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Don McIvor
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Cumulative Effects to Birds, Bats, and Land Cover from Renewable Energy Development in the Columbia Plateau Ecoregion of Eastern Oregon and Washington

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EXECUTIVE SUMMARY

The Columbia Plateau Ecoregion (CPE) of eastern Oregon and Washington has been a focal point of renewable energy development for the past two decades. Approximately 83% of wind energy generation in Idaho, Oregon, and Washington occurs within the CPE. Over the next decade, renewable energy development will significantly increase to accommodate population growth and government policies that mandate a shift in energy generation from fossil fuels to non-carbon emitting sources. Although hydroelectric power will likely remain the region's predominant source of renewable energy, wind energy and solar energy generation is expected to increase substantially in order to replace a retiring fleet of coal-fired power plants. To meet climate change policy objectives, between 8–12 gigawatts (GW) of new installed capacity by 2030 is projected, which is slightly less than two times the current installed wind energy capacity of 6,757 megawatts (MW). To meet this need, a combination of wind energy, utility-scale solar energy (USSE), battery storage, and improvements in energy efficiency will be needed.

The effect of renewable energy development on wildlife and land cover in the CPE has been a topic of research since the first wind energy facility was installed in 1998. Johnson and Erickson (2008, 2010, 2011) provided a regional summary and characterization of the effects of wind energy development on birds and bats in the CPE. This assessment extended upon their framework by including a decade of new post-construction fatality monitoring (PCFM) data of birds and bats, updated bird population estimates, updated remotely-sensed land cover data, and incorporated the emergence of USSE as an energy source to support carbon free policy objectives. The primary questions for wind energy and USSE development were,

- Do the current and future levels of wind energy generation increase the potential for sustained direct impacts that negatively affect bird and bat populations in the CPE?
- Using spatially explicit constraints and solar resource models, what are the affected biological resources in areas where USSE development is most likely to occur?

The basis of the wind energy assessment combined data from post-construction fatality monitoring studies conducted from 1999−2020 in the CPE with breeding bird population estimates to extrapolate the estimated number of annual bird and bat fatalities expected to occur under various wind energy development scenarios. Based on projections of future installed capacity from the region's leading energy utilities, we modeled 10 GW of new capacity and assumed 40–60% wind energy combined with a comparable amount of solar energy would be needed to achieve renewable energy policy objectives. We compared current and future fatality rates with population sizes and trends in the CPE to evaluate whether wind energy development would contribute to cumulative impacts of species or species groups.

A total of 3,073 bird fatalities were documented at 42 wind energy facilities during 55 studies. Passerines composed the majority of all fatalities (60.5%) followed by Upland Game Birds (11%),

Unidentified Birds (9%), and Diurnal Raptors (8%). Collectively, Owls and Vultures composed less than 2%. The remaining 12% of species included the Doves/Pigeons group and other species' groups that had comparatively fewer fatalities. Species commonly associated with aquatic habitats (Gulls/Terns, Loons/Grebes, Rails/Coots, Shorebirds, Waterbirds, Waterfowl) comprised approximately 2% of the total fatalities. Compared to Johnson and Erickson (2011), mean fatalities/MW/year estimated from PCFM increased from 2.36 to 2.57 birds/MW/year (8.8%) for the All Bird group, increased from 0.08 to 0.12 birds/MW/year (50%) for the Raptor group, and decreased from 1.14 to 1.08 bats/MW/year (5.3%) for the Bat group; however, species composition within each group (i.e., Passerine, Upland Game Bird, migratory tree roosting bat, etc.) was similar.

Based on the current and future levels of wind energy development within the CPE, between 17,000–33,000 birds (excluding raptors) would be killed annually, the majority (67%) of which would be composed of species in the Passerine group that have robust populations (>1 million individuals) followed by non-native species in the Upland Game Bird group (12%) that have open hunting seasons. Based on the current and future levels of wind energy development within the CPE, between 800–1,500 raptors would be killed annually, of which, the majority (81.5%) would be species in the Diurnal Raptor group. Red-tailed hawk (*Buteo jamaicensis*) and American kestrel (*Falco sparverius*) fatalities would be highest but composed 0.4–0.8% of their estimated population in the CPE, respectively.

Results of the analysis suggested no significant population level effects are likely associated with bird species most often found during PCFM (Passerines and Upland Game Birds) based on the small proportion of the robust populations affected. However, some species may be disproportionately affected by wind energy development due to small populations or low reproductive rates. Ferruginous hawk (*Buteo regalis*) is a Washington state endangered species with increased conservation concern due to declining population trends in the region and a small population size. Elevated projected fatality estimates for the breeding population of ferruginous hawk in future development scenarios will likely contribute to cumulative effects with other stressors in the CPE (e.g., habitat loss, prey availability, shooting). Although fewer ferruginous hawk fatalities have been documented at wind energy facilities compared to other raptors, ferruginous hawk breeding populations in the CPE are comparatively small with sustained declining populations that makes the species more sensitive to increased mortality from any source.

Overall, wind energy mortality did not have a measurable population-level impact on the majority of bird species found during PCFM and is comparatively much smaller than other anthropogenic sources of bird mortality including cat predation, collisions with vehicles and buildings, electrocutions, or pesticides, among others. In North America, the difference in bird mortality between other anthropogenic sources and wind energy development can be measured in the order of magnitudes but may affect species differently. For example, an estimated 2.9 billion birds are killed annually by domestic and feral cats but typically do not affect raptors. The concern of cumulative impacts to raptors are comparatively higher than other bird species because raptors are typically long-lived species with delayed reproductive maturity, low reproductive rates and flight behaviors that make them more susceptible to wind turbine collisions.

Reliable estimates of bat populations in the CPE and larger regional scales remain unavailable, making conclusions about the cumulative impact from wind energy development difficult to determine. Based on current and future levels of wind energy development, between 7,300–13,800 bats would be killed annually, of which, the majority (96%) would be composed of migratory tree roosting bats that include hoary bat (*Lasiurus cinereus*) and silver-haired bat (*Lasionycteris noctivagans*). Although the proportion of wind energy derived mortality on bat populations and other sources of bat mortality in the CPE are unknown, bat occupancy rates in the CPE have declined in past years, suggesting declining populations. White-nose syndrome (WNS; *Pseudogymnoascus destructans*), a lethal fungus that has decimated bat populations in the Midwestern and Eastern US, was first detected in Washington in 2016 and within the CPE (Kittitas County) in 2018 and Chelan and Yakima counties in 2020. The scale of bat mortality in the US caused by WNS is analogous to cat mortality in songbird populations. Of the 14 bat species that occur within the CPE; six species have exhibited a symptomatic lethal response to the fungus, three species have been asymptomatic (including silver-haired bat), and five species currently have no documented response (including hoary bat). As the disease spreads in the western US and potentially changes pathology to affect more bat species, WNS could have a decimating impact on bat populations in the CPE as observed elsewhere in the US. Better estimates of bat population sizes and dynamics are crucially needed as a first step to understanding the effect of wind energy mortality on bat populations.

We used the current electrical transmission grid, topographic slope, biological and human-built constraints to model the potential USSE development corridor within the CPE. The affected land cover and biological resources within the development corridor were compared to the resources outside the corridor to evaluate whether USSE would disproportionately impact a particular resource. Land cover included vegetation types from the National Land Cover Dataset and National Wetland Inventory; biological resources included federal or state-listed or sensitive wildlife, plant, or high-value plant communities tracked by state Natural Heritage Programs (NHP) and Audubon Important Bird Areas (IBA).

The potential effect of USSE on habitat integrity and connectivity of two focal species that require large areas of habitat were evaluated in greater detail and included Rocky Mountain mule deer (*Odocoileus hemionus hemionus*; mule deer) and greater sage-grouse (*Centrocercus urophasianus*; sage-grouse). After exclusion criteria were applied (e.g., land >2 mi from the electrical grid, topography >10% slope, all perennial waters, Urban Growth Boundaries, federal/First Nation ownership), the potential USSE development corridor composed 32% of the CPE. Modeling corresponded well with USSE development and included the location of all 48 operational, under construction, approved or proposed USSE projects planned through 2025, as of December 2020. No land cover type was disproportionately within the corridor than outside; however, approximately 45% of the cultivated cropland in the CPE was within the corridor. Shrub-steppe (Shrub/Scrub in NLCD) was the sensitive land cover type with the largest amount of area

(29% of mapped area) within the corridor. The second most abundant wetland type in the CPE, freshwater emergent wetland, had the highest proportion (41%) located within the corridor. Four IBAs had a larger proportion of their area located within the corridor than outside, the most relevant being the Boardman Grasslands (61%) in Oregon.

Records of two wildlife species, pygmy rabbit (*Brachylagus idahoensis*; federal and state endangered) and sagebrush lizard (*Sceloporus graciosus*; state candidate) were located more often within the corridor than outside. Of the 11 rare plant species that had proportionately more records within the corridor than outside, gray cryptanta (*Cryptantha leucophaea*; state threatened) had the largest area (10.6 mi^2) but was the sixth most documented rare plant species.

Abundant and widely-distributed land cover, high-quality plant communities and wildlife species are more vulnerable to impacts by USSE, but because of their abundance, are less susceptible to cumulative impacts. Areas with limited distribution such as the Potholes Reservoir IBA or high-quality plant communities such as needle-and-thread grasslands (*Hesperostipa comata*) whose records are located almost entirely within the corridor, are less likely to be affected but impacts would be proportionately greater because of their scarcity on the landscape.

Models of mule deer and sage-grouse habitat concentration areas and their connectivity within the USSE corridor showed areas where development would affect habitat connectivity and impede seasonal movement but also highlighted opportunities where appropriate preconstruction assessments and site selection would be able to avoid sensitive areas. Wildfire is the greatest threat to sage-grouse populations in the CPE and encroachment of USSE into core areas or impeding connectivity between areas would be a cumulative impact. Excluding associated USSE infrastructure (e.g., roads), land use estimates of 4.2 ac/MW for solar tracking arrays represented less than 0.5% of the modeled USSE corridor regardless of development scenario. Site selection and the appropriate biological assessments to avoid cumulative impacts to sensitive biological resources will be crucial to achieve renewable energy policy objectives in a sustainable, environmentally compatible manner.

Our model scenario of 10 GW of new renewable energy in the CPE by 2030 represented the median in a predicted range and a reasonable and understandable starting point but likely underestimates the scope of development. Nevertheless, if predictions hold, renewable energy development in the CPE is beginning another period of intense development pressure, similar or greater to what was observed in the 2000s. The rate of development is outpacing the biological paradigms of yesteryear and updated data-driven policies, procedures, and guidance are needed to match the scale of renewable energy development. Of particular importance is the need to update decade old wind energy guidelines and the development of regional science-based USSE guidelines which are currently absent within the CPE. At the end of this document, we outline a list of processes that would improve the siting opportunities for renewable energy development in the CPE and future cumulative impact assessments.

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PHOTO CREDITS

Cover Page: Shepherds Flat Wind Project and surrounding wind energy projects, Morrow County, Oregon, May 2020. All Photographs: E. W. Jansen

Unit Conversions

Imperial	Metric
1 foot	0.3048 meter
3.28 feet	1 meter
1 mile	1.61 kilometer
0.621 mile	1 kilometer
1 acre	0.40 hectare
2.47 acre	1 hectare
Common Conversions	
0.5 miles	800 meters
0.12 miles	200 meters
0.5 miles	0.8 kilometers
10 miles	16.1 kilometers

Imperial units are used unless otherwise noted.

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ABBREVIATIONS AND ACRONYMS

APLIC	Avian Power Line Interaction Committee
BBS	Breeding Bird Survey
BCC	Bird of Conservation Concern
BCR	Bird Conservation Region
BGEPA	Bald and Golden Eagle Protection Act
BLM	Bureau of Land Management
BPA	Bonneville Power Administration
CPE	Columbia Plateau Ecoregion (Level III)
CRP	Conservation Reserve Program
DOE	United States Department of Energy
ECPG	Eagle Conservation Plan Guidance
EFSC	Energy Facility Siting Council (Oregon)
EFSEC	Energy Facility Site Evaluation Council (Washington)
EPA	Environmental Protection Agency
GIS	Geographic Information System
GW	gigawatt
IRP	Integrated Resource Plan
MW	megawatt
NABat	North American Bat Program
NLCD	National Land Cover Database
NPCC	Northwest Power and Conservation Council
NPP	Northwest Power Plan
OAR	Oregon Administrative Rules
ODFW	Oregon Department of Fish and Wildlife
PCFM	post-construction fatality monitoring
PED	Population Estimate Database
PIF	Partners in Flight
PV	photovoltaic
RSH	rotor-swept height
US	United States
USSE	utility scale solar energy
USDHS	United States Department of Homeland Security
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WECC	Western Electricity Coordinating Council
WNS	white-nose syndrome (*Pseudogymnoascus destructans*)

1 INTRODUCTION

Since the early 2000's, the Columbia Plateau Ecoregion (CPE) of eastern Oregon and Washington has been a regional focus for renewable energy development which has included wind energy and most recently solar energy. The electrical transmission systems originally developed to supply power from hydroelectric dams to communities and urban areas during the 20th century has grown into a vast network of distribution systems for load centers located throughout the Pacific Northwest and beyond. Combined with a transmission system and robust wind resource capable of utility-scale power generation, wind energy has grown into the leading form of renewable energy development within the CPE, excluding hydroelectric, which accounts for over 50% of the regions electrical supply (Northwest Power and Conservation Council [NPCC] 2021; Photo 1). More recently, advances in photovoltaic solar energy technology and legislation mandating carbon free energy sources has resulted in increased development of utility scale solar energy (USSE) within the CPE.

Over the next decade, installation of renewable energy facilities are projected to significantly increase to accommodate population growth and government policies that focus on shifting energy generation from fossil fuels to non-carbon emitting sources. The region is losing 60% of its coal fleet over the next decade and replacement resources will be needed to complement the existing system and meet power supply demand (NPCC 2021). Mandated by policy, Oregon and Washington have passed Renewable Portfolio Standards that aim to generate a substantial proportion of their energy supply from renewable energy sources over the next several decades. In Oregon, Senate Bill 1547 mandated at least 50% of the utility-scale electrical supply must be produced by renewable energy sources by 2040[1] while House Bill 2021[2] mandated 100% by 2040 for investor-owned utilities. In Washington, Senate Bill 5116 mandated an electricity supply free of greenhouse emissions by 2045[3].

Cumulative impacts to bird, bats, and associated habitats from the development and operation of wind and solar energy is an area of active research within the United States (US) and around the World (International Finance Corporation 2017, Gill and Hein 2022). Because of the geographic scale of development, concerns of population-level effects have been raised and actions are necessary to prioritize conservation efforts and management action. Recent studies have used various analytical approaches to evaluate cumulative impacts to birds, bats and habitat. Diffendorfer et al. (2021) used demographic and biological removal models to quantify impacts on 14 raptor species, assuming a future US wind energy scenario of 241 gigawatts (GW) of installed capacity. Katzner et al. (2020) described a cumulative impact framework and used genetic data to evaluate impacts from solar energy to greater roadrunners (*Geococcyx californianus*) in the US southwest desert and impacts from wind energy to red-tailed hawk (*Buteo jamaicensis*) in central California. Macgregor and Lemaitre (2020) used bat fatalities, facility size,

[1] Oregon Senate Bill 1547

[2] Oregon House Bill 2021

[3] Washington Senate Bill 5116-2019-20

elevation, and geographic location to predict the cumulative impacts to bats in Quebec, Canada. Walston et al. (2021) modeled ecosystem services at 30 solar energy facilities in the midwestern US In general, studies of cumulative impacts typically note the inherent difficulties in evaluating effects to wide-ranging species with varying degrees of accuracy in population estimates, demographic rates, and other anthropogenic stressors (Stanton et al. 2019, Katzner et al. 2020). This report provides a contemporary review of available bird and bat fatality data, and impacts to land cover from wind and solar energy development to assist stakeholders in future planning decisions within the CPE of eastern Oregon and Washington.

1.1 Assessment Objective

The objective of this assessment was to contextualize, on a broad geographic scale, the past, current, and future direct effects of wind and solar energy development on birds, bats, and land cover within the CPE through 2030. The Environmental Protection Agency (EPA) defines cumulative impacts as “when the effects of an action are added to or interact with other effects in a particular place and within a particular time” (EPA 1999). A slightly different version is considered in the context of the National Environmental Policy Act (NEPA), where cumulative impacts are defined as “impacts on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions (40 Code of Federal Regulations 1508.7).” This assessment blends the EPA and NEPA definitions to define cumulative impacts when “impacts resulting from the construction and operation of wind or solar energy facilities increase the potential for sustained impacts to negatively affect species’ group populations or land cover types over time”.

Over a decade ago, Johnson and Erickson (2008, 2010, 2011) visited the same question in regards to cumulative impacts resulting from wind energy development in the CPE. The primary differences between the previous version and this assessment are the inclusion of contemporary bird and bat post-construction fatality data, biological and remotely sensed data, and the emergence of USSE as an energy source to support carbon free policy objectives.

Although USSE development is still relatively recent in the CPE and rigorous studies on impacts to bird and bats from USSE in the CPE are lacking, the projected level of development and increasing scale of land use intensity over the next decade warrants the inclusion of this development type in this assessment. In addition, without electrical transmission and distribution, wind and solar projects would not be developed; therefore, transmission was considered a factor in this assessment. Because the potential effects to birds, bats, and land cover differ significantly between wind and USSE development, the organization of the assessment was divided among the two renewable energy types, where the questions involving wind energy and USSE were considered separately.

- Do the current and future levels of wind energy generation increase the potential for sustained direct impacts (collision mortality) that negatively affect bird and bat populations in the CPE?
- Using spatially explicit constraints and solar resource models, what are the affected biological resources in areas where USSE development is most likely to occur?

<u>What this Assessment Does Not Do</u>

This assessment does not model species-specific demographic parameters that estimate the effect of renewable energy impacts on population trends or viability over time. The inclusion of demographic parameters such as birth, death, immigration, and emigration traditionally used in population matrix models or viability analyses are not within the scope of the current study. This was not a sensitivity analysis to understand mortality thresholds. Rather, the construct of this assessment was to contextualize the magnitude of the effect on a species or primary species group (group) and qualitatively evaluate the direct impacts based on existing population trends and other environmental stressors. Conversely, the effects of compensatory mitigation or other conservation programs as a result of renewable energy development have not been factored into the assessment. This assessment is not meant to inform project specific impacts, and while it may be useful in evaluating cumulative impacts of future renewable energy scenarios, environmental assessments of individual renewable energy projects should continue to follow applicable federal, state, and county guidelines/protocols.

Photo 1. Wind energy turbines in Sherman County, Oregon, March 2022.

2 CHARACTERIZATION OF THE ANALYSIS AREA

Defining the geographic scale and current characteristics within the analysis area is a fundamental step in impact analyses (Katzner et al. 2020). This section characterizes the past, current, and future conditions of the natural environment and human-built environment within the geographic boundary of the Level III CPE which is defined as the 32,097 mi^2 (20,542,106 acre [ac]) area within Idaho, Oregon, and Washington (Omernik 1987; Figure 1). Where possible, comparisons between the datasets used in the Johnson and Erickson (2011) report and contemporary datasets were made to help contextualize how conditions have changed over the past decade. Consistent with Johnson and Erickson (2011), Oregon and Washington were the focus for data summaries and subsequent analyses because no operational or proposed renewable energy facilities occur in the Idaho portion of the CPE.

2.1 Natural and Human Environment

This section characterizes the land cover, land ownership and management, and the human-built environment that may affect cumulative impacts to bird and bat communities within the CPE. Impacts of the human built environment are presented in the results and discussion section (*see* Section 4 and 5) where past and future characteristics provide context, where applicable.

2.1.1 Land Cover

Located predominantly within Oregon and Washington, the CPE is bound in all directions by comparatively more mountainous ecoregions; the diverse topographic relief is a function of its dynamic geologic history. Rising approximately 4,500 feet above sea level, topography in the CPE is characterized by broad, flat plateaus, rolling hills with lakes and potholes, channeled scablands and bisected by steep canyons and river systems and reservoirs (Cleland et al. 2007). Annual precipitation averages seven to 18 inches. Soils are derived from parent material resulting from erosion and re-deposition by great floods and strong winds across the relatively level lava plateau (Cleland et al. 2007). Windblown sediment (loess) covers most of the CPE providing deep fertile soil, only to be interrupted by the geologic mayhem of the Missoula Floods that created areas of flood-scoured, channeled scablands (Spokane Valley, WA), potholes (Othello area, WA), and steep topography (Columbia River Gorge, OR, Blue Mountain Foothills, OR, Saddle Mountain, WA), present throughout the CPE (Alt 2001).

Grasslands and shrub-steppe form a mosaic of native vegetation that comprise the dominant habitat types within the CPE. Clinal variation in vegetation communities range from grasslands and shrub-steppe in lower elevations transitioning to landscapes dominated by trees in higher elevations (Figure 1). Regional variation of vegetation communities throughout the CPE exists; however, generally, native grass species consist of Idaho fescue (*Festuca idahoensis*), needle-and-thread (*Hesperostipa comata*), and bluebunch wheatgrass (Pseudoroegneria spicata). Forbs include buckwheat (*Eriogonum* spp.), hawkweed (*Hieracium* spp.), salsify (*Tragopogon* spp.), balsam arrowroot (*Balsamorhiza sagittata*), and an assortment of wildflowers (e.g., larkspur [*Delphinium* spp.]). Dominant shrubs include a variety of sagebrush (*Artemisia* spp), rabbitbrush (Ericameria spp.), antelope bitterbrush (*Purshia tridentata*), greasewood (*Sarcobatus vermiculatus*), and buckbrush (*Ceanothus cuneatus*). Higher elevations and drainages have ponderosa pine (*Pinus ponderosa*), western juniper (*Juniperus occidentalis*), cottonwood (*Populus* spp.), Siberian elm (*Ulmus* spp.), and hawthorn (*Crataegus* spp.; Clarke and Bryce 1997). Introduced from Eurasia and the Mediterranean, cheatgrass (downy brome, *Bromus tectorum*) continues to be a major threat to biodiversity, functionally eliminating native plant species in areas, modifying wildlife populations and increasing the risk of wildfire (Pilliod et al. 2021). The establishment of other non-native grasses (e.g., wiregrass, *Ventenata dubia*) in the CPE has been identified as an emerging conservation threat and in need of additional research (Ridder et al. 2022).

Promoted by the Columbia Basin Project Act, hydroelectric development began in 1941 with the Grand Coulee dam in Grant and Okanogan counties and agricultural irrigation began in 1952, forever changing the land cover in the CPE (US Bureau of Reclamation 1964). Between 1973 and 2000, the proportion of lands converted to agriculture steadily increased, only outpaced in 1986−1992 with more lands enrolled in Conservation Reserve Program (CRP) lands (Sleeter et al. 2012). Currently, natural land cover in the CPE is characterized by a mosaic of shrub-steppe and grasslands[4] that composed approximately 50% of the CPE in 2019. Cultivated crops, predominantly winter wheat, continue to represent the dominant land cover type in the CPE as it has since the early 1970's (Table 1, Figure 1; Sleeter 2012). Land cover and land use within the CPE has changed substantially over the past decade (Table 1, Figure 1). Between 2006 and 2019 shrub-steppe land cover decreased approximately 700,000 ac (13%) while grasslands increased over 500,000 ac (10%). Most conversion of shrub-steppe to developed areas occurred around the urban areas including Moses Lake and the Tri-cities area of Kennewick, Pasco, and Richland, Washington (Figure 2). Beyond urban areas, broader areas of shrub/scrub conversion to developed cover types were in areas of higher-density wind energy development along the Columbia River of the Oregon/Washington border.

Impacts to land cover from the construction of wind and solar projects must be offset through compensatory habitat mitigation per Oregon and Washington policy[5]. The Oregon Department of Fish and Wildlife (ODFW) and Washington Department of Fish and Wildlife (WDFW) implement mitigation policy standards as described in wind energy guidance documents and department policy (ODFW 2008; WDFW 1999, 2009). Although Oregon and Washington habitat mitigation policies differ, the general approach is to achieve no net loss of habitat resulting from construction activities. In both policies, habitat (i.e., land cover types) are assigned to a category or class, depending on its conservation value for wildlife. A higher mitigation ratio (amount of mitigation: amount of impact) is assigned for habitats that have greater conservation value for a particular species and whether habitat impacts are permanent or can be restored through habitat restoration following construction. Habitat mitigation strategies vary by project and state but can include land acquisition of conservation parcels held in perpetuity, on site restoration activities, a fee option paid by the developer to support state conservation programs, or combination of strategies.

[4] Analogous to shrub/scrub and herbaceous NLCD cover types presented in Table 1, Figures 1 and 2, and described by Johnson and O'Neil (2001).

[5] Oregon Administrative Rule (OAR) 635-415; Washington Administrative Code (WAC) 463-60-332.

Table 1. Change among National Land Cover Database (NLCD) land cover types between 2006 and 2019 and percent composition (% Comp.) within the Columbia Plateau. Data sorted by % *change.*

NLCD Land Cover Type[1]	2006 Area (ac)	2019 Area (ac)	2019 % Comp.[2]	2006−2019 Difference (ac)	2006−2019 % Change
Developed					
Developed, High Intensity	23,732	31,741	0.2	8,010	33.8
Developed, Medium Intensity	134,766	169,665	0.8	34,899	25.9
Developed, Low Intensity	260,085	264,893	1.3	4,808	1.8
Developed, Open Space	402,807	382,270	1.9	-20,537	-5.1
			Net Change	***27,179***	***56.4***
Vegetated and Barren					
Herbaceous	5,225,389	5,754,282	28.0	528,893	10.1
Cultivated Crops	7,943,204	8,103,839	39.4	160,635	2.0
Deciduous Forest	4,334	4,393	0	59	1.4
Hay/Pasture	331,537	335,172	1.6	3,634	1.1
Mixed Forest	1,606	1,559	0	-47	-2.9
Evergreen Forest	372,692	354,121	1.7	-18,571	-5.0
Shrub/Scrub	5,282,369	4,582,935	22.3	-699,434	-13.2
Barren Land	7,104	5,622	0	-1,482	-20.9
			Net Change	***-26,313***	***-27.4***
Waters and Wetlands					
Woody Wetlands	57,809	58,615	0.3	806	1.4
Emergent Wetlands	141,920	143,697	0.7	1,777	1.3
Open Water	352,626	349,177	1.7	-3,450	-1.0
			Net Change	***-867***	***1.7***

1. Included 125 acres (ac) of land cover categorized as Unclassified in 2006 and 2019. Descriptions of land cover types are found in Homer et al. (2020).
2. 2019 % composition was calculated as the 2019 land cover type (ac) divided by the total area of the CPE (20,542,106 ac).

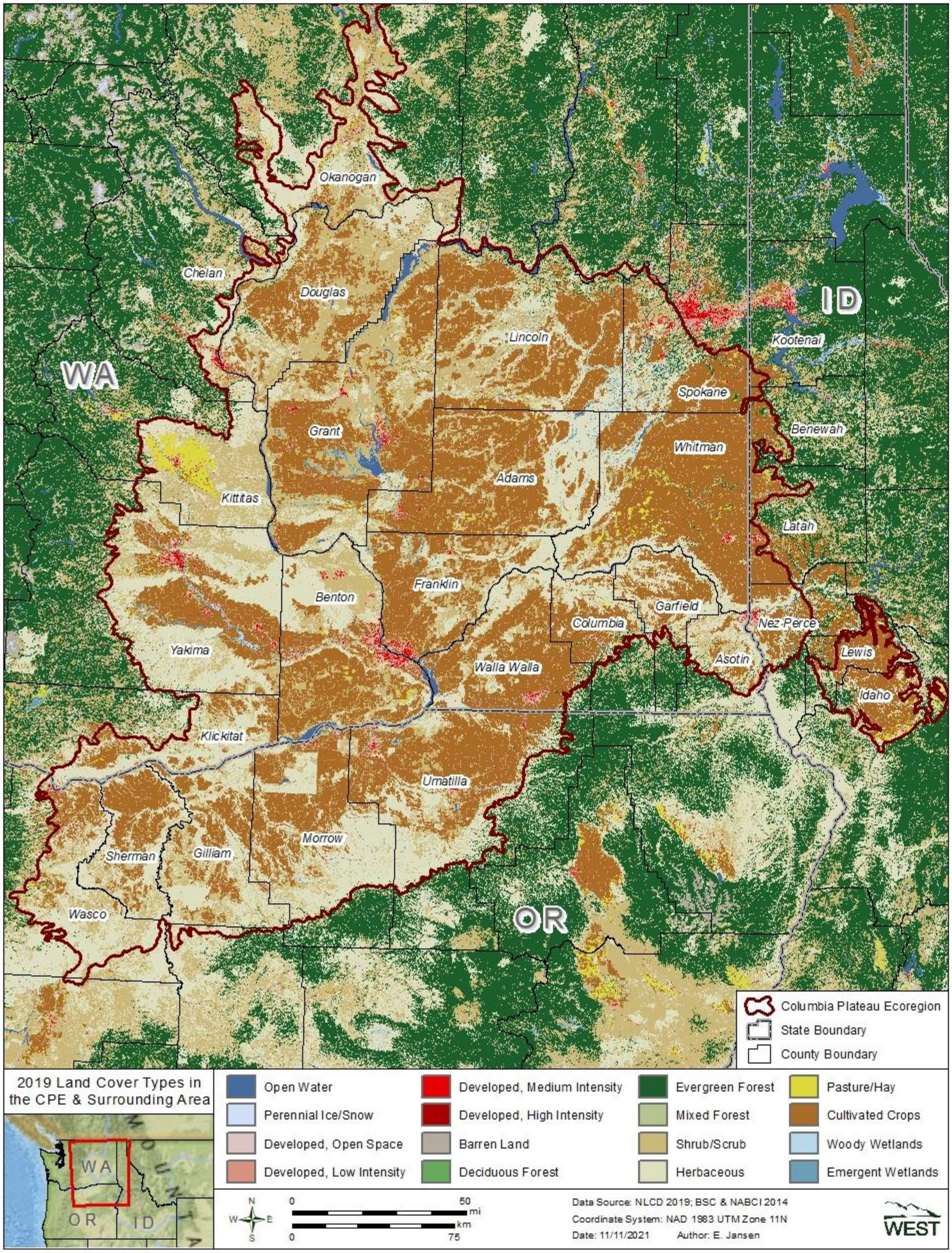

Figure 1. Land cover types within the Columbia Plateau Ecoregion.

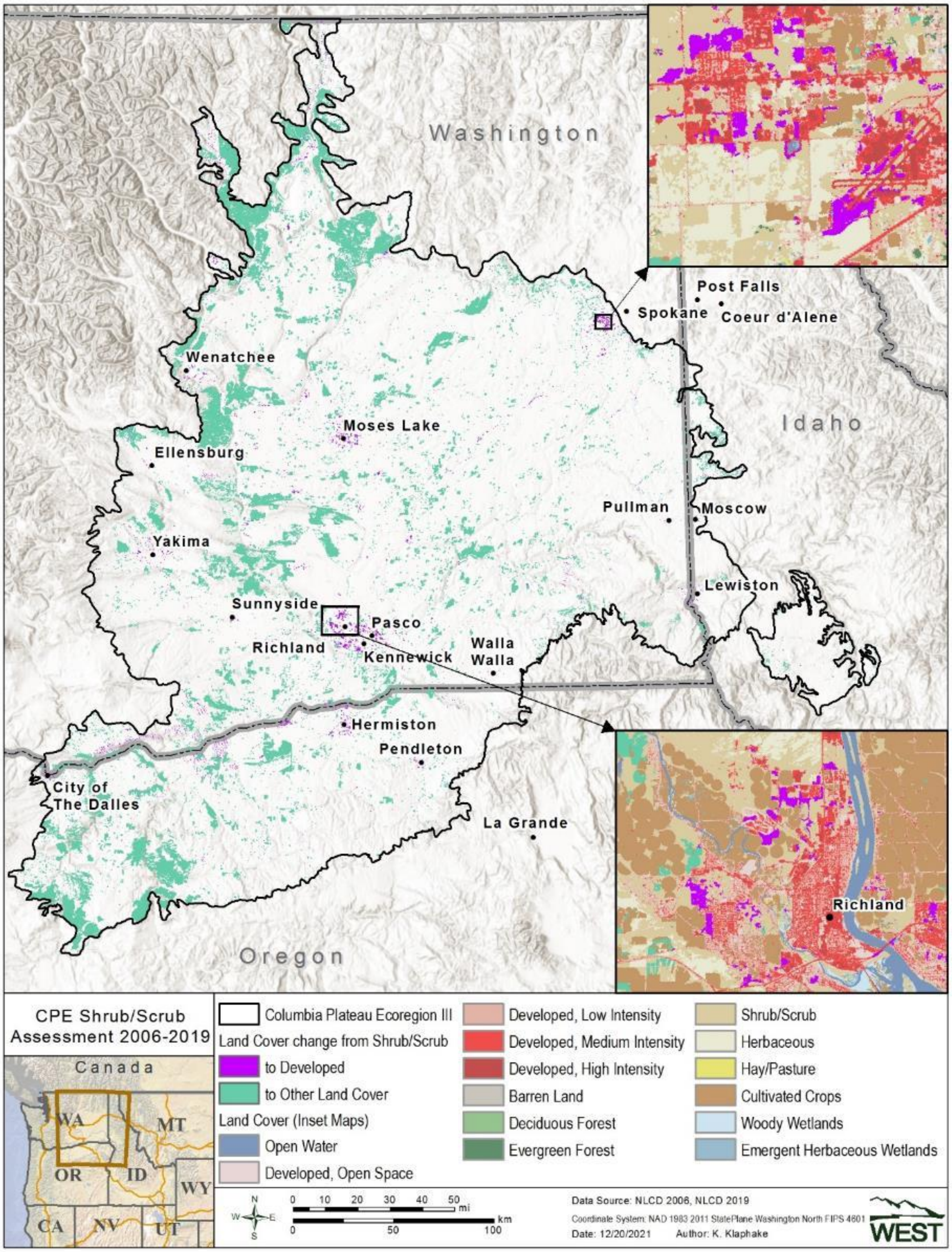

Figure 2. Conversion of shrub/scrub to developed or other land cover types 2006–2019 within the Columbia Plateau Ecoregion.

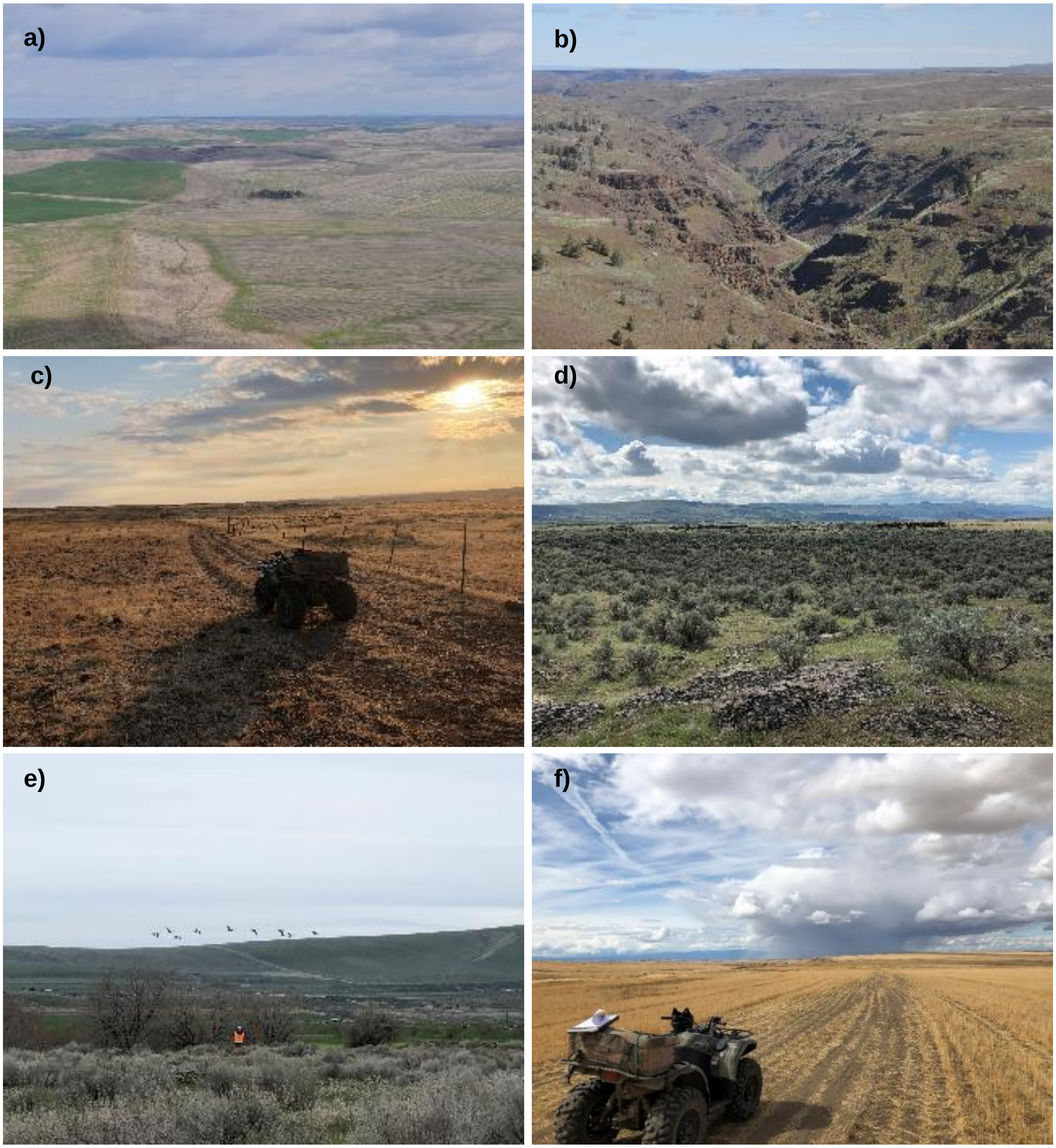

Photo 2. Representative photographs of land cover and topography within the Columbia Plateau Ecoregion, 2018–2022.

Photos include a) rolling agricultural fields of the Palouse Hills, Adams County, Washington; b) dissected basalt canyons near the John Day River, Sherman County, Oregon; c) heavily grazed grasslands, Wasco County, Oregon; d) depression of dense sagebrush, Adams County, Washington; e) sandhill cranes over rabbitbrush and Russian olive, Adams County, Washington; f) flat plateau of harvested winter wheat, Wasco County, Oregon.

2.1.2 Land Ownership and Management

Reflective of land cover characteristics, land within the CPE is predominantly privately owned (74%) and primarily managed for cultivated crops or livestock (Tables 1 and 2; Appendix F1).

Private lands managed for conservation are encouraged by a number of Farm Service Agency programs to incentivize conversion of cropland to native vegetation through the Conservation Reserve Program (CRP) and similar initiatives. Contract length with the landowner is 10-15 years until renewal is needed. The majority of CRP lands in Oregon and Washington are located within the CPE. For 35 years, Washington has consistently accounted for an average of 67% ± 4% of CRP lands within the CPE, annually, followed by Oregon (28% ± 4%) and Idaho (4.8% ± 1%). Since the beginning of the program in 1985, CRP had the highest enrollment in 2007 with approximately 1,900,000 acres. In 2019, there were approximately 1,450,000 acres of CRP enrolled in counties within the CPE, which is equivalent to CRP enrollment in the early 2000's (Figure 3). Approximately 1,430,000 acres are set to expire in the CPE by 2030 unless contracts are renewed (annual 12-year average = 119,179 ± 135,675 ac; Figure 3). CRP lands enhance soil, water, and habitat productivity for many wildlife species and provide a landscape-scale conservation opportunity for grassland birds (Pavlacky et al. 2021) and synergistic environmental benefits when combined with non-carbon emitting sources of renewable energy (Wiesner 2007). The persistence of greater sage-grouse (*Centrocercus urophasianus*) in Washington has been attributed to the amount of lands enrolled in CRP, particularly in Douglas and Lincoln counties (Schroeder and Vander Haegen 2006, 2011; Shirk et al. 2017) and CRP continues to be an important conservation tool for wildlife in modified landscapes, particularly for native grassland birds such as ferruginous hawk (*Buteo regalis*; Shaffer et al. 2019, Hayes and Watson 2021).

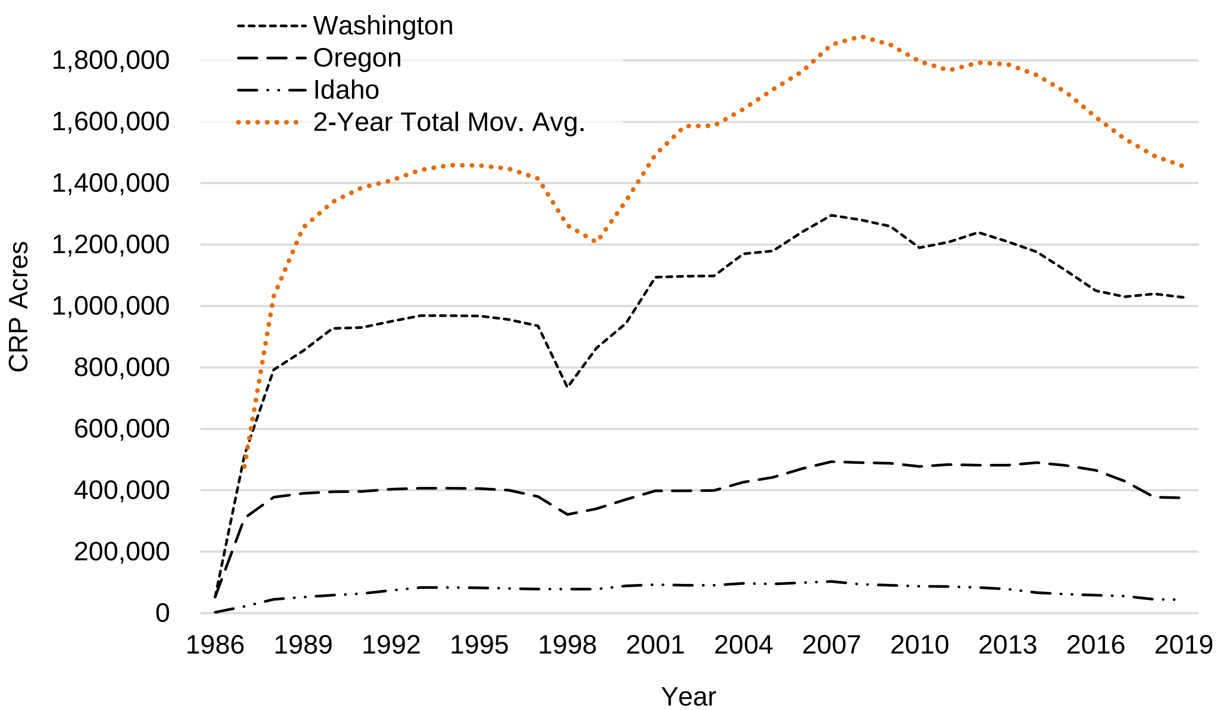

Figure 3. Total acres of land enrolled in the Conservation Reserve Program in 27 counties within the Columbia Plateau Ecoregion, 1986−2019 (NRCS 2021).

Following private, ownership within the CPE consists of federal agencies (12%), First Nations (8%), state agencies (6%), non-governmental organizations (<1%) and an assortment of county, city or other designations (<1%; Table 2). The majority of federal ownership within the CPE is managed by the Bureau of Land Management with the largest parcels along the designated Wild and Scenic John Day River and Deschutes River in Oregon, both of which provide excellent raptor nesting habitat. Additional BLM-managed lands include Areas of Environmental Concern and Wilderness Study Areas scattered throughout the CPE. The US Fish and Wildlife Service is the second largest federal land manager in the CPE with a large system of National Wildlife Refuges and Monuments that provide important year-round and migratory habitat for birds and bats (USFWS 2011). First Nations are administered by the Bureau of Indian Affairs and consist of the Confederated Tribes and Bands of the Yakima Nation (WA), Colville (WA), Spokane (WA), Umatilla (OR), Warm Springs (OR), Nez Perce (ID), and Coeur d'Alene (ID). First Nation ownership within the CPE is approximately 8% and managed independently as a sovereign nation. State ownership is approximately 6% of the CPE with the majority managed by Washington Department of Natural Resources as Trust Lands intended to generate revenue by leasing for agriculture, ranching, mineral, and wind energy development. Departments of Fish and Wildlife in Oregon and Washington and Fish and Game in Idaho manage a variety of Wildlife Complexes and Natural Areas for the explicit purpose of wildlife conservation. Non-governmental organizations (NGO; land conservancies and trusts) form a small portion of land ownership in the CPE (<1%) and management objectives typically include land stewardship and habitat conservation. Many NGOs in the CPE provide options to assist renewable energy developers to mitigate habitat impacts from wind and solar energy development.

Table 2. General land ownership and management agency within the Columbia Plateau Ecoregion. Data sorted by sub-total (*italics*).

Ownership/Management		Acres	% Composition
Private	***Sub-Total***	***15,227,100***	***74***
Federal			
Bureau of Land Management		670,035	28
Fish and Wildlife Service		478,076	20
Department of Defense		394,910	17
Forest Service		294,849	12
Army Corps of Engineers		213,392	9
Department of Energy		211,091	9
Bureau of Reclamation		46,511	2
National Park Service		43,827	2
National Resource Conservation Service		11,157	0
	Sub-Total	***2,363,848***	***12***
First Nations	***Sub-Total***	***1,734,886***	***8***
State			
Washington Department of Natural Resources		614,526	52
Department of Fish & Wildlife/Game		495,928	42
Parks and Recreation		34,555	3
Oregon Department of Lands		7,093	1
	Sub-Total	***1,152,102***	***6***
Non-Governmental Organization	***Sub-Total***	***39,136***	***<1***
Other[1]	***Sub-Total***	***25,035***	***<1***
	Total	**20,542,107**	**100**

1. Other = City, County, or other designation.

Source: US Geological Survey (2020).

2.1.3 Human Population Growth

Population growth and the underlying land management decisions to accommodate an expanding population and the associated economy are inextricably linked with changes in land cover, renewable energy development, and impacts to bird and bat populations. From 2020–2030, annual population growth within the CPE is projected to increase approximately 1% per year to 1,887,351 individuals, a 10.3% increase by 2030 (Washington Office of Financial Management 2018, Portland State University 2021). Growth management acts in Oregon and Washington guide land use decisions in response to the growing population as well as intersect with energy development to ensure consistency with policy statues that mandate sustainable and thoughtful development. The demands for increased energy production extend far beyond the boundary of the CPE to the growing population of the western US. The decentralized transmission system in the CPE is part of the Western Interconnection that services states in the western US and will have a regional influence in the scale of energy development within the CPE.

Photo 3. Expanding urbanization into the Horse Heaven Hills fragments shrub-steppe and encroaches into ferruginous hawk nesting areas, Benton County, Washington. May 2022.

2.1.4 Vertical Obstruction

As populations grow and society continues to change into an increasingly digital world reliant upon electricity, the numbers of radio and microwave towers, communication systems, transmitters and repeaters (collectively, communication towers) have grown exponentially in the CPE. A vast network of infrastructure has been installed and modified over decades to support cellular, television, microwave, and paging communications from civilian and military applications. Infrastructure takes a variety of forms, dependent upon purpose, but all are raised to free-stand or supported by guy wires, illuminated with various indicator systems, and occupy variable amounts of airspace (Photo 4). Occupation of the airspace by this infrastructure has resulted an on-going source of mortality to birds and bats for decades (Gehring et al. 2009; Kerlinger et al. 2010; Longcore et al. 2012, 2013; Lundston et al. 2013). In general, studies have shown that a combination of taller towers with solid or pulsating red lighting and guy wires increase the likelihood of attraction and mortality (Manville 2013).

When adjusted for sample effort, searcher efficiency, and carcass persistence, Longcore et al. (2012) estimated bird collision mortality was approximately 6.8 million birds a year at 70,414 communication towers in the US and Canada, with approximately 20,700 birds (0.00−0.06 birds/km^2) in the Great Basin BCR, where the CPE is located (Appendix F2). Neotropical migrants incur the greatest mortality (97.4%) which are composed mostly of warblers (Parulidae; 58.4%), vireos (Vireonidae; 13.4%), thrushes (Turdidae; 7.7%), and sparrows (Emberizidae; 5.8%; Longcore et al. 2013). The number of fatalities of a particular species may be disproportionate to their abundance, which suggests that mortality is not a random factor that affects all migratory birds equally (Longcore et al. 2013). Although bats appear deterred by magnetic fields surrounding air traffic control radar stations (Nicholls and Racey 2007), bat use has been documented at communication towers (Gehring 2012). However, no bats were discovered during a three-year study at two monopole towers (31-40 m tall) in Washington D.C. and, unlike birds, evidence of collisions with communication towers has been largely anecdotal (Dickey et al. 2012, Manville 2016).

Publicly available data report approximately 946 communication structures have been permitted in the CPE since 1992, which range between 1−148 m tall (Figure 4; TowerMaps 2020, US Department of Homeland Security 2021). Longcore et al. (2012) estimated approximately 15.6% (1.02 million) of bird fatalities in the US occur at towers 60−150 m tall, which are approximately 1.5−3.5 times taller than the average height, but includes the range of tower heights found in the CPE (Table 3). Bird mortality estimates from communication tower collisions in the US are mostly derived from studies in the eastern and mid-western US Because of the differences in the total number and type of towers, bird species composition, weather and migration patterns, Longcore et al. (2012) cautions against extrapolation of mortality patterns to towers in the western US, pending regional-specific study.

Table 3. Summary of communication towers located in the Columbia Plateau Ecoregion.

		Tower Height (m)			
Tower Type[1]	**# Structures**	**Min**	**Max**	**Average**	**St. Dev.**
Tower	547	3	148	44	25
Pole	169	1	66	26	12
Lattice Tower	103	8	92	49	22
Structure	42	2	83	30	22
Monopole	41	12	59	31	12
Guy Tower	32	18	110	73	26
Mast	12	9	73	37	21

[1.] As defined by the Federal Communication Commission (FCC 2010):

Tower – A free standing or guyed structure used for communications purposes

Pole – Any type of pole, used only to mount an antenna

Lattice Tower – Free standing or guyed

Structure – Mounted on buildings, smokestacks, silos, or other structure

Monopole – Singular, free standing or guyed

Guyed Tower – Guyed structure used for communication purposes

Mast – Structure used to elevate mounted antennas to reach height for quality signals

m = meter; St. Dev. = Standard Deviation

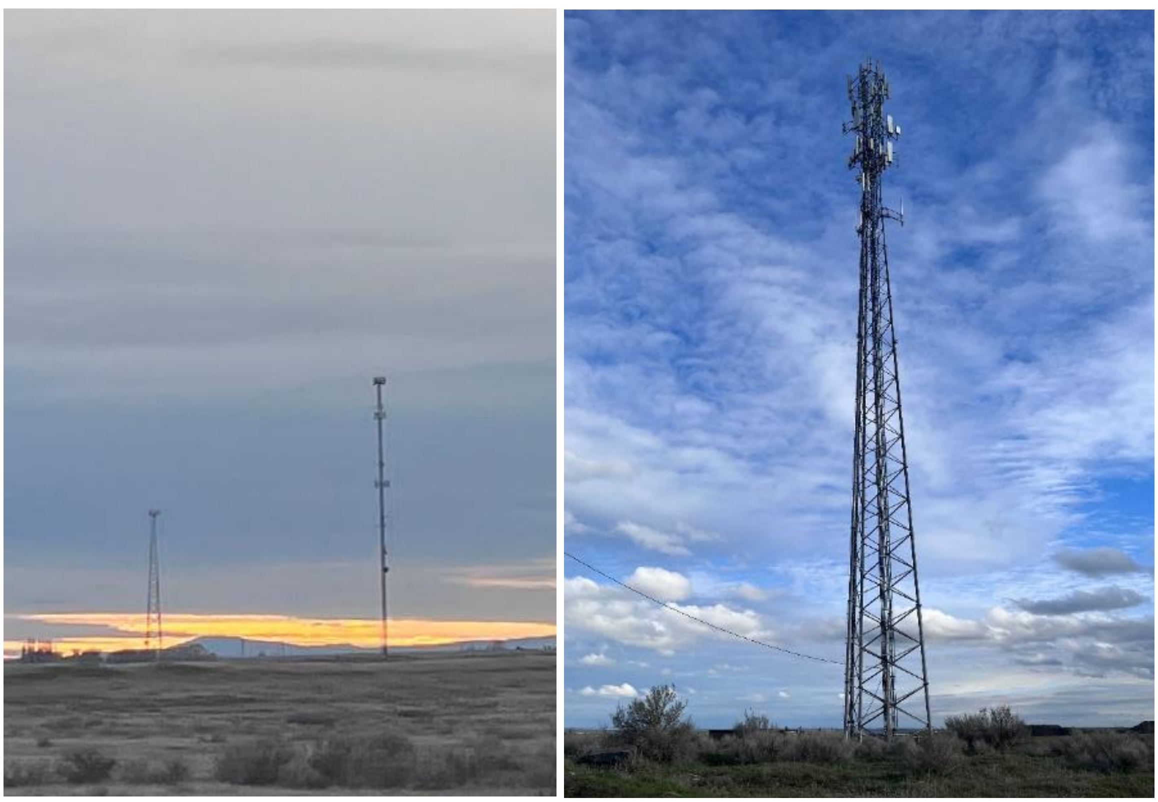

Photo 4. Examples of self-supported and guyed communication towers (left) and self-supporting tower (right) in Franklin County, Washington, March 2022.

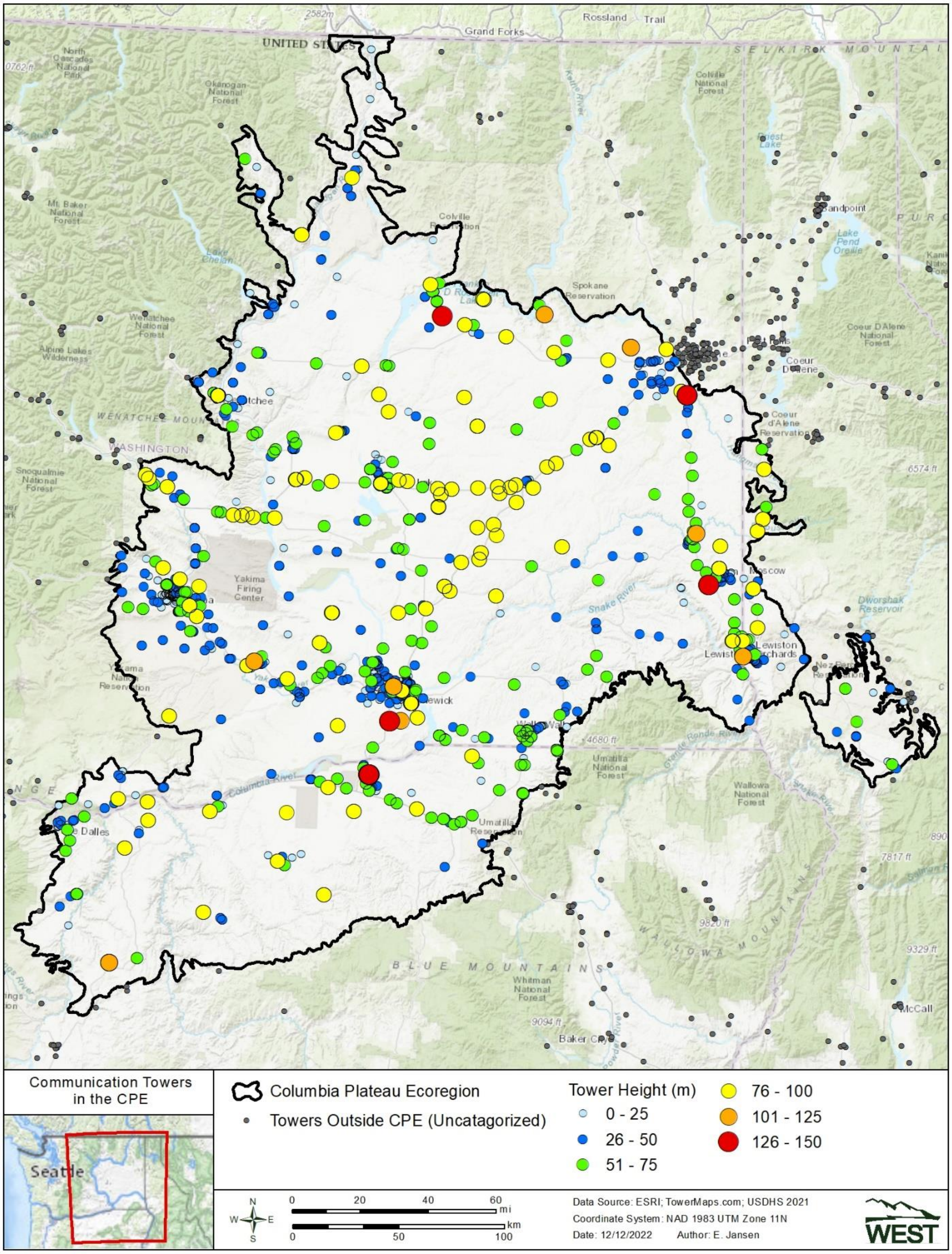

Figure 4. Communication towers located within the Columbia Plateau Ecoregion, 1992–2021. Tallest tower height displayed in cases where co-location occurs.

2.1.5 Electrical Transmission and Distribution

Energy production, in any form, must include a system of distribution networks to deliver the energy produced at a facility to the consumer. As discussed, a concerted effort to organize electrical transmission within the CPE began with the advent of hydroelectric in the mid-1940s which extended beyond the border of the CPE. The electric transmission grid in the CPE is part of a broader, decentralized market of the Western Interconnection under the auspice of the Western Electricity Coordinating Council (WECC) that covers 14 western states (Appendix F3). Similar to communication towers, electrical systems are raised structures that pose a collision risk but also include risk of electrocution. The impacts to birds from electrical systems have been a long-standing concern (Olendorff et al. 1981) and substantial efforts have been taken by electrical utilities and renewable energy developers to avoid, minimize, and mitigate impacts (Avian Power Line Interaction Committee [APLIC] 2012, 2014, 2015; USFWS 2013). Electrocutions occur primarily at low-voltage distribution lines with voltages between 2.4 and 60 kilovolts (kV) while collisions occur at both distribution lines and transmission lines with voltages >60 kV (APLIC 2012, Dwyer et. al 2014).

Loss et al. (2014) used 14 studies throughout the US to estimate between 12 and 64 million birds are killed each year at US power lines, with between 8 and 57 million birds killed by collision and between 0.9 and 11.6 million birds killed by electrocution. Because of their comparatively larger body size, bird species most commonly electrocuted are eagles, hawks, and ravens (Kagen 2016, McClure et al. 2018, Mojica et al. 2018). Mortality rates are not uniform over the landscape but are influenced by species, surrounding environmental factors, and structure related factors (Loss et al. 2014, Bedrosian et al. 2020, Biasotto et al. 2022).

The Bonneville Power Administration (BPA) was, and continues to be, the primary electrical provider in the CPE. Electrical systems are designed where power generated at a facility is converted through a series of substations and infrastructure to allow long-distance transmission to the consumer or load center. As a result, the electrical network in the CPE consists of distribution (<115 kV), sub-transmission (115−161 kV), and high-voltage transmission lines (>230 kV) that span over 9,120 mi (Figures 5 and 6; Photo 5; US Department of Homeland Security [USDHS] 2021). Measured per mile by voltage class, high-voltage transmission systems comprise approximately 52% of the electric system in the CPE, followed by sub-transmission (40%), and distribution (8%; USDHS 2021). Smaller-voltage distribution lines that supply exurban areas such as ranches and farmsteads are likely underestimated in the dataset because of the inherent difficulty in tracking and mapping. Although widely distributed throughout the CPE, electric systems, especially high-voltage transmission and sub-transmission voltages, are typically co-located and follow established corridors where the rights-of-way have been established, thus consolidating the footprint of the grid as seen around Boardman, Oregon, for example (Figure 6). Several regional working groups have been established to help facilitate the future design and planning of electrical transmission.

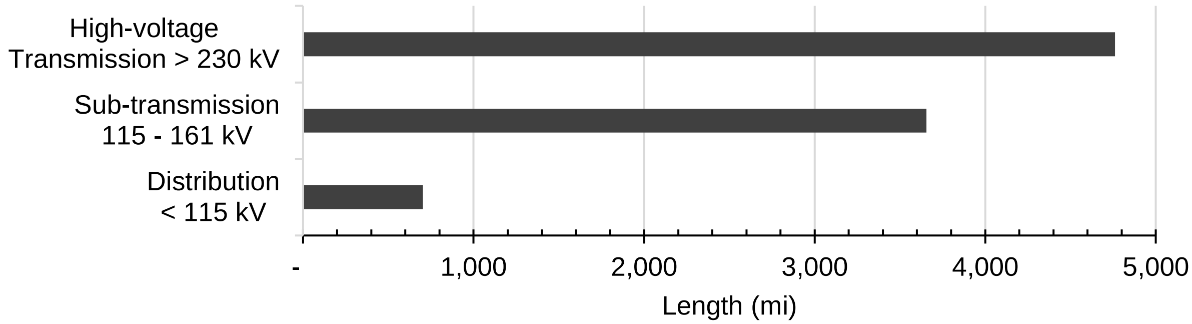

Figure 5. Electrical transmission systems in the Columbia Plateau Ecoregion (USDHS 2021).

Photo 5. Example of a high-voltage (500 kV) transmission tower with a raptor nest on the upper truss, Morrow County, Oregon (left), and distribution line with long-billed curlew (*Numenius americanus*) in the foreground, Gilliam County, Oregon, April 2021 (right).

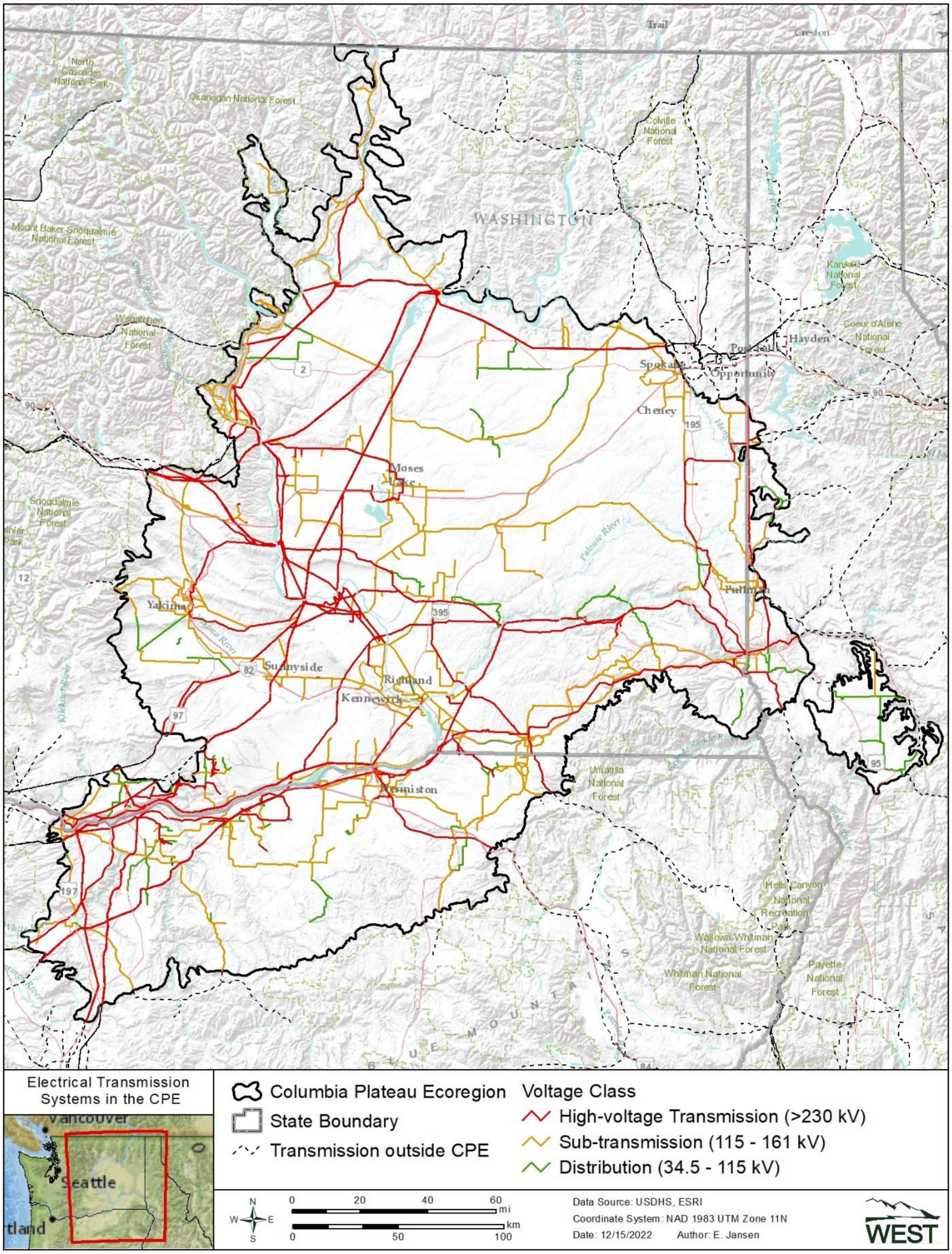

Figure 6. Electrical transmission systems in the Columbia Plateau Ecoregion. Highest voltage class displayed in cases where co-location occurs.

Photo 6. Example of a Bonneville Power Administration high-voltage electrical transmission corridor in southern Benton County, Washington, April 2022.

2.1.6 Bird Community

The diverse geologic, land cover, and ownership types within the CPE provide suitable nesting, foraging, and migratory stopover habitat for a high diversity of bird species. The CPE is a geographic subset of the Great Basin BCR 9 and lies within the Pacific Administrative Flyway (Appendix F2; Bird Studies Canada and US North American Bird Conservation Initiative [NABCI] 2014, USFWS 2014, EPA 2016). Located along the Pacific Flyway, birds within the CPE are a mixture of year-round residents, summer breeding species and migratory species. Summer breeding species may arrive in the CPE from as far away as South America to nest (e.g., Swainson's hawk [*Buteo swainsonii*]; Kochert et al. 2011), while some highly migratory species that winter in California fly through the CPE to nest in Alaska (i.e., sandhill crane [*Antigon canadensis*]; Stinson 2017). Twenty species that occur within the CPE are listed by state and federal agencies as sensitive species[6] (Appendix T1).

The National Audubon Society (Audubon) identified approximately 10% of the CPE occurs in 29 separate state priority and two global priority Important Bird Areas (IBAs; Audubon 2022). IBAs are defined as distinct areas that provide essential habitat for one or more species of birds during

[6] As defined here "sensitive" species include any species in Oregon or Washington which is either a) listed as an endangered, threatened, or candidate species under the federal Endangered Species Act of 1973, subject to the Bald and Golden Eagle Protection Act of 1940, or Oregon Endangered Species Act, or Washington State Environmental Protection Act; b) is designated by federal or state law, regulation, or other formal process for protection and/or management by the relevant agency or other authority; or c) has been shown to be significantly adversely affected by renewable energy development (WDFW 2009, USFWS 2012a)

breeding, wintering, or migration. Approximately 56% of areas identified as IBAs are located on lands managed by federal or state agencies with the remaining area privately owned. Annual Breeding Bird Surveys (BBS) conducted in the month of June along 147 routes within the Great Basin BCR 9 of Oregon, Washington, and Idaho provide population estimates and long-term population trends. Pardieck et al. (2020) provides BBS survey protocols and the 1966−2019 dataset (Appendix F4). Partners in Flight used BBS data to calculate population estimates for 172 species that occur within the Great Basin BCR 9 and CPE that are used in this assessment (Will et al. 2020). Further discussion regarding how bird populations within the CPE were estimated is provided in Section 3.2.

2.1.7 Bat Community

Bat population sizes in the Pacific Northwest are not well understood (Hayes and Wiles 2013, Rodhouse et al. 2019). Their high seasonal mobility, cryptic roosting and nocturnal behaviors result in a notoriously difficult group to obtain reliable population estimates. Previous focal inventory surveys conducted in the National Wildlife Refuges, Hanford Nuclear Site, and Yakima Training Center form the basis for our understanding of species composition (Christy et al. 1995, Gitzen et al. 2002, Hagar et al. 2013, Barnett 2014). Based on net capture and acoustic monitoring data, 14 bat species occur within the CPE (Table 4). Seven species are considered species of conservation concern due to low relative abundance, perceived threats, or for which population viability is a concern (Table 4).

Buildings, bridges, mine adits and shafts, lava tubes, basalt cliffs, and riparian areas provide suitable bat habitat for roosting, maternity colonies, and hibernacula throughout the CPE (Hayes and Wiles 2013). Data from the Priority Habitats and Species Program in Washington report 54 maternity colonies, 54 roosting colonies, and three hibernacula within the CPE (WDFW 2021). Although the data do not represent a randomized sample, maternity colonies were more often reported in buildings (74%), roosts were mostly under bridges and in mines (78%), and two hibernacula were identified in a cave in Douglas County. The majority of reported features were in Okanagan County (44%, 49 features) and Lincoln County (23%, 25 features) in the northern portion of the CPE (WDFW 2021).

Bats migrate in diffuse movement patterns, which are influenced by their hibernating strategy; species that hibernate underground tend to migrate shorter distances than tree-roosting bats that occur aboveground year-round where temperatures are less stable (Cryan and Veilleux 2007). A small bat population in the CPE appears to reside year-round and does not migrate as evidenced by a small number (<2%) of the 1,512 records of bat occurrence data in disparate locations throughout Washington collected in winter (WDFW 2021). Of the 14 bat species known to occur within the CPE, hoary bat and silver-haired bat are tree and leaf roosting species that undergo long-distance migration and typically do not occur in the CPE in winter (Cryan 2003). First detected in the eastern US in 2006, white-nose syndrome (WNS) — caused by a highly lethal fungus (*Pseudogymnoascus destructans*) — was first detected in Washington in 2016 and within the CPE (Kittitas County) in 2018 and Chelan and Yakima counties in 2020 (WNS Response Team 2021). Severe impacts to populations (i.e., >90% mortality), particularly for species that form large hibernacula, have been recorded in 27 states and two Canadian provinces

(Cheng et al. 2021). Six species (43%) that occur within the CPE have symptomatic, lethal responses to the fungus, of which two species are considered species with conservation status (Table 4).

Table 4. Bat species known to occur within the Columbia Plateau Ecoregion and response to white-nose syndrome.

Common Name	Scientific Name	Status (BLM; State)[1]	WNS Response[2]
big brown bat	*Eptesicus fuscus*	-- ; --	S
California myotis	*Myotis californicus*	-- ; --	--
canyon bat	*Parastrellus hesperus*	-- ; --	--
fringed myotis	*Myotis thysanodes*	OR-SEN ; --	S
hoary bat	*Lasiurus cinereus*	-- ; OR-SEN	--
little brown bat	*Myotis lucifugus*	WA-SEN ; --	S
long-legged myotis	*Myotis volans*	-- ; --	S
pallid bat	*Antrozous pallidus*	OR-SEN ; OR-SEN	--
silver-haired bat	*Lasionycteris noctivagans*	-- ; OR-SEN	D, AS
spotted bat	*Euderma maculatum*	OR-SEN ; OR-SEN	--
Townsend's big-eared bat	*Corynorhinus townsendii*	OR-SEN ; OR-CRI, WA-CAN	D, AS
western long-eared myotis	*Myotis evotis*	-- ; --	S
western small-footed myotis	*Myotis ciliolabrum*	-- ; --	D, AS
Yuma myotis	*Myotis yumanensis*	-- ; --	S

1. OR-CRI: Oregon Critical, OR-SEN: Oregon Sensitive, WA-CAN: Washington Candidate, WA-SEN: Washington Sensitive; -- ; -- = no federal or state status.

2. S = Symptomatic, lethal response; D, AS = Fungus detected, asymptomatic response; -- = No current documented response to WNS.

Source: Hayes and Wiles (2013), ISSSSP (2021), ODFW (2021), WDFW (2021), WNS Response Team (2021).

The most comprehensive bat population sampling effort applicable to the CPE consisted of the Bat Grid interagency bat-monitoring program conducted form 2003−2010 at 241 sample sites throughout Oregon and Washington (Ormsbee et al. 2006; Hayes et al. 2009; Rodhouse et al. 2012, 2015). Researchers used forest cover, elevation, precipitation and topographic roughness to model the probability of species occurrence on the landscape (occupancy probability; Rodhouse et al. 2015). Multi-year occupancy models and the inherent changing occupancy probabilities not only reflect changes in bat species distribution but also reflect the underlying latent changes in population size (Rodhouse et al. 2019). Two measures of population variability were modeled as *trend*, which was the estimated total proportional change in the probability of occurrence 2003−2010, and *turnover,* which was the estimated probabilities a previously unoccupied sample site would become occupied. The occupancy probabilities were modeled for 11 of the 14 bat species known to occur within the CPE (Appendix F5). Townsend's bat, spotted bat and pallid bat were encountered so infrequently that predictive maps could not be generated. Percent forest cover was the strongest predictor of bat occupancy. Occupancy patterns were distinctly higher outside the CPE for leaf and tree roosting bats that include long-legged myotis, long-eared myotis silver-haired bat, and little brown bat (Appendix F5). Of the 11 species modeled, fringed myotis was the only species that exhibited declining occurrence probability with reliable precision (Rodhouse et al. 2015). Measures of net trend over the eight year study period resulted in flat or slightly positive trends (~1 or >1) among most species; yearly trends provided similar evidence but had low precision. Exceptions included the high but imprecise positive trend for the canyon bat and positive trends for the long-eared myotis and hoary bat. Turnover was also low among many species but variable. The lowest and most precise estimates were for long-eared myotis, little brown myotis, small-footed myotis, Yuma myotis and big brown bat. Turnover was comparatively lower for cliff and cave roosting species than migratory species (silver-haired bat, hoary bat), presumably because of higher site fidelity and the security of cave and cliff roosts.

When restricted to the CPE, mean predicted occupancy probabilities ranged from 0.18−0.93 (Figure 7). The unique physical characteristics of the CPE relative to the surrounding regions resulted in distinct occupancy patterns, particularly for arid-land species that include small-footed bat and canyon bat. The relatively homogenous landscape characteristics of the CPE (e.g., low % forest cover, low precipitation and even topographic roughness) resulted in a uniform distribution of predicted occupancy across the CPE (Appendix F5). However, there were distinct patterns in summertime occupancy for some species with unique habitat requirements. For example, canyon bats had a higher likelihood to occur along the steep cliffs adjacent to the Deschutes and John Day rivers in Oregon and Grand Coulee and Columbia River in Washington, whereas long-eared myotis were predicted to occur more often in higher elevations, away from major drainages (Appendix F5). Identification of habitat requirements for bats on the landscape can assist in predicting the likelihood of occupancy for bats, particularly for species associated with niche features that include cliffs, waters, or forests.

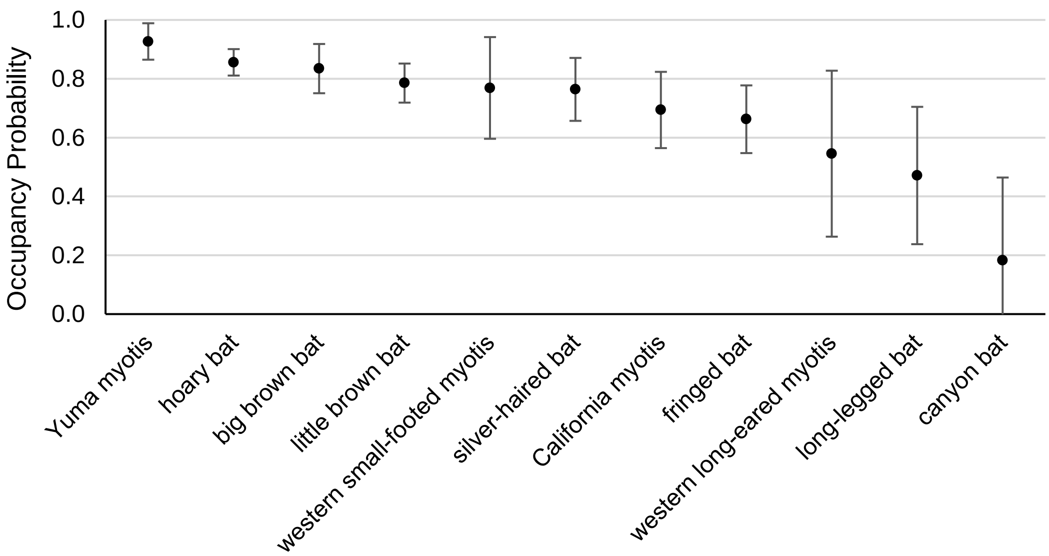

Figure 7. Mean predicted occupancy probability of bats during summer within the Columbia Plateau Ecoregion, 2010, conditioned on occurrence states 2003-2009. Variation expressed as the standard deviation of the sample mean. Data derived from Rodhouse et al. (2015).

Following the arrival of WNS and expanded wind energy development in the Pacific Northwest, Rodhouse et al. (2019) modeled little brown bat and hoary bat occupancy probabilities with additional data collected form 2016−2018 at 190 sample sites using the same Bat Grid methodology as Rodhouse (2015). Rodhouse et al. (2019) updated analysis found evidence of region-wide summertime decline for the hoary bat ($\hat{\lambda}$=0.86 ± 0.10) since 2010, but no evidence of decline for the little brown bat ($\hat{\lambda}$=1.1 ± 0.10).

Concurrent with Rodhouse et al.'s regional efforts in the Pacific Northwest, Loab et al. (2015) developed a continent-wide program (NABat; Program) to monitor bat distributions and indices of abundance at range wide, regional, and local scales in response to the decimating effects of WNS, on-going threats, and uncertainty of bat population sizes. The general approach of the Program is to conduct systematic-random monitoring of bats over a broad geographic area to document species occurrence and derive population estimates or trends in abundance. The sample framework is a grid-based approach similar to Ormsbee et al. (2006), with a number of sample grids located within the CPE. The number of projects contributing to the Program has exponentially increased since 2019; however, no population estimates are currently available for the CPE or Pacific Northwest.

2.2 Renewable Energy Development

This section characterizes past, current and future wind and USSE development within the CPE. Discussion of past and future characteristics provide context to current conditions, where applicable. The effects of renewable energy development in context with other biological resources are briefly discussed here with greater detail in Sections 4 and 5.

2.2.1 Wind Energy Development

The CPE is the Pacific Northwest's leading producer of wind energy in the tri-state area of Oregon, Washington, and Idaho. As of December 2021, there were 65 operational wind energy projects (includes phases) in the CPE with an estimated 6,757 MW of installed nameplate capacity, which represents approximately 83% (8,105 MW) of all wind energy capacity in the tri-state area (Figure 8; Oregon Department of Energy 2021, USGS 2021, WDFW 2021).

Since the installation of the first facility in 1998, the amount of development has varied over time, largely following the renewal of tax subsidies such as the Production Tax Credit (PTC; Figure 9; NWRC 2021). Spatially, early wind energy development focused on the Columbia River Gorge where wind energy resources and access to existing high-voltage transmission systems were readily available. Compared to the early boom of wind energy in the CPE from 1999−2009, which saw a 113% average annual increase in installed capacity, the average annual rate of development between 2010−2020 was 6% (22-year compound average growth of 29%; Figure 4). Post 2009, wind energy development has continued to consolidate in the form of in-fill projects that use existing land leases and infrastructure to add additional capacity to areas where wind energy is already present, repowering projects to modernize outdated turbine technologies, or have expanded to other portions of the CPE.

Wind energy siting considers the wind energy resource, land ownership, transmission, and energy needs, among other factors (Christol et al. 2021). Numerous federal and state wind energy guidance documents have been developed to assist in the assessment of biological resources (ODFW 2008; WDFW 2009; USFWS 2012, 2013). Unsurprisingly, there is a high correspondence between wind resources and wind energy development within the CPE. In the CPE, high quality wind resources are restricted to particular geographic regions that are typically higher elevation with prevailing winds such as found in the Columbia River Gorge, Oregon, and Kittitas Valley and Snake River foothills, Washington, for example (Figure 10). All operational or proposed wind energy projects are located in areas with average annual wind speeds ≥ 6 m/sec as measured 100 m above ground level. In areas of high wind speeds, development typically occurs on private lands because of the comparatively less complex permitting process than federal and state lands. The distance to and availability of electrical transmission is a major consideration, particularly for smaller projects that do not have the economy of scale to construct new transmission, which has been estimated at over $1,000,000 per mile, even for lower voltage classes (i.e., 69 kV; MISO Energy 2019, Desantis et al. 2021). Power purchase agreements with electrical utilities also guide the siting process; a down-stream power consumer and utility must be established to make any renewable energy project viable. We assume future wind energy development within the CPE should generally follow the geographically constrained nature of high wind resources, leverage the existing infrastructure in the CPE, and expand to areas with viable wind resource potential if transmission becomes available (*see* Section 2.2.3).

The aging fleet of wind turbines installed in the early 2000's are nearing the limits of their operational life and will most likely be replaced or retrofitted with contemporary technology in a process called repowering. Repowering optimizes energy production, extends the operational lifetime and involves the replacement of entire turbines with new turbines or retrofitting the components on existing towers (i.e., the nacelle and rotors). Repowering may result in taller turbines with larger rotor diameters that occupy larger air space, but also reduces the total number of turbines due to the increased energy production and land use constraints (Kitzing et al. 2020). A number of repowering projects have already occurred or are currently underway (Shepherds Flat, Stateline and Vancycle) and repowering is expected to continue throughout the CPE.

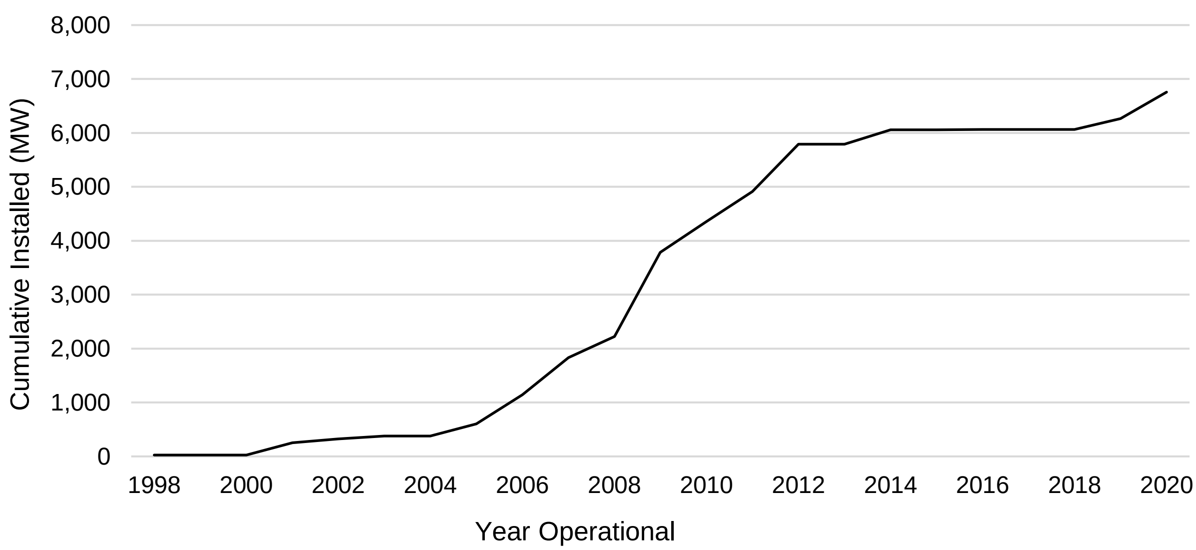

Figure 8. Cumulative installed wind energy (MW) per year within the Columbia Plateau Ecoregion, 1998−2020. Energy production represents the cumulative nominal nameplate capacity.

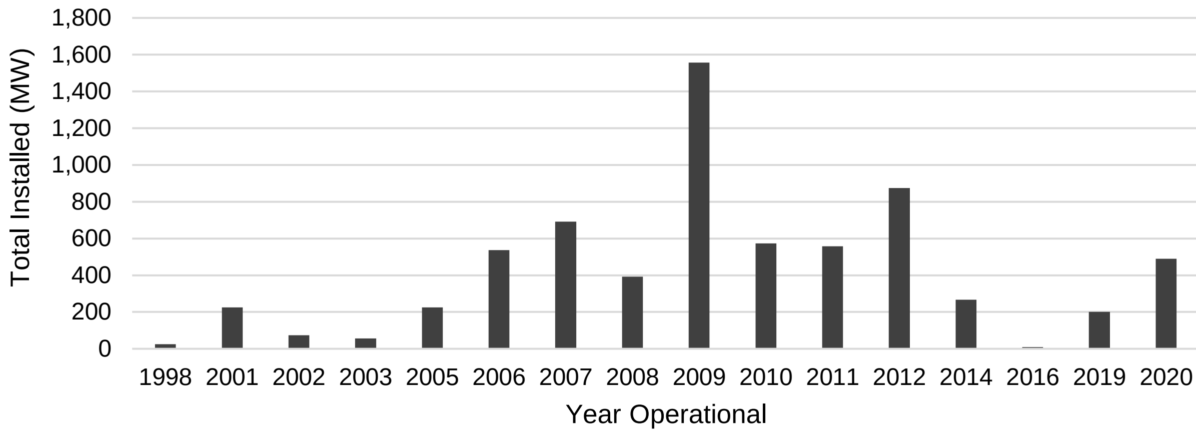

Figure 9. Total installed wind energy (MW) per year within the Columbia Plateau Ecoregion, 1998−2020. Energy production represents the total nominal nameplate capacity.

Photo 7. Operational wind energy turbines in eastern Klickitat County, Washington, May 2020.

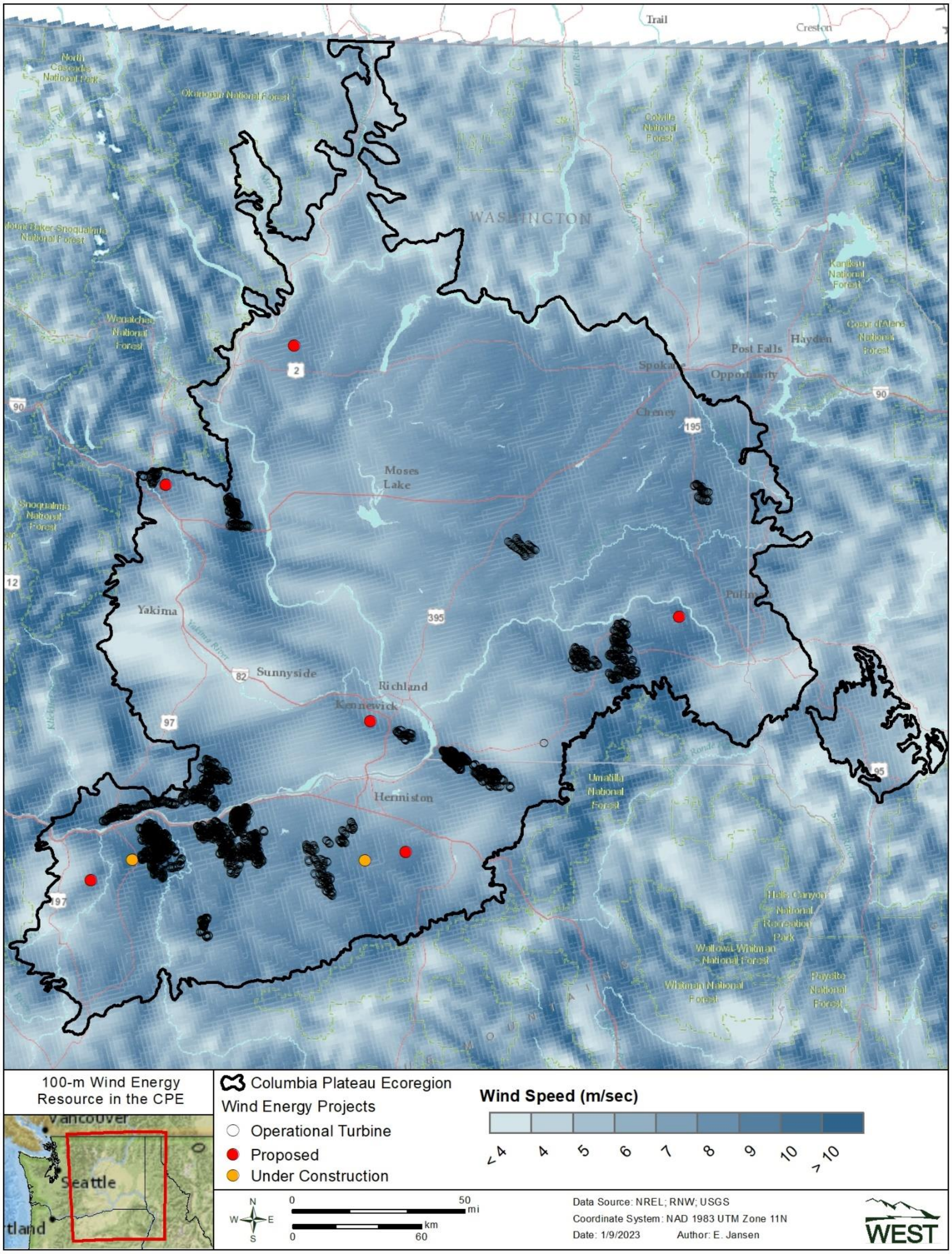

Figure 10. Wind energy projects and average annual wind speed at 100 m above ground level within the Columbia Plateau Ecoregion.

2.2.2 Solar Energy Development

The majority of installed USSE in Oregon and Washington was located outside the CPE; development of USSE in the CPE has been recent compared to wind energy development. Solar development in the CPE began in 2016 with the installation of the 1.3 MW Moyer-Tolles Solar Station by the Umatilla Electric Cooperative. Development remained relatively stagnant for the next three years until 2020 when the amount of installed or proposed capacity increased from 236 MW to 3,603 MW planned through 2025[7] (Figure 11). Of the 48 USSE projects in the CPE, five were operational, nine were approved or under construction, and 34 were proposed as of December 2020. The range of installed or proposed project capacity is high (1.3−500 MW, average = 94 ± 119 MW) although projections included in permit applications do not always result in the eventual installed capacity. Modifications to project capacity after the permit application has been submitted results from a number of factors including engineering, environmental, and financial.

Absent federal or state-specific USSE siting guidelines for the CPE, solar siting currently relies on the procedures and guidance described in the aforementioned wind energy siting guidelines. Siting considerations for USSE differ from the issues posed by wind energy development and focus more on impacts to land cover and land use because of the design of USSE that consolidates development on blocks of land (Bolinger and Bolinger 2022). The tracking panels commonly used in the CPE have a lower power production per acre (0.18 MW/ac) compared to fixed panels (0.28 MW/ac) because of the wider space needed between rows to avoid self-shading (Bolinger and Bolinger 2022). The most productive solar resources, as measured by the average annual solar potential (kW hrs/kW potential), are located in the western third of the CPE; however, solar resources are more uniform through the CPE compared to wind resources, resulting in greater flexibility in siting options (Figure 12). The capacity of USSE typically requires development closer to existing transmission lines (i.e., ≤ 2 mi) unless the scale of the project allows the construction of new transmission. For example the scale of the proposed 500 MW Wagon Trail Solar Project allows the construction of a new eight mile 230-kV transmission line, whereas smaller projects like Goose Prairie Solar (80 MW) and Quincy Solar (120 MW) are directly underneath existing transmission. We assume future USSE development will generally align with the existing and proposed transmission infrastructure within the broad area of solar resource potential within the CPE.

[7] Includes 26 projects for which data were available and should be interpreted as a minimum estimate

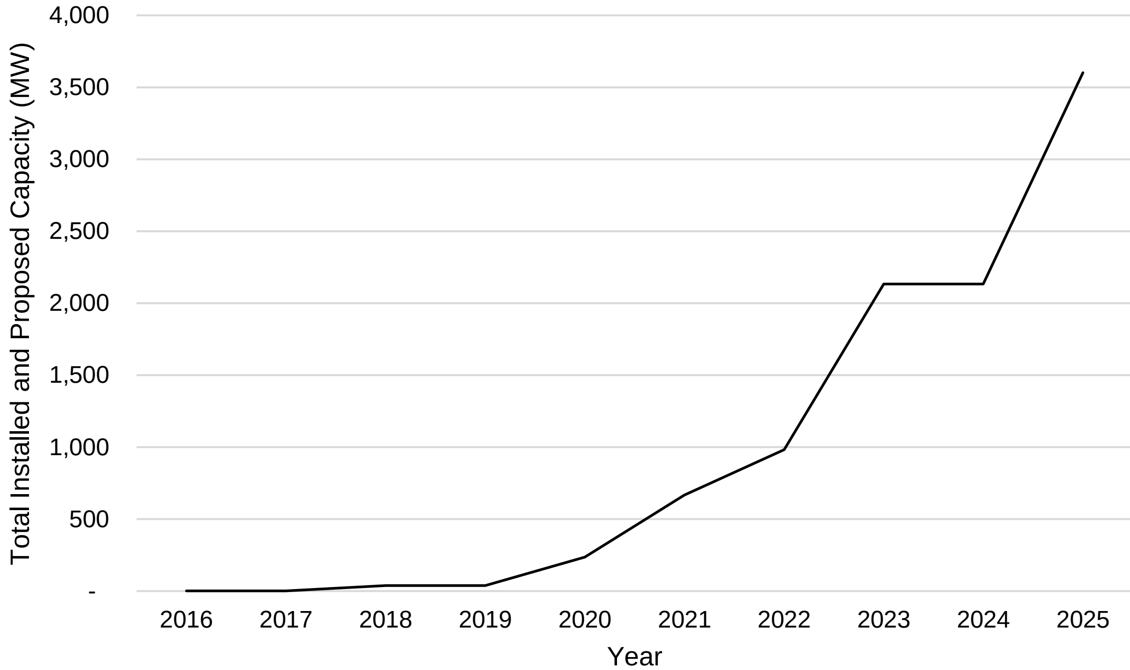

Figure 11. Cumulative installed and proposed USSE projects within the CPE.

Photo 8. An example of a newly constructed USSE facility co-located with wind energy in dryland wheat agriculture, Sherman County, Oregon, March 2022.

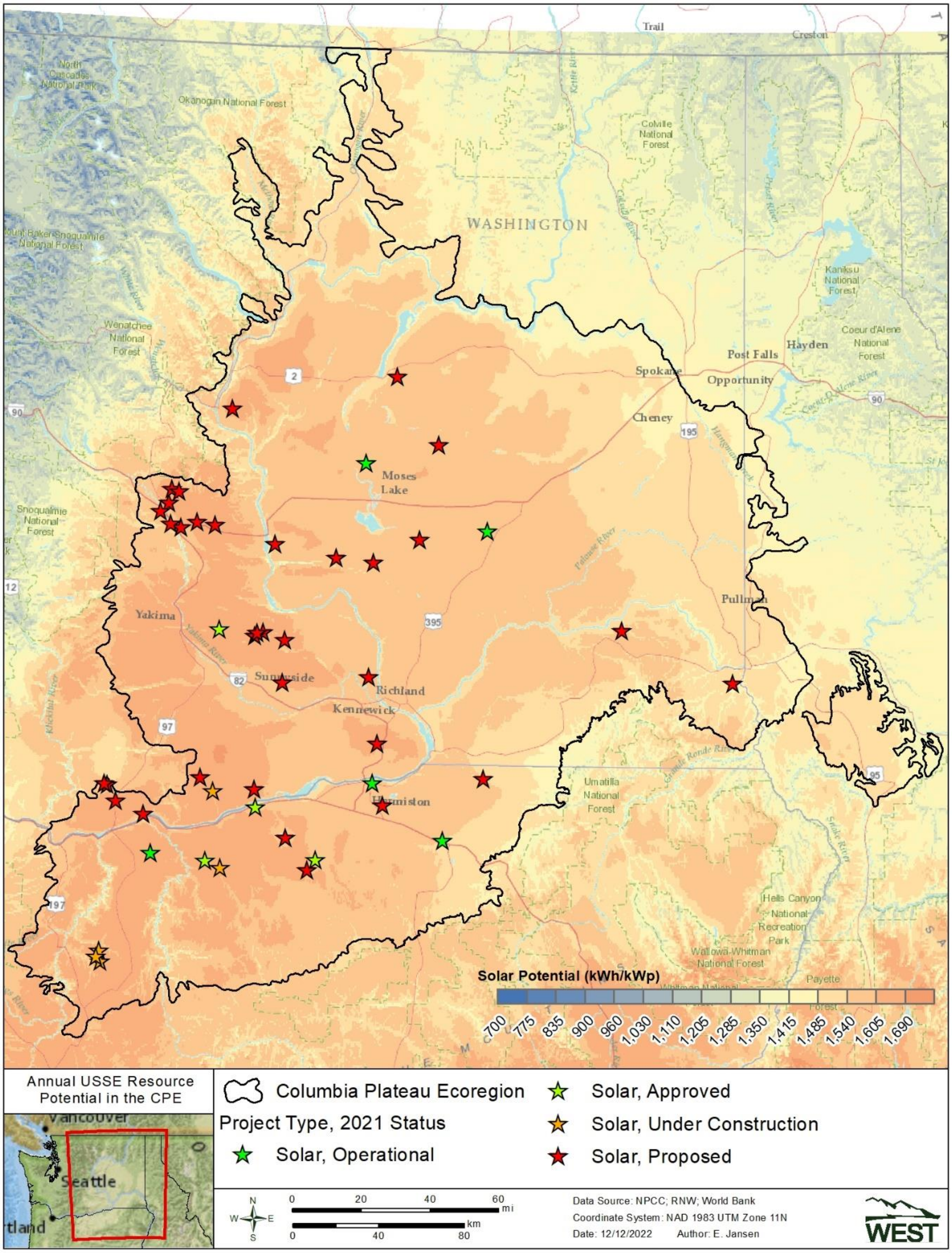

Figure 12. Average annual USSE power potential, 1999−2018 (World Bank 2020). Potential is calculated as kW produced per hour divided by annual kW produced at peak performance.

Photo 9. Construction of a USSE project in Morrow County, Oregon, March 2022. Visible infrastructure includes access roads, PV panels, posts, and associated electrical infrastructure.

2.2.3 Projected Scenario of Installed Capacity

The 2021 Northwest Power Plan (NPP) provides the most comprehensive analysis of current and future renewable energy scenarios over the next two decades (Northwest Power and Conservation Council [NPCC] 2021). The NPP models integrate technological, economic, social and political drivers that forecast various renewable energy development scenarios at multiple scales including the WECC and the NPP Region located primarily in Oregon, Washington, Idaho and Montana (Region; Appendix F3). The Region is defined as all areas within the Columbia River Basin plus areas outside the Basin where BPA is able to sell power (NPCC 2021). Located within the Region, the CPE is part of a broader decentralized electrical grid that exchanges power throughout the WECC and between subregions with local utilities that require unique resource potential and seasonal demands (Appendix F3). Accordingly, forecasted estimates of installed capacity within the CPE will respond to the regional trends and the WECC. Aside from policy initiatives, the most influential factors affecting renewable development in the CPE include the retirement of coal-fired power plants and the elimination of new natural-gas-fired generation from the fleet of available resources in the Region (NPCC 2021).

This assessment used three models from the NPP as a basis for comparison to forecast a range of reasonably foreseeable scenarios of installed capacity within the CPE, 1) Baseline, 2) Early

Coal Retirement, and 3) Early Coal Retirement – No New Natural Gas. Each scenario has a wide array of assumptions[8] that introduce uncertainty and are not intended to represent a particular forecast of an expected future (NPCC 2021). However, in the context of this assessment, the range of installed capacity described by the scenarios provided the sideboards for estimating cumulative impacts.

- Baseline: Develops the foundation from which subsequent scenarios are modeled. The baseline does not assume business as usual, rather, the baseline is responsive to meet renewable energy policy objectives, assumes increases in energy efficiency, affects from climate change on river flows for hydropower generation, and alignment with the expected retirement schedule[9] for regional coal plants, among other factors. The NPP recommends a minimum of 3.5 GW of new renewable generation by 2027 as a cost-effective option for meeting demand and policy objectives (NPCC 2021).
- Early Coal Retirement: Assumes an advanced retirement schedule for coal fired plants within the Region. Early retirement of 13 coal plants in the Region by 2026 will create a deficit of 7.43 GW of capacity (NPCC 2021). Greenhouse emissions will be reduced by 80% in the Region and 40% throughout the WECC; the discrepancy related to the strong hydrological power system that supports the Region compared to other parts of the WECC. Without limiting the types of new generation, approximately 1,400 MW of new natural-gas-fired generation is expected in the Region by 2030 (NPCC 2021). The proportion of wind to solar development is similar to the baseline but due to the lower nameplate capability compared to coal-fired generation, renewable development proceeds at an accelerated rate over the next decade (Figure 13).
- Early Coal Retirement – No New Natural Gas: Assumes similar conditions in the previous scenario but excludes the development of new natural gas-fired generation in the Region. Considering the decisions that would lead to early coal retirement, it seems unlikely that new natural-gas-fired generation would be considered for replacing retired coal generation (NPCC 2021). By eliminating new natural-gas-fired generation from consideration, the expected renewable-energy addition in the Region substantially increases (Figure 13). Conversely, removing limits to new natural gas generation would substantially reduce the need for renewable energy to supplement the demand; however, policy objectives would not be met.

The NPP scenarios estimated between 8.2 GW and 12.3 GW of new renewable energy capacity within the Region by 2030 (Figure 13). The extreme complexity of long-term forecasting and the associated uncertainty resulted in a simplification for the purposes of this assessment. NPP models and electrical utilities function at much larger geographic scales than the CPE; therefore,

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8 Nearly every facet of the supply and demand chain of power generation was modeled in the NPP; from energy efficiency and demand responses, fluctuating energy prices, population changes, greenhouse gas parameters, climate change considerations, to social costs of carbon, each factor having a different effect on the scenario. Readers are directed to the 2021 NPP and supplemental material for a comprehensive description of each scenario, which is beyond the scope of this assessment.

9 As defined as the announced retirement date or end-of-useful life dates used in utility Integrated Resource Plans.

to simplify the application and interpretation, this assessment considered a development scenario of 10 GW in the CPE by 2030 (Figure 13). This assessment addressed uncertainty in which types of technology will be used to achieve the 10 GW scenario using two models to derive the percent of new capacity expected from wind and USSE in the CPE.

- *Model 1*: Considering the Early Coal Retirement scenario, total new installed capacity was calculated WECC-wide for wind energy and USSE by 2030. Of the 370.9 GW of new capacity in the WECC, approximately 156.5 GW (42%) will be from wind energy and 214.4 GW (58%) will be from USSE (Table 5).
- *Model 2*: Preferred portfolio objectives from Integrated Resource Plans[10] of five major regional utilities were used to calculate Regional new capacity expected from wind and USSE sources by 2030. Utility IRP's forecast approximately 11.7 GW of new resource additions, of which approximately 7.2 GW (62%) will be from wind energy and 4.5 GW (38%) from USSE (Table 5).

Table 5. The proportion of new wind and USSE capacity used to estimate the range of potential development outcomes in the CPE by 2030. The balance of this estimate was used to generalize productive estimates.

Model	Data Source	Scale	Total (GW)	% Wind	% USSE
1	NPP Early Coal Retirement	WECC	370.9	42	58
2	Utility IRP*	Region	11.7	62	38

* IRP = Integrated Resource Plan. See footnote [10]

Models illustrate a regional difference in the level of wind energy development versus USSE; likely influenced by the strong solar resources found in the arid southwest region of the WECC. Nevertheless, this assessment considered a range of scenarios to account for uncertainty that included 40% new USSE and 60% new wind energy development and vice versa to achieve 10 GW of new generating capacity. Assuming a current wind generating capacity of 6,757 MW, future nominal installed capacity would be 10,757 MW and 12,757 MW, for the 40% and 60% scenarios, respectively.

[10] 2021 IRPs from Avista Corporation, Idaho Power, PacifiCorp, Portland Gas & Electric, and Puget Sound Energy were referenced and can be found on their corporate websites. Analysis excluded battery storage technology, for consistency.

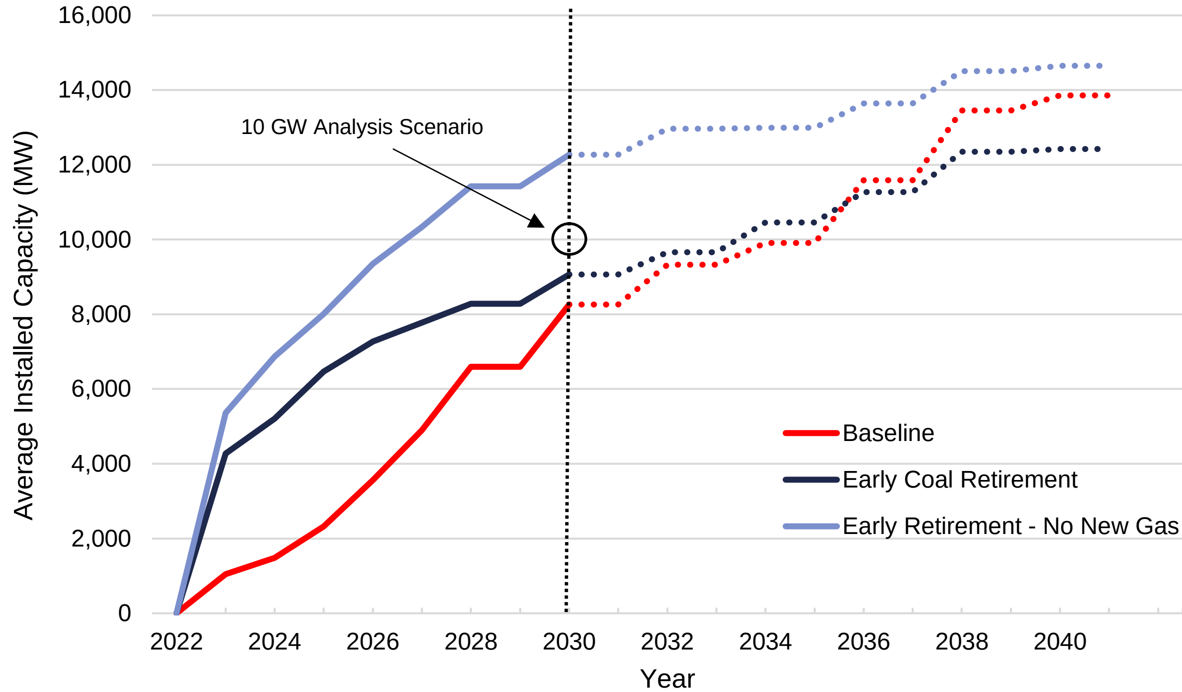

Figure 13. Forecasted new renewable energy generation scenarios within the NPP Region through 2030 and beyond.

2.2.3.1 Transmission

To meet renewable energy policies, the construction of new electrical systems and system upgrades will form the backbone of the expanding renewable energy demand. In response, electrical utilities are undertaking a number of projects throughout the CPE to accommodate the expansion or upgrade of all voltage classes and related infrastructure (substations). In 2022, BPA identified 116 requests for transmission totaling 5,842 MW of capacity, mainly from proposed solar and wind energy projects in the CPE that would require $845 million in system upgrades (Harrison 2022). The 290 mi 500-kV Boardman to Hemingway Transmission Line Project will increase the transmission capacity by one gigawatt between eastern Oregon and Idaho and is scheduled for service in 2026. The 100 mi Cascade Renewable Transmission Project will increase the transmission capacity by 1.1 GW, linking the renewable energy sources in the CPE to load centers in Portland, Oregon via a submarine cable trenched into the Columbia River and is scheduled for service in 2026. BPA's Tri-cities Reinforcement Project will include a number of new 115-kV lines, substations, and system upgrades from 2022−2025 that will increase transmission capacity by 1.75 gigawatts and provide reliability in the Kennewick, Pasco, and Richland area. Public utility district's pursue distribution and sub-distribution projects to maintain and expand electrical services to the growing population within the CPE. The expanding application of battery storage and pumped storage (i.e., non-wire alternatives) will play an emerging role to balance distribution during off-peak time and supplement traditional renewable energy sources. Strategic use and placement of battery storage can optimize a constrained transmission system, eliminate the need for new transmission, and increase overall renewable capacity (NPCC 2021).

3 METHODS

For wind energy development, this assessment provided a qualitative analysis of post-construction fatality monitoring (PCFM) studies, estimated bird populations, and published literature of existing sources of mortality to compile a cumulative impact assessment of bird and bat populations. The general approach was to summarize fatality monitoring studies at operational wind energy facilities within the CPE, and use those results to estimate impacts for a projected 4–6 GW of additional wind energy development within the same ecoregion. Impacts from wind energy development were placed in context with other sources of bird and bat mortality.

For USSE development, this assessment assumed a land-based modeling framework that developed a spatially explicit model that quantified the underlying land cover and biological resources in areas where development may occur in the future. The general approach was to summarize potential resources affected assuming a projected 4–6 GW of additional USSE development. This assessment used a land-based approach due to the limited publicly available data on bird and bat fatalities at USSE.

3.1 Wind Energy Development

3.1.1 Fatality Estimates from Post-construction Fatality Monitoring (PCFM)

The foundation of this cumulative impact assessment was to quantify bird and bat fatalities documented at wind energy facilities within the CPE. Prior to analyses, state wildlife agencies, county planning departments and state permitting councils were contacted to obtain all publicly available PCFM studies. All details of the project (number and specification of turbines), study area (primary habitat types), species counts, and fatality estimates of primary groups (all birds [excluding raptors], raptors, and bats) were entered into a relational database that contained PCFM data throughout the US to facilitate comparisons of wind mortality within the CPE to broader geographic scales (WEST 2021). A *project* was defined as a facility that was permitted or developed as a unique entity; separate phases were considered separate projects (e.g., Biglow Canyon I, II, and III represent three separate projects). A *study* was defined as a survey period when PCFM was reported and traditionally consisted of one full year (four seasons) of data collection. *Seasons* were defined as spring (March – May), summer (June – August), fall (September – November), and winter (December – February). Data as reported in the original study were used without modification or reanalysis. Caveats reflecting the statistical robustness of each study are presented in Appendix T2.

The average annual fatality rate per MW (fatalities/MW/study period) was calculated by group. Estimates on a per-MW scale facilitated comparisons across projects with wind turbines that have varying dimensions. Fatality estimates were reported for primary groups including All Birds, Raptors (including Diurnal Raptors, Owls and Vulture groups), and Bats. The All Bird group was divided further into similar phylogenetic groupings (e.g., Passerines, Waterbirds, Shorebirds) to calculate species composition and temporal patterns of fatalities.

3.1.2 Bird Population Estimates

To define the bird population within the CPE, the assessment used BBS data collected from 2006−2015 within the Great Basin BCR 9 and the Partners in Flight approach (PIF; Will et al. 2020). The PIF Population Estimate Database (PED) represents the most recent analysis of BBS data available for the region and substantially improved previous versions (Blancher et al. 2007) to incorporate confidence intervals that address uncertainty, adjustments to account for detection probability, and incorporate adjustments for time-of-day and groups of birds (Will et al. 2020). Estimates from the PIF PED represent the most statistically rigorous estimates of bird populations within North America and were used in all analyses unless otherwise noted.

The PIF's population estimation methodology was designed to provide a consistent approach across all landbird species and across the Great Basin BCR and subregions. Thus the PED breeding season estimates provide regional context for environmental impact assessments, assessments of population vulnerability and resiliency, and the cumulative effects of various sources of mortality on bird populations (Will et al. 2020). To provide additional context, this assessment used BBS population trend estimates (percent annual change, 2006–2019), associated confidence intervals, and measures of regional credibility to further inform bird population trends and the potential effects of cumulative impacts (Thomas and Martin 1996; Appendix T5).

PIF population estimates used species counts collected from 2006−2015 along 147 BBS routes within the Great Basin BCR 9 of Idaho, Oregon and Washington (Physio-political Region). Using these data to represent the total breeding population of the Tri-state area, this assessment extracted population estimates from the PIF PED by Physio-political Region to obtain a population estimate within the BCR by state. Bird populations within the CPE were calculated as a proportion of area located within the Great Basin BCR 9 (Table 6, Figure 14). Unrounded population estimates within each Physio-political Region were multiplied by the percentage of CPE located within the Great Basin BCR 9, then summed to derive a single population estimate for 172 bird species (Table 6; Appendix T5). Using this reductive, proportional approach, confidence intervals calculated in the PIF PED for the entire Great Basin BCR were not applicable to the CPE population estimates. An example using American kestrel (*Falco sparverius*) is calculated in Table 7.

Birds were divided into two primary groups that included an All Bird group (excluding raptors) and a separate Raptor group to identify possible relative cumulative impacts to bird species. Groups were differentiated to distinguish between the variable resilience to stressors on a population in groups that include shorter-lived species with high biological productivity (e.g., passerines; r-selected species) and longer-lived species with low biological productivity (e.g., raptors; K-selected species) that may be more susceptible to changes in populations from environmental or demographic stressors (Parry 1981). Because of their conservation concern, bird species characterized as sensitive were evaluated in greater detail to identify potential issues of cumulative impacts from wind energy development (Appendix T1).

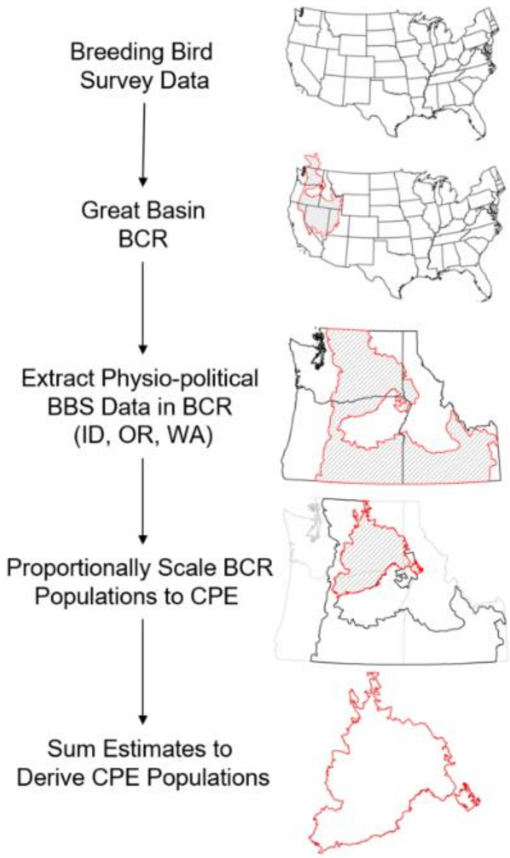

Figure 14. Geographic scales used to derive bird population data in the CPE.

Despite the robust modeling framework on which the PIF PED and BBS was built, this assessment acknowledges a number of important limitations identified during the application of this methodology.

- Bird population abundance was uniform throughout the Great Basin BCR and each corresponding Physio-political Area.
- Species' population estimates were based on BBS data collected during the breeding season at a time of year when some migratory species may not be present. Impacts to species that migrate thought the CPE may not represent the local population found in the CPE.
- Species abundance may be so low that population estimates were unavailable despite on-going conservation concern.

To address these uncertainties, population data for a sensitive species that were unavailable or noted as deficient in the PIF PED were queried through alternative sources. Other sources included technical species assessments, abundance and population tends to evaluate potential effects of cumulative impacts (USFWS 2016, eBird 2021). Data requested from the USFWS for CPE-specific information on golden eagle and bald eagle mortality was unavailable at the time of writing; therefore, data regarding eagle mortality and population sizes in the CPE were derived from USFWS (2016, 2019, 2022).

Table 6. Percent of Columbia Plateau Ecoregion Level III within the Great Basin Bird Conservation Region 9.

State	Area of CPE by State (ac)	Area of Great Basin by State (ac)[1]	State-specific % of CPE in GB
Idaho	945,584	27,307,900	3.46
Oregon	4,370,940	28,552,400	15.31
Washington	15,226,200	24,525,800	62.08

[1] Physio-political Region.

Table 7. Example population estimate of American kestrel within the Columbia Plateau Ecoregion, derived from Great Basin BCR Population Estimates within each Physio-political Region (Will et al. 2020)

State	GB Pop. Estimate	Lower 95%	Upper 95%	% of CPE in GB	Pop. in CPE by State[1]
Idaho	91,115	47,954	161,624	3.46	3,155
Oregon	73,959	35,355	131,624	15.31	11,322
Washington	55,126	28,123	95,453	62.08	34,223
				Total Population in CPE	**48,700**

[1.] Example population estimate reflects minor rounding errors. For example, as expressed, Idaho was 91,115 × 0.346 = 3,152 birds.

Current and projected annual bird mortality from wind turbines were derived from publicly available PCFM data and future wind energy scenarios. First, to estimate the number of annual fatalities in each primary group, the average annual fatality rate by group was multiplied by the total nominal generating capacity (MW) for each development scenario. Second, the total number of individuals by species documented during PCFM was divided by the total number of individuals per group to estimate the percent composition of each species. Finally, total annual mortality by group or species was estimated by multiplying the percent species composition by the predicted generating capacity for each development scenario.

The potential for cumulative effects to occur for a particular group or species was evaluated by calculating the proportion of the CPE population affected by turbine mortality, considered BBS population trend indices (Appendix T5) and life history traits for a particular species (e.g., r-selected versus K-selected). For example, sustained population-level impacts resulting from 10% annual mortality in a population of 10,000 red-tailed hawks (*Buteo jamaicensis*) was more likely than 10% mortality in a population of 10,000 yellow warblers (*Setophaga petechia*).

3.1.3 Bat Population Estimates

Bat populations continue to be a difficult group to estimate reliable population sizes (O'Shea and Bogan 2003). No reliable population estimates were available in the western US that can be reduced to a regional scale, similar to the methodology used to estimate bird populations in the CPE. Absent reliable bat population data in the western US, impacts to bat populations from wind energy operation were quantified from post-construction fatality studies and compared to other sources of bat mortality.

3.2 Solar Energy Development

Areas of USSE development and the associated impacted land cover and biological resources were developed using areas of USSE potential and land use constraints. A Geographic Information System (ArcMap 10.7.1, Redlands, California) was used for all aspects of the model framework. A number of USSE developers operating in the CPE were contacted prior to data collection to identify primary constraints considered during USSE siting. Combined with their feedback, exclusionary criteria identified in BLM and DOE (2010) were used to develop a constraints layer.

The spatially explicit model used a hierarchical approach that first identified areas where USSE development was mostly likely based on the existing electrical transmission grid. Proximity to transmission lines and substations is a limiting factor in USSE development and projects are typically sited as close as possible to reduce the amount of new transmission construction. All transmission lines, regardless of voltage, were buffered by a 2-mi radius (potential development area; PDA). After the PDA was created, areas where USSE development was unlikely were excluded based on a variety of bio-physical and human-built constraints. Bio-physical constraints included topography greater than 10% slope and perennial water features including lakes and freshwater ponds. Human-built constraints included lands managed by federal agencies, non-governmental organizations, First Nations, and delineated as urban growth boundaries (Table 8; Appendix F6).

The remaining areas in the PDA considered the USSE development corridor (corridor) were quantified and included land cover and biological resources (Figure 15). Land cover included NLCD land cover types and USFWS wetlands; biological resources included federal or state-listed or sensitive wildlife, plant, or high-value plant communities tracked by state Natural Heritage Programs (NHP) and Audubon IBAs (Table 8). The NHP species with a greater number of records in the corridor were analyzed for species-specific affects and spatial patterns. In addition, potential overlap with habitat concentration areas (HCA) and least cost pathways (LCP) between HCAs were evaluated for two focal species that require large areas of habitat, Rocky Mountain mule deer (*Odocoileus hemionus hemionus*; mule deer) and greater sage-grouse (*Centrocercus urophasianus*; sage-grouse; Appendix F6). Modeled specifically for the CPE, HCAs were defined as significant habitat areas that are expected or known to be important for focal species based on survey data or habitat association modeling, and LCPs were defined as optimal connectivity corridors between HCAs with the least resistance to movement (Washington Wildlife Habitat Connectivity Working Group [WHCWG] 2012). Focal species represented a highly mobile species that can move long distances between summer and winter ranges (mule deer) and a sagebrush obligate species with isolated sub-populations that rely on connectivity for genetic intermixing and population viability (sage-grouse).

The proportion of an area or number of biological resources within a corridor was compared with resources outside the corridor. Resources were mapped and quantified to provide an indication of resources most likely to be impacted by USSE. Adjusted for area, the relative proportion of a resource within the corridor compared to outside the corridor was used as a metric to identify resources that may be more at risk of impacts from USSE development. A resource was identified as having a relatively disproportionate risk of impacts from USSE development by calculating the proportional difference between resources within and outside the corridor using an index called a vulnerability score. A vulnerability score (*V*) was calculated as,

$$V = \frac{a_i}{x} - \frac{a_o}{x}$$

where a_i was the amount (mi, mi^2, or #) of a particular resource inside the corridor divided by the total resource documented in the CPE (x) subtracted by the amount of the resource outside the corridor (a_o) divided by the total resource documented in the CPE (x). The difference of the proportions was interpreted as a vulnerability score on a scale of -1 to 1 where negative values represented resources with proportionally less resources located inside the corridor, values near zero indicated an equal proportion of resources within and outside the corridor, and positive values represented a higher proportion of resources within the corridor than the larger area of the CPE. For focal species, linear regression was used to identify the correlation between the vulnerability score and the total size/length of the HCA/LCP within the CPE.

Caveats to note when interpreting results include the sampling bias inherent with Natural Heritage Program data which often do not represent a systematic sample of the species range or habitats. Because a resource has not been recorded in a particular area does not necessarily mean it is absent and may rather result from a lack of survey effort. Similarly, the number of records of a species does not reflect the biological abundance of a species in a particular area, rather, records are used as a relative comparison of where a species was most often documented and proxy for occurrence absent more rigorous data of population abundance on a landscape scale. Issues with spatial accuracy and resolution can result in misrepresenting the geographic location of the resource. Spatial accuracy issues arise when records are plotted from written notes or coarse mapping, while resolution issues arise when the location of sensitive data are generalized (masked) for resource protection purposes. In Washington, spatial accuracy varied up to 0.25 mi and had fine resolution, while accuracy in Oregon varied up to 2.5 mi and had poor resolution. Because of the poor resolution in Oregon with an average spatial resolution of 10 ± 76 mi^2, Natural Heritage data were only analyzed for Washington Priority Habitat and Species (WDFW 2022). Finally, the ranges of some species are highly restricted (greater sage-grouse) and do not have an equal probability of occurring throughout the CPE; thus comparisons between the affected resource and habitat availability/resource occurrence outside the corridor should be interpreted with caution.

Table 8. Covariates used to model biological resources potentially affected by USSE development in the Columbia Plateau Ecoregion.

Covariate	Measurement Type	Description	Reference
Inclusion Layer			
Electrical Transmission	Area	All lands within 3 mi radius of all voltage types	Oak Ridge National Laboratory 2022
Exclusion Layers			
Slope	Percent	>10% average slope in 30×30 m DEM	Leu et al. 2008
Wetlands	Area	Perennial waters (lake, freshwater pond)	USFWS 2022
Ownership	Area	Federal, Non-governmental organization, First Nations	USGS 2022
Urban Areas	Area	Urban Growth Boundary	DLCD 2022, Washington GeoServices 2022
Resource Layers			
Land Cover	Area	All land cover types excluding Developed and Waters	NLCD 2019
Natural Heritage Data	Area, # Occurrence	Federal and state listed wildlife, plants, and vegetative communities	WDFW 2022
Rare Plant Locations	Area # Occurrence	Current rare and imperiled species and plant communities	WDNR 2022
Rock Mountain Mule Deer	Area, Length	Habitat Concentration Areas and Least Cost Path Linkages	WHCWG 2010
Greater Sage-grouse	Area, Length	Habitat Concentration Areas and Least Cost Path Linkages	WHCWG 2010
Important Bird Areas	Area	Global and State classifications	Audubon 2022
Wetlands	Area	All wetland types, excluding lakes and freshwater ponds	USFWS 2022

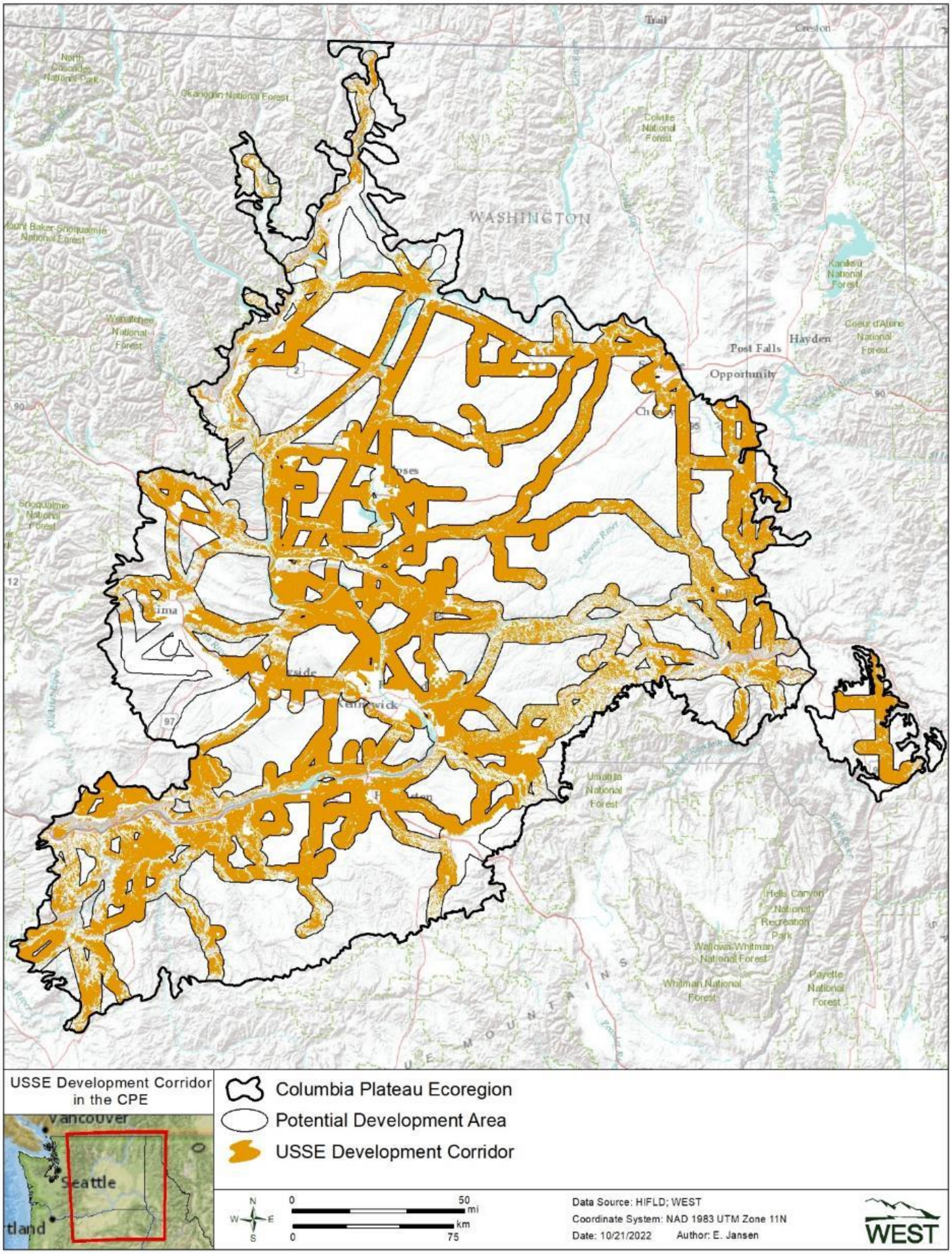

Figure 15. Corridor used to identify land cover and biological resources potentially affected by USSE development within the Columbia Plateau Ecoregion.

4 RESULTS

Of the 65 operating wind energy facilities in the CPE[11], 55 PCFM studies at 42 projects were used to calculate overall fatality estimates. Raptor fatalities were not reported in seven studies and were reported as zero in 10 studies (Appendix T2). Bat fatalities were reported in 48 PCFM studies at 37 projects. Collectively, PCFM data used in this assessment reflected a 120% increase of available studies and 61% increase of projects reporting bird and bat fatality estimates since Johnson and Erickson (2011). Fatality estimates from Nine Canyon II and Condon were not used due to the limited study period, as well as the absences of bias trials and use of a statistically meaningful estimator (Fishman Ecological Services 2003, Erickson et al. 2005). Statistical caveats inherent to PCFM studies used to calculate average annual fatalities are noted in Appendices T2 and T4.

4.1 Existing Data from Wind Energy Facilities

4.1.1 Overall Bird and Bat Fatality Estimates

The average All Bird (excluding raptors) fatality estimate was 2.57 birds/MW/year (0.16−8.45 ± 1.95 birds/MW/year). The average Raptor fatality estimate was 0.12 birds/MW/year (0.00−0.47 ± 0.12 birds/MW/year). Annual estimated Bat fatalities were 1.08 bats/MW/year (0.0−3.78 ± 0.12 bats/MW/year; Figure 16). Compared to Johnson and Erickson (2011), mean fatality rates for the All Bird group increased from 2.36 to 2.57 birds/MW/year (8.8%), increased from 0.08 to 0.12 birds/MW/year (50%) for the Raptor group, and decreased from 1.14 to 1.08 bats/MW/year (5.3%) for the Bat group. Based on the average fatality rate from PCFM studies conducted in the CPE from 1999−2020, current annual estimated bird and bat mortality from wind energy was 17,369 birds, 793 raptors, and 7,292 bats based on the installed nameplate capacity of 6,757 MW as of December 2021 (Table 9).

Table 9. Annual estimated bird and bat fatalities at wind energy facilities within the Columbia Plateau Ecoregion. Assumed operational capacity of 6,757 MW as of December 2021.

Group	Range	Median/MW	Mean/MW[1]	1st and 3rd Quartile of the Mean	Estimated Annual Fatalities
All Bird[2]	0.16−8.45	2.33	2.57	1.25−3.10	17,369
Raptor[3]	0.00−0.47	0.08	0.12	0.00−0.15	793
Bat	0.00−3.78	0.77	1.08	0.41−1.75	7,292

1. Summary statistics rounded for simplicity and consistency. For example, mean annual raptor fatalities was 0.11733 birds/MW/year. Use of 0.12 raptors/MW/year would result in 811 raptors/MW/year.
2. Excludes raptors
3. Included diurnal raptors, owls, and turkey vulture (*Cathartes aura*)

[11] As of December 2021 (Hoen et al. 2018 v. 4.2.0).

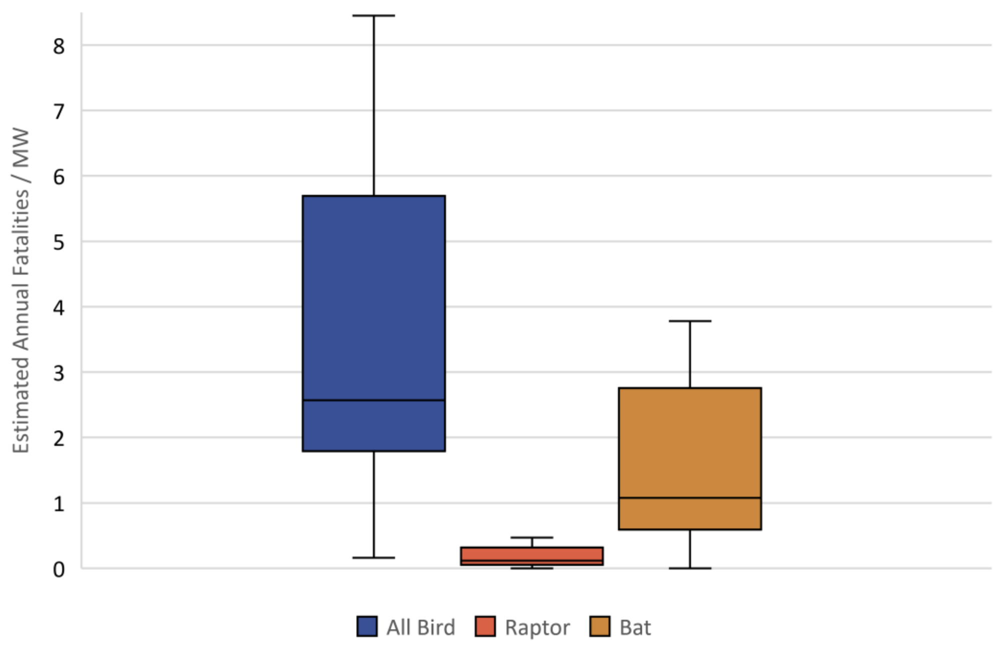

Figure 16. Annual bird and bat fatality estimates from 55 post-construction monitoring studies conducted in the Columbia Plateau Ecoregion, 1999−2020. Box blots represent the average (bar) fatalities within the interquartile range and corresponding maximum and minimum estimates.

4.1.2 Bird Fatalities and Species Composition

A total of 3,073 birds was documented at 42 wind energy facilities during 55 studies conducted from 1999−2020 (Appendix T2). Passerines composed the majority of fatalities (60.5%) followed by Upland Game birds (approximately 11%), Unidentified birds (approximately 9%), and Diurnal Raptors (approximately 8%). Collectively, Owls and Vultures composed less than 2%. The remaining 12% of species included the Doves/Pigeons group and other species' groups that had comparatively fewer fatalities (Table 10). Species commonly associated with aquatic habitats (Gulls/Terns, Loons/Grebes, Rails/Coots, Shorebirds, Waterbirds, Waterfowl) composed approximately 2% of the total fatalities. Aggregated, bird fatalities were documented most often during fall, relatively equal during spring and summer and least often during winter (Figure 17). Of the five groups most commonly found during PCFM, Passerines, Upland Game Birds, Unidentified Birds, and Doves/Pigeons were found most often during fall, whereas raptors were found in relatively equal numbers across seasons (Figure 18).

Since 2011, the total number of estimated passerine fatalities approximately tripled and the number of upland game bird and raptor fatalities doubled, while there was a marginal increase in the collective Waterbird/Waterfowl/Shorebird group from 24 to 37 fatalities (Johnson and Erickson 2011).

Table 10. Total count of fatalities by group documented during post-construction fatality monitoring at operational wind energy facilities within the Columbia Plateau Ecoregion, 1999−2020.

Group	Total Fatalities	Composition (%)
Passerines	1,859	60.49
Upland Game Birds	334	10.87
Unidentified Birds	274	8.92
Diurnal Raptors[1]	242	7.88
Doves/Pigeons	131	4.26
Owls[1]	51	1.66
Large Corvids	34	1.11
Woodpeckers	33	1.07
Swifts/Hummingbirds	28	0.91
Waterfowl	22	0.72
Nightjars	21	0.68
Gulls/Terns	14	0.46
Shorebirds	10	0.33
Rails/Coots	6	0.20
Loons/Grebes	5	0.16
Waterbirds	5	0.16
Vultures[1]	4	0.13
Total	**3,073**	**100**

[1.] groups included in the Raptor group.

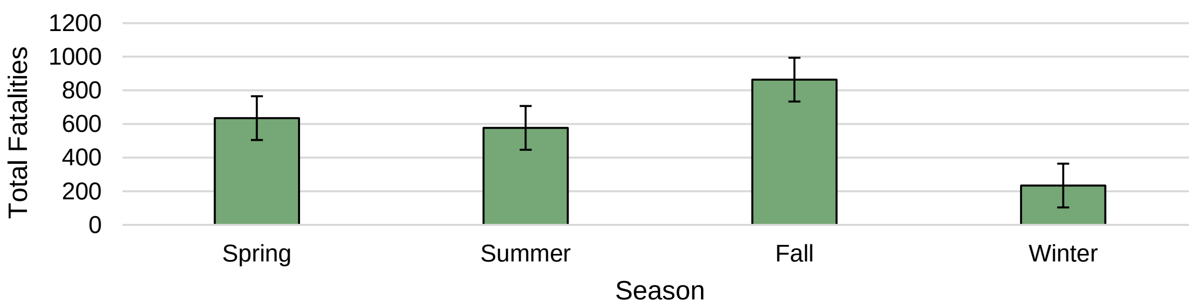

Figure 17. Seasonal count of bird fatalities documented during post-construction fatality monitoring at operational wind energy facilities within the Columbia Plateau Ecoregion (1999−2020). Variance expressed as standard error.

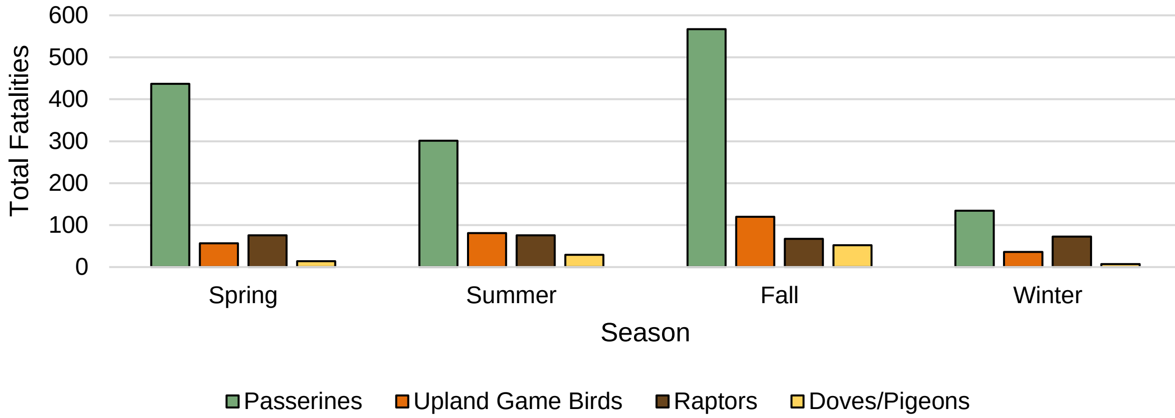

Figure 18. Total bird fatalities by season of the four groups documented most often during post-construction fatality monitoring in the Columbia Plateau Ecoregion, 1999−2020.

4.1.2.1 All Bird Group (Excluding Raptors)

Horned lark (*Eremophila alpestris*) composed the majority of the 2,776 bird fatalities (34.5%) documented during PCFM studies and approximately 48% of fatalities in the Passerine group (1,937 total individuals; Appendix T3). The second most frequent fatality documented during PCFM was an unidentified bird of unknown size (184 occurrences; 7%). Unidentified birds of unknown size were documented when a carcass was either too decomposed to classify into a more specific size class or group (e.g., unidentified large bird or unidentified shorebird) or when the remaining evidence of a fatality are feathers that cannot be identified. If found within a PCFM search plot, the disposition of an unidentified carcass or feather spot was attributed to turbine mortality despite the possibility that the feather spot was the result of a predation event (e.g., raptor plucking area).

As discussed, Passerines composed the majority of all fatalities in the CPE. In addition to horned lark (48% of fatalities), golden-crowned kinglet (*Regulus satrapa*; 6%), western meadowlark (*Sturnella neglecta*; 5%), unidentified passerine (4%), and the non-native European starling (*Sturnus vulgaris*; 5%) composed the top five abundant fatalities in the Passerine group. Both migratory and resident passerine species were documented. Seasonal patterns of fatalities were more pronounced for migratory species such as golden-crowned kinglet, a boreal nesting species, than horned lark, which occurs in the CPE year-round.

Upland game birds composed approximately 11% of all fatalities. Within the Upland Game Bird group, three non-native species accounted for 98% of all mortality: gray partridge (*Perdix perdix*; 46%), ring-necked pheasant (*Phasianus colchicus*; 30%), and chukar (*Alectoris chukar*; 22%).

Bird groups commonly associated with aquatic habitats (gulls/terns, loons/grebes, rails/coots, shorebirds, waterbirds, waterfowl) composed approximately 2% fatalities in the All Bird group. Eighteen species associated with aquatic habitats composed 62 fatalities, of which Canada goose (*Branta canadensis*) was documented most often (18%, 11 fatalities) followed by long-billed curlew (15%, 9 fatalities); however, both species are not obligate aquatic species and are often found in agricultural or grassland habitats, respectively. Obligate aquatic species such as horned grebe (*Podiceps auritus*), Virginia rail (*Rallus limicola*), and sora (*Porzana carolina*), and American white pelican and composed approximately 19% (12 fatalities) of aquatic associated species but <1% of bird fatalities overall (Appendix T2).

Excluding raptors, 8 of the 14 sensitive species that occur within the CPE were documented during PCFM. The sensitive species most frequently documented was common nighthawk (*Chordeiles minor*; 18 fatalities; ODFW Sensitive, WDFW Candidate; Appendix T1). Although upland game birds composed approximately 11% of fatalities, greater sage-grouse and Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*), both WDFW endangered, were not documented during PCFM.

In addition to the species in the Upland game bird group discussed above, species found during PCFM not protected under the Migratory Bird Treaty Act (85 FR 21262) composed approximately 16% (481 fatalities) of all fatalities. Species included European starling (76 fatalities), rock pigeon (*Columba livia*; 61 fatalities), and house sparrow (*Passer domesticus*; 10 fatalities).

4.1.2.2 Raptor Group

The *Buteo* group (broad-winged or soaring hawks) comprised the majority (45%) of the 297 raptor fatalities documented during PCFM studies, followed by species in the Accipiter and Falcon group (33%), and Owls (17%; Figure 19). The remaining species in the Eagle group, Other group (turkey vulture [*Cathartes aura*] and osprey [*Pandion haliaetus*]) and Unidentified Raptor group comprised approximately 5% of raptor fatalities documented during PCFM studies (Figure 19).

Collectively, red-tailed hawk and American kestrel accounted for over half (53%) of all raptor fatalities documented during PCFM conducted from 1999–2020. Red-tailed hawk was the species most frequently documented (80 fatalities) and comprised 61% of the *Buteo* group. Although documented less often than red-tailed hawk, American kestrel (73 fatalities) was the predominant species documented (80%) in the Accipiter and Falcon group. Compared to the *Buteo* and Accipiter and Falcon groups, where fatalities disproportionately comprised one species, short-eared owl (*Asio flammeus*; 16 fatalities, 31%) and barn owl (*Tyto alba*; 14 fatalities, 27%) had a relatively similar number of fatalities documented in the Owl group (Figure 19). Golden eagle carcasses (4) were documented more often than bald eagle carcasses (1).

Six of the seven sensitive raptor species that occurred within the CPE were documented during PCFM. (Figure 19; Appendix T1). The species most frequently documented included Swainson’s hawk (33 fatalities, ODFW Sensitive), followed by short-eared owl (16 fatalities; USFWS Sensitive, USFWS BCC) and ferruginous hawk (8 fatalities; WDFW Endangered; Appendices T1 and T3).

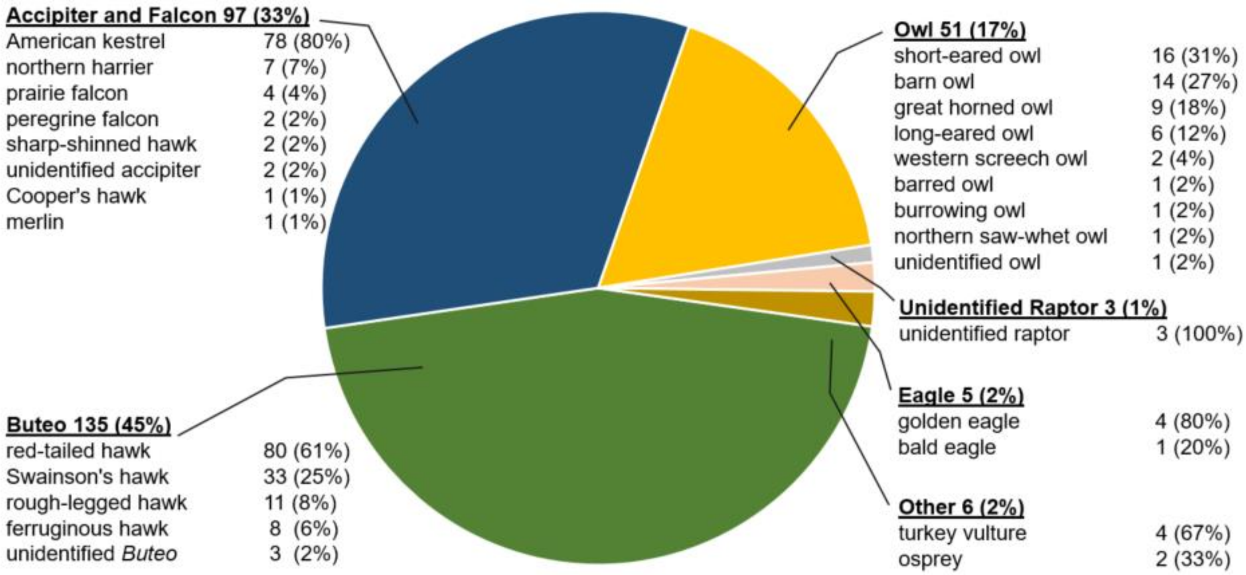

Figure 19. Species composition of 297 raptor fatalities documented in 48 post-construction monitoring studies at wind energy facilities in the Columbia Plateau Ecoregion, 1999−2020.

4.1.3 Bat Fatalities and Species Composition

A total of 1,124 bat fatalities were documented at 37 wind energy facilities during 48 studies conducted from 1999−2020 (Appendix T4). Migratory tree and leaf roosting species including hoary bat (*Lasiurus cinereus*) and silver-haired bat (*Lasionycteris noctivagans*) composed 96% of the bat fatalities in the CPE (Table 11). Fatalities typically occur from April through September, peaking during the fall migration which is consistent with patterns observed in other regions in the US (Figure 20; Goldenberg et al. 2021).

Compared to 2011, the total number of hoary bat and silver-haired bat fatalities nearly doubled with hoary bat replacing silver-haired bat as the species most often found during PCFM. There were marginal increases in the total number of fatalities found for other species with one additional little brown bat and three additional big brown bats documented (Johnson and Erickson 2011).

Table 11. Total count and species composition of bat fatalities documented at 37 projects (48 studies) during post-construction fatality monitoring at operational wind energy facilities within the Columbia Plateau Ecoregion, 1999−2020.

Common Name	Total Fatalities	Composition (%)
hoary bat	573	51.0
silver-haired bat	506	45.0
unidentified bat	29	2.6
little brown bat	8	0.7
big brown bat	7	0.6
unidentified myotis	1	0.1
Total	**1,124**	**100**

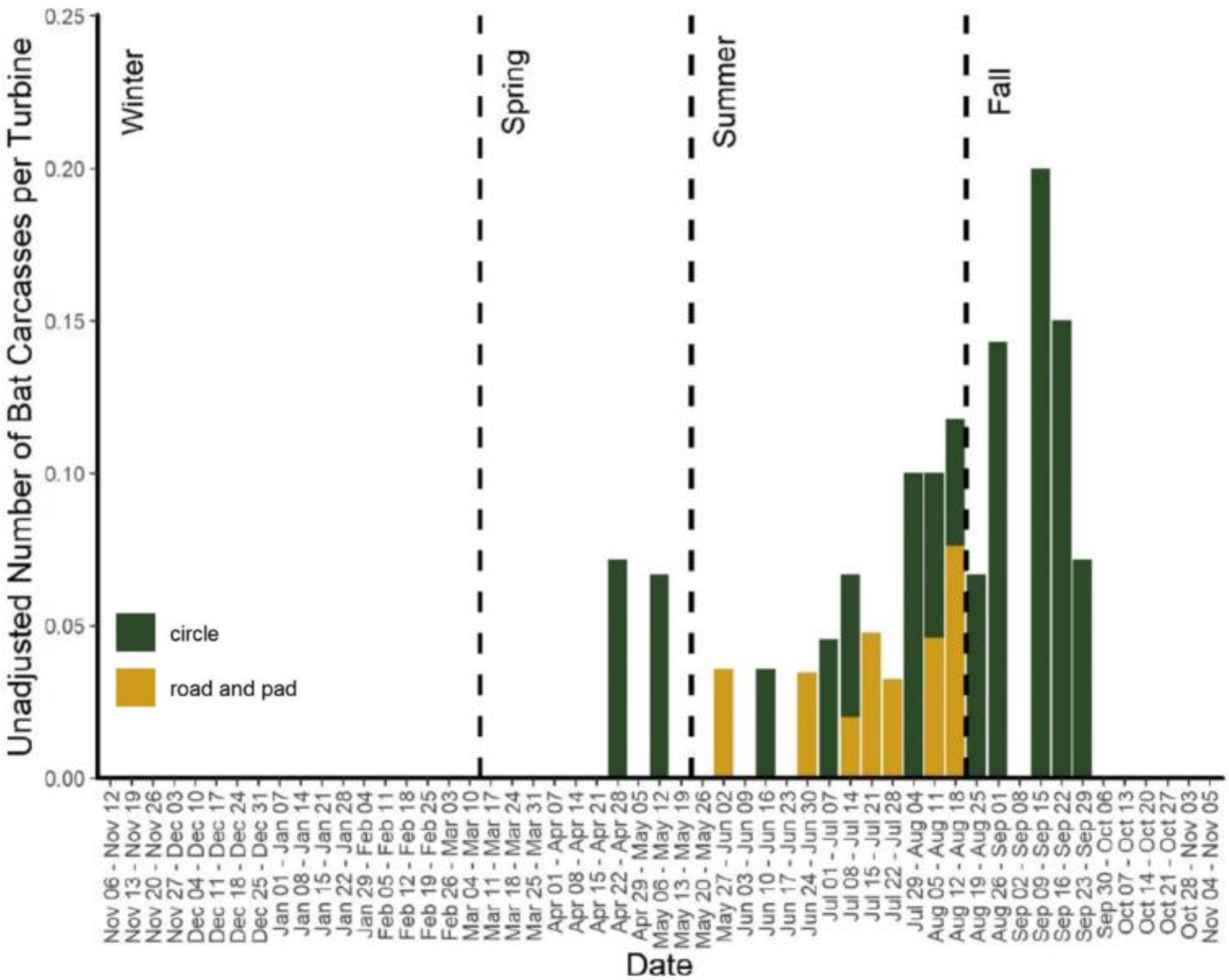

Figure 20. Example of the typical temporal distribution of bat fatalities in the Columbia Plateau Ecoregion. Data from Montague Wind Power Project, Gilliam County, Oregon, November 12, 2019 to November 5, 2020 (Chatfield and Martin 2021). Legend distinguishes PCFM search areas: circle = all ground within 150 m of turbine base, road and pad = high visibility (graveled) areas within 150 m of turbine base. Variable search effort.

4.2 Mortality Estimates and Population Effects

4.2.1 All Bird Group (Excluding Raptors)

Passerines composed the majority of bird fatalities and were found at every project in the CPE (Table 12). Assuming species composition and overall fatality rates remain stable over time, it is estimated that 11,600−22,000 Passerines would be killed annually, depending on development scenario. Fatalities were not found during PCFM for species with PIF populations less than an estimated 5,000 individuals (Appendix T5). A migratory species, ruby-crowned kinglet (*Corthylio calendula*) had the highest percent of its population affected by wind energy development because of its comparatively smaller population size. Although ruby-crowned kinglet composed only 2% (40 individuals) of all passerine fatalities, the estimated 240–453 annual fatalities expected to occur from wind energy development represent 1.9% of the estimated CPE population (23,456 individuals). This species prefers nesting in more mountainous and forested regions in North America, habitats that do not occur in the CPE. Because no breeding habitat is present in the CPE, the majority of ruby-crowned kinglet fatalities occurred during spring (13%) and fall (84%) migration. Migratory ruby-crowned kinglets found in the CPE are part of the much larger Great Basin BCR 9 population of 273,000 individuals and average population trends from 2006−2019 were positive albeit statistically insignificant (0.39, 97.5%CI: -2.51–3.58; Appendix T5). Average apparent adult survival rates of ruby crowned kinglet from 15 years (1992–2006) of banding data was 0.38 (SE ± 0.05), indicating a large proportion of the population does not survive to the preceding year (Desante et al. 2015). Despite sustaining high annual mortality (0.68), population trends appear stable and the species is not on a watchlist (Rosenburg et al. 2019); thus a cumulative impact of 1.9% to the CPE population is negligible. Although a higher percent of the population was affected compared to other species in the Passerine group, cumulative effects would not be expected due to the small number of fatalities in an overall large, stable population.

Horned lark fatalities were disproportionately higher (48%; 936 individuals) than the second and third most abundant species found during PCFM, golden-crowned kinglet (6%; 113 individuals), and western meadowlark (5%; 101 individuals). As a wide-spread, abundant species throughout the CPE during all seasons, an estimated 5,600−10,600 horned larks would be killed annually, depending on the wind energy development scenario. Horned larks are the fourth most abundant passerine in the CPE with an estimated population of 1.22 million birds (Appendix T5). The estimated number of horned lark fatalities from wind turbine collisions would be <1% of the horned lark population and therefore, cumulative impacts would not be expected. Similarly, cumulative effects to species with larger populations including golden-crowned kinglet (1.36 million) and western meadowlark (1.42 million) but less abundant during PCFM are thought to be negligible. American robin (*Turdus migratorius*), the most abundant passerine in the CPE (2.53 million), composed <0.01% (16 individuals) of documented fatalities in the Passerine group and no cumulative effect on the CPE population would be expected.

Table 12. Species composition of current and future estimated fatalities in the All Bird group under different wind energy development scenarios.

Group	% Comp.[1]	Current (2020)[2]	40% New Wind[2]	60% New Wind[2]
Passerines	67.0	11,631	18,517	21,959
Upland Game Birds	12.0	2,090	3,327	3,945
Unidentified Birds	9.9	1,714	2,729	3,237
Doves/Pigeons	4.7	820	1,305	1,547
Large Corvids	1.2	213	339	402
Woodpeckers	1.2	206	329	390
Swifts/Hummingbirds	1.0	175	279	331
Waterfowl	0.8	138	219	260
Nightjars	0.8	131	209	248
Gulls/Terns	0.5	88	139	165
Shorebirds	0.4	63	100	118
Rails/Coots	0.2	38	60	71
Loons/Grebes	0.2	31	50	59
Waterbirds	0.2	31	50	59
Total	**100**	**17,369**	**27,651**	**32,792**

1. composition derived from 55 PCFM studies conducted in the CPE, 1999−2020 and assumed a constant average annual fatality rate of 2.5704 birds/MW/year.

2. current capacity = 6,757 MW; 40% = 10,757 MW, 60% = 12,757 MW.

Upland game birds were the second most abundant group (12%; 334 individuals) found during PCFM, but measurably lower than the Passerine group (Table 12). Gray partridge composed the majority of fatalities (46%; 154 individuals), followed by ring-necked pheasant (30%; 99 individuals), and chukar (22%; 75 individuals). Assuming species composition and overall fatality rates remain stable over time, an estimated 960−1,800 gray partridge, 620−1,170 ring-necked pheasant, and 470−885 chukar would be killed annually, depending on the wind energy development scenario. When maximum fatality estimates are considered (60% new wind), wind energy fatalities would comprise 15%, 1%, and 3% of gray partridge, ring-necked pheasant, and chukar populations, respectively. Although wind energy mortality would affect a higher percent of the gray partridge population, average population trends 2006–2019 were positive (1.37, 97.5%CI: -4.75–8.2; Appendix T5) and populations are robust (WDFW 2014, ODFW 2016). All upland game bird species documented during PCFM have hunting seasons with populations regulated through bag limits and wildlife habitat enhancement programs. Large annual fluctuations in game bird populations are a result of weather rather than hunting pressure which is managed at sustainable levels (ODFW 2020). The majority of upland game bird hunting in Washington occurs in the CPE. Upland game bird harvest data from WDFW report an average 4,207 gray partridge, 60,308 ring-necked pheasant, and 11,474 chukar were harvested annually from 2013−2021 (WDFW 2022). Because hunting upland game birds typically does not increase mortality rates that would otherwise occur from other sources (compensatory mortality; ODFW 2020), cumulative effects to populations from the comparatively small numbers of fatalities associated with wind energy development are not anticipated.

Excluding raptors, the remaining bird groups composed approximately 10% of bird fatalities anticipated in future wind energy development scenarios. Excluding European starling, an introduced species with no regulatory protection, the species with the next highest number of fatalities was dark-eyed junco (*Junco hyemalis*), with 330−624 total annual fatalities, depending on development scenario. However, this represents less than 0.1% of the estimated population in the CPE and no cumulative impacts are expected.

4.2.2 Raptor Group

Diurnal Raptors composed the majority of raptor fatalities and were documented in 37 of the 55 PCFM studies from 1999−2020 (Table 13). Assuming species composition and overall fatality rates remain stable over time, it is estimated 800−1,500 raptors would be killed annually, depending on development scenario. Two of the most abundant raptor species, red-tailed hawk and American kestrel, composed a relatively equal proportion (~26–27%) of all documented raptor fatalities. Depending on the development scenario, approximately 215–400 red-tailed hawks and 210−395 American kestrels would be killed annually. As wide-spread species that occupy a variety of habitats, red-tailed hawk and American kestrel populations in the CPE are approximately 47,990 and 48,700 individuals, respectively. Estimated annual fatality rates would comprise 0.4–0.8% of the populations of both species. In the absence of human-caused mortality, annual raptor survival rates (inversely, mortality rates) correlate with body mass with approximately 0.70–0.85 annual survival for species in the genus *Falco* and *Buteo* (Newton et al. 2016). An increase of <1% of direct impact to red-tailed hawks and American kestrel populations from wind energy development is not expected to contribute to declines in long-term population trends. Both species are considered year-round residents in the CPE, although portions of both populations are likely partially migratory, especially American kestrel. Average BBS population trends in the Great Basin BCR 9 from 2006−2019 were stable to increasing for red-tailed hawk (1.64 [95%CI: 0.42−2.90) while American kestrel were decreasing (-1.41 [95%CI: -2.89−0.14; Appendix T5). Both species are two of the most common raptors found during PCFM in the US (WEST 2021).

Estimates of sustainable harvest rates of raptors from falconry offers a metric of sensitivity to raptor populations and were calculated as 1–5% of their US population size, depending on the species demographic vital rates (Millsap and Allen 2006). Red-tailed hawk was estimated to be able to sustain a 4.5% maximum harvest rate while other species found during PCFM were had comparatively lower harvest rates including American kestrel (1.5%) and ferruginous hawk (1%). In a public records request, Ash (2016) found 288 raptors were harvested by falconers from 2000–2009, of which red-tailed hawk (52%, 188 individuals), northern goshawk (14%, 40 individuals), and American kestrel (11%, 34 individuals) composed the majority of species. In the maximum wind energy development scenario, annual red-tailed hawk fatalities (403 fatalities) would represent 0.84% of the CPE population and American kestrel fatalities (393 fatalities) would represent 0.81% of the CPE population; thus contributing a marginal cumulative effect in the CPE. However, in a study that considered up to 241 GW of new wind capacity nationwide, both American kestrel and red-tailed hawk showed relatively larger estimated declines in population growth rates with increasing levels of wind energy development (Diffendorfer et al. 2021). Although both species are abundant, on-going and increased number of fatalities within the CPE may contribute to cumulative effects the species incur throughout their range (Katzner et al. 2020).

Of the 23 raptor species documented as fatalities during PCFM, six (26%) were classified as sensitive by state or federal agencies (Appendix T1). Raptor species found as fatalities included both eagle species occurring in the CPE (bald eagle and golden eagle), two migratory owl species (burrowing owl [*Athene cunicularia*] and short-eared owl) and two migratory hawk species (ferruginous hawk and Swainson's hawk). Sensitive species are discussed in further detail in Section 4.2.3.

Three of the 14 raptor species with PIF population data in the CPE were not documented during PCFM: great gray owl (*Strix nebulosi*), northern goshawk (*Accipiter gentilis*), and northern pygmy owl (*Glaucidium californicum*). These three species are associated with more forested habitats which are largely absent in the CPE. Future population level effects to these species from wind energy related mortality are not anticipated.

Table 13. Species composition of current and future estimated fatalities by raptor group under different wind energy development scenarios.

Group	Comp. (%)[1]	Current (2020)[2]	40% New Wind[2]	60% New Wind[2]
Diurnal Raptors	81.5	646	1,028	1,220
Owls	17.2	136	217	257
Vultures	1.3	11	17	20
Total	**100**	**793**	**1,262**	**1,497**

1. composition derived from 48 PCFM studies conducted in the CPE, 1999−2020 and assumed a constant average annual fatality rate of 0.1173 raptors/MW/year.
2. current capacity = 6,757 MW; 40% = 10,757 MW, 60% = 12,757 MW.

4.2.3 Sensitive Bird Species

Of the 20 species listed in Oregon and/or Washington as sensitive (Appendix T1), 14 (70%) were documented during PCFM conducted from 1999–2020 (Table 14; Appendix T1). Raptor species composed 43% of the sensitive species found during PCFM. Swainson's hawk was documented most frequently, totaling 33 individuals. Assuming the 2020 level of installed wind energy capacity, fatalities of all but the ferruginous hawk composed less than 1% of populations of sensitive bird species within the CPE (Table 14). Although ferruginous hawk composed a comparatively small proportion of raptor fatalities documented during PCFM with approximately 3% of Raptor fatalities and 6% in the *Buteo* group, the species status warrants additional analysis and is discussed in further detail below (Section 4.2.3.1). Seven sensitive species (30%) present in the CPE were not found during PCFM and included two upland gamebirds (sage-grouse, sharp-tailed grouse), a forest-nesting raptor (northern goshawk), shrub-steppe passerine (loggerhead shrike [*Lanius ludovicianus*]), and two waterbird species (sandhill crane and upland sandpiper [*Bartramia longicauda*]). Seasonal abundance of sensitive species in the CPE ranged from extremely rare (e.g., upland sandpiper) to more abundant (e.g., sandhill crane) and are discussed in greater detail below.

Compared to other upland gamebird species documented more frequently during PCFM, turbine -collision mortality of sage-grouse and sharp-tailed grouse has not been documented. To date, wind turbine-related fatalities of upland game birds in the CPE have been associated with introduced, non-native species with open hunting seasons (Section 4.2.1). Due to habitat modification from urban/rural and agricultural development, the distribution of both sage-grouse and sharp-tailed grouse are highly restricted in the CPE and do not overlap with current installed wind energy development (Schroeder et al. 2015, Hoen et al 2018). As habitat-limited species that require large areas of habitat for breeding and nesting, native grouse in the CPE may be more prone to the indirect effects of renewable energy development which include avoidance and displacement that may affect survival or fecundity (Lloyd et al. 2022). Sage-grouse are evaluated as a Focal Species in Section 4.5.2.2.2.

Sandhill crane is a charismatic and celebrated species in the CPE. Three subspecies (greater sandhill crane [*A. c. tabida*], lesser sandhill crane [*A. c. canadensis*], and Canadian sandhill crane [*A. c. rowani*) occur in the CPE (Stinson 2017). The majority of individuals in the CPE migrate to nesting areas in Canada and Alaska although several small (<100 individuals) breeding populations occur in Klickitat and Yakima counties. Migratory birds use the mosaic of agriculture-grassland-wetlands as stopover habitat, important for refueling along their long migratory path. No sandhill crane fatalities have been documented at wind energy facilities in the CPE and studies of flight behavior suggest high flight avoidance of wind energy turbines (Nagy et al. 2013, Pearse et al. 2016, Derby et al. 2018). Based on the absence of documented sandhill crane fatalities during PCFM and high flight avoidance behavior, cumulative impacts to sandhill crane are not expected in current or future wind energy development scenarios.

Once a nesting species in the grasslands of the CPE, upland sandpiper is considered extirpated in Oregon and Washington (WDFW 1995, ODFW 2015). The CPE is located at the edge of the nesting range in North America and the species has historically been a rare breeder in the CPE. The most recent publicly-available record of possible nesting in the CPE is from 1993 in Kittitas County, Washington (WDFW 1995). Extensive modification of suitable grassland nesting habitat has likely shifted the species ability to reestablish a stable breeding population in the CPE. Absent large-scale landscape conservation efforts to protect grassland nesting habitat, upland sandpiper occurrence in the CPE will likely remain rare, comprised of vagrants from more robust populations east of the CPE (WDFW 1995). Based on the scarcity and likely extirpation of the species in the CPE, wind energy development is unlikely to contribute to cumulative impacts that would further reduce the occurrence or persistence of upland sandpiper.

4.2.4 Focal Species: Ferruginous Hawk

With a breeding and nesting population at the northwestern edge of the species distribution in the US Pacific Northwest, ferruginous hawk population trends in the CPE have been a conservation concern for nearly half a century (Hayes and Watson 2021). Landscape-scale conversion of nesting and foraging habitat to agricultural and residential development in the CPE has eliminated most of the species historical habitat (Richardson 1996, Sleeter 2012). Combined with a prolonged drought that has reduced the availability of an essential prey base (small mammals) and other environmental stressors, ferruginous hawk breeding populations in the CPE have declined at a rate that prompted listing the species as Washington state endangered in 2021.

Photo 10. Adult nesting ferruginous hawk, Benton County, Washington, May 2019.

Although fewer ferruginous hawk fatalities were documented during PCFM compared to other raptor species, the effect on the nesting population in the CPE was higher because of the smaller estimated population size (Table 14). Eight ferruginous hawk fatalities were documented at six facilities during PCFM studies conducted from 1999–2020 (WEST 2021). The majority of fatalities were adults (5 individuals) followed by juvenile (1 individuals) and 2 of unknown age. Of the eight ferruginous hawk fatalities documented during PCFM, four (3 adults and 1 juvenile) were at two wind facilities in Washington. Hayes and Watson (2021) estimated there were 32 breeding pairs in the Washington portion of the breeding population based on 2016 raptor nest surveys. Based on the installed wind energy capacity in 2020, annual ferruginous hawk mortality of 21 individuals could account for approximately 3.4% of the 626 birds based on PIF population data (Table 14). Impacts would be sustained across the age range of breeding and non-breeding individuals and could occur year-round although winter resident populations (~6%) in the CPE appear small (Watson et al. 2018); thus, impacts to the breeding adult population would likely be lower than 3.4%. Using a model for red-tailed hawk as a surrogate, Millsap and Allen (2006) estimated a 1% sustainable harvest rate of juvenile ferruginous hawks for falconry purposes. Considering an updated North America PIF population estimate of 110,000 ferruginous hawks (Will et al. 2020) composed of 30% juveniles (derived from Millsap and Allen 2006), a 1% sustainable annual falconry harvest would result in 330 individuals in the US. For context, the average number of juvenile ferruginous hawks harvested for falconry in the US during 2003 and 2004 was 6.5 birds which represented 2% of the sustainable harvest modeled by Millsap and Allen (2006). Mortality levels from wind energy fatalities or harvested for falconry appear small compared to background mortality rates sustained by ferruginous hawk. Annual mortality rates are highly variable throughout the range and life stages of ferruginous hawk (Hayes and Watson 2021) with an estimated 57% annual juvenile mortality (fledge to 1 year) and adult mortality (≥ 1 year old) ranging 24–30% (Watson and Pierce 2003, Schmutz et al. 2008).

The effect of wind energy mortality on ferruginous hawk populations in increasing levels of wind energy development is expected to increase when combined with other environmental stressors in the CPE and as well as within their broader distribution in the western US. Although BBS population trend estimates in the Great Basin from 2006–2019 indicate a non-significant annual rate of change of 2.44% (95%CI: -0.78–5.83), breeding populations in Washington have continuously declined over the past half century; thus, a population size of 626 individuals in the CPE is likely an overestimate. Results from a four-year study of migratory movements that tracked 28 ferruginous hawks trapped in Washington and tracked by satellite telemetry indicated the population was self-sustaining (Watson 2003); however, when combined with other sources of ferruginous hawk mortality (e.g., shooting, poisoning), continued and potential increases in fatalities at wind turbines under all development scenarios may result in an additive cumulative effect on population growth in the CPE because of the small population size and low reproductive rates of this species.

Table 14. Sensitive bird species documented during PCFM at wind energy facilities in the CPE from 1999–2020 and the proportion of the estimated population affected under various development scenarios.

Common Name	# Fatalities	% Comp.[1]	Current (2020) 6,757 MW	40% New Wind 10,757 MW	60 % New Wind 12,757 MW	Pop. Est.	Min % Pop.[2]	Pop. Source
Swainson's hawk	33	11.11	88	140	166	9,128	0.97	PIF 2021[3]
common nighthawk	18	0.65	5	8	10	263,624	0.00	PIF 2021
short-eared owl	16	5.39	43	68	81	5,109	0.84	PIF 2021
Brewer's sparrow	14	0.50	4	6	8	442,080	< 0.01	PIF 2021
long-billed curlew	9	0.32	3	4	5	4,000	0.06	Fellows and Jones 2009[4]
ferruginous hawk	8	2.69	21	34	40	626	3.41	PIF 2021[5]
golden eagle	4	0.14	1	2	2	786	0.15	USFWS 2016[6]
sage thrasher	2	0.07	1	1	1	175,169	< 0.01	PIF 2021
American white pelican	1	0.04	0	0	1	5,656	0.01	Stinson 2022[7]
bald eagle	1	0.34	3	4	5	1,032	0.26	USFWS 2016[8]
burrowing owl	1	0.34	3	4	5	1,590	0.17	PIF 2021
grasshopper sparrow	1	0.04	0	0	1	161,261	< 0.01	PIF 2021
Lewis's woodpecker	1	0.04	0	0	1	9,717	< 0.01	PIF 2021
sagebrush sparrow	1	0.04	0	0	1	56,575	< 0.01	PIF 2021

1. Percent composition of documented fatalities within the All Bird (n = 2,776) or Raptor (n = 297) groups.
2. Percent of the population affected by the estimated annual fatalities in the Current (2020) development scenario (6,757 MW).
3. PIF 2021 = CPE population estimate derived from PIF Great Basin BCR 9 data (Section 3.2).
4. Conservative population estimate from the entire Columbia Basin BCR 10.
5. Hayes and Watson (2021) estimated 47 occupied nests and 32 breeding pairs (64 individuals) in eastern WA based on 2016 survey data.
6. Based on proportion of CPE in the BCR × 2014 median population estimate in BCR 9 (0.119 × 6,596 eagles).
7. Includes total number of pelicans at the largest breeding colony in WA (Badger Island) in 2018.
8. Based on the proportion of CPE in the North Pacific Flyway Eagle Management Unit (EMU) × 2014 median population estimate in the EMU (0.028 × 14,792 eagles).

4.2.5 Bats

A disproportionate number of migratory tree and leaf roosting bats were found during PCFM studies. Hoary bat and silver-haired bat composed nearly 96% of all bat fatalities; therefore, the total number of fatalities from new wind energy development should affect these two species comparatively more than little brown bat or big brown bat. Assuming species composition of fatalities is similar over time and overall fatality rates remain stable, it is estimated that 11,600-13,800 bats would be killed annually, depending on the wind energy development scenario (Table 15).

Table 15. Species composition of current and future estimated bat fatalities under different wind energy development scenarios.

Common Name	% Comp.[1]	Current (2020)[2]	40% New Wind[2]	60% New Wind[2]
hoary bat	51	3,717	5,918	7,018
silver-haired bat	45	3,283	5,226	6,197
unidentified bat	3	188	299	355
little brown bat	1	52	83	98
big brown bat	1	45	72	86
unidentified myotis	< 1	6	10	12
Total Fatalities	**100**	**7,292**	**11,608**	**13,766**

1. composition derived from 48 PCFM studies conducted in the CPE, 1999−2020 and assumed a constant average annual fatality rate of 1.079 bats/MW/year.

2. current capacity = 6,757 MW; 40% = 10,757 MW, 60% = 12,757 MW.

It is difficult to place the relative effects from wind energy mortality on bats in context because population sizes and other sources of mortality are poorly understood, particularly in the western US (Hayes and Wiles 2013, Weller et al. 2018). At a national scale, the average bat fatality rate in the CPE (1.08 bats/MW/year) was lower than regions in the midwest and eastern US where karst limestone and mines that provide hibernacula, tree lots and forested areas that provide roosting habitat, and perennial waters that provide foraging habitat are more abundant. Examples include wind energy projects in Iowa (8.7 bats/MW/year), Texas (15.3 bats/MW/years) and Tennessee (>30 bats/MW/year; Arnett et al. 2008, Miller 2008). Hayes (2013) estimated approximately 600,000−900,000 bats were killed in 2012 at 21 wind energy facilities throughout the US with fatality rates that ranged from 0.2−53.3 bats/MW/year. An emerging threat in the CPE includes WNS, which was first detected in Washington in 2016. The fungus has decimated hibernating bat populations in the eastern US; however, the magnitude of its effect on western migratory tree roosting bat populations is currently unknown (WNS Response Team 2021). All species documented during PCFM, except hoary bat, are susceptible to the disease and WNS may have a larger effect on bat populations than turbine collisions. Nevertheless, multiple studies have quantified a sustained decline in occupancy and thus species abundance of hoary bat and little brown bat prior to the arrival of WNS (Loeb et al. 2015, Rodhouse et al. 2019). Although bat fatality rates appear to be comparatively lower in the CPE than other regions in the US, collisions with wind turbines are likely to contribute to cumulative effects sustained throughout the year and compound with impacts sustained in their winter ranges located outside the CPE (Hayes et al. 2015, Wieringa et al. 2021).

4.3 Bird Mortality in Context

In a human-built environment, bird species are exposed to a wide variety of environmental stressors that contribute to population level-effects (Calvert et al. 2013, Loss 2016). Characterizing mortality from wind energy development in context with other sources of anthropogenic mortality is helpful to understand its contribution to potential cumulative effects on a population (Smith and Dwyer 2016). Studies that summarized the effects of anthropogenic sources of bird mortality in the US and Canada reported similar patterns where the overall leading mortality sources included cat predation, collisions with buildings, vehicles, communication towers and electric transmission lines, and electrocution at distribution lines (Calvert et al. 2013, Loss 2016). Among the sources of mortality, direct mortality from collisions with wind turbines ranked last (Table 16, Figure 21). European summaries followed similar patterns where vehicle collision was the source most often attributed to bird mortality, although fatalities were not quantified similarly to summaries in the US and Canada (Garcês et al. 2020). Although mortality estimates among sources are not directly comparable because of the different data collection methods, variable spatial and temporal scales, and the susceptibility of different groups and their associated responses to a mortality source; the overall magnitude of mortality from wind energy is relatively smaller than other sources of anthropogenic mortality. Median All Bird fatality rates (# fatalities/MW/year) documented in the CPE (Table 9) were within the range of the 95% Confidence Interval of the All Bird fatality estimate for the western US (Table 16; Loss et al. 2013) and the national estimate for Passerine group (Table 16; Erickson et al. 2014). A Canadian study (Zimmerling et al. 2013) that estimated mortality from turbine collision and habitat loss was not included because estimates were reported per turbine, instead of per MW. Median fatality rates for all primary groups were lower than fatality estimates calculated by Smallwood (2013) who included older-generation lattice towers in their analysis which are no longer widely used. Older generation towers have a different risk profile than newer generation tubular monopole designs due to the increased perching opportunities that place birds at greater risk of mortality (USFWS 2012, Durr and Rasran 2017) although turbine height, when adjusted for nameplate capacity, appears less of a factor influencing fatality rates (Huso et al. 2021).

Summaries of anthropogenic sources of mortality are useful to show the magnitude in the differences between human-induced mortality; however, species-specific effects of impacts from wind energy are lost in this generalization. Although overall mortality appears low compared to other forms of anthropogenic sources, wind energy may disproportionately affect species with small populations, or may affect demographic vital rates differently between species due to the spatial or temporal timing of the impact. An example of potential effects to small populations comes from Diffendorfer et al. (2021) who modeled the vulnerability in maintaining stable or positive population growth rates for 14 raptor species from current (106 gigawatt [GW]) and future (241 GW) installed wind energy generation scenarios in the US. The authors found barn owl (*Tyto alba*), ferruginous hawk, golden eagle, American kestrel, and red-tailed hawk were more susceptible to changes in populations from turbine-related mortality compared to other species. The population-level effect of turbine mortality may be more likely in the CPE on a species like ferruginous hawk as their populations are relatively low in this region (Hayes and Watson 2021). Despite the observed stability of ferruginous hawk populations across the US, BBS trend results in Washington corresponded with a -1.59% annual change (97.5% CI: -7.01−3.66) from 1999–

2019 (Sauer et al. 2019). Small changes to the breeding population may be more acute in populations with few individuals particularly when combined with other sources of mortality that include vehicle collisions, shooting, and poisoning (Horne et al. 2020).

In a study of bird mortality from collisions with communication towers and buildings in North America, Arnold and Zink (2011) found horned lark strongly avoid collisions with both types of structures, characterizing the species as a ‘super-avoider.’ Although horned lark fatalities are rarely documented at these structures, horned lark compose the majority of Passerine fatalities at wind energy facilities in the Pacific, Midwest, and Mountain-prairie regions in the US (WEST 2021). Estimated overall bird mortality from communication towers and buildings are magnitudes higher than wind turbines but affect horned larks at a lower rate. Cumulative impacts to horned lark populations from wind energy are not anticipated because of the robust populations in the CPE and surrounding regions; however, observed fatality rates suggest a species-specific response of horned lark to the type of mortality threat on the landscape.

Timing of the fatalities varies among species and can disproportionately affect nesting success and fecundity when fatalities occur during the nesting period (Beston et al. 2016). An example of this dynamic is with Swainson’s hawk, a neotropical migrant that only occurs in the CPE during the summer nesting period. The risk of turbine collision is highest in the breeding range of North America (Watson 2021). Swainson’s hawks nest throughout the CPE and were the second most abundant *Buteo* found during PCFM. Because of the species’ long lifespan, low fecundity, and flight behavior that make Swainson’s hawk more susceptible to turbine collision, Beston et al. (2016) identified Swainson’s hawk as having a greater relative risk of experiencing population declines from wind energy. In a two-year study in the CPE, Kolar and Bechard (2016) attributed reduced juvenile survival at nests within three mi of wind turbines to collision mortality of adults, or the indirect effects of disturbance or displacement of adults who are no longer able to provision juveniles. Reduced juvenile survival may have generational effects in the population demographics when the pattern of reduced nesting success and fecundity persists over time.

The totality of anthropogenic pressure on bird and bat populations in North America is vast and the relative contribution from wind energy is clear even if estimates are off by several magnitudes due to uncertainty (Figure 21). Although previous research suggests bird collision mortality at wind energy facilities has no discernable effect on population trends of North American birds compared to other mortality sources (Arnold and Zink 2011) or species within a particular group such as Passerines (Erickson et al. 2014), certain species within the CPE, particularly those with small populations that exhibit relatively higher levels of mortality, unique habitat niches, or pressured by other environmental stressors, are at risk of cumulative effects. Environmental stressors include declining prey availability due to drought, persecution, and degraded or eliminated nesting or foraging habitats (Loss et al. 2015, Katzner et al. 2020, Hayes and Watson 2021). Wide ranging or migratory species are at greater exposure to environmental stressors as they navigate hazards at multiple spatial and temporal scales. In a review of 428 breeding bird species in the US, it was found that raptors were most vulnerable to these deleterious stressors (Beston et al. 2016). Results from Beston et al. (2016) are consistent with other studies that highlight raptors as a primary group of conservation concern, sensitive to fluctuations in habitat and prey availability, survival, and the additive effects of turbine-related mortality (Diffendorpher et al. 2020). Patterns from these studies translate into increased conservation concern for species that occur within the CPE including golden eagle, ferruginous hawk, and Swainson's hawk.

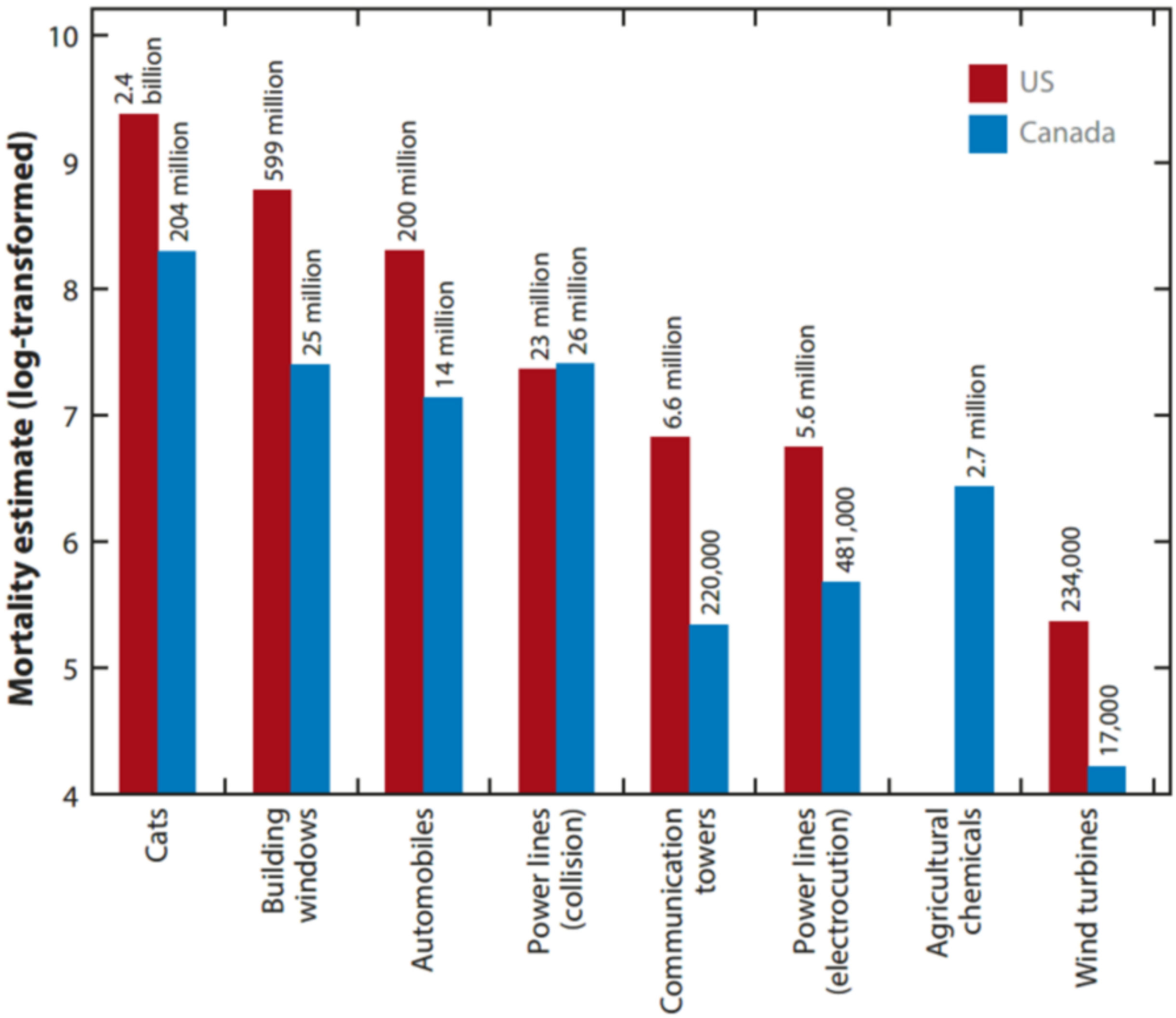

Figure 21. Comparison of major sources of anthropogenic mortality of birds in the United States and Canada (Loss et al. 2015). Note logarithmic scale in mortality estimate for comparisons.

Table 16. Comparison of anthropogenic mortality of birds and bats from human infrastructure and activities in the US and Canada.

Mortality Source	Estimate	Annual Mortality/Unit x = median; r = range	Unit	Primary Group Affected[1]	Source
Cat Predation	2.9 billion 95%CI: 1.3 − 5.3 billion	r = 24.4 – 51.4	cat	2	Loss et al. 2013[2]
Building Collision	599 million 95%CI: 365 − 988 million	x = 3.7 95%CI: 2.0 − 6.8	building	2	Loss et al. 2014
Residence	253.2 million	x = 2.1 95%CI: 1.3 − 3.1	building	2	Loss et al. 2014
Low-rise	245.5 million	x = 6.3 95%CI: 4.1 − 44.0	building	2	Loss et al. 2014
High-rise	409.4 million	x = 24.3 95%CI: 5.0 − 76.6	building	2	Loss et al. 2014
Vehicle Collision	197 million 95%CI: 78 – 398 million	x = 48.8 95%CI: 19.4 − 98.5	km	2, 3, 4	Loss et al. 2014[3]
Transmission Line Collision	25.5 million 95%CI: 8 − 57 million	x = 29.6 95%CI: 9.3 − 66.4	km/pole	3, 5, 6	Loss et al. 2014
Distribution Line Electrocution	5.63 million 95%CI: 0.9 − 11.6 million	x = 0.03 95%CI: 0.01 − 0.06	km/pole	3	Loss et al. 2014
Agricultural Pesticides	2,695,415 95%CI: 960,011 − 4,430,819	NA	NA	1	Calvert et al. 2013[4]
Oilfield Wastewater Ponds	500,000 − 1 million	NA	NA	5, 6	USFWS 2009
Wind Turbines (Lattice and Monopole)					
All Bats	x = 650,538 90%CI: 352,427 − 948,650	x = 12.6 90% CI: 6.83 − 18.37	MW	7	Smallwood 2013[5]
All Birds	x = 573, 093 90%CI: 467,097 − 679,089	x = 11.1 90% CI: 9.1 − 13.15	MW	2, 3	Smallwood 2013[5]
All Raptors	x = 82,608 90%CI: 56,123 − 109,094	x = 1.6 90% CI: 1.1 − 2.1	MW	3	Smallwood 2013[5]
Wind Turbines (Monopole only)					
All Birds (US)	x = 234,012 95%CI: 140,438 − 327,586	x = 4.1 95%CI: 2.47 − 5.76	MW	2, 3	Loss et al. 2013[6]
All Birds (Western US)	x = 27,117 95%CI: 19,671 − 34,682	x = 2.83 95%CI: 2.05 − 3.62	MW	2, 3	Loss et al. 2013[6]
Passerines	19,896 – 31,871	r = 2.09 – 3.35	MW	2	Erickson et al. 2014[7]
Communication Tower Collision	20,744	r = 0.00 – 0.06	km^2	2	Longcore et al. 2012[8]
Oil and Gas Activities	x = 20,008 (all) 90%CI: 14,957 − 27,539	x = 13,260 (well pads) 95% CI: 10,550 − 16,265	NA	2	Van Wilgenburg et al. 2013[9]

Table 16. Comparison of anthropogenic mortality of birds and bats from human infrastructure and activities in the US and Canada.

Mortality Source	Estimate	Annual Mortality/Unit x = median; r = range	Unit	Primary Group Affected[1]	Source
Oil Sands Tailing Ponds	r = 458 − 5,029	x = 50.16 r = 7.15 − 189.5	km^2	5, 6	Timoney and Ronconi 2010[10]

1. 1 = all bird groups, 2 = passerines, 3 = raptors, 4 = corvids, 5 = waterfowl, 6 = waterbirds, 7 = tree roosting.
2. Data from US studies only; included both owned and un-owned cats.
3. Data from US studies only; reflected full set of studies that met inclusion criteria.
4. Data from Canada.
5. Estimated from 71 studies, including 19 at the Altamont Pass Wind Resource Area, California and at an operating capacity of 51,630 MW.
6. Estimated from 53 studies through US at operating capacity of 56,852 MW; Western US estimates from 17 studies in 7 states, excluding California at an operating capacity of 9,590 MW.
7. Estimated from 41 studies, within the Intermountain West at an operating capacity of 9,500 MW.
8. Data from Great Basin BCR 9 – estimates extrapolated to a national scale were approximately 6.6 million birds, annually.
9. Data from western Canada; estimate included all activities associated with oil and gas including clearing well pads, pipeline right-of-way, seismic lines.
10. Data from Canada; inclusive of systematic mortality surveys and landing-oiling rates.

4.3.1 Focal Species: Bald Eagle and Golden Eagle

Because of their regulatory status and life history traits, bald and golden eagles exhibit a level of management and conservation concern greater than most other bird species. Protected by BGEPA, both species are long-lived with high adult survival, low fecundity (K-selected species), and flight behaviors that increase susceptibility with turbine collisions and increase stressors on populations (USFWS 2016, Millsap et al. 2022). In the CPE, bald eagles are found in higher densities along large river and reservoir systems associated with the Columbia River, Deschutes River, John Day River, Snake River, and their tributaries, whereas golden eagles are associated with arid shrub-steppe grasslands that provide suitable nesting substrates including cliffs, trees, rock outcroppings, and transmission towers (Photos 11 and 12; Isaacs and Anthony 2011, Isaacs 2021).

Photo 11. Adult bald eagle nesting with at least one young along the Snake River, Garfield County, Washington, March 2022.

Comparatively few bald eagle and golden eagle fatalities have been documented in the CPE during PCFM relative to other raptor groups; eagles composed approximately 2% of the 297 raptor fatalities documented during PCFM from 1999−2020 (Table 15). In the ETP for the Marengo I & II Wind Facility in Columbia County, the USFWS reported 29 unpermitted golden eagle fatalities from wind turbine collisions and 19 electrocutions from 2011–2020 (USFWS 2021). Eagle mortality from wind energy persists in the CPE despite measures undertaken to minimize collision risk via removal of nests in proximity to turbines or turbine curtailment. Electrocution risk persists at non-APLIC compliant electrical structures despite the construction and retrofit of electrical infrastructure in compliance with APLIC standards throughout the CPE.

In the US, Pagel et al. (2013) reported six bald eagle fatalities and 79 golden eagle fatalities, found from 1997–2012, with the majority detected incidentally to PCFM. Reports since then indicated a larger breadth of the impacts, particularly in Wyoming where eagle densities were relatively much higher than the CPE (Department of Justice 2013, 2022). In the US, the leading cause of natural mortality of golden eagles from 1997–2016 was starvation/disease while the leading anthropogenic cause was shooting (Millsap et al. 2022). Although national summaries were not available for bald eagle, data from Michigan (1986–2017), and Canada (1991–2016) implicated collisions with vehicles and transmission lines as the leading causes of mortality (Mathieu et al. 2020, Simon et al. 2020). Both species continue to sustain exposure to lead poisoning in the CPE and surrounding regions at levels high enough to suppress population growth (Photo 13; Slabe et al. 2022).

Contemporary publicly-available information on eagle mortality in the CPE are from analyses provided by the USFWS for the Skookumchuck Wind Energy Project in Lewis County, western Washington (USFWS 2019). The radius of the Local Area Population (LAP; natal dispersal area) for bald and golden eagles (89- and 109-mi radius, respectively) analyzed by the USFWS overlapped the CPE and provided insights into other sources of mortality. The USFWS reported shooting bald eagles as the most prevalent known cause of death in the LAP and incidents of poaching remain a conservation concern (USFWS 2019). Over the past decade, incidents in and around the Yakama Nation involved more than 100 eagles where parts from at least 31 bald eagles were recovered (KHQ 2010; DOJ 2015a, 2015b). Poisoning was another major cause of death for bald eagles in the LAP, with nine bald eagles killed in five events documented between 2007 and 2017, including three involving pesticides. Electrocution accounted for seven suspected or confirmed cases documented between 2003 and 2015. Six eagles were found dead due to trauma from 2004 through 2016, in several cases apparently following collisions with vehicles, wires, or other objects. One bald eagle was found dead in 2009 after being caught in a trap (USFWS 2019). From 2002–2016, 29 bald eagles were reported succumbing to various natural causes (e.g., starvation, disease, accident). Sources of mortality correspond to patterns observed at the national scale (USFWS 2016). Despite these sources of regional and national mortality, bald eagle populations are increasing or stable (USFWS 2022). Because of the increasing to stable regional population trends, low fatality estimates, and siting of wind energy projects where bald eagles are less likely to occur, cumulative impacts from wind energy development are unlikely.

Photo 12. Adult golden eagle nesting in a Douglas-fir tree along Bakeoven Creek in Wasco County, Oregon, March 2018.

Similar to bald eagle, shooting was the most prevalent mortality source in the LAP of golden eagles (USFWS 2019). The same 2009 event on the Yakama Nation resulted in 26 golden eagles and multiple incidences thereafter (USFWS 2015, 2022). Second to shooting mortality, collisions with wind turbines was the only other known cause of death for golden eagles within the LAP for the years 2002 through 2017 (USFWS 2019). In 2019, three wind energy facilities were in the process of acquiring eagle take permits (ETP) under BGEPA, and the mortality rates associated with these facilities was an estimated average of 1.77 golden eagles/yr (USFWS 2019). Wind turbines may also affect golden eagle nest occupancy, thus altering the raptor nest community in the surrounding area. Using a before-after-control-impact study design, Watson et al. (2021) recorded fewer nesting golden eagles and higher densities of common raven within 2-mi of CPE wind energy facilities compared to preconstruction levels, although results were proportionally similar to the control site and statistically insignificant. In an evaluation of cumulative effects, the USFWS listed energy production as one of nine additional stressors that affect eagle populations within the LAP (USFWS 2016). The disparity between the levels of human persecution and wind-related mortality are difficult to reconcile;

however, because of the small regional population and decreasing BBS population trends, wind energy-related mortality has the potential to contribute to golden eagle declining population trends (USFWS 2019).

Historically, permits authorizing eagle take were not available under the BGEPA; however, rule changes in 2009 and 2016 provided a mechanism to acquire permits for incidental take associated with otherwise lawful activities, including wind energy generation (50 CFR § 22.26). The policy framework mandates compensatory mitigation for eagle take which typically includes retrofitting dangerous electrical power pole infrastructure to avoid eagle electrocution. The longevity of the retrofit depends on the type of infrastructure that is repaired or replaced but is commensurate with the level of take anticipated for the duration of the ETP. While the incidental take of eagles is anticipated to continue, and possibly increase depending on the development scenario, offsetting compensatory mitigation required under such permits should at least offset the impacts of "permitted take" resulting from wind energy development. A recent assessment of permitted and unpermitted table of golden eagle and bald eagle for a wind energy facility with an LAP overlapping the majority of the CPE, found cumulative impacts from wind facilities represented <5% threshold of the prescribed take level (USFWS 2021).

Photo 13. Golden eagle fatality found during preliminary pre-construction biological field surveys in Yakima County, Washington, April 15, 2019. Posture and disposition suggests poisoning.

4.4 Bat Mortality in Context

Bat populations sustain mortality from multiple natural and human-caused sources in North America. In a review of 688 reports of bat mortality events (defined as studies that reported ≥ 10 bat fatalities counted or estimated) in North America from 1790–2015, O'Shea et al. (2016) classified the causes of bat mortality into nine groups including abiotic, accidental, bacterial/viral disease, biotic, contaminants, intentional killing, unexplained, wind turbines, and WNS. Anthropogenic sources (e.g., intentional killing, contaminants, wind energy) of mortality accounted for 41% of the reported sources of mortality whereas 59% of the reported mortality sources were from other causes listed above (e.g., abiotic, accidental, bacterial/viral disease, etc.; O'Shea et al. 2016). Anthropogenic sources of mortality likely contributes to a larger proportion since unexplained sources were suspected as a result of exposure to organochlorine insecticides and other pesticides. Consistent with O'Shea et al. (2016), WNS was not considered an anthropogenic source of mortality. Literature reporting bat mortality events from bacterial or viral diseases ranked lowest in North America (1.9%) and globally (2.1%).

Historically, intentional killing and human persecution composed the greatest number of reported bat mortalities in North America. Destruction of hibernacula or roosting areas, and poisoning directly or indirectly through chemical exposure has been reported in North America for over 100 years; however, a notable shift in the literature occurred around the year 2000 when reports of bat mortalities caused by wind energy turbines and WNS were dominant. Of the 688 reports of bat mortality events in North America, wind energy turbines (31%) and WNS (39%) comprised 70% and occurred in the span of approximately 15 years (O'Shea et al. 2016). Although the order of magnitude of the maximum unadjusted number of carcasses documented at wind energy turbines (10^2) was lower than abiotic sources (10^5), unexplained (10^5), or even WNS (10^4) the spatial extent of wind energy development and disproportionate effect on migratory tree roosting bats has been a growing conservation concern (Frick et al. 2017).

The representation of scientific literature quantifying impacts to bats from wind energy development and WNS compared to other sources of mortality is likely a combined function of policy/regulations, funding, and interest in the conservation community. For example, multiple years of PCFM, analyses, and reporting are required as a condition of permit approval at many wind energy facilities in the US, whereas pest control services or other commercial/industrial/agricultural sectors are not required to report the number of bat deaths from fumigation, pesticide application, or other sources of known bat mortality. Despite the irregularities in reporting in the scientific literature, it is clear the emergence of wind energy generation and WNS can substantially impact bat populations (Hoyt et al. 2021). In a simulation of the effect of wind energy-related mortality and WNS on the federally endangered Indiana bat (*Myotis sodalis*), Erickson et al. (2016) found effects of wind turbines were localized and focused on specific spatial subpopulations whereas WNS had a depressive effect on the species across its range. Together, the combined effect of the two stressors were greater than would be expected from either alone. When characterizing the effect of WNS on bat populations, Hoyt et al. (2021) stated WNS "…has resulted in the collapse of North American bat populations and restructured species communities." Although the extent of WNS is not yet pervasive in the CPE, bat populations should not presumed to be immune to the synergistic, deleterious effects from wind energy development with other greater stressors (WNS) that have been observed in other regions of the US (*see* Section 2.1.7; Table 4).

4.5 Solar Energy Resource Assessment

Without the exclusion criteria applied, approximately 51% of the CPE is located within 2 mi of an electrical transmission line (V = 0.03; Table 17). Approximately 6,077 mi^2 were excluded from the PDA after bio-physical and human-built constraints were applied, resulting in approximately 63% (10,400 mi^2) of the PDA within the corridor. The corridor composed approximately 32% of the CPE (V = -0.35; Table 17). All proposed or operational USSE projects in the CPE overlapped the boundary of the PDA (Figure 22; Photo 14). All except two of the 48 USSE projects had the majority (>50%) of the project boundary within the corridor which shows close correspondence between the modeled corridor, where USSE occurs or is planned, and the underlying affected resources. Each resource layer is discussed in further detail below.

Table 17. Modeling results of areas used to characterize biological resources inside and outside the USSE development corridor within the Columbia Plateau Ecoregion.

Type	Inside		Outside		V^1	CPE Total (mi^2)
	mi^2	%	mi^2	%		
Potential Development Area	16,478.1	0.51	15,618.9	0.49	0.03	32,097
Development Corridor	10,401.5	0.32	21,695.5	0.68	-0.35	32,097

1. V = vulnerability score (Section 3.4)

Photo 14. Early phase construction of USSE in Gilliam County, Oregon, May 2022. Racking systems (white posts) are installed with solar arrays staged nearby. Wind energy turbines in the distance.

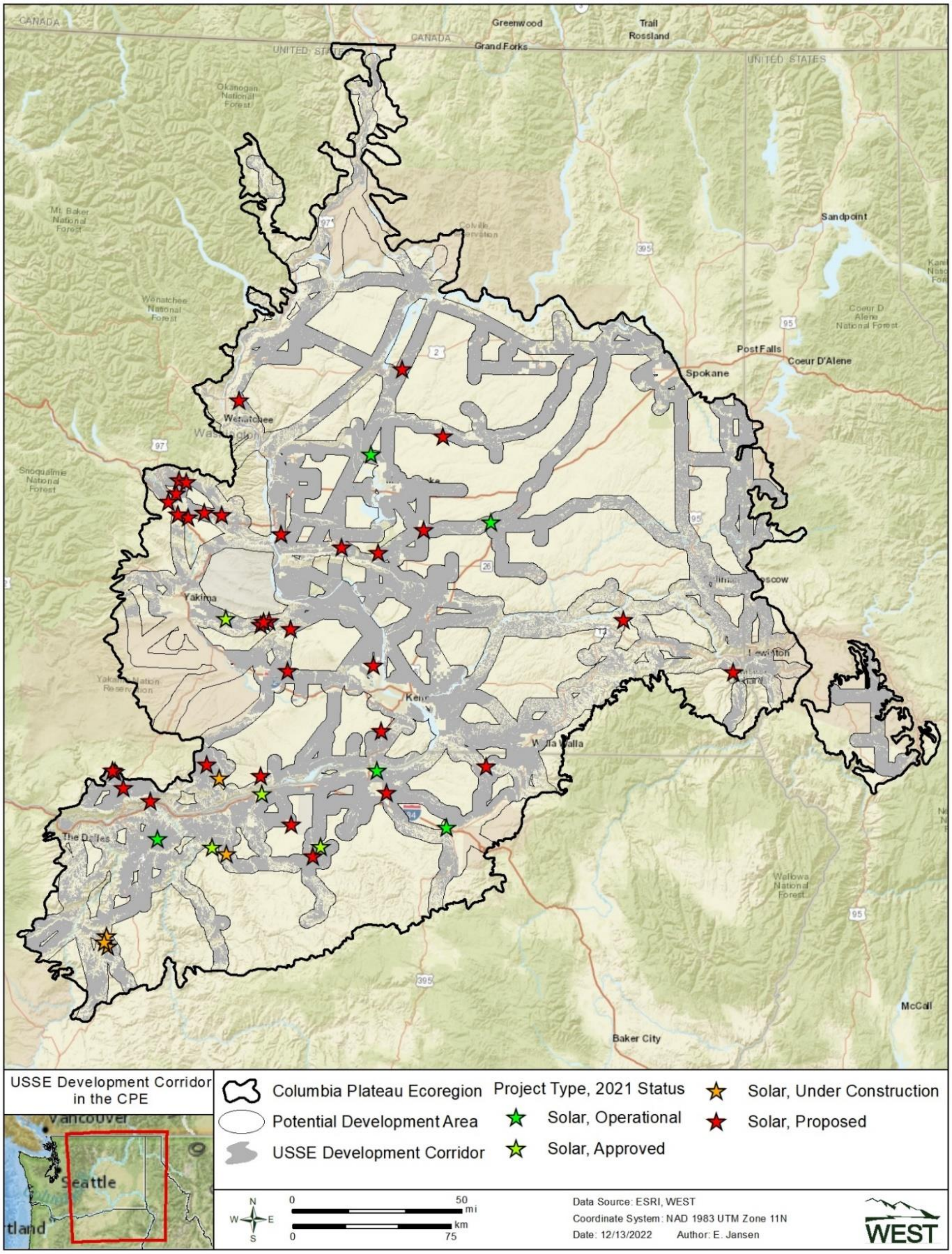

Figure 22. Location of USSE development within the development corridor.

4.5.1 Land Cover

Eight land cover types were located within the corridor, excluding developed and aquatic land cover types which were either exclusionary criteria or quantified by NWI data. Cropland, the most abundant land cover in the CPE, had the highest vulnerability index and nearly in equal proportion to the amount of cropland found outside the corridor (55%; *V* = -0.10; Table 18). Vulnerability indices were inconsistent with the relative abundance of land cover within the CPE. Approximately 20% of grasslands, the second most abundant land cover type in the CPE, was located inside the corridor (*V* = -0.60). However, shrub/scrub (e.g., shrub-steppe), the third most abundant land cover type in the CPE, was comparatively more abundant in the corridor (29%) than grasslands and had a higher vulnerability score (*V* = -0.42). Grasslands and shrub-steppe habitat have been identified as priority habitats in need of conservation (WDFW 2015, ODFW 2016). If avoidance is not possible, compensatory mitigation for impacts to grassland and shrub-steppe habitats from USSE construction would follow Oregon and Washington state mitigation policies[12].

In general, large areas of forested habitat are rare in the CPE and are typically confined to drainages or in larger stands at higher elevations around the periphery of the CPE (Figure 1). Because of their rarity, forested land cover types are also designated as conservation priorities that would follow the similar mitigation framework as grasslands and shrub-steppe. Of particular conservation interest are Deciduous and Mixed Forest land cover types predominantly composed of Oregon white oak (*Quercus garryana*). In Washington, the distribution was restricted to drainages and adjacent uplands in Klickitat, Kittitas, and Yakima counties on the western boundary of the CPE where approximately 22% (2.69 mi^2) was located within the corridor (*V* = -0.55). Future impacts to Oregon oak woodlands are unanticipated due to its distribution along drainages and immediately adjacent uplands, which USSE typically avoids.

Table 18. NLCD land cover types inside and outside the USSE development corridor within the Columbia Plateau Ecoregion. Excludes developed and aquatic land cover types.

Type	Inside Corridor		Outside Corridor			
	mi^2	%	mi^2	%	*V*	Total (mi^2)[1]
Cultivated Crops	5,688.6	0.45	6,973.7	0.55	-0.10	12,662.2
Hay/Pasture	211.7	0.40	312.0	0.60	-0.19	523.7
Shrub/Scrub	2,063.5	0.29	5,097.3	0.71	-0.42	7,160.8
Deciduous Forest	1.7	0.24	5.2	0.76	-0.51	6.9
Mixed Forest	0.5	0.22	1.9	0.78	-0.55	2.4
Herbaceous	1,781.0	0.20	7,210.1	0.80	-0.60	8,991.1
Barren Land	1.5	0.17	7.3	0.83	-0.67	8.8
Evergreen Forest	58.1	0.10	495.2	0.90	-0.79	553.3

[1.] rounding resulted in minor rounding errors.

Excluding lakes and ponds, the overall area of NWI wetlands within the corridor (36%) composed proportionately less area than outside the corridor (64%, *V* = -0.28; Table 19). The majority of wetlands within the corridor were freshwater emergent wetlands (96 mi^2) followed by riverine (90

[12] Oregon: OAR 635-415
Washington: WAC 463-60-332

mi^2) and freshwater forested/scrub wetlands (20 mi^2). The extent of wetlands typically followed a predictable pattern along drainage bottoms and lowlands where riverine and freshwater forested/ scrub wetlands were most abundant. Freshwater emergent wetlands were mostly located in the uplands within swales, potholes, and depressions and form biologically high-value playas, vernal pools, and alkaline depressions where rare plant species occur. Wetlands located within the uplands are most susceptible to impacts from USSE because development typically avoids drainage bottoms; however, roads and associated linear infrastructure may cross drainages where riverine and freshwater forested/scrub wetlands occur. If avoidance is not possible, compensatory mitigation for impacts to wetlands and other waters of the state would follow Oregon and Washington state mitigation policies[13] and related federal Clean Water Act regulations.

Table 19. NWI wetland types inside and outside the USSE development corridor within the Columbia Plateau Ecoregion.

	Inside Corridor		Outside Corridor			
Type	**mi^2**	**%**	**mi^2**	**%**	***V***	**Total (mi^2)**
Freshwater Emergent Wetland	96.3	0.41	137.2	0.59	-0.18	233.5
Freshwater Forested/Shrub Wetland	20.0	0.31	43.9	0.69	-0.37	63.9
Riverine	90.7	0.33	184.3	0.67	-0.34	275.0
Overall	207.0	0.36	365.5	0.64	-0.28	572.5

4.5.2 Important Bird Areas, Wildlife, and Rare Plant Species/Communities

4.5.2.1 Important Bird Areas

Thirty-one distinct areas classified as state- or globally-recognized IBAs comprise approximately 3,196 mi^2 (10%) of the CPE and 27% was located in the corridor (*V* = -0.46). Six State IBAs totaling 125 mi^2 were located entirely outside the corridor. Overall, there was comparatively more area of State IBA within the corridor than Global IBA (Table 20). Four State IBAs had a larger proportion of their boundary within the corridor than outside (*V* = 0.01–0.87; Table 20).

The largest, most contiguous area of State IBA within the corridor included the Boardman Grasslands in Gilliam and Morrow counties, Oregon, west of the Boardman Naval Systems Weapons Training Facility. Ranked the fourth largest IBA in the CPE, the corridor contained 61% of the 326 mi^2 Boardman Grasslands (*V* = 0.22). Despite a large BPA electrical transmission and interstate transportation corridor along the northern perimeter of the IBA and degraded rangelands in the west, native land cover types provide habitat for high concentrations of burrowing owl, grasshopper sparrow (*Ammodramus savannarum*), and long-billed curlew. Located in proximity to existing transmission corridors and load centers increases the suitability for USSE but may be incompatible with the conservation of grassland birds and habitat if USSE is sited in areas with higher conservation value. Three remaining IBAs with positive vulnerability scores were small areas strategically located around aquatic habitats that provide important overwintering habitat for high concentrations of waterfowl. Although located in the corridor, the

[13] Oregon: ORS 196.795-990
Washington: WAC 173-201A

small size of the IBAs and proximity to aquatic habitats decreases the potential of impacts from USSE development.

Of the two globally-recognized IBAs in the CPE, the majority of the Yakima Training Center was excluded due to federal ownership; however, approximately 30% (248 mi^2) of the Leahy-Junction – Moses Coulee IBA was within the corridor (*V* = -0.38; Table 20). The corridor is oriented parallel to Banks Lake, on the eastern edge of the IBA with several short corridors into the IBA. The IBA is recognized for its relatively larger sage-grouse subpopulation compared to other areas of Washington. USSE development, particularly within the IBA would affect year-round sage-grouse habitat and populations. Sage-grouse was included as a focal species and is discussed in further detail below.

Table 20. Audubon Important Bird Areas inside and outside the USSE development corridor within the Columbia Plateau Ecoregion. Ten IBAs with the highest vulnerability index (*V*) presented.

	Inside Corridor		Outside Corridor			
IBA Priority	**mi^2**	**%**	**mi^2**	**%**	***V***	**Total (mi^2)[1]**
State	577.2	0.30	1,378.0	0.70	-0.41	1,955.2
Global	277.7	0.22	962.7	0.78	-0.55	1,240.4
IBA Name						
Potholes Reservoir	2.9	0.94	0.2	0.06	0.87	3.1
Boardman Grasslands	199.0	0.61	127.3	0.39	0.22	326.2
Snake and Clearwater Rivers Confluence	1.2	0.60	0.8	0.40	0.21	2.1
Cold Springs National Wildlife Refuge	2.5	0.51	2.4	0.49	0.01	4.9
Columbia National Wildlife Refuge	39.2	0.44	50.9	0.56	-0.13	90.1
Columbia Hills	65.3	0.37	112.2	0.63	-0.26	177.5
Hanford Reach	11.9	0.34	23.0	0.66	-0.32	34.9
Lake Creek	161.5	0.32	343.4	0.68	-0.36	505.0
Antelope Creek Basin	2.0	0.32	4.3	0.68	-0.37	6.4
Leahy Junction - Moses Coulee	256.0	0.31	569.7	0.69	-0.38	825.7

1. rounding resulted in minor rounding errors.

4.5.2.2 Wildlife

Records of 89 species composed of 27,015 occurrences were found in the PHS database. Approximately 27% of the total number of occurrences in the PHS database were documented within the corridor (*V* = -0.46). Of the 89 wildlife species recorded in the CPE, 68 species (76%) occurred within the corridor. Species with the highest number of records included Columbia sharp-tailed grouse and sage-grouse (both state endangered) which had 5 to 10 times the records than the third most documented species, pygmy rabbit (*Brachylagus idahoensis*; federal and state endangered). Sage-grouse and sharp-tailed grouse have been the subjects of intense research due to their state endangered status, which resulted in comparatively more records in the CPE than other wildlife species. Both grouse species had low vulnerability scores with ≤ 25% of the records occurring in the corridor (Table 21). Three of the 20 species most frequently documented were recorded more often within the corridor than outside the corridor and included pygmy rabbit (*V* = 0.44), unidentified jackrabbit species (*Lepus* spp.; *V* = 0.53; state candidate), and sagebrush lizard (*Sceloporus graciosus*; *V* = 0.15; State Candidate; Table 21).

Considered a sagebrush-steppe obligate species, pygmy rabbit populations in the CPE are located within three recovery areas in Douglas and Grant counties, Washington (Hayes 2018). Reintroductions have occurred since 2011 to help species recovery, although populations remain small (<200 individuals) and continue to be impacted by disease and wildfire (Gallie and Hayes 2020). The majority of occurrences within the corridor were located in Douglas County, which is part of the Sagebrush Flats Recovery Area. Habitat fragmentation of sagebrush-steppe from USSE development would have additive cumulative effects to this small, geographically isolated population. USSE development within or immediately surrounding recovery areas should be avoided to minimize impacts to native habitat and population viability.

Signsof unidentified jackrabbit species was documented three times more often within the corridor than outside (V = 0.53; Table 21). The majority of records occurred in a geographically small cluster within Douglas County, Washington as part of a WDFW study in 2010. The majority (>98%) of occurrences consisted of pellets, followed by tracks, and observations of individuals. The occurrence of sign (pellets and tracks) does not necessarily correspond to relative species abundance within the corridor where one rabbit can be responsible for multiple sign. In fact, observations of individual white-tailed jackrabbit (*Lepus townsendii*; V = -0.31) and black-tailed jackrabbit (*L. californicus*; V = -0.58) were documented more often outside the corridor than within the corridor (Table 21). Spatial data of jackrabbit HCA and connectivity are available from WHCWG and can be used during the project development phase to minimize impacts to jackrabbit species.

Over half of the 157 occurrences of sagebrush lizard occurred within the corridor and were distributed throughout the CPE. Closely associated with unstabilized dunes intermixed with sandy shrub-steppe land cover, much of the historical land cover for sagebrush lizard has been lost to conversion for agricultural use or modified by non-native, invasive plant species (Green et al. 2001, Drake 2018). Wildfire and the resulting sweeping changes in plant communities post-fire have altered vast portions of once suitable habitat within the lizards' range (Drake 2018). Although USSE development has not been considered a primary threat (ODFW 2016, WDFW 2015), precautions can be taken to locate facilities away from dune and sandy shrub-steppe habitats to minimize impacts to sagebrush lizard populations.

One record of one species was documented within the corridor that was not located outside the corridor; Rocky Mountain tailed frog (*Ascaphus montanus*; State Candidate) was documented in the Walla Walla Valley. Primarily associated with aquatic habitats, the species in not expected to be impacted from USSE development.

Table 21. Washington Priority Habitat and Species records within and outside the USSE development corridor. Data sorted by 20 most abundant species inside the corridor. Bold species indicate species with higher proportion of records inside the corridor.

	Inside Corridor		Outside Corridor			
Common Name	**#**	**%**	**#**	**%**	***V***	**Total**
greater sage-grouse	2,657	0.25	7,915	0.75	-0.50	10,572
Columbian sharp-tailed grouse	791	0.15	4,491	0.85	-0.70	5,282
pygmy rabbit	**716**	**0.72**	**279**	**0.28**	**0.44**	**995**
loggerhead shrike	452	0.47	503	0.53	-0.05	955
burrowing owl	444	0.46	515	0.54	-0.07	959
Northern leopard frog	354	0.44	448	0.56	-0.12	802
Western gray squirrel	285	0.31	637	0.69	-0.38	922
sage thrasher	183	0.28	460	0.72	-0.43	643
jackrabbit spp.	**168**	**0.76**	**52**	**0.24**	**0.53**	**220**
ring-necked pheasant	155	0.37	268	0.63	-0.27	423
sagebrush sparrow	149	0.25	440	0.75	-0.49	589
white-tailed jackrabbit	146	0.34	280	0.66	-0.31	426
ferruginous hawk	106	0.19	441	0.81	-0.61	547
sagebrush lizard	**90**	**0.57**	**67**	**0.43**	**0.15**	**157**
Washington ground squirrel	83	0.14	518	0.86	-0.72	601
black-tailed jackrabbit	42	0.21	160	0.79	-0.58	202
Yuma myotis	34	0.20	134	0.80	-0.60	168
Western small-footed myotis	31	0.15	174	0.85	-0.70	205
little brown bat	29	0.19	120	0.81	-0.61	149
Columbia spotted frog	27	0.32	57	0.68	-0.36	84

Records of 21 species were located entirely outside the corridor. Primary habitat associations of species outside the corridor included aquatic (10 species), forested (9 species) and canyon (1 species) habitats typically unconducive to USSE development. One record of one shrub-steppe and grassland associated species was documented outside the corridor and consisted of hundreds of giant Palouse earthworms (*Driloleirus americanus*; State Candidate) in the uplands above the Columbia River in Chelan County.

4.5.2.2.1 Focal Species: Rocky Mountain Mule Deer

An iconic symbol of the American West, mule deer represent an important component of the cultural, recreational, and ecological structure in the CPE (Meyers 2012). To utilize resources, mule deer exhibit seasonal movements that vary in distance and elevation, depending on the herd, but can migrate long distances between summer and winter ranges making connectivity between these areas a topic of conservation concern (Wakeling et al. 2015).

Photo 15. Mule deer in a CRP field with wind turbines on the horizon, Klickitat County, Washington, May 2020.

Fifty-five discrete HCAs composing approximately 6,527 mi^2 was modeled within the CPE. Despite a comparatively small overall total area of HCAs located within the corridor (10%; V = -0.81), portions of 48 of the 55 HCAs (87%) were located within the corridor. There was high variability around the average proportion of the HCA's located within the corridor (12 ± 11%, range: <1%−42%). The largest HCA (418 mi^2) with the highest proportion (25%) within the corridor was located along the Snake River breaks within Columbia, Garfield, and Walla Walla counties, Washington. All HCAs had a greater proportion of their total area located outside the corridor (V < 0.01). The most effected HCAs included 19.7 mi^2 (V = -0.197) in the Lake Creek area of northcentral Lincoln County, Washington. There was a poor correlation between the vulnerability score and the total size of the HCA (R^2 = <0.001), suggesting the proportion of the HCA within the corridor was independent of the total area of the HCA. Overall, HCAs in Washington had a higher proportion within the corridor than HCAs in Oregon where HCA are grouped at higher elevations along the southern boundary of the CPE, bordering the Blue Mountains Ecoregion.

One hundred discrete LCP composing approximately 1,725 mi was modeled in the CPE. Although there was a greater overall proportion of LCPs outside the corridor (V = -0.34), 23 of 100 LCPs were disproportionately affected totaling approximately 394 mi (Table 22). Of the 23 LCPs with V > 0.5, the average proportion was comparatively higher (63 ± 8%, range: 50−78%) than the proportion of HCA within the corridor. The longest LCP (66 mi) with the highest proportion (40%) within the corridor connects the largest HCA along the Snake River breaks within Columbia, Garfield, and Walla Walla counties with the Rattlesnake Hills HCA in northern Benton County, Washington. There was a poor correlation between the vulnerability score and the total length of the LCP (R^2 = 0.06), suggesting the proportion of the LCP within the corridor was independent of the total LCP length. Washington had a greater proportion of LCPs within the corridor than Oregon and the LCPs were spatially grouped in higher concentrations within the northcentral portion of the CPE in Adams, Douglas, Grant, and Lincoln counties. Seven of the 10 LCPs with the highest vulnerability score were less than 4 mi long, indicating short LCPs connecting close groups of HCAs may have a comparatively larger affect to their continuity than larger HCAs with multiple LCPs.

Although mule deer populations within the CPE appear stable and support recreational hunting, impacts to the species and habitats are considered by ODFW and WDFW during USSE development. Mule deer HCAs represent some of the remaining contiguous areas of intact shrub-steppe and channelized scablands necessary to support this widespread species with seasonal movements throughout the CPE (Myers 2013). Although HCAs were widely distributed around the CPE, biological and human-made barriers constrict the connectivity corridors between HCAs, which are essential to seasonal dispersal, gene flow and sub-population viability. Models indicate some state highways and wide water courses present the strongest barriers to mule deer movement (Myers 2013). However, impacts that further reduce access to seasonal habitats or restrict connectivity may compound existing stressors to mule deer populations (Wakeling et al. 2015).

Secretarial Order 3362 provided guidance and financial incentive for states in the CPE to enhance and improve the quality of big-game winter range and migration corridors on federal and state lands, while recognizing private property rights (USDOI 2018). Within the CPE, WDFW has implemented restoration projects that include fence modification in the Moses Coulee area, incentivizing SAFE Program participation and habitat restoration along the Crab Creek drainage in Grant County to enhance connectivity between HCAs (WAFWA 2019). ODFW continues planning and prioritization efforts (ODFW 2019). Future USSE development within the CPE can utilize spatial data from WHCWG and leverage knowledge from resource agencies with site-specific field surveys to minimize cumulative impacts to connectivity corridors or on-going conservation efforts to improve big-game habitat.

Table 22. Mule deer least cost pathways with a positive vulnerability score documented within the USSE development corridor in the Columbia Plateau Ecoregion.

	Inside Corridor		Outside Corridor			
LCP ID[1]	mile	%	mile	%	V	Total (mi)
54	8.7	0.78	2.5	0.22	0.56	11.2
124	1.9	0.76	0.6	0.24	0.52	2.5
1	2.0	0.76	0.6	0.24	0.51	2.6
111	0.5	0.71	0.2	0.29	0.41	0.7
63	2.5	0.69	1.1	0.31	0.38	3.6
3	1.9	0.68	0.9	0.32	0.37	2.8
46	1.3	0.68	0.6	0.32	0.36	1.9
80	4.6	0.65	2.5	0.35	0.30	7.0
51	10.4	0.63	6.0	0.37	0.27	16.4
7	1.0	0.63	0.6	0.37	0.25	1.6
86	13.3	0.62	8.0	0.38	0.25	21.4
150	24.5	0.62	15.0	0.38	0.24	39.5
72	6.2	0.62	3.8	0.38	0.24	10.0
94	28.1	0.60	18.5	0.40	0.21	46.6
129	39.6	0.60	26.8	0.40	0.19	66.4
67	3.3	0.59	2.2	0.41	0.19	5.5
100	15.3	0.59	10.6	0.41	0.18	25.8
76	22.1	0.57	16.9	0.43	0.13	39.0
65	5.2	0.55	4.2	0.45	0.11	9.3
179	0.6	0.52	0.5	0.48	0.03	1.1
96	34.5	0.52	32.5	0.48	0.03	67.0
70	6.0	0.51	5.8	0.49	0.01	11.8
119	0.3	0.50	0.3	0.50	0.00	0.6

1. Myers 2012 for location of LCP corridors

4.5.2.2.2 Focal Species: Greater Sage-grouse

A shrub-steppe obligate species, sage-grouse populations in the CPE have been relegated to three subpopulations with a total of 775 birds at 21 leks as of 2020 (Stinson 2021). The species can have large home ranges and are mostly reliant on large areas of shrub-steppe for all stages in their life cycle (Knick and Connelly 2011).

Four discrete HCAs composing approximately 1,440 mi^2 were modeled within the CPE; however, a reintroduced population by the Yakama Nation was lost between 2018–2019 (Table 23; Stinson 2021). Despite a comparatively small overall total area of HCAs located within the corridor (17%; V = -0.66), portions of all HCAs were located within the corridor. There was high variability in the proportions of the HCA located within the corridor (mean = 16% ± 14%, range: 1−34%). The largest HCA (724 mi^2) that had the second highest proportion within the corridor was the Moses Coulee – Mansfield Plateau HCA located in Douglas County, Washington. The largest populations within the CPE are located within the Moses Coulee – Mansfield Plateau HCA. The HCA with the greatest proportion within the corridor included 54.2 mi^2 (V = -0.33) of the Crab Creek area in northcentral Lincoln County, Washington (Table 23). There was a poor correlation between the vulnerability score and the total size of the HCA (R^2 = <0.01), suggesting the proportion of the HCA within the corridor was independent of the total area of the HCA.

Table 23. Greater sage-grouse habitat concentration areas inside and outside the USSE development corridor within the Columbia Plateau Ecoregion.

		Inside Corridor		Outside Corridor			
HCA ID[1]	HCA Name	mi^2	%	mi^2	%	V	Total (mi^2)
1	Crab Creek	54.2	0.34	107.0	0.66	-0.33	161.2
2	Moses Coulee – Mansfield Plateau	143.8	0.20	577.6	0.80	-0.60	721.4
6	Yakima Training Center	45.6	0.10	393.7	0.90	-0.79	439.4
7[2]	Toppenish Ridge	1.6	0.01	116.1	0.99	-0.97	117.8

1. Robb and Schroeder (2012) for locations of HCAs.
2. Yakama Nation reintroduction believed extirpated in 2018–2019 (Stinson 2021).

Three discrete LCPs composing approximately 146 mi were modeled within the CPE. Despite a greater overall proportion (86%) of connections located outside the corridor, portions of all three LCPs were within the corridor (Table 24). The LCP with the highest proportion within the corridor was between the Moses Coulee – Mansfield Plateau HCA and Crab Creek HCP (29%, Table 24). The longest LCP was between the Yakama Training Center and Toppenish Ridge, where populations are believed to be extirpated. The correlation between the vulnerability score and the total length of the LCP was uninformative due to the low sample size; however, impacts from development within LCPs that hamper connectivity or survival are likely biologically meaningful due to the small overall population size and importance of gene flow between subpopulations (Robb and Schroeder 2012).

Table 24. Greater sage-grouse least cost pathways inside and outside the USSE development corridor within the Columbia Plateau Ecoregion.

LCP ID[1]	HCA Connection[2]	Inside Corridor mi	Inside Corridor %	Outside Corridor mi	Outside Corridor %	V	Total (mi)
1	1-2	12.2	0.29	29.9	0.71	-0.42	42.0
4	2-6	3.7	0.09	39.0	0.91	-0.83	42.8
5	6-7	4.8	0.08	56.0	0.92	-0.84	60.9

1. Robb and Schroeder (2012) for locations of LCPs.
2. HCA IDs connected by the LCP.

Photo 16. Shrub-steppe habitat near the Toppenish Ridge sage-grouse population on the Yakama Nation, Yakima County, Washington, April 2017.

In 2020, wildfires burned tens of thousands of acres of eastern Washington sage-grouse habitat. Habitat loss was the single greatest threat to this species and was exacerbated by the immediate threat of wildfire. WDFW estimates the full impacts to grouse populations may not be known for two to three years but fires may eventually reduce the number of greater sage-grouse by 30 to 70 percent, bringing the statewide population dangerously low (Stinson 2021). Reintroductions into the Toppenish Ridge subpopulation and Crab Creek subpopulations are believed to have failed. The overall outlook for greater sage-grouse population sustainability in the CPE appears dire, with nearly all subpopulations trending downward and some trending toward extinction (Stinson 2021). Impacts from future USSE development in and surrounding populations with suitable sage-grouse habitat (sagebrush dominant shrub-steppe grasslands) are likely cumulative to the host of other environmental stressors on the landscape and should be avoided.

4.5.2.3 Rare Plants Species/Communities

Approximately 82% (100 species) of the 122 rare plant species within the CPE had at least one record within the corridor. The majority of rare plants in the corridor are listed by WDNR as threatened (51%), followed by sensitive (34%) and endangered (15%). Of these species, four are listed by the USFWS as federally threatened. Records of two species, rosy pussypaws (*Calyptridium roseum*, state threatened) and shortstemmed mousetail (*Myosurus sessilis*, state endangered), were only documented within the corridor and composed approximately 0.8 mi^2. Records of rosy pussypaws were limited to the area of the Hanford Nuclear Site and shortstemmed moustail is a vernal pool obligate with a restricted distribution in the northeastern corner of the CPE. Records of 11 rare plant species were located in greater proportion within the corridor than outside (Table 25). Gray cryptantha (*Cryptantha leucophaea*, state threatened) had the largest area within corridor with approximately 52% of records within the corridor (V = 0.03; Table 25). Associated with sandy areas in shrub-steppe and grassland habitats, this species is comparatively more vulnerable from USSE because of its broad distribution throughout the central portion of the CPE and narrow habitat niche that requires wind-derived movement of open sands (Camp and Gamon 2011). Although gray cryptantha had the largest area documented in the corridor, the species was sixth most documented rare plant in the CPE. This relationship shows the spatial heterogeneity in the distribution of rare plants in the CPE.

Table 25. WDNR rare plant species documented in the corridor with a positive vulnerability score (*V*).

Common Name Scientific Name	WDNR Status[1]	Inside Corridor mi²	Inside Corridor %	Outside Corridor mi²	Outside Corridor %	*V*	Total (mi²)
Columbia crazyweed *Oxytropis campestris var. columbiana*	E	0.1	1.00	0.0	0.00	0.99	0.1
Thompson's sandwort *Eremogone franklinii var. thompsonii*	S	4.5	0.97	0.1	0.03	0.94	4.6
arrow thelypody *Thelypodium sagittatum sagittatum*	T	0.6	0.90	0.1	0.10	0.80	0.7
spreading pygmyleaf *Loeflingia squarrosa*	T	2.9	0.88	0.4	0.12	0.76	3.2
red poverty-weed *Micromonolepis pusilla*	T	0.7	0.77	0.2	0.23	0.55	1.0
delicate gilia *Lathrocasis tenerrima*	T	1.1	0.73	0.4	0.27	0.47	1.5
hairy bugseed *Corispermum villosum*	S	1.4	0.68	0.7	0.32	0.36	2.1
Great Basin gilia *Aliciella leptomeria*	T	1.0	0.57	0.7	0.43	0.15	1.7
woven-spore lichen *Texosporium sancti-jacobi*	T	0.6	0.55	0.5	0.45	0.09	1.0
ribseed biscuitroot *Lomatium tamanitchii*	S	1.2	0.52	1.1	0.48	0.03	2.3
gray cryptantha *Cryptantha leucophaea*	T	10.6	0.52	9.9	0.48	0.03	20.5

1. E = Endangered; T = Threatened; S = Sensitive

Sixty-six of the 100 high-quality plant communities documented in the CPE also occurred in the corridor. Although WDNR does not assign regulatory status to high-quality plant communities, high-quality native plant communities may contain rare plant species, and ODFW and WDFW consider generalized habitat types (e.g., grasslands, oak woodlands, shrub-steppe) would qualify for compensatory habitat mitigation (*see* Section 4.4.1). Records of one plant community, streamside wildrye (*Elymus lanceolatus*)/needle-and-thread was only documented in the corridor and composed approximately 0.12 mi². This high-value plant community is associated with inland sand dunes with one record near the Desert Unit of the South Columbia Basin State Wildlife Recreation Area in Grant County, Washington. The most abundant vegetation communities are likely the most vulnerable to USSE where 69–75% of the Antelope Bitterbrush (*Purshia tridentata*)/Indian Ricegrass (*Achnatherum hymenoides*) and Wyoming Big Sagebrush (*Artemisia tridentata* ssp. *wyomingensis*)/Needle-and-thread shrublands were within the corridor, primarily in northern Benton County and southern Grant County, Washington, and both are associated with shrub-steppe habitat (Table 26). Potential effects from USSE development increases for larger-sized high-value plant communities that have a greater proportion of their area within the corridor.

Table 26. High-value plant communities documented in the corridor with a positive vulnerability score (*V*). Sorted by descending order for plant communities with greater proportion (*V*) of the documented area within the corridor.

Plant Community[1]	Inside Corridor		Outside Corridor			
	mi^2	%	mi^2	%	*V*	Total
Needle-and-thread Grassland	2.0	0.99	< 0.01	0.01	0.99	2.0
Ponderosa Pine Forest	< 0.01	0.99	< 0.01	0.01	0.98	< 0.01
Oregon White Oak - Ponderosa Pine Forest	0.1	0.96	< 0.01	0.04	0.92	0.1
Greasewood/Saltgrass Wet Shrubland	0.2	0.95	< 0.01	0.05	0.91	0.2
Clustered Field Sedge Wet Meadow	< 0.01	0.91	< 0.01	0.09	0.82	< 0.01
Sandbar Willow/Field Horsetail Shrubland Wet Shrubland	< 0.01	0.89	< 0.01	0.11	0.79	< 0.01
Bitterbrush/Indian Ricegrass	12.7	0.75	4.1	0.25	0.51	16.8
Wyoming Big Sagebrush/Needle-and-thread	11.3	0.69	5.1	0.31	0.38	16.4
Sand Dropseed - Sandberg's Bluegrass	0.4	0.68	0.2	0.32	0.37	0.6
Black Cottonwood/Western Water-hemlock Riparian Forest	< 0.01	0.67	< 0.01	0.33	0.35	0.1
Saltgrass Alkaline Wet Meadow	< 0.01	0.63	< 0.01	0.37	0.26	< 0.1
Bluebunch Wheatgrass - Sandberg's Bluegrass	0.6	0.63	0.4	0.37	0.26	1.0
Douglas' Buckwheat/Sandberg's Bluegrass	0.5	0.55	0.4	0.45	0.10	1.0

1. Common species names provided. Classification follows US National Vegetation Classification Group and Associations. Detailed descriptions of plant communities are provided by Rocchio and Crawford (2015)

5 DISCUSSION

5.1 Wind Energy and Avian Mortality

Our assessment summarized over 20 years of PCFM data at wind energy facilities in the CPE and evaluated the potential cumulative direct impacts to bird and bat populations. Species composition and seasonal patterns of bird and bat mortality from wind energy were similar to patterns reported over one decade ago (Johnson and Erickson 2011) and consistent with patterns documented on a broader scale at wind energy facilities throughout the western US (AWWI 2020, WEST 2021). Compared to Johnson and Erickson (2011), mean fatalities/MW were slightly higher (8.8%) for the All Bird group, increased 50% for the Raptor group, and decreased 5.3% for the Bat group; however, species composition by group (i.e., Passerine, Upland Game Bird, migratory tree roosting bat, etc.) was similar. Results of the analysis suggested no significant population level effects are likely associated with species most often found during PCFM (Passerines) based on the small proportion of the robust populations affected. In an analysis of 116 PCFM studies throughout the US, Erickson et al. (2014) found Passerines composed 62.5% of all fatalities; however, the cumulative species-specific effects from wind mortality affected <0.1% of the populations. When bird population sizes were proportionally adjusted for populations assumed to occur in the CPE, results from this study were consistent with population-level affects calculated at larger spatial scales. PCFM are typically performed by humans which studies have shown to underestimate the true number of fatalities compared to dogs, which have a higher detection probability, particularly for smaller-sized species (Mathews et al. 2013, Reyes et al. 2016, Smallwood et al. 2020). Assuming fatality estimates of horned lark, the species most often found during PCFM in the CPE, are doubled or tripled, population-level effects of collision mortality would still result in affecting <1% of the population. However, conservation initiatives generally do not focus on abundant, wide-ranging species with robust populations. Rather, future concerns will undoubtedly focus on species found ‘in the middle’, where species mortality is not prevalent but because of their population size and life-history traits, mortality levels may be a source of conservation concern.

To address the ecological and conservation significance of wind energy mortality, permitting authorities have attempted to set mortality thresholds where exceedance would result in remedial measures to minimize or compensate for impacts. Examples include the European Union (EU) who set mortality limits ranging from 1–5% of the overall annual natural mortality in the relevant biogeographical populations, depending on species and county (European-Commission 1993, Backes and Akerboom 2018). The USFWS set a cumulative limit of 5% of populations for golden eagle and bald eagle take within a particular LAP or EMU (USFWS 2016).

In Oregon, facilities permitted by EFSC adhere to ‘thresholds of concern’ for sensitive groups that include All Raptors, Raptor Species of Concern, Grassland Birds, State Sensitive Birds, and Bats. EFSC recognizes the thresholds are a rough measure to inform Council intervention and based on limited scientific basis (EFSC 2006). Thresholds of concern are defined as annual fatalities/MW and are essentially an indicator used to compare facility-level impacts with average fatality rates within the region. EFSC thresholds are currently 28% below the mean fatality rate calculated for raptors (0.09 raptors/yr/MW) and 79% higher than the mean fatality rate for bats (2.5 bats/yr/MW; Table 9). In this analysis, EFSC group fatality rates were not calculated for other groups (e.g., Raptor Species of Special Concern, Grassland Species, State Sensitive Species), but future work can help calibrate thresholds to align with contemporary mortality levels and species of conservation concern using more sophisticated analytical methods.

In their assessment of mortality thresholds in the EU, Schippers et al. (2020) used potential biological removal (PBR) models to predict population trajectories for eight species ranging from European starling to white-tailed eagle (*Haliaeetus albicilla*) as a result of incremental increases in mortality. Researchers found small changes in mortality had disproportionate effects on population trends over 10 years, particularly for long-lived species with low reproductive rates that would be more sensitive to increases in adult mortality and less able to compensate by increasing reproduction (K-selected; Schippers et al. 2020). Using PBR, Diffendorfer et al. (2021) studied the response of 14 raptor species to wind energy development scenarios in the US and found greater susceptibility to population changes for barn owl, ferruginous hawk, golden eagle, American kestrel, and red-tailed hawk, whereas burrowing owl, Cooper’s hawk (*Accipiter cooperii*), great horned owl (*Bubo virginianus*), northern harrier (*Circus hudsonius*), turkey vulture, and osprey had a relatively lower potential for population impacts.

In a comparative risk assessment of 428 species from wind energy development that incorporated both direct and indirect impacts to breeding birds in the US, Beston et al. (2016) found raptors, specifically long-eared owl (*Asio otus*), ferruginous hawk, Swainson’s hawk, and golden eagle to be more susceptible to population impacts than species in the Passerine group. The patterns found by Diffendorfer et al. (2021) and Beston et al. (2016) were largely reflected in this assessment where species with low populations and sustained mortality such as golden eagle and ferruginous hawk may be more susceptible to cumulative impacts from renewable wind energy development in the CPE.

5.2 USSE and Renewable Energy Land Use

Our solar energy resource assessment modeled sensitive resources where USSE development is most likely to occur and identified resources that would potentially be affected. Our assessment identified pygmy rabbit and sagebrush lizard as species more likely to be affected by USSE, based on the greater proportion of records within the development corridor than outside the corridor. Records of 11 rare plants and 13 ecologically high-value plant communities were found in greater proportions within the corridor than outside. Sensitive plant species and communities that have a larger distribution or area within the corridor have a higher likelihood to be affected; in particular, species and communities with limited distribution or small extent that are only located within the corridor have the highest potential for deleterious cumulative impacts from development. For example, approximately 75% (12.7 ac) of Bitterbrush/Indian Ricegrass plant community was found within the corridor. Impacts to this high-value plant community are relatively higher than the small distribution of needle-and-thread grassland (2 ac); however, nearly all recorded occurrences of needle-and-thread grasslands were found within the corridor. Although less likely to be impacted, the limited extent of needle-and-thread grasslands that only occur within the corridor warrants increased conservation concern.

With sensitive plant and vegetation communities identified, early project development can integrate these data into project siting decision that avoid sensitive resources. The occurrence of sensitive resources in publicly-available spatial layers do not represent a systematic sample of resources in the CPE; rather, the data reflect opportunistic reports/observations or focal surveys in specific areas that were part of research studies. Therefore, desktop project-specific assessments should always be supplemented with field surveys that identify, quantify, or delineate sensitive resources following the tiered approach described in various guidelines and protocols (e.g., WDFW 2009; USFWS 2012, 2013; Fertig 2020). Not all resources with a negative *V*-score merit a lower conservation concern. Although there was proportionally less shrub-steppe land cover within the corridor, overall shrub-steppe land cover decreased approximately 13% in the CPE from 2006–2019 and nearly 80% of its historical range has been lost in Washington (Azerrad et al. 2011). Combined with the reliance of various shrub-steppe obligate wildlife species, and long regeneration time to recover degraded or deteriorated stands, avoidance of shrub-steppe land cover should be a priority when siting renewable energy projects in the CPE.

An expanding USSE sector in the CPE will include blocks of land where solar arrays, inverters, access roads, electrical systems and related infrastructure are consolidated. The amount of land necessary for USSE to achieve renewable energy objectives will be limited, in part, by the technological efficiency of the solar arrays. In a study of 736 USSE facilities in the US installed from 2007–2019, the median power density (MW Direct Current [$_{DC}$]/ac) of fixed-tilt solar arrays was 0.35 MW_{DC}/ac and 0.24 MW_{DC}/ac for tracking arrays that reposition themselves according to the orientation of the sun (Bolinger and Bolinger 2022). Thus, 1 MW of solar energy produced from tracking arrays would require approximately 4.2 ac. Based on power densities reported by

Bolinger and Bolinger (2022) and assuming tracking arrays will be the prevalent technology used in the CPE, approximately 16,667–25,000 ac of new USSE arrays (excludes infrastructure) would be needed in the CPE, depending on development scenario. The amount of land estimated for new USSE arrays represents 0.25–0.38% of the total area modeled within the corridor (6,656,980 ac). This land use estimate excludes other infrastructure associated with USSE including roads, electrical substations, operations and maintenance buildings, if not already constructed for a co-located wind energy facility, and does not include the biological effects from fencing or other indirect effects.

Future advances in solar technology will increase power densities resulting in less land necessary for equivalent levels of energy generation. Bolinger and Bolinger (2022) estimates of power density underrepresented bifacial solar arrays which did not significantly infiltrate the USSE industry by 2019, and represented the last year of their sample period. Bifacial solar arrays maximize energy generation by utilizing reflected irradiation on the underside of the solar panels and could have a significant influence of the land needed for USSE development (Bolinger and Bolinger 2022). In addition, co-location of USSE (and battery storage) within the footprint of existing wind energy facilities provides efficiencies in leveraging existing infrastructure (i.e., access roads, electrical distribution lines, substitutions) and also minimizes new greenfield development in areas where no development exists (Pattison 2015). In an assessment of 39 facilities in the US, the total amount of land transformed by the development of a wind energy facility varied substantially from 0.27 to 10.6 ac/MW of installed capacity, which may constitute 5% to 10% of the total project area (Diffendorfer and Compton 2014). Assuming the average land use estimate of 0.74 ac/MW from 172 wind energy facilities within the US, approximately 2,960–4,440 ac of new wind energy development would be needed (Denholm et al. 2009). Thus, spacing between and among turbines inherent in wind energy facility designs provides co-location opportunities. Although land use intensity has the potential to increase at co-located facilities, consolidating technologies increases energy security, reduces costs and most importantly, reduces the extent of new development across the landscape (Boroski 2019).

5.3 Indirect Effects

Our assessment focused on direct impacts to bird and bat populations from turbine collision and direct impacts to land cover and vegetation from USSE. However, indirect impacts from habitat fragmentation or loss and species avoidance or displacement that result in reduced survival or reproductive productivity can also impact populations. Combined with direct effects, indirect effects can be amplified, particularly for small populations or species that occupy a small ecological niche such as sagebrush obligate species. Greater sage-grouse are an example of a species that requires large areas of shrub-steppe and has small, isolated subpopulations with tenuous population levels (Stinson 2021). Development activities that modify the landscape can change predator communities, habitat quality/selection, sage-grouse movement and survival rates (Doherty et al. 2011; LeBeau et al. 2014, 2017; Gibson et al. 2018). In Washington, sage-grouse nest locations were located further away from distribution lines (~12kV) and contained greater shrub cover (Stonehouse et al. 2015). LeBeau et al. (2019) found that transmission lines had a negative effect on sage-grouse habitat selection and survival. However, the authors determined that the effect varied by proximity to occupied leks and habitat suitability, suggesting that the magnitude of effects may be minimized by siting transmission lines in unsuitable habitats when they occur within 1.9 mi from an occupied lek (LeBeau et al. 2019). Another example of a species with a small population and vulnerable to indirect effects is ferruginous hawk, which simulations have shown population trends declining at greater rates due to permanent loss of suitable nesting territories compared to collision mortality in the Washington nesting population (Jansen and Swenson 2022).

Indirect effects sustained by already struggling populations may compound existing environmental stressors and have cumulative effect on population growth when combined with other environmental stressors. Spatial and temporal buffers surrounding areas of biological importance (e.g., nesting territories, breeding or roosting areas or areas of high concentrations) can be implemented during construction or operation that minimize the potential for indirect effects (Romin and Muck 1999, Larson et al. 2004, ODFW 2008)

The effects of renewable energy development on big game is a concern, particularly the interruption of movement and connectivity corridors to seasonal winter and summer ranges (Lutz et al. 2011, Wakeling et al. 2018). In a 17-year study of mule deer response to oil and gas development in Wyoming, mule deer were less abundant and avoided development up to 0.6 mi even after restoration efforts were completed (Sawyer et al. 2017). Although the study did not measure the demographic response of mule deer, oil and gas development has a much higher land use intensity than wind energy and patterns of mule deer avoidance and reduced recruitment have been documented (Sawyer et al. 2013, Johnson et al. 2017, Wyckoff et al. 2018). Disruption to movement corridors connecting seasonal ranges (defined as LCPs in this study) can increase energy expenditure and alter migratory routes that may increase exposure to impacts for both resident and migratory herds (Sawyer et al. 2020). Fences surrounding USSE and land parcels have been shown to limit pronghorn (*Antilocapra americana*) movement and habitat connectivity (Jones et al. 2019, Reinking et al. 2019, Sawyer et al. 2022). Combined with project-level assessments, remotely sensed spatial data similar to products from the WHCWG can be used to site projects that avoid impacts to movement and connectivity and minimize potential indirect impacts from renewable energy development. A more comprehensive review of indirect impact potential on bird and bat populations due to renewable energy development can be found in Beston et al. (2016) and Moorman et al. (2016).

5.4 Toward 2030 and Beyond

The effects of renewable energy development on wildlife and other environmental resources cannot be consolidated into a winners and losers framework (Rand and Hoen 2017). Relative impacts to birds and bats should be viewed upon a spectrum in conjunction with other stressors in the environment where proactive measures may manifest into conservation outcomes that supersede the marginal relative benefits from minimization measures proposed at renewable energy facilities. For example, mortality from building collisions are magnitudes higher than wind energy-derived mortality (Loss et. al. 2014). Realization of on-going initiatives to darken night skies from artificial night would reduce collision rates of neotropical migrants and reestablish disrupted migratory routes (Korpach et al. 2022, Sordello et al. 2022). The basis of species recovery plans outline holistic approaches to species conservation that address multiple conservation concerns. For example, WDFW discussed a range of conservation efforts needed for ferruginous hawk that included installment of artificial nest platforms, comprehensive monitoring and research, increased funding and emphasis placed on habitat management and enhancement programs, reduced application of industrial chemicals, and strategic conservation planning that minimizes human encroachment into unfragmented native habitats (Richardson 1996, Hayes and Watson 2021). Mitigation of stressors that affect wildlife, plants, and habitat should be implemented across the broad range of factors within the human-built environment in order to maintain viability of local populations over time.

Looking toward the future, energy generation within the CPE will continue to be bolstered by the region’s large amount of hydropower, nuclear, and traditional thermal resources including those that burn natural gas and coal (NPCC 2021). Success in meeting state-mandated renewable energy goals in the CPE will depend on technological advances in energy efficiency, battery storage, optimization in electrical distribution loads and capacity. If projections hold, renewable energy development in the CPE is beginning another period of intense development pressure, similar or greater to what was observed in the 2000s. The balance between energy efficiency and ecological integrity and conservation will rely on clear and consistent guidance from regulatory agencies that developers can use to develop, construct, operate, and decommission energy facilities in a manner that is consistent with current environmental conditions.

Wind energy guidance for wildlife and habitats in Oregon and Washington are over a decade old and solar energy guidance is absent (ODFW 2008, WDFW 2009). Advances in Oregon to map wildlife connectivity and linkages, similar to WHCWG (2012), are promising but currently lack directives that synchronize with renewable energy guidance and wildlife issues (ODFW 2019). In conversations with participants during the development of this assessment, two common themes emerged that could be grouped into two general categories that deal with processes and systems. In general, *processes* were related to guidance and implementation of environmental policies whereas *systems* were related to the opportunities and challenges in energy generation, storage, and distribution. System concerns included repowering, strategic placement of battery storage, advances in energy efficiency, and transmission queue issues but are outside the scope of this assessment. Reflecting process-oriented recommendations from the study participants and previous researchers (Allison et al. 2019, Copping et al. 2020, Conkling et al. 2021), processes that would improve future cumulative impact assessments include:

- Updating wind energy development guidelines using contemporary science, methods and metrics to facilitate consistent and measurable outcomes throughout the project life-span.
- Developing USSE policy, procedure, and guidance/guidelines that provide clear, measurable, replicable science-based methods and metrics.
- Allocating greater funding to resource agencies to develop or update state- or county-specific distributions of sensitive resources that can be used to proactively identify sensitive resources early in the development process.
- Encouraging and funding long-term, systematic sampling of bat populations within the CPE such as NABat protocols.

- Developing spatial data layers of sensitive species and resources with uniform spatial accuracy and resolution, similar to CPE products available from WHCWG.
- Facilitating the exchange of information in a way that provides a non-punitive process to collect and aggregate data in a manner that allows informed analyses and adaptive management in siting decisions and analyses.

Biologically, the CPE represents a unique ecosphere carved out by the epic Missoula Floods and bound in all directions by different habitats, higher elevations, and different wildlife and plant species associations. Energetically, the CPE represents a discrete geographic renewable resource area in the Pacific Northwest that maximizes energy generation in the broader WECC which supplies the western US with its growing energy demands. Despite biological and energetic uniformity, the CPE is fractured by multiple scales of administrative boundaries, each with different policies, procedures, and guidance. The majority of the CPE encompasses two states with two separate state-level permitting Councils, a handful of various resource agencies, and 25 different counties (excluding Idaho) with their own Comprehensive Management Plans and local regulations. The discontinuity between the biological similarities within the CPE and the regulatory discordance throughout the various jurisdictions results in difficulties for developers to site and develop early-stage projects that avoid impacts, biologists to recommend viable alternatives and perform necessary studies, and resource agencies unable to provide standardized guidance to inform proactive and science-based measures. The ability to truly evaluate the cumulative impact of wildlife, plants, and habitats from renewable energy development, and strategically plan for future development that minimizes environmental impact will hinge on the collective assembly of stakeholders to form collaboratives that address these issues for the next decade and beyond.

Photo 17. Mountain bluebird nest box with wind turbines in the background, Klickitat County, Washington, May 2020.

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Appendix T1. Bird species of conservation concern and regulatory status known to occur within the Columbia Plateau Ecoregion.

		ODFW[1]		WDFW[2]		BLM / USFS[3]		USFWS[4]	
Birds	**Scientific Name**	**S**	**CR**	**E**	**T**	**C**	**OR-S**	**WA-S**	**BCC**
American white pelican	*Pelecanus erythrorhynchos*	–	–	–	X*	–	X	X	X*
bald eagle	*Haliaeetus leucocephalus*	–	–	–	–	–	X	X	–
Brewer's sparrow	*Spizella breweri breweri*	X	–	–	–	–	–	X	–
burrowing owl	*Athene cunicularia hypugaea*	–	–	–	–	X	–	X	X
common nighthawk	*Chordeiles minor*	X	–	–	–	–	–	–	–
ferruginous hawk	*Buteo regalis*	–	X	X	–	–	–	–	X
golden eagle	*Aquila chrysaetos*	–	–	–	–	X	–	–	–
grasshopper sparrow	*Ammodramus savannarum perpallidus*	X	–	–	–	–	X	–	–
greater sage-grouse	*Centrocercus urophasianus*	–	–	X	–	–	X	X	X
Lewis's woodpecker	*Melanerpes lewis*	–	X	–	–	–	X	X	X*
loggerhead shrike	*Lanius ludovicianus*	X	–	–	–	X	–	–	–
long-billed curlew	*Numenius americanus*	–	X	–	–	–	–	X	X
northern goshawk	*Accipiter gentilis*	–	–	–	–	X	–	X	–
sage thrasher	*Oreoscoptes montanus*	–	–	–	–	X	–	X	X*
sagebrush sparrow	*Artemisiospiza nevadensis*	–	X	–	–	X	–	X	–
sandhill crane	*Antigone canadensis*	–	–	X	–	–	–	X	–
sharp-tailed grouse	*Tympanuchus phasianellus col.*	–	–	X	–	–	–	X	–
short-eared owl	*Asio flammeus flammeus*	–	–	–	–	–	–	X	X*
Swainson's hawk	*Buteo swainsoni*	X	–	–	–	–	–	–	–
upland sandpiper	*Bartramia longicauda*	–	–	X	–	–	X	–	X

1. ODFW (OAR 635-100-0040). S = Sensitive: small or declining populations, are at-risk, and/or are of management concern; CR = Critical: current or legacy threats that are significantly impacting their abundance, distribution, diversity, and/or habitat.

2. WDFW (WAC 220-200-100; 220-610-010). E = Endangered: seriously threatened with extinction throughout all or a significant portion of its range within the state; T = Threatened likely to become endangered within the foreseeable future throughout a significant portion of its range within the state without cooperative management or removal or threats; C = Candidate: factors suggest species may be a candidates for listing as Endangered, Threatened, or Sensitive.

3. BLM (Manual Section 6840). S = Sensitive: species that require special management consideration to avoid potential future listing under the ESA; USFS (Manual Section 2670.5 & .32). S = Sensitive: population viability is a concern, as evidenced by significant current or predicted downward trends in population numbers or density and habitat capability that would reduce a species' existing distribution; management must not result in a loss of species viability or create significant trends toward federal listing.

4. USFWS (16 U.S.C. 2901–2912). BCC = Bird of Conservation Concern: species, subspecies, and populations of all migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act. Species included only if included in other State/Federal Lists; Asterix notates designation specific to Great Basin BCR 9; all other species are of continental concern. Eagles are protected under the Bald and Golden Eagle Act.

* American white pelican down listed to state sensitive by the Washington Fish and Wildlife Commission September 23, 2022

Source: ISSSSP 2021, ODFW 2021, USFWS 2021, WDFW 2021

Appendix T2. All bird and raptor fatality estimates at operating wind energy facilities in the Columbia Plateau Ecoregion.

Project Name, State, Study Period	All Bird Fatalities/MW/Study Period	Raptor Fatalities/MW/Study Period	Reference
Windy Flats, WA (2010-2011)	8.45	0.04	Enz et al. 2011
Biglow Canyon II, OR (2009-2010)	7.72	0.20	Enk et al. 2011
Montague, OR (2019-2020)*	7.61	0.07	Chatfield and Martin 2021
Leaning Juniper, OR (2006-2008)*	6.66	0.21	Gritski et al. 2008
Linden Ranch, WA (2010-2011)*	6.65	0.27	Enz and Bay 2011
Shepherd’s Flat North (2012-2014)*	6.39	0.06	Smith et al. 2015a
Biglow Canyon III, OR (2011-2012)*	4.41	0.06	Enz et al. 2013
White Creek, WA (2007-2011)*	4.05	0.47	Downes and Gritski 2012
Shepherd’s Flat Central (2012-2014) *	3.74	0.15	Smith et al. 2015b
Mary Hill & Hoctor Ridge, WA (2011-2012)*	3.42	0.11	Enz et al. 2012
Willow Creek (2009-2011)	3.22	0.38	Northwest Wildlife Consultants 2011
Tuolumne, WA (2009-2010)	3.20	0.29	Enz and Bay 2010
Stateline, OR, WA (2001-2002)*	3.17	--	Erickson et al. 2004
Klondike II, OR (2005-2006)*	3.14	--	NWC and WEST 2007
Klondike IIIa, OR (2009-2010)*	3.06	0.12	Gritski et al. 2011
Hopkins Ridge, WA (2008-2008)*	2.99	0.07	Young et al. 2009
Shepherd’s Flat South (2012-2014)*	2.86	0.09	Smith et al. 2015c
Nine Canyon, WA (2002-2003)*	2.76	0.03	Erickson et al. 2003
Stateline, OR, WA (2003-2003)*	2.68	0.09	Erickson et al. 2004
Klondike III, OR (2007-2009)*	2.65	0.27	Gritski et al. 2010
Biglow Canyon II, OR (2010-2011)	2.60	--	Enk et al. 2012
Combine Hills, OR (2004-2005)*	2.56	0.00	Young et al. 2006
Big Horn, WA (2006-2007)	2.54	0.15	Kronner et al. 2008
Klondike IIIa, OR (2008-2009)*	2.54	0.00	Gritski et al. 2011
Leaning Juniper II, OR (2011-2013)*	2.50	0.07	Downes et al. 2013
Biglow Canyon I, OR (2009-2009)*	2.47	0.00	Enk et al. 2010
Juniper Canyon, WA (2011-2012)*	2.44	0.16	Enz and Bay 2012
Combine Hills, OR (2011-2011)*	2.33	0.05	Enz et al. 2012
Biglow Canyon III, OR (2010-2011)*	2.28	0.00	Enk et al. 2012
Hay Canyon, OR (2009-2010)	2.21	0.00	Gritski and Kronner 2010
Rattlesnake Road (2009-2011)*	2.16	0.06	Gritzki et al. 2011
Pebble Springs, OR (2009-2010)	1.93	0.04	Gritski and Kronner 2010
Chopin, OR (2016-2017)*	1.80	--	Hallingstad and Riser-Espinoza 2017
Biglow Canyon I, OR (2008-2008)*	1.76	0.03	Jeffrey et al. 2009
Wild Horse, WA (2007-2007)*	1.55	--	Erickson et al. 2008
Kittitas Valley, WA (2012-2013)*	1.54	0.31	Stantec Consulting 2013

Appendix T2. All bird and raptor fatality estimates at operating wind energy facilities in the Columbia Plateau Ecoregion.

Project Name, State, Study Period	All Bird Fatalities/MW/Study Period	Raptor Fatalities/MW/Study Period	Reference
Tucannon River, WA (2015-2015)*	1.50	0.16	Hallingstad et al. 2016
Wheat Field (2009-2011)	1.42	0.28	Gritzki and Downes 2011
Goodnoe Hills, WA (2009-2010)*	1.40	0.17	URS 2010
Lower Snake River, WA (2012-2013)*	1.30	0.31	Thompson et al. 2018
Vantage, WA (2011-2012)*	1.27	0.29	Ventus Environmental Solutions 2012
Hopkins Ridge, WA (2006-2006)*	1.23	0.14	Young et al. 2007
Stateline, OR, WA (2006-2006)	1.23	--	Erickson et al. 2007
Lower Snake River, WA (2017-2017)*	1.17	0.09	Thompson et al. 2018
Tucannon River, WA (2018-2018)*	1.14	0.12	Hallingstad et al. 2019
Kittitas Valley, WA (2011-2012)*	1.06	0.09	Stantec Consulting 2012
Klondike, OR (2002-2003)*	0.95	0.00	Johnson et al. 2003
Vansycle, OR (1999-1999)*	0.95	0.00	Erickson et al. 2000
Star Point, OR (2010-2011)	0.80	0.00	Gritski and Downes 2011
Palouse Wind, WA (2012-2013)*	0.72	--	Stantec 2013
Stateline 3, OR (2011-2012)*	0.36	0.05	Kronner et al. 2012
Marengo I, WA (2009-2010)*	0.27	0.00	URS 2010
Marengo I, WA (2010-2011)*	0.22	0.03	URS Corporation 2011
Marengo II, WA (2010-2011)*	0.17	0.00	URS Corporation 2011
Marengo II, WA (2009-2010)*	0.16	0.05	URS 2010

* issues identified with the study included unclear bias trial reporting, study length less than or greater than one year, or estimates not designated as overall.

Appendix T3. Bird population data derived from Partner in Flight Population Estimate Database from the Tri-state physio-political region within the Great Plains BCR. Great Basin BBS trend estimates are the percent change per year and associated credible intervals (CI), 2006–2019. Credibility levels assigned by USGS BBS Program.

Group / Species[1]	CPE Population PIF Estimate (2006 – 2015)	Great Basin BCR BBS Trend (2006 – 2019)	2.5% CI	97.5% CI	Credibility
Upland Game					
California Quail	428,289	-0.43	-2.32	1.44	🔵
Ring-necked Pheasant	229,832	-2.52	-4.11	-0.84	🔴
Chukar	26,814	-0.81	-5.12	3.33	🟡
Gray Partridge	11,694	1.37	-4.75	8.2	🔵
Gambel's Quail	1,409	-2.88	-12.89	8.92	🟡
Mountain Quail	726	1.91	-3.35	8.68	🔵
Sharp-tailed Grouse	38	-1.24	-10.40	8.52	🟡
Pigeons and Doves					
Mourning Dove	668,326	-5.11	-6.29	-3.93	🔴
Rock Pigeon	245,357	-1.28	-4.00	1.35	🔵
Eurasian Collared-Dove	76,517	42.17	35.92	48.96	🔵
Band-tailed Pigeon	5,374	2.28	-2.07	7.79	🟡
Swallows, Swifts and Goatsuckers					
Cliff Swallow	1,374,999	-1.42	-3.45	0.58	🔵
Northern Rough-winged Swallow	435,986	-1.17	-3.26	0.79	🔴
Common Nighthawk	263,624	-0.88	-2.82	0.95	🟡
Barn Swallow	373,784	-1.45	-2.70	-0.25	🔴
Bank Swallow	251,532	-3.23	-7.57	1.29	🟡
White-throated Swift	108,597	-0.98	-5.25	4.07	🟡
Vaux's Swift	38,448	-1.42	-5.11	1.73	🟡
Common Poorwill	24,942	0.40	-2.85	4.78	🟡
Black Swift	1,378	-2.61	-11.25	7.11	🔴
Hummingbirds					
Rufous Hummingbird	490,184	-1.59	-2.68	-0.30	🔴
Calliope Hummingbird	176,532	-1.74	-4.45	0.87	🟡
Black-chinned Hummingbird	26,630	0.85	-1.42	3.65	🔵
Anna's Hummingbird	6,557	3.24	-3.60	13.94	🔵
Broad-tailed Hummingbird	4,343	-0.11	-3.14	2.90	🔵
Diurnal Raptors and Vulture					
American Kestrel	48,700	-1.41	-2.89	0.14	🔴
Red-tailed Hawk	47,991	1.64	0.42	2.90	🔵
Turkey Vulture	18,980	3.94	1.23	6.98	🔵
Northern Harrier	16,913	-0.77	-2.59	1.07	🟡
Swainson's Hawk	9,128	3.85	1.92	5.87	🔵
Osprey	6,052	2.33	-0.56	5.54	🔵
Cooper's Hawk	4,665	0.56	-2.40	3.54	🔵
Prairie Falcon	3,274	1.33	-1.18	2.80	🔵

Appendix T3. Bird population data derived from Partner in Flight Population Estimate Database from the Tri-state physio-political region within the Great Plains BCR. Great Basin BBS trend estimates are the percent change per year and associated credible intervals (CI), 2006–2019. Credibility levels assigned by USGS BBS Program.

Group / Species[1]	CPE Population PIF Estimate (2006 – 2015)	Great Basin BCR BBS Trend (2006 – 2019)	2.5% CI	97.5% CI	Credibility
Sharp-shinned Hawk	1,547	-0.44	2.61	1.51	🔵
Northern Goshawk	1,437	-0.11	-2.55	2.34	🔵
Ferruginous Hawk	626	2.44	-0.78	5.83	🔵
Merlin	134	3.72	-3.06	11.14	🔵
Owls					
Great Horned Owl	26,530	1.37	-1.02	3.9	🔵
Barred Owl	8,285	1.94	-2.54	6.9	🔵
Western Screech-Owl	5,330	0.09	-2.26	3.95	🔵
Short-eared Owl	5,109	-9.52	15.63	-3.88	🟡
Long-eared Owl[3]	4,438	-	-	-	-
Barn Owl	2,034	2.65	-1.42	5.87	🔵
Burrowing Owl	1,590	-0.45	-4.71	4.28	🟡
Northern Pygmy-Owl	1,414	0.06	-1.43	2.35	🟡
Great Gray Owl[3]	19	-	-	-	-
Woodpeckers					
Northern Flicker	80,604	-0.2	-4.08	3.9	🟡
Hairy Woodpecker	61,837	-0.34	-1.79	1.81	🔵
Red-breasted Sapsucker	41,548	-2.02	-4.98	0.89	🔵
Red-naped Sapsucker	31,250	-4.35	-7.21	-1.51	🔴
Williamson's Sapsucker	19,048	-0.94	-4.89	1.99	🟡
Downy Woodpecker[3]	14,618	-	-	-	-
Lewis's Woodpecker	9,717	-0.2	-4.08	3.9	🟡
Black-backed Woodpecker	6,815	2.19	-4.25	8.84	🔵
Pileated Woodpecker	6,394	-0.52	-2.98	2	🔵
White-headed Woodpecker	4,844	2.26	-0.33	4.68	🔵
American Three-toed Woodpecker	150	3.27	-4.31	11.62	🔵
Kingbirds and Flycatchers					
Western Kingbird	416,991	-1.97	-3.23	-0.8	🔵
Hammond's Flycatcher	398,892	-0.93	-3.00	1.04	🔵
Pacific-slope Flycatcher	243,524	-0.45	-1.84	0.97	🔴
Dusky Flycatcher	209,191	-1.67	-3.14	-0.16	🟡
Say's Phoebe	136,103	1.43	-0.34	3.26	🔵
Eastern Kingbird	127,492	-2.01	-3.83	-0.27	🔴
Gray Flycatcher	92,018	0.89	-1.55	3.06	🔵
Loggerhead Shrike	26,602	0.1	-2.22	2.5	🟡
Olive-sided Flycatcher	18,123	-0.2	-2.1	1.73	🔴
Cordilleran Flycatcher	11,689	-0.45	-1.84	0.97	🔴
Ash-throated Flycatcher	9,752	-0.6	2.33	2.2	🔵

Appendix T3. Bird population data derived from Partner in Flight Population Estimate Database from the Tri-state physio-political region within the Great Plains BCR. Great Basin BBS trend estimates are the percent change per year and associated credible intervals (CI), 2006–2019. Credibility levels assigned by USGS BBS Program.

Group / Species[1]	CPE Population PIF Estimate (2006 – 2015)	Great Basin BCR BBS Trend (2006 – 2019)	2.5% CI	97.5% CI	Credibility
Least Flycatcher	798	-1.33	-6.46	3.97	🔵
Corvids and Allies					
Black-billed Magpie	169,969	-2.24	-3.62	0.86	🔴
American Crow	62,286	-1.62	-2.77	0.49	🟡
Steller's Jay	45,850	0.56	-0.68	1.85	🔵
Common Raven	44,632	2.03	0.43	3.59	🔵
California Scrub-Jay[2]	8,591	-1.15	-3.44	1.07	🔵
Canada Jay	8,436	0.66	-2.5	4.07	🟡
Clark's Nutcracker	4,016	0.79	-2.39	3.79	🔵
Pinyon Jay	1,703	-0.41	5.32	5.05	🟡
Passerines and Allies					
American Robin	2,527,860	-2.32	-2.94	-1.70	🟡
Western Meadowlark	1,416,927	-1.20	-2.24	-0.19	🟡
Golden-crowned Kinglet	1,362,970	-2.56	-5.29	0.08	🔴
Horned Lark	1,228,334	-0.96	-2.13	0.20	🔴
European Starling	1,153,507	-0.60	-1.92	0.74	🟡
Red-winged Blackbird	1,078,517	-1.14	-2.15	-0.14	🟡
House Sparrow	1,072,434	-1.69	-3.13	-0.22	🔴
Chipping Sparrow	880,616	-3.32	-4.39	-2.25	🔴
Brewer's Blackbird	856,017	-2.79	-4.03	-1.61	🔴
Brown-headed Cowbird	819,184	-3.45	-4.55	-2.37	🟡
Dark-eyed Junco	752,244	-3.70	-5.02	-2.43	🔴
House Finch	737,633	-0.94	-2.98	1.13	🔵
Spotted Towhee	709,688	0.36	-0.97	1.85	🔵
Song Sparrow	627,045	-2.13	-3.18	-1.13	🔵
Townsend's Warbler	606,219	-3.44	-5.30	-1.47	🔴
Savannah Sparrow	603,485	-3.49	-5.16	-1.96	🔴
Yellow-rumped Warbler	587,798	-0.38	-1.43	0.66	🟡
Warbling Vireo	509,861	-0.93	-2.05	0.17	🔵
Pine Siskin	502,657	7.58	0.94	14.72	🟡
Black-headed Grosbeak	490,047	1.86	0.71	2.91	🔵
Western Tanager	482,040	0.43	-0.64	1.57	🔵
Swainson's Thrush	470,642	0.22	-1.43	23.84	🟡
Cedar Waxwing	457,974	0.27	-1.81	2.38	🔵
Brewer's Sparrow	442,080	-3.84	-6.21	-1.59	🟡
Vesper Sparrow	360,470	-2.98	-4.29	-1.69	🟡
Evening Grosbeak	356,636	-6.01	11.34	-0.31	🔴
Western Wood-Pewee	325,515	-0.56	-1.46	0.35	🔵

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Group / Species[1]	CPE Population PIF Estimate (2006 – 2015)	Great Basin BCR BBS Trend (2006 – 2019)	2.5% CI	97.5% CI	Credibility
Yellow Warbler	317,932	-1.53	-2.60	-0.52	🟡
House Wren	305,032	3.59	2.03	4.99	🔵
Red-breasted Nuthatch	303,122	-0.92	-2.78	1.10	🔵
Bullock's Oriole	290,986	0.11	-0.99	1.21	🔵
Chestnut-backed Chickadee	289,054	-1.33	-4.43	1.42	🟡
MacGillivray's Warbler	286,529	-0.56	-1.89	0.79	🔴
American Goldfinch	272,720	0.78	-2.26	0.70	🟡
Nashville Warbler	229,554	-0.82	-2.98	1.34	🔵
Mountain Chickadee	222,072	-2.74	-4.12	-1.40	🔴
Lazuli Bunting	213,880	4.07	2.18	6.62	🔵
Yellow-headed Blackbird	204,450	-1.79	-4.88	1.15	🟡
Willow Flycatcher[2]	177,590	0.02	-1.35	1.35	🔴
Sage Thrasher	175,169	-2.00	-1.14	-0.06	🟡
Violet-green Swallow	169,967	-2.56	-4.52	-0.67	🟡
White-crowned Sparrow	164,542	3.15	0.95	7.21	🔵
Black-capped Chickadee	163,062	-3.66	-5.72	-1.67	🟡
Tree Swallow	161,599	-1.08	-2.82	0.59	🔵
Grasshopper Sparrow	161,261	-4.17	-7.26	-1.03	🟡
Pacific Wren	150,575	-6.98	-9.52	-4.58	🟡
Red Crossbill	144,223	2.07	-2.32	7.11	🔵
Hermit Thrush	142,286	0.60	-1.09	2.33	🔴
Varied Thrush	137,883	-1.31	-3.98	1.34	🟡
Marsh Wren	126,274	1.94	0.06	4.06	🔵
Mountain Bluebird	122,264	-0.82	-2.84	0.97	🔵
Wilson's Warbler	120,346	-0.64	-3.83	2.08	🟡
Cassin's Finch	120,285	1.59	-0.54	3.69	🔵
Cassin's Vireo	119,890	1.43	-0.18	3.15	🔵
Brown Creeper	116,525	-1.60	-4.23	0.92	🟡
Western Bluebird	112,264	2.93	0.11	6.40	🔵
Black-throated Gray Warbler	98,244	0.94	-2.31	3.82	🔵
Rock Wren	89,302	-1.59	-3.49	0.33	🔵
Gray Catbird	85,925	1.75	-0.43	4.01	🔵
Common Yellowthroat	84,154	2.68	0.08	4.85	🔵
Green-tailed Towhee	58,775	-1.35	-4.09	0.90	🟡
Pygmy Nuthatch	57,458	-0.64	-4.54	3.11	🔵
Sagebrush Sparrow[2]	56,575	-1.39	-3.85	0.93	🔴
Purple Finch	46,816	0.88	-1.71	3.82	🔴
Veery	41,684	0.41	-1.10	2.12	🔴

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Group / Species[1]	CPE Population PIF Estimate (2006 – 2015)	Great Basin BCR BBS Trend (2006 – 2019)	2.5% CI	97.5% CI	Credibility
Black-throated Sparrow	34,210	-7.57	-10.53	-4.52	●
Lark Sparrow	33,497	-0.48	-2.72	1.77	●
Orange-crowned Warbler	31,562	-2.50	-4.74	-0.09	●
Yellow-breasted Chat	31,379	1.86	-0.12	3.62	●
White-breasted Nuthatch	27,465	-0.98	-3.38	1.48	●
Lincoln's Sparrow	26,963	5.19	1.96	8.74	●
Townsend's Solitaire	25,033	1.67	-0.37	3.80	●
Ruby-crowned Kinglet	23,456	0.39	-2.51	3.58	●
Red-eyed Vireo	23,393	-0.73	-3.29	1.89	●
Fox Sparrow	13,665	-3.44	-12.89	1.83	●
Hermit Warbler	13,529	-0.14	-3.96	4.23	●
Canyon Wren	9,776	-0.05	-3.69	3.33	●
Lesser Goldfinch	8,057	2.42	-6.88	12.17	●
Belted Kingfisher	7,406	-0.83	-2.83	1.23	●
Bobolink	7,372	-1.09	-7.12	6.53	●
Bewick's Wren	5,943	0.86	-4.02	5.99	●
Hutton's Vireo	5,620	2.57	-5.16	11.14	●
Blue-gray Gnatcatcher	5,184	3.58	-0.05	7.76	●
American Dipper	3,072	-0.21	-2.18	1.47	●
Bushtit	2,958	-1.46	-10.89	6.80	●
American Redstart[3]	1,052	-	-	-	-
White-winged Crossbill	732	-15.42	-37.85	9.26	●
Plumbeous Vireo	192	1.71	-2.61	8.40	●
Northern Mockingbird	160	0.79	-2.07	5.06	●
California Towhee	134	-1.41	-7.99	1.56	●
Juniper Titmouse	49	1.70	-1.98	5.59	●
Common Grackle	36	-0.88	-9.96	7.10	●
Virginia's Warbler	16	0.45	-5.17	7.37	●
Great-tailed Grackle	14	1.94	-7.97	14.48	●
Lark Bunting	4	1.57	-21.03	36.88	●

1. Phylogenetic order roughly follows Chesser et al. 2021. PIF population estimates unavailable for the following species: Ruffed Grouse, Greater Sage-Grouse, Dusky Grouse, Sooty Grouse, Wild Turkey, Golden Eagle, Bald Eagle, Peregrine Falcon

2. BBS trends are grouped for the following species: Woodhouse's Scrub-jay grouped with California Scrub-Jay; Alder Flycatcher grouped with Willow Flycatcher; Bell's Sparrow grouped with Sagebrush Sparrow

3. BBS population trend data unavailable

Reference to Credibility Levels from the USGS BBS Program in Appendix T3

This category reflects data with an important deficiency. In particular:

- 1. The regional abundance is less than 0.1 birds/route (very low abundance),
- 2. The sample is based on less than 5 routes for the long term (very small samples), or
- 3. The results are so imprecise that a 5%/year change (as indicated by the half-width of the credible intervals) would not be detected over the long-term (very imprecise).

  A variety of circumstances may lead to imprecise results. For example, imprecise results are sometimes a consequence of a failure of the models to converge in those local areas, even though the model performs adequately in larger regions.

This category reflects data with a deficiency. In particular:

- 1. The regional abundance is less than 1.0 birds/route (low abundance),
- 2. The sample is based on less than 14 routes for the long term (small sample size), or
- 3. The results are so imprecise that a 3%/year change (as indicated by the half-width of the credible intervals) would not be detected over the long-term (quite imprecise), or

This category reflects data with at least 14 samples in the long term, of moderate precision, and of moderate abundance on routes.

Note:

- 1. Due to changes in the way N of samples (in BBS analysis, it is defined as the N of routes on which the species occurred), relative abundance (taken directly from the hierarchical model results), and the precision (half-width of the credible intervals), these categories are slightly different than those used in earlier analyses.
- 2. Even data falling in the category may not provide valid results. There are many factors that can influence the validity and use of the information, and any analysis of BBS data should carefully consider the possible problems with the data. As noted above, judging whether technical issues associated with model convergence are leading to imprecise results can be difficult in analyses based on many strata, but these categories help users to screen for suspect results.

Appendix T4. Number and species composition of bird fatalities documented at post-construction fatality studies at wind facilities located within the Columbia Plateau Ecoregion, 1999−2020.

Common Name	Total Fatalities	Composition (%)
horned lark	936	30.46
unidentified bird (unknown size)	184	5.99
gray partridge	154	5.01
golden-crowned kinglet	113	3.68
western meadowlark	101	3.29
ring-necked pheasant	99	3.22
red-tailed hawk	80	2.60
American kestrel	78	2.54
unidentified small bird	78	2.54
European starling	76	2.47
chukar	75	2.44
mourning dove	70	2.28
rock pigeon	61	1.99
unidentified passerine	56	1.82
dark-eyed junco	55	1.79
white-crowned sparrow	49	1.59
ruby-crowned kinglet	40	1.30
yellow-rumped warbler	38	1.24
Swainson's hawk	33	1.07
Townsend's warbler	33	1.07
northern flicker	27	0.88
common raven	24	0.78
red-breasted nuthatch	22	0.72
common nighthawk	18	0.59
Savannah sparrow	17	0.55
Vaux's swift	17	0.55
American robin	16	0.52
short-eared owl	16	0.52
warbling vireo	15	0.49
winter wren	15	0.49
barn owl	14	0.46
Brewer's sparrow	14	0.46
unidentified sparrow	14	0.46
unidentified warbler	13	0.42
unidentified large bird	12	0.39
vesper sparrow	12	0.39
Wilson's warbler	12	0.39
Canada goose	11	0.36
house wren	11	0.36
rough-legged hawk	11	0.36
chipping sparrow	10	0.33
house sparrow	10	0.33
spotted towhee	10	0.33
black-billed magpie	9	0.29
cliff swallow	9	0.29
great horned owl	9	0.29
long-billed curlew	9	0.29
white-throated swift	9	0.29
ferruginous hawk	8	0.26
orange-crowned warbler	8	0.26
unidentified kinglet	8	0.26
western tanager	8	0.26

Appendix T4. Number and species composition of bird fatalities documented at post-construction fatality studies at wind facilities located within the Columbia Plateau Ecoregion, 1999−2020.

Common Name	Total Fatalities	Composition (%)
northern harrier	7	0.23
song sparrow	7	0.23
house finch	6	0.20
long-eared owl	6	0.20
ring-billed gull	6	0.20
California quail	5	0.16
common yellowthroat	5	0.16
golden-crowned sparrow	5	0.16
Lincoln's sparrow	5	0.16
mallard	5	0.16
unidentified gull	5	0.16
yellow warbler	5	0.16
American goldfinch	4	0.13
Cassin's vireo	4	0.13
golden eagle	4	0.13
great blue heron	4	0.13
MacGillivray's warbler	4	0.13
prairie falcon	4	0.13
turkey vulture	4	0.13
varied thrush	4	0.13
western grebe	4	0.13
American coot	3	0.10
bank swallow	3	0.10
common poorwill	3	0.10
dusky flycatcher	3	0.10
Hammond's flycatcher	3	0.10
hermit thrush	3	0.10
herring gull	3	0.10
mountain bluebird	3	0.10
Pacific wren	3	0.10
red-winged blackbird	3	0.10
unidentified *Buteo*	3	0.10
unidentified duck	3	0.10
unidentified kingbird	3	0.10
unidentified raptor	3	0.10
unidentified vireo	3	0.10
western kingbird	3	0.10
American pipit	2	0.07
black swift	2	0.07
Brewer's blackbird	2	0.07
Bullock's oriole	2	0.07
downy woodpecker	2	0.07
fox sparrow	2	0.07
gray flycatcher	2	0.07
Nashville warbler	2	0.07
northern rough-winged swallow	2	0.07
osprey	2	0.07
Pacific-slope flycatcher	2	0.07
peregrine falcon	2	0.07
pine siskin	2	0.07
purple finch	2	0.07
rock wren	2	0.07

Appendix T4. Number and species composition of bird fatalities documented at post-construction fatality studies at wind facilities located within the Columbia Plateau Ecoregion, 1999−2020.

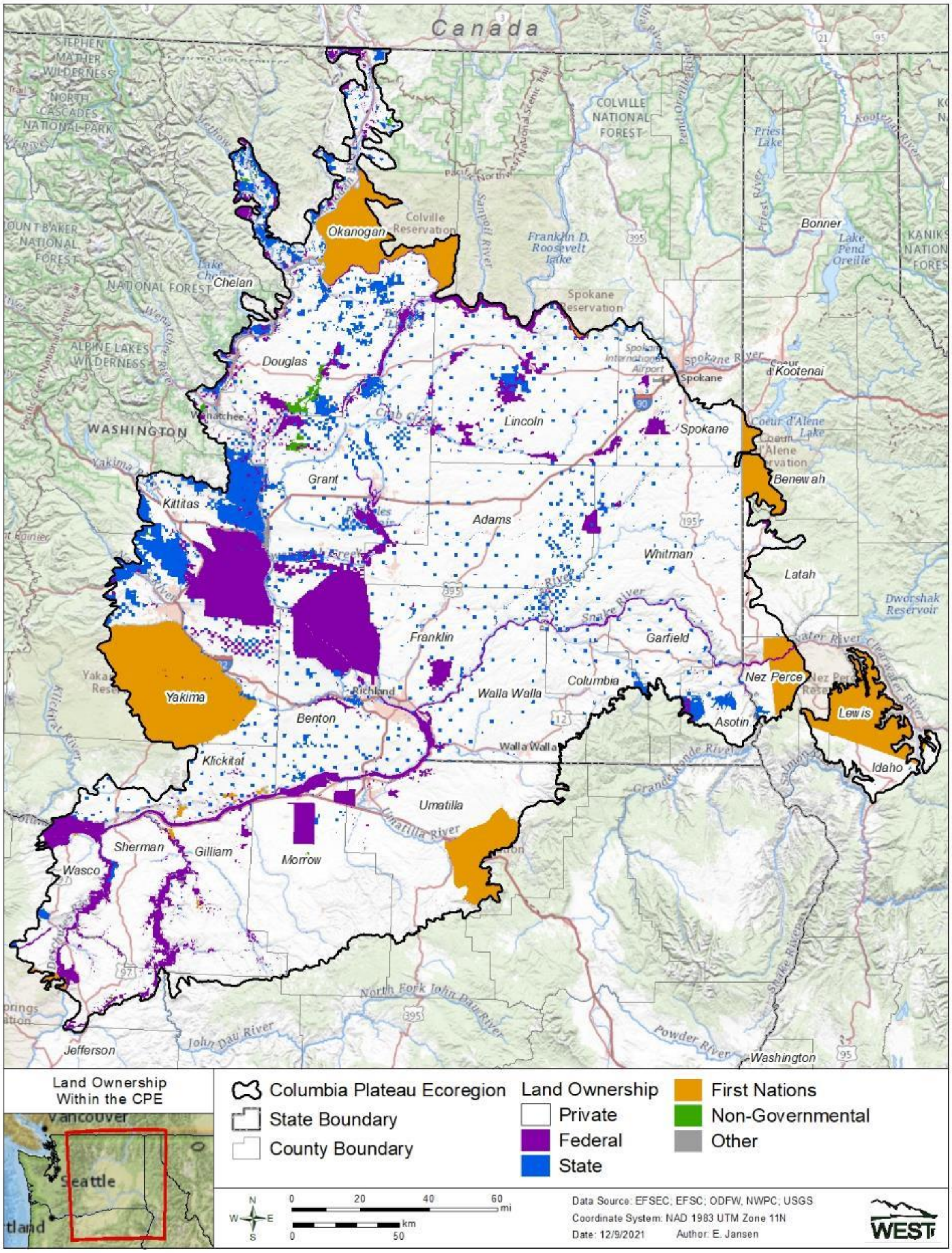
Common Name	Total Fatalities	Composition (%)
sage thrasher	2	0.07
Say's phoebe	2	0.07
sharp-shinned hawk	2	0.07
Swainson's thrush	2	0.07
Townsend's solitaire	2	0.07
tree swallow	2	0.07
unidentified *Accipiter*	2	0.07
unidentified *Corvid*	2	0.07
unidentified *Empidonax*	2	0.07
unidentified swallow	2	0.07
Virginia rail	2	0.07
western screech owl	2	0.07
white-breasted nuthatch	2	0.07

Species with one (1) fatality (3% composition) recorded during PCFM included: American crow, American white pelican, ash-throated flycatcher, bald eagle, barred owl, black-throated gray warbler, black-throated sparrow, brown-headed cowbird, bufflehead, burrowing owl, cackling goose, Cooper's hawk, eastern kingbird, evening grosbeak, grasshopper sparrow, gray catbird, hairy woodpecker, horned grebe, killdeer, lark sparrow, lazuli bunting, Lewis's woodpecker, merlin, northern bobwhite, northern pintail, northern saw-whet owl, northern shrike, olive-sided flycatcher, red-naped sapsucker, sagebrush sparrow, sora, Steller's jay, unidentified blackbird, unidentified owl, unidentified thrush, western bluebird, western wood-pewee, Williamson's sapsucker, willow flycatcher.

Appendix T5. Bat fatality estimates from post-construction fatality monitoring studies at operational wind energy facilities within the Columbia Plateau, 1999-2020.

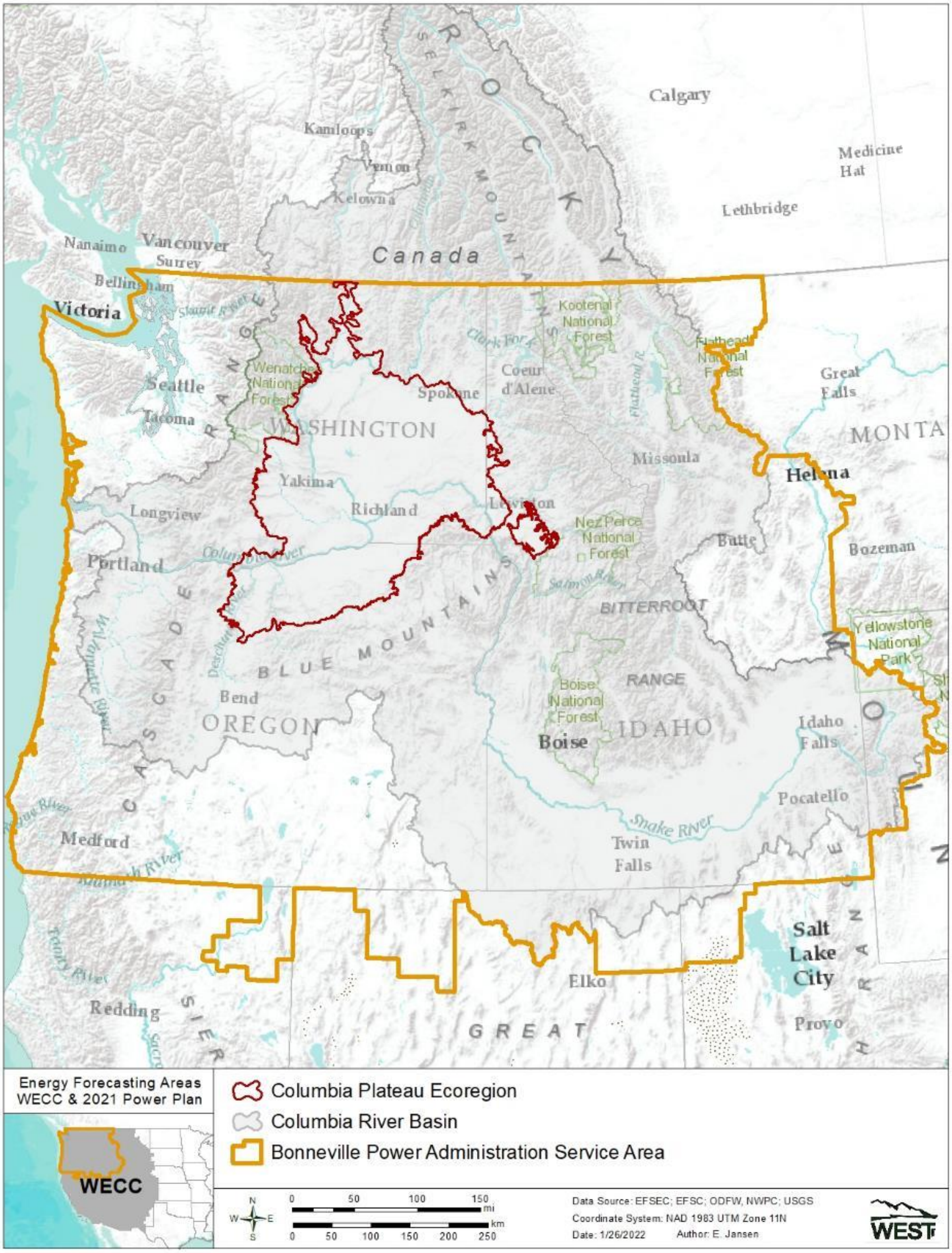
Facility Name, State, Study Period	All Bat Fatalities/MW/Study Period	Reference
Biglow Canyon II, OR (2009-2010)	3.78	Enk et al. 2011
Rattlesnake Road (2009-2011)	2.87	Gritzki et al. 2011
Nine Canyon, WA (2002-2003)	2.47	Erickson et al. 2003
Tucannon River, WA (2018-2018)	2.32	Hallingstad et al. 2019
Stateline, OR, WA (2003-2003)	2.29	Erickson et al. 2004
Tucannon River, WA (2015-2015)	2.22	Hallingstad et al. 2016
White Creek I	2.04	Downes and Gritski 2012
Biglow Canyon I, OR (2008-2008)	1.99	Jeffrey et al. 2009
Big Horn, WA (2006-2007)	1.90	Kronner et al. 2008
Chopin, OR (2016-2017)	1.90	Hallingstad and Riser-Espinoza 2017
Chopin, OR (2016-2017)	1.90	Hallingstad and Riser-Espinoza 2017
Combine Hills, OR (2004-2005)	1.88	Young et al. 2006
Linden Ranch, WA (2010-2011)	1.68	Enz and Bay 2011
Juniper Canyon, WA (2011-2012)	1.60	Enz and Bay 2012
Pebble Springs, OR (2009-2010)	1.55	Gritski and Kronner 2010
Hopkins Ridge, WA (2008-2008)	1.39	Young et al. 2009
Stateline 3, OR (2011-2012)	1.18	Kronner et al. 2012
Vansycle, OR (1999-1999)	1.12	Erickson et al. 2000
Mary Hill and Hoctor Ridge, WA (2011-2012)	1.04	Enz et al. 2012
Shephard's Flat North (2012-2014)	1.03	Smith et al. 2015a
Stateline, OR, WA (2006-2006)	0.95	Erickson et al. 2007
Tuolumne, WA (2009-2010)	0.94	Enz and Bay 2010
Lower Snake River, WA (2012-2013)	0.88	Thompson et al. 2018
Willow Creek (2009-2011)	0.81	Northwest Wildlife Consultants 2011
Combine Hills, OR (2011)	0.73	Enz et al. 2011
Montague, OR (2019-2020)	0.73	Chatfield and Martin 2021
Wheat Field (2009-2011)	0.69	Gritzki and Downes 2011
Biglow Canyon III, OR (2011-2012)	0.66	Enz et al. 2013
Hopkins Ridge, WA (2006-2006)	0.63	Young et al. 2007
Leaning Juniper II, OR (2011-2013)	0.63	Downes et al. 2013
Biglow Canyon II, OR (2010-2011)	0.57	Enk et al. {,2012 #14130}
Lower Snake River, WA (2017-2017)	0.54	Thompson et al. 2018
Hay Canyon, OR (2009-2010)	0.53	Gritski and Kronner 2010
Star Point, OR (2010-2011)	0.49	Gritski and Downes 2011
Shephard's Flat Central (2012-2014)	0.42	Smith et al. 2015b
Klondike II, OR (2005-2006)	0.41	NWC and WEST 2007
Windy Flats, WA (2010-2011)	0.41	Enz et al. 2011
Vantage, WA (2011-2012)	0.40	Ventus Environmental Solutions 2012
Wild Horse, WA (2007-2007)	0.39	Erickson et al. 2008
Goodnoe, WA (2009-2010)	0.34	URS 2010
Kittitas Valley, WA (2012-2013)	0.31	Stantec Consulting 2013
Marengo II, WA (2009-2010)	0.27	URS {2010
Shephard's Flat South (2012-2014)	0.25	Smith et al. 2015b
Biglow Canyon III, OR (2010-2011)	0.22	Enk et al. 2012
Marengo I, WA (2009-2010)	0.17	URS 2010
Marengo I Yr 2, WA (2010-2011)	0.15	URS Corporation 2011
Kittitas Valley, WA (2011-2012)	0.12	Stantec Consulting 2012
Marengo II Yr 2, WA (2010-2011)	0.00	URS Corporation 2011

* 2-year study.

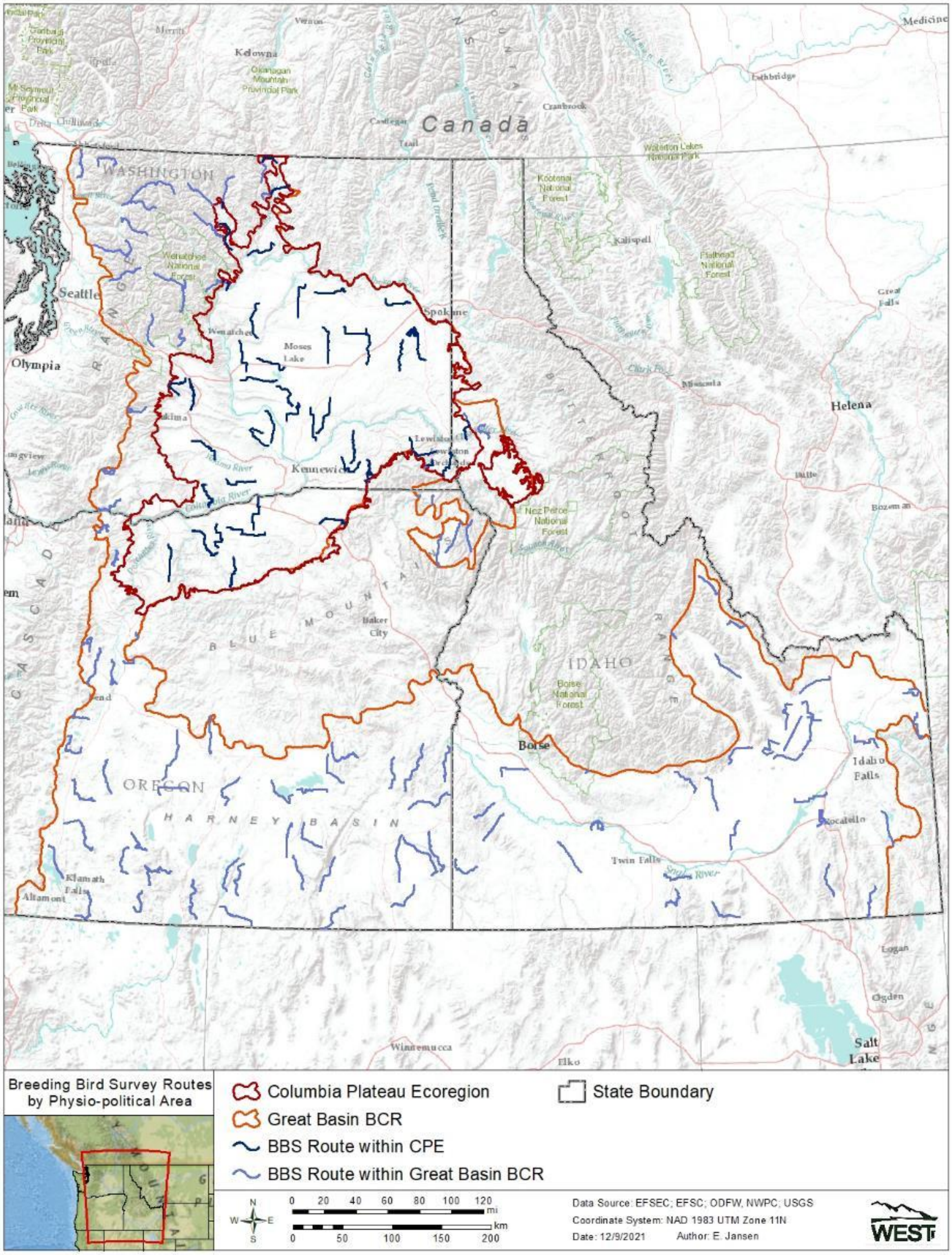


Appendix F1. Land ownership within the Columbia Plateau Ecoregion.

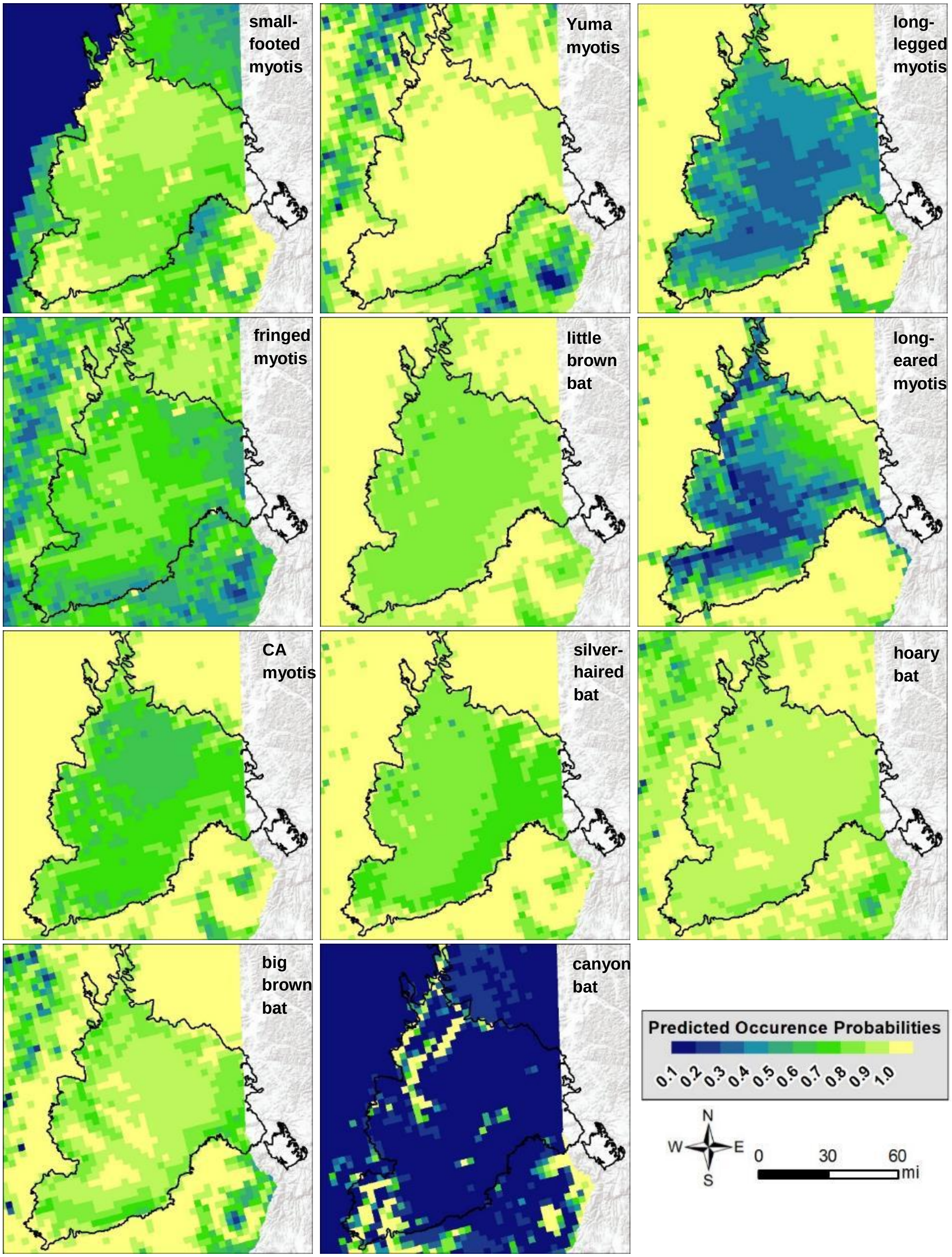
Appendix F2. Columbia Plateau Ecoregion within the Great Basin BCR and USFWS Pacific Administrative Flyway.



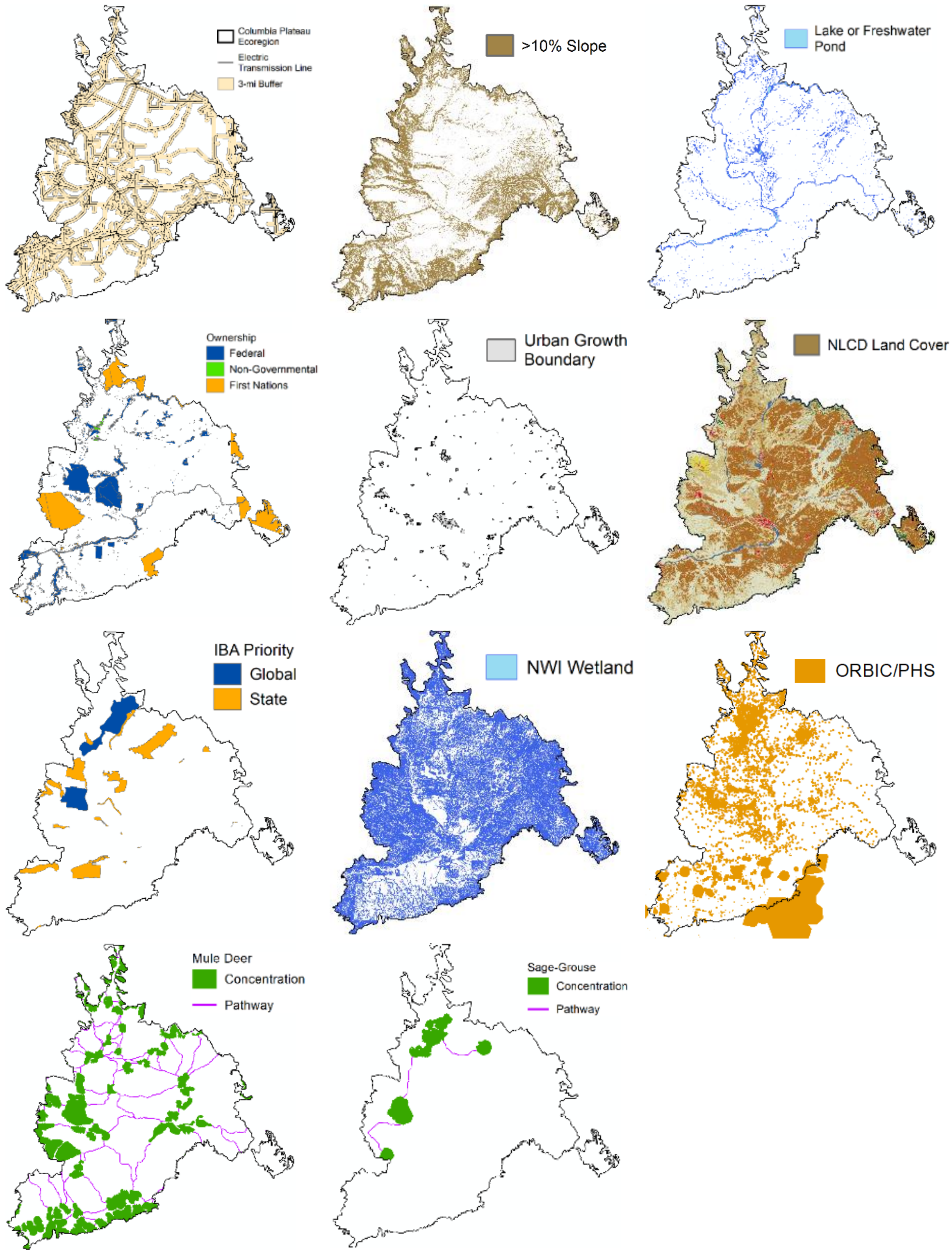
Appendix F3. Multi-scale relationship of energy markets in the western US Renewable energy projections in the CPE were derived from the NPP analyses in the BPA Service Area, which are influenced by trends in the larger Western Interconnection region of the WECC.



Appendix F4. USGS Breeding Bird Survey Routes within the Great Basin Bird Conservation Region 9 Physio-political boundary of Idaho, Oregon, and Washington and subset within the Columbia Plateau Ecoregion.



Appendix F5. Bat predicted distribution and occurrence probabilities in 2010 within the Columbia Plateau Ecoregion. Occupancy probabilities were conditioned on the occurrence states of the previous seven years, 2003-2009 (Rodhouse et al. 2015).



Appendix F6. Data layers used as spatial covariates to model USSE resources within the Columbia Plateau Ecoregion.