FINAL REPORT

AVIAN AND BAT CUMULATIVE IMPACTS ASSOCIATED WITH WIND ENERGY DEVELOPMENT IN THE COLUMBIA PLATEAU ECOREGION OF EASTERN WASHINGTON AND OREGON

Prepared For:

Klickitat County Planning Department

Prepared By:

Gregory D. Johnson and Wallace P. Erickson

Western EcoSystems Technology, Inc.
2003 Central Avenue
Cheyenne, Wyoming 82001

WEST, Inc.

Specializing in Ecological Field Studies

October 30, 2008

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION AND BACKGROUND

Over the last decade, there has been a surge of interest in wind energy development in Oregon and Washington within the Columbia Plateau physiographic region (ecoregion). A central issue for wind power development is 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. As more wind energy developments are constructed within the Columbia Plateau Ecoregion, cumulative impacts from multiple wind-energy facilities have become a concern.

With the possible exception of golden eagles (*Aquila chrysaetos*) at the Altamont Pass wind-energy facility, California, where an estimated 40–70 golden eagles are killed each year (Hunt 2002, Smallwood and Thelander 2004), no wind-energy facilities have been documented to cause population declines of any species. The purpose of this report is to estimate cumulative impacts associated with all existing, permitted, and currently proposed wind-energy facilities within the Columbia Plateau Ecoregion (CPE) of eastern Washington and Oregon. 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

As of mid–2008, 17 wind-energy facilities totaling 2464 MW were in operation in the CPE (Table 1), and an additional 30 wind-energy facilities are currently planned or being constructed within the CPE (Table 1). There are currently approximately 6665 MW of existing or proposed wind-energy facilities in the CPE. For the purpose of this analysis, we assumed that 6700 MW of wind power would be present in the CPE. However, past experience indicates that not all permitted projects are built, so these figures likely overestimate what will actually be constructed.

Most wind energy development in northern Oregon and southern Washington has been within the Columbia Plateau Level III Ecoregion (Thorson et al. 2003; Figure 1). The Columbia Plateau was historically characterized by open, arid shrub-steppe and grassland-steppe habitats. The current predominant land use of the Ecoregion 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 broad, qualitative analysis using existing public information about existing and proposed wind-energy facilities in the region, estimated population sizes of birds in the CPE, results of fatality monitoring studies, and published literature to compile a cumulative impact analysis for bird and bat resources. The analysis relies heavily on existing information from studies in the CPE. Information about wind project proposals was gathered from a variety of sources such as federal and state agencies (e.g., Bonneville Power Administration (BPA), Oregon Energy Facility Siting Council (EFSC)), permitting agencies (e.g., Klickitat County, WA), non-profit renewable energy advocates (e.g. Renewable Northwest Project), wind energy developers, and other public sources such as internet resources. Basic information such as the proposed capacity and location of each wind-energy facility identified was gathered and summarized to the extent possible.

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 then use those results to estimate impacts for all constructed and proposed wind-energy facilities within the same ecoregion. Habitat and land use throughout the entire CPE are similar.

This cumulative effects analysis relies heavily on data from 11 wind-energy facilities in the CPE where monitoring for fatalities has occurred. Most of the operating facilities have had or will have some sort of bird or casualty monitoring associated with them, and post-construction fatality monitoring data are available from 11 operational wind energy facilities in the CPE (Table 2). 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 new 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 data sets used in this report were collected using similar methods, where 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 wind-energy facilities because of habitat and land use similarities throughout the ecoregion, and thus are 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 recent publication that estimates breeding 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.

Raptors

Pre–construction raptor use estimates and post-construction raptor fatality estimates are available for 11 facilities in eastern Washington and Oregon. 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. 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 3). 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. 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 11 existing wind-energy facilities in eastern Washington and Oregon ranges from 0 to 0.15/MW/year, with a mean of 0.07/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, it is likely not appropriate to predict raptor mortality in the CPE using per turbine estimates from the other wind-energy facilities, as several of the existing facilities used smaller turbines, ranging from 0.66 – 1.5 MW in size. Therefore, we used per megawatt estimates of raptor mortality for extrapolating the estimated numbers of raptor fatalities in the CPE. We used a range of 0.07 (mean) to 0.15 (maximum) raptor fatalities/MW/year for estimating raptor mortality at each of the CPE wind energy facilities. To estimate cumulative mortality of individual species, we assumed that species composition of bird and bat fatalities associated with 6700 MW of wind energy would be similar to species composition of fatalities found at the 11 existing facilities in the CPE. For example, American kestrels (*Falco sparverius*) composed 38.6% of the raptor fatalities found at existing wind-energy facilities. To estimate the total number of American kestrel fatalities associated with 6700 MW of wind energy development, we assumed that they would also compose 38.6% of the total cumulative number of raptor fatalities per year.

All Birds

Compared with raptors, there is little correlation between total numbers of birds (all species) observed during pre-construction surveys (most of which are song birds) and post-construction mortality, presumably because many of the collision fatalities are nocturnal migrants, 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 24 wind-energy facilities in the CPE has ranged from 5–23.6 birds/survey and averaged 13.4 birds/survey (Table 3). Total bird use at the 11 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 12.4 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 at CPE wind-energy facilities would be similar to that observed at the 11 existing wind-energy facilities in the CPE. Therefore, we multiplied the total number of MW by 2.1 fatalities/MW/year (the mean among the 11 CPE wind-energy facilities) to estimate total bird mortality. Based on the range of fatality rates at existing wind energy projects in Washington and Oregon (0.9–3.2 fatalities/MW/year), we multiplied the total number of MW by 0.9 fatalities/MW/year to get a more conservative estimate, and by 3.2 fatalities/MW/year to get a more liberal estimate of total bird mortality. To estimate total cumulative mortality by bird type and/or species, we assumed the fatalities associated with 6700 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 (1.18/MW/year). Based on the range of fatality rates at existing wind energy projects in Washington and Oregon (0.39–2.46 fatalities/MW/year), we multiplied the number of MW by 0.39 fatalities/MW/year to get a more conservative estimate, and by 2.46 fatalities/MW/year to get a more liberal estimate of cumulative bat mortality. 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.

RESULTS

Existing Data for CPE Projects

Raptors
Pre–construction raptor use estimates and post-construction raptor fatality estimates are available for 11 wind-energy facilities in eastern Washington and Oregon. Pre-construction raptor use estimates at these wind-energy facilities have ranged from 0.26 raptors/survey at Nine Canyon, to 0.90 raptors/survey at Bighorn I, and averaged 0.50/survey (Table 2). Raptor mortality was not documented at three of these wind-energy facilities (Klondike I, Vansycle and Combine Hills) during one-year post-construction mortality surveys, and was relatively low at the other eight, ranging from 0.05/MW/year at Nine Canyon, Washington to 0.15/MW/year at Bighorn I, Washington. Quantitative mortality estimates were not made for Condon, but only one raptor fatality was documented at that facility.

The 57 raptor fatalities found at CPE wind-energy facilities have composed 8.6% of the total bird mortality. Most of the raptor fatalities have been American kestrels (22 fatalities; 38.6%), red-tailed hawks (*Buteo jamaicensis*; 14 fatalities; 24.6%) and short-eared owls (*Asio flammeus*; 7 fatalities; 12.3%). Other raptors found as fatalities at CPE wind-energy facilities include four ferruginous hawks (*Buteo regalis*), three Swainson's hawks (*Buteo swainsonii*) and one each of the following: rough-legged hawk (*Buteo lagopus*), Cooper's hawk (*Accipiter cooperii*), northern harrier (*Circus cyaneus*), great horned owl (*Bubo virginianus*), long-eared owl (*Asio otus*), barn owl (*Tyto alba*) and unidentified accipiter (Table 4).

<u>All Birds</u>

Seventy-seven species have occurred as fatalities at existing wind energy facilities in the CPE. Passerines (songbirds) have been the most abundant bird fatality at wind-energy facilities outside California, often comprising more than 80% of total bird fatalities (Erickson et al. 2001a). 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 bird mortality at CPE wind-energy facilities. Horned larks (*Eremophila alpestris*) have been the most commonly observed songbird fatality in the CPE, composing 31.1% of all bird fatalities (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, horned larks are likely one of the most common birds in the Columbia Plateau. No other resident songbird 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*; 43 fatalities; 6.5% of all fatalities).

Mourning doves (*Zenaida macroura*) and rock pigeons (*Columba livia*) have composed 3.2% of the mortality at CPE wind-energy facilities. Waterfowl, waterbirds and shorebirds have composed only 1.7% of the fatalities, and include four Canada geese (*Branta canadensis*), two mallards (*Anas platyrhynchos*), and one each of the following species: great blue heron (*Ardea herodias*), American coot (*Fulica americana*), bufflehead (*Bucephala albeola*), killdeer (*Charadrius vociferous*), and western grebe (*Aechmophorus occidentalis*). Mortality compared to use by these groups is very low. For example, only two Canada goose fatalities were documented at the Klondike, Oregon wind-energy facility (Johnson et al. 2003a), even though 43 flocks totaling 4845 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. Shorebirds as a group are rarely killed at wind-energy facilities; of 1036 avian fatalities collected at US wind-energy facilities and summarized in Erickson et al. (2001), only one was a shorebird (a killdeer found at Buffalo Ridge wind-energy facility, Minnesota). 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 gamebirds 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*). Some upland gamebird mortality has been documented at many wind-energy facilities (Erickson et al. 2001a; Erickson et al. 2002). In the CPE, upland gamebirds are one of the most common fatalities, composing 14.5% of all identified fatalities (Table 5). Based on habitat present, results from other regional wind-energy facilities, and the presence of upland gamebirds during baseline surveys, some mortality of upland gamebirds is expected to occur at nearly all wind-energy facilities in the CPE.

Bats
Bat mortality estimates have been made for 10 existing wind-energy facilities in the CPE, where they ranged from 0.39–2.46 fatalities/MW/year, and averaged 1.18 fatalities/MW/year (Table 6). Bat mortality patterns at wind-energy facilities in Washington and Oregon have followed patterns similar to the rest of the country. Of 337 bat fatalities collected at existing wind-energy facilities in eastern Oregon and Washington, 315 (93.5%) have been the two migratory species that occur in the CPE, including 152 hoary bats (*Lasiurus cinereus*) and 163 silver-haired bats (*Lasionycteris noctivagans*). The other mortalities have consisted of small numbers of big brown bats (*Eptesicus fuscus*), little brown bats (*Myotis lucifugus*), and unidentified bats (Table 7). Virtually all of the mortality has occurred in late summer and early fall, during the fall migration period for hoary and silver-haired bats.

Mortality Estimates and Population Consequences

Birds (Excluding Raptors)
For all birds combined, we estimate that total annual mortality in the CPE would be 14,070 birds/year, with a reasonable range of 6,030 to 21,440 birds/year. Despite several thousand bird fatalities from 6700 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 gamebirds would compose 14.5%, doves/pigeons would compose 3.2%, waterfowl/waterbirds/shorebirds would compose 1.7% and other bird types, such as woodpeckers, nighthawks and swifts, would compose 2.6%. Approximately 3.3% of the mortality would be composed of non-protected European starlings (*Sturnus vulgaris*) and rock pigeons.

Raptors
Using raptor mortality estimates from existing wind energy facilities in the CPE, we estimate total raptor mortality in the CPE would be 469 fatalities per year, with an upper bound of 1005 per year. The upper bound assumes that all projects would have raptor fatality rates similar to those experienced at the wind farm with the highest raptor mortality rate (0.15/MW/year), which is unlikely. Therefore, we feel the projected number of fatalities using the mean raptor fatality rate at existing CPE wind projects is the most appropriate metric for cumulative impacts analysis. American kestrels account for 38.6%, red-tailed hawks account for 24.6% and short-eared owls account for 12.3% of the raptor fatalities recorded at the regional wind projects studied (see Table 4). Assuming this trend holds true for all proposed wind-energy facilities in the CPE, and assuming there would be 469 raptor fatalities per year, it would be expected that on average 181 American kestrels, 115 red-tailed hawks and 58 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 golden eagle, peregrine falcon (*Falcon peregrinus*) or prairie falcon (*Falcon mexicanus*) fatalities have been found to date; therefore, our mortality estimate for these species is necessarily zero. Two species of concern in the region, ferruginous hawk and Swainson's hawk, have both been found as turbine collision victims in the CPE. Ferruginous hawks have composed 7.0% of the raptor fatalities (four of 57), while Swainson's hawks have composed 5.3% (three of 57). Assuming a total of 469 raptor fatalities could occur each year in the CPE, this would result in 33 ferruginous hawk and 25 Swainson's hawk fatalities per year.

The three species of raptors with the largest expected numbers of fatalities due to wind energy development in the CPE are American kestrel, red-tailed hawk and short-eared owl. Raptor fatalities in the CPE have occurred throughout the year, with 22.8% in the spring, 45.6% in the summer, 17.5% in the fall, and 12.3% in the winter (Table 8). Approximately 52.6% of the raptor fatalities have occurred during the spring and 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 45.6% of the mortality would occur during the breeding season, it would be expected that approximately 83 American kestrel, 52 red-tailed hawk and 26 short-eared owl 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, 77,000 breeding red-tailed hawks and 21,000 breeding short-eared owls (Blancher et al. 2007). Annual collision mortality in the CPE would represent approximately 0.05% of the breeding population of American kestrels, 0.07% of the breeding population of red-tailed hawks and 0.12% of the breeding population of short-eared owls. Even if we assumed all mortality (instead of 45.6%) would occur to adult breeding birds, this would still represent only 0.11%, 0.15% and 0.28% of the breeding American kestrels, red-tailed hawks and short-eared owls, 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% of juveniles and 45% of adults (Millsap and Allen 2006). Annual survival data are not available for short-eared owls (Wiggins et al. 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 <0.30% associated with projected wind power development in the CPE would lead to measurable population effects for American kestrels, red-tailed hawks and short-eared owls. Based on an analysis of population sizes and survival rates, the US Fish & 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 comprising 15 species (Milsap 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 and three Swainson's hawk 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) and as "critical" by the Oregon Department of Fish and Wildlife (ODFW), while the Swainson's hawk is listed as "vulnerable" by the ODFW. 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 33 ferruginous hawk fatalities on an annual basis, even if all turbine mortality occurred to resident breeding adult birds, this would represent 3.3% 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 3.3%, 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%. 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 6700 MW of wind energy development in the CPE would not likely have measurable population consequences.

The above analysis is for the entire population of 1000 ferruginous hawks in the CPE. It assumes that wind energy development and ferruginous hawk populations are spread uniformly across the entire CPE, which is not the case. Given the actual locations of existing and proposed wind energy facilities and ferruginous hawk population centers, actual impacts are likely lower. For example, the existing and proposed wind energy development in Klickitat County, Washington is approximately 1751 MW, or 26% of all wind energy development in the CPE. However, only three breeding pairs of ferruginous hawk are known to occur in the county (Jim Watson, Wildlife Research Scientist, Washington Department of Fish and Wildlife, pers. commun). Therefore, the county with the largest amount of wind energy development has a low breeding population of ferruginous hawks, which reduces the potential for significant impacts to this species across its entire range in the CPE. According to Watson (2003), the core breeding area for ferruginous hawks in Washington is in Benton and Franklin Counties. To date, no wind energy facilities have been proposed in Franklin County and only three of the existing/proposed facilities are in Benton County (Figure 1). Therefore, there is little overlap between areas of intensive wind energy development and core breeding areas for ferruginous hawk, which further reduces the potential for cumulative impacts to this species. Although local populations of ferruginous hawk may be reduced in areas of intensive wind energy development, the evidence suggests that this impact is not likely to affect the ferruginous hawk population in the entire CPE.

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 appropriate buffers around ferruginous hawk breeding territories at future wind energy facilities, erecting artificial nest structures, or otherwise improving habitat for ferruginous hawks in the CPE (Johnson et al. 2007).

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 25 Swainson's hawks per year, this would represent only 0.25% 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 <0.3% would be considered sustainable and would not have measurable population consequences.

Upland Gamebirds

Upland gamebirds represent a higher percentage (14.5%) of the bird fatalities in the Columbia Plateau than in other regions in the US. No native upland gamebirds 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 14,070, approximately 2,040 upland gamebird 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 0.55% of the population. As with non-native (non-protected) passerine species, there is generally lower concern over impacts to exotic upland gamebirds. Given the vast amount of suitable habitat and the ability of these species to withstand harvest rates substantially higher than 0.55%, 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 (1.7%) of all fatalities at existing wind energy projects in the CPE. Based on our total bird mortality estimate of 14,070, approximately 239 fatalities could result on an annual basis, including 152 waterfowl, 65 waterbirds, and 22 shorebirds.

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, no fatalities of this sensitive species have been documented at any wind-energy facility in the CPE, and no cumulative impacts are likely from collision mortality.

Passerines

For projects in the CPE, approximately 69.5% of the bird fatalities have been passerines (Table 5). Assuming that 69.5% of all bird mortality would be composed of passerines, approximately 9,779 passerine fatalities would occur annually in the CPE. Of all passerine fatalities recorded during the regional monitoring studies, horned lark made up nearly half (44.7%) of the fatalities. Assuming this pattern holds for all CPE wind-energy facilities, it could be expected that on average there would be 4,371 horned lark fatalities per year. Another common grassland breeder in the CPE, western meadowlark (*Sturnella neglecta*), composed approximately 4.6% of the passerine fatalities at wind-energy facilities, and therefore total annual mortality of this species related to wind turbine collisions would be approximately 450 individuals. At wind-energy facilities in the CPE, migrant passerines of several species generally composed approximately 32.9% of the bird fatalities. Assuming these estimates are representative of all CPE wind-energy facilities, approximately 3,217 nocturnal migrant fatalities would be expected per year if 6700 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 9.3% of the passerine fatalities were of this species; therefore, estimated annual mortality for this species would be approximately 909 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 4,371 horned lark fatalities, and if it is assumed that the horned lark fatalities are spread equally over the year, then roughly 25% (~1,093) 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 of song birds typically range from 30–70% (Lack 1966; Welty 1982), losses amounting to less than one percent 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 450 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 30% 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 909, which would represent 0.13% 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. As with horned lark, 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 ferruginous and Swainson's hawks discussed above, other species classified as sensitive species by the WDFW and/or ODFW have been found as fatalities at CPE wind energy projects. These include Lewis's woodpecker (*Melanerpes lewis*), grasshopper sparrow (*Ammodramus savannarum*), sage thrasher (*Oreoscoptes montanus*), sage sparrow (*Amphispiza belli*) and Vaux's swift (*Chaetura vauxi*). Only one fatality of each of the above species has been found at CPE wind energy projects. Given that 663 bird fatalities have been found at these projects and estimated total bird mortality is 14,070, the estimated mortality for each of these species would be approximately 21 fatalities per year. The estimated population sizes of each of these species in the CPE based on Blancher et al. (2007) is 25,000 Lewis's woodpeckers, 149,000 grasshopper sparrows, 1,060,000 sage thrashers, 314,000 sage sparrows, and 110,000 Vaux's swifts. Given these estimated populations sizes, the loss of 21 individuals per year would not have measurable populations consequences.

Bats

Based on bat mortality estimates at the other regional wind-energy facilities, total bat mortality in the CPE was estimated at 7,906 per year, with an expected range of 2,613–16,482 fatalities per year. Based on species composition of bat fatalities found at CPE wind-energy facilities, approximately 3,827 silver-haired and 3,566 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 the US and Canada have been tree roosting bats that are long-distance migrants. Silver-haired bats throughout the US and species in the *Lasiurus* genus, the hoary bat in the west and the eastern red bat (*L. borealis*) in the east, are the most abundant fatalities found at wind-energy facilities. Less common fatalities include big brown bats and *Myotis* species (Johnson 2005). The highest mortality occurs during the fall migration period for bats, from roughly late-July through September (Arnett et al. 2007, Johnson 2005). 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. 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) and mixed deciduous woods and agricultural settings (Maple Ridge, New York). For example, a wind project in dryland agricultural prairie type habitats in southern Alberta has reported fairly high observed bat mortality (not corrected for searcher and carcass removal biases) of 12-15 bats per turbine per year or seven to eight bats per MW per year (Baerwald 2007). In contrast, other nearby (within 15.5 miles or 25 km) wind-energy facilities to that site have reported similar bat mortality (one to two bats per MW per year) to the wind-energy facilities studied in the CPE (Baerwald, pers. comm.). 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 *Corynorhinus townsendii 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 (*Corynorhinus townsendii 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 very little information available regarding 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 47.5 bat fatalities/turbine/ year (Kerns et al. 2005), substantially higher than the average of 1.18 bat fatalities/MW/year observed in the Pacific Northwest.

In general, mortality levels on the order of one to two bats per turbine or 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, hoary bats and silver-haired bats typically raise only one or two young per year and only breed once per year (Shump and Shump 1982; Kunz 1982). 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.

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 & 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 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 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. 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 wind-energy facilities are located in, we assume that approximately 25% of the existing and proposed facilities would be in cultivated cropland. Based on terrestrial vegetative communities in the CPE (Figure 2), only seven of the 47 existing or proposed wind energy facilities are in communities classified as shrub steppe, with two additional facilities in areas classified as grasslands. The remainder is all within vegetative communities classified by Quigley and Arbelbeide (1997) as agricultural lands. These lands include croplands as well as rangelands used for cattle grazing, but are apparently degraded such that they are no longer classified as shrublands or grasslands. Therefore, most of the wind energy facilities in the CPE are in areas already degraded to some extent from conversion to pastures and cultivated cropland.

Assuming that on average the permanent impacts associated with a turbine and the associated access roads are 1.5 acres per turbine, and that 1.5-3.0 MW turbines are used for all new projects in the foreseeable future, then approximately 5,000 acres (7.8 mi^2) of non-agricultural vegetation types, primarily grassland 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 6700 MW of wind energy development would represent only 0.02% of the area.

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.

The presence of wind turbines may alter the landscape so that wildlife habitat use patterns are altered, thereby displacing wildlife away from the wind-energy facilities. Development of wind turbines near raptor nests may result in indirect impacts to the nesting birds; however, the only published report of avoidance of wind turbines by raptors occurred at Buffalo Ridge, Minnesota, where raptor nest density on 101 mi^2 (261.59 km^2) of land surrounding a wind project was 5.94/39 mi^2 (5.94/ 101.01 km^2), yet no nests were present in the 12 mi^2 (31.08 km^2) wind-energy facility itself, even though habitat was similar (Usgaard et al. 1997). However, this analysis assumes that raptor nests are uniformly distributed across the landscape, an unlikely event, and even though no nests were found, only two would be expected for an area 12 mi^2 in size if the nests were distributed uniformly. No red-tailed hawks or golden eagles are known to nest within the Altamont Pass WRA (APWRA), suggesting that the large numbers of turbines present within that area may discourage nesting by raptors, or that collision mortality prevents nesting in the APWRA. At the Foote Creek Rim wind-energy facility in southern Wyoming, one pair of red-tailed hawks nested within 0.3 miles (0.48 km) of the turbine strings, and seven red-tailed hawk, one great horned owl, and one golden eagle nests located within one mile (1.61 km) of the wind-energy facility successfully fledged young (Johnson et al. 2000a). The golden eagle pair successfully nested a half-mile (0.80

km) from the wind-energy facility for three different years after it became operational. Additionally, a Swainson's hawk nested within a half-mile mile of the Klondike, Oregon Wind Project (Johnson et al. 2003a). Studies at the Stateline Wind Project in Oregon and Washington have shown no measurable short-term effects to nesting raptors (Erickson et al. 2004). Maintaining permanent nest buffers would reduce the potential for indirect impacts.

At the Foote Creek Rim wind-energy facility in Carbon County, Wyoming, results of a long-term mountain plover monitoring study found that mountain plover use of the of the area declined during and immediately after construction of the facility. Mountain plover use slowly increased following operation of the facility, although not to the same level as it was prior to construction. It is possible that construction of the wind-energy facility resulted in some displacement of plovers, although a regional decline in mountain plover populations may also have contributed to the decline. Mountain plover use also declined during this same period at a nearby reference area and a more regional decline was documented by Fritz Knopf (Personal communication) and the USFWS (1999). Some mountain plovers have apparently become habituated to the turbines, as several mountain plover nests have been located within 246 ft (75 m) of turbines, many of which were successful (Young et al. 2005).

At a large wind-energy facility at Buffalo Ridge in Minnesota, the abundance of shorebirds, waterfowl, upland game birds, woodpeckers, and several groups of passerines was found to be statistically significantly lower at survey plots with turbines than at plots without turbines. There were fewer differences in avian use as a function of distance from turbines; however, suggesting that the area of reduced use was limited primarily to those areas within 328 ft (100 m) of the turbines (Johnson et al. 2000b). These results are similar to those of Osborn et al. (1998), who reported that birds at Buffalo Ridge avoided flying in areas with turbines. Also at Buffalo Ridge, Leddy et al. (1999) found that densities of male songbirds were significantly lower in Conservation Reserve Program grasslands containing turbines than in CRP grasslands without turbines. Grasslands without turbines and portions of grasslands located at least 590 ft (180 m) from turbines had bird densities four times greater than grasslands located near turbines. Reduced bird use near turbines was attributed to avoidance of turbine noise and maintenance activities and reduced habitat effectiveness because of the presence of access roads and large gravel pads surrounding turbines (Leddy 1996; Johnson et al. 2000b). Some birds apparently do become accustomed to turbines, as Osborn et al. (1998) reported a mallard nest within 102 ft (31 m) of a turbine in Minnesota.

Preliminary results from the Stateline Wind Project in Oregon and Washington (Erickson et al. 2004) suggest a relatively small-scale impact of the wind-energy facility on grassland nesting passerines. Transect surveys conducted prior to and after construction of the wind-energy facility indicated that grassland songbird use was significantly reduced only within 164 ft (50 m) of turbine strings; areas further away from turbine strings did not have reduced avian use. The reduced use was attributed to temporary and permanent habitat disturbance near the turbines. Horned larks appeared least impacted, likely because this species prefers areas of bare ground such as those created by turbine pads and access roads (Beason 1995). A long-term grassland bird displacement study at a wind energy facility in South Dakota found that chestnut-collared longspur (*Calcarius ornatus*) and western meadowlarks did not appear to avoid turbines, whereas grasshopper sparrows appeared to avoid turbines out to a distance of 200 m (D. H. Johnson and J.A. Shaffer, US Geological Survey, personal communication).

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. 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

Mortality estimates for this analysis were based on species composition of fatalities found at 11 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 7.0% of all raptor fatalities based on four ferruginous hawk fatalities out of 57 raptor fatalities found at the existing wind energy facilities. This ratio could easily change as additional fatality data are collected at new wind energy facilities in the CPE.

Our cumulative mortality estimates should be considered tentative, as no comparable fatality data exist for the large 2.0-3.0 MW turbines proposed for many of the future wind-energy facilities in the CPE. These estimates assume bird and bat fatality rates for a 2.0-MW turbine would be twice as high than for a 1.0-MW turbine, which may not be accurate. Although the 2.0-3.0 MW turbines have a larger rotor diameter, which may increase collision risk to raptors, the rotor-swept area is higher off the ground and the turbine rotates at slower speeds, which may actually reduce risk to some raptors. Based on an analysis of avian fatality data at wind farms with turbines ranging in size from 0.04–1.8 MW, tower heights ranging from 24–94 m and rotor diameters ranging from 15–80 m, Barclay et al. (2007) concluded that avian fatality rates were not affected by any of these parameters. Therefore, inflating our estimates to account for larger turbines may lead to over-estimates of avian mortality.

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.

A few studies of wind-energy facilities in other regions of the country have provided information on background mortality. During a four-year study at Buffalo Ridge, Minnesota, 2,482 fatality searches were conducted on study plots without turbines to estimate reference mortality in the study area. Thirty-one bird fatalities comprising 15 species were found (Johnson et al. 2000a). Reference mortality adjusted for searcher efficiency and carcass removal for the study was estimated to average 1.1 fatalities per plot per year. At a second study, pre-project carcass searches were conducted at a proposed wind-energy facility in Montana (Harmata et al. 1998). Three bird fatalities were found during eight searches of five transects, totaling 10.94 miles (17.61 km) per search. On average, approximately 1.12 miles (1.8 km) of transect are searched within each turbine plot in the referenced studies for the CPE (Table 2). The amount of transect searched at the Montana site per search was equivalent to searching approximately seven to nine turbines for the regional studies. The background estimate for observed mortality would be approximately 0.33 per turbine plot per year, unadjusted for scavenging and searcher efficiency. The background mortality information from the Minnesota and Montana studies suggests that the estimates of bird mortality include some fatalities not related to turbine collision, and this factor alone would lead to an over-estimate of actual bird collision mortality for wind-energy facilities.

REFERENCES

Arnett, E.B., W.K. Brown, W.P. Erickson, J.K. Fiedler, B.L. Hamilton, T.H. Henry, A. Jain, G.D. Johnson, J. Kerns, R.R. Koford, C.P. Nicholson, T. O'Connell, M.D. Piorkowski, and R.D Tankersley, Jr. 2007. Patterns of bat fatalities at wind energy facilities in North America. *Journal of Wildlife Management* 72: 61-78.

Baerwald, E. 2007. Bat Fatalities in Southern Alberta. Proceeding of the Wildlife Research Meeting VI, November 2006, San Antonio, Texas. National Wind Coordinating Collaborative.

Barclay, R.M.R., E.F. Baerwald, and J.C. Gruver. 2007. Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height. Canadian Journal of Zoology 85:381-387.

Beason, R. C. 1995. Horned Lark (*Eremophila alpestris*). *In* The Birds of North America, No. 195 (A. Poole and F. Gill, Eds.). The Birds of North America, Inc., Philadelphia, PA.

Blancher, P.J., K.V. Rosenberg, A.O. Panjabi, B. Altman, J. Bart, C.J. Beardmore, G.S. Butcher, D. Demarest, R. Dettmers, E.H. Dunn, W. Easton, W.C. Hunter, E.E. Inigo-Elias, D.N. Pashley, C.J. Ralph, T.D. Rich, C.M. Rustay, J.M. Ruth, and T.C. Will. 2007. Guide to the Partners in Flight Population Estimates Database. Version: North American Landbird Conservation Plan 2004. Partners in Flight Technical Series No. 5. http://www.partnersinflight.org/

England, A. Sidney, Marc J. Bechard and C. Stuart Houston. 1997. Swainson's Hawk (Buteo swainsoni), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/265doi:10.2173/bna.265

Erickson, W.P., G.D. Johnson, M.D. Strickland, and K. Kronner. 2000. Avian and bat mortality associated with the Vansycle Wind Plant, Umatilla County Oregon. 1999 study year. Technical report submitted to Umatilla County Department of Resource Services and Development, Pendleton, Oregon. 22 pp.

Erickson, W.P., G.D. Johnson, M.D. Strickland, D.P. Young, Jr., K.J. Sernka and R.E. Good. 2001. Avian collisions with wind turbines: A summary of existing studies and comparisons to other sources of avian collision mortality in the United States. National Wind Coordinating Committee Publication. http://www.nationalwind.org/pubs/default.htm

Erickson, W.P., G.D. Johnson, D.P. Young, Jr., M.D. Strickland, R.E. Good, M. Bourassa, K. Bay. 2002. Synthesis and comparison of baseline avian and bat use, raptor nesting and mortality information from proposed and existing wind developments. Technical Report prepared for Bonneville Power Administration, Portland, Oregon.

Erickson, W.P., B. Gritski, and K. Kronner. 2003. Nine Canyon Wind Power Project Avian and Bat Monitoring Report, September 2002 – August 2003. Technical report submitted to Energy Northwest and the Nine Canyon Technical Advisory Committee.

Erickson, W.P., J. Jeffrey, K. Kronner, and K. Bay. 2004. Stateline Wind Project Wildlife Monitoring Final Report, July 2001 – December 2003. Technical report peer-reviewed by and submitted to FPL Energy, the Oregon Energy Facility Siting Council, and the Stateline Technical Advisory Committee.

Erickson, W.P., K. Kronner, and K.J. Bay. 2007. Stateline II Wind Project Wildlife Monitoring Report, January – December 2006. Technical report submitted to FPL Energy, the Oregon Energy Facility Siting Council, and the Stateline Technical Advisory Committee.

Erickson, W.P., J.D. Jeffrey, and V.K. Poulton. 2008. Puget Sound Energy Wild Horse Wind Facility Post-Construction Avian and Bat Monitoring: First Annual Report, January – December 2007. Prepared by WEST, Inc. for Puget Sound Energy, Ellensburg, WA.

Fishman Ecological Services, LLC. 2003. Carcass survey results for SeaWest Windpower, Inc., Condon Site, 2002-2003. Prepared for SeaWest WindPower, Inc., Condon Wind Project, Gilliam County, Oregon.

Hunt, G. 2002. Golden eagles in a perilous landscape: predicting the effects of mitigation for wind turbine blade-strike mortality. California Energy Commission Report P500-02-043F.

Johnson, D.H. and T.A. O'Neil (managing editors). 2001. *Wildlife-Habitat Relationships in Oregon and Washington.* Oregon State University Press, Corvallis, OR. 768 pp.

Johnson, G.D. 2005. A review of bat collision mortality at wind-energy developments in the United States. Bat Research News 46:45-49.

Johnson, G.D. and M.D. Strickland. 2003. Biological Assessment for the Federally Endangered Indiana Bat (*Myotis sodalis*) and Virginia Big-Eared Bat (*Corynorhinus townsendii virginianus*), Nedpower Mount Storm Wind Project, Grant County, West Virginia. Unpublished report prepared for NedPower Mount Storm LLC, Chantilly, Virginia, by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. October 8, 2003. http://www.west-inc.com.

Johnson, G. D., D. P. Young, Jr., C. E. Derby, W. P. Erickson, M. D. Strickland, and J. W. Kern. 2000a. Wildlife monitoring studies, SeaWest Windpower Plant, Carbon County, Wyoming, 1995-1999. Technical Report prepared by WEST, Inc. for SeaWest Energy Corporation and Bureau of Land Management. 195pp.

Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd and D.A. Shepherd. 2000b. Avian Monitoring Studies at the Buffalo Ridge Wind Resource Area, Minnesota: Results of a 4-year study. Technical report prepared by WEST, Inc. for Northern States Power Co., Minneapolis, MN. 212pp.

Johnson, G.D., W.P. Erickson, and K. Bay. 2002a. Baseline Ecological Studies For the Klondike Wind Project, Sherman County, Oregon; Final Report prepared for Northwest Wind Power, Goldendale, Washington.

Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd, D.A. Shepherd, and S.A. Sarappo. 2002b. Collision mortality of local and migrant birds at a large-scale wind power development on Buffalo Ridge, Minnesota. *Wildlife Society Bulletin* 30: 879-887.

Johnson, G., W. Erickson, J. White, R. McKinney. 2003a. Avian and Bat Mortality During the First Year of Operation at the Klondike Phase I Wind Plant, Sherman County, Oregon. Technical report prepared for Northwestern Wind Power, Goldendale, Washington. March 2003.

Johnson, G.D., M.D. Strickland, W.P. Erickson, and D.P. Young, Jr. 2007. Use of data to develop mitigation measures for wind power development impacts to birds. Pages 241-257 *In* Birds and Wind Farms, Risk Assessment and Mitigation. M. de Lucas, G.F.E. Janss, and M. Ferrer, (eds.). Quercus Press, Madrid, Spain.

Kerns, J. and P. Kerlinger. 2004. A Study of Bird and Bat Collision Fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003. Technical Report prepared for FPL Energy and Mountaineer Wind Energy Center Technical Review Committee. Curry and Kerlinger, LLC. 39 pp.

Kerns, J., W.P. Erickson, and E.B. Arnett. 2005. Bat and Bird fatality at wind energy facilities in Pennsylvania and West Virginia. Pages 24-95 *in* E.B. Arnett, technical editor, Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Kronner, K., B. Gritski, Z. Ruhlen, and T. Ruhlen. 2007. Leaning Juniper Phase I Wind Power Project, 2006-2007 Wildlife Monitoring Annual Report. Unpubl. report prepared by Northwest Wildlife Consultants, Inc. for PacifiCorp Energy, Portland, OR.

Kronner, K., R. Gritski, and S. Downes. 2008. Big Horn Wind Power Project Wildlife Monitoring Final Report, 2006-2007. Technical report prepared by Northwest Wildlife Consultants, Inc., Goldendale, WA. Prepared for PPM Energy and the Big Horn Technical Advisory Committee.

Kunz, T.H. 1982. Silver-haired Bat, *Lasionycteris noctivagans*. Mammalian Species 172:1-5.

Lack, D. 1966. Population Studies of Birds. Clarendon Press, Oxford.

Leddy, K.L. 1996. Effects of wind turbines on nongame birds in Conservation Reserve Program grasslands in southwestern Minnesota. M.S. Thesis, South Dakota State Univ., Brookings. 61pp.

Leddy, K.L., K.F. Higgins, and D.E. Naugle. 1999. Effects of wind turbines on upland nesting birds in Conservation Reserve Program grasslands. Wilson Bull. 111:100-104.

Marshall, D.B., M.W. Chilcote, and H. Weeks. 1996. Species at risk: sensitive, threatened and endangered vertebrates of Oregon. 2nd edition. Oregon Department of Fish and Wildlife, Portland, Oregon.

Millsap, B.A. and G.T. Allen. 2006. Effects of falconry harvest on wild raptor populations in the United States: Theoretical considerations and management recommendations. Wildlife Society Bulletin 34:1392-1400.

NWC and WEST, 2007. Avian and bat monitoring report for the Klondike II Wind Power Project, Sherman County, Oregon. Unpubl. report prepared by Northwest Wildlife Consultants and WEST, Inc. for PPM Energy, Portland, OR.

Osborn, R.G., C.D. Dieter, K.F. Higgins, and R.E. Usgaard. 1998. Bird flight characteristics near wind turbines in Minnesota. Am. Midl. Nat. 139:29-38.

Quigley, T.M.; Arbelbeide, S.J., tech. eds. 1997. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins: Vol 2. Gen. Tech. Rep. PNWGTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Vol 1-4. (Quigley, Thomas M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: Scientific Assessment).

Sauer, J. R., J. E. Hines, and J. Fallon. 2008. *The North American Breeding Bird Survey, Results and Analysis 1966 - 2007. Version 5.15.2008. USGS Patuxent Wildlife Research Center, Laurel, MD.*

Schmutz, J.K. and R.W. Fyfe. 1987. Migration and mortality of Alberta ferruginous hawks. Condor 89:169-174.

Schmutz, J.K., D.T.T. Flockhart, C.S. Houston, and P.D. McLoughlin. 2008. Demography of ferruginous hawks breeding in western Canada. Journal of Wildlife Management 72:1352-1359.

Schmutz, J.K., P.D. McLoughlin, and C.S. Houston. 2006. Demography of Swainson's hawks breeding in western Canada. Journal of Wildlife Management 70:1455-1460.

Shaffer, J.A. and D.S. Johnson. 2006. Wind Energy Development and Grassland Breeding Birds: How compatible? Presented at the NWCC avian interactions meeting, San Antonio, Texas, November 14, 2006.

Shump, Jr., K.A. and A.U. Shump. 1982. Hoary bat, *Lasiurus cinereus*. Mammalian Species 185:1-5.

Thorson, T.D., Bryce, S.A., Lammers, D.A., Woods, A.J., Omernik, J.M., Kagan, J., Pater, D.E., and Comstock, J.A., 2003. Ecoregions of Oregon (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,500,000).

Usgaard, R.E., D.E. Naugle, R.G. Osborn, and K.F. Higgins. 1997. Effects of wind turbines on nesting raptors at Buffalo Ridge in southwestern Minnesota. Proceedings of the South Dakota Academy of Science 76: 113-117.

U.S. Fish and Wildlife Service. 1999. Endangered and threatened wildlife and plants: proposed threatened status for the Mountain Plover. Federal Register 64(30):7587-7601.

U.S. NABCI Committee. 2000. North American Bird Conservation Initiative: Bird Conservation Region Descriptions. A Supplement to the North American Bird Conservation Initiative Bird Conservation Regions Map. U.S. Fish and Wildlife Service, Arlington, VA.

Watson, J.W. 2003. Migration and winter ranges of ferruginous hawks from Washington. Final Report. Washington Department of Fish and Wildlife, Olympia, Washington, USA.

Welty, J.C. 1982. The Life of Birds, 3rd Edition. Saunders College Publishing, Philadelphia.

Wiggins, D. A., D. W. Holt and S. M. Leasure. 2006. Short-eared Owl (Asio flammeus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/062doi:10.2173/bna.62.

Woofinden, N.D. and J.R. Murphy. 1989. Decline of a ferruginous hawk population: A 20-year summary. Journal of Wildlife Management 53:1127-1132.

Young, D.P. Jr., W.P. Erickson, R.E. Good, M.D. Strickland, and G.D. Johnson. 2003. Avian and bat mortality associated with the initial phase of the Foote Creek Rim Wind Power Project, Carbon County, Wyoming: November 1998 - June 2002. Technical Report prepared by WEST, Inc. for PacifiCorp, Inc., SeaWest Windpower, Inc. and Bureau of Land Management. 35 pp.

Young, Jr., D.P., J.D. Jeffrey, W.P. Erickson, K. Bay, K. Kronner, B Gritski, and J. Baker. 2005. Combine Hills Turbine Ranch Wildlife Monitoring First Annual Report, March 2004-March 2005. Technical report prepared for Eurus Energy America Corporation, Umatilla County, and the Combine Hills Technical Advisory Committee.

Young, Jr., D.P. and W. P. Erickson. 2006. Wildlife Issue Solutions: What Have Marine Radar Surveys Taught Us About Avian Risk Assessment? Proceedings of the American Wind Energy Association Windpower 2006 Conference and Exhibition, Pittsburgh, Pennsylvania, June 4-7, 2006.

Young, Jr., D.P., W.P. Erickson, J.D. Jeffrey, and V.K. Poulton. 2007. Puget Sound Energy Hopkins Ridge Wind Project Phase 1 Post-Construction Avian and Bat Monitoring First Annual Report, January - December 2006. Technical report for Puget Sound Energy, Dayton, Washington and Hopkins Ridge Wind Project Technical Advisory Committee, Columbia County, Washington. **W**estern **E**co**S**ystems Technology, Inc. Cheyenne, Wyoming, and Walla Walla, Washington. 25pp.

Table 1. Wind power projects constructed or planned in the Columbia Plateau Ecoregion of Washington and Oregon.

Project	Max. Capacity (MW)	Project Information Source
Existing		
Combine Hills I (Umatilla Co., OR)	41	http://www.rnp.org/News/pr_EurusCombineJun03.html
Vansycle Ridge (Umatilla Co., OR)	25	http://www.rnp.org/Projects/vansycle.html
Stateline (Umatilla Co., OR)	300	http://www.ppmenergy.com/cs_stateline.html
Klondike I (Sherman Co., OR)	24	http://www.rnp.org/Resources/Klondike%201%20pager.pdf
Klondike II (Sherman Co., OR)	75	http://www.portlandgeneral.com/about_pge/ current_issues/klondikeII/Default.asp?bhcp=1
Condon (Gilliam Co., OR)	50	http://www.efw.bpa.gov/environmental_services/ Document_Library/Condon_Wind/RODwMAP.pdf
Leaning Juniper I (Gilliam Co., OR)	104	http://www.efw.bpa.gov/environmental_services/ Document_Library/Arlington_PPM/ROD031105.pdf
Nine Canyon I (Benton Co., WA)	64	http://www.energy-northwest.com/downloads/ninecan.pdf
Nine Canyon II (Benton Co., WA)	16	http://www.energy-northwest.com/downloads/9Canyon.pdf
Hopkins Ridge (Columbia Co., WA)	157	http://www.rnp.org/News/pr_PSEHopkinsDec05.htm Adding 4 more towers according to Columbia Co. Planning 1/15/08
White Creek/Last Mile (Klickitat Co., WA)	206	Klickitat Co. Planning Dept.
Big Horn (Klickitat Co., WA)	250	http://www.efw.bpa.gov/environmental_services/ Document_Library/Big_Horn/BigHornROD03242005.pdf
Hoctor Ridge (Klickitat Co., WA)	60	Klickitat Co. Planning Dept.
Marengo (Columbia Co., WA)	140	http://www.pacificpower.net/Homepage/Homepage35750.html
Wild Horse (Kittitas Co., WA)	230	http://www.res-ltd.com/wind-farms/wf-wildhorse/htm
Biglow Canyon (Sherman Co., OR)	450	http://www.bpa.gov/corporate/pubs/ RODS/2006/RODKlondikeIIIBiglowCanyon.pdf
Klondike III (Sherman Co., OR)	272	http://egov.oregon.gov/ENERGY/SITING/docs/ KWPPublicFilingNotice.pdf
Permitted/Proposed		
Marengo II (Columbia Co., WA)	90	http://www.pacificpower.net/Homepage/Homepage35750.html Under construction Jan 2008
Seven Mile Hill (Wasco Co., OR)	50	http://www.oregon.gov/ENERGY/SITING/ review.shtml#Seven_Mile_Hill_Wind_Project
Leaning Juniper II (Gilliam Co., OR)	279	http://www.oregon.gov/ENERGY/SITING/ review.shtml#Leaning_Juniper_Wind_Power
Arlington CEP/Rattlesnake Rd. (Gilliam Co., OR)	104	http://www.bpa.gov/corporate/pubs/rods/2005/EFW/ Arlington-Wind-Interconnection-ROD-1-14-05.pdf
Shepherds Flat (Gilliam & Morrow Co., OR)	909	Data provided by BPA, Morrow County Planning Dept.
Willow Creek (Morrow Co./Gilliam Co., OR)	50	http://www.transmission.bpa.gov/PlanProj/Wind/willow.cfm

Project	Max. Capacity (MW)	Project Information Source
Combine Hills II (Umatilla Co., OR)	63	http://www.efw.bpa.gov/environmental_services/ Document_Library/Combine_Hills/Combine_Hills_Cx.pdf
Windy Point (Klickitat Co., WA)	242.5	Klickitat Co. Planning Dept.
Windy Point II (Klickitat Co., WA)	152.5	Klickitat Co. Planning Dept.
Windy Flats (Klickitat Co., WA)	190	Klickitat Co. Planning Dept.
Goodnoe II (Klickitat Co., WA)	34	Klickitat Co. Planning Dept.
Juniper Canyon (Klickitat Co., WA)	250	Klickitat Co. Planning Dept.
Harvest (Klickitat Co., WA)	100	Klickitat Co. Planning Dept.
Linden Ranch (Klickitat Co., WA)	58	Klickitat Co. Planning Dept.
Miller Ranch (Klickitat Co., WA)	98	Klickitat Co. Planning Dept.
Imrie (Klickitat Co., WA)	100	Klickitat Co. Planning Dept.
Mariah (Klickitat Co., WA)	16	Klickitat Co. Planning Dept.
Nine Canyon III (Benton Co., WA)	32	http://www.energy-northwest.com/news/2006/06_07.php
Desert Claim (Kittitas Co., WA)	180	
Kittitas Valley (Kittitas Co., WA)	130	
Scenic Vista (Umatilla Co., OR)	60-80	Umatilla County Planning Dept.
Helix (Umatilla Co., OR)	102	Iberdrola Renewables, Inc.
Oregon Trail (Sherman Co., OR)	10	Sherman County Planning Dept.
Star Point (Sherman Co., OR)	102.9	Iberdrola Renewables, Inc.
Hay Canyon (Sherman Co., OR)	<105 MW	Sherman County Planning Dept.
Golden Hills (Sherman Co., OR)	400	Sherman County Planning Dept.
Three Mile (Morrow Co., OR)	15	Morrow County Planning Dept.
Oregon Wind Farms, LLC (Morrow Co., OR)	60	Morrow County Planning Dept.
Pebble Springs (PPM) (Gilliam Co, OR)	104	Gilliam Co. Planning
Wheat Field Wind (AWP) (Gilliam Co, OR)	104	Gilliam Co. Planning
Totals	**~6665**	

Table 2. Avian use estimates and avian fatality estimates for existing wind energy projects in the Columbia Plateau Ecoregion.

Project	**Mean annual avian use** (#/20-min survey)		**Mean annual mortality** (#/MW/year)			Source
	Raptors	**All birds**	**Raptors**	**All birds**	**Nocturnal Migrants**	**Source**
Combine Hills, OR	0.60	6.0	0	2.6	0.27	Young et al. 2005
Klondike, I OR	0.47	17.5	0	0.9	0.35	Johnson et al. 2003a
Klondike II, OR	0.47	17.5	0.11	3.1	2.11	NWC and WEST, 2007
Vansycle, OR	0.41	13.1	0	1.0	0.32	Erickson et al. 2000
Stateline, WA/OR	0.41	13.1	0.10	2.4	0.78	Erickson et al. 2004, 2007
Hopkins Ridge, WA	0.64	8.7	0.14	1.2	0.46	Young et al. 2007
Nine Canyon, WA	0.26	9.4	0.05	2.8	0.45	Erickson et al. 2003
Wild Horse, WA	0.40	5.0	0.09	1.6	0.88	Erickson et al. 2008
Bighorn I, WA	0.90	16.6	0.15	2.6	0.57	Kronner et al. 2008
Leaning Juniper, OR	0.52	23.6	0.06	3.2	na	Kronner et al. 2007
Condon, OR	0.37	5.8	0.02[a]	0.05[a]	NR	Fishman Ecological Services 2003
Mean	**0.50**	**12.4**	**0.07**	**2.1**	**0.69**	

[a] 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.

Table 3. 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**
Hopkins Ridge	Columbia Co., WA	0.64	8.7
Nine Canyon	Benton Co., WA	0.26	9.4
Desert Claim	Kittitas Co., WA	0.77	15.3
Kittitas Valley	Kittitas Co., WA	0.90	12
Wild Horse	Kittitas Co., WA	0.40	5
Big Horn I	Klickitat Co., WA	0.90	16.6
White Creek	Klickitat Co., WA	0.66	11.9
Linden Ranch	Klickitat Co., WA	1.64	11.1
Hoctor Ridge	Klickitat Co., WA	1.38	15.3
Imrie	Klickitat Co., WA	0.70	19.2
Windy Point	Klickitat Co., WA	0.77	16.0
Windy Flats	Klickitat Co., WA	0.83	19.9
Reardan	Lincoln Co., WA	0.90	13
Zintel Canyon	Benton Co., WA	0.44	19
Maiden	Benton/Yakima Co., WA	0.38	11.6
Combine Hills	Umatilla Co., OR	0.60	6
Klondike I & II	Sherman Co., OR	0.47	17.5
Biglow	Sherman Co., OR	0.30	9.1
Vansycle	Umatilla Co., OR	0.41	13.1
Elkhorn	Union Co., OR	1.05	21.7
Shepherd’s Ridge	Morrow Co., OR	0.61	6.5
Leaning Juniper	Gilliam Co., OR	0.52	23.6
Condon	Gilliam Co., OR	0.37	5.8
Stateline	Walla Walla Co., WA/Umatilla Co., OR	0.41	13.1
Mean		**0.68**	**13.4**
Range		**0.26 – 1.64**	**5 – 23.6**

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

Species	Number of Fatalities	Percent Composition
horned lark	206	31.1
golden-crowned kinglet	43	6.5
ring-necked pheasant	37	5.6
gray partridge	36	5.4
American kestrel	22	3.3
chukar	22	3.3
western meadowlark	21	3.2
unidentified passerine	19	2.9
dark-eyed junco	18	2.7
European starling	17	2.6
white-crowned sparrow	17	2.6
mourning dove	16	2.4
red-tailed hawk	14	2.1
ruby-crowned kinglet	9	1.4
unidentified bird	9	1.4
yellow-rumped warbler	9	1.4
short-eared owl	7	1.1
winter wren	7	1.1
house wren	6	0.9
unidentified kinglet	6	0.9
black-billed magpie	5	0.8
Brewer’s sparrow	5	0.8
golden-crowned sparrow	5	0.8
rock dove	5	0.8
Townsend’s warbler	5	0.8
unidentified sparrow	5	0.8
American robin	4	0.6
Canada goose	4	0.6
common nighthawk	4	0.6
ferruginous hawk	4	0.6
northern flicker	4	0.6
rock pigeon	4	0.6
red-breasted nuthatch	3	0.5
song sparrow	3	0.5
Swainson's hawk	3	0.5
white-throated swift	3	0.5
Cassin’s vireo	2	0.3
house finch	2	0.3
Macgillivray's warbler	2	0.3

Species	Number of Fatalities	Percent Composition
mallard	2	0.3
sage thrasher	2	0.3
savannah sparrow	2	0.3
vesper sparrow	2	0.3
American coot	1	0.2
American goldfinch	1	0.2
American pipit	1	0.2
barn owl	1	0.2
black-throated sparrow	1	0.2
brown-headed cowbird	1	0.2
bufflehead	1	0.2
chipping sparrow	1	0.2
common raven	1	0.2
Cooper’s hawk	1	0.2
downy woodpecker	1	0.2
grasshopper sparrow	1	0.2
gray catbird	1	0.2
great blue heron	1	0.2
great horned owl	1	0.2
hairy woodpecker	1	0.2
house sparrow	1	0.2
killdeer	1	0.2
Lewis's woodpecker	1	0.2
long-eared owl	1	0.2
mountain bluebird	1	0.2
northern harrier	1	0.2
orange-crowned warbler	1	0.2
red-shafted flicker	1	0.2
red-winged blackbird	1	0.2
rough-legged hawk	1	0.2
sage sparrow	1	0.2
spotted towhee	1	0.2
Swainson's thrush	1	0.2
Townsend’s solitaire	1	0.2
unidentified accipiter	1	0.2
unidentified empidonax	1	0.2
unidentified partridge	1	0.2
unidentified thrush	1	0.2
varied thrush	1	0.2
Vaux’s swift	1	0.2
warbling vireo	1	0.2
western grebe	1	0.2

Species	Number of Fatalities	Percent Composition
western kingbird	1	0.2
western tanager	1	0.2
Williamson's sapsucker	1	0.2
yellow warbler	1	0.2
Totals (77 species)	**663**	**100.0**

Table 5. Percent composition of avian fatalities by species group for existing Columbia Plateau Ecoregion wind energy projects.

Species	Number of Fatalities	Percent Composition
Passerines	461	69.5
Upland gamebirds	96	14.5
Raptors	57	8.6
Doves/pigeons	21	3.2
Waterbirds/waterfowl/shorebirds	11	1.7
Other birds[a]	17	2.6
Totals	**663**	**100**

[a] woodpeckers, nighthawks, swifts

Table 6. Summary of bat mortality at existing wind energy projects in the Columbia Plateau Ecoregion.

Project Name [state]	No. Bats /turbine/year	Bats per MW[1]	Reference
Stateline [OR/WA]	0.95	1.44	Erickson et al. 2004, 2007
Vansycle [OR]	0.74	1.12	Erickson et al. 2000
Klondike [OR]	1.16	0.77	Johnson et al. 2003b
Klondike II [OR]	0.63	0.41	NWC and WEST, Inc. 2007
Hopkins Ridge [WA]	1.13	0.63	Young et al 2007
Wild Horse [WA]	0.70	0.39	Erickson et al. 2008
Nine Canyon [WA]	3.21	2.46	Erickson et al. 2001b
Leaning Juniper [OR]	1.28	0.86	Kronner et al. 2007
Big Horn I [WA]	2.85	1.90	Kronner et al. 2008
Combine Hills [OR]	1.88	1.88	Young et al. 2005
Average	**1.46**	**1.18**	

[1] Most reports do not provide number per MW of energy produced so this number was calculated based on the mortality per turbine and capacity of turbines studied.

Table 7. Number and species composition of bat fatalities found at eight existing Columbia Plateau wind energy projects.

Species	Number of Fatalities	Percent Composition
silver-haired bat	163	48.4
hoary bat	152	45.1
unidentified bat	9	2.7
little brown bat	8	2.4
big brown bat	5	1.5
Totals (4 species)	**337**	**100**

Table 8. Seasonal timing of raptor fatalities at existing wind energy facilities in the Columbia Plateau.

Wind Energy Project	Season				
	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
Vancycle, OR	0	0	0	0	0
Stateline, WA/OR	3	8	6	1	18
Hopkins Ridge, WA	1	3	1	1	6
Nine Canyon, WA	1	0	0	0	1
Wild Horse, WA	1	5	0	0	6
Bighorn I, WA	4	5	2	5	16
Leaning Juniper, OR	2	1	0	0	3
Condon, OR	1	0	0	0	1
Totals	**13**	**26**	**10**	**7**	**57**
Percent	**22.8**	**45.6**	**17.5**	**12.3**	**100**

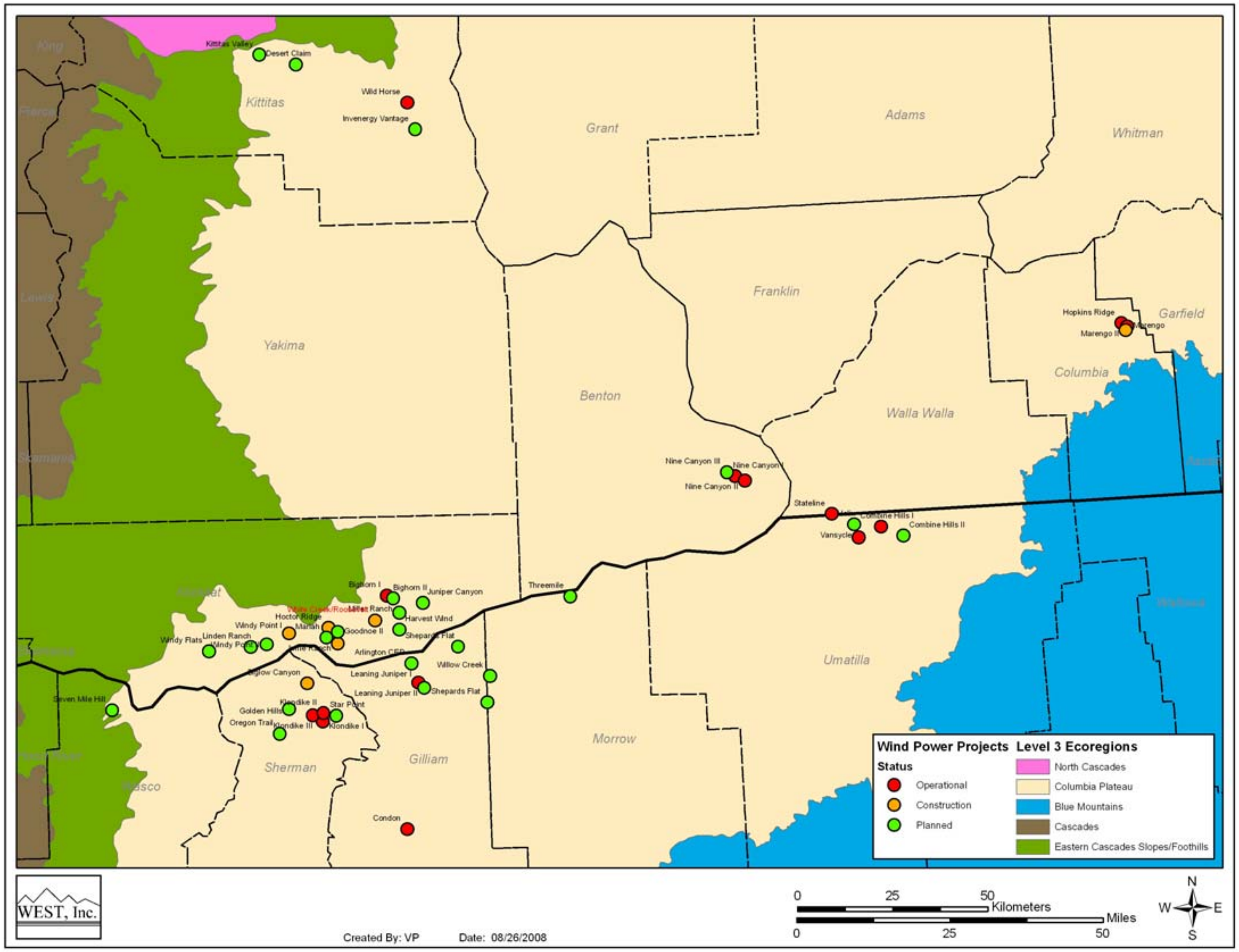

Figure 1. Location of existing and proposed wind energy facilities in the Columbia Plateau Ecoregion of southeastern Washington and northeastern Oregon.

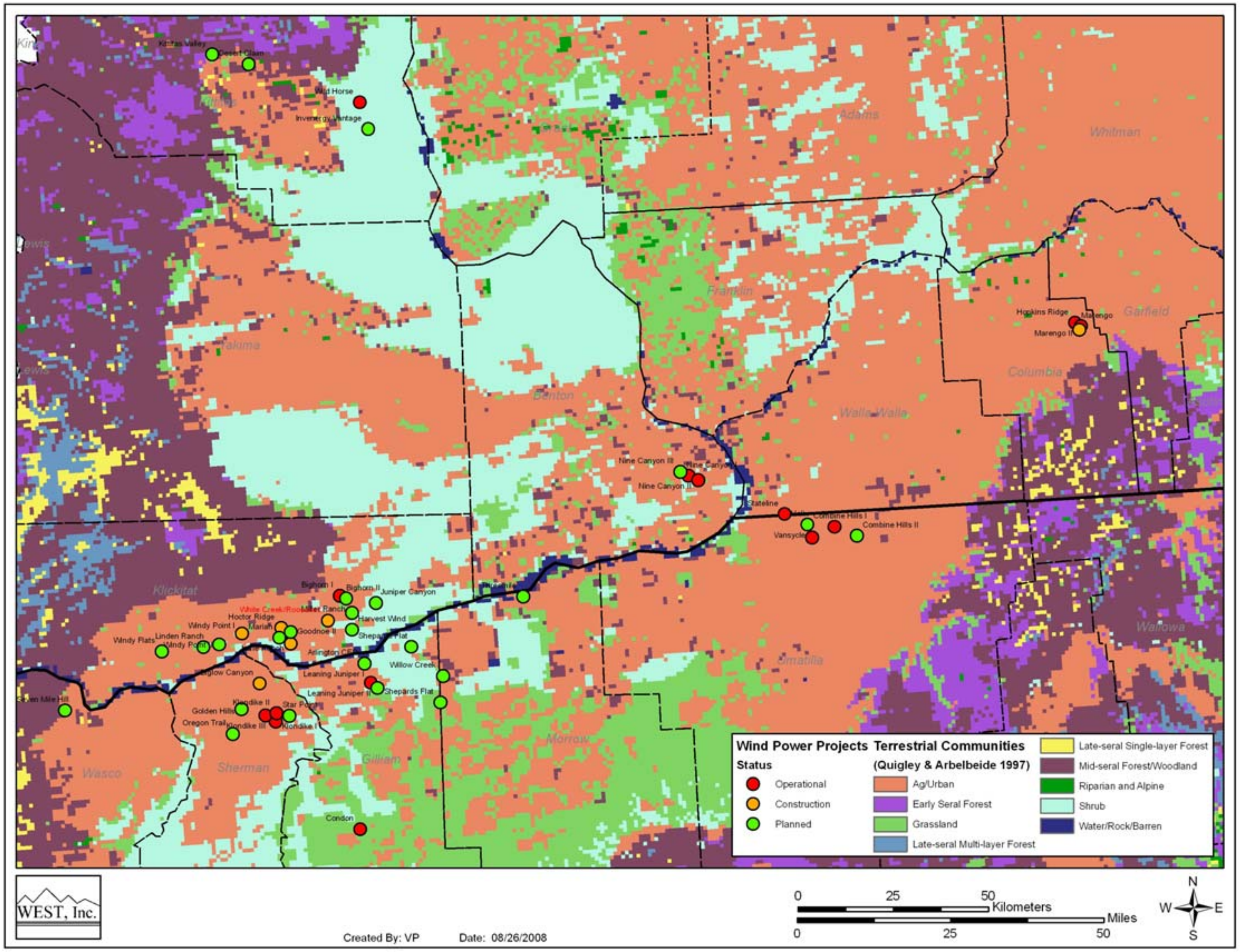

Figure 2. Terrestrial vegetative communities within the Columbia Plateau Ecoregion.