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Oregon Department of Fish and Wildlife
Solar Siting Guidance
December 2023

SUPPORTING THOUGHTFULLY SITED, ADEQUATELY MITIGATED AND RESPONSIBLY OPERATED RENEWABLE ENERGY TO PROVIDE STRONG LEADERSHIP IN OREGON'S EFFORT TO RESPOND TO CLIMATE AND OCEAN CHANGE

EXECUTIVE SUMMARY

The goal of this document if provide a summary of current siting realities within the state of Oregon from the perspective of the Oregon Department of Fish and Wildlife (ODFW). ODFW is committed to being a partner in meeting the state's climate goals, and to meet these goals there will need to be additional energy resources developed within the state. Much of this energy will be derived from wind and solar installations. With the Columbia Plateau Ecoregion Wind Energy Siting and Permitting Guidelines and the Federal Wind Energy Guidelines ODFW staff have adequate direction and uniformity on how to approach applications for new wind energy projects. This document is meant to bridge the gap and provide a consistent baseline for ODFW to utilize in response to solar energy projects.

The six steps included in this document are meant to provide staff and interested parties with a general idea of likely input points in a permitting scenario. The first step is the Exploratory Planning step, and it is designed with early engagement and relationship development in mind. ODFW recognizes the challenges in developing a solar project, and we strive to make ourselves available as a resource in addition to the online planning tools provided in the document to highlight known resources to developers scoping potential project locations.

The Preliminary Project Planning step highlights environmental considerations once a developer has identified an area where a project may be sited. The materials in this step, which includes detailed information contained within appendix A, is put forth to help inform avoidance and minimization measures when designing site plans in a larger area chosen for siting a project.

Early Project Consultation is likely to coincide with pre-application conferences at the county level or concurrent with the Notice of Intent for larger projects. ODFW requests information on project location, description of project size and details, and an initial biological assessment. For many projects, this information may have already been relayed prior to this step depending on the developer and the pre-existing relationship they may have with local ODFW staff.

The fourth step in this guidance focuses on Addressing Wildlife in the PV Solar Application. This step is the most in-depth, as it will generally be the point at which ODFW staff have the greatest need for input. In addition to looking at projected impacts this step also looks at plans to address mitigation, revegetation and noxious weeds.

The fifth step notes timing for mitigation once the plan is developed and finalized, providing guidance consistent with existing policy that mitigation should occur prior to or concurrent with initial construction activities.

Finally, items generally addressed post-construction such as monitoring and data analysis are the basis for step six.

The appendices and annotated bibliography provide the opportunity for summary of current conditions and knowledge in a format that facilitates consistent updates and inclusion of new information.

This document is developed to be dynamic in nature, and ODFW is committed to updating the information provided within as new data and tools come available. We encourage partners and interested parties to forward any new science, online tools or other items that would be of benefit to these guidelines to the agency to be considered for inclusion.

CONTENTS

ACRONYMS

COA	Conservation Opportunity Area
CUP	Conditional Use Permit
DLCD	Department of Land Conservation and Development
EFSC	Energy Facility Siting Council
OAR	Oregon Administrative Rule
ODOE	Oregon Department of Energy
ODFW	Oregon Department of Fish and Wildlife
ORS	Oregon Revised Statute
PV	Photovoltaic

INTRODUCTION

Oregon's diverse geology, climate, and ecological regions support a unique collection of species and habitats, which help define the state's culture and economy. Oregon's prosperity depends on use of land for agriculture, timber, industry, ranching, and outdoor recreation. These working landscapes, along with wilderness and other natural areas provide the rich mix of habitat that supports Oregon's fish and wildlife.

Abundant and accessible habitat is the foundation on which fish and wildlife populations persist. Challenges to the persistence of native fish and wildlife are increasingly complex and intersectional. Fish and wildlife are increasingly impacted by changing land and water use, climate, water quality and quantity and other anthropogenic issues as Oregon's human population and development needs grow.

The Oregon Department of Fish and Wildlife (ODFW) is charged with managing Oregon's fish and wildlife resources. It is the policy of the State of Oregon that wildlife "shall be managed to prevent serious depletion of any indigenous species" (ORS 496.012). The policy also describes seven coequal goals of wildlife management, including "to develop and manage the lands and waters of this state in a manner that will enhance the production and public enjoyment of wildlife." Protecting and enhancing habitat is a core action to preventing the serious depletion of Oregon's fish and wildlife species.

The Earth's climate and oceans are changing because of activities that emit greenhouse gases into the atmosphere. Oregon is already experiencing climatic changes that are consistent with changes observed and projected globally, such as increased average air and water temperatures, disrupted precipitation patterns, and increased ocean acidification and hypoxia. These changing conditions are undermining the ability of Oregon's lands and waters to support native fish and wildlife, and the cultural and economic benefits they provide. This represents a serious and immediate threat to ODFW's ability to achieve its mission and meet its statutory mandates to manage the public trust resources in its care. ODFW's Climate and Ocean Change Policy directs the agency to give highest priority to protecting habitat for native fish and wildlife that is currently high functioning and projected to remain or become high functioning despite the impacts of changing climate and ocean conditions.

ODFW recognizes it is vital to reduce global greenhouse gas emissions for Oregon to fulfill the state's wildlife policy. Reducing global greenhouse gas emissions should slow and prevent future systemic change that will be detrimental to fish and wildlife. While energy efficiency and energy conservation are an integral part of Oregon's clean energy future, development of new renewable energy resources in Oregon is also an essential part of the solution.

Renewable energy development, like any other land or water use, has impacts on fish and wildlife habitat. The effort to prevent future climate and ocean change should also seek to avoid impacts to essential and important habitats to the greatest extent possible. Therefore, *ODFW supports thoughtfully sited, adequately mitigated, and responsibly operated renewable energy projects*. These guidelines are intended to support such projects.

To facilitate responsible development of renewable energy resources while avoiding and minimizing impacts to fish, wildlife, and habitat, ODFW offers the following guidance specific to utility-scale photovoltaic (PV) solar projects. The focus on PV solar is in response to the rapid increase in projects in recent years (a five-fold increase between 2015-2019; Oregon 2020 Biennial Energy Report), the absence of other types of solar energy proposals in Oregon (i.e., concentrated solar power or solar trough), and the availability of other guidelines for wind energy (i.e., Oregon Columbia Plateau Ecoregion Wind Energy Siting and Permitting Guidelines; US Fish and Wildlife Service Land-Based Wind Energy Guidelines).

The purpose of these guidelines is to promote responsible development and siting of utility-scale PV solar consistent with Oregon's wildlife habitat protection policies. These guidelines are designed to assist ODFW staff when reviewing applications, but may also inform project proponents, permitting agencies, and other parties involved in utility-scale PV solar energy. The recommendations in these guidelines are based on the best available science (see the Annotated Bibliography section of this document) and are designed to avoid and minimize impacts to fish and wildlife, while remaining practical, feasible, and hopefully streamlining the wildlife resource review process. Recommendations are offered for mitigating impacts consistent with the ODFW Fish and Wildlife Habitat Mitigation Policy (OAR 635-415-0000 through -0025) and can be applied to all lands within the state. These guidelines do not duplicate or supersede other legal or permitting requirements, and do not mandate or limit the alternatives an agency or permitting authority may choose to recommend or require.

This is a living document. The state's knowledge regarding the impacts of PV solar development to fish and wildlife – and effective solutions for addressing these impacts –continues to increase as science becomes available. We expect to modify these recommendations as new findings inform our understanding. We welcome new research and commit to maintaining these recommendations as a living document. We encourage input that may improve future revisions. Please direct comments and questions to Oregon Department of Fish and Wildlife's Energy Coordinator; Jeremy Thompson.

EARLY SITING CONSIDERATIONS

All potential impacts to wildlife and associated habitats are reviewed based on a mitigation hierarchy: *avoid* impacts first, *minimize* impacts as much as possible, and *mitigate* unavoidable impacts through compensatory offsets. The selection of project sites is the most critical choice in avoiding impacts to fish and wildlife from renewable energy development. Avoidance is best achieved in the exploratory stage of the siting process when project proponents are first evaluating opportunities at the landscape scale. In the exploratory stage of siting, wildlife and conservation priorities can be evaluated and balanced among other physical, cultural, legal, or social constraints to find areas that minimize conflict while still capitalizing on the renewable energy resource, transmission capability, and market demand. It is easier to avoid impacts to wildlife and habitats if they are considered early in the siting process before projects have executed land leases or permits.

In general, project proponents should seek to use previously disturbed areas or areas with lower wildlife habitat value when possible. Examples of areas deemed previously disturbed include lands that had been previously tilled or farmed, brownfields, or other areas where past human practices have reduced the overall habitat value or utilization by species. Proponents should avoid high-value or sensitive wildlife resources and large areas of unfragmented habitat. Some examples of the types of wildlife values to be considered at the exploratory stage of siting include areas occupied by threatened, endangered, and sensitive species, mapped sage-grouse habitat, ungulate (big game) migration corridors and wintering areas, Priority Wildlife Connectivity Areas (PWCA) and Oregon Conservation Strategy Habitats and Conservation Opportunity Areas (COA's). For a recommended list of siting tools and resources to help inform renewable energy siting, see Step 1. Exploratory Planning below.

While considering impacts to fish and wildlife, project proponents should also consider the potential impact of limiting public access or altering the character of the proposed project location. Additionally, consideration should be given to the surrounding landscape in which the project will be sited and the potential for cumulative impacts to fish and wildlife resources.

CONSTRUCTING UTILITY-SCALE PV SOLAR PROJECTS IN OREGON

Various federal, state, and county laws regulate the permitting of PV solar development in Oregon. Recent legislation has changed the acreage threshold that dictates the permitting pathway, and associated rules for a specific solar application based on the acreage of the project footprint. Table 1 below describes permitting pathways based on final legislative changes adopted in House Bill (HB) 3179 (2023).

There are specific wildlife standards found in the various regulatory pathways for permitting PV solar in Oregon:

- For PV solar projects permitting by the Energy Facility Siting Council, there is the Fish and Wildlife Habitat Standard (OAR 345-022-0060) and the Threatened and Endangered Species Standard (OAR 345-022-0070)

- For PV solar projects permitted by County, the wildlife standards depend on the acreage of the project (see table below for reference):

    - For County permitting with HB 2329 (2021) and HB 3179 (2023), see ORS 215.446

    - For County permitting of other PV solar projects not subject to ORS 215.446, see the Land Conservation and Development Commission's Solar Rules found in OAR 660-033-0130(38)

    - Project proponents should also refer to each County's applicable Goal 5 Programs addressing Natural Resources, Scenic and Historic Areas, and Open Spaces

Oregon Permitting Pathway for PV Solar Acreage Limitations by Permit and Land Type			
	County CUP under DLCD solar rule OAR 660-033-0130(38)	**County CUP via ORS 215.446 HB 2329 (2019) and 3179 (2023)**	**EFSC**
High-Value[1] Farmland	≤ 100	100 ≤ 240	≥ 240
Arable[2] Farmland	≤ 100	100 ≤ 2560	≥ 2560
Other Land[3]	≤ 320	320 ≤ 3840	≥ 3840

1. See ORS 195.300(10)
2. Land that is cultivated, or has soils capable of cultivation
3. Those lands not suitable for cultivation.

ODFW FISH AND WILDLIFE HABITAT MITIGATION POLICY

MITIGATION POLICY GUIDANCE

ODFW works cooperatively with project proponents and coordinates with the regulatory permitting agencies to identify potential impacts of PV solar projects on fish, wildlife, and their habitats. Where permitted by law or policy, ODFW may make recommendations to the permitting agency on strategies to avoid, restore, or replace habitat that would be impacted by a proposed project. The permitting agency determines what mitigation will be required within the final permit.

The Oregon Fish and Wildlife Commission directs ODFW staff to base comments and recommendations on the framework set forth in the Fish and Wildlife Habitat Mitigation Policy (OAR 635-415-0000 through 0025). The policy identifies preferred strategies to avoid or mitigate the impact of the proposed project on fish and wildlife habitat based on the importance of the habitat to a particular species of fish or wildlife. Depending upon the importance of the habitat, ODFW may recommend a variety of approaches to offset or replace habitat affected by the proposed project. The Fish and Wildlife Habitat Mitigation Policy also guides the review of projects where ODFW is the permitting agency, including fish screening and passage, and in-water blasting permits.

While the final decision on the project is made by another agency, proponents are encouraged to discuss the proposed project with staff from an ODFW regional office as early as possible. This may help identify potential issues and impacts on fish and wildlife habitat. Projects that are being considered within the occupied range for Greater Sage Grouse will also need to consider rules designed specifically for the protection of the species within Oregon. Once the permitting process is underway, ODFW and the permitting agency can work with the proponents to identify appropriate mitigation for those impacts, but addressing impacts while the project is still being designed may speed up final action on the permit by the permitting agency.

HABITAT CATEGORIZATION AND MITIGATION STRATEGIES

The Fish and Wildlife Habitat Mitigation Policy classifies habitat on a site into one of six categories, depending on the importance of the habitat to a specific species of fish or wildlife or the overall value of an individual habitat type. The more important the habitat, the greater the potential that disturbing the habitat will have a negative impact on fish or wildlife species.

FISH AND WILDLIFE HABITAT MITIGATION - KEY DEFINITIONS

Habitat	The physical and biological conditions withing the geographic range of occurrence of a species, extending over time, that affect the welfare of the species or any sub-population or members of the species.
Essential habitat	Any habitat condition or set of habitat conditions which, if diminished in quality or quantity, would result in depletion of a fish or wildlife species.
Limited habitat	An amount insufficient or barely sufficient to sustain fish and wildlife populations over time.

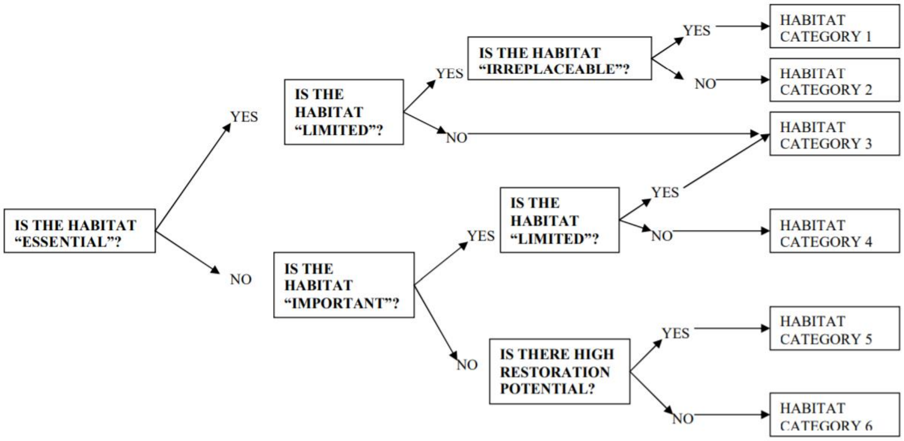
Important habitat	Any habitat recognized as a contributor to sustaining fish and wildlife populations over time.
Irreplaceable habitat	Successful in-kind habitat mitigation to replace lost habitat quantity and/or quality is not feasible within an acceptable period of time or location or involves an unacceptable level of risk or uncertainty.
Habitat with High Restoration Potential	Previous uses or activities that have reduced habitat values need to be able to be eliminated or severely reduced.

HABITAT CATEGORIES

The Fish and Wildlife Habitat Mitigation Policy establishes mitigation goals for each category of habitat and, depending upon the importance of the habitat, identifies preferred strategies to avoid or mitigate the impact of proposed actions on fish and wildlife habitat. The policy sets sideboards within which ODFW recommends options and alternatives for mitigation. There is a greater diversity of options for mitigation available for habitats with lower function or quality. For example, if a project is sited in essential limited habitat (Category 2 or 3) for a species of concern, mitigation should be performed within similar (in-kind) habitat. If the same project was able to identify a site within an area that is not deemed important (Category 5 or 6), mitigation, if necessary, may occur in any area that provides a benefit. The flow chart and table below further explain how the Fish and Wildlife Habitat Mitigation Policy links mitigation strategies to the quality of habitat impacted by the proposed project.

Habitat Category	Definition	Goal for Mitigation	Mitigation Strategy
Category 1	Essential, limited, and irreplaceable habitat	No loss of habitat quantity or quality	Avoidance
Category 2	Essential and limited habitat	No net loss of habitat quantity or quality and to provide a net benefit of habitat quantity or quality	In-kind, in-proximity mitigation
Category 3	Essential habitat, or important and limited habitat	No net loss of habitat quantity or quality	In-kind, in-proximity mitigation
Category 4	Important habitat	No net loss of habitat quantity or quality	In-kind or out-of-kind, in-proximity or off-proximity mitigation
Category 5	Habitat having high potential to become either essential or important habitat	Net benefit in habitat quantity or quality	Actions that improve habitat conditions

Category 6	Habitat that has low potential to become essential or important habitat	Minimize impacts	Minimize direct habitat loss and avoid off-site impacts



THE PROJECT REVIEW PROCESS

Project proponents are encouraged to engage early and directly with local ODFW staff to guide project siting and to assess and plan for mitigating potential fish and wildlife concerns. The following six steps lay out ODFW's recommended process for assessing potential fish and wildlife habitat impacts associated with utility-scale PV projects in Oregon, and additional detail and guidance is contained in the appendices. This process is intended to be applicable to any project regardless of the regulatory pathway.

STEP 1. EXPLORATORY PLANNING

Recognizing that many factors are considered by project proponents, coordination with local ODFW staff as early as possible in project scoping can assist with locating potential conflicts within prospective project footprints. This collaboration, in addition to the siting tools listed below, can assist with identification of habitats or species within a geographic region that could potentially add complexity to the permitting process.

SITING TOOLS

There are a growing number of renewable energy siting tools and decision support systems available to assist with PV solar project siting. Many of these tools offer more than just fish and wildlife information and allow for project proponents, regulatory agencies, and the public to explore the multiple constraints and criteria facing renewable energy project exploration and the intersectional nature of land use decision making. These tools are also useful for multi-stakeholder collaborative processes designed to support place-based renewable energy solutions.

Below is a current list and brief description of known available online renewable energy siting tools. ODFW will continue to update this list as more tools become available:

Siting Tool	Web Address	Brief Description

Oregon Renewable Energy Siting Assessment (ORESA) Mapping and Reporting Tool	https://www.oregon.gov/energy/energy-oregon/Pages/ORESA.aspx	Data and information about renewable energy, military training and operational areas, economic development opportunities; land use considerations; natural, cultural, and environmental resources; and other regulatory requirements.
ODFW Centralized Oregon Mapping Products and Analysis Support System (COMPASS)	https://www.dfw.state.or.us/maps/compass/	Online system of wildlife information and maps to help plan land use, energy, transportation, conservation, and other large projects. Provides access to spatial representations of Oregon Conservation Strategy components. Includes a Strategy Reporting Tool that provides an aggregate report of Strategy data (such as species presence) within a user submitted area of interest.
Oregon Sage-Grouse Development Siting Tool	https://oregonexplorer.info/content/sage-grouse-development-siting-tool?topic&ptopic	Interactive application that allows prospective developers in Oregon to access information about potential project impacts to greater sage-grouse and estimates sage-grouse mitigation requirements specific to a project area.
Priority Wildlife Connectivity Areas (PWCA)	https://experience.arcgis.com/experience/6979b6598f904951bd0af1821e1595f1/	ODFW Priority Wildlife Connectivity Areas (PWCAs) provide non-regulatory information on the parts of the landscape expected to have the highest overall value for facilitating wildlife movement. The network of PWCAs serves as a science-based, informational tool to support planning for habitat enhancement, restoration, conservation, transportation mitigation, land-use, and development projects.
Oregon Explorer Natural Resources Digital Library	https://oregonexplorer.info/	Digital library that integrates and provides access to data and information from state and federal agencies, local governments, university scientists, and citizens to support informed decisions and actions by people concerned with natural resources, environment, and communities throughout Oregon.
Argonne National Laboratories Geospatial Energy Mapper (GEM)	https://gem.anl.gov/	A free online mapping tool for identifying areas within the US that may be suitable for power generation and energy corridors. Originally an Eastern Interconnection tool, recently expanded to be nationwide. Flexible modeling of facility siting factors such as slope and land protections.
Western Electricity Coordinating Council (WECC) Environmental and Cultural Data Viewer	www.wecc.org https://ecosystems.azurewebsites.net/WECC/Environmental/	Web mapping application to view and access environmental/cultural risk classification data layers developed by WECC stakeholders. Intended for use in regional transmission expansion planning, and siting level analysis.

Biological Information

The resources listed in the table below, in coordination with the siting tools listed above, assist with preliminary assessment of potential species presence in a project vicinity.

Biological Information	**Web Address**	**Brief Description**
USFWS Information for Planning and Consultation (IPaC)	https://ipac.ecosphere.fws.gov/	Allows users to integrate the USFWS environmental review process into project design by identifying USFWS managed resources in the project location.

Oregon Biological Information Center (ORBIC)	https://inr.oregonstate.edu/orbic	ORBIC's key function is to maintain, develop and distribute biodiversity information in the state. ORBIC also coordinates projects on biodiversity monitoring and provides technical assistance for the Oregon Natural Areas Program. ORBIC works with a variety of agency, non-profit, and private partners and is a member of the NatureServe network.
USGS Breeding Bird Survey (BBS)	https://www.pwrc.usgs.gov/bbs/	The BBS is a cooperative effort between the U.S. Geological Survey's Patuxent Wildlife Research Center and Environment Canada's Canadian Wildlife Service to monitor the status and trends of North American bird populations
Audubon Christmas Bird Count (CBC)	https://www.audubon.org/conservation/science/christmas-bird-count	Long-term citizen science project to document species presence annually within designated areas.
StreamNet	https://www.streamnet.org/	StreamNet is a cooperative information management and data dissemination project focused on fisheries and aquatic data and data-related services in the Pacific Northwest, with a focus on the Columbia River Basin
National Oceanic and Atmospheric Administration (NOAA)	https://www.fisheries.noaa.gov/science-and-data	NOAA Fisheries is responsible for the stewardship of the nation's ocean resources and their habitat.

STEP 2. PRELIMINARY PROJECT PLANNING

PROJECT LOCATION

The selection of a project site is the most critical choice in avoiding impacts to fish and wildlife from PV solar development. Proponents should seek to use previously disturbed areas or lower value wildlife habitat (Fish and Wildlife Habitat Mitigation Policy Habitat Categories 5 and 6) when possible. Co-location of PV solar projects with existing human disturbances is encouraged. Additional project location considerations for avoiding and minimizing impacts to fish, wildlife, and habitat are included in Appendix A.

STEP 3. EARLY PROJECT CONSULTATION WITH ODFW

WHAT TO SUBMIT

This step will likely correspond with initiation of the permitting process, either a pre-application conference with county planning or the Notice of Intent with ODOE. The amount of preliminary project and site information initially requested by ODFW is dependent on the project's stage of development.

For projects in the earliest conceptual design phase with multiple alternative sites or a general region under exploration for development (like the Exploratory Planning phase described above), ODFW can provide an initial assessment of the project location(s). ODFW will provide insight into the scope of potential impacts for fish and wildlife, and whether there are areas of known conflict within or among proposed sites. In this case, proponents should submit:

1) A GIS layer, or similar file, of the potential project area.

2) A brief description of the project scope (acres, land ownership, and potential timing of construction).

For proponents who contact ODFW for the first time with fixed project boundaries or who have less flexibility in project location, ODFW requests the information below. Some counties encourage project proponents to participate in pre-application meetings, and this is the ideal time to invite ODFW to attend and to share the following:

- **Proposed project location**. Provide the legal description, GIS layer, and maps identifying the proposed project location. Delineation of the project area should include associated infrastructure, such as proposed power line corridors and access roads. Proponents should describe any considerations that were implemented in the selection of the project location to reduce impacts to fish and wildlife resources (see Appendix A).

- **Project description.** Please provide the following:
    - Acreage of the project
    - Nameplate energy generation capacity
    - Planned infrastructure including PV solar energy generation components, roads, fencing, power lines and lighting
    - Seasonal timing and duration of construction
    - Preliminary concepts for revegetation of temporary impact areas, invasive species management, and proposed fish and wildlife protections or mitigation

- **Initial biological assessment.** The project proponent should arrange for a qualified biologist who is knowledgeable about fish and wildlife in the region to conduct an initial desktop biological assessment of the proposed project location (see the Siting Tools section above). This assessment should include:
    - A description of the current land use, zoning, and the project site in relation to the larger landscape (e.g., proximity to high-priority fish and wildlife habitats, existing or previously disturbed areas, areas of industrial land use).
    - A habitat map delineating land cover, including major vegetation communities, existing surface disturbance, significant topographic or biological features (e.g. rock outcroppings, ridgelines, caves) and ephemeral and perennial waterbodies. This preliminary habitat map can be created using best available aerial imagery and remotely sensed datasets (see the resources listed above).
    - A list of potential or known threatened, endangered, or sensitive species or habitat within the project area and a 1-mile buffer surrounding the project area. The species list can be generated using ORBIC and/or iPAC, see above in the Resources for Biological Information section.
    - Results of any preliminary biological surveys or habitat assessments performed on site.
    - ODFW recommends including a preliminary categorization of habitats within the project area, following the habitat category definitions in the ODFW Fish and Wildlife Habitat Mitigation Policy.

ODFW Preliminary Review

After receiving preliminary project and site information from the project proponent (Steps 1, 2, and 3), ODFW will offer the following preliminary review:

1) Assess the biological values of the proposed site(s).
2) Identify potential or known impacts to fish and wildlife resources.

3) Recommend appropriate biological surveys or habitat assessments to measure and quantify potential or known impacts. In areas potentially within greater sage-grouse habitat, contacting the Sage Grouse Mitigation Coordinator is encouraged for direction on how to assess potential impacts and specific data needs.
4) Provide preliminary recommendations for project location, micro-siting of infrastructure, as well as applicable design, construction, and operations best practices (see Appendix A and Appendix B).
5) Work cooperatively with the project proponent and the permitting agency to ensure habitat mitigation plans adequately avoid, minimize, and mitigate project impacts. See the Mitigation Policy section above, and the Mitigation Planning section below.

    Note: the Oregon Fish and Wildlife Commission directs ODFW staff to use the definitions, goals, and standards in the Fish and Wildlife Habitat Mitigation Policy as the framework for recommendations in land use and energy project review. However, the final determination of project siting conditions resides with the permitting authority.

STEP 4. ADDRESSING WILDLIFE IN THE PV SOLAR APPLICATION

In each of the regulatory processes discussed in the Constructing Utility-Scale PV Projects in Oregon section above, impacts to fish and wildlife and their habitats must be addressed and applicants are expected to work with relevant fish and wildlife agencies to develop wildlife habitat mitigation plans consistent with the standards specified in the relevant statutes and/or rules.

As a project proponent develops its application for county conditional use permit or EFSC site certificate, there are some key elements that help demonstrate fish, wildlife and habitat impacts have been considered and addressed, and that adverse effects will be offset. These key elements include an **impact assessment**, design, construction, and operational **minimization measures** including revegetation and noxious weed plans, and **a habitat mitigation plan** for how unavoidable impacts will be offset.

ODFW recommends project proponents begin developing their habitat mitigation plans as early as possible in their project planning process (Step 2 or 3, above) as mitigation planning takes time. From impact assessment, to designing avoidance and minimization measures, to determining appropriate offsets and establishing performance and durability measures, there are many milestones along the way in mitigation planning that will necessitate consultation with the regulatory entity and with ODFW.

ODFW recommends use of the mitigation framework laid out in the Fish and Wildlife Habitat Mitigation Policy as a known, consistent, and robust method of assessing and offsetting impacts to fish and wildlife habitat. This framework follows the classic mitigation approach of Avoid – Minimize – Mitigate impacts.

Project proponents may consult with ODFW staff on any of the following elements as they are developed. In many cases, a site visit to proposed mitigation sites may be of value, and other partners in the process may also provide valuable input if included in the process (local county officials, landowners, conservation partners/entities, etc.)

IMPACT ASSESSMENT

A project application should include an assessment of potential and likely impacts to fish, wildlife, and their habitats. An impact assessment should consider the potential impacts to species on or in the vicinity of the project, impacts to the quality and condition of the vegetation community, and the duration of the impacts.

Project proponents should consider and address all manner of impacts, including direct, indirect, temporary, and permanent impacts. Definitions are provided below:

> **Direct impacts**: mortality or physical harm of wildlife caused by collision with infrastructure or collision with – or trampling by - construction equipment; and removal of habitat including vegetation, nests, or roost structures above or below-ground.
>
> > *Examples: grading and clearing to prepare a site for PV panel arrays, areas within a fence enclosure no longer accessible to species*
>
> **Indirect impacts**: altering habitat structure, quality (including vegetation, light levels, noise levels, human activity levels), and function in ways that have 'downstream' effects on animal occurrence, behavior, reproduction, and migration.
>
> > *Examples: increased traffic on project access roads, displacement of wildlife out of areas of increased human activity, reduced species diversity*
>
> **Temporary impacts**: any area impacted by construction but not permanently covered by pavement or infrastructure or permanently cleared for a right-of-way. Some temporary impacts may require mitigation, as the time for reestablishment may provide for loss of habitat. (i.e.. Sage-steppe shrubs or certain forest types)
>
> > *Examples: construction and equipment storage areas capable of revegetating, temporary access roads, staging areas, laydown areas, fly yards, and pulling/tensioning sites outside of the fenced facility.*
>
> **Permanent impacts**: part of the final facility, typically under pavement or infrastructure, or permanently cleared of vegetation, no longer accessible to the focal wildlife species, for the life of the project's impacts.
>
> > *Examples: new access roads, paved or graveled areas, building footprints, permanently cleared rights-of-way, fenced panel arrays*

Impacts should be assessed by a qualified wildlife professional using desktop methods as well as any recommended field surveys as described in Steps 1, 2, 3, and 5.

Once project impacts are enumerated, ODFW recommends project proponents categorize the habitats in their project area according to the definitions in the Fish and Wildlife Habitat Mitigation Policy (see the Habitat Categorization and Mitigation Strategies section, above). This methodology helps compare habitat functions and values with the potential direct and indirect impacts of the project and allows proponents to begin to identify strategies for offsetting unavoidable impacts.

The project's impact assessment should be included in the project application and/or the project's habitat mitigation plan.

AVOIDANCE AND MINIMIZATION MEASURES FOR DESIGN, CONSTRUCTION, AND OPERATIONS

Impacts to fish and wildlife can be minimized at PV solar developments through carefully designed project features, proper timing of construction and major maintenance work, minimization of human activity, and appropriate reclamation. Careful placement of roads, power lines, and other project infrastructure will further reduce impacts, especially if these associated project features can be co-located with existing infrastructure. Project design and infrastructure micro-siting may be informed by investigation and recommendations during preliminary project planning and further refined during pre- and post-construction monitoring. See Appendix A and Appendix B for more detailed recommendations on project design and siting, and best management practices for project design construction, and operations.

Avoidance and minimization measures included in the design and plans for a project should be described in a proponent's habitat mitigation plan and included in the project application.

REVEGETATION AND NOXIOUS WEED PLANS

Revegetation should focus on ecologically appropriate seeds and plants based on project location and pre-construction surveys. In many instances local National Resource Conservation Service, Oregon State Extension, or Soil and Water Conservation Districts can be valuable sources of information on appropriate revegetation strategies. In addition, having soil survey data for areas in need of revegetation can increase overall success of efforts and planning. Soil data for Oregon can be found here.

Noxious weed plans should reference both county and state listed weed species, as well as any invasive plant species introduced through the construction process. Information and assistance with invasive weeds can be found here.

Successful revegetation of temporary impacts can reduce the need for additional mitigation in cases where the habitats affected are dominated by vegetation that is relatively easy to establish.

WILDLIFE HABITAT MITIGATION PLANS

Mitigation for impacts that cannot be avoided or minimized can be accomplished in multiple ways. Regardless the avenue a project proponent chooses to pursue for mitigating impacts, highlighting the chosen path in a mitigation plan allows for review from the relevant permitting agency, and for review to be completed by ODFW as required in current siting rules in the state. The elements included below are meant to provide an example derived from past approved mitigation plans that provided adequate information for easy assessment by all parties.

Impact Assessment
- As described above

Avoidance and Minimization Measures
- Summary of onsite activities or actions directly taken in response to resources noted in consultation with ODFW staff or found in the impact assessment. Past examples include modifications to project footprint to avoid higher quality habitats, fencing modifications to allow passage through or around the project footprint, or seasonal timing restrictions to minimize impacts to special status species.

Habitat Categorization of the impact site and summary of impacts
- Summary table showing acres of temporary and permanent impact by habitat type, habitat category, and proposed acres of offset.

Proposed Mitigation Site(s)
- Location, size, description.

- Baseline assessment of habitats (the more quantitative the better including acres by habitat type, habitat category, % cover of dominant vegetation, notable water or riparian features), and current uses/human activities on the land.
- Proposed boundary.
- Proposed mitigation acres to account for no net loss or net gain, as appropriate based on impact assessment. Sufficient acres of additional mitigation should be planned for to buffer success of mitigative actions (2:1 ratio for Cat. 2 is generally used to account for net gain with success buffer on permanent impacts).

Proposed habitat enhancement or restoration actions, accounting for potential success of chosen actions.

- Enhancement should be site-specific with measurable outcomes based on desired future conditions of the mitigation site.

Proposed conservation or durability measures to ensure the mitigation meets the habitat goals for at least the life of the project's impacts.

- Copy of or description of the conservation instrument securing the mitigation site including all allowable uses and documentation of willing landowner(s).

Monitoring and reporting

- Success criteria, monitoring plan, reporting schedule, and adaptive management actions if success criteria are not met.

Timing the Final Mitigation Plan

- Regulatory entities should require applicants to provide a complete mitigation plan prior to permit approval. This plan should provide enough specificity to ensure that mitigation proposed will be durable for at least the life of the impacts and that the approved mitigation site and/or actions are appropriate to offset impacts based on pre-construction assessment of the development location. If the applicant desires flexibility or options in final mitigation outcome the approved plan, at a minimum, regulators should ensure that each option desired is detailed enough that all interested parties can assess each potential outcome against the total impact for the project.

ODFW RECOMMENDATIONS

For a county level project ODFW staff will provide the county and the project proponent with formal, written recommendations for a proponent's plan of development as a component of the conditional use permit application. For projects permitted with EFSC, comments will be provided first with the Notice of Intent, and then as necessary during application for site certificate process and the draft proposed order. This formal input will be consistent with input provided throughout the project development process if ODFW has been engaged early in the proceedings. Project proponents should use this information to guide the selection of a project location and for infrastructure micro-siting, as well as design, construction, and operations to mitigate impacts to fish and wildlife to the maximum extent possible.

STEP 5. IMPLEMENTATION OF MITIGATION

Final plans should designate timing for implementation of agreed upon mitigation measures. Mitigation for temporary and permanent impacts should occur prior to or concurrent to any action that creates disturbance or other effects.

STEP 6. FISH, WILDLIFE AND HABITAT MONITORING, DATA ANALYSES

Monitoring and Reporting

ODFW will recommend that success criteria for revegetation, weed abatement, and mitigation are clearly defined and measurable. It is common to request monitoring for effects to sensitive species (ie. Washington ground squirrels, eagle nests etc.). Monitoring and reporting protocols vary based on the specific surveys agreed upon within the permitting process. Some local variability may occur due to differences in plant compositions and growing conditions by region, but in general, this monitoring will be requested to occur within the first two years after completion of designated activities, and on regular intervals (~5 years) thereafter for the life of the project.

Data Sharing

Where feasible, ODFW requests that data and reports generated through project monitoring be shared with the agency. ODFW's analyses of project data over time supports better recommendations by the agency in the future, will inform future updates to this document and may reduce the need for some monitoring on future projects if impacts are determined to be understood or not exist.

APPENDIX A. INFRASTRUCTURE SITING AND PROJECT LOCATION CONSIDERATIONS

The selection of a project location and siting of infrastructure within the project area are the most critical choices in avoiding impacts to fish and wildlife from PV solar development. Proponents should avoid high-value or sensitive fisheries and wildlife resources and large areas of unfragmented habitat, which can be identified through coordination with ODFW biologists and using geospatial data resources found in ODFW's COMPASS tool as well as the Oregon Renewable Energy Siting Assessment Mapping Tool (ORESA). Projects that are placed in areas with fewer fish and wildlife concerns and that adopt best practices in layout, design, construction, and operations will result in reduced conflict with fish and wildlife values, and consequently will have reduced need for monitoring and further mitigation.

The following table identifies the factors commonly considered by ODFW when assessing biological values of a proposed PV solar site, as well as ODFW's most common recommendations for avoiding or minimizing potential impacts. Not all recommendations will apply to all projects, and recommendations will be made on a project-specific basis determined by the biological values of a particular site. These recommendations may be modified as new scientific findings become available.

TABLE A.1. CONSIDERATIONS AND RECOMMENDATIONS FOR ADDRESSING BIOLOGICAL IMPACTS OF A PROPOSED PV SOLAR DEVELOPMENT.

AQUATIC RESOURCES
Considerations • Will soil disturbance occur in areas sensitive to wind and water erosion? • Does the site contain any inventoried wetlands? • Will project development potentially impact any fish-bearing waterways, or waters that contain an Oregon Conservation Strategy Species? • Does the site and/or infrastructure have the potential to act as barrier to fish passage?
Recommendations

- Avoid construction, and staging of equipment, including servicing, fueling, and cleaning, within 500 feet of aquatic and riparian habitats
- Avoid instream construction to minimize impacts to spawning fish. Spawning dates vary based on elevation and species. Follow ODFW In-water Work Timing Guidance.
- Ensure all sediments and other pollutants are contained within the boundaries of the work area. Disturbed areas that are contributing sediment to surface waters because of project activities should be promptly revegetated to maintain water quality
- In some instances, presence of aquatic wildlife may further impact available in-water work timing. Local ODFW staff can provide additional guidance in areas where this may occur.
- Avoid obstructing fish passage and aquatic species movement. In the event of potential trigger of Oregon fish passage statute (ORS 509.580-910) and rule (OAR 635-412-0035), contact the ODFW Fish Passage Program as early as possible
- Prevent the spread of aquatic invasive species from one body of water to another
- Follow best management practices for cleaning of equipment used on site.

SAGE-GROUSE

Considerations

- Is the project compliant with the current State of Oregon Greater Sage-grouse Rules (OAR 660-023-0115) and Greater Sage-grouse Conservation Strategy (OAR 635-140-0000 through -0025)?
- Where is the site in relation to significant greater sage-grouse core areas, low-density habitat, and general habitat as identified in Goal 5 Sage-Grouse OAR 660-023-0115?
- Is the proposed development considered a conflicting use in sage-grouse habitat as defined in OAR 660-023-0115(7)?
- Is all associated proposed development infrastructure being discussed while coordinating on the sage-grouse impact assessment?

Recommendations

- Coordinate with the ODFW Sage-Grouse Mitigation Program to work through State of Oregon greater sage-grouse rules and assessment of potential project impacts to sage-grouse through the Habitat Quantification Tool
- Use the Oregon Sage-grouse Development Siting Tool to guide project siting to reduce or eliminate direct and indirect impacts to sage-grouse habitat
- Once final project design has been determined the Habitat Quantification Tool will provide final mitigation requirements based on all project components and existing habitat quality. This tool is generally managed by the Sage-Grouse Mitigation Program
- Utility-scale PV solar development, and associated transmission lines, are not recommended in significant greater sage-grouse core or low-density habitats
- Any PV solar project that is constructed in core, low-density, or general habitat must comply with State of Oregon greater sage-grouse administrative rules referenced above for both land use and mitigation standards
- Above-ground infrastructure, such as roads and transmission lines should be sited to reduce impacts to contiguous sage-grouse habitat and occupied greater sage-grouse leks
- Avoid construction or operation activities from two hours before sunset to two hours after sun rise in significant greater sage-grouse habitat during the breeding and nesting seasons (March 1 to June 30).

RAPTORS (HAWKS, FALCONS, EAGLES, OWLS)

Considerations

- Are any of the following known or likely to occur on or near the proposed project site or its associated infrastructure?
    - Species federally listed as ‘threatened’ or ‘endangered’ or candidates for such listing or their habitats
    - Federally designated Critical Habitat components
    - Golden or bald eagles
    - Oregon Conservation Strategy Species:
        - Burrowing owl
        - Ferruginous hawk
        - Flammulated owl
        - Great gray owl
        - Northern goshawk
        - Northern spotted owl
        - Peregrine falcon
        - Short-eared owl
        - Swainson’s hawk
- Are any raptor nests within one mile of the site?
- Are the PV solar site or any new transmission lines in or near any known raptor flight paths, foraging areas, or areas of orographic uplift or thermal updrafts?

Recommendations

- Site energy collector components underground to the maximum amount feasible to reduce bird strike potential
- Follow the Avian Power Line Interaction Committee’s (APLIC) guidelines for mitigating electrocution and collision risk for birds (aplic.org; APLIC 2012)
- Avoid removal of raptor nests, which ODFW considers Category 1 Habitat (as defined in the ODFW Fish and Wildlife Habitat Mitigation Policy)
- Suspend construction within raptor nest buffers during the dates specified in Table A.2 (below) and in coordination with the US Fish and Wildlife Service (USFWS)
- Consult the USFWS for buffers associated with eagle winter roosts, concentrated prey resources, and high-use areas
- Avoid high-value golden eagle habitats (areas of high density, winter use, or movement) identified by the USFWS Western Golden Eagle Team

OTHER BIRDS (WATERFOWL, SONGBIRDS, ETC.)

Considerations

- Are the following known or likely to occur on or near the proposed project site?
    - Species federally listed as ‘threatened or endangered’ or candidates for such listing or their habitats
    - Federally designated Critical Habitat components
    - Oregon Conservation Strategy Species
- Is the site on or near important areas for seasonal movement, staging, wintering, foraging, roosting, nesting, or resting for birds?

Recommendations

- Avoid removal of bird nests and minimize disturbance to nesting birds during the general bird breeding season (March 1- July 15th)
- Minimize disturbance within 0.25 miles of known breeding concentrations of long-billed curlew, upland sandpiper, and western snowy plover during the general breeding season (April – July) to mitigate impacts to breeding individuals
- Maximize distance from wetlands and irrigated pastureland known to be used by waterbirds and waterfowl as migratory stopover sites

- Consider post-construction fatality monitoring and adaptive management plans in areas with state or federally listed species
- Consult the USFWS for opportunities to minimize impacts to migratory birds

BATS AND OTHER NONGAME MAMMALS

Considerations

- Are the following known or likely to occur on or near the proposed project site?
    - Species federally listed as 'threatened or endangered' or candidates for such listing or their habitats, including federally designated Critical Habitat components
    - Oregon Conservation Strategy Species
- Is the site on or near important areas for bat roosting, hibernacula, breeding/maternity colonies, migration, or foraging? Are there any caves, old-growth trees or standing dead trees (snags) with loose bark, ponds/wetlands, or riparian corridors within 0.25 miles of the project?
- Are there pygmy rabbit or white-tailed jackrabbit burrow complexes in areas of potential ground disturbance?
- Are there active Washington ground squirrel colonies within or near the areas of potential ground disturbance?
- Consult with USFWS to address any impacts to federally protected species

Recommendations

- Avoid disturbance or removal of known bat roosts, hibernacula, or colonies which ODFW considers Category 1 Habitat consistent with the ODFW Fish and Wildlife Habitat Mitigation Policy.
- Avoid impacts to occupied Washington Ground Squirrel (WGS) colonies which meet the Category 1 Habitat definitions in the ODFW Fish and Wildlife Habitat Mitigation Policy, including a 785-foot buffer of suitable habitat around the colony. This buffer is based on documented dispersal distances and juvenile foraging distances and is considered requisite habitat for Washington ground squirrel survival. Information on WGS can be found here.
- Avoid, minimize, and mitigate impacts to the Category 2 WGS suitable habitat, which extends out 1500 meters from the occupied colonies. This is based on the documented average dispersal distances of approximately 80% of WGS
- Provide training for construction personnel and environmental monitors on protocols for responding to new Washington ground squirrel colony discoveries, dead or injured squirrels, and other protocols related to avoiding and minimizing impacts.
- Restore temporarily disturbed areas identified as suitable habitat adjacent to Washington ground squirrel Category 1 habitat to the pre-construction form and function in a reasonable timeframe and monitor restoration efforts that may unintentionally cause adverse impacts to the species.
- Avoid, minimize, or mitigate impacts (digging, trenching, installation, roads, or trampling) to pygmy rabbit burrow complexes and white-tailed jackrabbit denning sites as both are considered Category 2 habitat as defined in the ODFW Fish and Wildlife Mitigation Policy.
- Protect underground cabling and wiring systems from rodent chewing or consider above-ground cabling systems, especially if implementing dual-use pollinator/native seed understory programs as those seed-bearing or flowering plants may inadvertently attract rabbits, rodents, and ground squirrels.

BIG GAME

Considerations

- Is the site within essential and/or important big game habitats such as winter range or summer range?

- Is the site within potentially irreplaceable and essential habitats such as known movement corridors?
- Does the surrounding landscape and project design, including fencing, allow for big game movement, as determined by best available science?
- Could the project impact any aspect of big game ecology or life history (e.g., will the project sever a migration corridor or otherwise subject wildlife to increased risks, such as highway/vehicle collisions)?
- What effects will habitat removal and fragmentation, as well as indirect disturbance from vehicles, human presence, and noise have on big game?

Recommendations

- Avoid siting PV solar facilities within known, documented big game migration corridors which may be considered irreplaceable habitats.
- Avoid, minimize, and mitigate impacts to essential and important big game habitats such as big game winter range and address impacts to other important big game habitats throughout their range. See Eastern Oregon Big Game Winter Range, Western Oregon Deer and Elk Habitat, and Oregon Pronghorn Essential and Limited Habitat maps and rationale.
- Avoid construction or development activities within big game winter range generally between December 1 and April 30, consulting with local Wildlife District Biologists for site-specific time frames.

HABITAT

Considerations

- Are there high-value fish and wildlife habitat features present such as rock outcroppings, cliffs, caves, riparian areas, springs, wetlands, water, native fish-bearing streams, or unique vegetation communities?
- What potential impacts to habitat connectivity would a proposed project have? Is the site located in a mapped Priority Wildlife Connectivity Area?
- Which species of fish and wildlife use the project area and how do their numbers vary throughout the year?
- Would the facility irreparably alter a fish or wildlife habitat not capable of being mitigated? For example, there is no current evidence demonstrating that migration corridors can be recreated or replicated.
- What potential impacts would the development have on the biological values and hydrology of the site?
- How will development alter the distribution of invasive species, including invasive annual grasses?
- Will temporary impacts to habitats realize enough temporal loss of function to necessitate additional mitigation?

Recommendations

- Develop and implement Revegetation Plans for the project to restore temporary disturbance areas to their pre-disturbance form and function, to minimize permanent impacts to wildlife habitat. Include monitoring and adaptive management in the plans.
- Develop and implement Noxious Weed Plans for the project to avoid, minimize, and mitigate introduction and spread of noxious weeds during construction and operation of the facility. Include monitoring and adaptive management and conduct for the life of the project.
- Develop and implement Habitat Mitigation Plans to avoid, minimize, and mitigate potential adverse effects of the PV solar project and associated infrastructure on fish, wildlife, and their

habitats. ODFW recommends Habitat Mitigation Plans be consistent with the standards and goals of the ODFW Fish and Wildlife Habitat Mitigation Policy.

- The above plans should be approved by the appropriate regulatory agency with jurisdiction for the project consistent with their relevant statutes and rules, and ODFW welcomes agency and developer consultation early and often throughout the permitting and implementation process.
- See other sections of this table for addressing impacts to specific species' habitats on the site.

LAND USE

Considerations

- Will the proposed site require an exception to the statewide planning goals?
- Is the proposed site already impacted, or part of a larger intact landscape?
- Does existing law, regulation, or policy allow development at the site?
- Are there any culturally significant plants, cultural resources, and sacred or important spaces for Oregon's tribes within the project area?

Recommendations

- ODFW welcomes and encourages consultation with ODFW Regional Habitat Biologists, District Wildlife Biologists, and/or the Statewide Energy Coordinator in the pre-application phase of PV solar project scoping so that potential issues can be addressed early and avoid delays in project permitting.
- ODFW recommends consultation with Oregon's tribes and SHPO on potential impacts of PV solar projects and associated infrastructure on areas of cultural significance.

PUBLIC ACCESS

Considerations

- What are the tribal traditional values of the site, such as culturally significant plant gathering sites?
- Will construction of the project at this site impede or restrict fish and wildlife-related recreation access to public lands? What are the potential fish, wildlife, and habitat consequences if alternative travel routes are constructed to facilitate access?
- Will any increase in public access (e.g., through road construction) negatively affect fish, wildlife, or habitat?

Recommendations

- Minimize public travel on new access and maintenance roads within the project area, as applicable for management purposes
- Access for hunting or tribal traditional use should be allowed to continue within project lease areas on public lands and on private land with landowner permission. ODFW encourages project developers to work with landowners who are willing to provide public access.

CUMULATIVE IMPACTS

Considerations

- Are there existing or predicted localized or statewide cumulative impacts to fish, wildlife, or habitat?
- Will this project contribute to population decline or habitat loss for wildlife species of concern?
- Are there development thresholds or caps in the proposed project area?

Recommendations

- Consult with ODFW and USFWS early in project siting and design to consider the proposed project in the context of local and regional wildlife population trends
- In greater sage-grouse habitat, consult with county governments to ensure large-scale projects achieve the goal of protecting significant sage-grouse habitat in a core area (see OAR 660-023-0115(9)).

TABLE A.2. DISTURBANCE-FREE DATES AND BUFFERS FOR RAPTOR NESTS IN OREGON.

Dates cover territory establishment through fledging. Release dates can be used for unoccupied or failed nests.* Some geographic variation in seasonal restriction dates, please consult with local ODFW Regional Habitat or District Wildlife Biologists. ** Indicates Oregon Conservation Strategy Species.

Species	Spatial Buffer	Seasonal Restriction	Release Date if Unoccupied
Golden eagle	0.5 – 1 mile	Feb 1 – Aug 15	May 15
Bald eagle	0.5 mile	Jan 1 – Aug 15	May 31
Ferruginous hawk**	0.5 mile	Mar 15 – Aug 15	May 31
Northern goshawk**	0.5 mile	May 1 – Aug 15	June 30
Peregrine falcon**	0.25 mile	Jan 1 – Jul 1	May 15
Swainson's hawk**	0.25 mile	Apr 1 – Aug 15	May 31
White-tailed kite	0.25 mile	Jan 1 – Aug 15	
Osprey	0.25 mile	Mar 1 – Sep 15	
Burrowing owl**	0.25 mile	Apr 1 – Aug 15	May 31
Flammulated owl**	0.25 mile	May 1 – Jul 31	June 15
Great gray owl**	0.25 mile	Apr 1 – Jul 31	May 31
Red-tailed hawk	0.10 mile	Mar 1 – Aug 15	May 31
Other hawks and owls	0.25 mile	Mar 1 – Aug 15	May 31

APPENDIX B. BEST PRACTICES FOR DESIGN, CONSTRUCTION, AND OPERATIONS

This appendix provides recommendations and best practices for siting, design, construction, operations, and reclamation. These are recommendations and may be modified or added as new practices and technologies emerge. These recommendations do not supersede regulatory agency requirements and/or landowner agreements or preferences. Projects that are placed in areas with fewer fish and wildlife concerns and that adopt recommendations and best practices in layout, design, construction, and operations will result in reduced conflict with fish and wildlife values, and consequently will have reduced need for monitoring or further mitigation.

SOLAR ENERGY GENERATION COMPONENTS AND FACILITIES

LIGHTING

Artificial lighting can have negative impacts to wildlife, including changing behavior and land use, disorienting wildlife, and potential increases in risk of mortality. The best approach to mitigate impacts from artificial lighting is to avoid its use whenever possible. Facilities should minimize light pollution whenever feasible and use the best available technologies.

Specific recommendations:

- Use only fully shielded, dark-sky friendly fixtures, so lights shine down towards the ground.
- Use only the amount of light needed.
- Install timers, motion sensors, or dimmer switches. Turn off lights when not in use.
- Limit the use of artificial lighting during peak migration periods.
- For facility lighting, use warmer-colored lights (<2200 Kelvin) versus cooler-colored light on the white-blue end of the spectrum (≥2200 Kelvin; Longcore et al. 2018).

FENCING

Fencing the Panel Array

The National Electric Code (2017; Section 110.31) requires utility-scale PV solar facilities to maintain a wall, fence, or screen to deter access by unauthorized people to certain portions of a project. The code further specifies that fences should be at least 7 feet tall, however big game species such as elk and deer can jump over fences less than 8 feet tall. To avoid entrapment of big game and potential damage to facility panels and wiring systems, ODFW recommends panel array fencing be at least 8 feet tall.

Where feasible, ODFW recommends fences be designed to allow permeability for smaller wildlife such as rabbits, meso-carnivores (coyote, badger, bobcat), and reptiles. Allowing for small gaps between the fence and the ground, at regular intervals around the perimeter fencing, reduces the habitat loss and fragmentation impacts for those smaller species. For large scale projects, ODFW may advocate for modifications in final fence design to facilitate landscape movements of larger mammals.

Gates for Egress

Big game can become entrapped inside exclusionary fencing that may be required at some renewable energy facilities. In such cases, having gates on multiple sides of the fenced perimeter can allow for easier egress. Include an adequate number of gates along the perimeter to facilitate big game egress (e.g., consider gates on opposite sides of facilities).

Wildlife-Friendly Fence Design

The construction of new fences should be avoided, if possible, to reduce collision risk and facilitate wildlife movement on the landscape. New fences, other than those intended to exclude wildlife, should be built to wildlife-friendly specifications. Fence design should include movement options around and through projects that maintain sufficient corridors and prevent loss of winter range habitat for big game. Consultation with local ODFW biologists is critical to ensure fences are appropriately sited.

Design specifications are available at:
https://efotg.sc.egov.usda.gov/references/Public/OR/382AAjs_OR_WildlifeFriendlyFence_4-15-10.pdf.

Fence Markers

Many species of birds are at risk of death by collision with fences. For locations or fencing types that pose a higher concern of collision risk, bird diverter fence markers are low-cost but effective approach to make fences more visible to birds and thereby reduce deaths.

- ODFW recommends:
  - Three-inch vinyl markers should be placed along the top wire at 3-foot intervals, with fence posts serving as markers.
  - Additional information is available through the Sage Grouse Initiative at: http://www.sagegrouseinitiative.com/wp-content/uploads/2014/08/FENCEMARKER-FAQ.pdf.
  - See information on stranded or injured wildlife provided below.

POWER LINES

Many species of birds are at risk of death by collision with or electrocution by power lines.

ODFW offers the following recommendations for any new power lines constructed in association with PV solar facilities:

- Site projects near substations or other points of tie-in to the energy grid to reduce the construction of new power lines.
- Burying transmission lines between facilities and substations will further reduce these risks.
- If burying is not feasible, proponents should follow the Avian Power Line Interaction Committee's (APLIC) guidelines for mitigating electrocution and collision risk for birds, which simultaneously minimizes power outages and fire risk associated with bird use (aplic.org; APLIC 2006, APLIC 2012).
- Avoid crossing naturally occurring perennial streams, lakes, reservoirs, riparian corridors, and large (>5 acres) wetlands with overhead power lines.
- Mark overhead lines using bird flight diverters per APLIC guidelines to mitigate collision risk (APLIC 2006, APLIC 2012).

REVEGETATION AND RECLAMATION

Construction of PV solar facilities will create soil disturbance and may lead to soil erosion and growth of non-native, invasive plants. ODFW recommends revegetation of temporary disturbance areas and underneath PV panels as quickly as possible after construction. The following recommendations apply to revegetation as well as final reclamation of the site once the facility is decommissioned.

Restoration following construction should contour soils to match the original topography as much as possible. Revegetation should re-establish native grasses, forbs, and shrubs to achieve cover, species composition, and life form diversity commensurate with the ecological site potential or pre-disturbance conditions. Where possible, use seed from local sources. ODFW can provide consultation on desirable plant seed mixes. Landowners should be consulted on a desired plant mix on private lands. Proponents should control noxious and invasive plant species and adopt the best management practices for topsoil handling.

Soils

Understanding the soils on the site can make the difference in successful revegetation and reclamation. ODFW recommends project proponents identify the soils on the project site.
Basic information can be obtained from the Natural Resource Conservation Service (NRCS) Soil Survey. Soil pits and testing properties on the site may be necessary to determine stability, pH, electrical conductivity, texture, calcium, carbonate, and gravel content. Properly preserved topsoil is critical for reclamation.

- ODFW recommends:
  - Maintaining existing vegetation or trampling vegetation is preferable to blading/removal of vegetation and grading of soils
  - If topsoil must be removed, remove topsoil from the site before facility construction activities, and salvage while at a low moisture content
  - Store topsoil stockpiles where:
    - Not disturbed by facility construction activities.
    - Not contaminated by foreign or spilled materials.
    - Movement of stockpiles would be minimal.
    - Exposure to erosional forces is minimal.
    - Pristine soils are not present.
  - Avoid mixing A horizon and B horizon soil layers.
  - Minimize soil compaction.
  - As an alternative to large-scale topsoil removal, skim surface vegetation with heavy equipment.

  - Best implemented generally between July 1 and March 14, outside of ground bird nesting season.

Vegetation

Identify native plant communities prior to disturbance and design revegetation plans to approximate pre-disturbance functions and values. It can be helpful to refer to Ecological Site Descriptions where available, to determine site potential post-disturbance.

ODFW recommends:

- Leave vegetative biomass in windrows to reduce wind and water erosion.
- Soil testing should be completed prior to re-establishment of desired vegetation.
- Appropriate soil amendments should be added prior to planting if necessary to establish native plant community.
- Reestablish on the replaced topsoil as quickly as possible to stabilize the site and prevent erosion.
- Commercial fertilizer is not recommended for native rangeland reestablishment due to the possibility of increased annual weeds.
- Regular monitoring should be conducted, and adaptive management implemented as needed to ensure no site degradation.

Invasive Weed Management Plan

The proponent should develop and implement a plan to control invasive species (including invasive annual grasses and noxious weeds), with an expectation that invasive plants will be controlled for the life of the renewable energy facility and until final reclamation is complete.

Thoroughly wash all surfaces and undercarriages of vehicles and equipment before moving to the project site and after leaving the site to remove any undesirable plant seeds. This will reduce the possibility of transporting noxious or non-native plants from one site to another.

All disturbed soils that will not be landscaped or otherwise permanently stabilized by construction should be seeded using species appropriate to the project vicinity.

Proponents should coordinate with the County Weed Offices for guidance.

STRANDED, INJURED OR DEAD WILDLIFE

During construction and operation of facilities reports of interactions with wildlife have occurred. In most cases, ODFW does not have the capacity to respond to such calls. ODFW recommends that project proponents have an operations plan for onsite staff on how to deal with wildlife encounters. Proper fencing and protocols on gate operations can assist with reducing the amount of stranded wildlife within facility boundaries. For injured wildlife found by staff, operational plans should include contact information for local rehabilitators, where available, or local ODFW offices. Some species may not be handled without a permit, so coordination is key. ODFW also requests that any dead wildlife found within facility boundaries be reported as soon as possible with date of discovery, location and photographs if available.

SEASONAL TIMING LIMITATIONS

Recommendations from ODFW may include specific guidelines on survey timing or limitations on construction and activities based on species utilization and presence within the project vicinity. The table below summarizes timing windows generally referred to in project review. Local conditions may alter these timing windows, and the table generally refers to maximum known periods of concern.

Oregon Species Timing Periods

	January		February		March		April		May		June		July		August		September		October		November		December	
Eagle Nesting	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■									
Raptor Nesting					■	■	■	■	■	■	■	■	■	■	■									
Big Game Winter	■	■	■	■	■	■	■	■															■	■
Sage Grouse Lek and Nesting					■	■	■	■	■	■	■	■												
In-Water Work Window	Varies by Watershed and Waterbody																							
WGS active			■	■	■	■	■	■	■	■														
Primary ground bird nesting					■	■	■	■	■	■	■	■	■											
Bat Migration					■	■	■	■							■	■	■	■	■	■				

APPENDIX C. ODFW AUTHORITIES

Comments offered by ODFW must be consistent with the authorities offered the agency through statute and rule. ODFW should consider the following authorities while reviewing applications:

Oregon Revised Statutes (ORS):

- ORS 496.012 State Wildlife Policy
- ORS 496.171-182 Threatened and Endangered Fish and Wildlife Species. A listing of State and Federal threatened, endangered and candidate species can be found on the Department's website at: http://www.dfw.state.or.us/wildlife/diversity/species/threatened_endangered_candidat e_list.asp
- ORS 498.301-346 Screening and By-pass devices for Water Diversions or Obstructions
- ORS 498.500-504 Oregon Sage-Grouse Mitigation
- ORS 506.036 Protection and Propagation of Fish
- ORS 506.109 Food Fish Management Policy
- ORS 509.140 Placing Explosives in Water
- ORS 509.580-910 Fish Passage; Fishways; Screening Devices. A listing of requirements under the Department's Fish Passage Program can be found on the Department's website at http://www.dfw.state.or.us/fish/passage/

Oregon Administrative Rules (OAR):

- OAR Chapter 635, Division 100 provides authority for adoption of the State sensitive species list and the Wildlife Diversity Plan and contains the State list of threatened and endangered wildlife and fish species. A current list of State sensitive species can be found on the Department's website at: http://www.dfw.state.or.us/wildlife/diversity/species/docs/SSL_by_category.pdf
- OAR Chapter 635, Division 140 provides background and definitions for the " Greater Sage-Grouse Conservation Assessment and Strategy for Oregon" (2011) as well as requires compensatory mitigation for direct and indirect impacts from developments within sage-

grouse core, low density and general habitats.

- OAR Chapter 635, Division 415 Fish and Wildlife Habitat Mitigation Policy can be found on the Department's website at: http://www.dfw.state.or.us/lands/mitigation_policy.asp describes six habitat categories and establishes mitigation goals and standards for each wildlife habitat ranging from Habitat Category 1 (irreplaceable, essential, limited) to Habitat Category 6 (non-habitat)
- OAR 635, Division 900 is the ODFW Climate and Ocean Change Policy, which directs ODFW to be a leader in response to changing climate and ocean conditions in the state.
- Native Fish Conservation Policy (OAR 635-007-0502-0535)
- Trout Management (OAR 635-500-0100-0120)
- Elk Management Plan (OAR 635-160-0000)
- Mule Deer Management Plan (OAR 635-190-0000)
- Black-tailed Deer Management Plan (OAR 635-195-0000)

ANNOTATED BIBLIOGRAPHY

Adeh, E.H., S.P. Good, M. Calaf, and C.W. Higgins. 2019. Solar PV Power Potential is Greatest Over Croplands. Scientific Reports 9(1): 1-6.

- Solar power production potential globally is greatest over croplands at approximately 28W/m^2
    - High insolation, light winds, moderate temperatures, and low humidity
- Agrivoltaic systems with dual land uses can resolve land use competition and reduce the spatial constraints on solar power development
- Global energy demand could be met with solar power if less than 1% of cropland were converted to agrivoltaic systems
    - This is restricted by intermittent availability and lack of storage technologies
- Crops like tomatoes, maize, pasture grass, and lettuce have successfully grown in the intermittent shade under solar PV panels

Agha, M., J.E. Lovich, J.R. Ennen, and B. D. Todd. 2020. Wind, sun, and wildlife: do wind and solar energy development 'short-circuit' conservation in the western United States? Environmental Research Letters 15: 075004.

- Incorporating energy development into already built or disturbed environments, brownfields, and agricultural areas conserves wildlands and can have substantial economic benefits
- Greater sage-grouse are negatively affected by energy development: surface disturbance, noise, and habitat fragmentation causing lower nest and brooding survival
- Scientific understanding of the ecological impacts of renewable energy is still scarce due to lack of before-after control-impact studies
    - So the actual impacts may be much higher than estimates in literature → need for precaution

Anderson, E.D., R.A. Long, M.P. Atwood, J.G. Kie, T.R. Thomas, et al. 2012. Winter resource selection by female mule deer *Odocoileus hemionus*: functional response to spatio-temporal changes in habitat. Wildlife Biology 18(2): 153-163.

- From the 1980's to 2009, mule deer increased habitat selection of agricultural fields and areas far from roads
    - Selection of agricultural fields likely a response to declining foraging habitat
- Juniper cover is important on mule deer winter range because it provides thermal and hiding cover
- Migrating from summer range to low elevation winter range is necessary for mule deer to survive the climatic stress of winter
    - Foraging on winter range reduces the loss of fat reserves
- Sagebrush-steppe habitat was the most important habitat type for winter range
- Healthy sagebrush-steppe ecosystems should be maintained, and juniper removal should be limited on winter range

Argonne National Laboratory & National Renewable Energy Laboratory. 2015. A review of avian monitoring and mitigation information at existing utility-scale solar facilities. Report prepared for US Department of Energy, SunShot Initiation and Office of Energy Efficiency & Renewable Energy.

- In a review of fatality monitoring data for 6 California utility-scale solar energy (USSE) facilities, water-dependent species represented 11.2% of fatalities (with high variability among facilities)
- Most fatalities were of resident species, but more fatalities of transient species occur during migratory periods
- Empirical research has not supported or refuted the "lake effect" hypothesis yet
- 54% of known fatalities detected at facilities were collision-related
- Potential deterrents:
    - Acoustic deterrents –birds and humans hear the same range, so humans would also hear the sound
    - Tactile deterrents – very little study on the use with flying animals, perch deterrents unsuccessful
    - Visual deterrents – success rate for wind energy still inconclusive
    - Chemosensory deterrents – still in development
- There is a need for systematic fatality data across solar facilities

Barron-Gafford, G.A., et al. 2016. The photovoltaic heat island effect: larger solar power plants increase local temperatures. Scientific Reports 6(1): 35070.

- Temperatures directly over a PV plant (within the bounds of the plant) were regularly 3-4 C warmer than adjacent wildlands at night
    - These results contrast other studies whose models show that PV systems should decrease ambient temperatures
- Heat island effects could be mitigated through revegetation, which would also aid local ecosystems after degradation

Beckman, J.P., K. Murray, R.G. Seidlier, and J. Berger. 2012. Human-mediated shifts in animal habitat use: sequential changes in pronghorn use of a natural gas field in Greater Yellowstone. Biological Conservation 147: 222-233.

- Carrying capacity theory shows that any reduction in habitat ultimately leads to population decline
- Human disturbance caused an 82% decline in nearby patches previously classified as high-quality habitat for pronghorns
    - Fine-scale avoidance of disturbed patches

    - Behavioral impacts (like high-quality habitat patch avoidance) often preclude larger-scale demographic impacts
- Over time, disturbance from energy development and land use change will decrease number and amount of high-quality habitat for pronghorn

Carson, R.G., and J.M. Peek. 1987. Mule deer habitat selection patterns in Northcentral Washington. The Journal of Wildlife Management 51(1): 46-51.

- Riparian and conifer cover types are used by mule deer in all seasons due to thermal and security cover and high forage availability and quality
- Mule deer select sagebrush and antelope bitterbrush habitats and areas with moderate slopes during winter
- Enhanced productivity of riparian and bitterbrush cover types would significantly benefit mule deer populations

Chock, R. Y., et al. 2020. Evaluating potential effects of solar power facilities on wildlife from an animal behavior perspective. Conservation Science and Practice 3(2):e319.

- Resident species affected by functional habitat fragmentation, dispersal limitations, population isolation, and altered habitat quality
- Agassiz's desert tortoises attracted to burrow at vegetation at the end of roads → risk of vehicle collision
- CSP facilities can have evaporation ponds with chemically treated waters that can poison, kill, or bio magnify in animals
- Albedo change from vegetation removal → local increases in temperature and evapotranspiration → impacts on movement, reproduction success, survival
- Insect abundance increases near high structures, attracts insectivores and increases risk of burning
- "lake effect" – migratory birds mistake solar facilities for bodies of water and are attracted to them, leading to injury, stranding, death
- Avoidance of solar facilities leads to lower quality habitat or population fragmentation
- Species attracted to facilities:
    - Low survival or reproduction on-site, causing regional source-sink pattern
    - May attract non-native or urban-adapted species
- Species unable to detect or avoid → collision or direct mortality
- Reflective surfaces of buildings and PV panels create polarized light pollution that attracts polarotactic organisms, including many insects
    - Insectivores: tradeoff between increased food source and increased competition + collision risks
    - Polarotactic organisms are those that are attracted to polarized light, such as water-associated insects that use the polarized light above the dark surface of water bodies as a visual cue for the resource
- Avoid siting projects in areas with species of special concern, high species richness, or high quality habitat
- Potential deterrents: acoustic, visual, and tactile; but impacts of these not well understood
- May be more effective to understand wildlife perception of facilities and minimize features that attract them (more details in article

Coe, P.K., et al. 2015. Identifying migration corridors of mule deer threatened by highway development. Wildlife Society Bulletin 39(2): 256-267.

- Movement models calculated for 359 migration mule deer in South-central Oregon

- Managers should prioritize migration corridors when considering fencing and passageways so they are most effective for maintaining corridors as development increases
- Mule deer have a natural tendency to use the same route when travelling to and from winter ranges
    - Need access to habitat areas where nutritional requirements can be met seasonally
- Mule deer concentrate on winter range near Highway 31 southeast of La Pine, and migration routes narrowed around Highway 97 as deer disperse for summer range
- Ungulate migration pathways could change or be eliminated over time due to changing landscapes and increased disturbance
- For new highways (and other infrastructure) migration corridors can be identified by radiomarking mule deer prior to construction

Coe, P.K., et al. 2017. Multiscale models of habitat use by mule deer in winter. The Journal of Wildlife Management 82(6): 1285-1299.

- Radio-collared 452 mule deer to develop regional habitat use models for mule deer on winter ranges
- Models showed increased probability of habitat use away from roads, indicating a need to reduce vehicle traffic on mule deer winter range
- Mule deer populations in Oregon peaked at ~575,000 in the 1960s and declined to 230,000 by early 2015
- High use of forested and unforested area during winter was recorded and results from the need for mule deer to seek tree cover for thermal protection and hiding and use shrubs for foraging
- Managers should implement permanent or seasonal road closures on mule deer winter range to minimize disturbance and displacement

Copeland, H.E., et al. 2011. Energy development and wildlife conservation in North America. Island Press Center for Resource Economics. Washington, DC, USA.

- USSE projects consisting of solar arrays, access roads, and other infrastructure requires ~1million ha to produce an exajoule of energy per year
    - This is half of required land for wind, orders of magnitude greater than geothermal or nuclear

D'eon, R.G., and R. Serrouya. 2005. Mule deer seasonal movements and multiscale resource selection using global positioning system radiotelemetry. Journal of Mammalogy 86(4): 736-744.

- Wildlife managers can identify potential mule deer winter habitat at broad scales based on warm aspects (or high solar duration) and low-elevation sites
- High road densities and vehicle traffic negatively affect wintering mule deer and should be minimized within winter ranges
- Migration is obligatory for mule deer where midwinter snow depths are above 40cm on summer range

Dinesh, H., and J.M. Pearce. 2015. The potential of agrivoltaic systems. Renewable and Sustainable Energy Reviews 54: 299-308.

- Agrivoltaics: integrating solar PV power and conventional agriculture
- The value of solar generated electricity coupled to shade-tolerant crop production created an over 30% increase in economic value from farms deploying agrivoltaic systems instead of conventional agriculture

- PV panels can facilitate effective water usage by acting as rainwater and irrigation runoff channels
- In more advanced systems, tilt can be altered to reduce shading during crop germination
- Partial shade can protect temperature-sensitive crops from heat

Dutcher, K.E., et al. 2020. Genes in space: what Mojave desert tortoise genetics can tell us about landscape connectivity. Conservation genetics 21:289-303.

- Utility-scale solar facilities, along with other manmade structures, create barriers to movement and gene flow in populations of native species in the Mojave
- Analysis of genotypes of 300 tortoises showing the population genetic structure showed historical gene flow among now-isolated populations
- Habitat fragmentation limits connectivity and has rapid genetic consequences
    - Reduced gene flow reduces the fitness of species → population decline or extinction

Energy Facility Siting Council. 2018. RAC Meeting #1 Staff Report.

- Solar PV panels can be classified as hazardous waste due to toxic constituents contained within the panels
    - EFSC waste minimization standard may sufficiently address end-of-life module disposal
- Use of machinery for clearing, grading, and trenching a project site can crush or trample wildlife
    - Rodents, nesting birds, reptiles, amphibians
- During operation, birds can collide with panels or transmission lines and ungulates can become entangled in fencing
- Future EFSC standard could address cumulative effect of habitat loss and fragmentation
- Solar PV modules may produce a heat island effect (Barron-Gafford et al., 2016 below), potentially impacting alfalfa production nearby

Estes-Zumpf, W.A., et al. 2010. Dispersal, gene flow, and population genetic structure in the pygmy rabbit (*Brachylagus idahoensis*). Journal of Mammology 91(1): 208-219.

- Dispersal and gene flow are important for maintaining genetic diversity, which allows populations to respond to changing environments
- Genetic diversity, gene flow, and population genetic structure of pygmy rabbits examined to determine the effects of gene flow barriers
    - Barriers include secondary roads, highways, creeks, agricultural pastures
- High levels of gene flow observed among locations (low to moderate genetic differentiation among sample sites)
- Creeks and roads were not determined to be significant barriers to gene flow, but agricultural expanses were barriers
    - Further study should determine how different land uses impact rabbit dispersal capabilities

Guiller, C., et al. 2017. Impacts of solar energy on butterfly communities in Mediterranean agro-ecosystems. Environmental Progress & Sustainable Energy 36(6): 1817-1823.

- Siting with landscape connectivity is important to maintain biodiversity in fragmented landscapes
- Recommendations based on ecology of grassland butterflies at USSE facilities:
    - Revegetate areas between and under rows of solar panels once installed
    - Adapt frequency of mowing to plant phenology
    - Increase diversity of host plant species and cover of flowering resources

Hanophy, W. Fencing with wildlife in mind. 2009. Report by Colorado Division of Wildlife.

- Ducks, geese, grouse, cranes, and hawks fly low and are especially vulnerable to fence collision and entanglement
- Ideal fence is highly visible to ungulates and birds, allows wildlife to jump over/crawl under, provides access to important habitats and travel corridors
- Recommendations for wildlife-friendly fencing:
    - Smooth /rounded wire on top and bottom
    - Height of top rail 42" or less
    - At least 12" between top two wires
    - At least 16" between bottom wire or rail and the ground
    - Posts at minimum 16' intervals
    - Gates, drop-downs, removable fence sections or other passages where animals concentrate and cross
    - Using a rail, high-visibility wire, flagging or other visual markers for the top

Harrington, J.L., and M.R. Conover. 2006. Characteristics of ungulate behavior and mortality associated with wire fences. 2006. Wildlife Society Bulletin 34(5): 1295-1305.

- Average annual ungulate mortalities from wire fences studied across 5 years 2004-2008
    - 0.08 mule deer mortalities/km of wire fencing
    - 0.11 pronghorn mortalities/km
    - 0.06 elk mortalities/km
- Most mortalities caused by animals getting caught in the top 2 wires
- Juveniles 8 times more likely than adults to die in fences
- Habitat fragmentation is worsened by wires fences as migration is inhibited, reducing the carrying capacity of habitats

Hawlena, D., D. Saltz, Z. Abramsky, and A. Bouskila. 2010. Ecological trap for desert lizards caused by anthropogenic changes in habitat structure that favor predator activity. Conservation Biology 24(3): 803-809.

- Increased structural complexities in anthropogenically changed landscapes favors avian predator activity, increasing predation risk for lizards
- Disturbed habitats can have negative effects beyond the immediate area as they become ecological traps

Hebblewhite, M., et al. 2006. Is the migratory behavior of montane elk herds in peril? The case of Alberta's Ya Ha Tinda elk herd. Wildlife Society Bulletin 34(5): 1280-1294.

- Migratory behavior in ungulates like elk are declining due to habitat fragmentation and land use changes
- The proportion of an elk population migrating into Banff National Park declined 75% from 1970-2005 and return to winter range one month earlier

Hernandez, R.R., et al. 2014. Environmental impacts of utility-scale solar energy. Renewable and Sustainable Energy Reviews 29:766-779.

- Habitat fragmentation and loss threaten biodiversity, reducing gene flow between populations
- USSE construction involves vegetation removal and soil grading, so avoid areas with sensitive ground and burrowing animals
- Habitat fragmentation and loss threaten biodiversity, reducing gene flow between populations

Hernandez, R.R., M.K. Hoffacker, M.L. Murphy-Mariscal, et al., 2015. Solar energy development impacts on land-cover change and protected areas. Proceedings of the National Academy of Sciences USA 112(44): 13579-84.

- Land use changes from solar development → increased isolation and nonnative species invasions, compromised movement potential of species tracking habitat shifts in response to climate change
- Integrity of protected areas compromised by adjacent land use conversions
- Value of spatial decision support systems in evaluating trade-offs between renewable energy needs and impacts to conservation values (ecosystem services, protected areas, biodiversity)
- Emphasize siting on human-impacted places to avoid deleterious land cover change
- US policies and regulations need to emphasize USSE development within the existing built environment and near population centers
- Minimize land use change by collocating with food production and converting degraded lands unsuitable for agriculture (on top of barns, parking lots, distribution centers in agricultural areas)

Horvath, G., G. Kriska, P. Malik, and B. Robertson. 2009. Polarized light pollution: a new kind of ecological photopollution. Frontiers in Ecology and the Environment 7(6):317-325.

- Polarized light pollution is light that has undergone linear polarization by reflecting off smooth, dark surfaces, and can serve as an ecological trap threatening polarization-sensitive species
    - Disrupts predatory relationships between species → altered community structure, diversity, dynamics
    - Unpolarized light (from the sun) is absorbed by panels, but polarized light reflects off the dark surface
- For organisms associated with water bodies, polarized light is primary guidance toward suitable water for feeding/breeding, habitat, oviposition sites
    - Complete reproductive failure, collision, energy costs of landing on surfaces reflecting artificial polarized light
- Alternative materials that reduce the polarization signature of human activity can support conservation of polarized light-sensitive species

Horvath, G., M. Blaho, A. Egri, G. Kriska, I. Seres, and B. Robertson. 2010. Reducing the maladaptive attractiveness of solar panels to polarotactic insects. Conservation Biology 24(6): 1644-53.

- Insects that lay eggs in water are attracted to solar PV panels because they use the horizontal polarized light that comes off bodies of water to locate them (polarotactic)
    - Can lead to reproductive failure or mortality
- Horizontal and unbordered solar panels can emit more polarized light than bodies of water
- Insects avoided PV cells with nonpolarizing white borders and white grates
    - 10 to 26 times less attractive than the same panels without white partitions

Hovick, T.J., et al. 2014. Evidence of negative effects of anthropogenic structures on wildlife: a review of grouse survival and behaviour. Journal of Applied Ecology 51:1680-1689.

- Infrastructure development should avoid areas with grouse populations, especially away from lekking locations as leks are sensitive to disturbance from anthropogenic structures
- Structures near breeding grounds alter site fidelity behaviour (usually high fidelity) and disrupt breeding cycles as animals are forced into novel environments
- Fence collision rates with deer fences are high for low flying grouse species
- Since grouse do not migrate, they are highly susceptible to landscape changes, i.e. non-forest dwelling grouse are not adapted to tall structures

    - Highly sensitive to energy development, causes declines in grouse survival and increased displacement
- Anthropogenic noise could mask noise of approaching predators, increasing likelihood of predation
- Grouse survival decreased during all periods of life cycle in presence of anthropogenic structures

Ironwood Consulting, Inc. 2014. 2014 fourth quarter and final report for biological resources monitoring. First Desert Sunlight Solar Project, Riverside County. Prepared for Bureau of Land Management.

- Biological checks performed during monitoring phase:
    - Daily tortoise perimeter fence inspection during active tortoise season, weekly when activity was low (determined by telemetry)
    - Regular security fence checks for biological issues
    - Animal mortality checks along roads every morning and evening; carcasses documented and removed to prevent raven activity
    - Weekly checks of netting on equipment and supplies in material storage yard to ensure no wildlife were entangled or birds had nested
    - Close observation of trash on site and in dumpsters to prevent ravens from subsidizing
- During all phases of construction, biological monitors swept each area and a 100m buffer area for tortoises, nesting birds, and other wildlife before construction began
- Avian mortality and injuries reported from 2011-2014 include 80 obligate water birds, 28 water/wetland affiliated birds, and 80 non-water birds
    - Most frequently found species: western grebe, eastern grebe, American cot, American avocet

Jeal, C., V. Perold, C.L. Seymour, S. Ralston-Paton, and P.G. Ryan. 2019. Utility-scale solar energy facilities – effects on invertebrates in an arid environment. Journal of Arid Environments 168:1-8.

- No difference in invertebrate species abundance between facility and adjacent rangeland, but significant differences in assemblage composition
- Differences could alter or disrupt ecological functions: pollination, nutrient cycling, seed dispersal, food availability for insectivores
- Potential trophic cascade effects and ecological trap

Johnson, H.E., J.R. Sushinsky, A. Holland, E.J. Bergman, T. Balzer, J. Garner, and S.R. Reed. 2017. Increases in residential and energy development are associated with reductions in recruitment for a large ungulate. Global Change Biology 23: 578-591.

- Long-term data on mule deer in western Colorado from 1980-2010 showed that increasing residential and energy development within deer habitat were correlated with declining recruitment rates, particularly within winter ranges
- Land use change directly causes habitat loss and fragmentation and indirect habitat loss through deer avoidance of the infrastructure and related activities
- Deer migrating through areas with high energy development detour from established routes, which increases energy costs and restricts access to high-quality forage
- Land use changes on winter ranges were more strongly correlated with declining recruitment than changes on summer ranges

Kagan, R.A., T.C. Viner, P.W. Trail, and E.O. Espinoza. 2014. Avian mortality at solar energy facilities in southern California: a preliminary analysis. National Fish and Wildlife Forensics Laboratory.

- Data on bird carcasses found at 3 solar facilities in CA; yellow-rumped warbler most frequently found, cause of death usually impact trauma

    - Desert Sunlight is a photovoltaic facility, Genesis uses trough systems with parabolic mirrors, and Ivanpah is a concentrated solar power facility
- Vertically oriented black glass surfaces are attractive to aquatic insects because they produce polarized light
- Lake effect appeared to affect waterbird mortalities (cormorants, coots, grebes) at Desert sunlight, where panels are placed uniformly and appear continuous
    - Predation mortalities seem to be more frequent in water species – potentially attempt to land and become injured, then later killed by predation trauma as they are unable to escape
    - Mitigation: solid white contrasting bands (gridding) on PV panels placed no more than 28 cm from each other
- When heliostats (concentrated solar power) are oriented vertically, they are a greater collision risk for birds
    - Vertically oriented black glass surfaces are attractive to aquatic insects because they produce polarized light (applicable to PV)
- Placing a white outline or white grid line on panels significantly reduces attractiveness to aquatic insects (and their predators, indirectly)

Kim, J.Y., D. Koide, F. Ishihama, T. Kadoya, and J. Nishihiro. 2021. Current site planning of medium to large solar power systems accelerates the loss of the remaining semi-natural and agricultural habitats. Science of the Total Environment 779: 146475.

- Installation of medium-sized solar facilities (0.5 to 10 MW) resulted in loss of natural and semi-natural habitats in Japan and South Korea
    - loss of secondary/planted forests, secondary/artificial grasslands, and agricultural lands
    - preference for cost-based site selection rather than habitat considerations
- increasing PV development in urban areas could help reduce the loss of natural and semi-natural habitats

Kosciuch, K., D. Riser-Espinoza, M. Gerringer, and W. Erickson. 2020. A summary of bird mortality at photovoltaic utility scale solar facilities in the Southwestern U.S. PloS one, 15(4), e0232034.

- Synthesis of fatality monitoring at 20 PV facilities across 13 site-years in CA and NV
- Mourning dove, horned lark, western meadowlark consistently found
    - Ground-dwelling, inhabit landscapes with low-growing vegetation, some associate with anthropogenic structures
- Water-obligate birds occurred at 90% of site-years
    - Detection of stranded, injured or deceased water-associated birds (egrets, herons) and water-obligate birds (loons, grebes) supports lake effect hypothesis, but this study does not speculate on the causes of these mortalities
    - Water obligates comprised 7.75% of all bird fatalities at solar facilities
- Average annual fatality estimate ~2.49 birds per megawatt per year

Lieberman, E., J. Lyons, and D. Tucker. Making renewable energy wildlife friendly. Defenders of Wildlife. Washington, D.C.

- Tortoises and other ground-dwelling wildlife can be crushed when the sites are graded
- New roads in previously undisturbed habitat can cause vehicle-related mortalities or increased predation by birds attracted to garbage
- Solar development can reduce and fragment high-quality habitat, leading to shrinking islands of habitat where it is difficult to find food, water, shelter, mates, and protection from predators

- Avoid areas of high-quality habitats and require all new utility-scale facilities to monitor and measure impacts to wildlife
- Site projects on previously degraded lands that have already been developed for intensive human uses

Lovich, J.E., and J.R. Ennen. 2011. Wildlife conservation and solar energy development in the Desert Southwest, United States. BioScience 61:982-92.

- Impacts from construction and decommissioning: surface disturbance, direct mortality from habitat loss, degradation, and/or modification
- USSED construction requires vegetation removal and leveling → dust emissions → altered soil fertility and water retention capability
- Dust reduces mirror and panel efficiency, so panels use dust suppressants → suppressants alter hydrologic regimes
    - May not be applicable to PV facilities
- Soil compaction during construction can entrap or kill subterranean animals like lizards through compression or burrow collapse
- Construction can alter soil density, water infiltration rate, vulnerability to erosion, secondary plant succession, invasion by exotic plant species, and stability of cryptobiotic soil crusts
    - Accelerated soil erosion physically and physiologically affects plants species → influence primary production
- Local increases of vegetation along roads due to runoff may provide food and shelter to animals but increase risk of vehicular collision
- Raw material extraction and processing, water extraction, and production of toxic wastes can affect wildlife adjacent to or far from facility
- Generation of electromagnetic fields (EMFs) are a potential health concern, although evidence is inconclusive; scientists urge use of precautionary principle regarding EMFs
- Solar facilities increase albedo by 30-56%, could alter microclimate by change in wind speed and evapotranspiration → change in temp and precipitation
- Habitat fragmentation can impede movement, create migration bottlenecks, and reduce effective winter range size for species like mule deer or bighorn sheep

Lutz, D.W., J.R. Heffelfinger, S.A. Tessman, R.S Gamo, and S. Siegel. 2011. Energy Development Guidelines for Mule Deer. Report prepared by Mule Deer Working Group.

- Mule deer are impacted by solar development through direct loss of habitat, habitat fragmentation, and hydrologic changes
    - Each significantly influenced whether deer can maintain robust or depressed populations in the developed area or abandon it altogether
- Habitat loss occurs within the fencing of a facility and along new or expanded substations, transmission lines, and access roads
- Adjacent facilities may exclude large areas of habitat; movement corridors need to be identified during project planning
- Hydrologic resources are affected by development of the project footprint, including land disturbance, erosion, and changes in runoff patterns
    - Any changes in hydrologic resources affect mule deer distribution and abundance
- Habitat mitigation options: corporate-owned lands under conservation management, conservation easements, grazing program, habitat improvements

Moore-O'Leary, K. A., Hernandez, R. R., Johnston, D. S., Abella, S. R., Tanner, K. E., Swanson, A. C., … Lovich, J. E. 2017. Sustainability of utility-scale solar energy—Critical ecological concepts. Frontiers in Ecology and the Environment 15(7):385–394.

- Solar PV panels attract insects that require water for their reproductive cycle into an “ecological trap”
- The land-energy-ecology nexus represents the interactions among energy production facilities or activities, the physical landscape within which an energy system is sited, and the populations of organisms and their habitats within the energy system and the surrounding environment
- Despite potential to reduce GHGs, USSE can result in land use, environmental, and conservation costs in sensitive natural habitats
- Impacts to wildlife: habitat fragmentation, dust, road mortality, EM field effects, changes to local and regional climates, pollution, water consumption, light pollution
- Some species benefit if they have behavioral flexibility or are protected by structures, others harmed if sensitive to disturbance
- Regional habitat fragmentation causes limited gene flow for animals and plants, modification of landscape structure like hydrological connectivity
- Disruption of ephemeral streams could have huge impacts due to critical ecological function loss
    - Nutrient and chemical transport, soil texture, shrubs along channels provide shelter
- Integrating solar with built environment has environmental benefits: conserving wildlands, revegetating disturbed lands, reducing heat-island effect at local scale, and enhancing thermal insulation for buildings
- To date, USSE facilities are sited in natural ecosystems away from the built environment where they have significant impacts; need to improve siting
- Planners should use tools like GIS models and site assessments to categorize land and identify where conservation goals can be advanced alongside energy and predict impacts
    - Habitat loss and fragmentation, disruption of connectivity and gene flow, alteration of biogeochemical processes, and direct mortality
- Take advantage of techno-ecological synergies like in floatovoltaics or agrivoltaics
- Retention of vegetation could maintain carbon sequestration, benefits ecosystem structure, and preserve species of interest, although it may attract sensitive species into areas that can put them at risk
- Species management: surveys, avoidance through site change, translocation for wildlife and rare plants, control of movement through selective fencing, mitigation programs, offsite mitigation banking, restoration after decommissioning

Northrup, J.M., and G.M. Wittemyer. 2013. Characterising the impacts of emerging energy development on wildlife, with an eye towards mitigation. Ecology Letters 16:112-125.

- The impacts of solar energy on wildlife are largely unexplored in peer-reviewed literature, warranting extra caution in development for desert wildlife where solar potential is greatest
- Desert organisms face biggest threats with USSED: habitat loss, fragmentation, alteration of microclimates

Oregon Department of Energy. 2020. Rapid advancements in technology have responded to and pioneered changes in our state and across the world. Technology & Resource Reviews pp 25-28.

- Solar energy statistics for Oregon as of 2019:
    - Total capacity: 592 MW
    - Facilities 1 kW to 56 MW: 18,000+ residential/commercial and 77 utility-scale

    - Total generation in 2018: 776,000 MWh
    - In-state consumption in 2018: 680,499 MWh
    - Total exports in 2018: 95,501 MWh
    - Oregon solar grew five-fold from 2015 to 2019, 91 MW to 592 MW
    - Utility-scale solar accounted for 79% of in-state solar generation
- Solar output in the U.S. more than doubled from 2015 to 2018 from 39 GWh to 93 GWh
- Solar energy provided 2.23% of U.S. electricity generation in 2018
- Utility-scale solar: large solar arrays, 1 MW of larger, installed to produce electricity for the electricity grid
- NREL estimates that solar needs 3.2-6.1 acres per MW of capacity

Oregon Department of Fish and Wildlife. 2013. 2013 ODFW big game winter habitat.

- Winter ranges of mule deer, rocky mountain elk, and bighorn sheep are considered limited and essential for long-term conservation of populations
    - Habitat Category 2: essential habitat for a wildlife species that is limited
- Winter habitat: areas identified and mapped as providing essential and limited function and values for big game species from December through April
- Essential habitat: any condition or set of habitat conditions which, if diminished in quality or quantity, would result in depletion of a wildlife species
    - Winter survival and subsequent reproduction is the primary limiting factor in species abundance and distribution in Oregon
- Limited habitat: an amount of habitat insufficient or barely sufficient to sustain wildlife populations over time
    - Big game has lost high quality winter range habitat to agriculture, housing developments, subdivisions, or fragmentation

Oregon Department of Fish and Wildlife. 2015. Mitigation framework for indirect road impacts to rocky mountain elk habitat.

- Construction of new energy facilities involves increased vehicular traffic on existing and new roads, which impacts elk populations
    - Reduced utilization of habitat, landscape fragmentation reducing migration corridors, impediment of life processes
- Infrastructure development should avoid elk winter and summer range where possible, or compensate for indirect habitat impacts through in-kind, in-proximity habitat mitigation to achieve no net loss of habitat
- Vehicle traffic has been proven to greatly influence elk distribution across landscapes and results in habitat avoidance
    - Caused by increases in noise or perceived risk and stress associated with vehicles and humans
    - An increase in traffic is an indirect impact on elk habitat
- Department recommends mitigation on either side of facility roads: 0.25 mile to 1.00 mile buffer as traffic increases
- Best management practices for facility roads:
    - Conduct construction outside activities outside winter restriction period (Dec 1-March 31)
    - Eliminate traffic on facility roads during operation phase (excluding biannual transmission line inspection)

    - Create a traffic management plan to identify segments of roads, estimate traffic rates, and propose traffic minimizing closure techniques and devices where necessary
- Facility roads should be monitored for increases or changes in traffic for 3 years post construction to determine whether additional mitigation is necessary

Oregon Department of Fish and Wildlife. 2017. 2017 ODFW Western Oregon Deer and Elk Habitat.

- Deer and elk populations are of ecological and economic importance in Western Oregon
- Deer and elk need connectivity between their required resources within their home range or across the landscape between discrete winter and summer concentration areas
- occupied CWTD habitat: critical, year round habitats including brushy deciduous trees and shrubs or oak savanna habitats necessary for life history needs
- winter and summer concentration areas are those identified and mapped as providing essential functions and values for migratory deer or elk
    - both are category 2: essential and limited
- impacted area: areas identified and mapped subject to anthropogenic development such as areas within urban growth boundaries, city limits, or otherwise less suitable habitat for elk and deer

Parker, K.L., C.T. Robbins, and T.A. Hanley. 1984. Energy expenditures by mule deer and elk. The Journal of Wildlife Management 48(2): 474-488.

- If mule deer and elk must avoid human-made obstacles by meandering, they increase energy expenditure
- Unnecessary energy expenditure can be limited by minimizing human disturbance
- Additional and unnecessary energy expenditures of fleeing animals in their winter range can be a factor in survival
    - Could restrict human access to ungulate winter range

Polfus, J.L. 2011. Literature review and synthesis on the effects of residential development on ungulate winter range in the Rocky Mountain West. Report prepared for Montana Fish, Wildlife, and Parks.

- Indirect effects of development include altered animal community composition and biotic interactions, fragmentation of natural land cover, avoidance of areas near development, and source-sink dynamics
    - All lead to interrupted dispersal and movement, which impacts population dynamics and decreases biodiversity
- Habitat fragmentation through development or avoidance of disturbed areas leads to extensive loss of habitat effectiveness
    - Human disturbances often have interacting, cumulative impacts
- Guidelines that help reduce human-wildlife conflict, support habitat, and reduce habituation at **local** scales:
    - Buffer development by the largest area possible
    - Reduce non-native vegetation and the spread of exotic species
    - Reduce fencing or use wildlife-friendly fencing
    - Reduce excessive lighting
    - Focus human impact on resilient areas
    - Maintain large, connected patches of undeveloped land
    - Keep zoning densities low within and immediately surrounding high value habitat
    - Manage road systems to minimize the number of new roads and new barriers to important animal movement corridors

  - Include a site level habitat assessment to inform project conditions and management actions
- due to large seasonal home ranges for ungulates, conservation is needed at landscape scale:
  - Maintain large, intact patches of vegetation by preventing fragmentation
  - Establish priorities for species protection and protect habitats that constrain the distribution and abundance of those species
  - Protect rare landscape elements, guide development toward areas of landscape containing "common" features
  - Use natural boundaries
  - Maintain connections among wildlife habitats by identifying and protecting corridors for movement
  - Maintain significant ecological processes in protected areas
  - Contribute to the regional persistence of rare species by protecting some of their habitat locally
  - Look beyond the life of the project

Saunders, D.A., R.J. Hobbs, and C.R. Margules. 1991. Biological Consequences of Ecosystem Fragmentation: A Review. Conservation Biology 5(1): 18-32.

- Ecosystem fragmentation alters the microclimate within and surrounding the remnant habitat and the isolation of each area from other remnant patches
- Removal of native vegetation changes the albedo of the landscape; cleared areas have higher daytime and lower nighttime temperatures
  - Microclimatic changes affect wildlife directly or indirectly by altering resource availability (e.g., increased foraging times, destabilized predator-prey interactions)
- Fragmentation reduces the total area of habitat available, possibly increasing densities of populations, and increases isolation among populations
- Management of fragmented systems requires:
  - (1) management of the natural system and internal dynamics of the remnant areas
    - Should be the management focus for large remnant areas
  - (2) management of the external influences on the natural system
    - Should be the management focus for small remnants

Sawyer, H., F. Lindzey, and D. McWhirter. 2005. Mule deer and pronghorn migration in western Wyoming. Wildlife Society Bulletin 33:1266-1273.

- Human infrastructure like housing developments and roadways reduced the effective width of a critical migration bottleneck for mule deer and pronghorn
  - Small changes in bottlenecks/habitat alterations could sever establish migration routes
- All seasonal ranges are important for maintaining healthy and productive and healthy mule deer and pronghorn populations
- Transition and winter ranges are often located on BLM land that has potential for habitat loss (e.g., for energy development)
- Fences, roads, and human disturbance can reduce the effectiveness of migratory routes

Sawyer, H., N.M. Korfanta, R.M. Nielson, K.L. Montieth, and D. Strickland. 2017. Mule deer and energy development—long term trends of habituation and abundance. Global Change Biology 23: 4521-4529.

- 17-year study of mule deer in the vicinity of natural gas development
- Mule deer consistently avoided energy development infrastructure through the time period, maintaining distance of about 1 km

- Mule deer abundance declined 36% during development period despite aggressive mitigation measures and 45% reduction in deer harvest
- Energy development displaces animals and functionally reduces their available habitat resulting in long term population consequences
    - these results refute the idea that ungulates habituate to human disturbance

Sawyer, H., M.S. Lambert, and J.A. Merkle. 2020. Migratory disturbance thresholds with mule deer and energy development. The Journal of Wildlife Management 84(5): 930-937.

- Analyzed GPS data for 56 deer across 15 years to evaluate how surface disturbance from natural gas well pads and access roads in Wyoming affected habitat selection of mule deer during migration
- Migratory use of habitat sections by mule deer declines as surface disturbance (above 3%) increases
    - Thresholds need to be identified to ensure migratory routes remain functional
- Mule deer can tolerate low levels of disturbance through short 1-3 km segments of their migratory route
- Migratory routes include stopover sites where animals forage and rest, and sites where animals move quickly through
    - Disturbance can reduce amount of stopover habitat

Sinha, P., B. Hoffman, J. Sakers, and L. Althouse. 2018. Best practices in responsible land use for improving biodiversity at a utility-scale solar facility. Case Studies in the Environment 2(1): 1-12.

- "solar reef" – responsibly developed large-scale PV facilities can provide shelter, protection, and stable use of land to support biodiversity while also generating renewable energy
- Conservation corridor allows kit foxes, pronghorn, and tule elk to freely pass between array fields
- Project area reseeded with native plant species to create habitat, provide food, and provide dust control; maintained by pulse grazing several thousand sheep
- Fencing designed to allow passage of federally endangered kit fox and exclude their primary predator (coyote) to allow them to thrive
- Perching avoidance features, fence reflectors, and other devices mitigate avian contact and collision
- Ground disturbance reduced using disk-and-roll method that contours land without changing the macro-level topography and existing drainage patterns

Smith, S.M. 2015. Winter habitat use by mule deer in Idaho and Montana. Northwestern Naturalist 96(1): 50-70.

- Winter survival for ungulates depend on the ability to meet energy demands with limited winter forage and fat and protein reserves
- Mule deer were more likely to use winter range areas with lower snow depths, thermal or security cover, and a combination of potential forages
- Maintaining landscape heterogeneity rather than prioritizing certain habitat components helps ensure mule deer use of winter range in varying conditions

Smith, J.A., and J.F. Dwyer. 2016. Avian interactions with renewable energy infrastructure: an update. The Condor 118:411-423.

- Many taxa of birds killed by impact trauma (ducks, wading birds, raptors, rails, shorebirds, songbirds) but waterbird deaths indicate possible attraction of birds to polarized light

        - This idea aligns with the lake effect hypothesis, though this study does not test this hypothesis
- Some songbirds attracted to solar arrays for shade and perching provision, others (raptors) avoid arrays
- High impacts with solar development because it occurs in areas of high endemism
- Some songbirds attracted to solar arrays for shade and perching provision, others (raptors) avoid arrays
- Disruption of local hydrology by groundwater extraction or channelization can reduce food and habitat availability (CSP facilities that use water)

Stoms, D.M., S.L. Dashiell, and F.W. Davis. 2013. Siting solar energy development to minimize biological impacts. Renewable Energy 57:289–298.

- Land use conflicts can be avoided by developing USSE on sites already ecologically degraded with low conservation value
    - Low off-site impacts when connecting to existing transmission infrastructure
- US National Environmental Policy Act (NEPA) mitigation hierarchy shows avoidance of impacts is least costly for any stakeholder
    - Areas that avoid impacts can be mapped to minimize impacts on a regional scale, connect development with biodiversity conservation
- 'win-win' strategy: site renewable energy close to roads and transmission infrastructure

Szaz, D., et al. 2016. Polarized light pollution of matte solar panels: anti-reflective photovoltaics reduce polarized light pollution but benefit only some aquatic insects. Journal of Insect Conservation 20:663-675.

- Polarized light from solar panels causes insects to oviposit on them instead of water
- anti-reflective coating (ARC) intended to increase energy efficiency variably reduces PLP from panels in certain weather conditions and sunlight angles
- ARCs (used with white gridding) are most likely to reduce PLP and benefit aquatic insects in sunny conditions but may exacerbate negative effects under overcast skies

Visser, E., V. Perold, S. Ralston-Paton, C.C. Alvaro, and P.G. Ryan. 2019. Assessing the impacts of a utility-scale photovoltaic solar energy facility on birds in the Northern Cape, South Africa.

- Bird species richness and density was lower at the PV facility than the surrounding area
- PV canopies alter microclimates such that they supplandt foraging, habitat, or nesting sites
- Overall fatality rate = 4.5 fatalities/MW/year; most fatalities were resident species and passerines
- Collisions could be reduced with greater spatial gaps between panels or fitting panels with color-contrasting white grids to reduce likelihood of "lake effect" collisions
- Potential to reduce collision by removing vegetation to reduce food and nesting sites, but this could have other ecological consequences (habitat loss)

US Fish and Wildlife Service. 2010. Interim guidelines for the development of a project-specific avian and bat protection plan for solar energy plants and related transmission facilities.

- Buffer zones for siting
    - Passerines – avoid disturbance activities within established buffers for active nests
    - Raptors – minimize human access, avoid disturbance activities within 8 km of an active raptor nest
    - Grouse – avoid construction of solar facilities within 8 km of all grouse lekking sites

    - Bats – avoid placement in close proximity to known roost sites, maternity colonies, or hibernacula
- Appropriate facility design:
    - Avoid any lattice structures, platforms, and external ladders to minimize perching and nesting
    - Reduce or buffer noise effects
    - Avoid use of guy wires for meteorological towers, avoid/minimize lighting them if possible
    - Focus facility lights downward to reduce skyward illumination, use motion detectors to reduce continuous illumination
    - Place electric power lines on or underground to avoid avian electrocution
    - Minimize number of roads created for a project to avoid habitat fragmentation
    - Reduce attractiveness of solar reflectors to polarotactic insects to reduce attractiveness to birds and bats
- Each solar facility can make an Avian and Bat Protection Plan (ABPP) to reduce fatalities to the extent practicable (regulatory enforcement from MBTA and ESA)
- Adaptive management approach should be used to establish clear biological goals and triggers tied to mitigation measures
- Report provides a template for creating an ABPP based on pre-siting data, habitat equivalency analysis, wildlife surveys, risk assessment, and reporting thereof
- Construction phase conservation
    - Minimize area disturbed to extent practicable, including access road construction
    - All vegetation within the project site that will be disturbed should be cleared outside of breeding season as much as possible
    - Minimize wildfire potential
    - Minimize attraction of prey and predators including proper garbage removal
    - Prevent the introduction and spread of invasive plant species within and surrounding the project, use only native plants for revegetation
- Post construction monitoring
    - Minimum of three years after operation of the facility begins (3 years each phase for projects with multiple)
        - Where risk is high or regular mortality observed, minimum 5 years of monitoring

Vore, J. 2012. Big game winter range recommendations for subdivision development in Montana: justification and rationale. Montana Fish, Wildlife, and Parks.

- Winter ranges for ungulates must have the right elevation, slope, aspect, and vegetation
    - Most threatened by human disturbance due to proximity to valley floors, foothills, rivers, and streams
    - All winter range is important to long-term survival of big game populations
- Habitat alterations like subdivisions on winter range can impact reproduction, population size, and migration patterns
- Development away from towns has impacts that reduce functional winter range beyond their immediate footprints
- Effects of development on wildlife: ecosystem fragmentation, edge effects and nest predation, creation of source-sink dynamics, disruption of wildlife dispersal and movement patterns, effects associated with roads, changes in community composition and structure, effects associated with domestic pets, and cumulative impacts

- Cumulative impacts of single development decisions result in isolated relic winter patches with little connectivity to other habitat and a highly modified matrix
- Characteristics of functional winter range:
    - Animals can use the habitat undisturbed
    - Animals can move easily to and from summer range
    - Animals do not create conflicts with people and their pets
    - Traditional human use and enjoyment of animals is maintained
    - All options for effective big game management can be employed if desired

Walker, B.L., D.E. Naugle, K.E. Doherty. 2007. Greater sage-grouse population response to energy development and habitat loss. The Journal of Wildlife Management 71(8): 2644-2654.

- Male sage-grouse lek attendance and lek persistence used as an index for disturbance by the development of natural gas development
    - Combined with associated habitat loss, energy development causes dramatic declines in breeding populations
- Power lines, roads, and vehicles also had a negative effect on lek persistence and on sage-grouse populations
- Need for regulatory agencies to increase spatial restrictions on development and for industry to rapidly implement more effective mitigation measures to reduce impacts on sage-grouse populations
- Mitigation of negative effects on sage-grouse populations
    - Maintain extensive stands of sagebrush habitat over large areas (6.4 km or more) around leks to allow breeding populations to persist
    - Bury power lines, minimize road and facility construction, vehicle traffic, and industrial noise

Walston, L.J., K.E. Rollins, K.E. LaGlory, et al. 2016. A preliminary assessment of avian mortality at utility scale solar energy facilities in the United States. Renewable Energy 92:405-14.

- Collision-related mortality: from direct contact of the bird with a solar project structure
- Solar flux related mortality: resulting from the burning/singeing effects of exposure to concentrated sunlight
    - Direct mortality
    - Singeing of flight feathers that cause loss of flight ability, leading to impact with other objects (concentrated solar power)
    - Impairment of flight capability to reduce the ability to forage or avoid predators
- USSE-related mortality rates are comparable to wind energy rates, much lower than other human activities
    - This includes concentrated solar power; number is likely much lower for PV (photovoltaic) facilities alone