Avian, Bat and Habitat Cumulative Impacts Associated with Wind Energy Development in the Columbia Plateau Ecoregion Of Eastern Washington and Oregon

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NATURAL RESOURCES ◆ SCIENTIFIC SOLUTIONS

EXECUTIVE SUMMARY

Wind energy development is occurring in Oregon and Washington within the Columbia Plateau physiographic region (ecoregion). With this development comes the potential for direct impacts to birds and bats through collision mortality and for indirect effects through habitat fragmentation or displacement of birds and other wildlife. Collision mortality is well documented at most wind energy facilities, but population level effects have not been detected, although few studies have addressed this issue. The purpose of this report is to estimate cumulative impacts associated with wind energy development projected to occur within the Columbia Plateau Ecoregion (CPE) of eastern Washington and Oregon through 2015. This report updates two previous versions to account for additional bird and bat fatality estimates from several wind energy facilities where monitoring reports recently became available. For the purpose of this analysis, we assumed that for cumulative impacts to occur, there must be a potential for a long-term reduction in the size of a population of birds or bats. When assessing the potential for cumulative impacts, it is necessary to first define the population potentially affected by wind energy development. Because birds and other animals do not recognize geopolitical boundaries, we have defined the affected population as those birds and bats of each species that breed, winter, or migrate through the CPE. As of December 14, 2010, there were 4,059 megawatts (MW) of installed wind energy in Washington and Oregon, most of which is within the CPE. For this analysis, we assumed that 6,700 MW of wind power would be present in the CPE.

This cumulative effects analysis used data from 25 year-long monitoring studies conducted at 23 wind energy facilities in the CPE, as well as preliminary carcass composition data from two additional facilities with post-construction monitoring data. For this analysis we assumed that the bird and bat communities are similar across all wind energy facilities because of habitat and land use similarities throughout the CPE, and thus data from existing facilities are applicable to proposed facilities in this same ecoregion. To define population sizes of those species most likely to be affected by wind energy development in the CPE, we used data from a Partners in Flight publication that estimates breeding population size of bird species in the CPE.

To predict raptor, all birds (excluding raptors), and bat mortality for 6,700 MW of wind energy development in the CPE, we assumed it would be similar to the other existing wind energy facilities in the CPE. Therefore, we estimated raptor mortality by multiplying the number of MW (6,700) by 0.08, the mean number of raptor fatalities/MW/year at the existing facilities. We multiplied the total number of MW by 2.28 fatalities/MW/year (the mean among the 22 CPE wind energy facilities) to estimate all bird mortality (excluding raptors), and by 1.14 fatalities/MW/year to estimate total bat mortality. To estimate total cumulative mortality by bird or bat type and/or species, we assumed the fatalities associated with 6,700 MW of wind energy would have the same species composition as fatalities found at existing wind energy facilities in the CPE.

Ninety-eight species of birds are represented among the 1,183 bird fatalities reported at existing wind energy facilities in the CPE. For all birds combined, we estimate that total annual mortality in the CPE would be 15,276 birds/year. Despite several thousand bird fatalities from 6,700 MW

of wind power, these impacts are spread across numerous species and bird groups, as well as across seasons. Therefore, the overall impact to any given species or population of a species is substantially less. Based on species composition of fatalities at existing CPE wind energy facilities, raptors would compose 8.7% of the fatalities, passerines would compose approximately 69.5% of the fatalities, upland game birds would compose 13.1%, doves/pigeons would compose 3.8%, waterfowl/waterbirds/shorebirds would compose 2.1% and other bird types, such as woodpeckers, nighthawks and swifts, would compose 2.7%. Approximately 4.5% of the mortality would be composed of non-protected European starlings, rock pigeons and house sparrows.

We estimate total raptor mortality in the CPE would be 536 fatalities per year. American kestrels account for 29.0%, red-tailed hawks account for 22.0%, Swainson's hawks account for 9.0%, and short-eared owls account for 8.0% of the raptor fatalities recorded at the regional wind projects studied. Assuming this trend holds true for all proposed wind energy facilities in the CPE, and assuming there would be 536 raptor fatalities per year, it would be expected that on average 155 American kestrels and 118 red-tailed hawks would be killed each year. The other species of raptors occurring in the CPE have had no or fewer fatalities at existing wind energy facilities, and would likely represent a much smaller number of fatalities. Three species of concern in the region, golden eagle, ferruginous hawk and Swainson's hawk, have all been found as turbine collision victims in the CPE. Ferruginous hawks have composed 4.0% of the raptor fatalities, Swainson's hawks have composed 9.0%, and golden eagles have composed 1.0%. Assuming a total of 536 raptor fatalities could occur each year in the CPE, this would result in 21 ferruginous hawk, 48 Swainson's hawk, and five golden eagle fatalities per year.

Annual collision mortality in the CPE would represent approximately 0.06% of the breeding population of American kestrels and 0.11% of the breeding population of red-tailed hawks. Background mortality for these species is much higher than this estimate and the additional wind energy related mortality is likely insignificant from a population standpoint. Given our estimate of 21 ferruginous hawk fatalities on an annual basis, even if all turbine mortality occurred to resident breeding adult birds, this would represent 2.1% of the breeding ferruginous hawks in the CPE. Because mortality would likely be spread out among migrants, winter residents, resident breeders, and juveniles, as well as adults, mortality of adult ferruginous hawks actually breeding in the CPE would be less than 2.1%, likely on the order of 1–2%. Given published annual mortality rates for adult ferruginous hawks of 24–30%, additional losses of 1–2% of resident breeders associated with 6,700 MW of wind energy development in the CPE would not likely have measurable population consequences. Given our mortality estimate of 48 Swainson's hawks per year, this would represent only 0.48% of the Swainson's hawks in the CPE. Compared to many other raptor species, there is little data on annual survival of Swainson's hawks. The annual mortality rate of Swainson's hawks was reported in one study from western Canada, where it was estimated to be 15.7%, and nestling mortality rates ranged from 56–81% over the multi-year study. Given estimated Swainson's hawk mortality rates of 15.7% for adults and 56-81% for juveniles, additional losses of <0.5% would be considered sustainable and would not have measurable population consequences. Given our annual estimate of five golden eagle fatalities, even if all turbine mortality occurred to resident breeding adult birds, this would represent 0.3% of the breeding golden eagles in the CPE. It has been estimated that only 50% of golden eagles survive to the age of three years. Given these published mortality rates for golden eagles, additional losses of <0.3% of the population associated with 6,700 MW of wind energy development in the CPE would not likely have measurable population consequences for golden eagles. Using similar analyses of estimated fatality rates, population sizes in the CPE, and published annual mortality rates for upland game birds, waterbirds, waterfowl, shorebirds, passerines, and sensitive bird species, it is unlikely that population consequences would be expected for these avian groups if 6,700 MW of wind energy was developed in the CPE.

Using the mean bat mortality estimate of 1.14/MW/year at regional wind energy facilities within the CPE, total bat mortality in the CPE was estimated at 7,638 per year. Based on species composition of bat fatalities found at CPE wind energy facilities, approximately 3,798 silver-haired and 3,670 hoary bat fatalities would occur in the CPE on an annual basis.

Unlike birds, there is little information available about population sizes of most bat species, especially the non-hibernating, solitary tree-roosting species that compose most of the wind energy facility related mortality in North America. The significance of wind energy impacts on hoary and silver-haired bat populations is difficult to predict, as there is no information available on the overall population sizes of these bats. However, hoary and silver-haired bats are widely distributed throughout North America. Most concern over impacts to bats is with wind energy facilities built on ridgetops in the Appalachian Mountains, where mortality levels have been as high as 39.7 bat fatalities/MW/year, substantially higher than the average of 1.14 bat fatalities/MW/year observed in the CPE. In general, mortality levels on the order of one to two bats per MW are likely not significant to populations, although cumulative effects may have greater consequences for long-lived, low-fecundity species such as bats.

Grassland and shrub-steppe communities are the most abundant native communities in the CPE, but they are also highly subjected to development and conversion to agriculture. In addition to potentially thousands of new vertical structures, added wind energy generation in the region will result in more roads (mostly dirt and gravel) and increased human activity due to turbine construction and maintenance. A substantial portion of these impacts will be to already heavily-disturbed agricultural fields and moderately disturbed rangeland used for livestock grazing. The percent of direct impacts actually occurring in native grassland or shrub-steppe habitat are difficult to predict and would be based on individual facility design and layout. However, based on the community types that existing and proposed wind energy facilities are located in, approximately 48% of the existing and proposed facilities would be in cultivated cropland. Assuming that on average the permanent impact associated with a turbine and the associated access roads is 0.74 acres per MW, then approximately 2,578 acres (4.0 mi^2) of non-agricultural vegetation types, primarily grassland and shrub-steppe vegetation, would be lost in the CPE with 6,700 MW of wind energy. These impacts would be spread over a large area geographically. Given that the CPE is 32,096 mi^2 in size, permanent impacts associated with 6,700 MW of wind energy development would represent only 0.01% of the area, with nearly half of this occurring in cultivated cropland.

Habitat loss associated with wind energy development is not expected to be a significant loss to any given species within the entire CPE. However, because existing and proposed wind energy facilities tend to be concentrated within certain regions within the CPE, habitat loss may lead to localized population declines of some species.

Avian population estimates used in this analysis relied on those developed by Partners in Flight (PIF) using breeding bird survey (BBS) data, and some of these estimates had relatively large standard errors. Because BBS data were designed to detect long-term population trends, use of these data for estimating population sizes has been questioned. Regardless of these concerns, in order to estimate cumulative impacts, information on sizes of affected populations is required, and the population estimates provided by PIF are the only ones available for the CPE. While these estimates may not be completely accurate for all species, they are the only ones available and therefore represent the best available data for this use.

Finally, this cumulative impacts assessment only examined cumulative impacts of birds and bats due to wind energy development in the CPE. Wind energy development is only one factor affecting wildlife populations in the CPE, and is likely minor compared to other past, present, and future actions in the CPE, including large-scale conversion of native shrublands and grasslands to crop land; expansion of urban areas and rural subdivisions; road and highway construction; energy development, including dams for hydropower; and increases in other infrastructure, such as communication towers and power lines. The ability to estimate wind energy development impacts on wildlife is unique because several studies have been conducted in the CPE to quantify bird and bat impacts and monitoring of fatalities is typically conducted for wind energy development. This is not done for any other type of development. Similar estimates of bird and bat impacts due to direct mortality and loss or fragmentation of habitat caused by other activities are not available. Also, this analysis does not account for the beneficial impacts on habitat from wind energy development, both from adding value to land and thus preserving it from subdivision and further habitat fragmentation, or from replacing fossil fuel sources, and its associated greenhouse gas emissions and ensuing habitat impacts.

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INTRODUCTION AND BACKGROUND

Wind energy development is occurring in Oregon and Washington within the Columbia Plateau physiographic region (ecoregion). With this development comes the potential for direct impacts to birds and bats through collision mortality and for indirect effects through habitat fragmentation or displacement of birds and other wildlife. Proposals for wind energy developments are commonly reviewed by natural resource agencies, private conservation groups, permitting authorities and other stakeholders. Frequently, baseline studies are conducted to estimate bird and bat abundance at proposed development sites for use in impact assessments and siting project features, followed by post-construction monitoring studies to measure actual impacts from the wind energy facility.

Collision mortality is well documented at most wind energy facilities, but population level effects have not been detected, although few studies have addressed this issue (Johnson and Stephens 2011). The purpose of this report is to estimate cumulative impacts associated with wind energy development projected within the Columbia Plateau Ecoregion (CPE) of eastern Washington and Oregon through 2015. This report updates two previous versions (Johnson and Erickson 2008, 2010) to account for additional bird and bat fatality estimates from several wind energy facilities where monitoring reports recently became available. For the purpose of this analysis, we assumed that for cumulative impacts to occur, there must be a potential for a long-term reduction in the size of a population of birds or bats. When assessing the potential for cumulative impacts, it is necessary to first define the population potentially affected by wind energy development. Because birds and other animals do not recognize geopolitical boundaries, we have defined the affected population as those birds and bats of each species that breed, winter, or migrate through the CPE.

ANALYSIS AREA AND WIND ENERGY PROJECTS

Current planning for the Northwest (Washington, Oregon, Idaho, and Montana) power grid has been based on the objective of accommodating 6,000 MW of wind energy development in the four-state region (Northwest Power and Conservation Council [NPCC] 2007). As of December 14, 2010, there were 4,059 megawatts (MW) of installed wind energy in Washington and Oregon (USDOE 2011), most of which is within the Columbia Plateau Level III Ecoregion (Thorson et al. 2003, Washington Biodiversity Council 2008; Figure 1). This includes 1,964 MW of installed capacity in Washington and 2,095 MW in Oregon. Information posted on Renewable Northwest Project’s web site indicates that approximately 5,800 MW of wind energy generating capacity is currently operating or under construction in Oregon and Washington. Because the level of wind energy development in the Northwest is approaching 6,000 MW, the Bonneville Power Administration and NPCC will reconvene the Wind Integration Forum Steering Committee in June 2011 to address the feasibility of accommodating continued growth of wind energy in the four-state region.

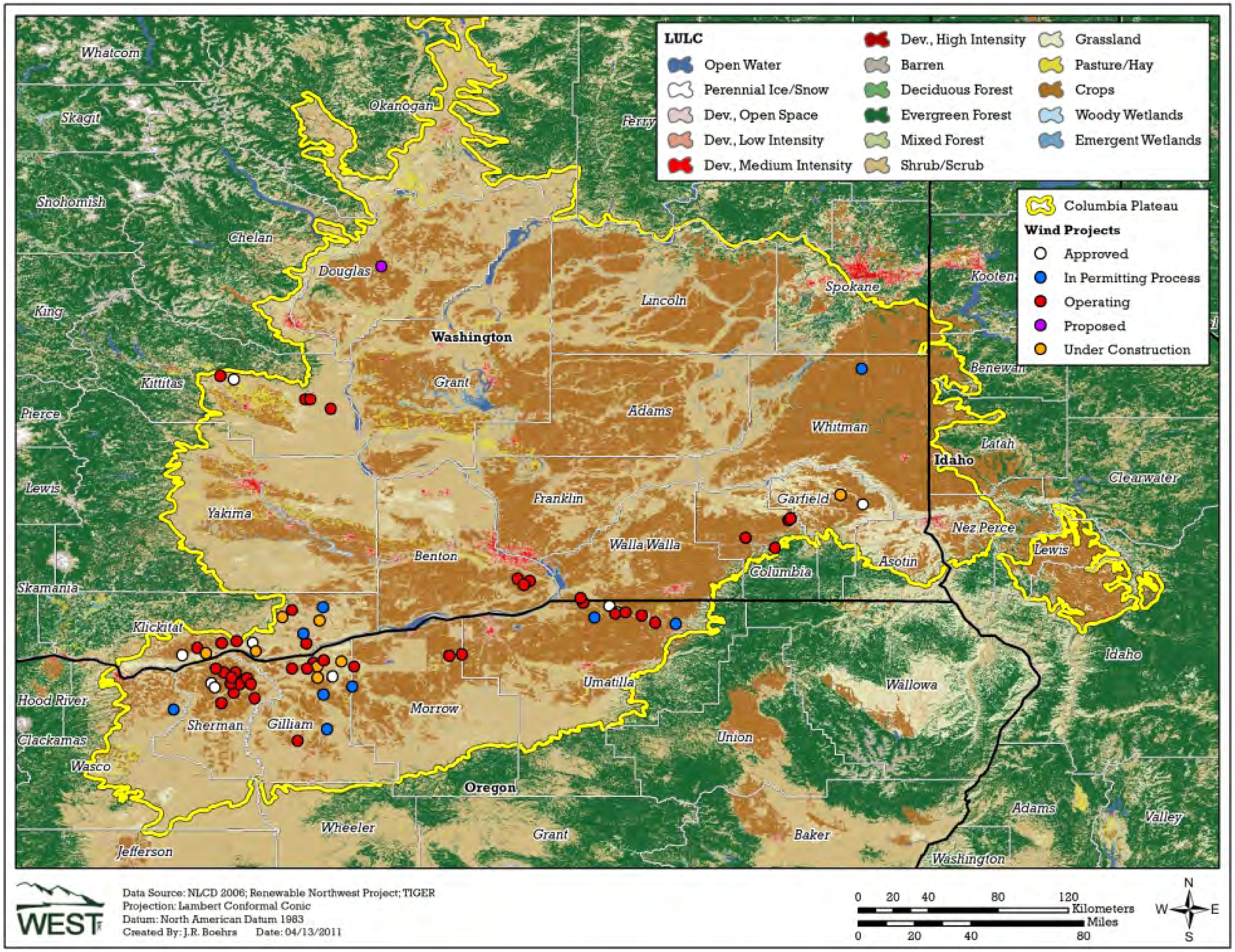

Figure 1. Existing and proposed wind energy facilities and land cover types in the Columbia Plateau Ecoregion.

In an earlier version of this cumulative effects analysis (Johnson and Erickson 2008), we attempted to contact every county within the CPE in an effort to estimate future wind energy development based on existing permit applications, which resulted in an estimate of 6,700 MW of wind energy development in the CPE. However, past experience indicates that not all of the projects that are proposed will ultimately be issued permits for the size originally proposed and not all permitted projects are built, or fully built-out. Consequently, this method can result in significantly over-estimating future wind energy development. However, to remain consistent, for the purpose of this analysis, we assumed that 6,700 MW of wind power would be present in the CPE by 2015.

The Columbia Plateau was historically characterized by open, arid shrub-steppe and grassland-steppe habitats. The current predominant land use of the CPE is dryland agriculture, land enrolled in the Conservation Reserve Program (CRP), and rangeland (Figure 2). Precipitation through the region is 6 to 12 inches (about 15-30 centimeters) per year (Thorson et al. 2003). Surrounding ecoregions are more mountainous, receive more precipitation, and are more forested than the Columbia Plateau.

METHODS

This report provides a qualitative analysis of results of regional fatality monitoring studies, estimated population sizes of birds in the CPE, and published literature to compile a cumulative impact analysis for bird and bat resources. The general approach to the cumulative effects analysis was to summarize results of fatality monitoring studies at operational wind energy facilities within the CPE, and use those results to estimate impacts for a projected 6,700 MW of wind energy development within the same ecoregion. Habitat and land use throughout the entire CPE are similar.

This cumulative effects analysis relies heavily on final results of 25 year-long monitoring studies conducted at 23 wind-energy facilities in the CPE, as well as preliminary carcass composition data from two additional facilities with post-construction monitoring data. For each of the individual study areas from which fatality results are available, the predominant land use was a mosaic of agriculture, mainly dryland wheat farming, and grassland or shrub- steppe rangeland used for livestock grazing. In general, the region where future wind energy facilities are being planned is similar in vegetation types (Quigley and Arbelbeide 1997), although, for any given facility, the amount of each type varies. It is assumed for the analysis that results from the existing studies would be applicable to proposed facilities.

With the exception of the Condon, Oregon, wind energy facility, where no scavenging or searcher efficiency trials were conducted to estimate total mortality, the 25 data sets used in this report were collected using similar methods, where the observed fatality rates calculated from standardized carcass searches were adjusted for searcher efficiency and carcass removal biases. The analysis operates under the assumption that the bird and bat communities are similar across all of these wind energy facilities because of habitat and land use similarities throughout the ecoregion, and thus the fatality results from these existing facilities are

Table 1. Avian and bat fatality estimates for existing wind energy facilities in the Columbia Plateau Ecoregion .

Facility Name, State	Raptor Fatalities/ MW/Study Period	All Bird Fatalities/ MW/Study Period	Nocturnal Migrants	References
Big Horn, WA	0.15	2.6	0.57	Kronner et al. 2008
Goodnoe Hills, WA	0.17	1.40	NR [a]	URS 2010a
Hopkins Ridge (Year 1), WA	0.14	1.23	0.46	Young et al. 2007
Hopkins Ridge (Year 2), WA	0.07	2.99	1.36	Young et al. 2009
Marengo I, WA	0	0.48	NR	URS 2010b
Marengo II, WA	0.05	0.16	NR	URS 2010c
Nine Canyon, WA	0.05	2.76	0.45	Erickson et al. 2003c
Nine Canyon II, WA	0	0.06	NR	Erickson et al. 2005
Stateline, WA/OR	0.09	2.92	0.83	Erickson et al. 2004
Stateline II, WA/OR	0.11	1.23	0.68	Erickson et al. 2007
Tuolumne (Windy Point I), WA	0.29	3.20	NR	Enz and Bay 2010
Wild Horse, WA	0.09	1.55	0.88	Erickson et al. 2008
Biglow Canyon I (Year 1), OR	0.03	1.76	0.44	Jeffrey et al. 2009
Biglow Canyon I (Year 2), OR	0.04	2.47	0.88	Enk et al. 2010
Biglow Canyon II (Year 1), OR	0.20	7.72	7.19	Enk et al. 2011
Combine Hills, OR	0	2.56	0.27	Young et al. 2006
Condon, OR	0.02 [b]	0.05 [b]	NR	Fishman Ecological Services 2003
Hay Canyon, OR	0	2.21	NR	Gritski and Kronner 2010a
Klondike, OR	0	0.95	0.35	Johnson et al. 2003
Klondike II, OR	0.11	3.14	2.11	NWC and WEST Inc. 2007
Klondike III, OR	0.15 [c]	3.19 [c]	0.90	Gritski et al. 2010
Klondike IIIa, OR	0 [c]	2.54 [c]	NR	Gritski et al. 2009
Leaning Juniper, OR	0.21	6.66	1.56	Gritski et al. 2008
Pebble Springs, OR	0.04	1.93	0.84	Gritski and Kronner 2010b
Vansycle, OR	0	0.95	0.32	Erickson et al. 2000
Mean	**0.08**	**2.36**	**1.18**	

[a] NR = Not reported or calculated
[b] These estimates are not adjusted for searcher efficiency or scavenger removal; study methods differed from other projects and were not as rigorous; therefore this estimate should be regarded as a minimum mortality estimate and it was not used in calculation of the mean values.
[c] Huso estimator used (see Huso 2010)

applicable to proposed facilities in this same ecoregion. Details about results, methods, and estimates of potential bird and bat impacts from each individual wind energy facility are available in the referenced facility reports.

To define population sizes of those species most likely to be affected by wind energy development in the CPE, we used data from a Partners in Flight (PIF) publication that estimates breeding population size of bird species by Bird Conservation Region, and then by that portion of each state within the Bird Conservation Region (see Blancher et al. 2007). Those portions of Washington and Oregon within the Great Basin Bird Conservation Region (see US NABCI Committee [2000] for a description) essentially comprise the same area that we have defined as the CPE. To our knowledge these are the only population estimates available for the entire CPE.

Raptors

Post-construction raptor fatality estimates are available for 23 facilities within the CPE of eastern Washington and Oregon (Table 1). Based on available data, it is likely that raptor mortality throughout the CPE would be on the same order of magnitude as other wind energy facilities in the western US outside California, where raptor fatality rates range from none to 0.15 fatalities/MW/year (Johnson and Stephens 2011). Raptor use (raptors/survey) at wind resource areas (WRAs) in the CPE ranges from 0.26 to 1.64, and averages 0.68 observations per 20-min survey (Table 2). This use is substantially lower than that at Altamont Pass and High Winds, two facilities in California that have had relatively high levels of raptor mortality (see Altamont Pass Avian Monitoring Team 2008, Kerlinger et al. 2006). Similar levels of raptor mortality in the CPE would not be expected.

To predict raptor mortality for all existing and proposed wind energy facilities in the CPE, we assumed it would be similar to the other existing wind energy facilities in the CPE. Mean annual raptor mortality (fatalities/MW/year) at the 23 existing wind energy facilities in eastern Washington and Oregon ranges from 0 to 0.29/MW/year, with a mean of 0.08/MW/year. Because the 1.5–3.0 MW turbines constructed or proposed for most new-generation wind energy facilities are larger than turbines used at most of the existing wind energy facilities, and as several of the existing facilities used smaller turbines ranging from 0.66 – 1.5 MW in size, it is likely not appropriate to predict raptor mortality in the CPE using per turbine estimates from the other wind energy facilities. Therefore, we used per MW estimates of raptor mortality for extrapolating the estimated numbers of raptor fatalities in the CPE. To estimate cumulative mortality of individual species, we assumed that species composition of bird and bat fatalities associated with 6,700 MW of wind energy would be similar to species composition of fatalities found at the 25 existing facilities in the CPE, including 23 with final quantified fatality estimates and two facilities with ongoing studies for which there are raw data on species composition and numbers of fatalities (White Creek and Harvest Wind wind energy facilities, both located in Klickitat County, Washington). For example, American kestrels (*Falco sparverius*) composed 29.0% of the raptor fatalities found at existing wind energy facilities in the CPE, and to estimate the total number of American kestrel fatalities associated with 6,700 MW of wind energy development, we assumed that they would also compose 29.0% of the total cumulative number of raptor fatalities per year.

Table 2. Avian use estimates (# observed per 20 minutes per plot with 800-m radius viewshed) for Wind Resource Areas in the Columbia Plateau Ecoregion.

		Mean Avian Use		
Wind Resource Area	**Location**	**Raptors**	**All Birds**	**Source**
Hopkins Ridge	Columbia Co., WA	0.64	8.7	Young et al. 2003a
Nine Canyon	Benton Co., WA	0.26	9.4	Erickson et al. 2001b
Desert Claim	Kittitas Co., WA	0.77	15.3	Young et al. 2003b
Kittitas Valley	Kittitas Co., WA	0.90	12	Erickson et al. 2003b
Wild Horse	Kittitas Co., WA	0.40	5	Erickson et al. 2003a
Big Horn I	Klickitat Co., WA	0.90	16.6	Johnson and Erickson 2004
White Creek	Klickitat Co., WA	0.66	11.9	NWC and WEST 2005
Linden Ranch	Klickitat Co., WA	1.64	11.1	Johnson et al. 2007a
Hoctor Ridge	Klickitat Co., WA	1.38	15.3	Johnson et al. 2006b
Imrie	Klickitat Co., WA	0.70	19.2	Johnson et al. 2006c
Tuolumne (Windy Point)	Klickitat Co., WA	0.77	16.2	Johnson et al. 2006a
Windy Flats	Klickitat Co., WA	0.83	19.9	Johnson et al. 2007b
Reardan	Lincoln Co., WA	0.90	13	WEST Inc. 2005a
Zintel Canyon	Benton Co., WA	0.44	19	Erickson et al. 2002
Maiden	Benton/Yakima Co., WA	0.38	11.6	Young et al. 2002
Combine Hills	Umatilla Co., OR	0.60	6	Young et al. 2003c
Klondike	Sherman Co., OR	0.47	17.5	Johnson et al. 2002a
Klondike III	Sherman Co, OR	0.78 [a]	8.18 [a]	Gritski 2009
Biglow	Sherman Co., OR	0.30	9.1	WEST Inc. 2005c
Vansycle	Umatilla Co., OR	0.41	13.1	WCIA and WEST Inc. 1997
Elkhorn	Union Co., OR	1.05	21.7	WEST Inc. 2005b
Shepherd's Flat	Morrow Co., OR	0.61	6.5	Young and Poulton 2007
Leaning Juniper	Gilliam Co., OR	0.52	23.6	Kronner et al. 2005
Condon	Gilliam Co., OR	0.37	5.8	URS et al. 2001b
Stateline	Walla Walla Co., WA /Umatilla Co., OR	0.41	13.1	URS et al. 2001a
Mean		**0.68**	**13.2**	
Range		**0.26 – 1.64**	**5 – 23.6**	

[a] Surveys were 10 minutes long; estimates provided were multiplied by 2 to estimate use during a 20-minute interval

All Birds (Excluding Raptors)

Compared with raptors, there is little correlation between total numbers of birds (all species except raptors) observed during pre-construction surveys (most of which are songbirds) and post-construction mortality, presumably because many of the collision fatalities are nocturnal migrants (see Table 1), which are not accounted for during diurnal surveys. In addition, the survey methods for quantifying use are more relevant for large birds than for small birds. Total bird use at 25 wind resource areas in the CPE has ranged from 5–23.6 birds/survey and averaged 13.2 birds/survey (Table 2). Total bird use at the wind energy facilities in eastern Washington and Oregon with post-construction fatality data ranged from 5.0 birds/survey at Wild Horse to 23.6 birds/survey at Leaning Juniper, and averaged 11.7 birds/survey (Table 2). Because total bird use at proposed wind energy facilities with pre-construction bird use data is within the range of similar bird use values for existing wind energy facilities in the CPE, it is reasonable to assume that mortality of all birds combined (except raptors) at CPE wind energy facilities would be similar to that observed at the 23 existing wind energy facilities in the CPE. Therefore, we multiplied the total number of MW by 2.28 fatalities/MW/year (the mean total bird fatality rate [minus mean raptor fatality rate] among the 23 CPE wind energy facilities) to estimate total bird mortality. To estimate total cumulative mortality by bird type and/or species, we assumed the fatalities associated with 6,700 MW of wind energy would have the same group and species composition as fatalities found at existing wind energy facilities in the CPE.

Bats

To estimate cumulative bat mortality for all projects in the CPE, we assumed that bat mortality would be similar to the existing wind energy facilities located in the CPE. Therefore, we multiplied the total number of MW by the mean number of bat fatalities/MW/year at the other CPE Projects (1.14 fatalities/MW/year; Table 3). We estimated the total number of fatalities by species assuming species composition would be similar to the species composition of bat fatalities found at existing wind energy facilities in the CPE.

Table 3. Summary of bat mortality at existing wind energy facilities in the Columbia Plateau Ecoregion.

Facility Name, State	Bat Fatalities per MW	Reference
Big Horn I, WA	1.90	Kronner et al. 2008
Goodnoe Hills, WA	0.17	URS 2010a
Hopkins Ridge, WA (Year 1)	0.63	Young et al. 2007
Hopkins Ridge, WA (Year 2)	1.39	Young et al. 2009
Marengo I, WA	0.17	URS 2010b
Marengo II, WA	0.27	URS 2010c
Nine Canyon, WA	2.47	Erickson et al. 2003c
Nine Canyon II, WA	0.32	Erickson et al. 2005
Stateline, OR/WA	1.70	Erickson et al. 2004
Stateline II, OR/WA	0.95	Erickson et al. 2007
Tuolumne (Windy Point I), WA	0.94	Enz and Bay 2010
Wild Horse, WA	0.39	Erickson et al. 2008
Biglow Canyon I, OR (Year 1)	1.99	Jeffrey et al. 2009
Biglow Canyon I, OR (Year 2)	0.58	Enk et al. 2010
Biglow Canyon II, OR (Year 1)	3.78	Enk et al. 2011
Combine Hills, OR	1.88	Young et al. 2006
Hay Canyon, OR	0.53	Gritski and Kronner 2010a
Vansycle, OR	1.12	Erickson et al. 2000
Klondike I, OR	0.77	Johnson et al. 2003
Klondike II, OR	0.41	NWC and WEST Inc. 2007
Klondike III, OR	1.17[a]	Gritski et al. 2010
Klondike IIIa, OR	0.23[a]	Gritski et al. 2009
Pebble Springs, OR	1.55	Gritski and Kronner 2010b
Leaning Juniper, OR	1.98	Gritski et al. 2008
Average	**1.14**	

[a] Huso estimator used (see Huso 2010)

RESULTS

Existing Data for CPE Projects

Raptors

Post-construction raptor fatality estimates are available for 23 wind energy facilities within the CPE of eastern Washington and Oregon (Table 1). Pre-construction raptor use estimates at these wind energy facilities have ranged from 0.26 to 1.64 raptors/survey, and averaged 0.68/survey (Table 2). Raptor mortality was not documented at seven of these wind energy facilities, including five in Oregon (Klondike I, Klondike IIIa, Vansycle, Combine Hills, Hay Canyon) and two in Washington (Marengo I, Nine Canyon II) during one-year post-construction mortality surveys, and was relatively low to moderate at the others, ranging from 0.03/MW/year at Biglow Canyon I, Oregon to 0.29/MW/year at Tuolomne, Washington (Table 1). Quantitative mortality estimates were not made for the Condon, Oregon site, but only one raptor fatality was documented at that facility (Fishman Ecological Services 2003).

The 100 raptor fatalities found at CPE wind energy facilities have composed 8.7% of the total identified bird mortality. Most of the raptor fatalities have been American kestrels (29 fatalities; 29.0%) and red-tailed hawks (*Buteo jamaicensis*; 22 fatalities; 22.0%). Other raptors found as fatalities at CPE wind energy facilities include nine Swainson's hawks (*Buteo swainsonii*), eight short-eared owls *(Asio flammeus),* five rough-legged hawks (*Buteo lagopus*), four ferruginous hawks (*Buteo regalis*), four unidentified buteos, three of each of the following: great horned owl (*Bubo virginianus*), long-eared owl (*Asio otus*), northern harrier (*Circus cyaneus*), two each of prairie falcon (*Falco mexicanus*) and sharp-shinned hawk (*Accipiter striatus*), and one each of the following: golden eagle (*Aquila chrysaetos*), Cooper's hawk (*Accipiter cooperii*), unidentified accipiter, barn owl (*Tyto alba*), barred owl (*Strix varia*), and unidentified owl (Table 4).

All Birds (Excluding Raptors)

Ninety-eight bird species have occurred as fatalities at existing wind energy facilities in the CPE. Passerines (songbirds) have been the most abundant bird fatality at modern wind energy facilities in western North America, comprising 59.3% of total bird fatalities (Johnson and Stephens 2011). Passerines are also the most commonly observed birds during pre-construction fixed-point bird use surveys at all of these sites. Both migrant and resident passerine fatalities have been observed. Songbird mortality at wind energy facilities in eastern Oregon and Washington has been reasonably consistent among sites. Songbirds have composed 69.5% of the identified bird mortality at CPE wind energy facilities. Horned larks (*Eremophila alpestris*) have been the most commonly observed songbird fatality in the CPE, composing 30.8% of all identified bird fatalities combined (Table 4), and have been the most abundant songbird observed during pre-construction fixed point bird use surveys at these sites. Based on long term Breeding Bird Survey (BBS) data (Blancher et al. 2007), horned larks are likely one of the most common birds in the Columbia Plateau. No other resident songbird

Table 4. Number and species composition of bird fatalities found at the existing Columbia Plateau Ecoregion wind energy projects [a].

Species	Number of Fatalities	Percent Composition
horned lark	354	29.9
ring-necked pheasant	70	5.9
golden-crowned kinglet	67	5.7
gray partridge	51	4.3
western meadowlark	36	3.0
unidentified passerine	33	2.8
unidentified bird (small)	31	2.6
dark-eyed junco	30	2.5
European starling	30	2.5
American kestrel	29	2.5
chukar	29	2.5
mourning dove	26	2.2
white-crowned sparrow	24	2.0
red-tailed hawk	22	1.9
Townsend's warbler	22	1.9
yellow-rumped warbler	20	1.7
rock pigeon	18	1.5
ruby-crowned kinglet	18	1.5
winter wren	14	1.2
northern flicker	12	1.0
Swainson's hawk	9	0.8
Brewer's sparrow	9	0.8
American robin	9	0.8
savannah sparrow	8	0.7
short-eared owl	8	0.7
common nighthawk	8	0.7
house wren	8	0.7
unidentified sparrow	7	0.6
warbling vireo	7	0.6
unidentified kinglet	6	0.5
red-breasted nuthatch	6	0.5
golden-crowned sparrow	5	0.4
Canada goose	5	0.4
black-billed magpie	5	0.4
rough-legged hawk	5	0.4
unidentified buteo	4	0.3
house sparrow	4	0.3
house finch	4	0.3
American coot	4	0.3
Vaux's swift	4	0.3
spotted towhee	4	0.3
Cassin's vireo	4	0.3
ferruginous hawk	4	0.3
song sparrow	4	0.3
western tanager	3	0.3
MacGillivray's warbler	3	0.3
orange-crowned warbler	3	0.3
Lincoln's sparrow	3	0.3
long-eared owl	3	0.3
great blue heron	3	0.3
vesper sparrow	3	0.3
unidentified vireo	3	0.3
northern harrier	3	0.3

Table 4. Number and species composition of bird fatalities found at the existing Columbia Plateau Ecoregion wind energy projects [a].

Species	Number of Fatalities	Percent Composition
mountain bluebird	3	0.3
great horned owl	3	0.3
chipping sparrow	3	0.3
common raven	2	0.2
common yellowthroat	2	0.2
downy woodpecker	2	0.2
mallard	2	0.2
American goldfinch	2	0.2
Virginia rail	2	0.2
white-throated swift	2	0.2
pine siskin	2	0.2
prairie falcon	2	0.2
unidentified warbler	2	0.2
northern rough-winged swallow	2	0.2
unidentified duck	2	0.2
sharp-shinned hawk	2	0.2
sage thrasher	2	0.2
western grebe	1	0.1
California quail	1	0.1
white-breasted nuthatch	1	0.1
Cooper's hawk	1	0.1
western kingbird	1	0.1
common poorwill	1	0.1
varied thrush	1	0.1
bufflehead	1	0.1
unidentified thrush	1	0.1
black-throated sparrow	1	0.1
Brewer's blackbird	1	0.1
barn owl	1	0.1
brown-headed cowbird	1	0.1
western wood-pewee	1	0.1
barred owl	1	0.1
ash-throated flycatcher	1	0.1
Williamson's sapsucker	1	0.1
Wilson's warbler	1	0.1
black-throated gray warbler	1	0.1
gray flycatcher	1	0.1
yellow warbler	1	0.1
long-billed curlew	1	0.1
killdeer	1	0.1
purple finch	1	0.1
red-winged blackbird	1	0.1
sage sparrow	1	0.1
horned grebe	1	0.1
hermit thrush	1	0.1
hairy woodpecker	1	0.1
unidentified large bird	1	0.1
grasshopper sparrow	1	0.1
unidentified owl	1	0.1
gray catbird	1	0.1
golden eagle	1	0.1
Swainson's thrush	1	0.1
Townsend's solitaire	1	0.1

Table 4. Number and species composition of bird fatalities found at the existing Columbia Plateau Ecoregion wind energy projects [a].

Species	Number of Fatalities	Percent Composition
tree swallow	1	0.1
turkey vulture	1	0.1
unidentified accipiter	1	0.1
unidentified empidonax	1	0.1
northern pintail	1	0.1
Total	**1,183**	**100**

[a] Species composition of bat fatalities is based on the data provided in those studies included in Table 1, as well as raw fatality data (species and numbers) for the Harvest Wind Farm and White Creek wind energy facilities in Klickitat County, Washington

species comprised a large proportion of the fatalities observed at the wind energy facilities in the CPE (Table 4). The one apparent migrant with the highest number of fatalities is the golden-crowned kinglet (*Regulus satrapa*; 67 fatalities; 5.7% of all identified fatalities; Table 4).

Mourning doves (*Zenaida macroura*) and rock pigeons (*Columba livia*) have composed 3.8% of the identified mortality at CPE wind energy facilities. Waterfowl, waterbirds and shorebirds have composed only 2.1% of the identified fatalities. However, mortality is very low compared to the relatively high use by these bird types. For example, only two Canada goose fatalities were documented at the Klondike, Oregon wind energy facility (Johnson et al. 2003), even though 43 flocks totaling 4,845 individual Canada geese were observed during pre-construction fixed-point bird use surveys (Johnson et al. 2002a). Shorebird use of wind energy facilities in the CPE has been low, with the most common species being killdeer (*Charadrius vociferous*). Generally, shorebirds species are rarely killed at wind energy facilities; of the 1,247 avian fatalities collected at modern wind energy facilities in western North America and summarized in Johnson and Stephens (2011), only three fatalities (0.2% of the total fatalities) were shorebirds. Low shorebird mortality has occurred even though shorebirds have been recorded at virtually every wind energy facility evaluated. Some waterfowl, shorebird and other waterbird mortality will occur at CPE wind energy facilities, but based on all available data from other facilities, the numbers are expected to be low relative to the use of each area.

Upland game bird fatalities documented during surveys of CPE wind energy facilities include ring-necked pheasant (*Phasianus colchicus*), gray partridge (*Perdix perdix*), chukar (*Alectoris chukar*), and California quail (*Callipepla californica*). Upland game bird mortality is fairly common, as upland game birds have comprised 9.6% of all fatalities at modern wind energy facilities in western North America, behind only passerines and raptors (Johnson and Stephens 2011). In the CPE, upland game birds are one of the most common fatalities, composing 13.1% of all identified fatalities (Table 5). Based on habitat present, results from other regional wind energy facilities, and the presence of upland game birds during baseline surveys, some mortality of upland game birds is expected to occur at nearly all wind energy facilities in the CPE.

Table 5. Percent composition of avian fatalities by bird type for existing Columbia Plateau Ecoregion wind energy facilities.

Bird Type	Number of Fatalities	Percent Composition
Passerines	800	67.6
Upland Game Birds	151	12.8
Raptors	100	8.5
Doves/Pigeons	44	3.7
Unidentified Birds	32	2.7
Other Birds[a]	31	2.6
Waterbirds/Waterfowl/Shorebirds	24	2.0
Vultures	1	0.1
Totals	**1,183**	**100**

[a] woodpeckers, nighthawks, swifts

Bats

Bat mortality estimates have been made for 23 existing wind energy facilities in the CPE, where they ranged from 0.17–3.78 fatalities/MW/year, and averaged 1.14 fatalities/MW/year (Table 3). Bat mortality patterns at wind energy facilities in Washington and Oregon have followed patterns similar to the rest of the country. Of 537 identified bat fatalities collected at existing wind energy facilities in eastern Oregon and Washington, 525 (97.8%) have been the two migratory species that occur in the CPE, including 267 silver-haired bats (*Lasionycteris noctivagans*) and 258 hoary bats (*Lasiurus cinereus*). The other mortalities have consisted of small numbers of big brown bats (*Eptesicus fuscus*), little brown bats (*Myotis lucifugus*), and unidentified bats (Table 6). Virtually all of the mortality has occurred in late summer and early fall, during the fall migration period for hoary and silver-haired bats.

Table 6. Number and species composition of bat fatalities found at existing Columbia Plateau Ecoregion wind energy projects[a].

Species	Number of Fatalities	Percent Composition
silver-haired bat	267	48.0
hoary bat	258	46.4
unidentified bat	19	3.4
little brown bat	7	1.3
big brown bat	4	0.7
unidentified myotis	1	0.2
Total	**556**	**100**

[a] Species composition of bat fatalities is based on the data provided in those studies included in Table 3, as well as raw fatality data (species and numbers) for the Harvest Wind Farm and White Creek wind energy facilities in Klickitat County, Washington

Mortality Estimates and Population Consequences

All Birds (Excluding Raptors)

For all birds combined (excluding raptors), we estimate that total annual mortality in the CPE would be 15,276 birds/year. Despite several thousand bird fatalities from 6,700 MW of wind power, these impacts are spread across numerous species and bird groups, as well as across seasons. Therefore, the overall impact to any given species or population of a species is substantially less. Based on species composition of fatalities at existing CPE wind energy facilities (Table 4), passerines would compose approximately 69.5% of the fatalities, upland game birds would compose 13.1%, doves/pigeons would compose 3.8%, waterfowl/waterbirds/shorebirds would compose 2.1% and other bird types (such as woodpeckers, nighthawks, and swifts) would compose 2.7%. Approximately 4.5% of the mortality would be composed of non-protected European starlings (*Sturnus vulgaris*), rock pigeons, and house sparrows (*Passer domesticus*).

Raptors

Using raptor mortality estimates from existing wind energy facilities in the CPE, we estimate total raptor mortality in the CPE would be 536 fatalities per year. American kestrels account for 29.0%, red-tailed hawks account for 22.0%, Swainson's hawks account for 9.0%, and short-eared owls account for 8.0% of the raptor fatalities recorded at the regional wind projects studied. Assuming this trend holds true for all proposed wind energy facilities in the CPE, and assuming there would be 536 raptor fatalities per year, it would be expected that on average 155 American kestrels, 118 red-tailed hawks, 48 Swainson's hawks, and 43 short-eared owls would be killed each year.

The other species of raptors occurring in the CPE have had no or few fatalities at existing wind energy facilities, and would likely represent a much smaller number of fatalities. For example, no peregrine falcon (*Falcon peregrinus*) or bald eagle (*Haliaeetus leucocephalus*) fatalities have been reported to date; therefore, our mortality estimate for these species is necessarily zero. Three species of concern in the region, golden eagle, ferruginous hawk, and Swainson's hawk, have all been found as turbine collision victims in the CPE. Ferruginous hawks have composed 4.0% of the raptor fatalities, Swainson's hawks have composed 9.0%, and golden eagles have composed 1.0%. Assuming a total of 536 raptor fatalities could occur each year in the CPE, this would result in 21 ferruginous hawk, 48 Swainson's hawk, and five golden eagle fatalities per year.

The two species of raptors with the largest expected numbers of fatalities due to wind energy development in the CPE are American kestrel and red-tailed hawk. Raptor fatalities in the CPE have occurred throughout the year, with 26.0% occurring in the spring (March 15 – May 31), 43.0% in the summer (June 1 – August 31), 15.0% in the fall (September 1 – November 15), and 16.0% in the winter (November 16 – March 14) (see Table 7). Approximately 31.0% of the raptor fatalities have occurred during the fall migration and during winter periods, when the affected population could contain birds from numerous local breeding populations in the Pacific Northwest as well as further north in Canada. Assuming approximately 69.0% of the mortality would occur during the spring and summer breeding season (March 15 – August 31), it would be expected that approximately 107 American kestrel and 81 red-tailed hawk fatalities would occur during the breeding season. An estimate of the breeding population in the Columbia Plateau, based on the BBS long-term average data, is approximately 170,000 breeding American kestrels and 77,000 breeding red-tailed hawks (Blancher et al. 2007). Annual collision mortality in the CPE would represent approximately 0.06% of the breeding population of American kestrels and 0.11% of the breeding population of red-tailed hawks. Even if we assumed all mortality (instead of 69.0%) would occur to adult breeding birds, this would still

Table 7. Seasonal timing of raptors and owls fatalities at existing wind energy facilities in the Columbia Plateau.

	Season				
Facility Name, State	**Spring**	**Summer**	**Fall**	**Winter**	**Overall**
Combine Hills, OR	0	0	0	0	0
Klondike, I OR	0	0	0	0	0
Klondike II, OR	0	1	1	0	2
Klondike III, OR	1	6	1	1	9
Klondike IIIa, OR	0	0	0	0	0
Vansycle, OR	0	1	0	0	1
Stateline I, OR/WA	1	4	4	0	9
Stateline II, OR/WA	1	2	0	1	4
Hopkins Ridge I, WA (Year 1)	1	2	1	1	5
Hopkins Ridge I, WA (Year 2)	0	1	2	1	4
Nine Canyon, WA	1	0	0	1	2
Wild Horse, WA	1	5	0	0	6
Big Horn I, WA	3	6	2	5	16
Hay Canyon, OR	0	0	0	0	0
Biglow Canyon I, OR (Year 1)	2	0	0	0	2
Biglow Canyon I, OR (Year 2)	0	1	1	0	2
Tuolumne (Windy Point I), WA	2	4	1	1	8
Goodnoe Hills, WA	1	3	0	1	5
Leaning Juniper, OR	3	2	2	0	7
Condon, OR	1	0	0	0	1
Marengo I, WA	0	0	0	0	0
Marengo II, WA	1	0	0	0	1
Pebble Springs, OR	2	0	0	0	2
Biglow Canyon II, OR	3	3	0	0	6
Harvest Wind Farm, WA	0	0	0	2	2
White Creek, WA (2009)	2	1	0	2	5
White Creek, WA (2010)	0	1	0	0	1
Nine Canyon II, WA	0	0	0	0	0
Totals	**26**	**43**	**15**	**16**	**100**
Percent	**26**	**43**	**15**	**16**	**100**

Data from the following sources:

Facility	**Reference**	**Facility**	**Reference**
Combine Hills, OR	Young et al. 2006	Hay Canyon, OR	Gritski and Kronner 2010a
Klondike, I OR	Johnson et al. 2003	Biglow Canyon I, OR (Yr 1)	Jeffrey et al. 2009
Klondike II, OR	NWC and WEST Inc. 2007	Biglow Canyon I, OR (Yr 2)	Enk et al. 2010
Klondike III, OR	Gritski et al. 2010	Tuolumne, WA	Enz and Bay 2010
Klondike IIIa, OR	Gritski et al. 2009	Goodnoe Hills, WA	URS 2010a
Vansycle, OR	Erickson et al. 2000	Leaning Juniper, OR	Gritski et al. 2008
Stateline, OR/WA (01-03)	Erickson et al. 2004	Condon, OR	Fishman Ecological Services 2003
Stateline II, OR/WA (06)	Erickson et al. 2007	Marengo I, WA	URS 2010b
Hopkins Ridge I, WA (Yr 1)	Young et al. 2007	Pebble Springs, OR	Gritski and Kronner 2010b
Hopkins Ridge I, WA (Yr 2)	Young et al. 2009	Marengo II, WA	URS 2010c
Nine Canyon, WA	Erickson et al. 2003c	Biglow Canyon II, OR	Enk et al. 2011
Wild Horse, WA	Erickson et al. 2008	Nine Canyon II, WA	Erickson et al. 2005
Big Horn I, WA	Kronner et al. 2008		

represent only 0.09% and 0.15% of the breeding American kestrels and red-tailed hawks, respectively, in the CPE. Background mortality for these species is much higher than this estimate and the additional wind energy related mortality is likely insignificant from a population standpoint. Typical annual mortality rates for red-tailed hawks are 54% of juveniles, 20% of subadults, and 20% of adults. American kestrels suffer even higher mortality, as the annual mortality rate is 69% for juveniles and 45% for adults (Millsap and Allen 2006). Given these numbers, plus the fact that most raptor populations can withstand additional harvest of nestlings and migrating birds by falconers of 10-20% or even higher (Millsap and Allen 2006), it is unlikely that the additional mortality of <0.20% associated with projected wind power development in the CPE would lead to measurable population effects for American kestrels or red-tailed hawks. Based on an analysis of population sizes and survival rates, the US Fish and Wildlife Service conservatively estimates that falconers could harvest 13,216 juvenile red-tailed hawks and 19,575 juvenile American kestrels each year in the US without any consequences to populations (Millsap and Allen 2006). Actual harvest by falconers in 2004 was only 1,062 raptors comprised of 15 species (Millsap and Allen 2006). Given these estimates of a sustainable harvest and the actual number of birds harvested, the number of birds killed in 2004 by wind turbines in North America should have fallen into a range of sustainable mortality.

Even though only four ferruginous hawk, nine Swainson's hawk, and one golden eagle fatalities have been found at existing wind energy facilities in the CPE, these raptors are species of concern and warrant additional analysis. The ferruginous hawk is listed as threatened by the Washington Department of Fish and Wildlife (WDFW 2010) and as "critical" by the Oregon Department of Fish and Wildlife (ODFW 2008), while the Swainson's hawk is listed as "vulnerable" by the ODFW (2008).

The estimated breeding population in the CPE is 1,000 ferruginous hawks (Blancher et al. 2007). Ferruginous hawks may occur in the CPE throughout the year and their populations include breeders, migrants and winter residents, as well as juveniles and adults. Given our estimate of 21 ferruginous hawk fatalities on an annual basis, even if all turbine mortality occurred to resident breeding adult birds, this would represent 2.1% of the breeding ferruginous hawks in the CPE. Because mortality would likely be spread out among migrants, winter residents, resident breeders, and juveniles, as well as adults, mortality of adult ferruginous hawks actually breeding in the CPE would be less than 2.1%, likely on the order of 1-2%. According to Millsap and Allen (2006), ferruginous hawk populations can sustain 1% harvest rates (limited to juveniles) without affecting populations. This harvest rate was considered conservative because it was modeled using data obtained from red-tailed hawk banding or marking studies, which typically greatly underestimate survival in raptors compared to telemetry studies. Therefore, the sustainable harvest rate is likely greater than 1%. To put a 1–2% mortality rate into perspective, we examined existing mortality rates of ferruginous hawks. A study of ferruginous hawks in Washington State found that annual adult mortality was 24%, and mortality of juvenile ferruginous hawks was 57% between the first and second year (Watson 2003). A ferruginous hawk banding study in Alberta, Canada found that first year mortality was 60% (Schmutz and Fyfe 1987), and a study of ferruginous hawks in Utah found that annual mortality was 25% for adults and 66% for juveniles the first year (Woffinden and Murphy 1989).

Another study in Canada (Alberta and Saskatchewan) found that annual adult mortality was 29.2%, and first year mortality of nestlings was 45.5% (Schmutz et al. 2008). Despite annual adult mortality of 29.2%, the authors concluded that adult survival was not limiting the population; abundance of ground squirrels, which affected nesting success, appeared to be the primary factor regulating population size (Schmutz et al. 2008). Given published annual mortality rates for adult ferruginous hawks of 24–30%, additional losses of 1–2% of resident breeders associated with 6,700 MW of wind energy development in the CPE would not likely have measurable population consequences.

Breeding Bird Survey data collected over the last 27 years (1980–2007) show a negative trend in population growth for ferruginous hawks in the CPE (Sauer et al. 2008), but the negative trend is not statistically significantly due to low sample sizes and uncertainty (Sauer et al. 2008). If ferruginous hawk populations are declining in the region, and wind energy development continues at its current rate of growth in the CPE, ferruginous hawk collision mortality could eventually reach a point that populations may begin to decline without some form of mitigation. Mitigation could include establishing conservation easements around ferruginous hawk breeding territories, erecting artificial nest structures, or otherwise improving habitat for ferruginous hawks in the CPE (Johnson et al. 2007c).

The estimated Swainson’s hawk breeding population in the CPE is 10,000 (Blancher et al. 2007). Unlike ferruginous hawks, Swainson’s hawks occur in the CPE only during summer and most are resident breeders. Given our mortality estimate of 48 Swainson’s hawks per year, this would represent only 0.48% of the Swainson’s hawks in the CPE. Compared to many other raptor species, there is little data on annual survival of Swainson’s hawks (England et al. 1997). The annual mortality rate of Swainson’s hawks was reported in one study from western Canada, where it was estimated to be 15.7%, and nestling mortality rates ranged from 56–81% over the multi-year study (Schmutz et al. 2006). Given these mortality rates, additional losses of <0.5% would be considered sustainable and would not have measurable population consequences.

The golden eagle is federally protected by the Bald and Golden Eagle Protection Act (BGEPA 1940) and is listed as a candidate species by the WDFW (2010), but does not have any special status in Oregon. The estimated breeding population in the CPE is 1,770 (Blancher et al. 2007). Golden eagles may occur in the CPE throughout the year and their populations include breeders, migrants and winter residents, as well as juveniles and adults. Given our annual estimate of five golden eagle fatalities, even if all turbine mortality occurred to resident breeding adult birds, this would represent 0.3% of the breeding golden eagles in the CPE. Because mortality would likely be spread out among migrants, winter residents, resident breeders, and juveniles as well as adults, mortality of adult golden eagles that breed in the CPE would be less than 0.3%. Mortality of golden eagles the first year after independence ranges from 54% to 82% (Kochert et al. 2002). At the Altamont Pass Wind Resource Area (APWRA) in California, mortality of radio-marked golden eagles was 16% the first year, 21% for floating birds one to three years old, and 9% for adult breeders (Hunt 2002). Based on a regression analysis of banding data, Harmata (2002) estimated that only 50% of golden eagles survive to the age of three years. Given these published mortality rates for golden eagles, additional losses of <0.3%

of the population associated with 6,700 MW of wind energy development in the CPE would not likely have measurable population consequences for golden eagles.

Upland Game Birds

Upland game birds represent a higher percentage (13.1%) of the identified bird fatalities in the Columbia Plateau than in other regions in the US. No native upland game birds have been found as fatalities at wind energy facilities in the CPE. All of the fatalities have been ring-necked pheasant, gray partridge, and chukar, which are all introduced species. Given our total bird mortality estimate of 15,276, approximately 2,000 upland game bird fatalities would be expected to occur on an annual basis.

The species most impacted, ring-necked pheasant, gray partridge, and chukar, are all common in mixed agricultural native grass/steppe habitats. Habitats throughout the Columbia Plateau are highly suitable for these species and the large populations likely influence the higher mortality rate for the regional wind energy facilities. The total estimated population size of these three species combined in the CPE of Oregon and Washington is 370,900 (Blancher et al. 2007); therefore, wind energy fatalities would compose approximately 0.54% of the population. As with non-native (non-protected) passerine species, there is generally lower concern over impacts to exotic upland game birds. Given the vast amount of suitable habitat and the ability of these species to withstand harvest rates substantially higher than 0.54%, it is unlikely that additional fatalities from wind energy development would be significant from a population standpoint.

Waterfowl, Waterbirds and Shorebirds

Waterfowl, waterbirds and shorebirds represent a very small percentage (2.1%) of all identified fatalities at existing wind energy projects in the CPE. Based on our total bird mortality estimate of 15,276, approximately 321 fatalities could result on an annual basis.

Populations of waterfowl, waterbirds and shorebirds in the CPE are considerable. In addition, members of these groups are present year-round in the form of resident breeders, migrants, and winter residents. Given that we estimate only a few hundred individuals will be killed by turbine collisions on an annual basis, no cumulative impacts on these species are likely. In addition to killdeer, another shorebird commonly associated with upland habitats where wind energy facilities are placed is long-billed curlew. To date, however, only one fatality of this sensitive species has been documented at existing wind energy facilities in the CPE.

Passerines

For projects in the CPE, approximately 69.5% of the identified bird fatalities have been passerines (Table 5). Assuming that 69.5% of all bird mortality would be composed of passerines, approximately 10,617 passerine fatalities would occur annually in the CPE. Of all passerine fatalities recorded during the regional monitoring studies, horned lark made up nearly half (44.3%) of the fatalities. Assuming this pattern holds for all CPE wind energy facilities, it could be expected that on average there would be 4,703 horned lark fatalities per year. Another common grassland breeder in the CPE, western meadowlark (*Sturnella neglecta*), composed approximately 4.5% of the passerine fatalities at wind energy facilities, and therefore total annual mortality of this species related to wind turbine collisions would be approximately 478 individuals. At wind energy facilities in the CPE, migrant passerines of several species generally composed approximately 50% of all bird fatalities (Table 1). Assuming these estimates are representative of all CPE wind energy facilities, approximately 7,638 nocturnal migrant fatalities would be expected per year if 6,700 MW of wind power were constructed. The most common migrant fatality at existing wind energy facilities in the CPE was golden-crowned kinglet (Table 4). Approximately 8.4% of the passerine fatalities were of this species; therefore, estimated annual mortality for this species would be approximately 892 individuals.

According to Blancher et al. (2007), the estimated size of the breeding population of horned larks in that portion of the CPE in Washington and Oregon is 2.2 million. Given our estimate of 4,703 horned lark fatalities, and if it is assumed that the horned lark fatalities are spread equally over the year, then roughly 25% (~1,176) of these fatalities would be during the breeding season. This represents approximately 0.05% of the breeding horned lark population. Given that most of the mortality will be composed of common species with widespread distribution and large populations, that annual mortality rates typically range from 31 – 49% for horned larks (Pearson et al. 2008, Camfield et al. 2010) and from 30–70% for passerines in general (Lack 1966, Welty 1982), losses amounting to less than 1% are impacts to individuals, and therefore not significant from a population standpoint.

While this example represents a plausible means of addressing potential population impacts under a number of assumptions, it illustrates the low level of effect on the common grassland/agricultural species that comprise the largest portion of the fatalities. Similar examples could be used for the other species that illustrate lower effects. For example, the BBS data indicate the breeding population of western meadowlarks in the CPE of Oregon and Washington is one million (Blancher et al. 2007). Given our estimate of 478 western meadowlark fatalities, the impact on the western meadowlark breeding population in the Columbia Plateau would be minor and insignificant. The number of fatalities from other species are even fewer (see Table 4) and unlikely to have any population effects.

In general, while modern turbines are getting taller, new wind energy facilities do not appear to have a large impact on migrant birds. Results of marine radar surveys for proposed wind energy facilities have indicated that the vast majority of nocturnal migrants fly at altitudes that do not put them at risk of collision with turbines (Young and Erickson 2006). Also, there have been only two multiple individual mortality events during a migration season reported at newer wind energy facilities in the US. At Buffalo Ridge, Minnesota, fourteen migrating passerine fatalities (vireos, warblers, flycatchers) were observed at two turbines during a single night in May 2002 (Johnson et al. 2002b), and 33 migrating passerine fatalities (mostly warblers) were observed near one turbine and a well-lit substation at the Mountaineer, West Virginia, wind energy facility in May 2004 (Kerns and Kerlinger 2004). At wind energy facilities in the CPE, migrant passerines of several species generally composed approximately 50% of the bird fatalities. Some impacts are expected for nocturnal migrating species; however, impacts are not expected to be great for the CPE. The apparent migrant with the greatest number of collision fatalities is golden-crowned kinglet. Our annual mortality estimate for golden-crowned kinglet was 892, which would represent 0.12% of the estimated breeding population size of this species in the

CPE of Oregon and Washington, which is 720,000 (Blancher et al. 2007). Golden-crowned kinglets are typically associated with forested habitats during the breeding season, so it is assumed that many of the impacted individuals were from surrounding mountainous ecoregions or populations further north (e.g., Canada), rather than from the CPE. Estimating the potential population size from which these birds came requires a number of assumptions. However, while the potential population size is unknown, it is possible that the individual fatalities came from several populations in surrounding or more northern ecoregions, thus further diluting the impacts on any one population. Other potential migrant species were found in lower numbers. Cumulatively the impacts to migrants would be spread over a much larger population base and are not considered significant.

Sensitive Bird Species

In addition to golden eagle, ferruginous hawk, and Swainson's hawk discussed above, other species classified as sensitive species by the WDFW and/or ODFW (WDFW 2010, ODFW 2008) have been found as fatalities at CPE wind energy projects. These include long-billed curlew (*Numenius americanus;* Oregon sensitive), grasshopper sparrow (*Ammodramus savannarum;* Oregon sensitive), sage thrasher (*Oreoscoptes montanus;* Washington sensitive), sage sparrow (*Amphispiza belli;* Washington and Oregon sensitive) and Vaux's swift (*Chaetura vauxi;* Washington sensitive). Four Vaux's swifts, two sage thrashers, and only one fatality of each of the other sensitive species have been found at CPE wind energy projects. Given that 1,183 bird fatalities have been found at these projects and estimated total bird mortality is 15,276, the estimated annual mortality would be 52 Vaux's swifts, 26 sage thrashers, 13 grasshopper sparrows, 13 sage sparrows and 13 long-billed curlews. The estimated population sizes of each of these species in the CPE based on Blancher et al. (2007) is 110,000 Vaux's swifts, 1,060,000 sage thrashers, 149,000 grasshopper sparrows and 314,000 sage sparrows; no estimate was provided for long-billed curlew. Given these estimated populations sizes, the loss of the estimated number of individuals per year would range from 0.002% of the population of sage thrasher to 0.05% of the population of Vaux's swift and would not have measurable population consequences.

Bats

Using bat mortality estimates at the other regional wind energy facilities, total bat mortality in the CPE was estimated at 7,638 per year. Based on species composition of bat fatalities found at CPE wind energy facilities, approximately 3,798 silver-haired and 3,670 hoary bat fatalities would occur in the CPE on an annual basis.

Unlike birds, there is little information available about population sizes of most bat species, especially the non-hibernating, solitary tree-roosting species that compose most of the wind energy facility related mortality in North America. Results of monitoring studies across the US and Canada have found similar trends in impacts. Risk to bats from wind turbines is unequal across species and across seasons. The majority of bat fatalities at wind projects in western North America have been tree roosting bats that are long-distance migrants (Johnson and Stephens 2011). Silver-haired bats throughout the US and species in the *Lasiurus* genus, the hoary bat in the western US and the eastern red bat (*L. borealis*) in the Midwest and eastern

U.S, are the most abundant fatalities found at wind energy facilities. Less common fatalities include big brown bats and *Myotis* species (Johnson 2005, Arnett et al. 2008, Johnson and Stephens 2011). The highest mortality occurs during the fall migration period for bats, from roughly late-July through September (Johnson 2005, Arnett et al. 2008). Much lower mortality rates occur in the spring and summer, particularly in the CPE.

More recently, studies at different locations in the US and Canada appear to indicate that bat mortality is not related to site features or habitat, and dissimilar results for ecologically similar facilities have been found (Baerwald and Barclay 2009). While it is hypothesized that eastern deciduous forests in mountainous areas may be the highest risk areas, relatively high bat mortality has also occurred at wind energy facilities in prairie/agricultural settings (Alberta, Canada; Baerwald 2008) and row crop agricultural settings in the Midwestern US (Jain 2005, Gruver et al. 2009, BHE Environmental 2010). Bat mortality in the CPE would involve primarily silver-haired and hoary bats. Most mortality is observed during the fall migration period. The regional monitoring studies suggest resident bats do not appear to be significantly affected because very low numbers of resident bat species have been observed as fatalities. One species of potential concern is the Townsend's big-eared bat (*Corynorhinus townsendii*), a state candidate species in Washington. Very little is known about the current distribution of Townsend's big-eared bat in Washington. According to Marshall et al. (1996) the subspecies *C. t. pallescens* occurs east of the Cascade Range, within the CPE. A Biological Assessment prepared to address the potential for a wind energy facility in West Virginia to impact the federally endangered Virginia big-eared bat (*C. t. virginianus*), a subspecies of Townsend's big-eared bat, concluded that the collision risk to this species is very low because it is non-migratory and forages well below the space occupied by turbine blades (Johnson and Strickland 2003). These conclusions are also likely applicable to Townsend's big-eared bat, and to date no fatalities of this species have been found at any wind energy facility in the CPE.

Hoary bats and silver-haired bats occupy forested habitats during the breeding season – habitat distinctly lacking and localized throughout the CPE. The significance of wind energy impacts on hoary and silver-haired bat populations is difficult to predict, as there is no information available on the overall population sizes of these bats. However, hoary and silver-haired bats are widely distributed throughout North America. Most concern over impacts to bats is with wind energy facilities built on ridgetops in the Appalachian Mountains, where mortality levels have been as high as 39.7 bat fatalities/MW/year (Kerns et al. 2005), substantially higher than the average of 1.14 bat fatalities/MW/year observed in the CPE.

In general, mortality levels on the order of one to two bats per MW are likely not significant to populations, although cumulative effects may have greater consequences for long-lived, low-fecundity species such as bats. Unlike many bird species that may have multiple clutches of multiple young per year, bats are long-lived species with relatively low reproductive rates. For example, hoary and silver-haired bats typically produce only two young per year (Kunz 1982, Shump and Shump 1982). As such, their populations are much slower to recover from large fatality events than other species, such as most birds, that have much higher reproductive rates. Bats tend to live longer than birds, however, and may have a longer breeding lifespan. The impact of the loss of breeding individuals to populations such as these may have greater consequences.

Because migratory tree bats are primarily solitary tree dwellers that do not hibernate, it has not been possible to develop any suitable field methods to estimate their population sizes (Carter et al. 2003). As a result, impacts on these bat species caused by wind energy development cannot be put into perspective from a population impact standpoint. To help solve this problem, population genetic analyses of DNA sequence and microsatellite data are being conducted to provide effective population size estimates, to determine if populations are growing or declining, and to see if these populations are comprised of one large population or several discrete subpopulations that use spatially segregated migration routes (Amy L. Russell, Assistant Professor, Grand Valley State University, Allendale, Michigan, pers. comm.).

Since it is most likely breeding populations from surrounding mountainous/forested ecoregions or from more northern areas (e.g., Canada) are affected at the Columbia Plateau wind energy facilities during the fall migration, the dynamics of these populations would need to be known to predict population effects. For large and stable populations the level of impact is not expected to be significant, although impacts could be more pronounced for less stable populations. Bat Conservation International (BCI), the American Wind Energy Association (AWEA), the US Fish and Wildlife Service (USFWS), and the US Department of Energy National Renewable Energy Laboratory (NREL) have initiated a research effort termed the Bat Wind Energy Cooperative (BWEC) to conduct research and further understand bat and wind turbine interactions and how to prevent or minimize bat fatalities at wind energy facilities.

Indirect Effects

Grassland and shrub-steppe communities are the most abundant native communities in the CPE, but they are also highly subjected to development and conversion to agriculture (Johnson and T.A. O'Neil 2001). In addition to potentially thousands of new vertical structures, added wind energy generation in the region will result in more roads (mostly dirt and gravel) and increased human activity due to turbine construction and maintenance. A substantial portion of these impacts will be to already heavily-disturbed agricultural fields and moderately disturbed rangeland used for livestock grazing. To estimate what vegetation communities would be affected by 6,700 MW of wind energy development in the CPE, we overlaid the 69 existing and proposed wind energy facilities obtained from the Renewable Northwest Project website on a map of land clover classifications (see Figure 1). Based on this, 33, or 48%, of the projects are sited in crop fields, 39% are sited in scrub-shrub, and the remaining 13% are sited in other community types.

The National Renewable Energy Laboratory (Denholm et al. 2009) used calculated direct impacts from 172 wind energy projects in the U.S. and estimated that the average direct impact is 0.74 acres per MW. Therefore, 4,958 acres of direct impact would be associated with 6,700 MW of wind energy development in the CPE. Because 48% of existing and proposed facilities are sited in cropland, then approximately 2,578 acres (4.0 mi^2) of non-agricultural vegetation types, primarily grassland and shrub-steppe vegetation, would be lost in the CPE with 6,700

MW of wind energy. These impacts would be spread over a large area geographically (see Figure 1). Given that the CPE is 32,096 mi^2 in size, permanent impacts associated with 6,700 MW of wind energy development would represent only 0.02% of the area, and nearly half of this would be in cropland. This does account for the fact that wind energy development tends to support existing rural uses, and can deter more intensive development, such as that associated with land subdivision.

While the CPE covers a large area, and characteristic grassland shrub-steppe habitat is widespread, it is also heavily fragmented by agricultural activities. Species that depend on native habitat face physical and ecological barriers within the region and at the region's edges. The Columbia River, and other smaller rivers in the area, cut deep canyons and present linear alteration to the general physiography and potential barriers to some animal species movement. Large swaths of agricultural land are less obvious, but may pose significant obstacles to small or less mobile animals. While many birds are not impeded by such physical barriers, some smaller, habitat-specific birds that depend on brushy habitats for cover could be affected by such habitat fragmentation. Habitat specialists and obligates such as greater sage-grouse (*Centrocercus urophasianus*) and sage sparrow (*Amphispiza belli*) require large tracts of continuous sage habitat (Johnson and O'Neil 2001), which is largely missing from the Columbia Plateau, and the range for these species in the Columbia Plateau is already severely restricted. Assuming that agricultural vegetation types are not important wildlife habitat, habitat loss impacts are not expected to be a significant loss to any given species within the entire CPE. However, because existing and proposed wind energy facilities tend to be concentrated within certain regions within the CPE (see Figure 1), habitat loss may lead to localized population declines of some species.

In addition to direct effects through collision mortality, wind energy development results in direct loss of habitat where infrastructure is placed and indirect loss of habitat through behavioral avoidance and habitat fragmentation. Direct loss of habitat associated with wind energy development is relatively minor compared to most other forms of energy development. Although wind energy facilities can cover substantial areas, the permanent footprint of facilities such as the turbines, access roads, maintenance buildings, substations and overhead transmission lines, generally occupies only 5 to 10% of the entire development area (Bureau of Land Management [BLM] 2005). Estimates of temporary construction impacts range from 0.2 to 1.0 ha (0.5 to 2.5 ac) per turbine (USDOE 2008). Behavioral avoidance, however, may reduce habitat suitability over much larger areas for some species of wildlife, depending on how far a species is displaced from wind energy facilities. The greatest concern with displacement impacts in western North America has been where facilities were constructed in native habitats such as grasslands or shrublands (Leddy et al. 1999, Mabey and Paul 2007).

Most studies on raptors at wind energy facilities indicate displacement effects to be negligible. A before-after/control impact study of avian use at the Buffalo Ridge wind energy facility in Minnesota found evidence that northern harriers (*Circus cyaneus*) avoided turbines on a small scale (< 100 m [328 ft] from turbines) and large scales (range of 105 - 5,364 m [345 – 17,598 ft]) in the year following construction (Johnson et al. 2000a). Two years following construction, however, no large-scale displacement was detected (Johnson et al. 2000a). The only published report of avoidance of wind turbines by nesting raptors occurred at the Buffalo Ridge facility, where raptor nest density on 101 mi^2 (261.6 km^2) of land surrounding the facility was 5.94 nests/39 mi^2 (101.0 km^2) yet no nests were present in the 12 mi^2 (31.1 km^2) facility itself, even though habitat was similar (Usgaard et al. 1997). At a facility in eastern Washington, raptors still nested in the study area at approximately the same levels after construction, and several nests were located within a half-mile (0.8 km) of turbines (Erickson et al. 2004). Howell and Noone (1992) found similar numbers of raptor nests before and after construction of Phase 1 of the Montezuma Hills facility in California, and anecdotal evidence indicates that raptor use of the APWRA in California may have increased since installation of wind turbines (Orloff and Flannery 1992, AWEA 1995). At the Foote Creek Rim wind energy facility in southern Wyoming, one pair of red-tailed hawks nested within 0.3 miles (0.5 km) of the nearest turbine, and seven red-tailed hawk nests, one great horned owl (*Bubo virginianus*) nest, and one golden eagle nest located within one mile (1.6 km) of the facility successfully fledged young (Johnson et al. 2000b, WEST, Inc. unpublished data). The golden eagle pair successfully nested a half-mile (0.8 km) from the facility for three different years after the project became operational.

Studies in western North America concerning displacement of non-raptor species have concentrated on grassland passerines and waterfowl. Wind energy facility construction appears to cause small-scale local displacement of some grassland passerines and is likely due to the birds avoiding turbine noise and maintenance activities. Construction also reduces habitat effectiveness because of the presence of access roads and large gravel pads surrounding turbines (Leddy 1996, Johnson et al. 2000a). Leddy et al. (1999) surveyed bird densities in Conservation Reserve Program (CRP) grasslands at the Buffalo Ridge wind energy facility in Minnesota, and found mean densities of 10 grassland bird species were four times higher at areas >180 m (591 ft) from turbines than they were at grasslands nearer turbines. Johnson et al. (2000a) found reduced use of habitat within 100 m of turbines by seven of 22 grassland-breeding birds following construction of the Buffalo Ridge facility. At the Stateline wind energy facility in Oregon and Washington, use of areas <50 m from turbines by grasshopper sparrow (*Ammodramus savannarum*) was reduced by approximately 60%, with no reduction in use >50 m from turbines (Erickson et al. 2004). At the Combine Hills facility in Oregon, use of areas within 150 m of turbines by western meadowlark was reduced by 86%, compared to a 12.6% reduction in use of reference areas over the same time period (Young et al. 2006). Horned larks, however, showed significant increases in use of areas near turbines at both of these facilities, likely because this species prefers areas of bare ground such as those created by turbine pads and access roads (Beason 1995).

Shaffer and Johnson (2009) examined displacement of grassland birds at two wind energy facilities in the northern Great Plains. Intensive transect surveys were conducted on plots with and without turbines. The study focused on five species at two study sites, one in South Dakota and one in North Dakota. Based on this analysis, killdeer, western meadowlark, and chestnut-collared longspur (*Calcarius ornatus*) showed no avoidance of wind turbines. However, grasshopper sparrow and clay-colored sparrow (*Spizella pallida*) showed avoidance out to 200 m (656 ft).

At the Buffalo Ridge facility, the abundance of several bird types including shorebirds and waterfowl was significantly lower at survey plots with turbines than at reference plots without turbines, indicating that the area of reduced use was limited primarily to areas within 100 m of the turbines (Johnson et al. 2000a). These results are similar to those of Osborn et al. (1998), who reported that birds at Buffalo Ridge avoided flying in areas with turbines.

Populations of mountain plovers (*Charadrius montanus*) at the Foote Creek Rim wind energy facility in Wyoming declined during construction but slowly increased after construction, although not to the same level present prior to construction. It is not known if the initial decline or subsequent increase was due to presence of the wind energy facility or to regional changes in mountain plover populations. Nevertheless, some mountain plovers apparently became habituated to the turbines, as 11 of 28 nests found during surveys (39%) were located within 75 m (246 ft) of turbines (Young et al. 2005).

Breeding dabbling ducks (mallard, blue-winged-teal [*Anas discors*], gadwall [*A. strepera*], northern pintail [*A. acuta*], and northern shoveler [*A. clypeata*]) were counted on wetland complexes at two wind energy facilities and similar reference areas in North and South Dakota during the 2008 and 2009 breeding seasons. The North Dakota project had 41 turbines and the project in South Dakota had 120 wind turbines. Results for both 2008 and 2009 found no evidence that the abundance of breeding waterfowl was different due to wind energy development. Results are preliminary and data collection continued in 2010 (USFWS 2009).

The CPE wind energy facilities will be sited in vegetation communities common to the region, and other similar vegetation types are abundant. Furthermore, the actual area occupied by turbines and other infrastructure in a typical modern wind energy facility is only 5-10% of the total project area (BLM 2005). However, it is not known if displaced individuals simply move somewhere else and breed successfully, have reduced breeding success, do not breed at all, or some combination of the above. In addition, habitat fragmentation and disturbance from turbines and maintenance activities may make the entire wind energy facility unsuitable for some species. If this occurs, a reduction in the number of breeding birds within the wind energy facility and adjacent areas may occur, and the effect may be more pronounced in areas with concentrated facilities in circumstances where habitat is a limiting factor. However, the total area occupied by wind energy facilities is only a small fraction of the CPE (see Figure 1), and measurable population impacts are not likely for the entire region.

DISCUSSION

Results of this analysis suggest that no significant population level effects are likely associated with wind energy development in the CPE, which is similar to findings of other investigations of cumulative impacts associated with wind energy development in the U.S. Even at the APWRA in California, where an estimated 40–70 golden eagles are killed each year (Hunt 2002, Smallwood and Thelander 2004), a 4-year radio telemetry study of golden eagles found that the resident golden eagle population appeared to be self sustaining despite sustaining high levels of fatalities, but the effect of these fatalities on eagle populations wintering within and adjacent to the APWRA was unknown (Hunt 2002). Additional research conducted in 2005 by Hunt and Hunt (2006) found that all 58 territories occupied by golden eagle pairs in the APWRA in 2000 remained active in 2005. The Wildlife Society reviewed available data from wind energy facilities and concluded that the data suggest that fatalities of passerines from turbine strikes generally are not significant at the population level, although exceptions could occur if facilities are sited in areas where migrating birds or rare species are concentrated (Arnett et al. 2007). Also, the National Academy of Sciences (NAS 2008) reviewed wind energy impacts on birds, and came to the following conclusion: "At the current level of wind energy development (approximately 11,600 MW of installed capacity in the United States at the end of 2006, including the older California turbines), the committee sees no evidence that fatalities caused by wind turbines result in measurable demographic changes to bird populations in the United States, with the possible exception of raptor fatalities in the Altamont Pass area." A study commissioned by the New York State Energy Research and Development Authority evaluated risk to wildlife populations associated with several forms of electricity production in the northeast US, including coal, oil, natural gas, nuclear, hydroelectric and wind power (Newman et al. 2009). All facets of electricity production were considered, including resource extraction; fuel transportation; construction of the facility; power generation, transmission and delivery; and decommissioning. The report concluded that wind power was the only power source that did not present population-level risks to birds, although effects to bat populations was unknown (Newman et al. 2009).

Mortality estimates for this analysis were based on species composition of fatalities found at 23 existing wind energy facilities in the CPE. Sample sizes for this analysis were relatively small for some groups. For example, we estimated ferruginous hawk mortality assuming that they would compose 4.0% of all raptor fatalities based on four ferruginous hawk fatalities out of 100 raptor fatalities found at the existing wind energy facilities (Table 4). This ratio could easily change as additional fatality data are collected at new wind energy facilities in the CPE.

This cumulative effects analysis was based largely on results of existing studies of wind energy facilities in the region, and in particular monitoring studies that estimated the direct impacts of a particular wind energy project. The overall design for these studies incorporates several assumptions or factors that affect the results of the fatality estimates. First, all bird casualties found within the standardized search plots during the study periods were included in the analyses. It is assumed that carcass found incidentally within a search plot during other activities would have been found during a standardized carcass search. Second, it was assumed that all carcasses found during the studies were due to collision with wind turbines. True cause of death is unknown for most of the fatalities. It is highly likely that some of the casualties included in the data pool for the various projects were due to natural causes or background mortality such as predation, disease, other natural causes, or manmade causes such as farming activity or vehicles on county/project roads. The overall effect of these assumptions is that the analyses provide a conservative estimate (an overestimate) of mortality.

Avian population estimates used in this analysis relied on those developed by PIF using BBS data, and some of these estimates had relatively large standard errors. Thogmartin et al. (2006)

reviewed the population estimation approach used by Blancher et al. (2007) and concluded that because BBS data were designed to detect long-term population trends, use of these data for estimating population sizes may be questionable. Regardless of these concerns, in order to estimate cumulative impacts, information on sizes of affected populations is required, and the population estimates provided by PIF (Blancher et al. 2007) are the only ones available for the CPE.

PIF is a cooperative effort involving partnerships among federal, state and local government agencies, philanthropic foundations, professional organizations, conservation groups, industry, the academic community, and private individuals. The mission of PIF includes 1) helping species at risk, 2) keeping common birds common, and 3) voluntary partnerships for birds, habitats and people (Blancher et al. 2007). PIF recognized the importance of generating estimates of bird populations across the US, which were lacking for most species and most regions. They used relative abundance counts from the North American BBS to form the basis of their bird population estimates.

Although PIF acknowledges that the BBS was not designed specifically to produce population estimates, and there are difficulties to overcome as a result, there are important advantages to having the information for review and use as appropriate. The data from across much of North America have been collected according to a single standardized method. Surveys employ random start points and directions, thus enhancing regional representation of the avifauna (roadside bias notwithstanding), and the data are readily available for the bulk of North American land birds. According to PIF, the population estimates are rough approximations for land birds breeding in the US and Canada, and the results and the underlying data of this first massive effort to estimate population numbers for all North American land birds can be used for several different purposes.

In order to prepare cumulative impacts analysis, estimates of population sizes are required. Otherwise, it is impossible to determine how bird fatalities associated with wind energy development could affect populations and therefore lead to cumulative impacts. The only population estimates available for most bird species in the Pacific Northwest are those estimates calculated by PIF (see Blancher et al. 2007). Although these estimates may not be completely accurate for all species, they are the only ones available and therefore represent the best available data for this use.

Finally, this cumulative impacts assessment only examined cumulative impacts of birds and bats due to wind energy development in the CPE. Wind energy development is only one factor affecting wildlife populations in the CPE, and is likely minor compared to other past, present, and future actions in the CPE, including large-scale conversion of native shrublands and grasslands to crop land; expansion of urban areas and rural subdivisions; road and highway construction; energy development, including dams for hydropower; and increases in other infrastructure, such as communication towers and power lines. For example, a review conducted by Erickson et al. (2001a) found that wind energy contributes only a minor fraction of the overall avian collision mortality in the US, with most fatalities due to powerlines, roads, communication towers, and other structures. The ability to estimate wind energy development impacts on wildlife is unique because several studies have been conducted in the CPE to quantify bird and bat impacts. Similar estimates of bird and bat impacts due to direct mortality and loss or fragmentation of habitat caused by other activities are not available.

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