Multiagency Avian-Solar Collaborative Working Group: Stakeholder Workshop

Welcome and Overview of Workshop Objectives

Dan Boff

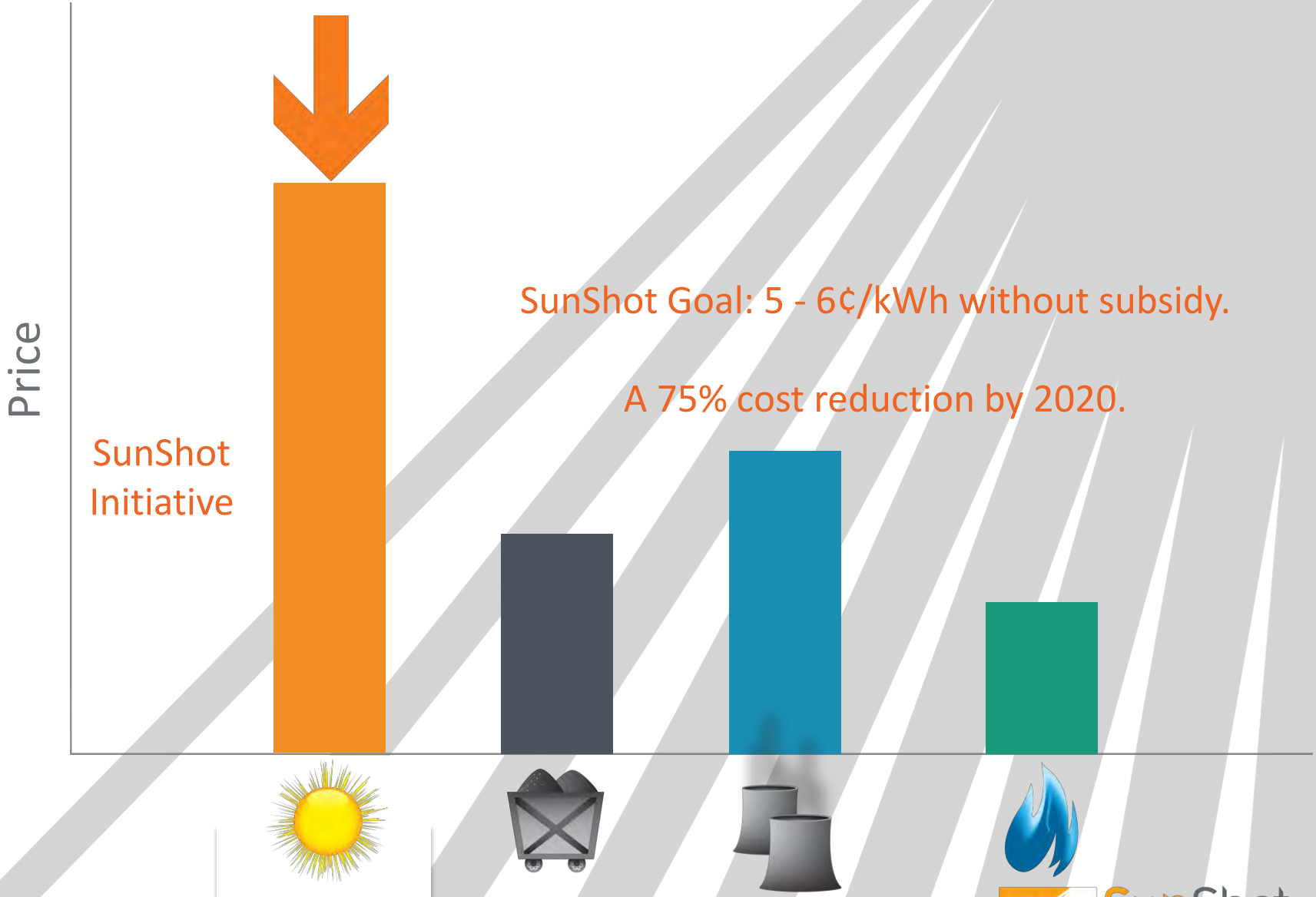
U.S. Department of Energy

SunShot Initiative

May 10-11, 2016

Sacramento, California

SunShot

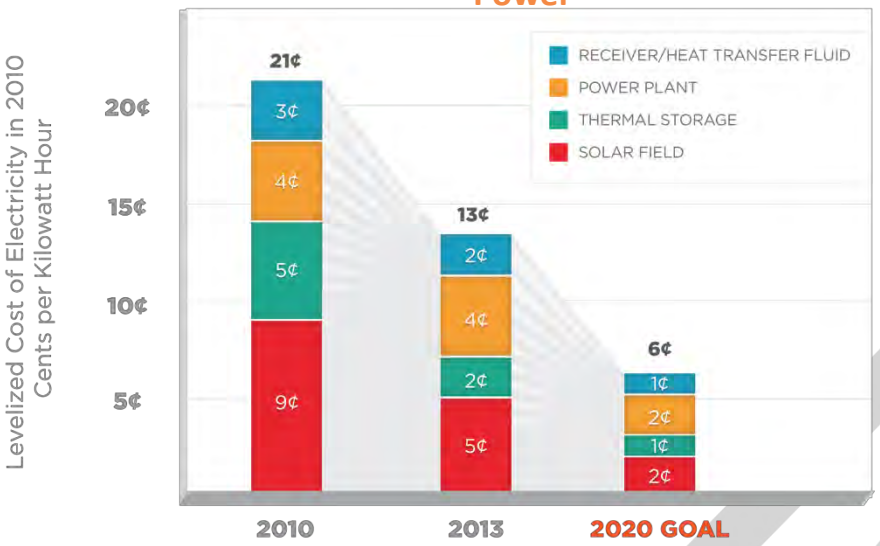


SunShot Goal: 5 - 6¢/kWh without subsidy.

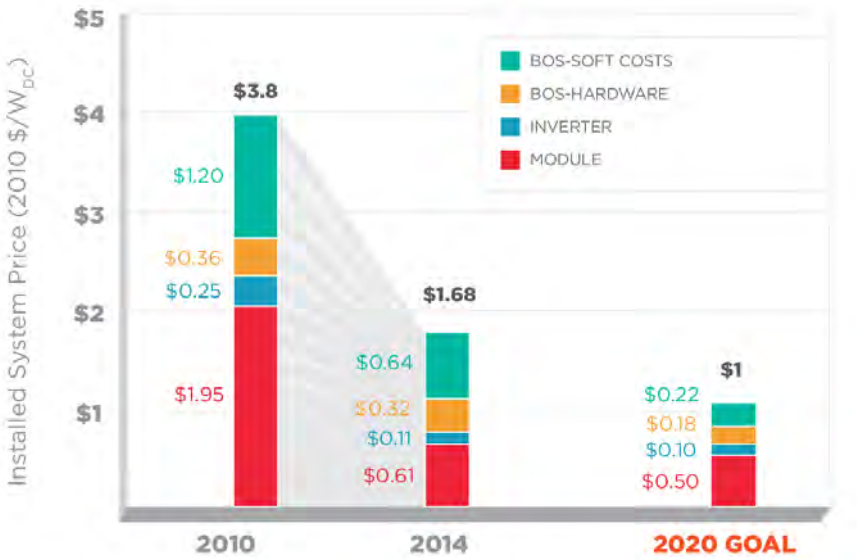
A 75% cost reduction by 2020.

SunShot
U.S. Department of Energy

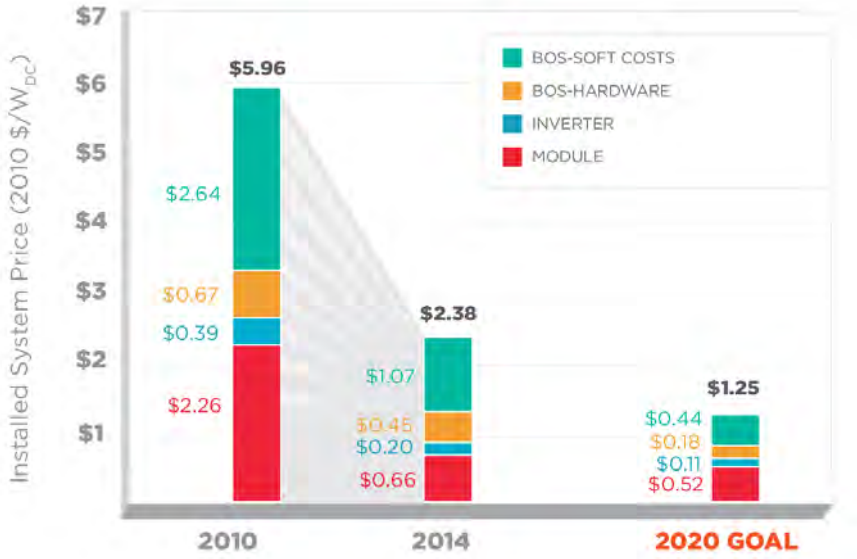
The Falling Cost of Concentrating Solar Power



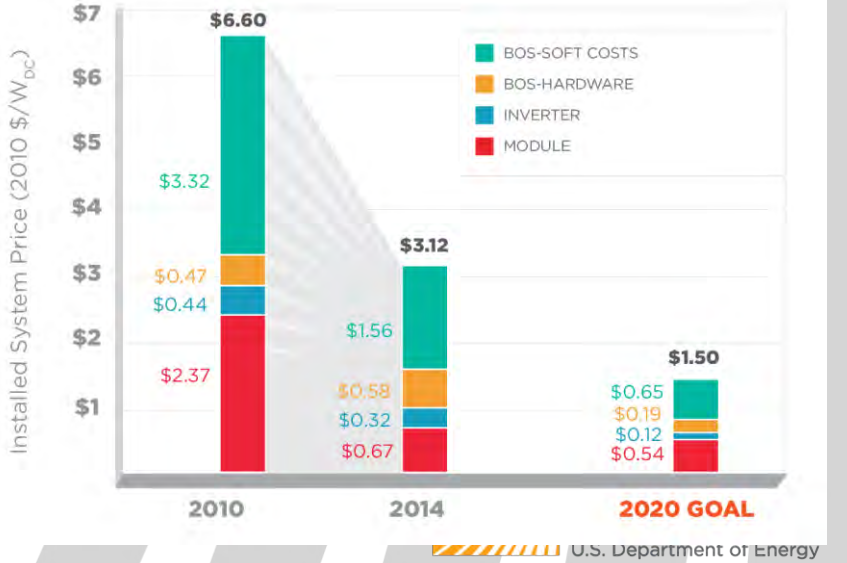
The Falling Cost of Utility PV



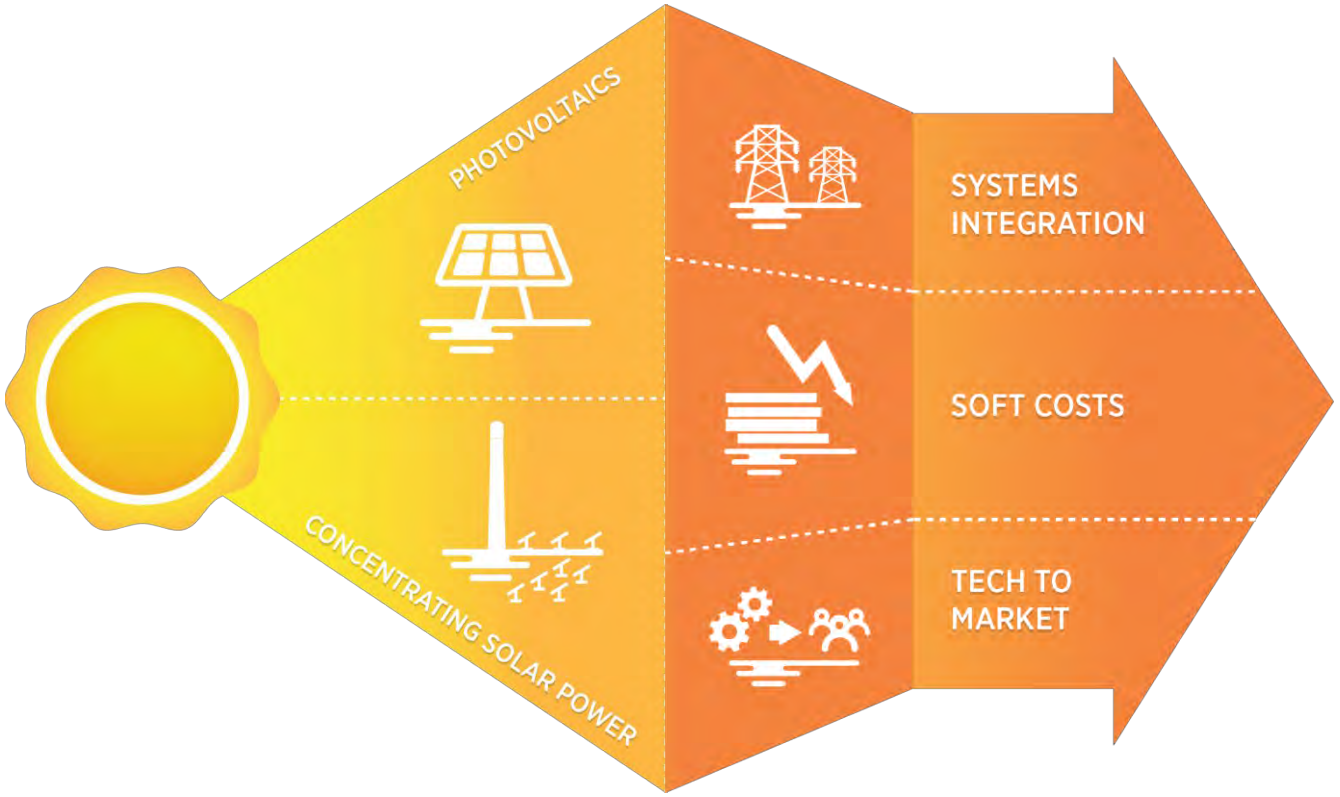
The Falling Cost of Commercial PV



The Falling Cost of Residential PV

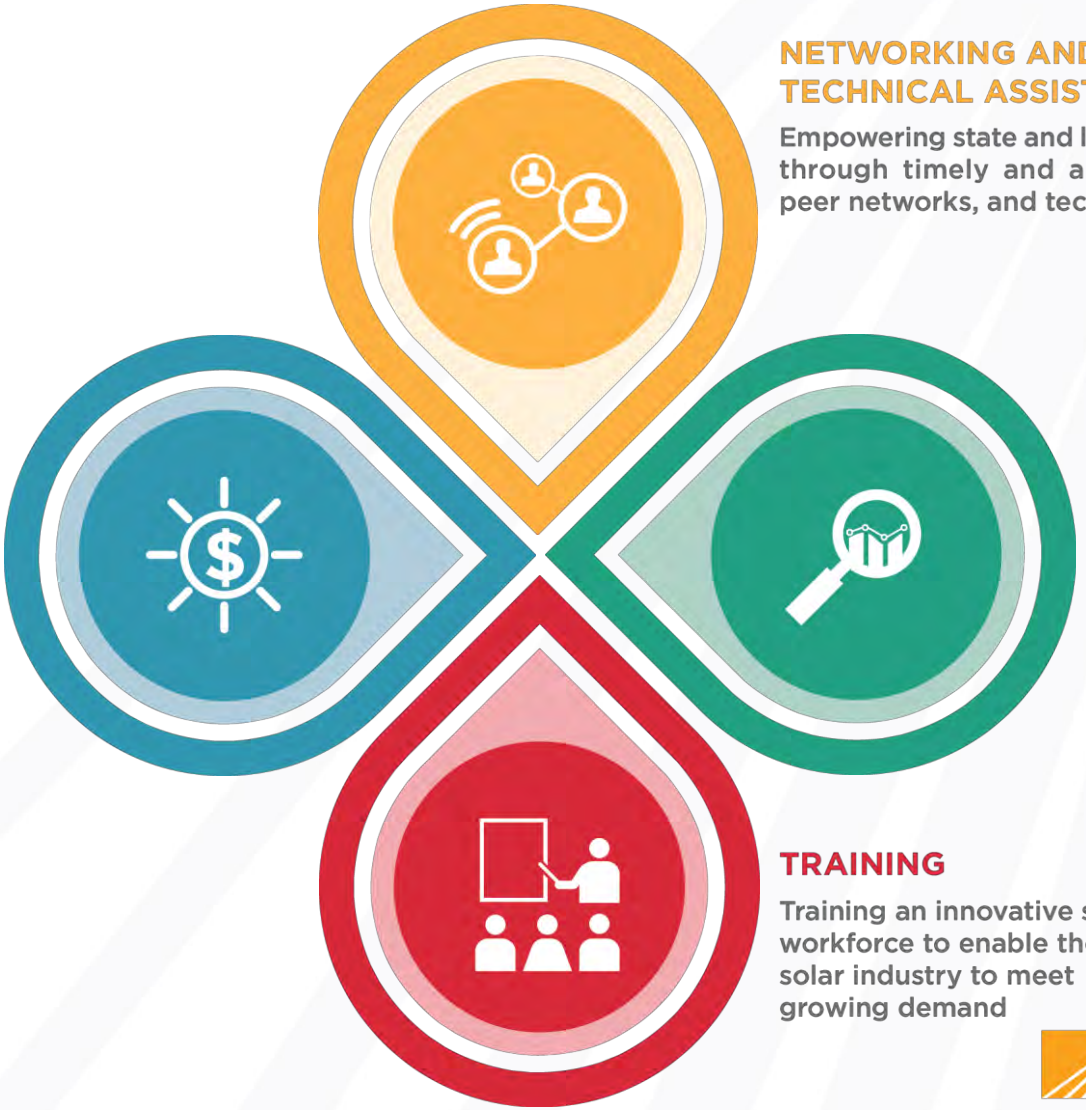


SunShot Program Structure



SunShot U.S. Department of Energy

Balance of Systems (Soft Costs)



NETWORKING AND TECHNICAL ASSISTANCE

Empowering state and local decision-makers through timely and actionable resources, peer networks, and technical assistance

BUSINESS INNOVATION

Developing solar finance and business solutions to expand access to capital and accelerate market growth

DATA ANALYSIS

Harnessing big data analysis and technical solutions to support the many stakeholders involved in solar deployment

TRAINING

Training an innovative solar workforce to enable the solar industry to meet growing demand

SunShot U.S. Department of Energy

Objectives of this Meeting

Bring together CWG members and stakeholders to:

- Share information about the CWG objectives, scope, activities, and timeline
- Provide a forum for stakeholders to provide comments relevant to the CWG efforts:
  - Concerns about avian-solar issues
  - Relevant existing data and studies
  - Understanding of avian-solar interactions
  - Focus of future research
  - Priorities for research needs
  - Future activities of the CWG

Agenda - Day 1

Time Slot	Topic
9:30-10:00	Welcome & Workshop Objectives
10:00-10:30	Information About the Multiagency CWG
10:30-10:45	Break
10:45-11:00	Summary of Available Avian-Solar Information
11:00-12:30	Lunch
12:30-2:15	Ongoing Related Initiatives
2:15-2:30	Break
2:30-4:30	Break-out Discussions
4:30-5:00	Wrap Up

Agenda - Day 2

Time Slot	Topic
9:00-9:15	Recap of Day 1
9:15-9:45	Conceptual Framework of Avian-Solar Interactions
9:45-10:15	Agency Management Questions & Related Research Needs
10:15-10:30	Break
10:30-12:30	Break-out Discussions
12:30-1:00	Wrap Up & Next Steps

Logistical Details

- All handouts and presentations will be available on the CWG webpage: http://blmsolar.anl.gov/program/avian-solar/
- If you want to continue to receive information about the CWG efforts, subscribe for email updates
  - Send request to rollins@anl.gov
- Using the microphone ensures everyone can hear you
- Identify yourself and your affiliation when you speak
- Please mute or turn off cell phones

Information About the Multiagency Avian-Solar Collaborative Working Group (CWG)

Greg Helseth

Bureau of Land Management

Multiagency CWG Stakeholder Workshop

May 10-11, 2016

Background

- Avian-solar concerns that have emerged in the past 2-3 years present potential barriers to utility-scale solar development
- Existing data are inadequate to define the magnitude and extent of potential avian impacts and causal factors
- Research is underway by multiple parties, including federal and state agencies, industry, and academics
- There is a growing consensus regarding the value of collaborating on defining research objectives and data needs, and on allocation of funding

Goal and Objectives

To develop better information to support future agency decisions regarding potential avian impacts at utility-scale solar facilities

OBJECTIVES

- Establish collaborative working group among federal and state agencies
- Develop multiagency avian-solar science plan
  - Document current and planned research activities
  - Identify cost implications and information gaps
  - Identify agency roles in funding and oversight
  - Develop feasible mitigation measures, if warranted
- Prepare education and outreach materials

CWG Members

Representatives of federal and state agencies with relevant missions and/or project authorization responsibilities

Federal Agencies	State Wildlife and Energy Agencies *
DOE Solar Energy Technologies Office	AZ Game and Fish Dept.
Bureau of Land Management	CA Dept. Fish and Wildlife
U.S. Fish and Wildlife Service	CA Energy Commission
U.S. Geological Survey	NV Dept. Wildlife
DOI Solicitor's Office	
U.S. Department of Defense	

** Other state energy agencies have been invited to participate*

Scope and Organization of the CWG

Scope

- Utility-scale solar technologies
  - All technologies
  - All facility components
- Initial geographic focus: Arizona, California, and Nevada

Organization

- CWG is led by a chair and co-chair
- Technical support and facilitation is provided by Argonne National Laboratory and the National Renewable Energy Laboratory

CWG Tasks, Deliverables, and Timeline

Task	Activities	Milestone(s) / Deliverable(s)
1 Establish the CWG and conduct meetings	Formalize CWG. Conduct quarterly CWG and stakeholder meetings.	Establish CWG charter, quarterly CWG meetings, and stakeholder events
2 Develop an Avian-Solar Science Plan	Summarize current activities, information gaps, and research needs; consolidate data and mitigation measures/BMPs. Develop hypothesis-based science plan applicable to all solar technologies and sites.	Avian-solar science plan by end of Oct. 2016
3 Prepare education and outreach materials	Prepare fact sheets or news items to inform the public of CWG activities, avian-solar data, and clarify information.	At least two in FY16: • Fact sheet • News item • Public webinar

Timeline & Progress in 2016

Red – complete; Black - anticipated

January	February	March	April	May	June	July-Oct
• Recruited agency participation • Held CWG kickoff meeting	• Finalized Charter • Assembled existing information	• Published 1st fact sheet • Launched CWG website • Developed conceptual framework	• Finalized workshop agenda • Developed CWG MQs	• Hold 1st public workshop • Incorporate stakeholder input • Finalize MQs & research needs	• Draft science plan	• Revise & finalize science plan • Hold public workshop or webinar • Release final public outreach publication

CWG = collaborative working group, MQ = management question

Avian-Solar Science Plan

Kirk LaGory, Argonne National Laboratory

Purpose: *Provide a consistent framework for research and monitoring of avian-solar interactions*

Objectives

- Define research questions and future research needs;
- Support development of monitoring protocols, evaluation of avian risk, and development of effective mitigation measures;
- Qualitatively discuss potential associated costs; and
- Define agency roles and processes for implementation.

Elements of an Avian-Solar Science Plan

- Executive Summary
- Introduction
  - Describe current solar energy development and trends, observed avian-solar interactions
  - Describe objectives of the plan, desired outcomes, CWG
  - Identify agency-specific management questions
- Conceptual Framework of Avian-Solar Interactions
  - Provides framework for science plan
  - Impacting factors
  - Technology-specific impacts
  - Direct, indirect, and cumulative effects
  - Factors that contribute to risk, including location, seasonality, type of birds
  - Local and population-level effects

Elements of an Avian-Solar Science Plan (Cont.)

- Summary of Existing Information
  - High-level summary with focus on published DOE “rapid report” and subsequent findings, technical reports, and communications with researchers
  - Which portions of the conceptual model are best understood?
- Information Gaps Related to Avian-Solar Interactions
  - Identify the information gaps that impede development of effective avoidance, minimization, and mitigation strategies
  - Which portions of the conceptual model are poorly understood?

Elements of an Avian-Solar Science Plan (Cont.)

- Research and Monitoring Needs
  - Based on management questions, conceptual model, and information gaps, identify research and monitoring that is needed to understand avian-solar interactions
  - Identify priorities for research and monitoring activities based on relative risk to birds
- Program Implementation
  - Identify best approaches to research and monitoring
  - Agency roles
  - Collaboration with ASWG and other stakeholders to ensure consistency and complementary activities
  - Role of adaptive management
  - Tiering from the plan
  - Approximate costs of activities

Stakeholder Engagement

- Agencies are seeking input from stakeholders on all matters relevant to the CWG objectives:
  - Concerns about avian-solar issues
  - Relevant existing data and studies
  - Understanding of avian-solar interactions
  - Focus of future research
  - Priorities for research needs
  - Future activities of the CWG
- Stakeholders can comment during this meeting and/or in writing following the workshop (target due date of June 1, 2016)
- A stakeholder webinar will be hosted to present and take comments on the draft avian-solar science plan (late summer 2016)
- For more information:
  - Subscribe for email updates: send request to rollins@anl.gov
  - CWG webpage: http://blmsolar.anl.gov/program/avian-solar/

QUESTIONS?

A Review of Avian Monitoring and Mitigation Information at Existing Utility-Scale Solar Facilities

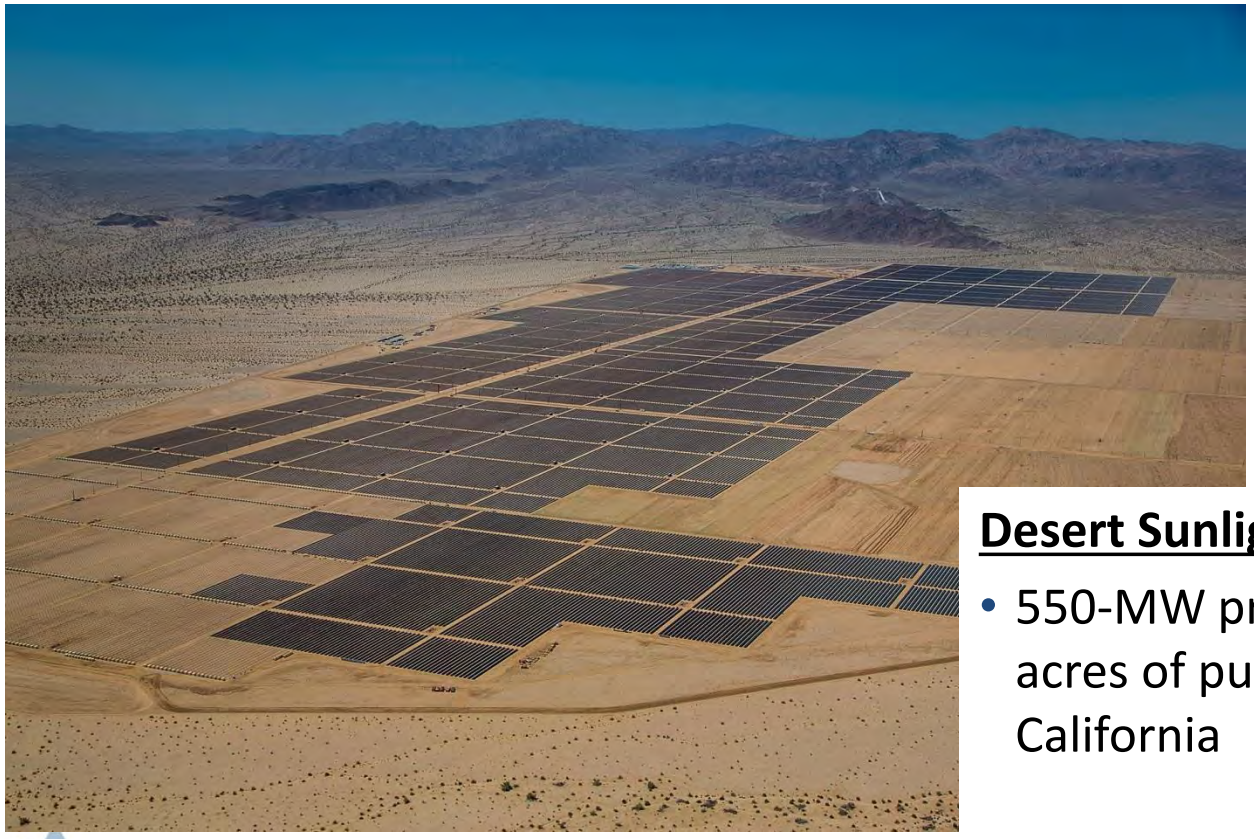
Lee Walston*, Katherine Rollins, Karen Smith, and Kirk LaGory
Environmental Science Division
Argonne National Laboratory

Karin Sinclair, Craig Turchi, Tim Wendelin, and Heidi Souder
National Renewable Energy Laboratory

* lwalston@anl.gov

What is Utility-Scale Solar Energy Development?

- Large solar fields – 10+ megawatt (MW); requires 5-10 acres per MW
- Three main technologies: 1) photovoltaic (PV) and concentrated solar power (CSP) technologies – 2) parabolic trough and 3) power tower



Desert Sunlight Solar Farm (PV)

- 550-MW project on over 4,000 acres of public land in southern California

What is Utility-Scale Solar Development? (cont'd)

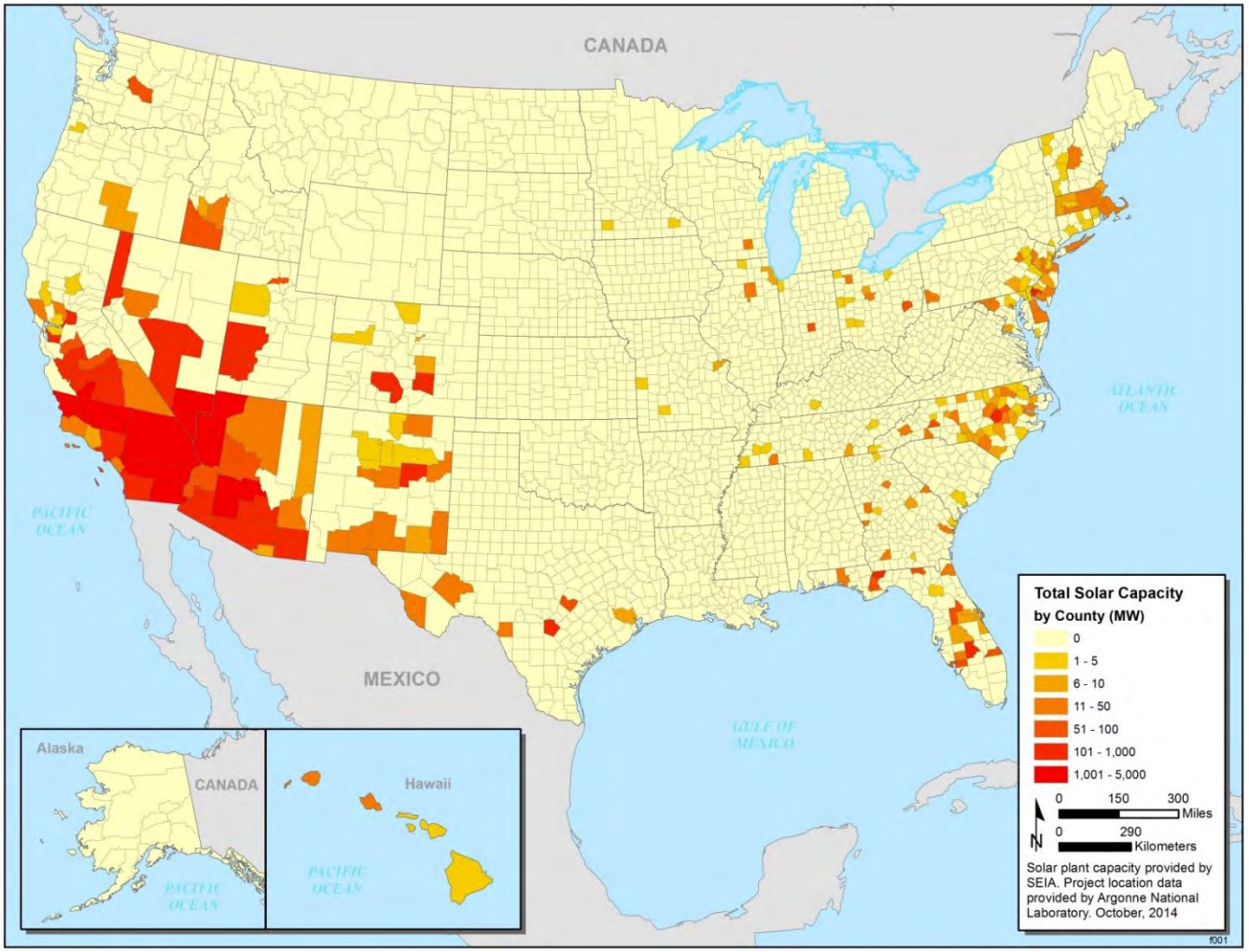
What is Utility-Scale Solar Development? (cont'd)

Ivanpah Solar Energy Generation Station (SEGS)

- 3 Solar power towers (377 MW)
- >3,400 acres of public land

Utility-Scale Solar Energy Development in the U.S.

- >14 GW utility-scale solar capacity (in operation or under construction)
- >1,200 facilities (>1 MW)
- >50% of this electric capacity in southern CA, NV, and AZ.



Source: Walston et al. 2015

Avian Impacts of Solar Development

2 direct sources of solar-avian fatalities

- Collision-related: documented at solar projects of all technology types.
- Solar flux-related: resulting from the burning/singeing effects of exposure to concentrated sunlight. Observed only at facilities employing power tower technologies.

Photo Credit: Robert Sullivan, Argonne National Laboratory

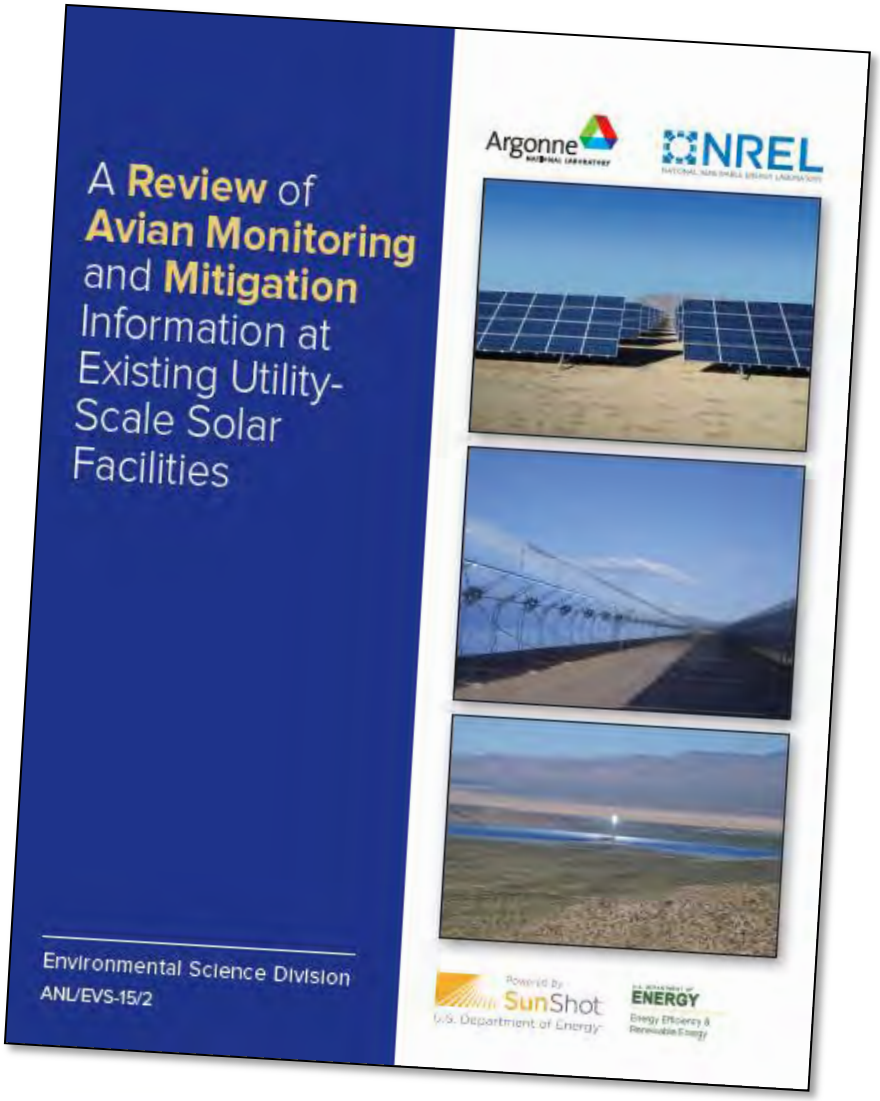
Factors that Affect Mortality Risk

- Project location
  - Near aquatic/riparian areas, stopover sites, etc.
- Project size
- Project technology / design
  - PV vs CSP
  - Evaporation ponds
  - Ancillary infrastructure

Copper Mountain PV facility in southern Nevada. Example for the “lake effect” hypothesis.
Photo Credit: Robert Sullivan, Argonne National Laboratory

"A Review of Avian Monitoring and Mitigation Information at Existing Utility-Scale Solar Facilities"

- Objectives:
  - Summarize avian fatality issues at solar facilities
  - Summarize current monitoring and reporting activities
  - Evaluate mitigation measures and BMPs used for other industries
  - Examine solar technology-specific aspects of avian fatality
  - Identify information gaps and next steps



Avian Fatality Information at Solar Facilities (updated)

- 16 Facilities with available avian monitoring information.
- Collection of avian fatality information:
  - Incidental or unknown survey effort at 6 facilities
  - Systematic survey effort at 10 facilities

Summary of Current Avian Monitoring Activities at Utility-Scale Solar Facilities as of May 2016

Project Name	Location	Technology Type and MW (in Parentheses)	Current Status	Land Type	Available Avian Monitoring Plan	Known Collection of Avian Fatality Data
Blythe Solar	Riverside County, CA	PV (485)	Under Construction	Public	Yes	Yes – Incidental and systematic
California Solar One	Daggett, CA	CSP – Power Tower (10)	Decommissioned in 1987	Private	NA	Yes – Systematic
California Valley Solar Ranch	San Luis Obispo County, CA	PV (250)	Operational – Oct 2013	Private	Yes	Yes – Systematic
Campo Verde	Imperial County, CA	PV (139)	Operational – Oct 2013	Private	NA	Yes – Incidental
Centinela Solar Energy	Imperial County, CA	PV (170)	Operational – August 2013	Private	Yes	NA
Crescent Dunes	Nye County, NV	CSP – Power Tower (110)	Construction completed	Public	Yes	Yes – Systematic

Avian Monitoring at Solar Facilities

- Fatality monitoring (and reporting) at very few solar facilities
  - Not required at all facilities
- Differences in monitoring designs and survey effort
  - Affects the ability to compare and integrate data
- Systematic vs. incidental fatality information
  - Systematic information allows hypothesis testing
  - Incidental observations may still be useful in understanding patterns of fatalities

Barn swallow with singed feathers observed at the California Solar One demonstration facility (Source: McCrary et al. 1986).

Avian Monitoring at Solar Facilities, Cont'd

- Variation in factors influencing mortality rate estimation and evaluation
  - **Search effort and searcher efficiency**
  - **Feather spots**
  - **Predation and scavenging**
    - Potential for predators to influence mortality rates by transporting carcasses to the project footprint from offsite locations
  - **Background mortality**
    - Mortality estimates at some solar facilities include adjustments for background mortality

Conclusions & Recommendations

- Avian monitoring
  - Not all utility-scale solar facilities are required to prepare and comply with project-specific avian monitoring protocols
- Existing avian fatality data
  - Standardization is important for integration and comparison
- Flux-related factors (power tower technologies)
  - Various approaches to heliostat standby aiming could significantly reduce flux levels and their impact on avian fatality
- Better collaboration among agencies, industry, and stakeholders to (1) collect scientifically rigorous and comparable data; (2) identify research priorities; and (3) identify appropriate mitigation measures.

Questions?

Photo Credit: http://cleaneasyenergy.com/

Presentations on Ongoing Related Initiatives

1. *Tom Dietsch – U.S. Fish and Wildlife Service*
2. *Mona Kahlil – U.S. Geological Survey*
3. *Avian Solar Work Group Representatives: Julie Falkner, Defenders of Wildlife and Laura Abram, First Solar*
4. *Tim Wendelin – National Renewable Energy Laboratory (NREL)*
5. *Elise DeGeorge - NREL*

Update on Solar-Avian Interactions in Southern California

Thomas Dietsch
Migratory Bird Division
US Fish and Wildlife Service
CWG Public Meeting
Sacramento, CA
May 10, 2016

Objectives for Presentation

- Provide a review of solar-avian interactions in Southern California
- Discuss hypotheses for avian interactions
- Provide update on actions being taken

Avian Impacts

Direct Effects: Collisions

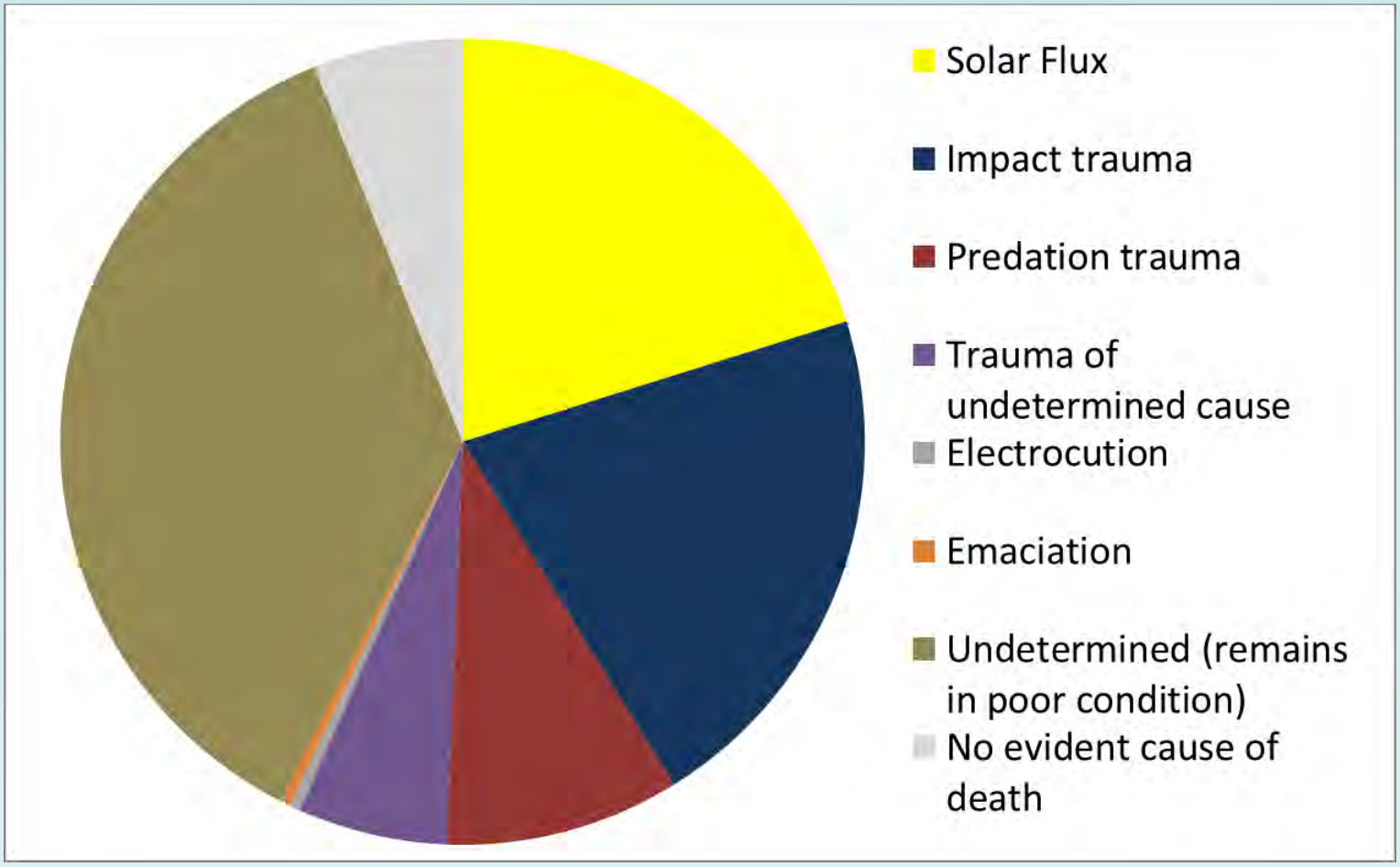
Collisions with panels are common

Concentrated Solar Technologies

Direct Effects

Solar Flux (power tower)

Cause of Death from National Fish and Wildlife Forensics Lab Report (Kagan et al. 2014)



From 3 solar projects, 233 carcasses from 71 species.

Data for Today's Presentation

- Mortality monitoring and reporting is required by lead agencies on many projects.
- Data from 7 projects in Southern California
  (4 Photovoltaic, 2 Solar Trough, 1 Power Tower)
- Data reported from 2012-April 2016.
- Each species was categorized by habitat, migratory group, and foraging guild.

Caveats on Solar Avian Mortality data

- Data are from a mix of incidental reports and systematic surveys on several projects.
- Magnitude of mortalities are not reported here.
- Only projects in Southern California are included in this presentation.
- Data can provide information on which species or taxonomic groups may be at risk.
- Project features and types of injuries also indicated.

Initial Findings

- National Fish and Wildlife Forensics Lab Report (Kagan et al. 2014)
  - “Significant Bat and Insect Mortality, including Monarch Butterflies”.
- 3545 mortalities from 183 species (2012-April 2016)
  - Only mortalities found and reported included, no estimation.
  - Mix of reports from incidental finds and systematic surveys.
  - Many mortalities occur due to dehydration/heat stress after initial injury/stranding.
- Birds of Conservation Concern

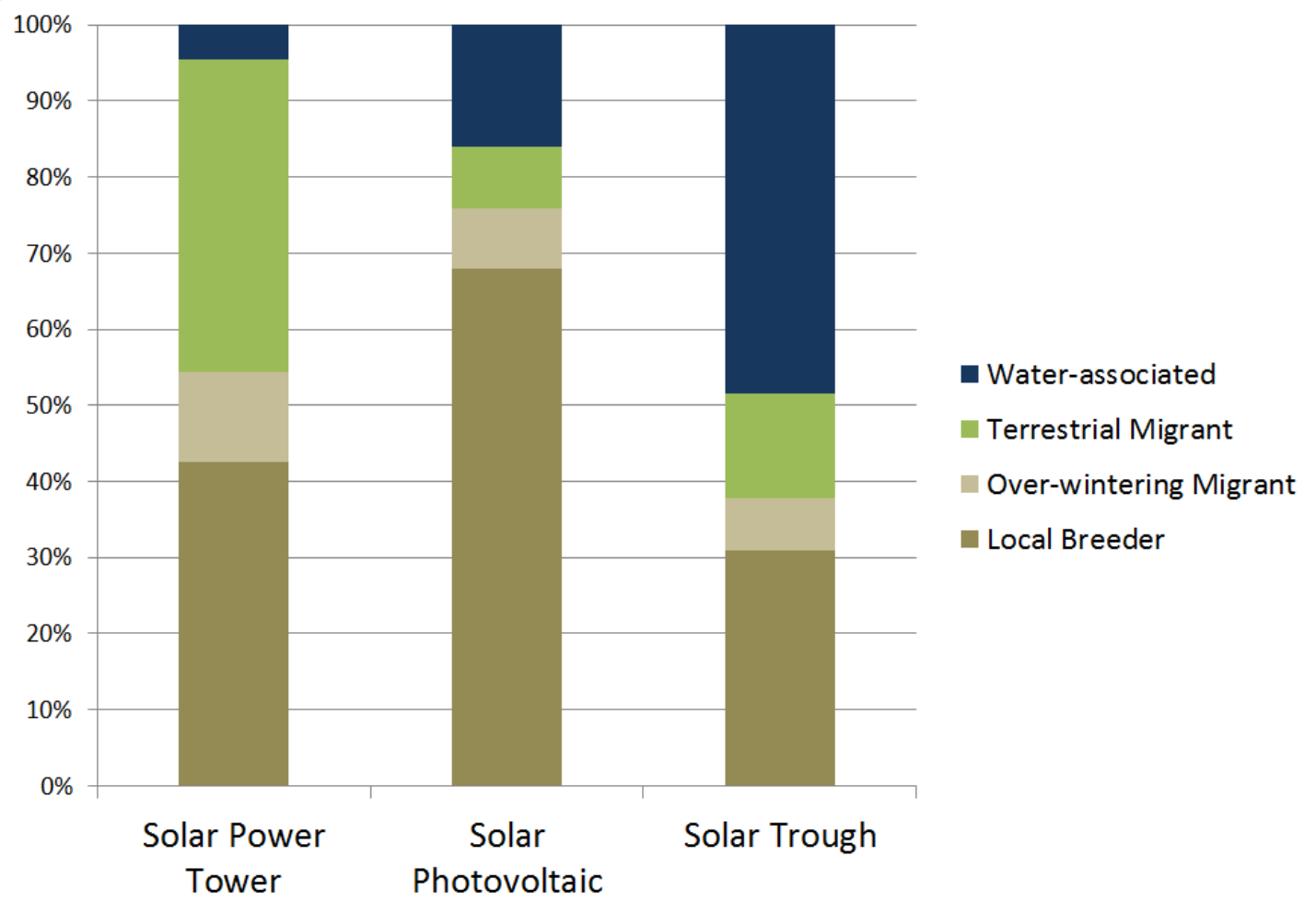
Species of Concern

- Federal Endangered/Threatened
  - Yuma Ridgeway's (Clapper) Rail
  - Willow Flycatcher
  - Yellow-billed Cuckoo
- State-listed/Fully Protected
  - Peregrine Falcon
  - Bank Swallow
- 19 Birds of Conservation Concern
  - Western Grebe
  - Horned and Eared Grebes
  - American White Pelican
  - Burrowing Owl
  - Calliope Hummingbird

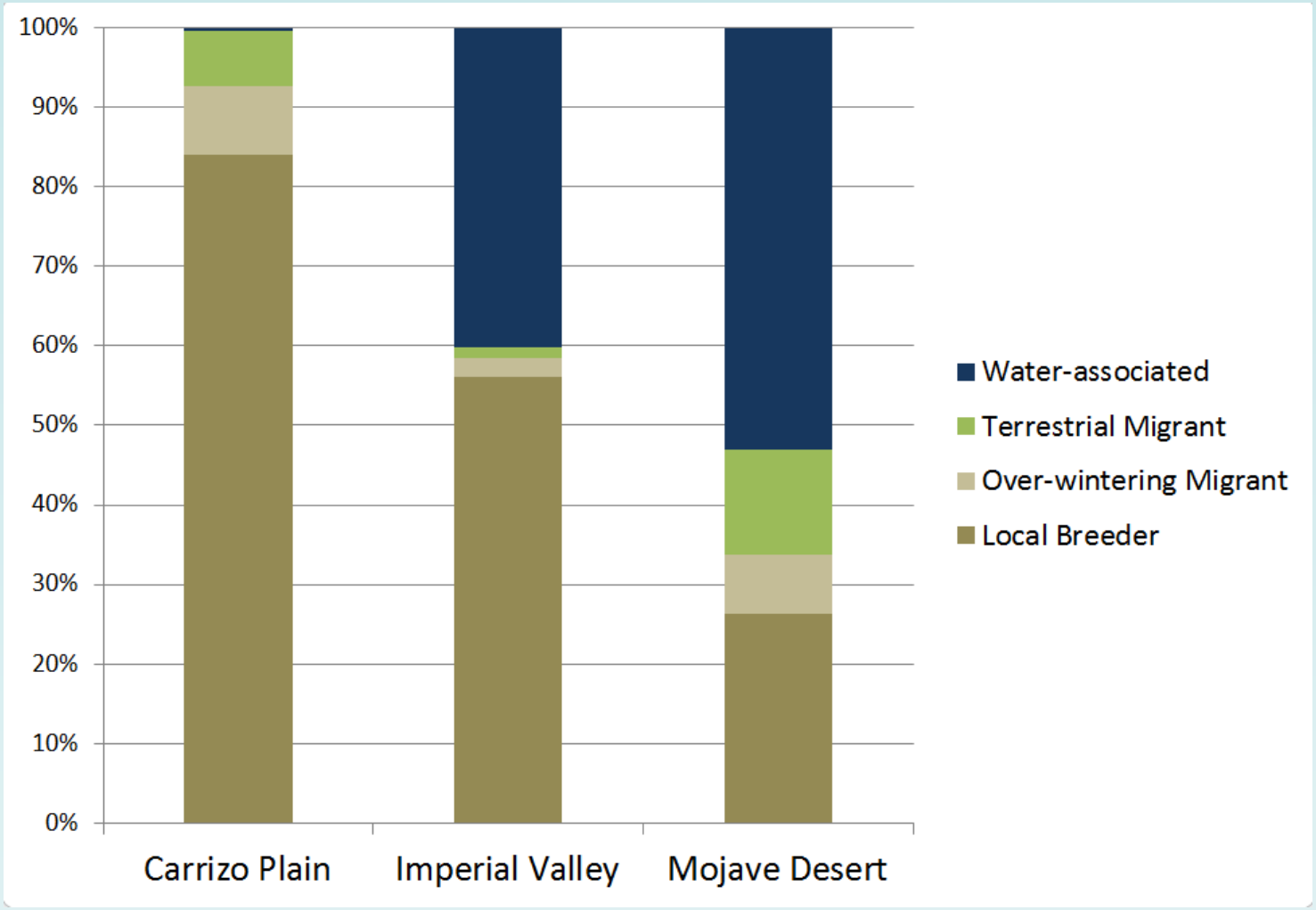
Hypotheses

- Mortalities represent background mortality.
- Mortalities occur during normal bird movements (Anthropogenic, no landscape-scale attraction).
- Polarized light may attract birds and insects to solar projects in the Mojave Desert (Horvath et al. 2009).
- Other resources attract birds to solar projects (Insects and Ponds).

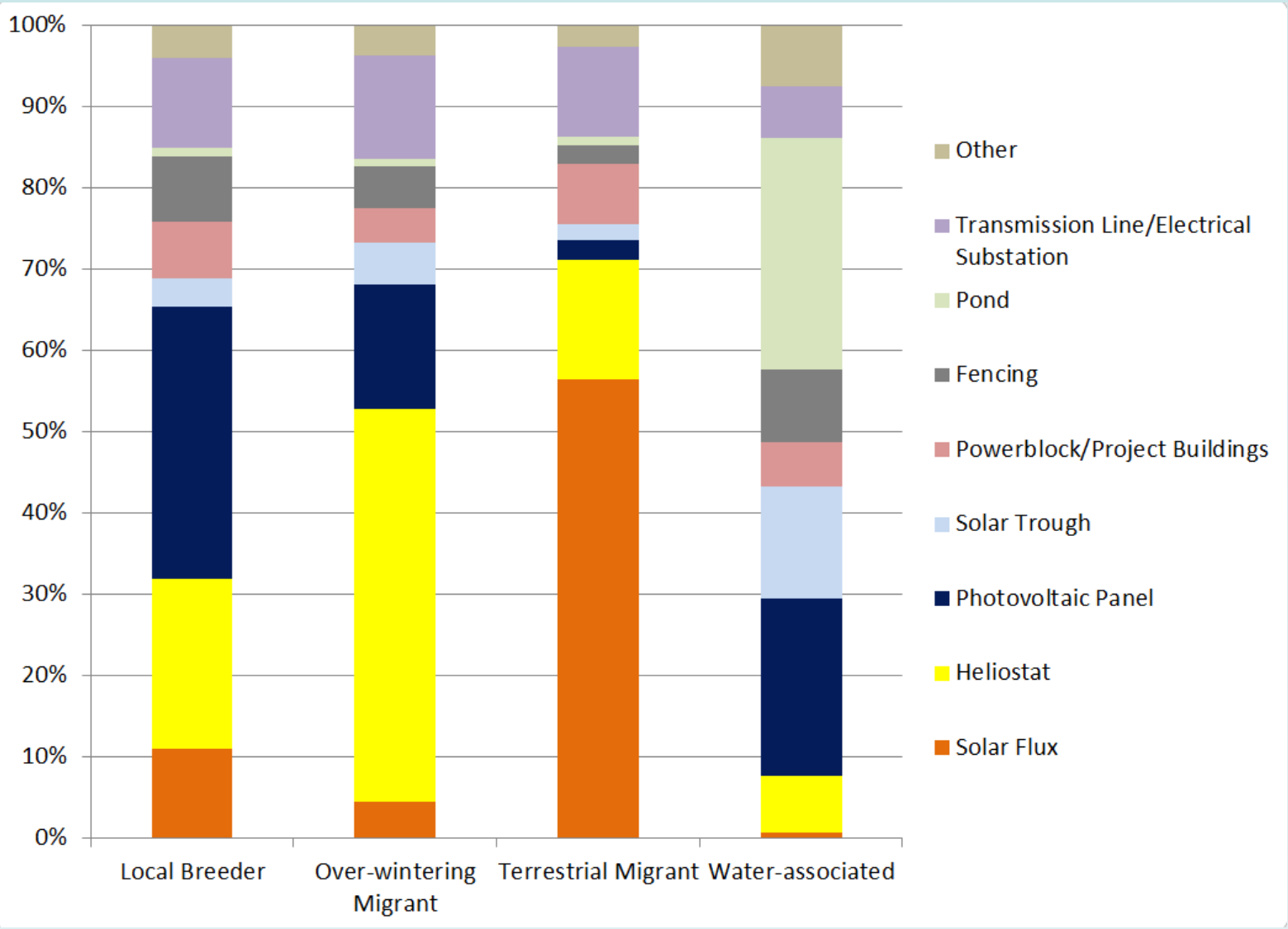
Habitat/Migratory Status of Birds found injured on Solar Projects



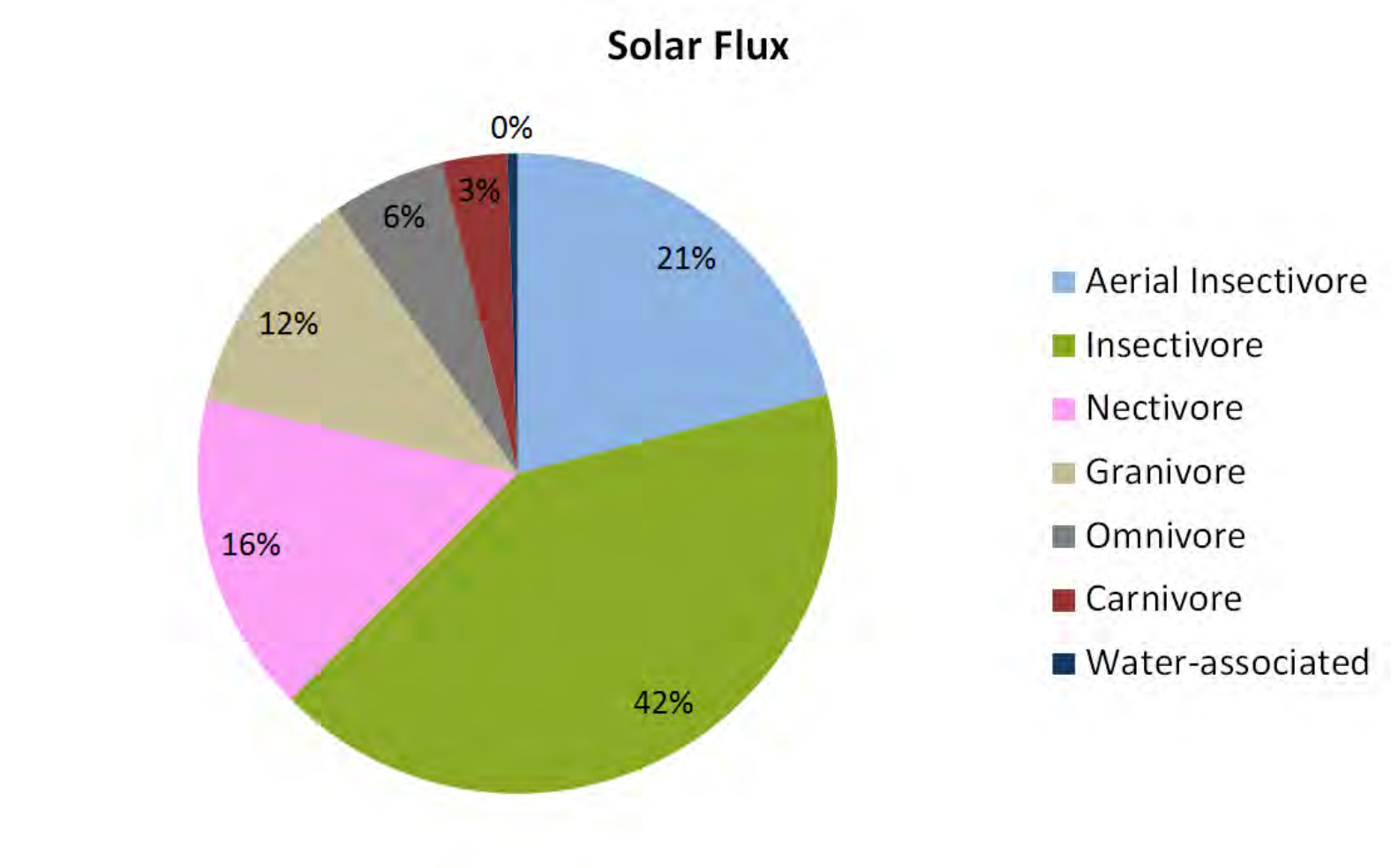
Regional Differences for Photovoltaic



Solar Project Features Associated with Mortalities



Foraging Guilds of Birds with Solar Flux Injuries



Findings

- There may be a “lake effect” associated with utility-scale solar projects similar to that described by Horvath et al. 2009.
- Many birds of conservation concern may be at risk.
- Regional (and site-specific) differences may affect which species are at risk.
- Insects may be attracting some birds to areas with elevated levels of solar flux.
- Many species affected are long-distance migrants, thus population level effects may be difficult to determine.
- Robust monitoring needed to better understand these phenomena and to support adaptive management.

Mortality Monitoring Objectives

- Estimate the total number of birds and bats killed at a facility within a specified time period.
- Determine whether there are spatial or temporal/ seasonal patterns of total bird fatality.
- Evaluate species composition and which taxonomic groups may be at risk.
- Provide results that allow comparisons with other solar sites and to evaluate changes in fatality due to adaptive management.

Research Needs

- Project-scale information needs
- Mojave and Sonoran Desert Migratory Pathways
- Migratory Connectivity Research to identify populations affected
  - Populations affected may be distant from the source of mortalities
  - Stable Isotopes (USGS)
  - Genotypes (UCLA)
  - Telemetry of appropriate-sized birds
- Avian Behavior related to projects
  - Perception and Settling Response
  - Technological Fixes
- Identify Best Management Practices and Deterrent Methods

Update on actions being taken

- Working with solar industry to implement robust mortality monitoring.
  - Searcher Efficiency and Carcass Persistence Trials.
- Solar Bird and Bat Conservation Strategy Guidelines in development.
  - Public meeting on June 22nd in Sacramento.
- Collaborated with USGS to develop Mortality Monitoring Protocols for Solar
  - Protocols for monitoring at each technology type.
- Coordinating with other agencies to find ways to avoid and minimize avian mortalities.
- Coordinating with Avian Solar Working Group (industry and other stakeholders)
- Supporting ongoing research efforts by USGS and UCLA

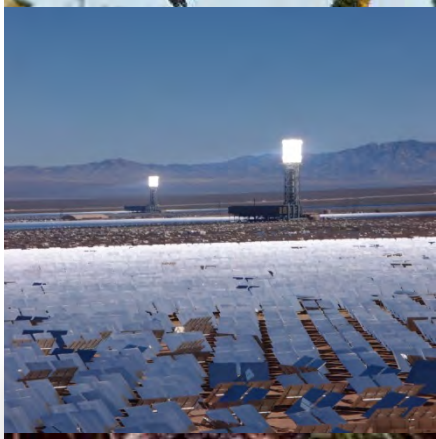
Questions?

Research to Address Wildlife Interactions with Solar Energy Facilities

Avian-Solar Collaborative Working Group

May 10, 2016

USGS Ecosystems Mission Area



U.S. Geological Survey

Ecosystems

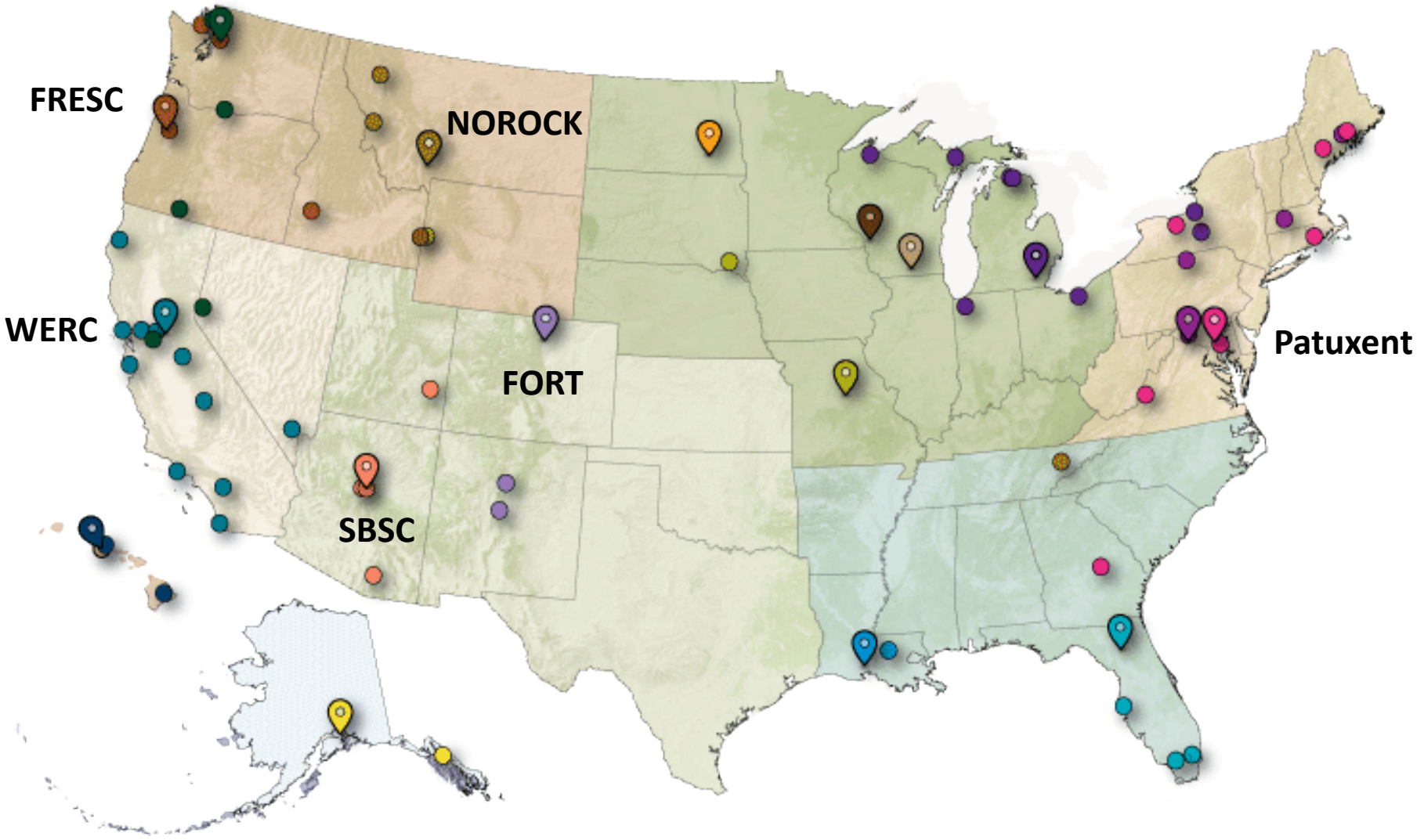
Natural Hazards **Energy and Minerals** **Core Science Systems**

Environmental Health **Water** **Climate and Land Use Change**

Provide the scientific information required for sound natural resource management and conservation decisions

USGS
science for a changing world

USGS Ecosystems Mission Area
17 Science Centers



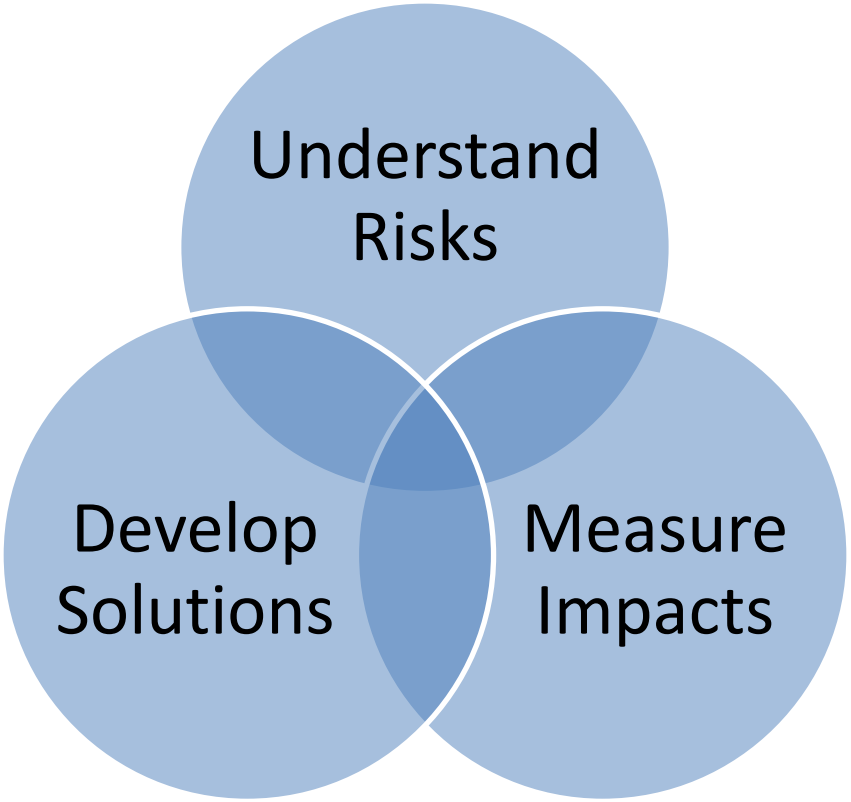
+ 40 Cooperative Research Units

USGS

Energy and Wildlife Research

Goals

- **Understand risks:** when and where wildlife occur and how they use space
- **Measure impacts** to wildlife, both direct and indirect
- **Develop solutions:** minimize impacts through technological fixes, management, mitigation



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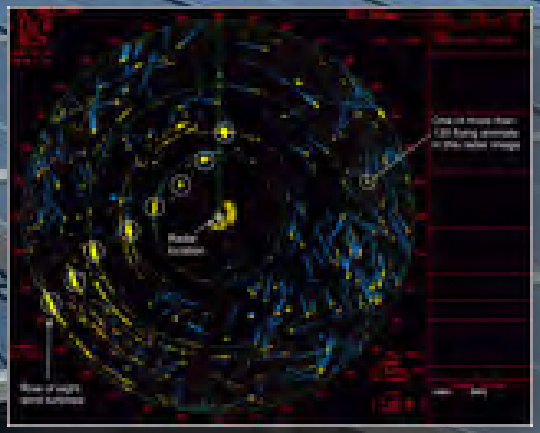
Measuring Impacts

- Characterize direct and indirect impacts to wildlife
- Define sources of fatality
- Develop consistent and accurate methods to detect and estimate fatalities



USGS

Efficacy of Wildlife Monitoring Technologies at the Ivanpah Solar Electric Generating System

Objective:

- Evaluate efficacy of monitoring technologies to detect birds, bats, and insects flying in the vicinity of flux fields produced at the ISEGS
- Tested technologies concurrently (portable radar, surveillance video, thermal video). Also performed invertebrate sampling
- Monitoring period covered ~20 days in May and September 2014 during bird migration season
- Developing data handling and analysis software (presence/absence, speed, direction, abundance)

PIs: Robb Diehl (NRMSC), Paul Cryan & Ernie Valdez (FORT)

Status: In review. Full data release will accompany publication

USGS

Monitoring Methodology for Solar Facilities

- No guidance currently exists for addressing wildlife conservation concerns at solar energy facilities
- Published studies have not directly addressed the methodology needed to accurately estimate fatality of birds and bats at solar facilities

Objective:

- Develop monitoring methodology for solar facilities to produce a consistent carcass search methodology

PI: Manuela Huso (FRESC)

Project completion: May 2016

US FWS Pacific Southwest Region

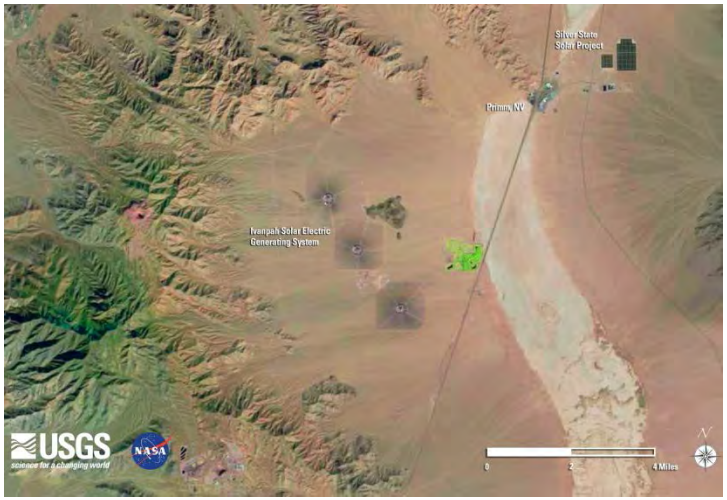
USGS

Solar Fatality Estimator and "*Evidence of Absence*" Software

Need consistent and accurate methods to detect and estimate fatalities from carcass searches at solar facilities

Objective:

- Modify existing software to produce unbiased estimates of fatalities at utility-scale solar facilities and "Evidence of Absence" software for rare species
- Define sources of fatality
- Estimate searcher efficiency and carcass persistence
- Determine when thresholds have likely been exceeded and mitigation might be considered



Ivanpah Solar Electric Generating System


Golden eagle at wind farm in CA.
Credit: Jeff Lovich

PI: Manuela Huso (FRESC)

Anticipated completion: April 2017

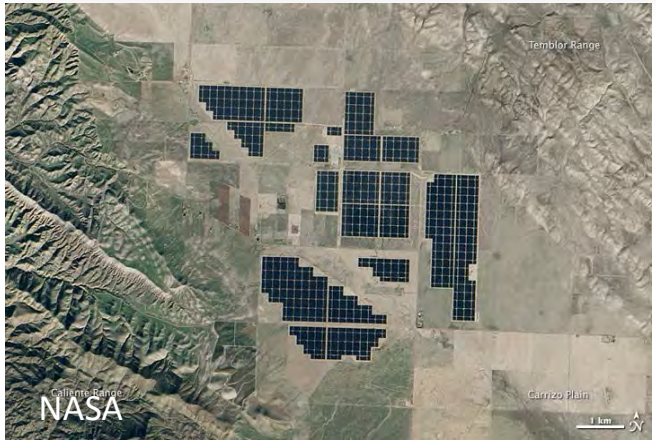
USGS

Assess Energy Development Impacts to Sensitive Bird and Bat Species and Populations

Need to more accurately estimate fatality rates and effectiveness of mitigation techniques

Project Objective:

- Estimate geographic scope of species impacted
- Use demographic modeling to assess how fatalities affect population increases or declines
- Determine best practices for conducting risk assessments and predicting mitigation outcomes

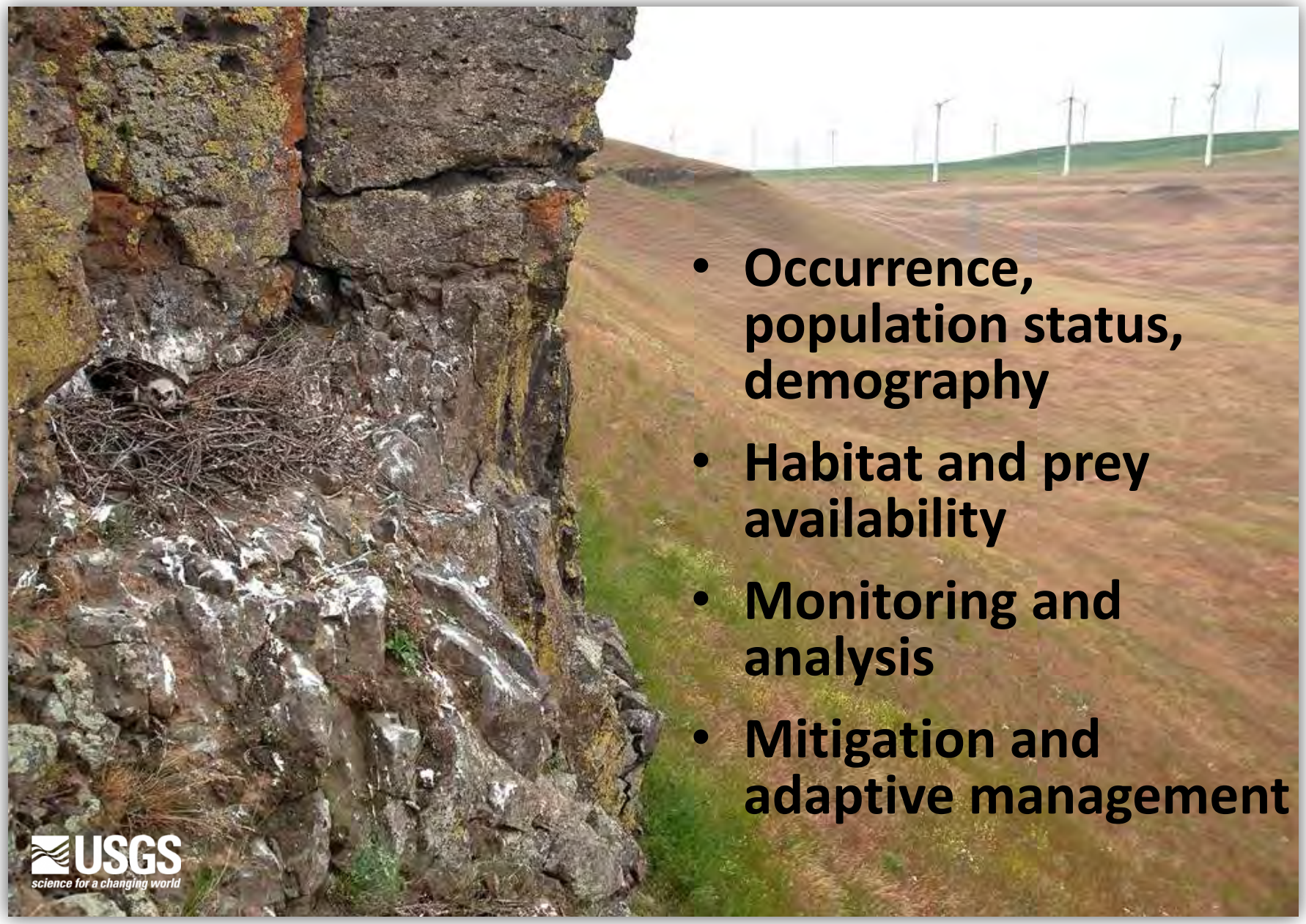


PI: Todd Katzner (FRESC)

Project period: 2015-2018

USGS

Understanding Risks



- Occurrence, population status, demography
- Habitat and prey availability
- Monitoring and analysis
- Mitigation and adaptive management

USGS
science for a changing world

Habitat Modeling to Inform Energy Development

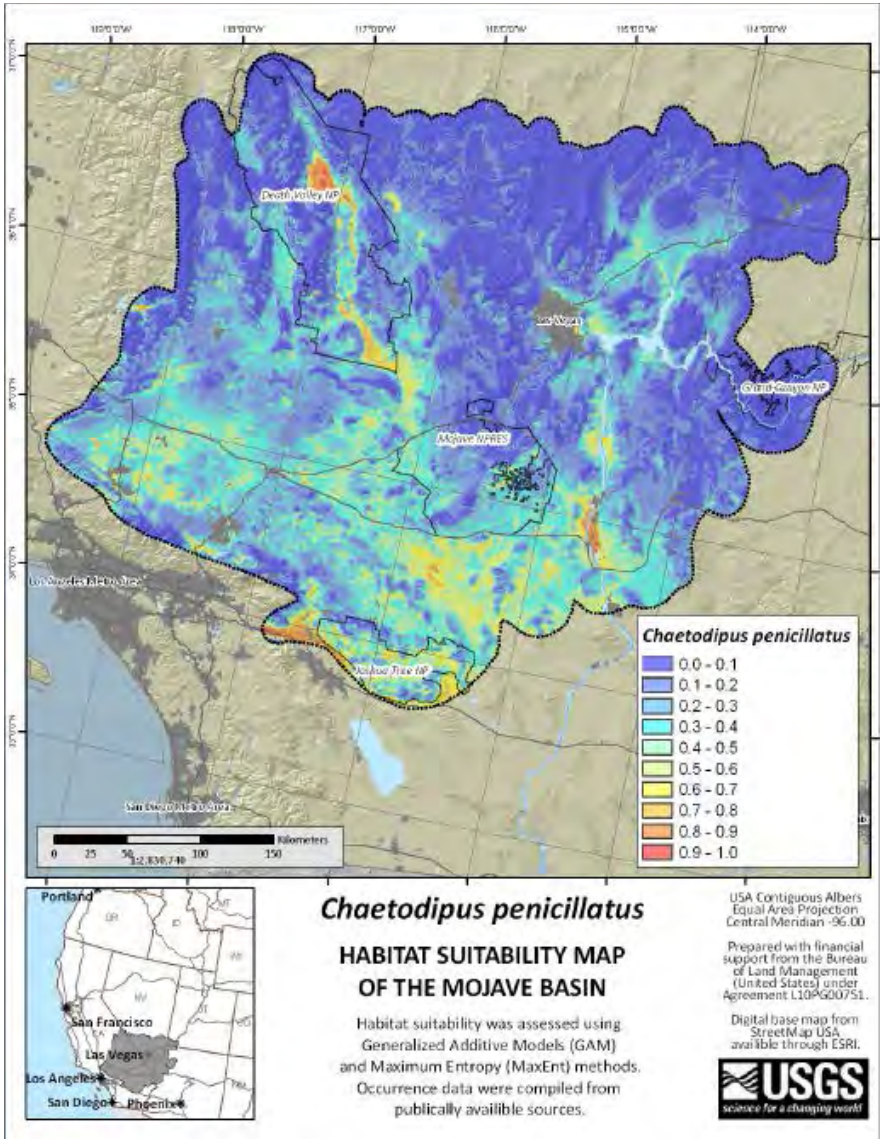
Renewable energy development in the Mojave Ecoregion is creating potential impacts to multiple species of wildlife

USGS Published Research

- Habitat suitability models for over 50 desert plant and animal species can be used to rank potential habitat loss
- Golden eagle status assessments and monitoring protocols

PIs: Todd Esque, Amy Vandergast (WERC)

Publication: Inman, R. D. et al., 2014. Mapping Habitat for Multiple Species in the Desert Southwest. Open File Report 2014-1134.



USGS

Linking Habitat and Prey Availability to Golden Eagle Ecology and Solar Energy in the Mojave

Inform energy and land-use planning ; assist with delineating conservation and development zones

Golden Eagle. Credit: USFWS

Objectives:

- Assess food habits, reproductive success and prey availability of nesting golden eagles in the Mojave
- Synthesize and review rabbit distribution and abundance in the Western US
- Develop a regional prey database for rabbit populations across 17 western states

PIs: Kathleen Longshore & Todd Esque (WERC)

Product completion: Spring/Summer 2016

USGS

Surveying and Monitoring Golden Eagles and Other Raptors in the DRECP Area

Effective surveys for eagles and status monitoring and mapping are needed to meet DRECP objectives

Objective:

- Develop survey designs and field procedures to determine the distribution of golden eagles
- Assess their occurrence and nesting success in the DRECP area
- Compile and analyze eagle population data for CA & NV, and the larger context of their full migratory range into a geospatial database

PI: David Wiens (FRESC)

Project Completion: Summer 2016

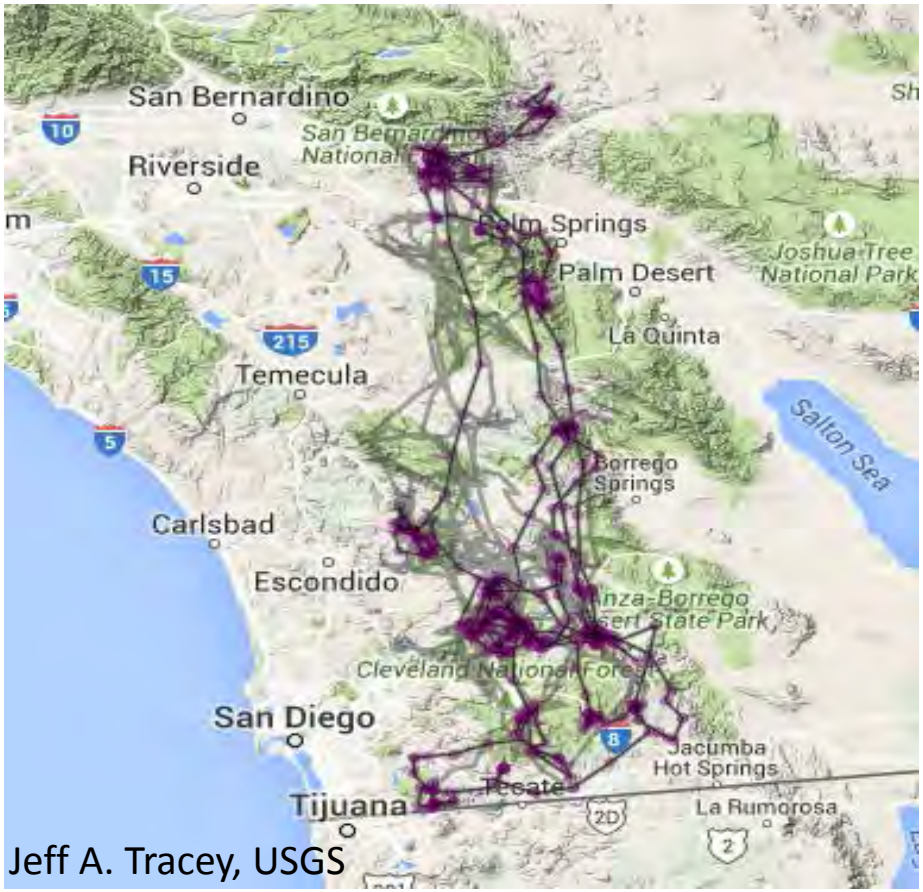
USGS

Helping Inform Siting Decisions

What are regional golden eagle nesting and foraging behaviors that may lead to eagle – infrastructure interactions?

Objectives:

- Population surveys, biotelemetry and genetics
- Focus on occupancy and movement
- Abundance and survival in relation to prey dynamics
- Regional understanding



Jeff A. Tracey, USGS

PIs: Jeff Tracey & Robert Fisher (WERC)

Products: Biotelemetry data for 24 eagles released May 2016

USGS

Needs and Future Directions

- Expand research on wildlife interactions with large scale solar power facilities
- Understand direct and indirect effects on species and landscapes
- Expand knowledge of where species are on the landscape
- Continue efforts to develop deterrents to minimize interactions of wildlife with facilities and effective mitigation strategies

USGS

USGS Energy and Wildlife Contacts

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U.S. Geological Survey (703)
648-6499 mkhalil@usgs.gov

USGS

Recent USGS Publications of Relevance to Solar Energy Development

- Braham, M.E., Miller, T.A., Duerr, A., Lanzone, M., Fesnock, A., Lapre, L., Driscoll, D., Katzner, T.E., 2015, Home in the heat- Dramatic seasonal variation in home range of desert golden eagles informs management for renewable energy development. DOI- 10.1016/j.biocon.2015.03.020: Biological Conservation, v. 186, p. 225-232.
- Duerr, A., Miller, T.A., Duerr, K.C., Lanzone, M., Fesnock, A., Katzner, T.E., 2015, Landscape-scale distribution and density of raptor populations wintering in anthropogenic-dominated desert landscapes. DOI- 10.1007/s10531-015-0916-6: Biodiversity and Conservation, v. 24, no. 10, p. 2365-2381.
- Simes, M.T., K.M. Longshore, K.E. Nussear, G.L. Beatty, D.E. Brown, and T.C. Esque, 2015, Black-tailed and white tailed jackrabbits in the American West: History, ecology, significance, and survey methods. Submitted to Western North American Naturalist 75(4):491-521. DOI: 10.3398/064.075.0406
- Simes, M.T., K.M. Longshore, K.E. Nussear, G.L. Beatty, D.E. Brown, and T.C. Esque. *In Review*. An annotated bibliography for the black-tailed jackrabbit (*Lepus californicus*) and white-tailed jackrabbit (Lepus townsendii). Prepared and submitted as a USGS Open-File Report
- Dilts, T. E., Weisberg, P. J., Leitner, P., Matocq, M. D., Inman, R. D., Nussear, K. E. and Esque, T. C. (2016), Multi-scale connectivity and graph theory highlight critical areas for conservation under climate change. Ecol Appl. Accepted Author Manuscript. doi:10.1890/15-0925
- Tracey, J.A., Madden, M.C., Sebes, J.B., Bloom, P.H., Katzner, T.E., and Fisher, R.N., 2016, Biotelemetry data for golden eagles (*Aquila chrysaetos*) captured in coastal southern California, November 2014–February 2016: U.S. Geological Survey Data Series 994, 32 p., http://dx.doi.org/10.3133/ds994.

ASWG Mission

The ASWG is a collaborative group of environmental organizations, academics, solar companies, and solar industry representatives that will advance coordinated scientific research to better understand how birds interact with solar facilities. Given the threat that climate change poses to avian species, participants will work with the shared interests of protecting avian species and developing solar projects in an environmentally responsible and a commercially viable manner.

Participants and Roles

- Convener: Large-scale Solar Association
- Facilitation team: Pivot Point
- Decision-making members:
  - Audubon California
  - Defenders of Wildlife
  - Duke Energy
  - First Solar
  - Large-scale Solar Association
  - Natural Resources Defense Counsel
  - NextEra Energy Resources
  - Recurrent Energy
  - SunEdison
  - SunPower

Progress to Date

2016

January

- ASWG meeting with Research Panel (1/13)
- Finalizing Terms of Reference
- Multiagency CWG meeting

February

- Research panel works independently
- ASWG call with research panel

March

- ASWG meeting
- Progress report on Research Panel from Science Advisors

April

- Research Panel develops draft report

Ongoing Engagement with Multiagency Avian-Solar Collaborative Working Group

ASWG Next Steps

2016

May

- Multiagency CWG meeting (Week of 5/9)
- Research panel shares draft report with ASWG

June

- ASWG meeting with research panel (6/1-2)
- ASWG discussion of priorities

July-August

- ASWG and agency observers to meet to discuss final report
- Finalize priorities after agency input

Ongoing Engagement with Multiagency Avian-Solar Collaborative Working Group

Research Panelists

Science Advisors		
Thomas Smith	UCLA	Director, Center for Tropical Research
Kristen Ruegg	UCLA / UCSC	Institute for the Environment and Sustainability, Center for Tropical Research
Research Panelists		
Steve Beissinger	UC Berkeley	Professor of Conservation Biology
Wally Erickson	WEST Consulting	CEO / Senior Statistician
Vasilis Fthenakis	Brookhaven National Lab	Principal Investigator
Luke George	Colorado State University	Senior Research Associate
Rodney Siegel	Institute for Bird Populations	Executive Director

ASWG Research Questions

I. Siting

1) Do avian mortality rates at PV solar power plants differ from background rates at control sites?

2) What is the relationship of mortality rates to site characteristics (e.g., panels, fence lines, overhead transmission lines, scale/configuration of installations, proximity to other solar facilities or other natural or human landscape features such as levels of fragmentation and loss of habitat, migratory flyways and stop over sites, etc.)?

3) How might siting be optimized to reduce potential impacts on vulnerable bird populations in a cost-effective manner?

ASWG Research Questions

II. Population level effects

1) Are solar sites causing avian mortality that is significant at the scale of the population for individual species?

a) How should populations be defined in this context?

b) What research and data would be required to determine if mortality associated with solar sites is additive or compensatory?

c) How do population impacts differ by species, guild, migratory pathway, taxonomic unit and classification (threatened versus non-threatened), etc.?

ASWG Research Questions

III. Lake Effect

1) Are water or other birds attracted to solar panels because they perceive them as water bodies (i.e., a “Lake Effect”)?
2) Is a possible Lake Effect related to geographic and environmental/infrastructure characteristics of sites?
3) Do birds show evidence of attraction to large solar arrays (e.g. show changes in flight direction or behavior as they approach arrays)?
4) What types of birds are affected?
5) Is possible mortality due to stranding, strikes or some other process?
6) If the Lake Effect is demonstrated, what cues are causing the birds to mistake the solar array as a water body (e.g., what wavelength of reflected light are they responding to)?
7) If a Lake Effect can be demonstrated, how might the threat be mitigated or eliminated?

ASWG Research Questions

IV. Avian attraction/mitigation/deterrents

1) What are the avian risk-reduction options that might lower avian mortality?

V. Feather spots

1) What do feather spots represent? Can feather spots be better defined and quantified?

a) What methods can be used to identify the species and number of individuals that comprise feather spots? Are feather spots a reliable indicator of avian strikes and/or fatalities.

b) Do feather spots from larger carcasses persist in the environment longer than spots from smaller ones?

ASWG Research Questions

VI. Climate change and other broader impacts

1) What demographic effects may result from climate change in the absence of large-scale solar development, and how do these compare with the impacts of solar facilities for specific bird populations?

2) Using historical and contemporary data on the abundance and distribution of avian species with future climate projections, what are the predictions for the future avian distribution and population trends in California?

    a) How can this be used to mitigate the impacts of PV facilities?

Achieving Mutual Goals

- Understanding common research interests
- Identifying key priorities
- Identifying funding mechanisms
- Continued collaboration to drive short and long term results

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Development of Tools, Training, and Outreach to Address Solar Glare and Flux-Related Avian Impacts

Multiagency Avian-Solar Collaborative Working Group Public Workshop

Timothy Wendelin
National Renewable Energy Laboratory

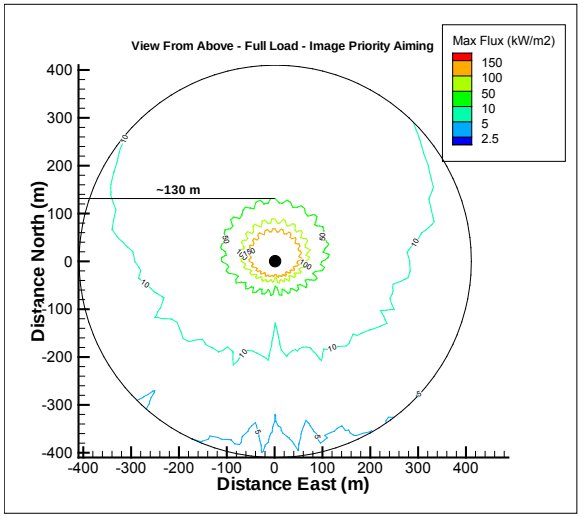
Clifford K. Ho
Sandia National Laboratories

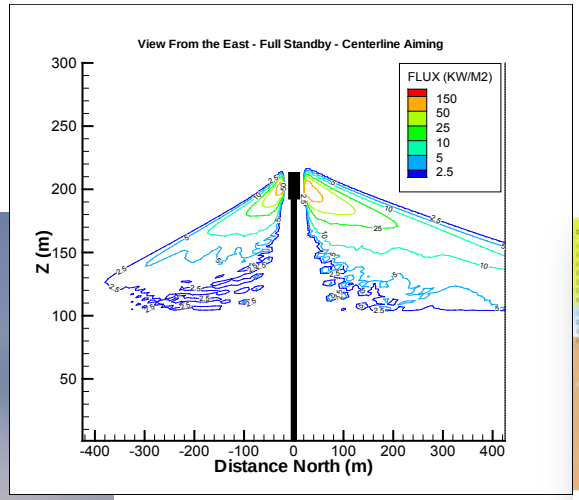
Cianin Sims
Sims Industries

May 10, 2016

Goals

- **DOE is funding work to address avian flux hazards**
  - Develop models and tools to quantify flux (power/unit area) from heliostat aiming strategies
  - Mitigate impacts of avian (and glare) hazards
  - Optimize operational performance





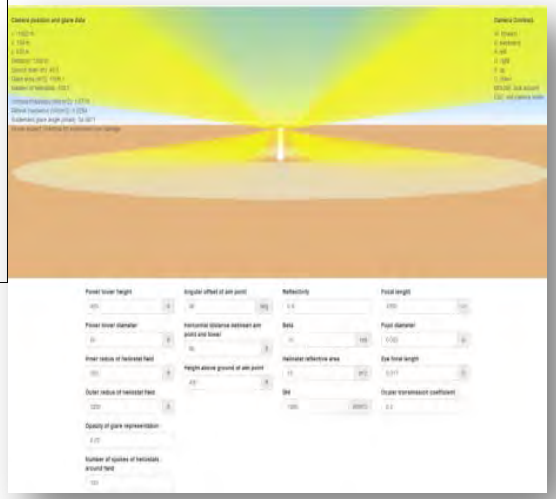
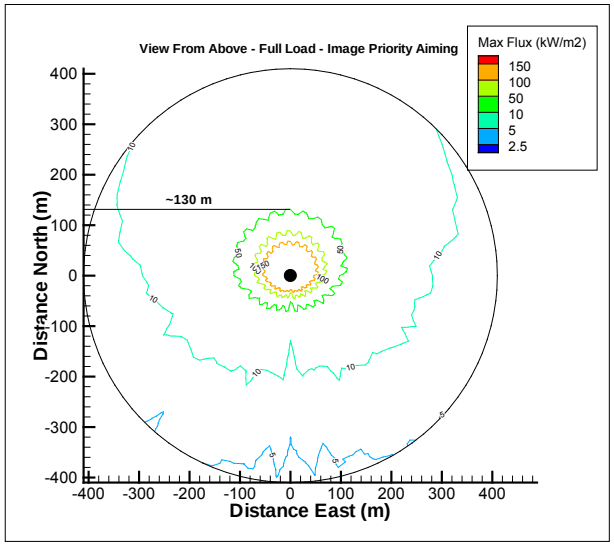
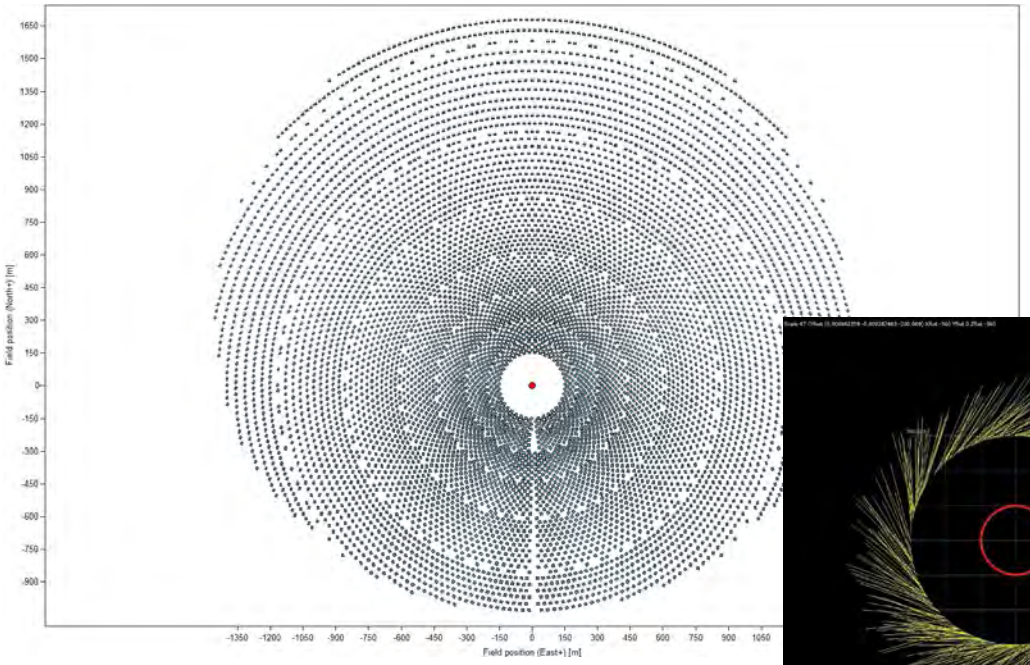


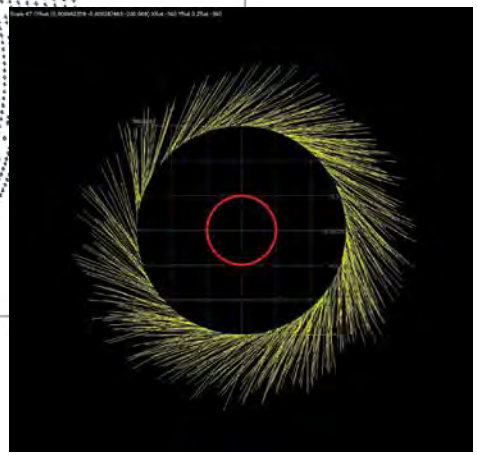
Photo and model of high-flux regions causing solar glare and avian hazards at Ivanpah Solar Electric Generating System

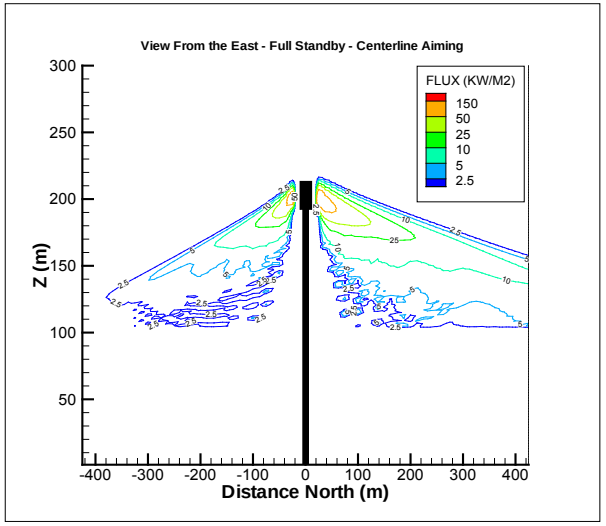
Previous Work

- **Argonne/NREL Study "A Summary Review of Issues Related to Avian Mortality at Utility-Scale Solar Facilities"**
  - Preliminary results compare well with previous analyses
  - Various approaches to standby aiming can significantly reduce flux levels and their impact on avian mortality.
  - Future work recommended to determine the impact of alternative aiming strategies which simultaneously minimize impacts to plant operations and avian health.









Approach

1. Identify metrics for safe solar flux levels

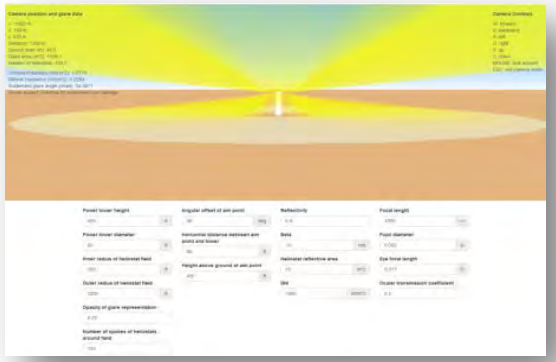
2. Develop tools to model solar flux in air space around power tower
   - Case studies: Ivanpah and NSTTF at Sandia (for validation)

3. Compare alternative heliostat standby-aiming strategies
   - Minimize solar flux according to metrics in (1) above
   - Minimize impact on plant operations

4. Develop user friendly assessment tool for agencies/stakeholders

Ivanpah Solar Electric Generating System

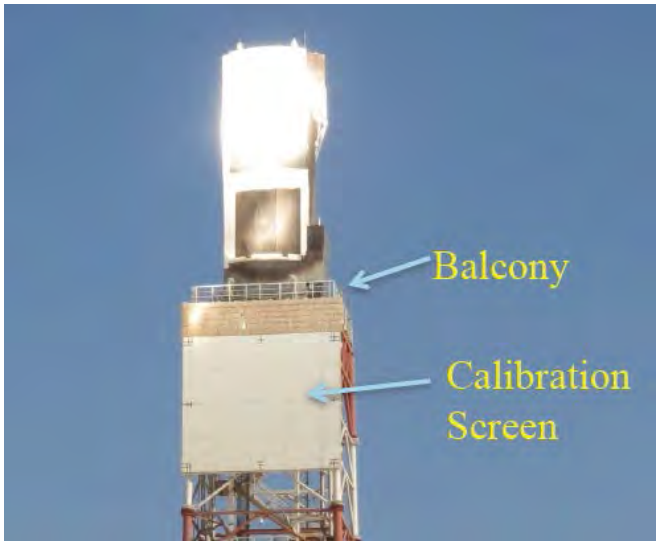
National Solar Thermal Test Facility (NSTTF)

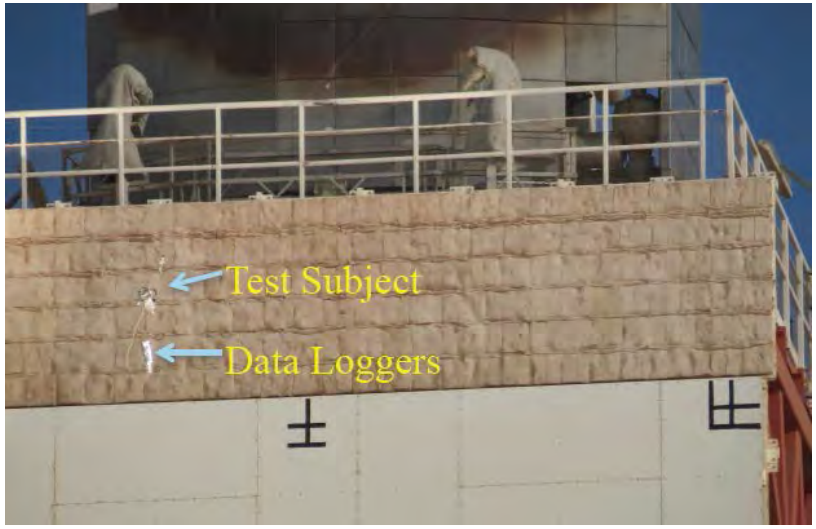


Tower Illuminance Model

Solar Energy Development Center
(Negev Desert, Southern Israel)

- Tests conducted with bird carcasses exposed to different flux levels (Santolo, 2012)
  - "no observable effects on feathers or tissue were found in test birds where solar flux was below 50 kW/m^2 with exposure times of up to 30 seconds."
  - California Energy Commission analytical study found that "a threshold of safe exposure does not exist above a solar flux density of 4 kW/m^2 for a one-minute exposure"





Crescent Dunes (SolarReserve)

(Tonopah, Nevada)

- **110 MW_e molten-salt power tower**
- **In January 2015, 3,000 heliostats were aimed at standby points above receiver**
  - 115 bird deaths in 4 hours
  - SolarReserve spread the aim points to reduce peak flux to < 4 kW/m^2
    - Reported zero bird fatalities in months following change

Figure 1 – The halo created by the reflected light of 3,000 heliostats which caused the bird mortalities.

Images from http://cleantechnica.com

Ivanpah Solar Electric Generating System

(Ivanpah, California)

- **390 MW_e direct steam power-tower plant (3 towers)**
- **Kagan et al. (2014) found 141 bird fatalities Oct 21 – 24, 2013**
  - 33% caused by solar flux
  - 67% caused by collisions or predation
- **H.T. Harvey and Associates found 703 bird fatalities in first year at ISEGS**
  - Study estimated 3500 bird fatalities accounting for search efficiency and scavengers removing carcasses
- **ISEGS has since implemented new heliostat aiming strategies and bird deterrents**

	Number of Detections				
Cause	**Winter**	**Spring**	**Summer**	**Fall**	**Total**
Singed	27	100	42	147	316
Collision	14	15	10	45	84
Other*	5	5	2	3	15
Unknown	51	82	61	94	288
Total	**97**	**202**	**115**	**289**	**703**

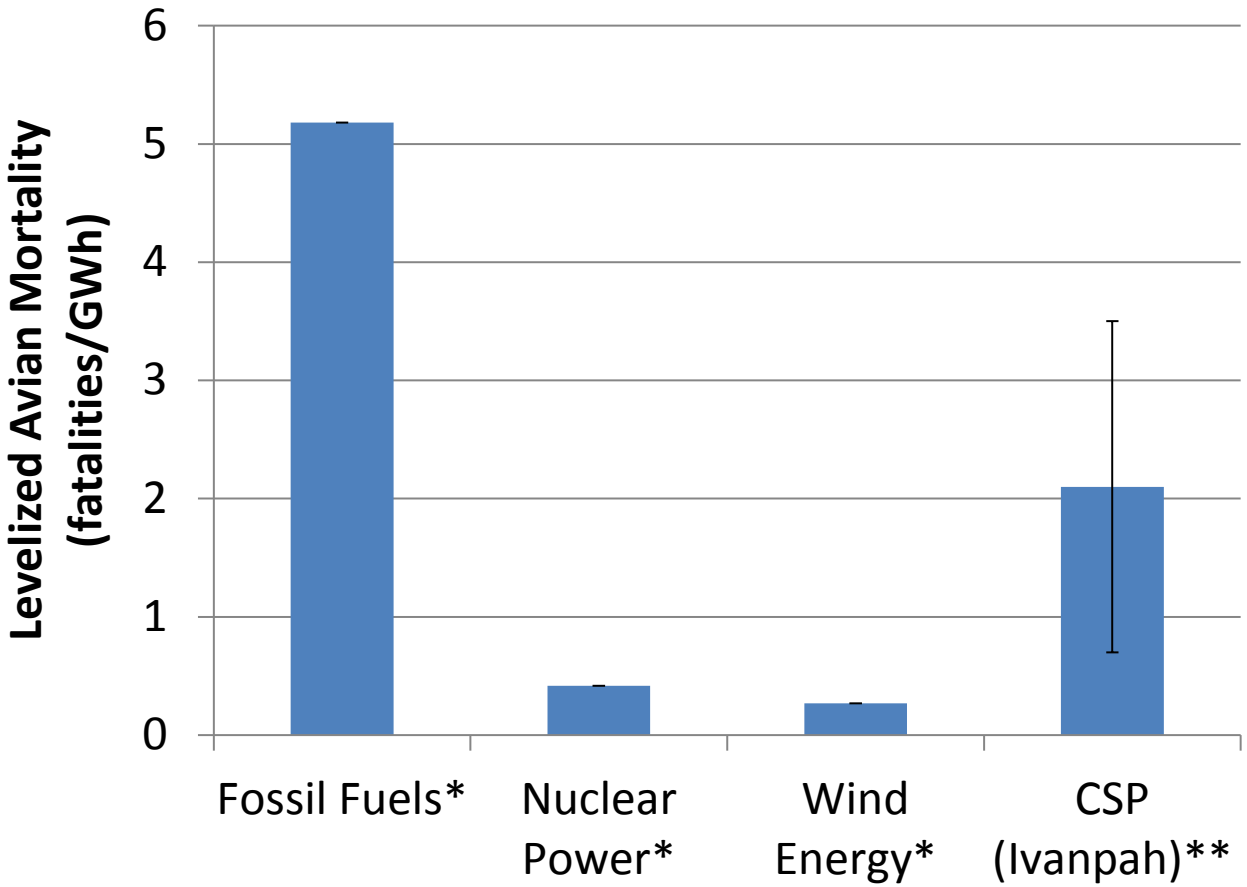
* Includes detections in ACC buildings without evidence of singeing or collision effects.

H.T. Harvey and Associates, 2013 - 2014

Gemasolar Thermosolar Plant
(Andalusia, Spain)

- 20 MW_e molten-salt power tower plant
- 14-month study revealed no avian fatalities in vicinity of tower (Dept. of Zoology, U. Granada)

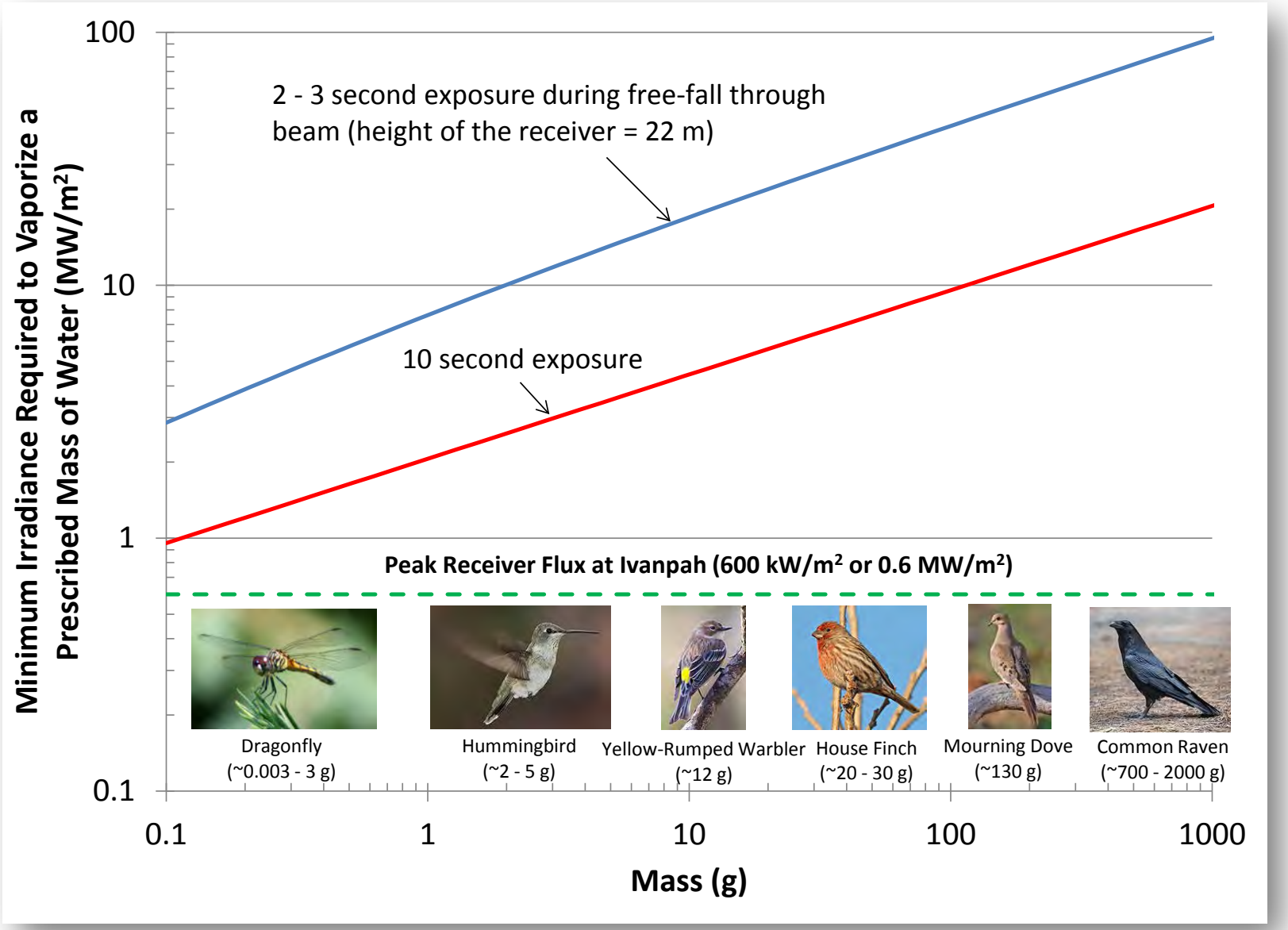
Levelized Avian Mortality for Energy (LAME)



*Sovacool (2009)

**During first year of operation at Ivanpah (2013 – 2014) before mitigation measures and deterrents were implemented

Feasibility of Bird Vaporization



Deterrents

- **Acoustic**
  - Painful or predatory sounds
- **Visual**
  - Intense lights and decoys
- **Tactile**
  - Bird spikes, anti-perching devices
- **Chemosensory**
  - Grape-flavored powder drinks (methyl anthranilate)

Conclusions from prior studies

- The large number of "streamers," or smoke plumes, observed and attributed to vaporization of birds is likely caused by insects flying into the concentrated flux
- Complete vaporization of birds flying into concentrated solar flux is highly improbable
- Safe irradiance levels for birds have been reported to range from 4 kW/m^2 to 50 kW/m^2
- Mitigation measures and bird deterrents can and are being used

Flux Hazard Analysis

- Create computer model of baseline power tower design (Ivanpah Unit #2) in SolarPILOT / SolTrace.
  - Heliostat geometry, positions and tower height from NRG.
- Create computer model of National Solar Thermal Test Facility in SolarPILOT / SolTrace.
  - Validate model using flux measurement tools

Flux Hazard Analysis

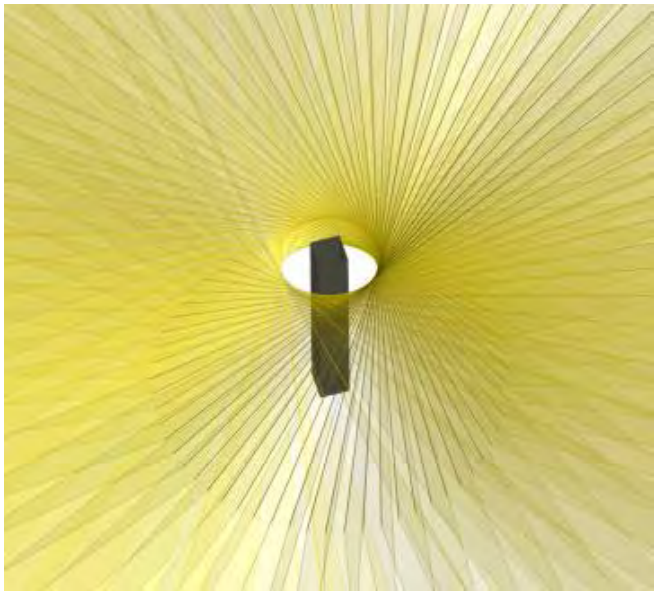
- Obtain/establish relevant information/parametric data from industry/stakeholder workshop
  - Baseline/novel aiming strategies.
  - Heliostat control capabilities (slew rates, aiming algorithms/capabilities)
  - Metrics for safe solar flux levels (I_{haz}, $V > I_{haz}$)
  - Performance metrics

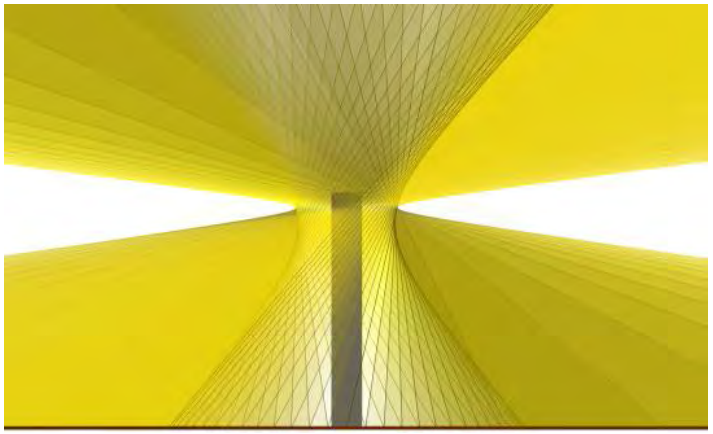
Flux Hazard Analysis

- Apply methodology to Ivanpah and NSTTF fields for analyzing baseline and alternative cases for standby conditions.
  - Generate volumetric flux maps for standby aim-point strategies for representative times and days of the year.
  - For representative flight paths through the volume, perform worse case thermal analysis to determine whether surface (feather) temperature exceeds 160^{o} C along given flight path.
  - Consider number of flight paths exceeding 160^{o}C or the total time of exceedance as metrics to determine the effectiveness of different stand-by aiming strategies.

Flux Hazard Analysis

- Evaluate successful aiming strategies for impact on annual performance
  - Quantify time from standby to operational for representative days of the year and for both baseline and alternative standby aiming strategies.
  - Quantify annual performance impact of alternative vs baseline cases with the goal of achieving zero loss of annual energy delivered.
- Provide both input and output data from methodology for validation of the enhanced Tower Illuminance Model (TIM)





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Wind Energy/Wildlife Interactions: Overview of the Challenges and Current Efforts to Address Them



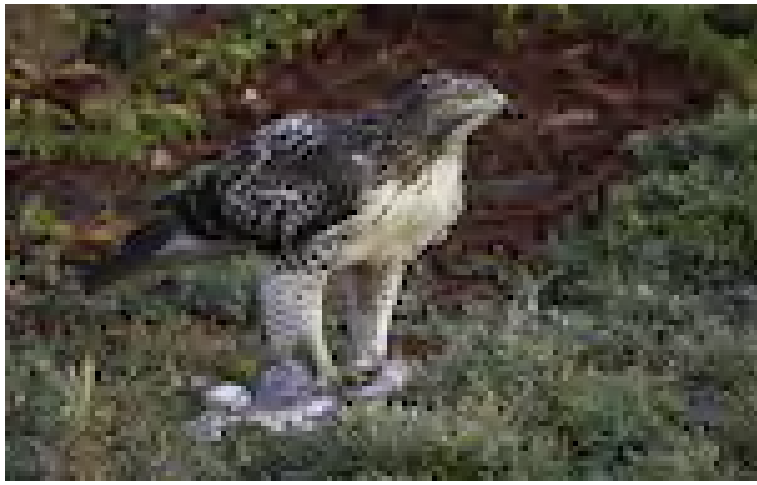

Elise DeGeorge, NREL

May 11, 2016



Outline

- Historical overview and statutory authority
- Challenges to wildlife
- Key species habitat distribution
- Research
- Collaboratives
- Conclusions



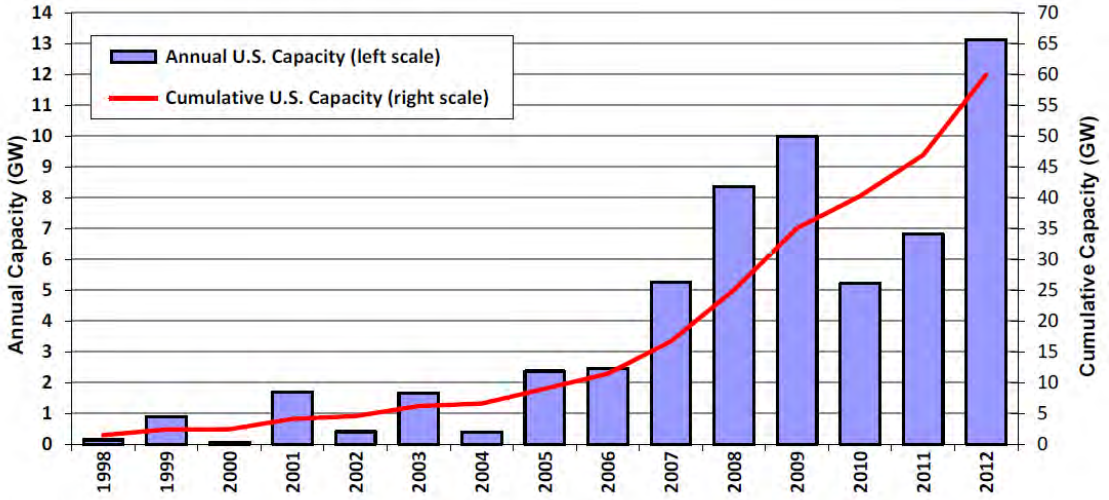
Red-tailed hawk eating a rabbit.
Photo by Dennis Schroeder, NREL 22325

Outline

- Historical overview and statutory authority
- Challenges to wildlife
- Key species habitat distribution
- Research
- Collaboratives
- Conclusions

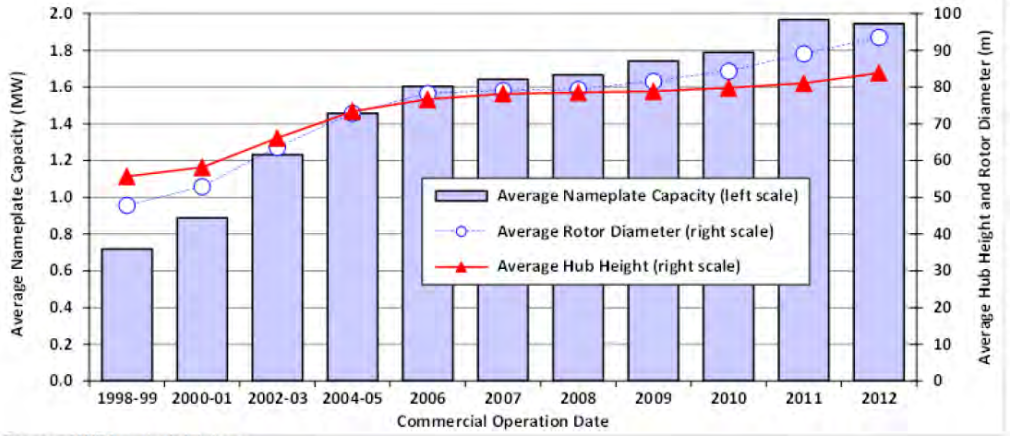
Photo by J. Lucas, Purdue University

Wind Installed Capacity over Time



Source: AWEA project database

Figure 1. Annual and Cumulative Growth in U.S. Wind Power Capacity

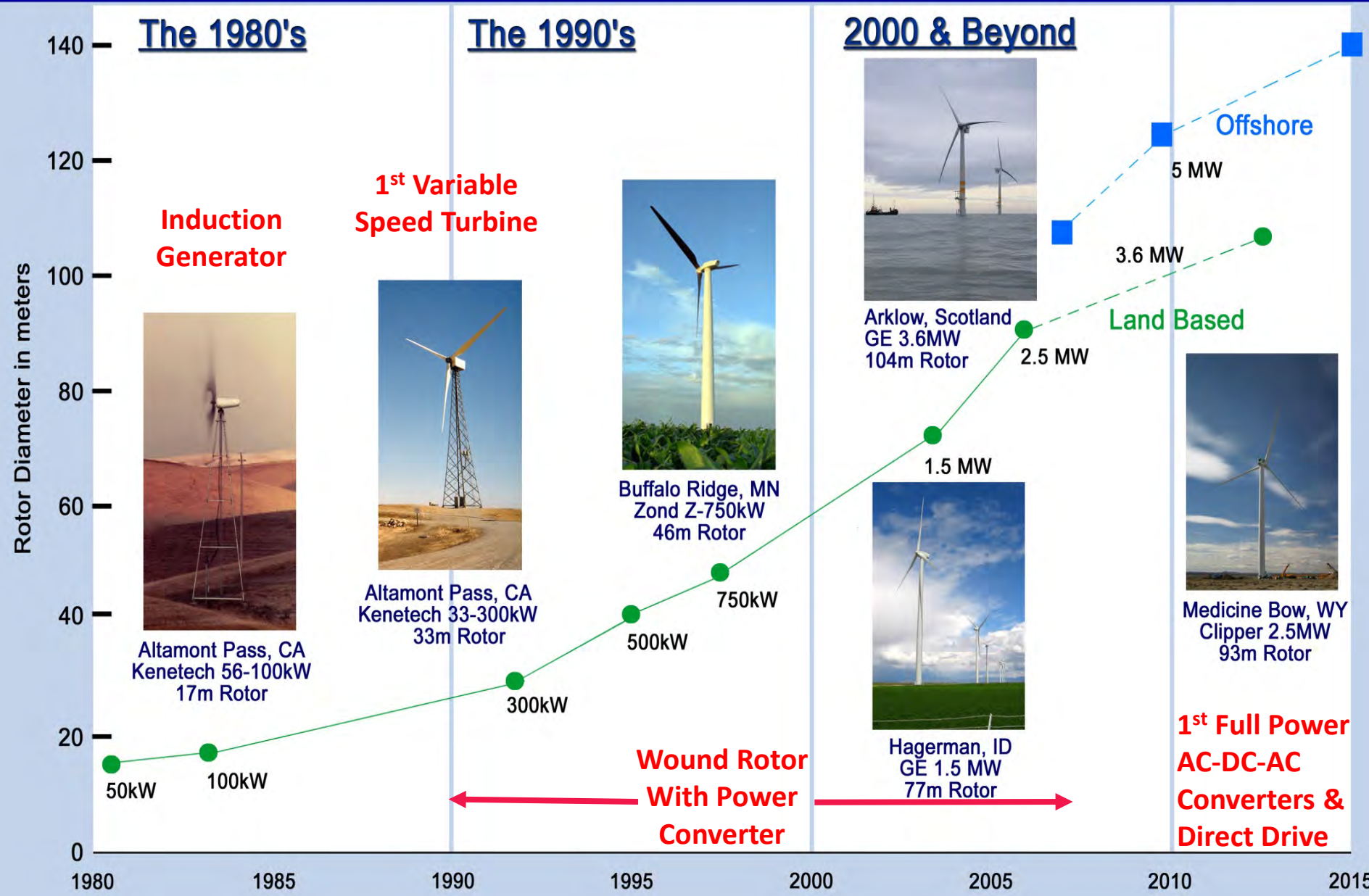


Source: AWEA project database

Figure 15. Average Turbine Nameplate Capacity, Rotor Diameter, and Hub Height Installed during Period (only turbines larger than 100 kW)

Source: 2012 Wind Technologies Market Report

Evolution of U.S. Commercial Wind Technology



Wind Turbines May Impact Wildlife & Habitats

The discussion of wind turbine impact on wildlife began at the Altamont Wind Resource Area, California, in the late 1980s and early 1990s

Junction Hill Top Wind Farm, Iowa. Five GE 1.6-megawatt (MW) turbines. *Photo by Tom Wind, NREL 26494*

Altamont Pass Wind Resource Area, California. Kenetech 56-100 kilowatt (kW) turbines. *Photo by Shawn Smallwood, NREL 17329*

Real or Perceived Wildlife Impacts can be a Challenge for Development

- Misinformation on potential of impacts is rampant
- Impacts are species- and habitat-specific
- Impacts are site-specific; micrositing is critical to reducing these impacts.

Combination of 221 Mitsubishi Heavy Industries 1-MW turbines and 53 GE 1.5-MW turbines at the Cedar Creek Wind Farm in Grover, Colorado. *Photo by Dennis Schroeder, NREL 30593*

Eight Nordex N60, 1,300-kW wind turbines in Garrett, Pennsylvania. *Photo by Green Mountain Energy* Company, *NREL 09699*

Figure 2: Summary of All Bird Mortality Rates at Various Wind Energy Facilities*

Bird Mortality at U.S. Wind Sites

The average is about three birds/MW/year

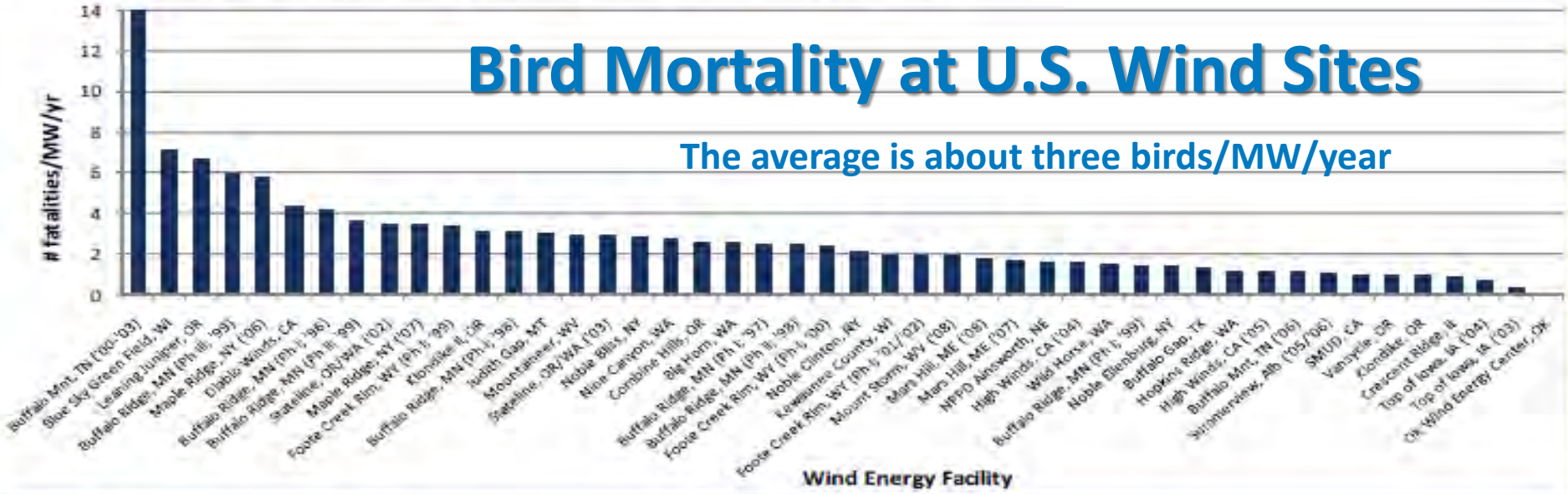
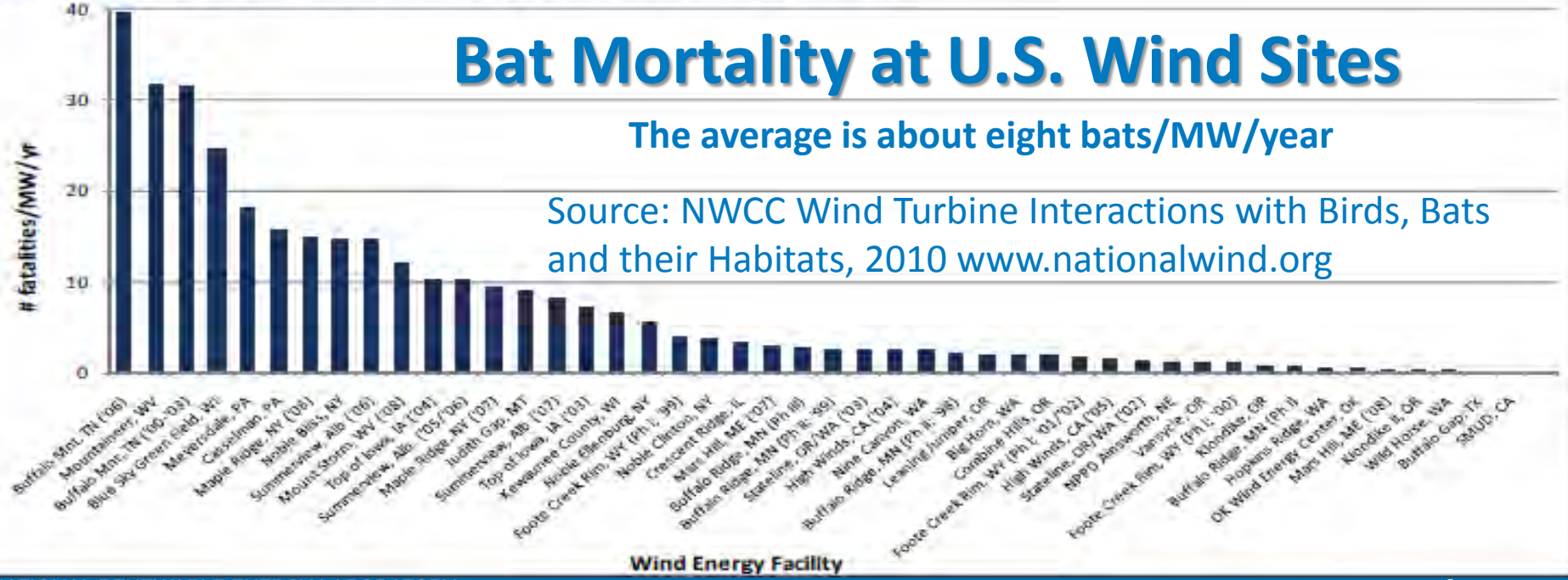


Figure 3: Summary of Bat Mortality Rates at Various Wind Energy Facilities*

Bat Mortality at U.S. Wind Sites

The average is about eight bats/MW/year

Source: NWCC Wind Turbine Interactions with Birds, Bats and their Habitats, 2010 www.nationalwind.org



U.S. Fish and Wildlife Service Statutory Authority for Wind Permitting Guidelines

- **Endangered Species Act:**
  - Directs the Service to identify and protect threatened and endangered species and their critical habitat
  - Must provide a means to protect the species' ecosystems.
- **Migratory Bird Treaty Act:**
  - Based on a strict liability statute
  - Does not require proof of intent, knowledge, or negligence to be deemed a violation
  - Does include actions resulting in the 'taking' or possession of a protected species, in the absence of a USFWS permit or regulatory authorization, is deemed a violation.
- **Bald and Golden Eagle Protection Act:**
  - Provides additional legal protection for bald and golden eagles. First enacted in 1940/ golden eagle added in 1962

Whooping Crane. *Photo by Karin Sinclair, NREL 27961*

Bald Eagle. *NREL 01101*

Outline

- Historical overview and statutory authority
- Challenges to wildlife
- Key species habitat distribution
- Research
- Collaboratives
- Conclusions

Challenges to Wildlife Related to Wind Energy

Wildlife challenges include:

- Habitat and species that are likely to be impacted vary by
  - Climate
  - Topography
  - Location
- No single solution
- Impacts expected to increase as more turbines are installed across the country—but these can be managed.

Ways of addressing the challenges:

- Identify-near-term research needs
- Use a multipronged approach
- Involve multiple stakeholders
- Garner support for collaborative field research, methods/metrics refinement, tools, mitigation strategies, and deterrent development/testing
- Disseminate information.

Challenges: Key Issues Being Addressed

Impacts of wind turbines on wildlife include:

- Bats (mortality)
- Raptors (mortality)
- Nocturnal migration (mortality)
- Prairie birds (habitat – displacement; genetic diversity)
- Cumulative (population impacts).

Tools to avoid problematic sites:

- Federal (e.g. Wind Energy Guidelines)
- State guidelines
- Pre versus post construction validation
- Mapping of migratory pathways
- Presiting assessments
- Risk assessments
- Literature archive
- Peer review (promote transparency)

Sage Grouse. *NREL 20649*

Avian Strike Probability Versus Turbine Size

Altamont Scale

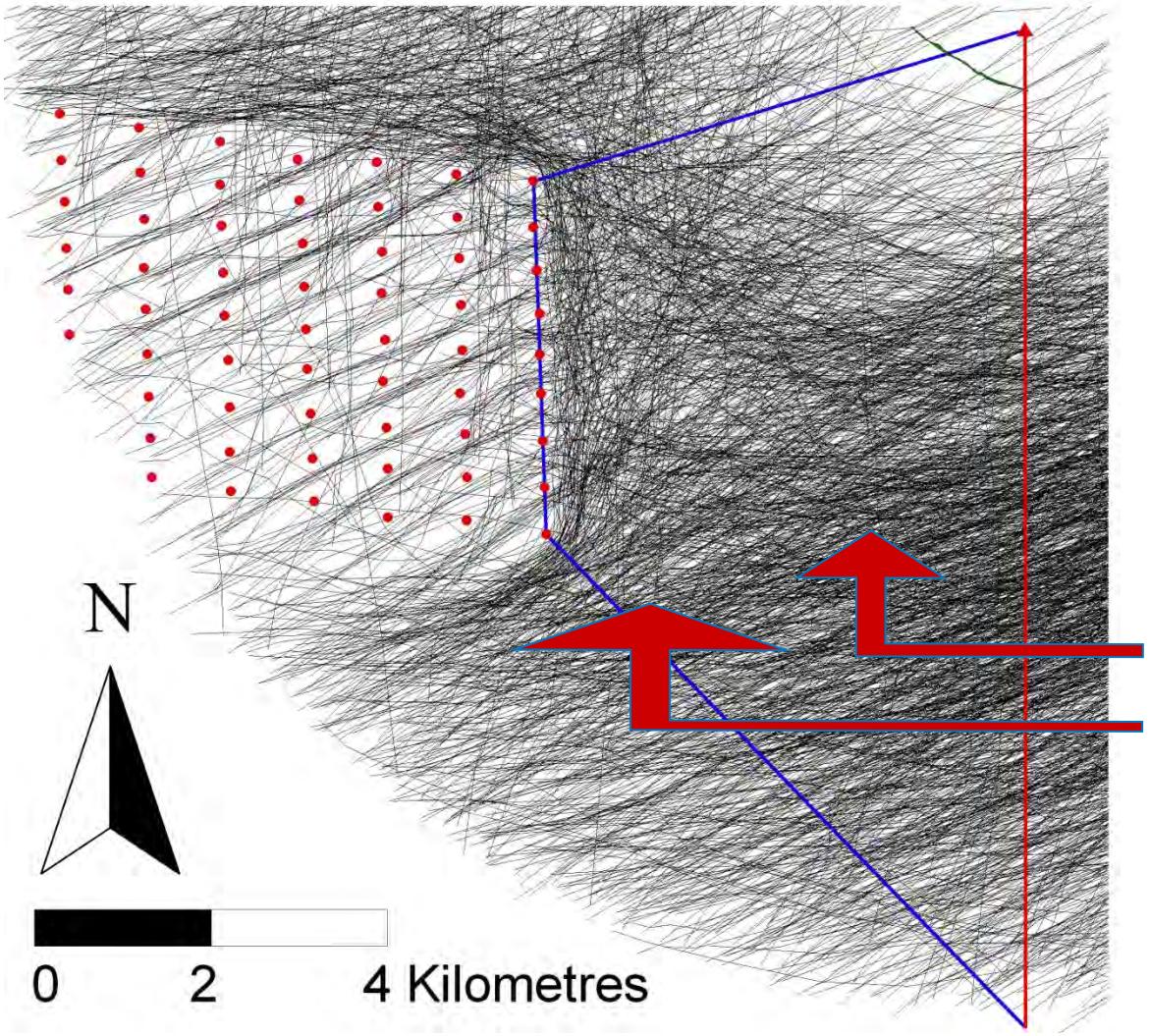
15-meter (m) diameter RSA and 100 kW

Next-Generation Scale

93-m diameter RSA and 2.5 MW

Avoidance Behavior can be Significant

Radar tracks of migrating birds through the Nysted Offshore Windfarm for operation in 2003

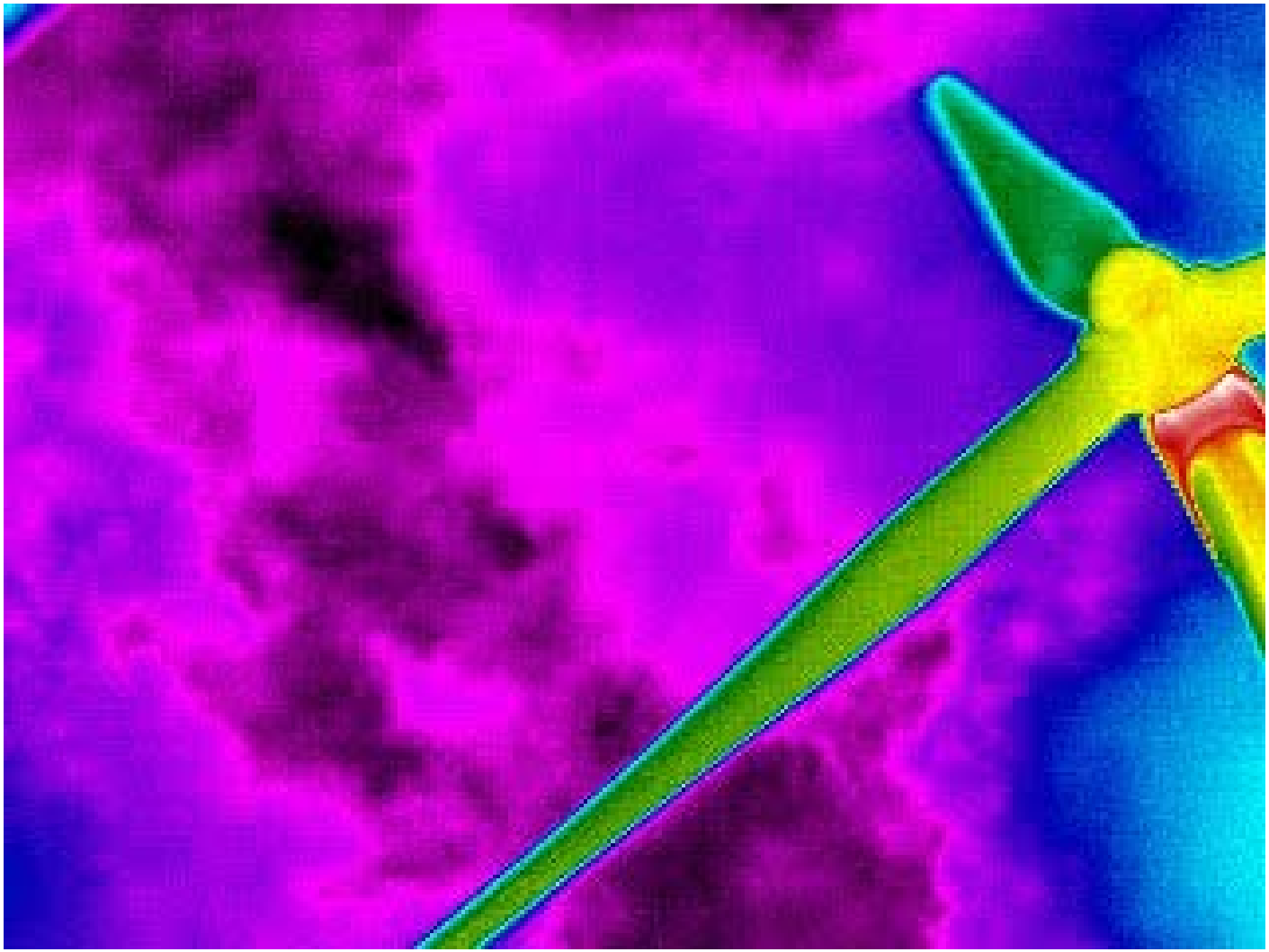


Response distance:

day = c. 3,000 meters (m)

night = c. 1,000 m

Bats Interactions: Curiosity?



Infrared Image of a Bat Flying Through a Wind Turbine Rotor

Video by Jason Horn, Boston University

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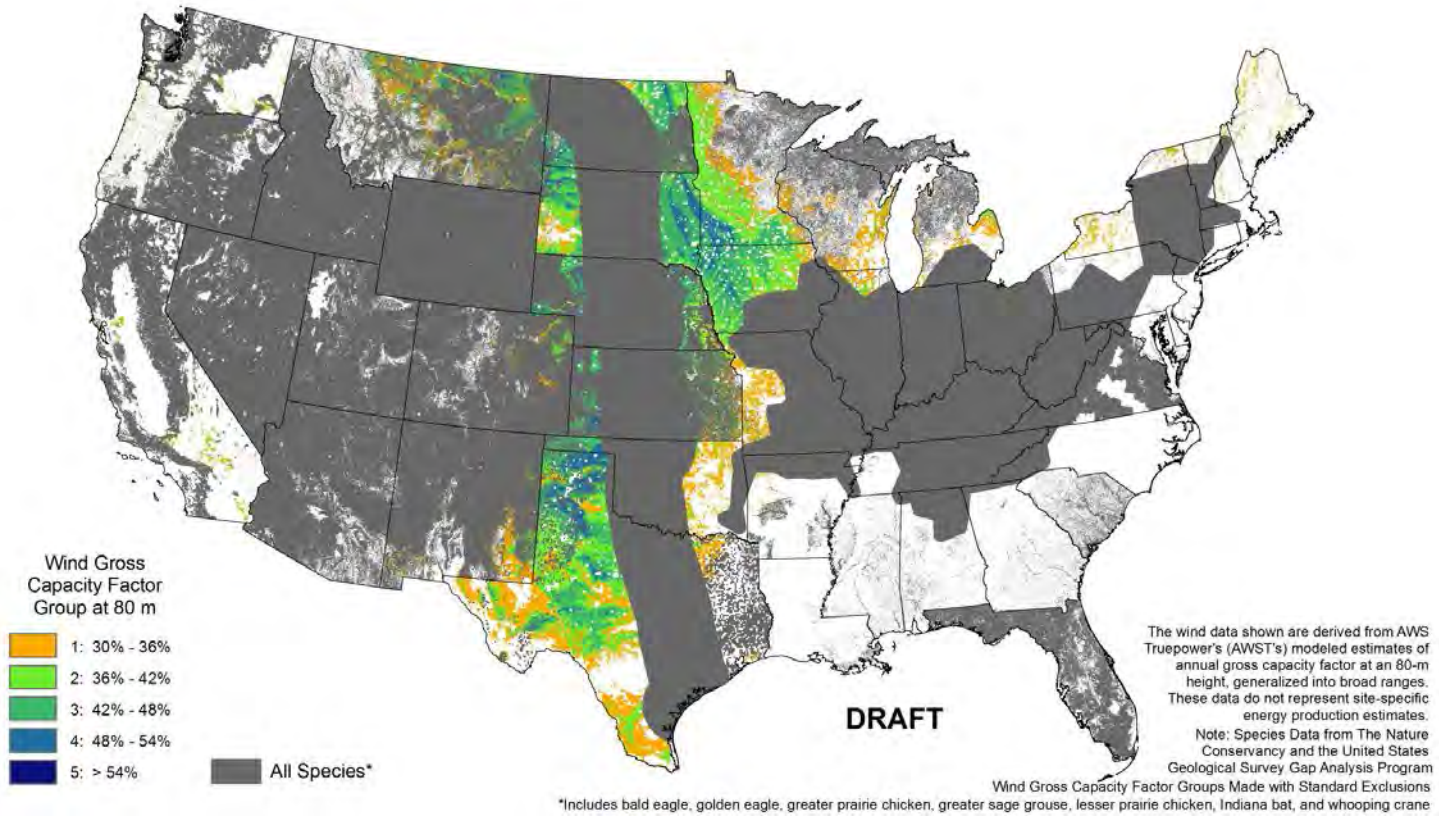
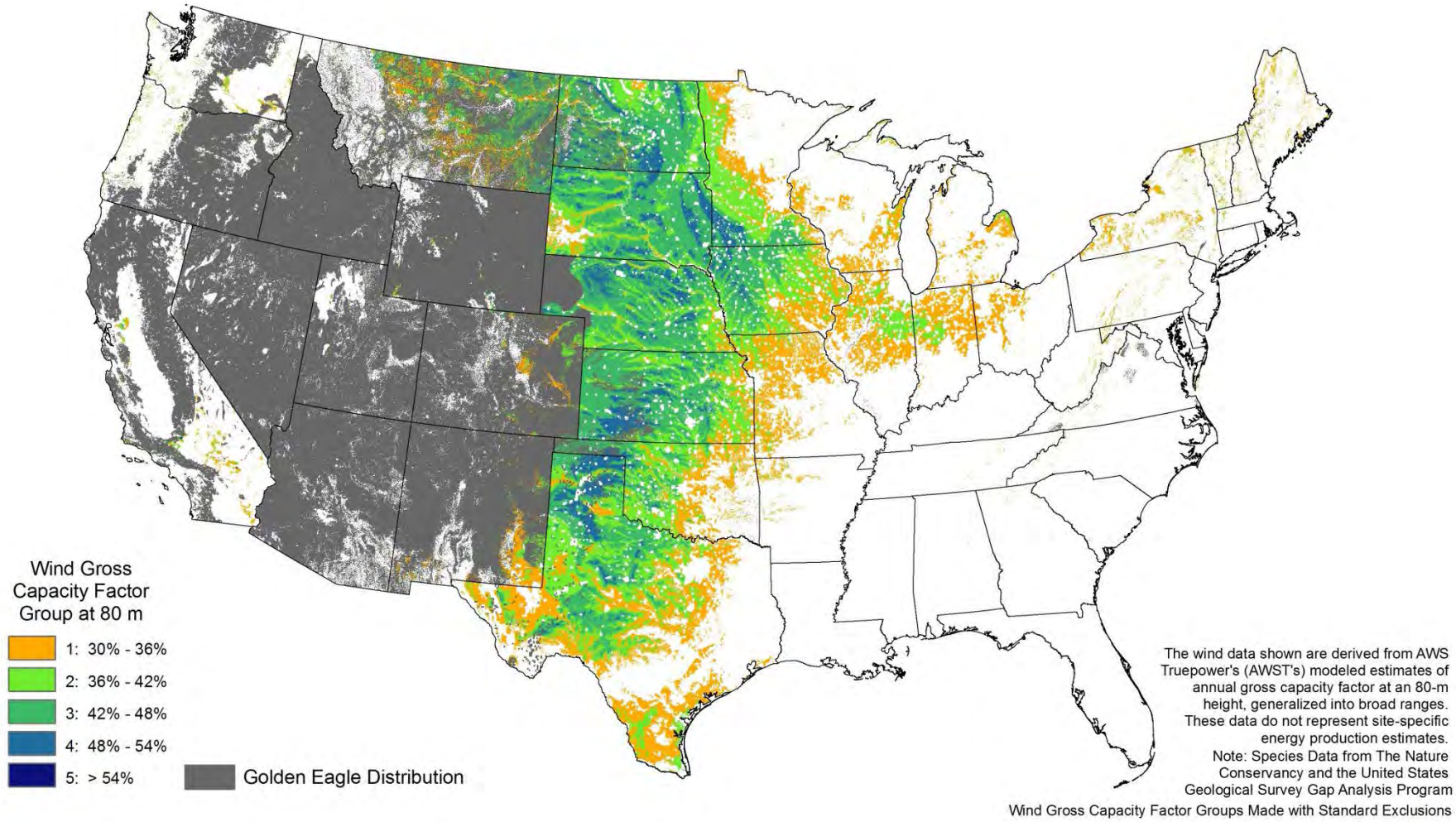
Key Species Habitat Distribution: Seven Species



Areas in grey indicate where wildlife species live, breed, and migrate. These areas are *not* no-build zones, but are of special concern for developers that could increase costs and time, or lead to project delays or cancellation.

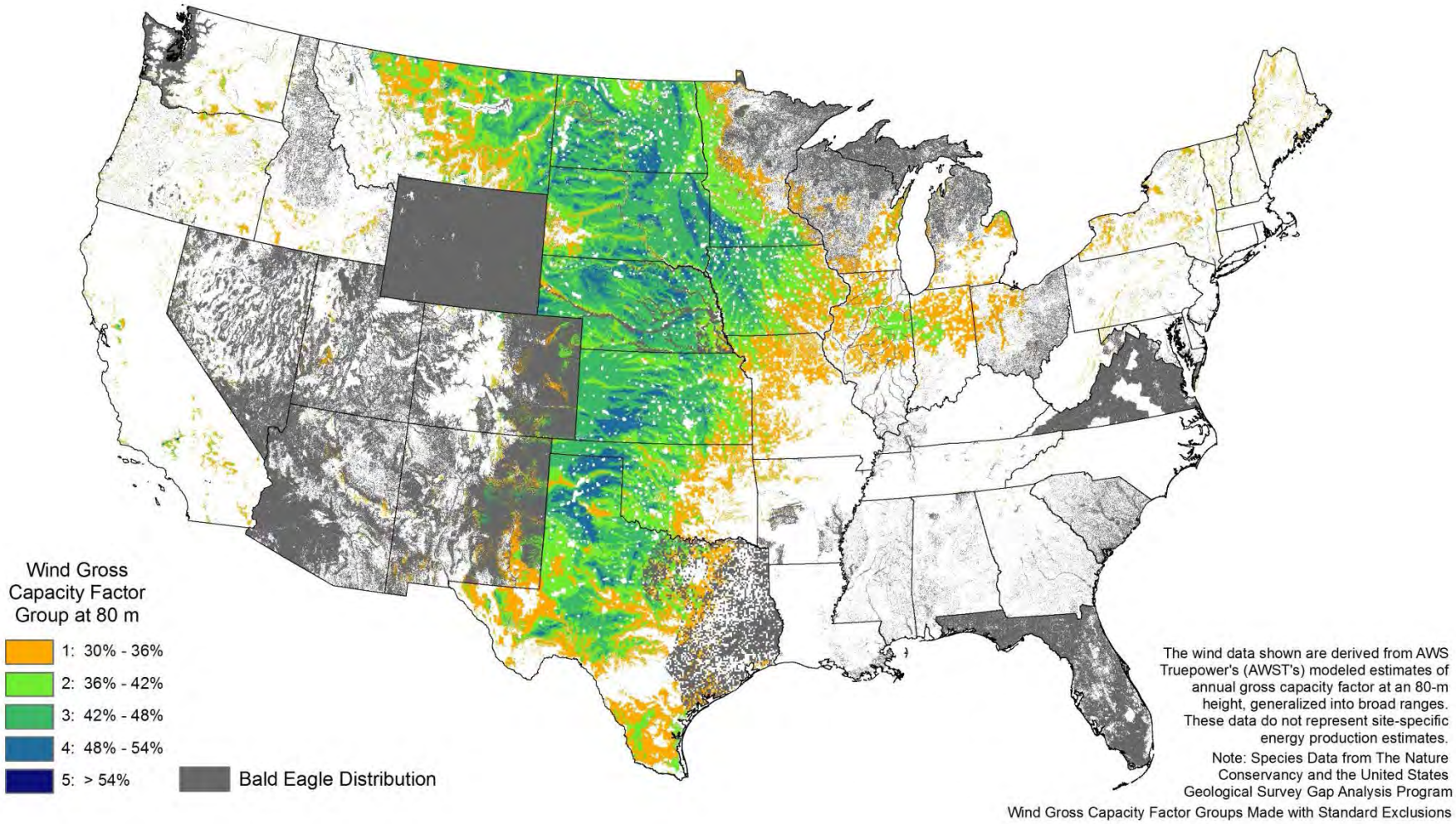
Wildlife distribution can impact local areas very differently. On a national scale, 44%–53% of land could be affected.

Key Species Habitat Distribution: Golden Eagles



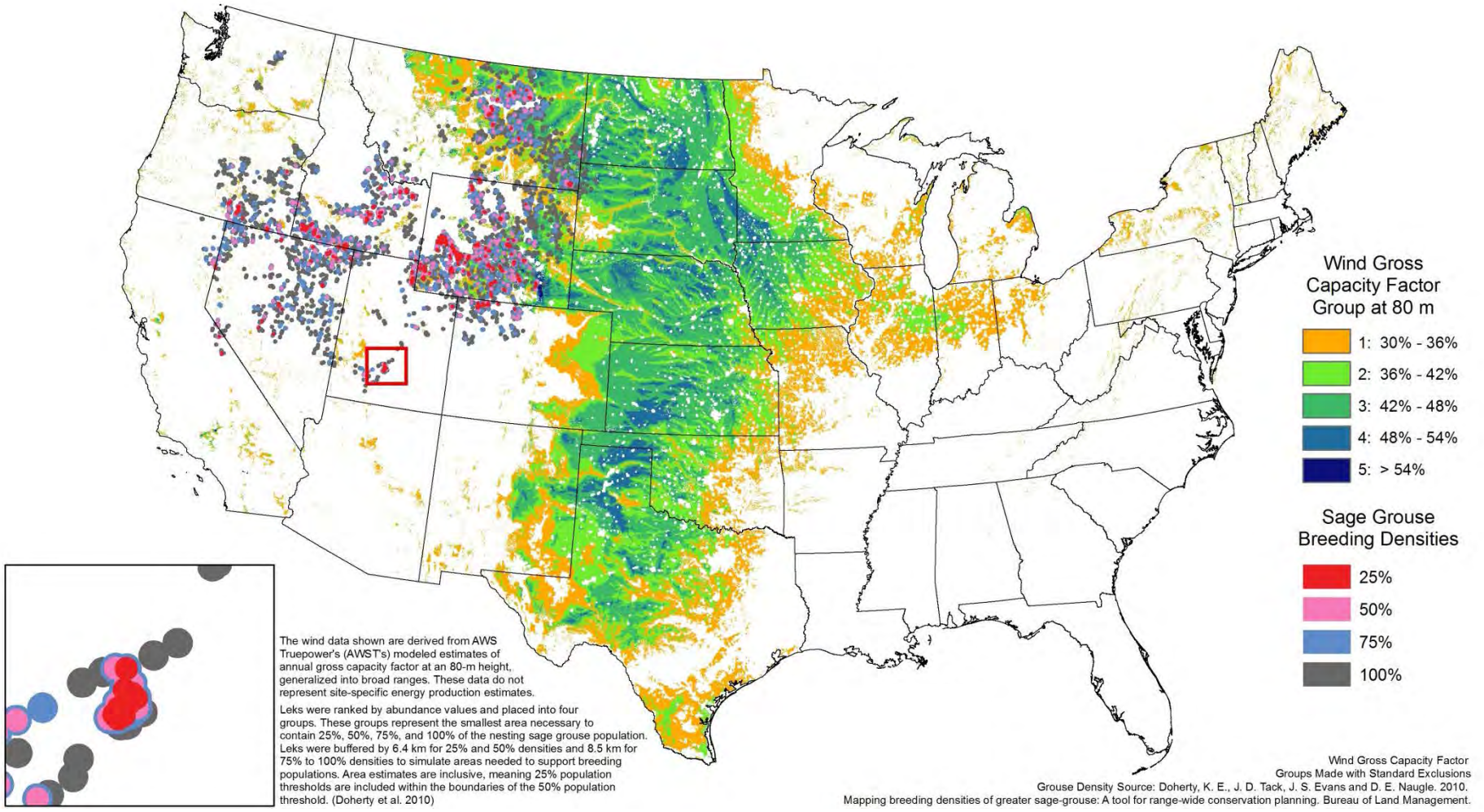
Golden eagle habitat: areas requiring additional consideration

Key Species Habitat Distribution: Bald Eagles



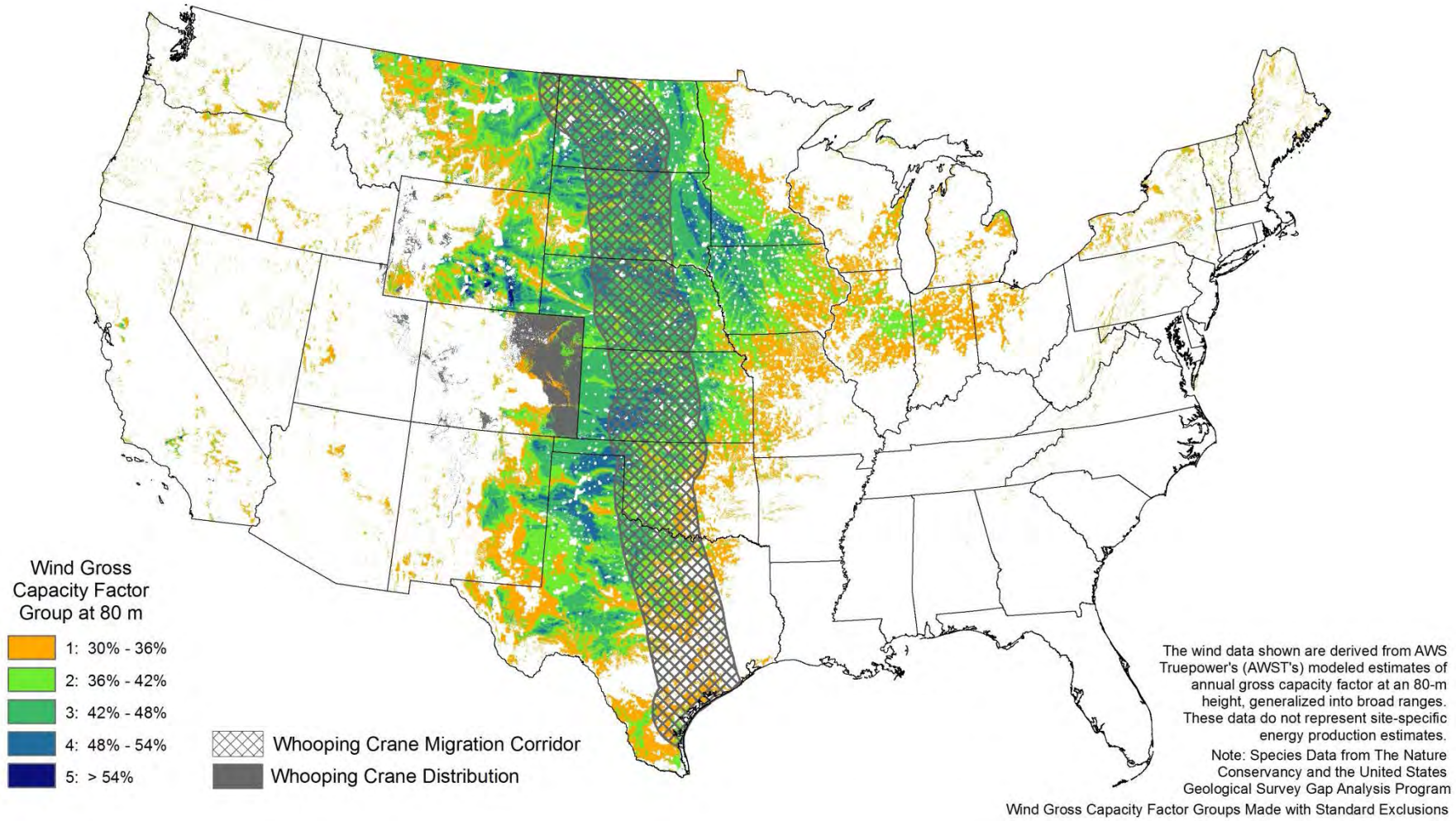
Bald eagle habitat: areas requiring additional consideration

Key Species Habitat Distribution: Sage Grouse



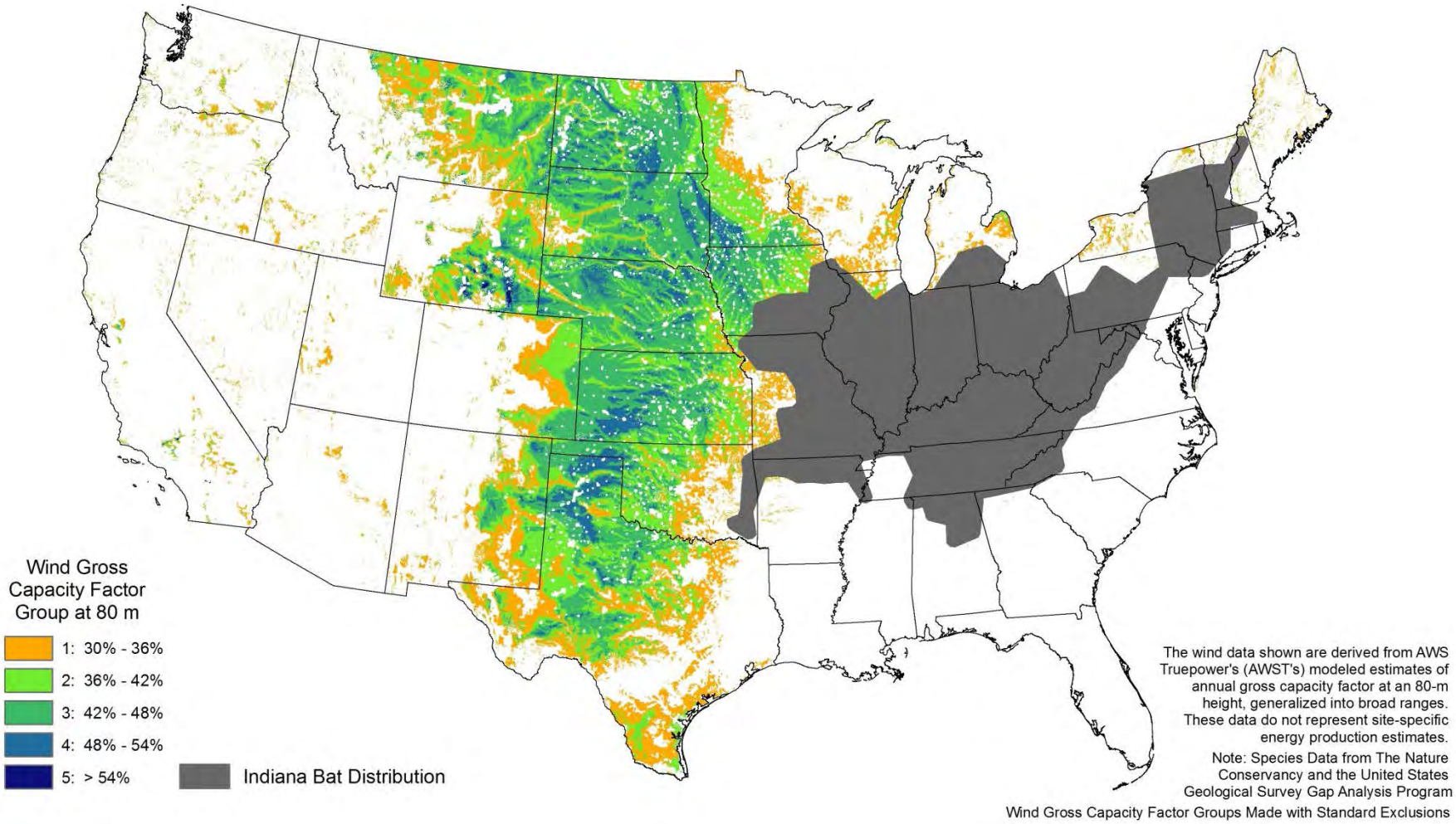
Sage grouse habitat and breeding sites: areas requiring additional consideration

Key Species Habitat Distribution: Whooping Crane



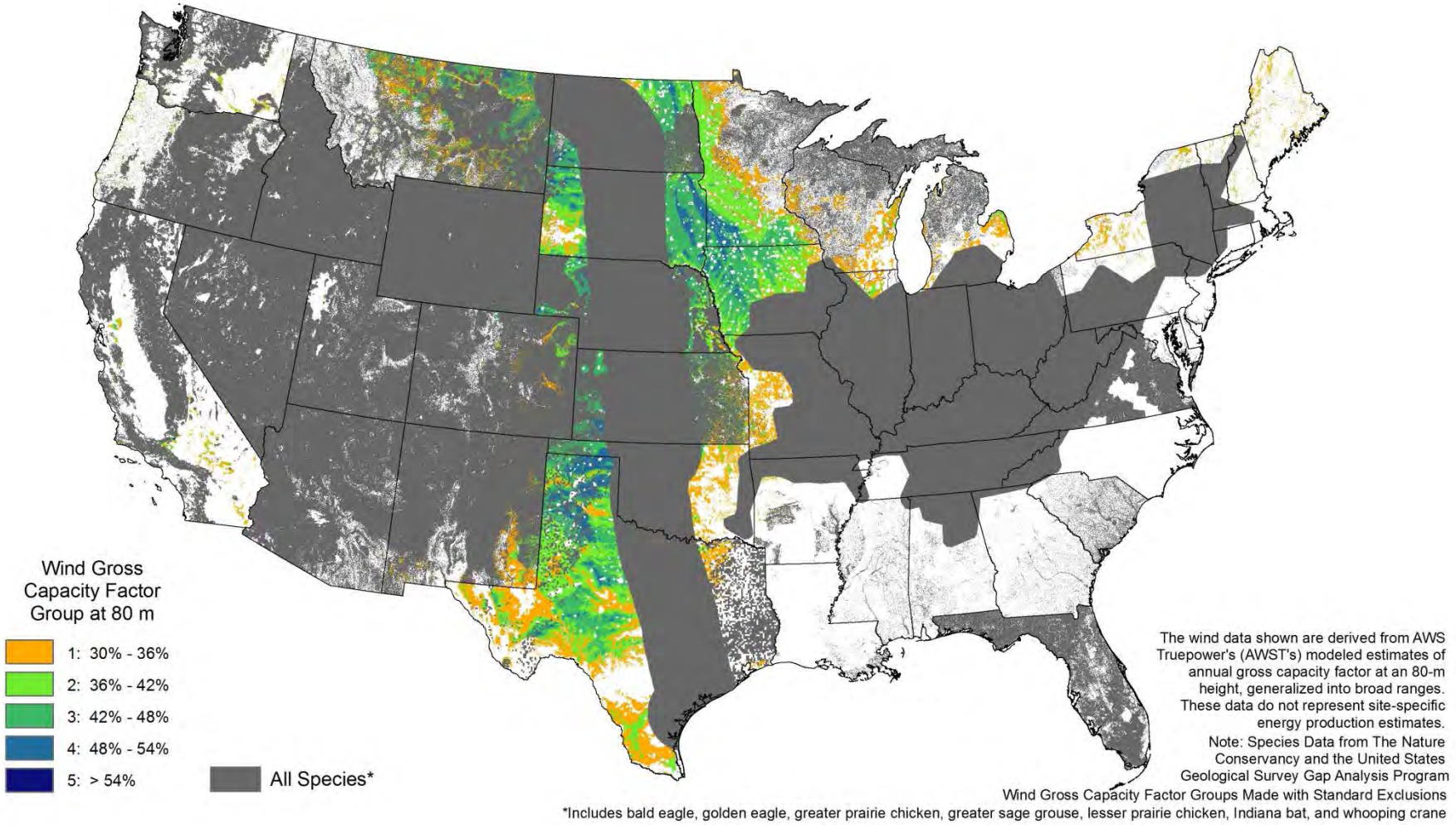
Whooping crane habitat and migratory corridor: areas requiring additional consideration

Key Species Habitat Distribution: Indiana Bat



Indiana bat habitat distribution: areas requiring additional consideration

Key Species Habitat Distribution: Combined



Combined wildlife impacts: areas requiring additional consideration

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Mitigation Research

Mitigation research focuses on:

- Deterrent development
- Correlating wind speed to utilization
- Correlating weather patterns to fatality patterns
- Offsite compensation
- Micrositing
- Turbine size
- Blade visibility
- Seasonal shutdowns
- Habitat manipulation
- Artificial roosts.

Greater Prairie Chicken. *Photo by Mark Herse, Kansas State University, NREL 27970*

Technology/Model Research

Technology/modeling research is focused on:

- Radar validation
- Thermal imaging cameras
- Near-infrared cameras
- Stable isotopes
- Predictive models.

Infrared camera. *Photo by Dennis Schroeder, NREL 20338*

Testing Detection Systems at the NWTC

Houdini in flight during FY15. GPS data logger can be seen on his right foot and UHF tracker can be seen on his left.

Testing of detection systems using Auburn University's golden and bald eagles

Importance of Convening Interdisciplinary Panel of Experts for Prioritizing Research

The National Renewable Energy Laboratory
together with
The Department of Energy's Wind and Water Power Technologies Office
are pleased to invite you to the
Eagle Detection and Deterrent Technology Research Gaps and Solutions Workshop

Land-based wind energy deployment is challenged by the lack of accepted solutions for reducing eagle fatalities at wind energy projects. Therefore, there is an expressed need for tools to reduce these fatalities and to facilitate permitting under the Bald and Golden Eagle Protection Act. For this workshop, we will be engaging experts from a wide range of fields to comprehensively assess the current state of technologies, key gaps, promising emerging technology solutions, novel ideas, and research and development needs.

Please join us…

The National Renewable Energy Laboratory
Research Support Facility
15013 Denver West Parkway
Golden, Colorado

Tuesday December 8th, 2015	Full day
Wednesday December 9th, 2015	Half day

CONTACTS

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Karin Sinclair karin.sinclair@nrel.gov	303.384.6946
Elise DeGeorge elise.degeorge@nrel.gov	303.384.7136

RSVP *required*.
Please provide a response **no later than September 21, 2015** to bethany.straw@nrel.gov.

NREL | NATIONAL WIND TECHNOLOGY CENTER

- Bringing people of different focus areas/expertise to the table to understand and prioritize solutions
- Outcome as it relates to wind energy and eagle impacts: need to understand fundamental behavior and physiology of species of concern

Recommendations from Physiology and Behavior Specialists

- Understand: population and habitat associations, threats, annual cycle, demography, flight behavior, diet, etc..
- Risk is when turbines intersect with a species basic needs (e.g. with eagles it is food, updraft and nesting sites)

Photo provided by T. Katzner

For auditory deterrent research, one expert recommends the following:

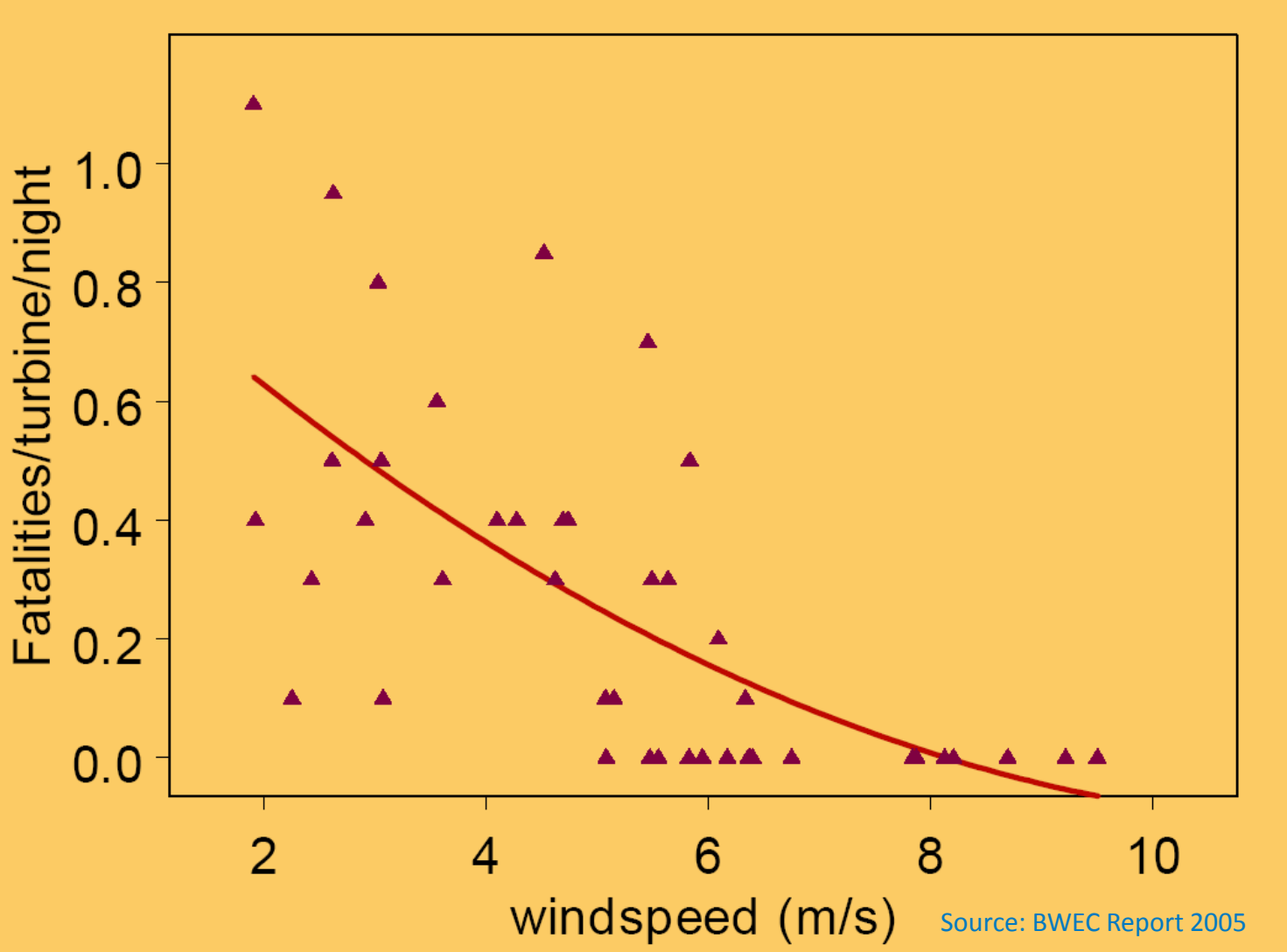
- Measure the auditory system of these birds
- Use this information to build a library of sounds that might be stressful (annoying)
- Use heart monitors to give us an index of stress (estimated by an increase in heart rate)
- Give a variety of different sounds to estimate stress induced by the sounds
- Test birds over different time intervals (hours to weeks) to estimate the rate of adaptation to these sounds

Golden eagle copulation call

Properties of the Vocal System Provide Clues about Properties of the Auditory System

Source: As presented by Jeff Lucas, Purdue University at Eagle Detection and Deterrent Technology Research Gaps and Solutions Workshop, December 2015

BWEC Study Results



Research Conducted from Settlement Agreements

Duke Energy at Top of the World Windfarm in Casper, Wyoming

- Onsite wildlife specialists during daylight hours
- Working with FWS on an eagle trapping and tracking project
- GPS help to understand eagle migration movements
- Advancing IdentiFlight camera system
- Opportunities for R&D when faced with unsupported requirements

An aerial view of Duke's Top of the World wind farm, located in Casper, Wyo.
Photo courtesy of Duke Energy Renewables

Source: http://nawindpower.com/online/issues/NAW1604/FEAT_01_Duke-s-Avian-Mitigation-Techniques-Take-Flight-What-s-Working-And-Why.html

Outline

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Collaboratives are Often Beneficial for Advancing the Knowledge Base

Benefits of collaboratives include:

- Access to third party, unbiased research
- Accepted experts within collaborative
- Agreement on study design
- The ability to develop relationships (trust)
- A safe forum for discussion
- The ability to engage early and often
- Transparency/credibility
- Leveraging of funds
- Project access
- Access to interim results
- Accepted results
- A model for future interactions.

705-MW project in Tehachapi Pass Wind Resource Area, California.

Photo by David Hicks, NREL 18455

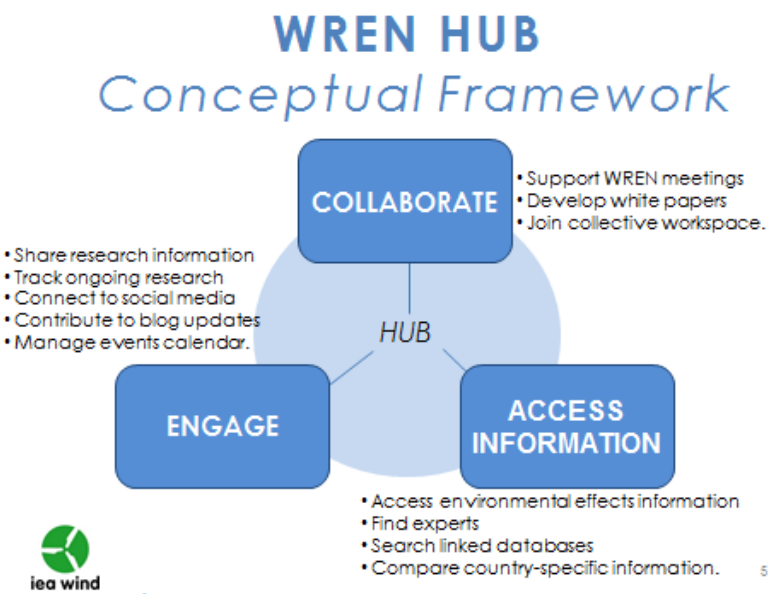
Current collaboratives

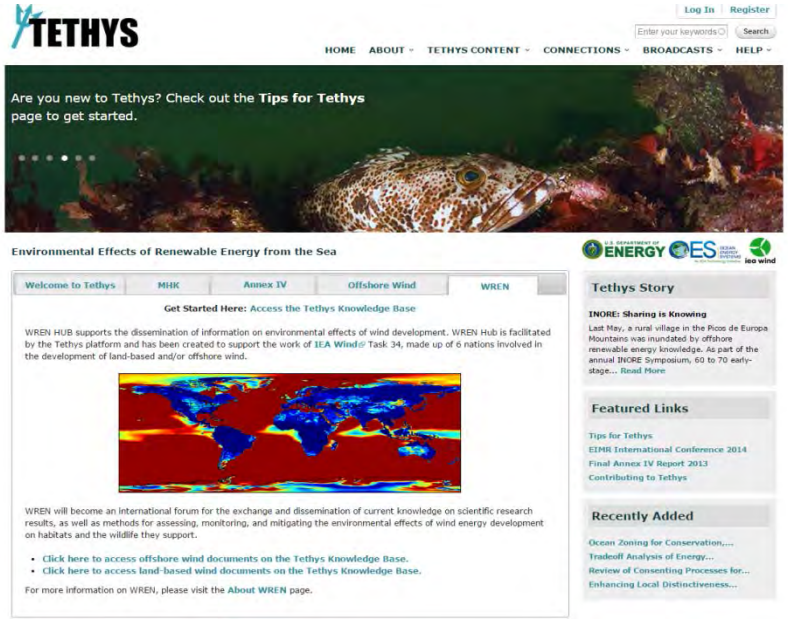
Current collaboratives include:

- The National Wind Coordinating Collaborative (NWCC). Includes federal, state, utilities, nongovernmental organizations (NGOs), and wind industry
  - Grassland Shrub Steppe Species Collaborative. Includes federal, state, NGOs, and wind industry
  - Sage Grouse Collaborative. Includes federal, state, NGOs, and wind industry
- Bats and Wind Energy Cooperative (BWEC). Includes federal, state, NGOs, and wind industry
- American Wind Wildlife Institute (AWWI). Includes industry and NGOs
- International Energy Agency Wind Task 34. Includes nine member countries.

More on International Energy Agency Wind Task 34

- Working Together to Resolve Environmental Effects of Wind Energy, known as **WREN**
- October 2012–2016; extension under discussion
- Current member countries: Ireland, Netherlands, Norway, Spain, Switzerland, United Kingdom, United States, France, and Sweden.





Primary products:

- WREN Hub/Tethys (http://tethys.pnnl.gov/)
- White papers: Adaptive management, individual impacts to population effects, green versus green, cumulative impacts, transboundary issues
- Webinars: on land/offshore, birds/bats/marine mammals, tools http://tethys.pnnl.gov/environmental-webinars?content=wind

Outline

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Conclusions

- Wind-wildlife impact concerns are complicated
- Micrositing is key to avoiding, minimizing, and mitigating impacts; some locations may just not be appropriate for wind development
- Research and development of tools is ongoing and benefits from interdisciplinary approaches
- Collaboratives provide opportunities to leverage resources to find solutions for common challenges.

Grand Ridge Wind Energy Center. GE 1.5-MW turbines in Lasalle County, Illinois. *Photo by Invenergy, LLC, NREL 16040.*

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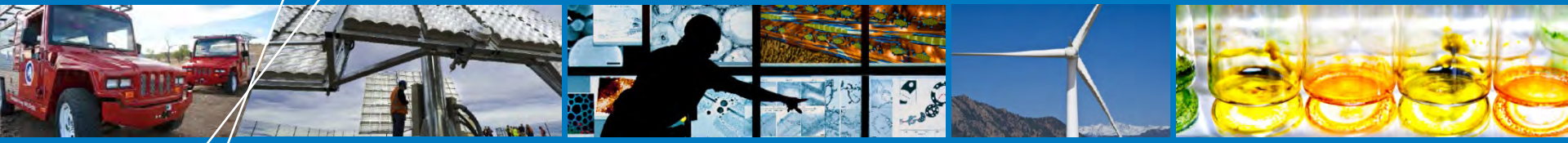
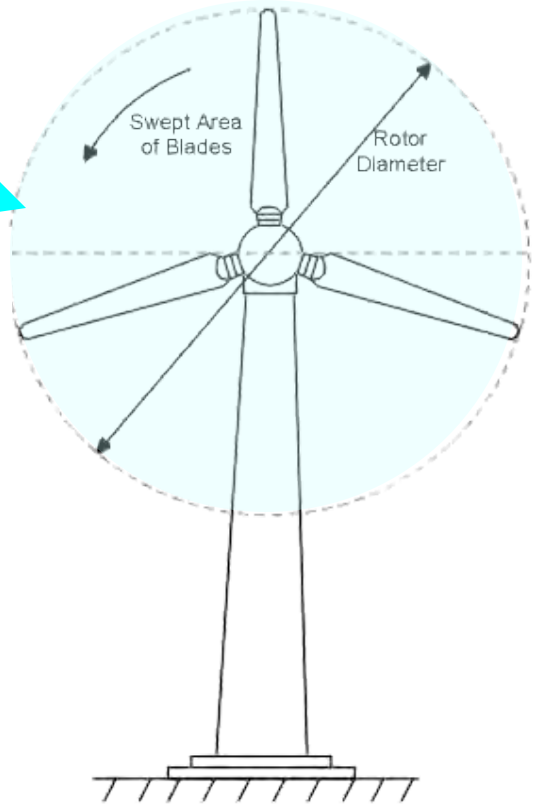
QUESTIONS?



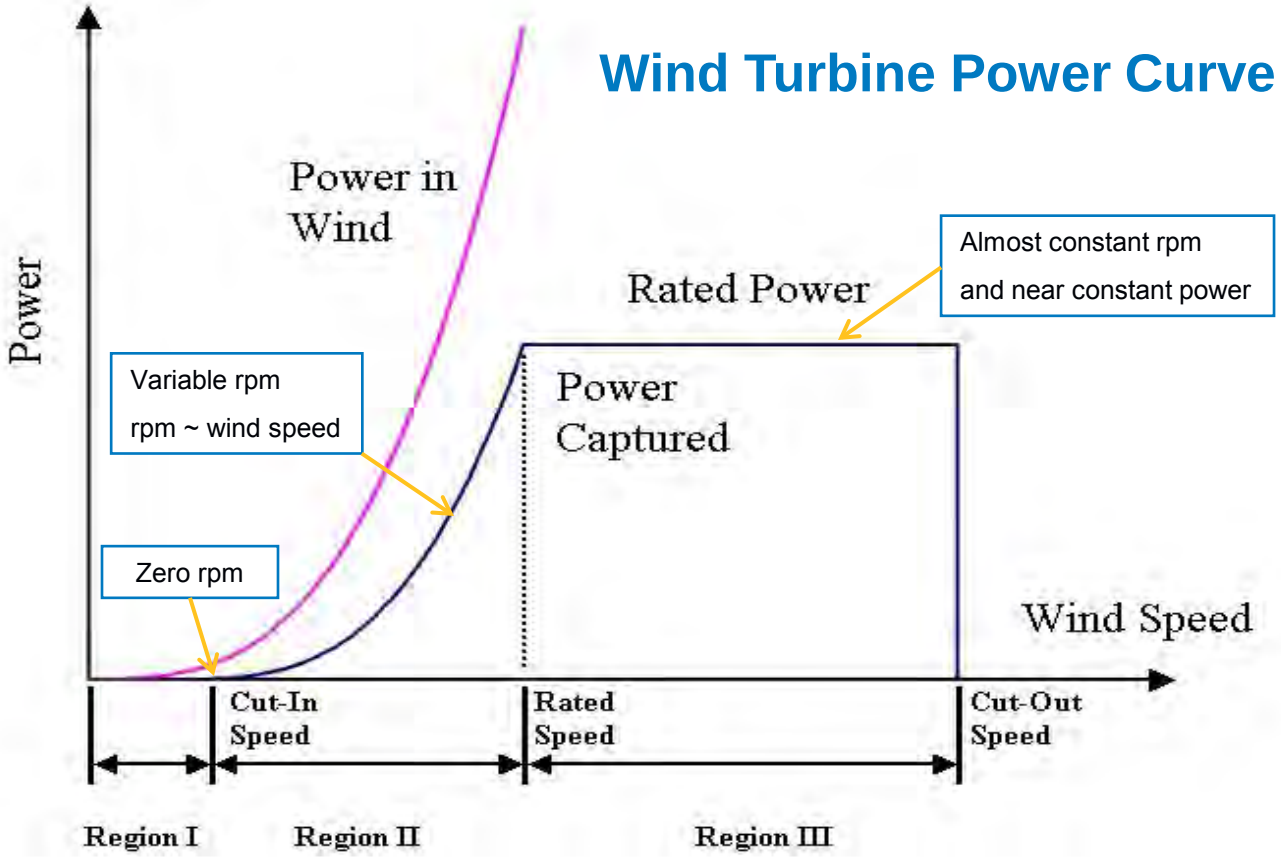
Turbine Power Basics

Power in the Wind = ½ρAV^3

A - Area of the circle swept by the rotor
ρ = Air density
V = Wind Velocity



Wind Turbine Power Curve



NWCC

Formed in 1994, founding members included NREL and DOE, the American Wind Energy Association, National Audubon Society, Electric Power Research Institute, and Union of Concerned Scientists. Membership currently exceeds 1,500 people.

Major features of the NWCC include:

- Multistakeholder
- Facilitated; ground rules for engagement
- Coordinated field research
- Information dissemination (e.g., website; coordination of report preparation and publication; presentations at meetings)
- Biennial Research Meeting (X in December 2014)

Recent research activities were initiated under the Grassland Shrub Steppe Species Collaborative, and include:

- Grassland Community Collaborative (Prairie-Chicken research)
- Sage Grouse Collaborative (Sage Grouse research)

http://www.nationalwind.org/

BWEC

Formed in 2004, founding members included the American Wind Energy Association, Bat Conservation International, USFWS, and NREL, with DOE and the U.S. Geological Survey later. Major features of the BWEC include:

- Objective, science-based
- International expertise tapped
- Organizational structure includes an oversight committee, technical committee, and science committee
- Coordination of field research (e.g., operational curtailment, acoustic deterrent, other)
- Information dissemination (e.g., website; coordination of report preparation and publication; presentations at meetings)
- Frequent science meeting.

http://www.batsandwind.org/

Source: Arnett, et al. 2008. Effectiveness of Changing Wind Turbine Cut-in Speed to Reduce Bat Fatalities at Wind Facilities

AWWI

Formed in 2008, board members consist of 50% industry and 50% NGOs.

Primary activities include:

- Research
- Data repository

Wind-Wildlife Research Information System

- Landscape tools

Landscape Assessment Tool

- Mitigation strategies for eagle take

Through the use of expert elicitation, AWWI has facilitated the development of two models to predict numerical effects of compensatory mitigation on golden eagle survival and reproduction through: lead abatement and vehicle collision reduction strategies.

- Education

http://www.awwi.org/

Golden Eagle with a transmitter on its back.
Photo by Randy Flament, NREL 23585

Candidate Avian Risk Metrics

Hypothesis: "Mortality risk increases with flight time in the rotor zone (yellow zone), if the turbine is operating"

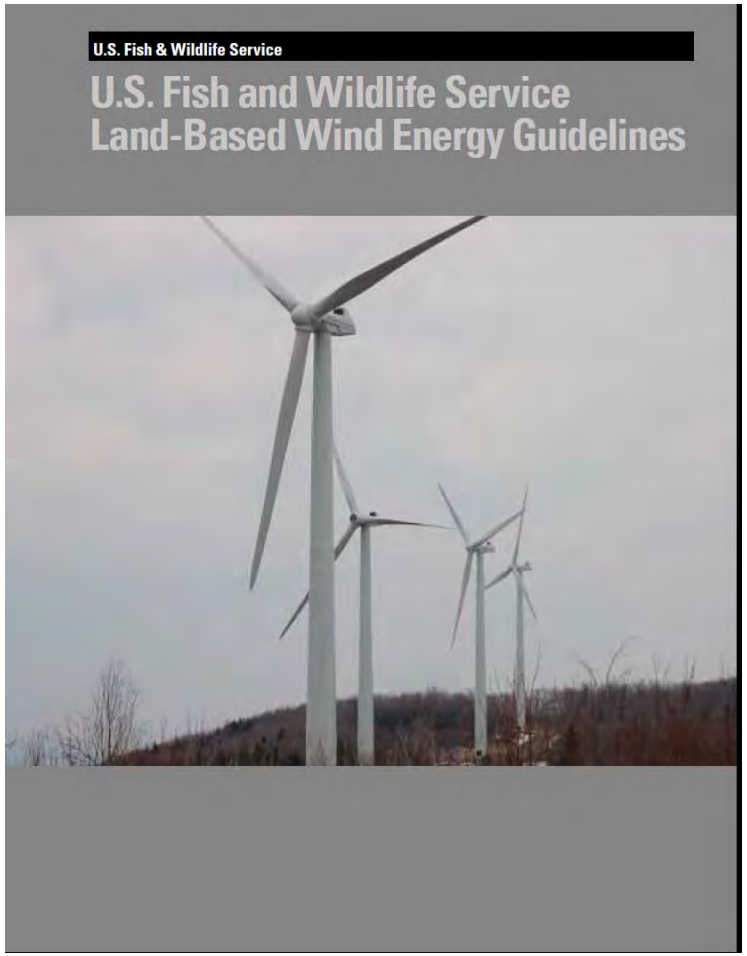
A Candidate Preconstruction Relative Risk Metric:

Species Relative Risk = (Flight Hours in Rotor Zone with Wind in Operating Range)/(Plant Swept Area x Hours with Wind in Operating Range)

A Candidate Postconstruction Fatality Metric:

Species Risk = Fatalities/(Swept Area x Turbine Operation Hours)

The USFWS Land-based Wind Energy Guidelines



Released March 2012

Provide a Tiered Approach, including:

- Tier 1 – Preliminary site evaluation (landscape-scale screening of possible project sites)
- Tier 2 – Site characterization (broad characterization of one or more potential project sites)
- Tier 3 – Field studies to document site wildlife and habitat and predict project impacts
- Tier 4 – Postconstruction studies to estimate impacts
- Tier 5 – Other postconstruction studies and research.

USFWS Guidelines: Developer and Service Roles

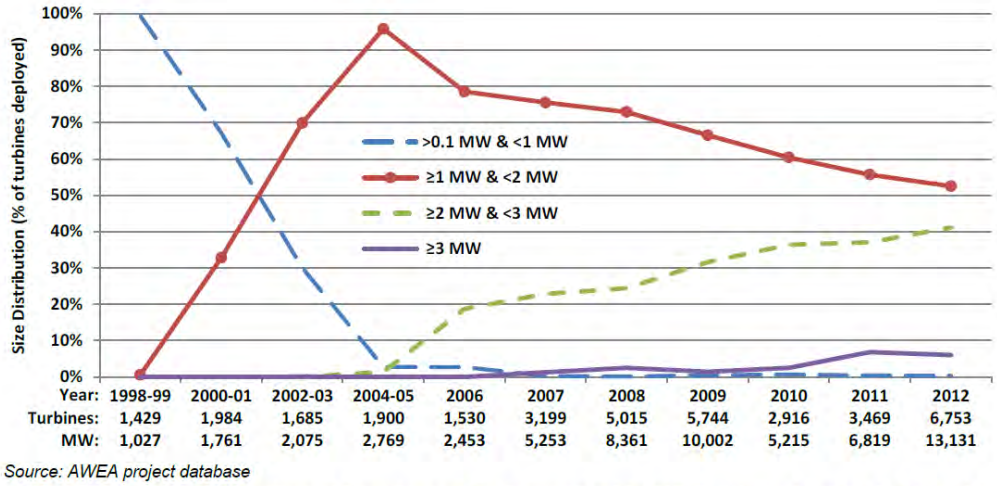
TIER	*Project Developer/Operator Role*	*Service Role*
Tier 1: Preliminary site evaluation	• Landscape level assessment of habitat for species of concern • Request data sources for existing information and literature	• Provide lists of data sources and references, if requested
Tier 2: Site characterization	• Assess potential presence of species of concern, including species of habitat fragmentation concern, likely to be on site • Assess potential presence of plant communities present on site that may provide habitat for species of concern • Assess potential presence of critical congregation areas for species of concern • One or more reconnaissance level site visit by biologist • Communicate results of site visits and other assessments with the Service • Provide general information about the size and location of the project to the Service	• Provide species lists, for species of concern, including species of habitat fragmentation concern, for general area, if available • Provide information regarding plant communities of concern, if available • Respond to information provided about findings of biologist from site visit • Identify initial concerns about site(s) based on available information • Inform lead federal agencies of communications with wind project developers
Tier 3: Field studies and impact prediction	• Discuss extent and design of field studies to conduct with the Service • Conduct biological studies • Communicate results of all studies to Service field office in a timely manner • Evaluate risk to species of concern from project construction and operation • Identify ways to mitigate potential direct and indirect impacts of building and operating the project	• Respond to requests to discuss field studies • Advise project proponent about studies to conduct and methods for conducting them • Communicate with project proponent(s) about results of field studies and risk assessments • Communicate with project proponents(s) ways to mitigate potential impacts of building and operating the project • Inform lead federal agencies of communications with wind project developers
Tier 4: Post construction studies to estimate impacts	• Discuss extent and design of post-construction studies to conduct with the Service • Conduct post-construction studies to assess fatalities and habitat-related impacts • Communicate results of all studies to Service field office in a timely manner • If necessary, discuss potential mitigation strategies with Service • Maintain appropriate records of data collected from studies	• Advise project operator on study design, including duration of studies to collect adequate information • Communicate with project operator about results of studies • Advise project operator of potential mitigation strategies, when appropriate

USFWS Eagle Conservation Plan Guidance (April 2013)

- To facilitate issuance of programmatic eagle take permits for wind energy facilities the USFWS finalized the Eagle Conservation Plan Guidance- Module 1- Land-based Wind Energy Version 2
- This Guidance provides a framework for developing and evaluating Advanced Conservation Practices, which is the framework for detect and deter technologies

Photo by T. Katzner

Power and Size of Turbines Over Time

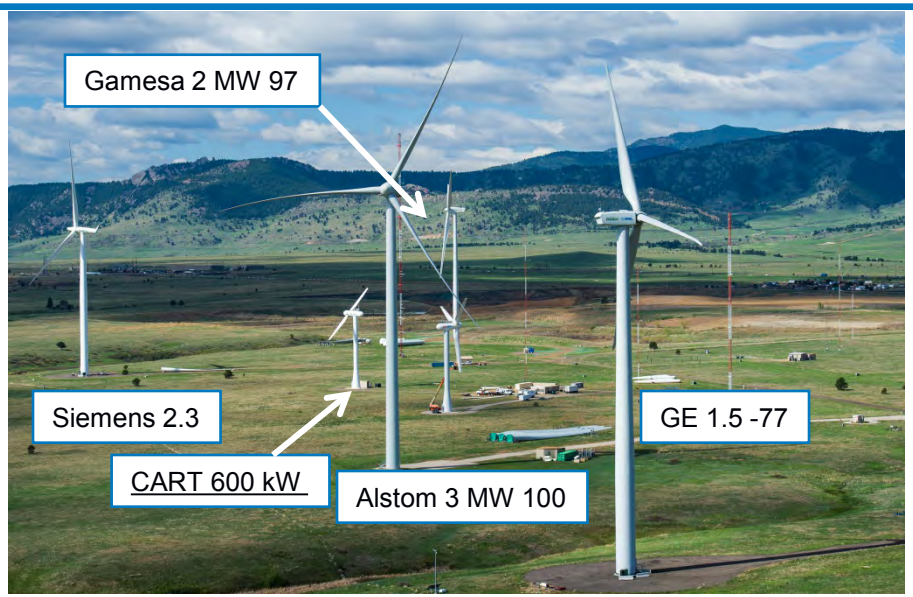


Source: AWEA project database

Figure 16. Size Distribution of Number of Turbines (>100 kW) Deployed in Each Period

Source: 2012 Wind Technologies Market Report

Representative Wind Turbine Specifications



National Wind Technology Center – NREL Pic 25898

Danish National Wind Test Center – Photo by R. Thresher

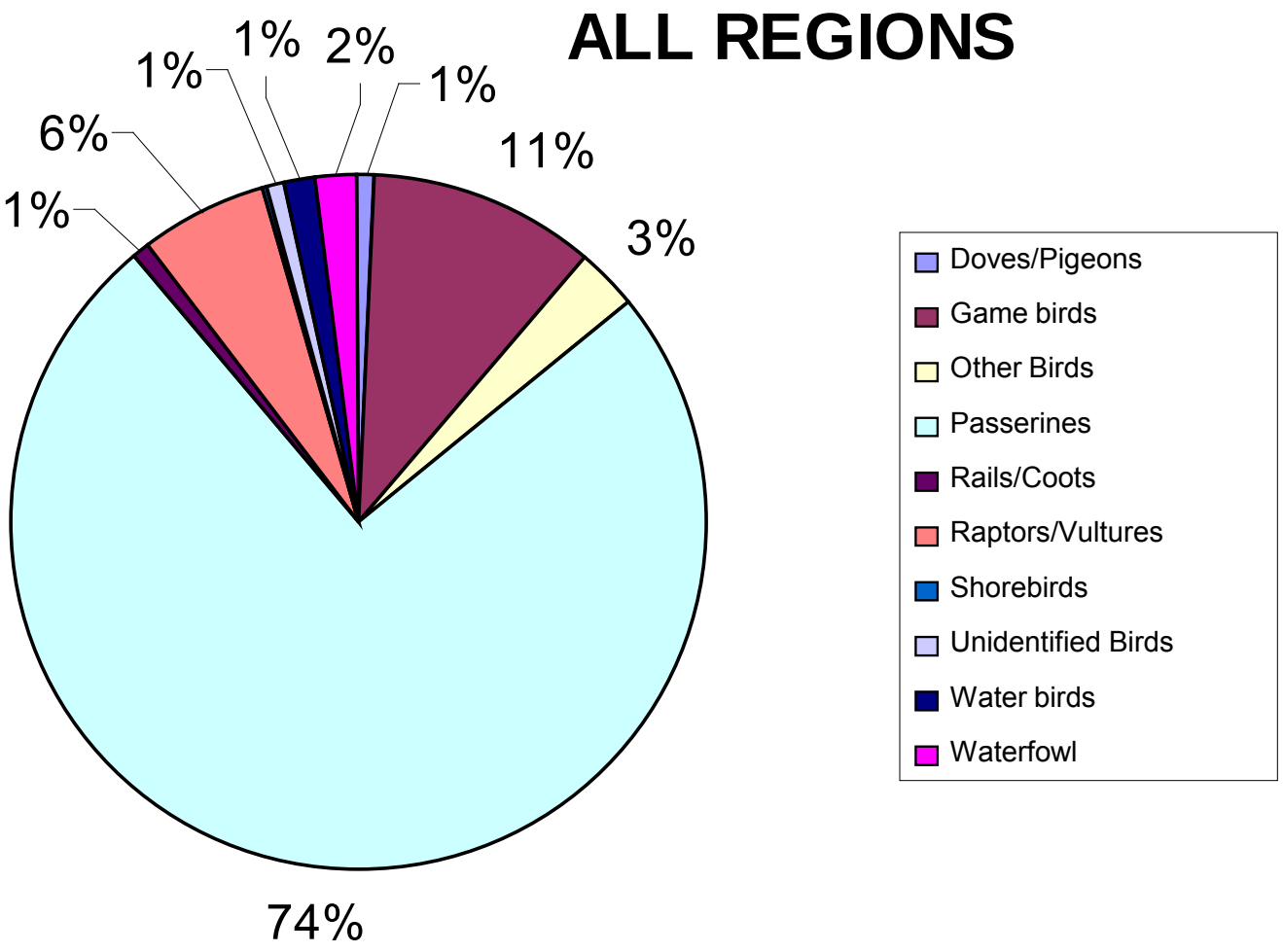
Turbine	Power - MW	Rotor Size - m	Rotor Area – m^2	Rotor Speed - rpm	Tower Height - m	Cut-in Wind Speed m/s
GE 1.5 se	1.5	70.5	3904	12-22.4	54.7 – 64.7	4
GE 1.5 sl	1.5	77	4657	11-20.4	61.4 - 100	3.5
GE 1.5 sle	1.5	77	4657	11-20.4	61.4 - 100	3.5
GE 1.5 xle	1.5	82.5	5346	10.1-18.7	58.7 - 100	3.5
GE 1.6 or 1.7	1.6 – 1.7	100	7854	?	80 -96	?
GE 2.5 -100	2.5	103	8333	?	75-100	3
GE 3.2 -103	3.2	103	8333	?	70-98	?
Siemens SWT 2.3	2.3	100	7854	6-16	80 or Site specific	3-4
Siemens Offshore SWT – 6.0 – 154	6	154	18,600	5-11	Site Specific	3-5

U.S. Department of Energy Wind Program's Mission

- Reduce challenges to project development to accelerate deployment of appropriate wind energy
- Support achievement of 20% wind energy by 2030
- Accelerate wind energy capacity growth/ development of domestic energy options (Energy Policy Act of 2005).

Northwind 100, 100-kW wind turbine; Hempstead, New York.
Photo by Town of Hempstead, NREL 28963

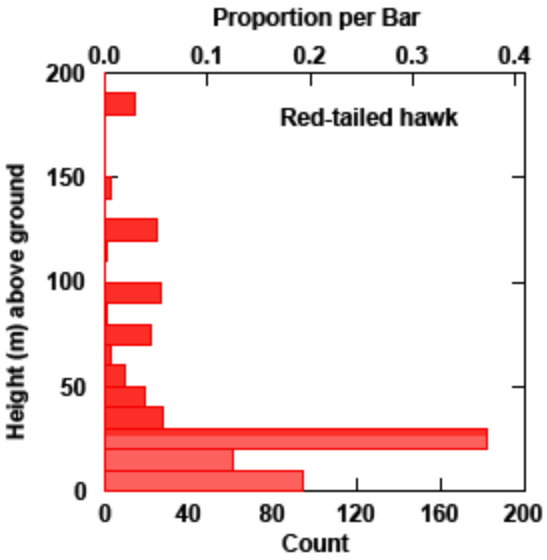
Research: Species Composition of Bird Fatalities



Proportion of fatalities at sites reporting fatalities by species, for all regions where studies have been conducted (the Pacific Northwest, Midwest, Rocky Mountains, and East).
Source: Strickland and Morrison, February 26, 2008.
http://www.fws.gov/habitatconservation/windpower/Past_Meeting_Presentations/Morrison_Strickland.pdf

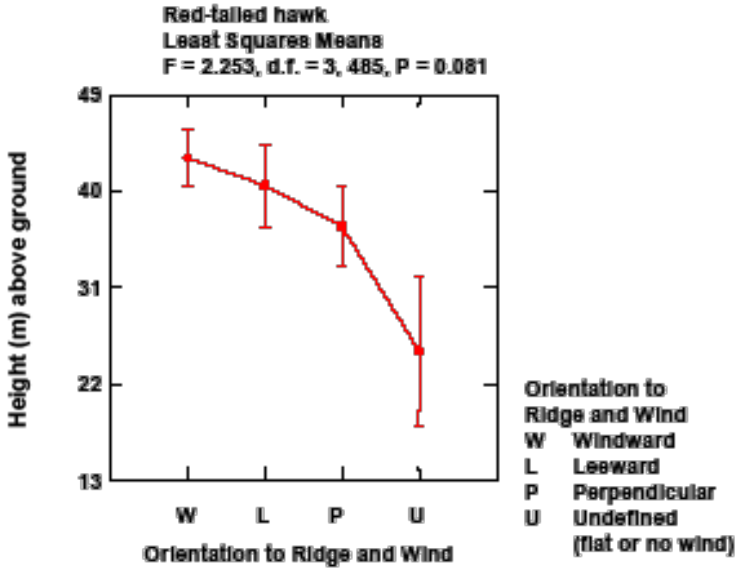
Red-Tailed Hawk Flight Observations in Altamont Pass

Height Histogram



Distribution of flight heights above ground level amount red-tailed hawks observed during behavioral observation sessions during 2003 and 2004 in the Altamont Pass Wind Resource Area.

Height versus Orientation



Mean flight heights of red-tailed hawk over aspect of ridge relative to oncoming winds.

Source: K. Smallwood and L. Neher, CEC-500-2005-005, December 2004

Highlights of One Interaction Study in Altamont Pass

Raptor Fatalities and Sightings

	Fatalities	Sightings	Rel. Risk F/S
Burrowing Owl	38	56	0.68
American Kestrel	22	429	0.05
Red-Tailed Hawk	100	1,780	0.06
Golden Eagle	10	401	0.02
Northern Harrier	2	114	0.02
Prairie Falcon	1	63	0.02
Turkey Vulture	0	756	0
Common Raven	0	792	0

From: *Bird Risk Behaviors and Fatalities at the Altamont Pass WRA*, Carl G. Thelander, et al

Sage Grouse Research

These are preliminary results and are not for distribution or citation.

Annual Report

A Study of the Impacts of a Wind Energy Development on Female Greater Sage-Grouse in Southeastern Wyoming

January 27, 2014

Presented to:
National Wind Coordinating Collaborative Sage-Grouse Research Collaborative Oversight Committee

Internal Document – Not for Distribution

Ecology of Male Greater Sage-Grouse in Relation to Wind Energy in Wyoming

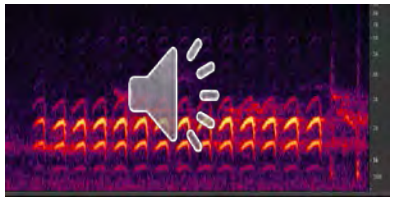
Research Team: Power Company of Wyoming and University of Missouri

Sage Grouse. *NREL 20649*

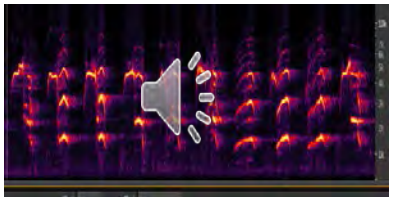
53

Properties of the Vocal System Provide Clues about Properties of the Auditory System

White-breasted nuthatch



Golden eagle copulation call



Golden eagle skonk call

Bald eagle chatter call

Examples of amplitude modulation and frequency spectrums

Source: As presented by Jeff Lucas, Purdue University at Eagle Detection and Deterrent Technology Research Gaps and Solutions Workshop, December 2015

Breakout Session 1 (Day 1)

Stakeholder Concerns, Additional Relevant Data Sources, and Additional Research underway

Breakout Group 1

Other things CWG should undertake?

- Greater stakeholder involvement
  - CWG & ASWG
  - FACA?
  - Use industry as a resource
  - Review of the Science Plan
- Outline next steps beyond the Science Plan
  - Implementation

New Information

- New solar project in Pahrump, NV
  - Panel spacing may diffuse the lake effect
- Widen the scope beyond AZ, CA, and NV
- USGS-FWS OFR on standardized monitoring

Group 2 (Day 2)

What other tasks should the CWG Undertake (1 of 2)

- Focusing on the science is the correct approach. Monitoring should be informed by research. Don't monitor for sake of monitoring. Interrelationship between monitoring and research.
- Consider costs when determining monitoring requirements (Danielle, Jeremiah)
- Monitoring should be designed to answer specific questions.
- Monitoring Guidelines due out in June. Will be publically available. Different from the CWG Science Plan.
- Monitoring procedures are a research question.
- Determine level of overall mortality
- Look at causation.
- Get data to focus the research
- Science plan should have priorities as a product
- What is the low hanging fruit?
- Leverage information and existing data

What other tasks should the CWG Undertake (1 of 2)

- Site specific monitoring vs understanding where projects should go
- What are we siting for? Any specific species? (Songbirds, migratory birds, etc.) E.g. wind now focuses on bats and raptors.
- Good model is San Juaquin Valley Least Conflict Plan (goes beyond science)
- What features in the landscape influence avian presence and behavior
- Keep in mind Technology specific effects
- Keep visibility on ongoing research efforts, common database? AWWI web site has extensive list of studies. When should studies be released?
- General research studies vs project data. CEC posts project data after review.
- Lots of folks want data/information, but many studies are still underway
- CWG and ASWG access to raw data? What questions can be answered?

Any ongoing or planned research or data collection efforts that are relevant to developing the science plan

- ASWG Research Panel looking at rough methodologies to answer ASWG questions
- ASWG Research Panel asked to sequence the research

Breakout Group 3

Stakeholder Concerns, Additional Relevant Data Sources, and Additional Research underway

Group 3

- Dan Boff, DOE
- Kirk LaGory
- Amy Fesnock,
- Bill Werner
- Katie Umekubo
- Chuck Griffin
- Juliette Falkner
- Karyn Coppinger
- Brian Boroski, H.T. Harvey
- Matt Hutchinson

Other things CWG should undertake?

- Need to specify focus on causation of mortality
- Look at sublethal effects (e.g., decreased reproduction, carrying capacity, etc.)
- Scope should go beyond regulatory requirements

Data and models

- Use of existing monitoring data: What does it tell us? What would we do differently?
- Making data available to the public. Data quality issues.
- Need to develop a toolkit

Relevant studies

- Genetic studies to examine population of origin
- Golden eagle research related to populations
- Look at rare and common species to provide bookends
- Condor Issue (vol 118): several papers population concerns related to renewable energy issues
- Draft article submitted to JWM, modeling estimates related to searcher efficiencies for rare species
- Draft paper looking at direct and indirect effects for solar, wind, and transmission

Conceptual Understanding of Avian-Solar Interactions

Lee Walston

Argonne National Laboratory

May 10-11, 2016

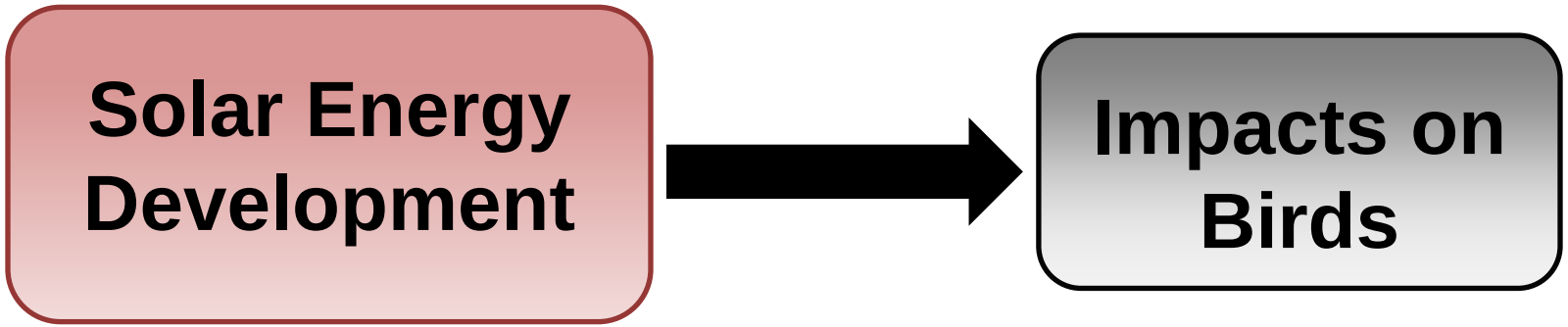
Sacramento, California

Why Develop a Conceptual Model?

- Illustrate important processes
  - Direct & indirect effects
  - Interactions and cumulative effects
- Synthesize current understanding of avian-solar interactions
  - Foster a common understanding
- Identify information gaps and research priorities
- Starting point for the avian-solar science plan

Avian-Solar Conceptual Model

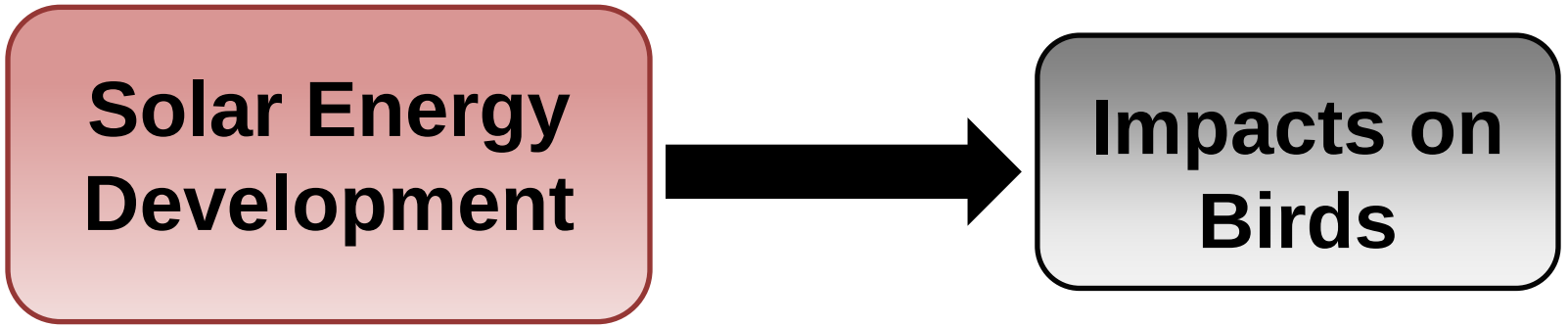
- Simple vs. Complex



- Two main focal points

Avian-Solar Conceptual Model

- Simple vs. Complex



- Impacting factors, pathways, and interactions

Technology?

Direct / Indirect Impacts?

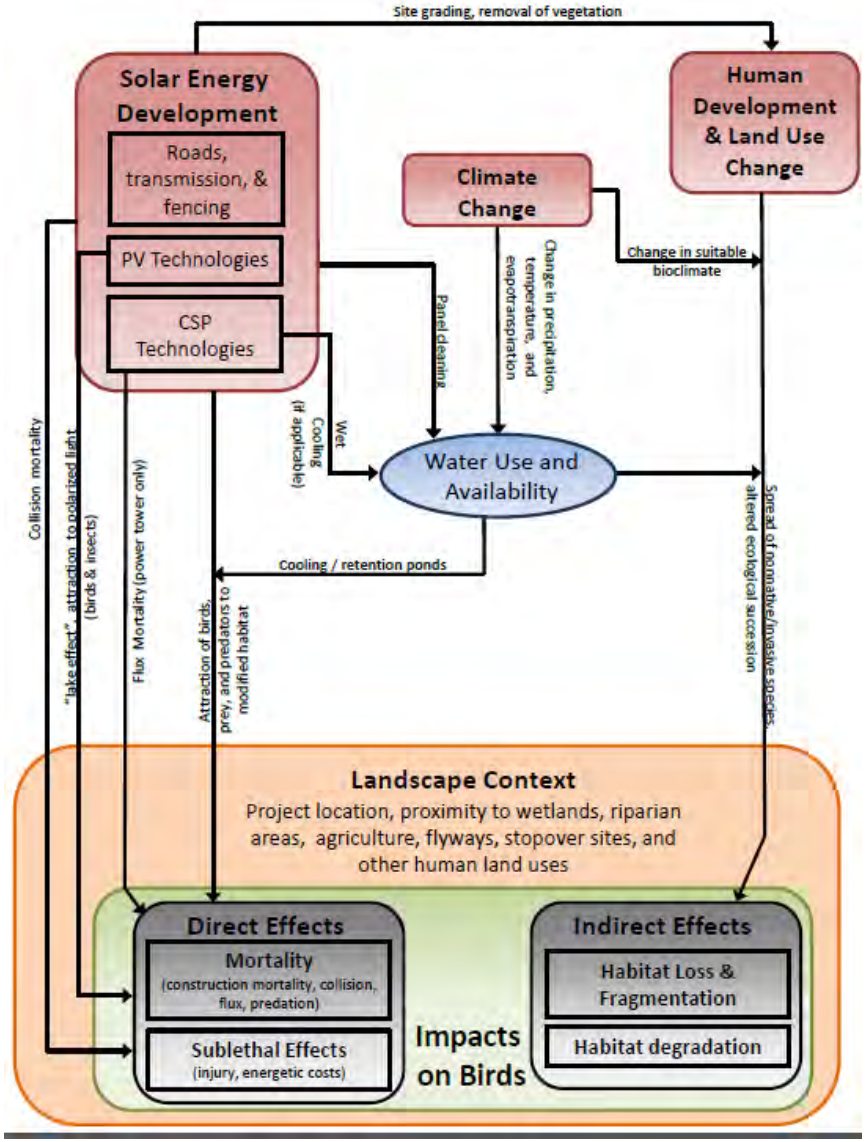
Climate Change?

Attraction?

Landscape Context?

Avian-Solar Conceptual Model

DRAFT



Avian-Solar Conceptual Model

Climate Change

Human Development & Land Use Change

Solar Energy Development

- Roads, transmission, & fencing
- PV Technologies
- CSP Technologies

Indirect Effects

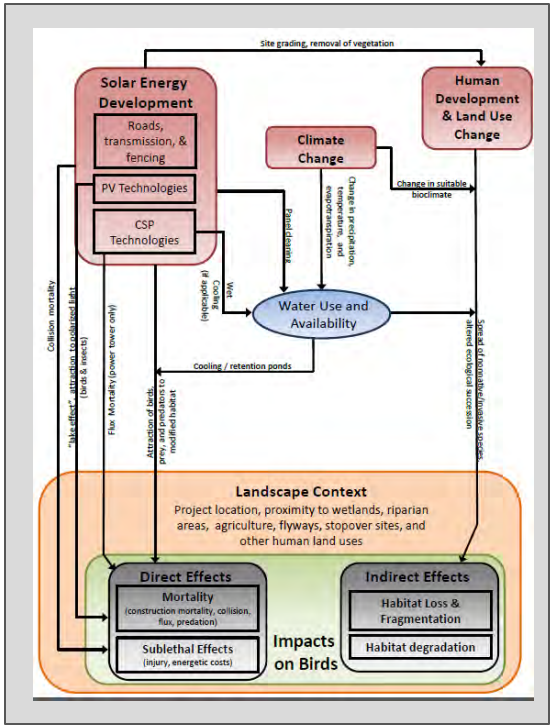
- Habitat loss & fragmentation
- Habitat degradation

Change in suitable climate

Habitat loss

Spread of nonnative / invasive species

Altered ecological succession



Avian-Solar Conceptual Model

Climate Change

Human Development & Land Use Change

Solar Energy Development

- Roads, transmission, & fencing
- PV Technologies
- CSP Technologies

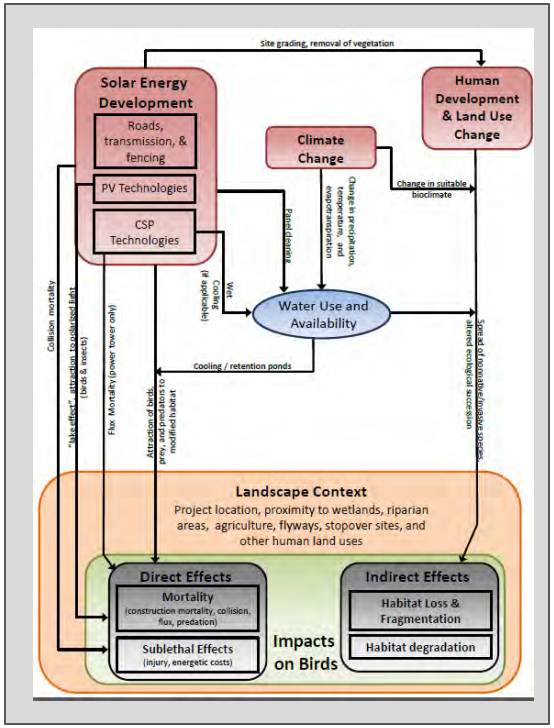
Direct Effects

- Mortality
- Sublethal Effects

Construction mortality, collision, flux, predation

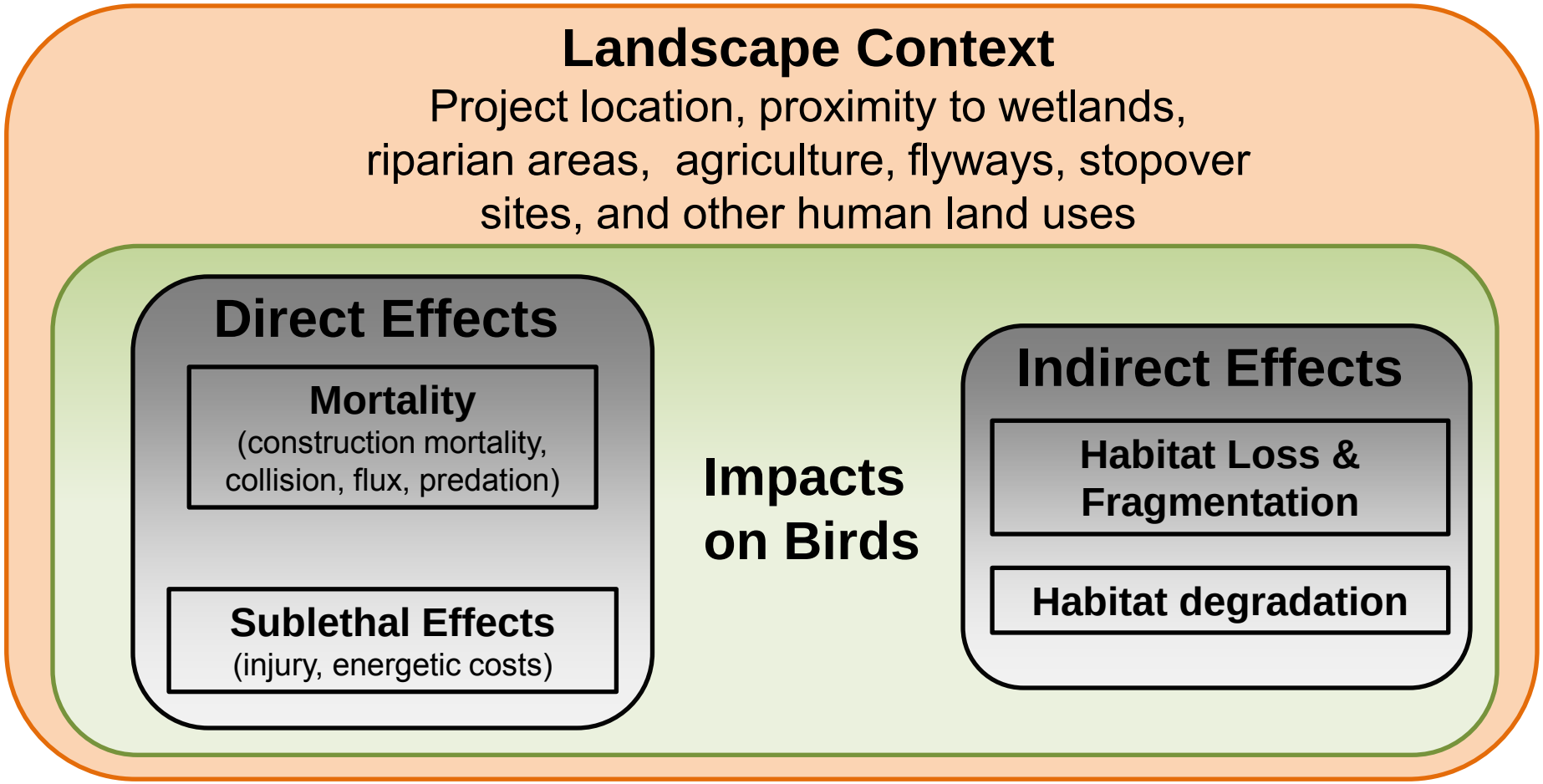
Attraction of birds, prey, and predators

Technological considerations & project design (e.g., water)



Avian-Solar Conceptual Model

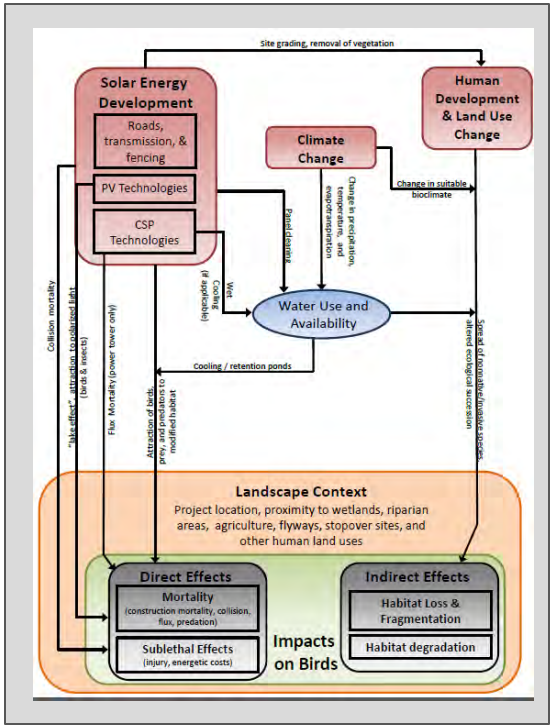
- Location matters



Avian-Solar Conceptual Model

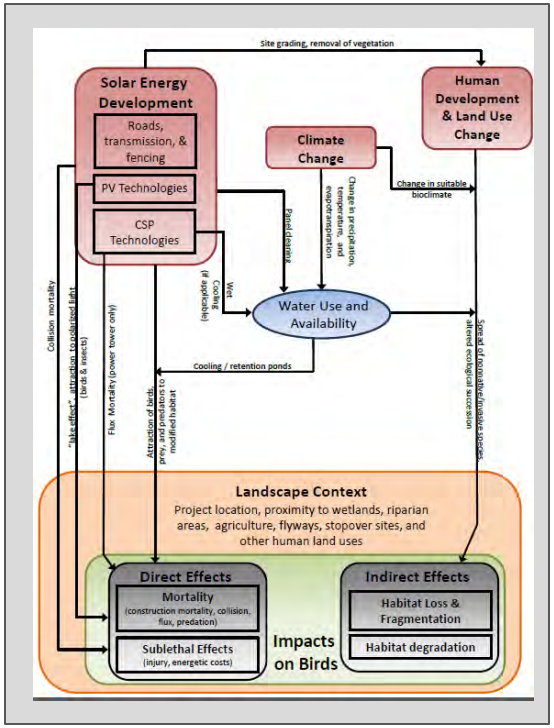
- Focus on processes and interactions the CWG may be most concerned about
- Supporting text to be provided in the science plan

- The diagram illustrates *potential* impacts that could occur
  - Projects sited on previously disturbed lands may have less impact
  - Projects with minimal water requirements (and no ponds) may have less impact



Avian-Solar Conceptual Model

- To inform selection and prioritization of the CWG management questions
  - Are any processes more important for agency decision making?
  - What are the information gaps?
  - Which information gaps should be addressed first?
- Future versions of the model may illustrate important information gaps and CWG priorities
  - Color / thickness of the arrows
  - Additional annotation



Questions?

Agency Management Questions and Related Research Needs

Tony Jimenez

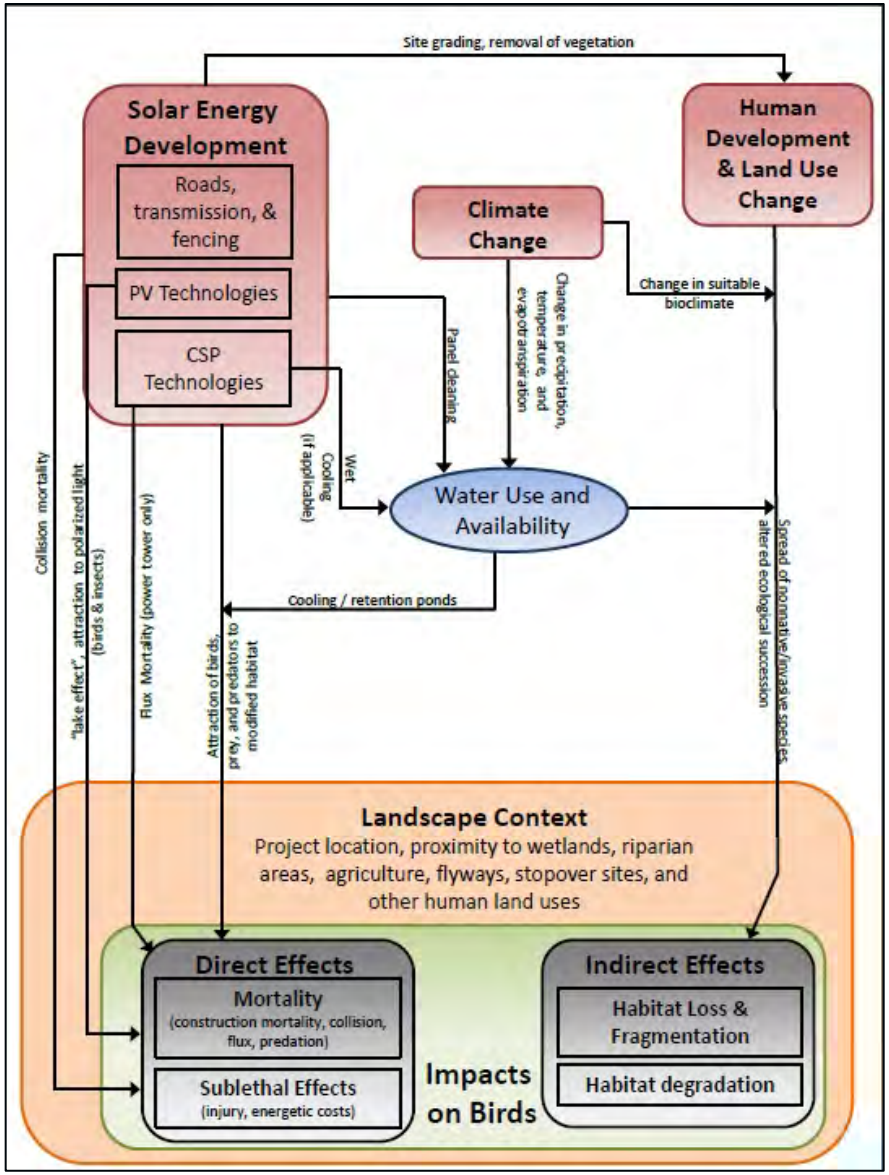
May 11, 2016

Outline

- Avian-Solar Interaction Model
- “Management Question” Defined
- Sample Questions
- Management Question Categories
- Generalized Management Questions
- Research Prioritization
- Discussion

Red-tailed hawk eating a rabbit.
Photo by Dennis Schroeder, NREL 22325

Avian Solar Conceptual Framework



Management Questions Background

- Define what information the agencies need
- Define research needs
- Tied to the conceptual model
- Due to differing missions, different agencies may have different questions
- Received 108 questions
- Questions grouped into seven (7) categories
- Questions consolidated into 14 “generalized questions”

Sampling of Management Questions

- What are the most scientifically rigorous and cost-effective population monitoring tools available for: 1) quickly identifying potential impacts to populations, and 2) determining effectiveness of mitigation strategies at local and regional scales?
- Is higher mortality realized during any particular time of year?
- Are birds being attracted to the site to forage on insects killed by the concentrated solar flux?

Management Questions Categories

1. Landscape Considerations
2. Methods to Evaluate Avian Risk and Impacts
3. Sources of Mortality and Injury
4. Avian Behavior (Attraction/Avoidance)
5. Impacts to Habitat and Other Wildlife That Might Affect Birds
6. Taxonomic and Guild-Specific Impacts
7. Minimization, Mitigation, and Adaptive Management

Generalized Management Questions

1. Landscape Considerations	What are the larger-scale avian movement patterns in the region (including seasonal movements and factors that influence avian movements such as the presence of stopover sites in the landscape)? What are the landscape-level cumulative impacts on regional bird populations or on bird populations migrating through landscapes targeted for solar development? What is the anticipated solar energy build-out for the foreseeable future? (e.g., project size, location, technology type)
2. Methods to Evaluate Avian Risk and Impacts	What are the best methods for monitoring and evaluating avian mortality, specific to each type of solar energy technology? What are the best methods for identifying the bird species that would be most vulnerable during all phases of solar development (pre-construction, construction, and post-construction)?
3. Sources of Mortality and Injury	What are the sources of avian mortality and injury at solar facilities (i.e., project features), and what factors (e.g., location, habitat characteristics, time of year, species) affect frequency of those mortalities and injuries?

Generalized Management Questions

4. Avian Behavior (Attraction / Avoidance)	How do solar facilities affect landscape level movements of birds (i.e., migration and dispersal movements), and what factors (e.g., location, habitat characteristics, time of year, species) affect these movements? How do solar facilities affect local-scale movements/behaviors of birds (i.e., foraging and breeding behaviors), and what factors affect these behaviors?
5. Impacts to Habitat and Other Wildlife That Might Affect Birds	What are the impacts of solar development to other wildlife (such as predators or prey) and habitat that might affect birds?

Generalized Management Questions

6. Taxonomic and Guild-Specific Impacts	How do solar developments affect different bird taxa or guilds? What are the population effects from solar developments to individual bird species, particularly those of conservation concern? Which population or species-specific impacts are of greatest conservation concern?
7. Minimization, Mitigation, and Adaptive Management	What are the most effective minimization and mitigation methods to reduce or eliminate avian mortality? (e.g., project siting, technology engineering and project design to reduce attractiveness of facilities to birds, construction timing, operational parameters, deterrents, or offset) What off-site mitigation is most effective for off-setting mortalities for affected populations/species?

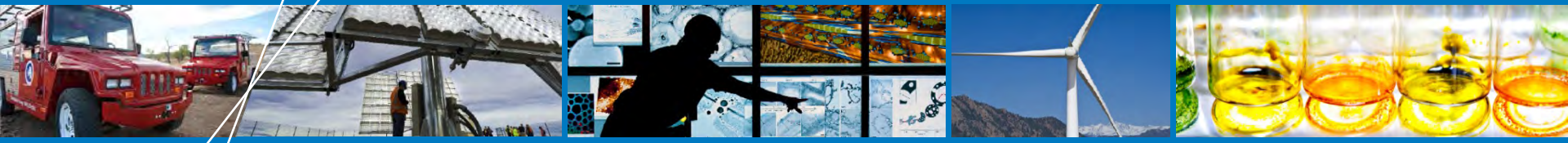
Research Prioritization

Based upon initial input from CWG members

- **Management:** Questions that are important for informing management decisions (management questions vs. research questions)
- **Timeliness:** Questions that can be answered in 3-5 years
- **Overlap:** Questions shared by multiple agencies

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

QUESTIONS / DISCUSSION



Day 2 Breakout Group Discussions

Group #1

Conceptual Framework

- Add stranding as another form of mortality
- Add dust suppression as water use

Management Questions (General)

- Research questions cannot be fully addressed through monitoring; require research/study design
- Not all questions can be answered with existing data
- Focus on natural history of taxa most likely to interact with solar facilities (e.g., insectivores).

#1 Landscape Considerations

- Scope concerns with the amount of foreseeable development question.
- Meta-analysis of existing data could address landscape considerations
  - ebird
  - Breeding bird survey

#2 Monitoring Methods

- Consider changes to pre-construction baseline surveys for taxa most likely to be affected ("better" baseline monitoring data)
  - Different seasons
  - Species-specific protocols
  - What taxa are most likely to interact with solar facilities?

#3 Source of Mortality and Injury

- It is possible ("maybe") for existing data and monitoring protocols to help inform sources of mortality and causation.

#4 Behavior

- Existing data/studies that could be used to understand avian behavior:
  - Pre-construction radar study for at least one solar project
  - Raptor telemetry data

#5 Impacts to habitat and other wildlife

- Could use predictive information on ravens, raptors, and desert tortoise.

#6 Population-level effects

- Monitoring data could help address how solar impacts different taxa differently.

#7 Mitigation

- Look at deterrents used in other industries (wind, aviation)
- Connect new approaches to systematic monitoring designs

Climate Change

- Could also be used to determine species of concern.

Criteria

- Budget & duration
- Would the answer to the question affect decisions?

Group 2 (Day 2)

Any Important elements missing or misrepresented in the conceptual framework?

- These were mostly captured in the discussion after Lee's presentation
- All birds lumped as one. Consider differential impacts to different guilds/species
- Take into account potential benefits and risks? Or relabel "Potential Negative Impacts" which acknowledges that there may be potential benefits.

Can any of the management questions be addressed with existing information/data? What questions would require additional field work?

- Do we have a good understanding of current monitoring protocols? Protocols evolve based on past experience.
- Look at monitoring approaches for uniformity.
- What are the sources of mortality? (Partial).
- How do impacts of development affect different guilds/taxonomies (Partial)
- Most of the questions will need research.
- Some/many effects appear to be location specific. Depend upon landscape and terrain features.
- Use existing data to develop hypothesis and inform the next iteration of research

Additional critical research needs that weren't identified

- Preconstruction monitoring (as research) to establish baseline mortality for areas that will see lots of development.
- How do we gather baseline mortality data? How funded?
- What before/after data already exists?
- Effect of emerging/future/sunsetting technologies? E.g. types of panels, antireflective coatings. tracking/fixed tilt.

What criteria should be considered by the agencies in establishing priorities for future research? Can you rank in terms of importance for guiding future research (e.g. allocation of funds)?

- Prioritize questions that can be answered sooner?
- Cost/difficulty
- Avoid duplication
- Foundationality
- Fills an important gap
- Should different agencies focus on different questions?
- What are the priorities of the individual agencies?
- Scope and applicability
- Unique to solar
- Solicit public comment on criteria & research needs

Other

- No definitive focus yet (as to priorities)
- Need to do background comparisons
- How do we ensure these agreed-upon priorities are carried out by the member agencies (implementation)

Breakout Session 3

Conceptual Framework, Management Questions, Research Needs and Priorities

Group 3

- Dan Boff, DOE
- Kirk LaGory
- Amy Fesnock,
- Bill Werner
- Katie Umekubo
- Chuck Griffin
- Juliette Falkner
- Karyn Coppinger
- Brian Borowski, H.T. Harvey
- Matt Hutchinson

Conceptual Framework

- Suggestions included
  - Place solar impact box within human development to show proper context
  - Solar should show as positive effect on climate change
  - Add season and weather as influencing factors
  - Present as hypothesis driven
  - Include avian behavior as factor
  - Define indirect
  - Factors are not comprehensive list. Add “e.g.,”
  - Water availability and use should be placed within solar box
  - Need to include potential benefits (e.g., use more neutral language regarding change rather than just degradation)

Management Questions

- Many questions have landscape context but not included in landscape bin
- Data are available on solar development projections, but may not have specific information on where these would go
- Monitoring data available on limited questions regarding mortality

Research Needs and Priorities

- What are the fundamental data needs to answer questions?
- Focus on basic processes:
  - Why are birds at site?
  - What are they exposed to?
  - What results in fatality?
- What is net effect on birds

Breakout 4 –

- *Landscape Framework comments*
  - *Broader context would be good beyond just solar.*
  - *Also, put INTO context to ensure it isn't misinterpreted when seen as a standalone document.*
  - *Should be entitled "pathway for potential impacts";*
  - *Suggest that at the core, it begins with the concepts lifecycle/life history perspective*

Breakout 4

- *Management questions comments*
  - *'landscape considerations' is not a management question but rather required background for solving other management questions.*
    - *Importance of background mortality*
  - *Level of pre-construction needed*
    - *BACI versus geospatial*
    - *Understand first what agency's want to see*
  - *Different ways to determine which guilds/species to study, e.g.*
    - *disproportional impacts, water birds, subset example of all guilds, other?*

Breakout 4

- ASWG compared to CWG questions
  - Feather spots…include clearly in CWG
  - *climate change futures with landscape considerations management question*
  - *Standardization - what attributes are needed to determine best methods?*
- *Criteria Ranking*
  - *#1 Fundamental need – recommend adding this*
  - *#2 Management*
  - *#3 Overlap*
  - *#4 Timeliness*

Multiagency Avian-Solar Collaborative Working Group: Stakeholder Workshop

Next Steps

May 10-11, 2016

Sacramento, California

Stakeholder Input Wanted

- All handouts and presentations will be available on the CWG webpage: http://blmsolar.anl.gov/program/avian-solar/
- Stakeholders can comment during this meeting and/or in writing following the workshop by **June 1, 2016**
- Agencies are seeking input from stakeholders on all matters relevant to the CWG objectives:
  - Concerns about avian-solar issues
  - Relevant existing data and studies
  - Understanding of avian-solar interactions
  - Focus of future research
  - Priorities for research needs
  - Future activities of the CWG
  - Level and mode of future stakeholder engagement

Draft Avian-Solar Science Plan

- Revise draft elements incorporating stakeholder comments
  - Summary of available data
  - Conceptual framework
  - Management questions
- Develop additional elements
  - Prioritization of management questions
  - Implementation plan
  - Comparative cost data
- Draft plan released for stakeholder review mid summer

Future Stakeholder Engagement

- A stakeholder webinar will be hosted to present and take comments on the draft avian-solar science plan (late summer 2016)
- For more information:
  - Subscribe for email updates: send request to rollins@anl.gov
  - CWG webpage: http://blmsolar.anl.gov/program/avian-solar/