utilized more varied amounts of pollinator supportive and native plant species are emerging; the 2023 data that we will present will provide a first look at these new data.

What Do Video Recordings Tell Us about Bird Interactions with Photovoltaic Solar Energy Facilities?

Presenter: Yuki Hamada (Argonne National Laboratory)

Format: On-Demand Presentation

Authors: Yuki Hamada (Argonne National Laboratory). Adam Szymanski (Argonne National Laboratory), Paul Tarpey (Argonne National Laboratory), Leroy Walston (Argonne National Laboratory), Heidi Hartmann (Argonne National Laboratory), Andrew Ayers (Argonne National Laboratory)

Abstract: How do birds interact with PV solar energy facility infrastructure? This is perhaps one of the most popular questions among wildlife-conscious solar stakeholders. The question was originally prompted by concerns about bird fatalities at PV facilities potentially being a result of collisions with infrastructure starting nearly a decade ago. Overtime stakeholder interests have grown in scope to encompass bird behavior/movement near PV panels and other facility infrastructures, attractants of PV facilities to birds, cues birds respond to, and birds' site use and interactions with other wildlife and their population implications. Our efforts to develop an avian-solar monitoring camera system have evolved

[56] NYSDEC 2019b. Draft List Under Part 182.5 Pre-proposal –October 2019. https://extapps.dec.ny.gov/docs/wildlife_pdf/preproposal182.pdf.

with these stakeholder priorities. As a part of technology development, we have collected over 17,000 hours of daytime video at PV solar facilities in the desert southwest and midwestern regions of the United States during the 2021–2022 period. This is likely the largest visual dataset observing real-time bird activities at PV solar facilities known to date (in contrast to after-the-fact observations collected through surveys). Although the primary purpose of these videos was to train and test machine/deep learning (ML/DL) models for an AI avian-solar monitoring camera system, we came to realize that extracting and cataloging bird activities or behaviors in these videos could tell us how birds respond to or use PV facilities and help us begin to understand functions of PV facilities in landscapes utilized by birds. In addition to manually-labeled bird activity data (a.k.a. training data) needed for development of the AI camera system, we have been extracting "tracks" consisting of all moving objects recorded in the remaining video recordings. To efficiently obtain bird activity data from the tracks, we run our ML/DL models originally developed for the camera system, which classifies objects (e.g., bird, insect, other wildlife) and bird activities (e.g., fly over, fly through, perch in panel, land on ground, perch in background, and collide with panel). These models have shown accuracies of 93% and 87% for classifying objects and bird activities, respectively; thus, we obtain bird activity data more efficiently and reliably than manual labeling. To date, approximately 18% of moving objects in the videos are recognized as birds. Of all birds identified, 51% flew over the facility but never approached panels. Approximately 32% of the birds flew close to panels; some flew right above panels, and some flew between or even below panels. Approximately 6% of the birds perched on panels and another 4% landed on the ground. We have not identified any birds colliding with panels in the videos processed to date. As we continue processing the recorded videos, we will update the audience with the most recent findings from our video analysis, along with our latest avian-solar monitoring camera technology.

The Ecological Impacts of Solar Energy Development in the Southwestern United States with a Case Study from the Gemini Solar Project

Presenter: Claire Karban (U.S. Geological Survey)

Format: On-Demand Presentation

Authors: Claire Karban (U.S. Geological Survey), Seth M. Munson (U.S. Geological Survey), Jeffrey E. Lovich (U.S. Geological Survey), Steven M. Grodsky (U.S. Geological Survey)

Abstract: To meet RE targets, solar energy development is expanding rapidly throughout the United States. In 2023, the United States plans to add nearly 30 GW of utility-scale solar energy capacity—the most of any year to date. Although solar energy can reduce carbon emissions relative to more traditional forms of energy, it has intensive land use, requiring approximately 1.8 times as much land as surface-mined coal and 15.8 times as much land as natural gas for the same energy generating capacity. Much of the solar energy capacity is being developed in the southwestern United States, where there is high solar irradiance across the Mojave, Sonoran, Chihuahuan, and Colorado Plateau Deserts. However, these deserts are sensitive to land use disturbance and the environmental consequences associated with solar energy land conversion are predominantly unknown or only beginning to be understood. To fill this knowledge gap, we present a novel framework for predicting the impacts of solar energy development to plants and wildlife by linking disturbance types associated with solar facility construction and operation to the morphological, physiological, life history, and behavioral traits of species and guilds. In the absence of empirical research on the impacts of solar development on the many organisms affected, this framework provides insights and suggests pathways for future research. Guided by this framework, we present the Gemini Solar Project as a case study. The Gemini Solar Project is a utility-scale PV solar energy development located in the Mojave Desert northeast of Las Vegas, Nevada. Disturbance types during the construction phase of the project include driving over and crushing vegetation, soil destabilization, road traffic, and noise pollution. We quantify declines in native perennial plant cover, plant

species richness, biocrust cover, and soil stability resulting from construction activities and compare these measured results to those predicted by the framework. We also demonstrate shifts in the plant community composition under and between PV panels. Our work highlights new insights to fill the current gap in our understanding of the impacts of rapidly expanding solar energy development and contributes a predictive framework for evaluating impacts to species and guilds.

Known and Potential Impacts of Solar Energy Development on Agassiz's Desert Tortoises (*Gopherus agassizii*) and their Habitat

Presenter/Author: Jeff Lovich (U.S. Geological Survey)

Format: On-Demand Presentation

Abstract: Solar energy development in the desert southwest United States started relatively recently and continues to experience meteoric growth. For example, in the year 2000, California received only 11% of its energy from renewable sources, including solar. By 2018 it rose to 34%. Future goals call for 60% by 2030 and 100% carbon-free energy by 2045. The initial blueprint for opening up millions of acres of public land for solar energy development in the southwestern United States was published in a draft EIS in 2011 and finalized in 2012. Included was habitat occupied by conservation-reliant desert tortoise populations that were already declining and threatened due to a host of factors unrelated to solar energy development. An estimated 129,000 adult tortoises were lost between 2001 and 2020, a 36% population decline. Despite the rapid pace of approved solar development in the desert southwest, in 2011 a review of the peer-reviewed scientific literature found only one publication documenting the effects of solar energy development and operation on wildlife in that region, and none on tortoises. Potential effects of solar energy development include direct mortality; destruction and modification of habitat, including impacts of roads; habitat fragmentation and barriers to gene flow; effects due to dust and noise; impacts to local and regional climate; fire; and off-site impacts related to construction material acquisition, processing, and transportation. Solar energy development continues in the Mojave Desert in habitat occupied by the desert tortoise despite their decline and protection under the ESA since 1991. Tortoises are now emblematic of the tension between conservation and solar energy development. Despite state and federal efforts to focus development in areas of lower conservation value, an estimated 700 km^2 of tortoise habitat may be lost to solar development. Cause and effect relationships of solar energy development on tortoise populations are unknown because before-after-control-impact studies are still lacking. The standard mitigation technique since 1986 has been to translocate tortoises from the project footprint into another area, sometimes far away. This strategy has been criticized in the scientific literature and remains controversial because translocation of tortoises is not always successful. Research on tortoises moved because of solar energy development is largely based on short-term projects that may have limited utility for such a long-lived species. The life history traits of desert tortoises including late maturity, longevity, and a relatively modest reproductive output make them slow to recover when populations decline for any reason.