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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February 2010

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INTRODUCTION AND BACKGROUND

Over the last decade, wind energy development has been 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.

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 (Johnson and Stephens 2010). 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. This report updates a previous version (Johnson and Erickson 2008) to account for additional bird and bat fatality estimates from the Leaning Juniper and Klondike III wind energy projects in Oregon, as well as additional raw data on species composition of turbine fatalities from the Goodnoe and White Creek wind energy facilities in Klickitat County, Washington and the Pebble and Hay Canyon wind energy facilities in 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 September 2009, there were 4159 MW of wind energy either built or under construction in Washington and Oregon (AWEA 2009), most of which has been within the Columbia Plateau Level III Ecoregion (Thorson et al. 2003; Figure 1). In the 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 6700 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, for consistency, for the purpose of this analysis, we assumed that 6700 MW of wind power would be present in the CPE. We also calculated the numbers of fatalities that reflect Northwest Power and Conservation Council (NPCC) estimates, which recognize constraints on wind development, such as transmission capacity. NPCC projects that 5,577 MW of wind energy development will be installed by the year 2013 (Jeff King, Senior Resource Analyst, presentation to the Northwest Wind Integration Forum Steering Committee, January 7, 2010).

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 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 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 12 wind-energy facilities in the CPE where at least one full year of 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 12 operational wind energy facilities in the CPE (Table 1). 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 11 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. To our knowledge these are the only population estimates available for the entire CPE.

Raptors

Raptor use estimates and post-construction raptor fatality estimates are available for 12 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, where it ranges from none to 0.15/MW/year (Johnson and Stephens 2010). 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. 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 12 existing wind-energy facilities in eastern Washington and Oregon ranges from 0 to 0.21/MW/year, with a mean of 0.077/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. 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 16 existing facilities in the CPE, including 12 with quantified fatality estimates and four with raw data on species composition and number of fatalities. For example, American kestrels (*Falco sparverius*) composed 31.4% 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 31.4% 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 (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 24 wind-energy facilities in the CPE has ranged from 5–23.6 birds/survey and averaged 13.4 birds/survey (Table 2). Total bird use at the 12 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 12.0 birds/survey (Table 1). 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 12 existing wind-energy facilities in the CPE. Therefore, we multiplied the total number of MW by 2.5 fatalities/MW/year (the mean among the 12 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 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 (1.20/MW/year). 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

Raptor use estimates and post-construction raptor fatality estimates are available for 12 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 0.52/survey (Table 2). Raptor mortality was not documented at four of these wind-energy facilities (Klondike I, Klondike III, 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 0.21/MW/year at Leaning Juniper, Oregon. Quantitative mortality estimates were not made for Condon, but only one raptor fatality was documented at that facility.

The 70 raptor fatalities found at CPE wind-energy facilities have composed 8.4% of the total bird mortality. Most of the raptor fatalities have been American kestrels (22 fatalities; 31.4%), red-tailed hawks (*Buteo jamaicensis*; 14 fatalities; 20.0%) and short-eared owls (*Asio flammeus*; 7 fatalities; 10.0%). Other raptors found as fatalities at CPE wind-energy facilities include six Swainson's hawks (*Buteo swainsonii*), four ferruginous hawks (*Buteo regalis*), three rough-legged hawks (*Buteo lagopus*), two of each of the following: great horned owl (*Bubo virginianus*), long-eared owl (*Asio otus*), northern harrier (*Circus cyaneus*), unidentified buteo, and one each of the following: golden eagle (*Aquila chrysaetos*), Cooper's hawk (*Accipiter cooperii*), sharp-shinned hawk (*Accipiter striatus*), barn owl (*Tyto alba*), unidentified owl, and unidentified accipiter (Table 3).

All Birds

Eighty-nine 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 2010). 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 67.1% 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 29.7% of all bird fatalities (Table 3), 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 3). The one apparent migrant with the highest number of fatalities is the golden-crowned kinglet (*Regulus satrapa*; 47 fatalities; 5.6% of all fatalities).

Mourning doves (*Zenaida macroura*) and rock pigeons (*Columba livia*) have composed 4.3% of the mortality at CPE wind-energy facilities. Waterfowl, waterbirds and shorebirds have composed only 2.1% of the fatalities. 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 1247 avian fatalities collected at modern wind-energy facilities in western North America and summarized in Johnson and Stephens (2010), only three (0.2%) 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 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*). Upland gamebird mortality is fairly common, as upland gamebirds have comprised 9.6% of all fatalities at modern wind energy facilities in western North America, behind only passerines and raptors (Johnson and Stephens 2010). In the CPE, upland gamebirds are one of the most common fatalities, composing 12.6% of all identified fatalities (Table 4). 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 11 existing wind-energy facilities in the CPE, where they ranged from 0.23–2.46 fatalities/MW/year, and averaged 1.20 fatalities/MW/year (Table 5). Bat mortality patterns at wind-energy facilities in Washington and Oregon have followed patterns similar to the rest of the country. Of 390 bat fatalities collected at existing wind-energy facilities in eastern Oregon and Washington, 364 (93.4%) have been the two migratory species that occur in the CPE, including 180 hoary bats (*Lasiurus cinereus*) and 184 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 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.

Mortality Estimates and Population Consequences

Birds (Excluding Raptors)

For all birds combined, we estimate that total annual mortality in the CPE would be 16,750 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 3), passerines would compose approximately 67.1% of the fatalities, upland gamebirds would compose 12.6%, doves/pigeons would compose 4.3%, waterfowl/waterbirds/shorebirds would compose 2.1% and other bird types, such as woodpeckers, nighthawks and swifts, would compose 3.0%. 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 516 fatalities per year. . American kestrels account for 31.4%, red-tailed hawks account for 20.0% and short-eared owls account for 10.0% of the raptor fatalities recorded at the regional wind projects studied (see Table 3). Assuming this trend holds true for all proposed wind-energy facilities in the CPE, and assuming there would be 516 raptor fatalities per year, it would be expected that on average 162 American kestrels, 103 red-tailed hawks and 52 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 prairie falcon (*Falco mexicanus*) fatalities have been reported to date during standardized monitoring; therefore, our mortality estimate for these species is necessarily zero. Although one prairie falcon was found at the White Creek wind energy facility, it was an incidental fatality and was therefore not included in this analysis. 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 5.7% of the raptor fatalities, Swainson's hawks have composed 8.6%, and golden eagles have composed 1.4%. Assuming a total of 516 raptor fatalities could occur each year in the CPE, this would result in 29 ferruginous hawk, 44 Swainson's hawk, and seven golden eagle 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 23.1% in the spring, 43.1% in the summer, 21.5% in the fall, and 10.8% in the winter (Table 7). Approximately 56.9% 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 43.1% of the mortality would occur during the breeding season, it would be expected that approximately 70 American kestrel, 44 red-tailed hawk and 22 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 0.04% of the breeding population of American kestrels, 0.06% of the breeding population of red-tailed hawks and 0.10% of the breeding population of short-eared owls. Even if we assumed all mortality (instead of 43.1%) would occur to adult breeding birds, this would still represent only 0.10%, 0.13% and 0.25% 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 1062 raptors comprised of 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 hawk, six 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) 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 1000 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 29 ferruginous hawk fatalities on an annual basis, even if all turbine mortality occurred to resident breeding adult birds, this would represent 2.9% 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 2.9%, 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 1902 MW, or 28% of the 6700 MW of all currently existing and proposed 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. There is consequently 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 conservation easements around ferruginous hawk breeding territories, 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 44 Swainson's hawks per year, this would represent only 0.44% 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 and is listed as a candidate species by the WDFW, but does not have any special status in Oregon. The estimated breeding population in the CPE is 1770 (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 seven golden eagle fatalities, even if all turbine mortality occurred to resident breeding adult birds, this would represent 0.4% 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 0.4%. 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 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 <0.4% of the population associated with 6700 MW of wind energy development in the CPE would not likely have measurable population consequences for golden eagles.

Upland Gamebirds

Upland gamebirds represent a higher percentage (12.6%) 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 16,750, approximately 2110 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 0.57% 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 0.57%, 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 fatalities at existing wind energy projects in the CPE. Based on our total bird mortality estimate of 16,750, approximately 352 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 67.1% of the bird fatalities have been passerines (Table 5). Assuming that 67.1% of all bird mortality would be composed of passerines, approximately 11,239 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 4975 horned lark fatalities per year. Another common grassland breeder in the CPE, western meadowlark (*Sturnella neglecta*), composed approximately 4.8% of the passerine fatalities at wind-energy facilities, and therefore total annual mortality of this species related to wind turbine collisions would be approximately 540 individuals. At wind-energy facilities in the CPE, migrant passerines of several species generally composed approximately 30% of the bird fatalities (Table 1). Assuming these estimates are representative of all CPE wind-energy facilities, approximately 5025 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 3). Approximately 5.6% of the passerine fatalities were of this species; therefore, estimated annual mortality for this species would be approximately 938 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 4975 horned lark fatalities, and if it is assumed that the horned lark fatalities are spread equally over the year, then roughly 25% (~1244) of these fatalities would be during the breeding season. This represents approximately 0.06% 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 540 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 3) 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 938, 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 golden eagle and 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 long-billed curlew (*Numenius americanus*), 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 837 bird fatalities have been found at these projects and estimated total bird mortality is 16,750, the estimated mortality for each of these species would be approximately 20 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; no estimate was provided for long-billed curlew. Given these estimated populations sizes, the loss of 20 individuals per year would not have measurable population consequences.

Bats

Based on bat mortality estimates at the other regional wind-energy facilities, total bat mortality in the CPE was estimated at 8040 per year. Based on species composition of bat fatalities found at CPE wind-energy facilities, approximately 3795 silver-haired and 3714 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 2010). Silver-haired bats throughout the US and species in the *Lasiurus* genus, the hoary bat in the western U.S. 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 (Arnett et al. 2008, Johnson 2005, Johnson and Stephens 2010). The highest mortality occurs during the fall migration period for bats, from roughly late-July through September (Arnett et al. 2008, 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 (Baerwarld 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. 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 *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 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 1.20 bat fatalities/MW/year observed in the Pacific Northwest.

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 (Shump and Shump 1982, Kunz 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. commun.).

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 as of late 2008 were in communities classified as shrub steppe, with two additional facilities in areas classified as grasslands. The remaining facilities were 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 5000 acres (7.8 mi^2) of non-agricultural vegetation types, primarily grassland shrub-steppe vegetation, would be lost in the CPE with 6700 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.

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 (AWEA 2009). 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. 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 (5.94 nests/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 Altamont Pass wind resource area 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, Western EcoSystems Technology, Inc. [WEST] 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. 2005a). 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 (2008) 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 (*Charadrius vociferous*), 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 have slowly increased since, 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 have apparently become 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. 2005b).

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 breeding season (Walker et al. 2008, unpublished report). Breeding duck numbers were similar between developed and undeveloped areas. The study is continuing through 2010 to further assess response of breeding ducks to wind-energy development.

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

Mortality estimates for this analysis were based on species composition of fatalities found at 16 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 5.7% of all raptor fatalities based on four ferruginous hawk fatalities out of 70 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 3.0-MW turbine would be twice as high as a 1.5-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.

This cumulative impacts analysis assumed that up to 6700 MW of wind energy could be developed in the CPE. However, based on recent estimates by the Northwest Power and Conservation Council (NPCC), which recognize constraints on wind development, such as transmission capacity, the NPCC projects that 5577 MW of wind energy development will be installed by the year 2013 (Jeff King, Senior Resource Analyst, presentation to the Northwest Wind Integration Forum Steering Committee, January 7, 2010). Because our estimates of bird and bat fatalities assuming that 6700 MW of wind energy would be developed are likely overestimates, for comparison purposes we also derived estimates assuming that 5577 MW of wind energy would be developed (Table 8).

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, 2482 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.

Avian population estimates used in this analysis relied on breeding bird survey (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 Blancher et al. (2007) are the only ones available for the CPE.

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. (2001) found that wind energy contributes only a minor fraction of the overall avian collision mortality in the US 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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Table 1. Avian use estimates and avian fatality estimates for existing wind energy projects in the Columbia Plateau Ecoregion[a].

Project	**Mean annual avian use** (#/20-min survey)		**Mean annual mortality** (#/MW/year)			
	Raptors	**All birds**	**Raptors**	**All birds**	**Nocturnal Migrants**	**Source**
Combine Hills, OR	0.60	6.0	0	2.6	0.27	Young et al. 2005a
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
Klondike III, OR	0.78 [b]	8.18 [b]	0	2.5	0.51	Gritski et al. 2009
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	0.21	6.7	1.56	Gritski et al. 2008
Condon, OR	0.37	5.8	0.02[c]	0.05[c]	NR	Fishman Ecological Services 2003
Mean	**0.52**	**12.0**	**0.077**	**2.5**	**0.75**	

[a] Quantitative fatality estimates are not yet available for the Goodnoe and White Creek wind energy facilities in Klickitat County, Washington and the Pebble and Hay Canyon wind energy facilities in Oregon

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

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

Species	Number fatalities	% composition
horned lark	249	29.7
golden-crowned kinglet	47	5.6
ring-necked pheasant	45	5.4
gray partridge	36	4.3
unidentified passerine	32	3.8
western meadowlark	27	3.2
European starling	25	3.0
mourning dove	24	2.9
chukar	23	2.7
American kestrel	22	2.6
dark-eyed junco	21	2.5
unidentified bird	20	2.4
white-crowned sparrow	17	2.0
red-tailed hawk	14	1.7
rock pigeon	12	1.4
yellow-rumped warbler	11	1.3
ruby-crowned kinglet	10	1.2
winter wren	10	1.2
American robin	8	1.0
Brewer’s sparrow	7	0.8
northern flicker	7	0.8
short-eared owl	7	0.8
common nighthawk	6	0.7
house wren	6	0.7
Swainson’s hawk	6	0.7
Townsend’s warbler	6	0.7
unidentified sparrow	6	0.7
unidentified kinglet	6	0.7
black-billed magpie	5	0.6
red-breasted nuthatch	5	0.6
golden-crowned sparrow	5	0.6
spotted towhee	4	0.5
Canada goose	4	0.5
ferruginous hawk	4	0.5
common raven	3	0.2
rough-legged hawk	3	0.4
song sparrow	3	0.4
vesper sparrow	3	0.4
white-throated swift	3	0.4
acorn woodpecker	2	0.2

American coot	2	0.2
Cassin’s vireo	2	0.2
chipping sparrow	2	0.2
great blue heron	2	0.2
great horned owl	2	0.2
house finch	2	0.2
long-eared owl	2	0.2
Macgillivray’s warbler	2	0.2
mallard	2	0.2
mountain bluebird	2	0.2
northern harrier	2	0.2
northern rough-winged swallow	2	0.2
pine siskin	2	0.2
sage thrasher	2	0.2
savannah sparrow	2	0.2
unidentified buteo	2	0.2
unidentified warbler	2	0.2
Vaux’s swift	2	0.2
western tanager	2	0.2
American goldfinch	1	0.1
American pipit	1	0.1
Barn owl	1	0.1
black-throated sparrow	1	0.1
brown-headed cowbird	1	0.1
bufflehead	1	0.1
California quail	1	0.1
Cooper’s hawk	1	0.1
downy woodpecker	1	0.1
golden eagle	1	0.1
grasshopper sparrow	1	0.1
gray catbird	1	0.1
hairy woodpecker	1	0.1
horned grebe	1	0.1
house sparrow	1	0.1
killdeer	1	0.1
Lewis’s woodpecker	1	0.1
long-billed curlew	1	0.1
northern pintail	1	0.1
orange-crowned warbler	1	0.1
red-winged blackbird	1	0.1
sage sparrow	1	0.1
sharp-shinned hawk	1	0.1
Swainson’s thrush	1	0.1
Townsend’s solitaire	1	0.1
tree swallow	1	0.1

turkey vulture	1	0.1
unidentified accipiter	1	0.1
unidentified duck	1	0.1
unidentified empidonax	1	0.1
unidentified gamebird	1	0.1
unidentified nuthatch	1	0.1
unidentified owl	1	0.1
unidentified thrush	1	0.1
unidentified vireo	1	0.1
unidentified woodpecker	1	0.1
varied thrush	1	0.1
Virginia rail	1	0.1
warbling vireo	1	0.1
western grebe	1	0.1
western kingbird	1	0.1
western wood-pewee	1	0.1
Williamson’s sapsucker	1	0.1
Wilson’s warbler	1	0.1
yellow warbler	1	0.1
Total	837	100

[a] Species composition of bird 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 Goodnoe and White Creek wind energy facilities in Klickitat County, Washington and the Pebble and Hay Canyon wind energy facilities in Oregon

Table 4. Percent composition of avian fatalities by species group for existing Columbia Plateau Ecoregion wind energy projects.

Species	**Number of Fatalities**	**Percent Composition**
Passerines	562	67.1
Upland gamebirds	106	12.6
Raptors	70	8.5
Doves/pigeons	36	4.3
Waterbirds/waterfowl/shorebirds	18	2.1
Other birds[a]	25	3.0
Unidentified birds	20	2.4
Totals	**837**	**100**

[a] woodpeckers, nighthawks, swifts

Table 5. Summary of bat mortality at existing wind energy projects in the Columbia Plateau Ecoregion.

Project Name [state]	Bats per MW[a]	Reference
Stateline [OR/WA]	1.44	Erickson et al. 2004, 2007
Vansycle [OR]	1.12	Erickson et al. 2000
Klondike [OR]	0.77	Johnson et al. 2003b
Klondike II [OR]	0.41	NWC and WEST, Inc. 2007
Klondike III [OR]	0.23	Gritski et al. 2009
Hopkins Ridge [WA]	0.63	Young et al 2007
Wild Horse [WA]	0.39	Erickson et al. 2008
Nine Canyon [WA]	2.46	Erickson et al. 2003
Leaning Juniper [OR]	1.98	Gritski et al. 2008
Big Horn I [WA]	1.90	Kronner et al. 2008
Combine Hills [OR]	1.88	Young et al. 2005a
Average	**1.20**	

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

Species	Number of Fatalities	Percent Composition
silver-haired bat	184	47.2
hoary bat	180	46.2
unidentified bat	13	3.3
little brown bat	8	2.1
big brown bat	5	1.3
Totals (4 species)	**390**	**100**

[a] Species composition of bat fatalities is based on the data provided in those studies included in Table 5 as well as raw fatality data (species and numbers) for the Goodnoe and White Creek wind energy facilities in Klickitat County, Washington and the Pebble and Hay Canyon wind energy facilities in Oregon

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

	Season				
Wind Energy Project	**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	0	0	0	0	0
Vansycle, 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	4	3	4	0	11
Condon, OR	1	0	0	0	1
Totals	**15**	**28**	**14**	**7**	**65**
Percent	**23.1**	**43.1**	**21.5**	**10.8**	**100**

Table 8. Comparison of avian and bat fatality estimates presented in this report between 6700 and 5577 megawatts of wind energy development in the Columbia Plateau ecoregion.

Fatality estimates by avian or bat species/group	MW of installed Capacity 5577	6700
All birds	13,942	16,750
All raptors	430	516
American kestrel	135	162
Red-tailed hawk	86	103
Short-eared owl	43	52
Ferruginous hawk	24	29
Swainson’s hawk	37	44
Golden eagle	6	7
Upland gamebirds	1756	2110
Waterfowl/waterbirds/shorebirds	293	352
Passerines	9351	11,239
Horned lark	4139	4975
Western meadowlark	449	540
Nocturnal migrants	4181	5025
Golden-crowned kinglet	780	938
Long-billed curlew	17	20
Lewis’s woodpecker	17	20
Grasshopper sparrow	17	20
Sage thrasher	17	20
Sage sparrow	17	20
Vaux’s swift	17	20
All bats	6689	8040
Silver-haired bat	3157	3795
Hoary bat	3090	3714

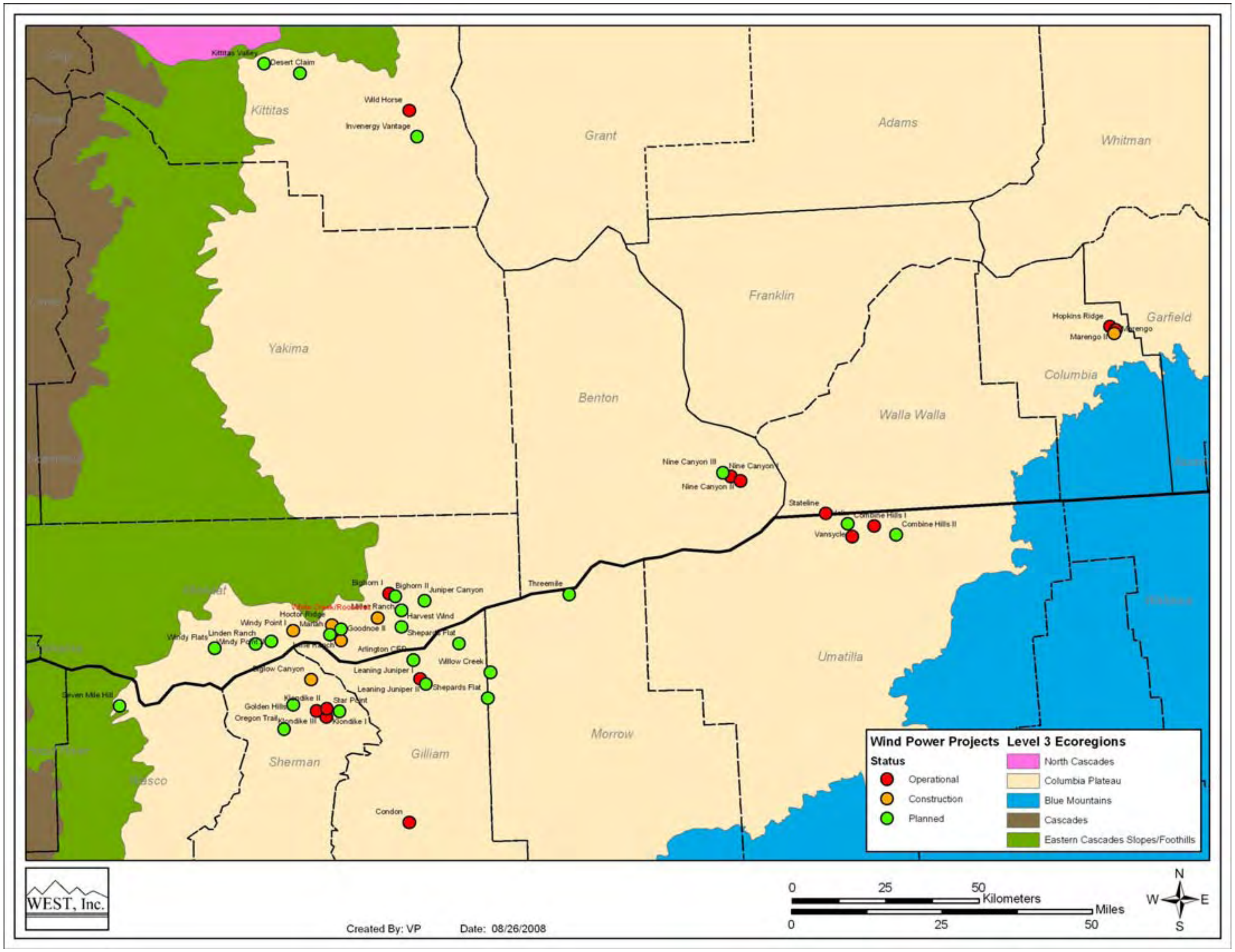

Figure 1. Location of existing and proposed wind energy facilities in the Columbia Plateau Ecoregion of southeastern Washington and northeastern Oregon, October 2008.

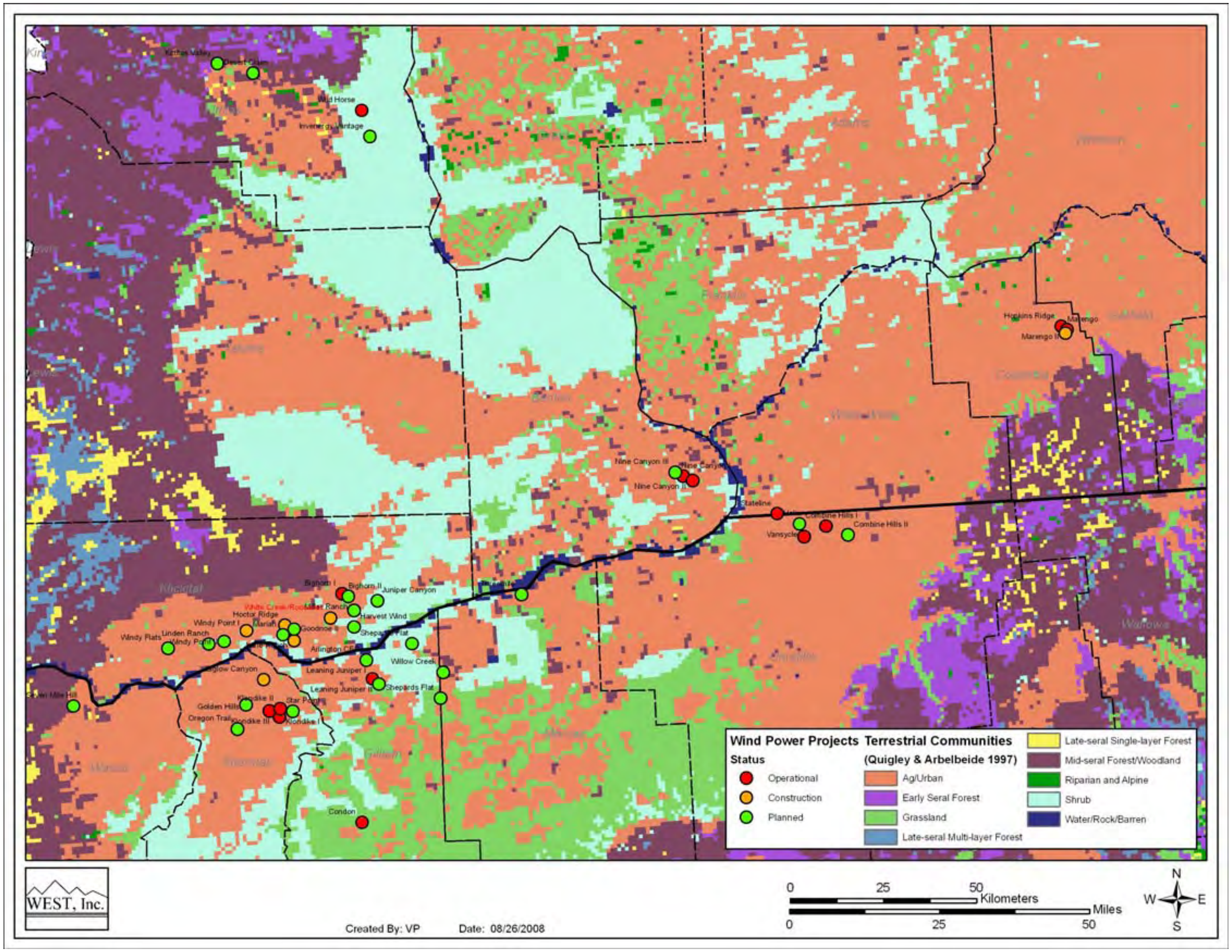

Figure 2. Terrestrial vegetative communities within the Columbia Plateau Ecoregion.