Appendix C. Post-construction Mortality Monitoring Studies

PACIFICORP ENERGY
A DIVISION OF PACIFICORP

Final Annual Report

High Plains and McFadden Ridge I Wind Energy Facility Avian and Bat Fatality Survey and Pronghorn Antelope and Greater Sage Grouse Displacement Assessment

Prepared for:

PacifiCorp Energy
1407 West North Temple, Suite 310
Salt Lake City, UT 84116

Prepared by:

John McCreight and Sarah Lehnen
Enercon Services, Inc.
6525 N. Meridian Ave, Suite 400
Oklahoma City, OK 73116

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1.0 Introduction

PacifiCorp Energy (PacifiCorp) has developed two (2) wind energy facilities near Rock River, in Albany County, Wyoming. The High Plains Wind Energy Facility (HPWEF) consists of 66 General Electric Company (GE) 1.5-megawatt (MW) wind turbine generators (WTG) with a nameplate output of 99 MW. The McFadden Ridge I Wind Energy Facility (MRIWEF) consists of 19 WTGs with a nameplate output of 28.5 MW. Each of the 1.5 MW turbines consists of an 80-meter tall tubular steel tower, an 82-meter diameter rotor, and a nacelle that houses the generator, transformer, and power trains. The towers have a base diameter of 4.5 meters and a top diameter of 2.5 meters. The rotors consist of three 41-meter long composite blades. Infrastructure to support the combined 85 WTGs includes transformers, an operation and maintenance (O&M) building, underground electric cable, fiber optic communication cable, WTG access roads, two (2) permanent 60-meter tall meteorological towers (MET), approximately five (5) miles of overhead power lines, and a supervisory control and data acquisition (SCADA) system.

The primary objective of this monitoring study is to estimate the avian and bat collision mortality at these facilities. The secondary objective is to examine pronghorn antelope (*Antilocapra americana*) and greater sage-grouse (*Centrocercus urophasianus*) displacement as assessed by pellet counts. This report conveys the results of avian and bat monitoring at both HPWEF and MRIWEF from 14 October 2009 through 31 October 2010, and pellet counts collected during October 2009, May 2010, and October 2010. Avian and bat monitoring involved five activities:

1. Standardized carcass searches at turbine and MET locations;
2. Search efficiency trials to estimate the proportion of carcasses found by searchers;
3. Carcass removal trials to estimate the length of time a carcass remains at the survey sites available for detection;

4. Statistical analysis to adjust fatality estimates for searcher efficiency and carcass removal rates to calculate a 90% confidence interval of the number of avian and bat fatalities associated with the wind energy facilities; and
5. Implement PacifiCorp's Wildlife Incident Reporting and Handling System (WIRHS) for wind project personnel. All avian and bat casualties found are handled under the WIRHS protocol, which is part of the long-term wind project monitoring (Young et al. 2005).

2.0 Study Area

The study area is located within the Laramie Basin subset of the Wyoming Basin ecoregion. The ecoregion is a broad arid intermontane basin interrupted by hills and low mountains. The Wyoming Basin ecoregion, which is nearly encompassed by forest-covered mountains, is drier than the northwestern Great Plains to the northeast. Additionally, the ecoregion does not have the extensive cover of pinion-juniper woodland found in the Colorado Plateau to the south. Major industries in this region include natural gas and petroleum fields, and coal, trona, bentonite, clay, and uranium mining (Chapman et al., 2004). The Laramie Basin is a wide intermontane valley consisting predominantly of mixed-grass prairie. Potential natural vegetation includes needle-and-thread grass, western wheatgrass, blue grama, Indian ricegrass, and other mixed-grass species. Although some riparian areas are present within the subset, it is generally drier than the sub-irrigated high valleys (Chapman et al., 2004).

This wind energy project is located in southeastern Wyoming in Albany County, five (5) miles southwest of Rock River and two (2) miles east of McFadden. The wind farm encompasses over 4,400 hectares of private and state-owned land, most of which is ranchland. Vegetation is dominated by native grasses and sagebrush on rolling hills. Elevation ranges from approximately 2,100 to 2,300 meters above mean sea level. Turbines and MET towers are located in Sections 1 & 3, Township 19 North, Range 77 West; Sections 24, 25, 26, 27, 33, 34, & 35, Township 20 North, Range 77 West; and Section 30, Township 20 North, Range 76 West.

3.0 Methodology

3.1 Search Plots

The two wind energy facilities have a combined eighty-five (85) turbines and two (2) MET towers. Approximately one-third (29) of the turbines and both MET towers were surveyed for carcasses. These turbines were searched year-round every 28 days. During the remainder of the 2009 fall migration (the surveys began 14 October 2009), 2010 spring migration (15 March to 1 June), and 2010 fall migration (1 August to 31 October) half of the turbines (15) and one of the MET towers were searched every seven (7) days. The search effort was spread throughout the entire study area by selecting turbines for sampling using a systematic design with a random start. The 160-meter-by-160-meter search plots were centered on each of the included turbines (plots extended 80 meters on each side of the turbine). For MET towers, the search plots were 120-meters-by-120-meters (60 meters on each side of the tower).

3.2 Standardized Carcass Searches

The two wind energy facilities were systematically searched for avian and bat casualties. Two trained personnel conducted the carcass searches, walking at a rate of approximately 45 to 60 meters per minute along each transect, depending upon terrain. The two searchers walked 6 to 10 meters apart, depending upon habitat type (closer in thick brush), while scanning an area approximately 3 to 5 meters wide on either side for carcasses as they walked. Prior to initiating the standardized carcass searches, all selected turbines and MET towers were searched to remove any carcasses found.

The condition of each carcass found was recorded using the following categories:

- **Intact**: A completely intact carcass, with little decomposition, and no indication of being fed upon by a predator or scavenger.
- **Scavenged**: An entire carcass that has been fed upon by a predator or scavenger. A scavenged carcass could also be a portion(s) of a carcass at a single location (e.g., wings, skeletal remains, etc.), or a carcass heavily infested by insects.

- **Feather Spot**: Ten or more feathers at a single location indicating predation or scavenging.

For each carcass found, searchers recorded species, sex and age when possible, date and time collected, global positioning system (GPS) location, condition (intact, scavenged, feather spot), and comments indicating cause of death. Data were entered into an Excel spreadsheet. All casualties were photographed as found and plotted on a detailed map of the study area. Carcasses were labeled with a unique number, placed in a bag with the data sheet, and frozen for future reference and possible necropsy.

Any carcasses found by wind farm personnel or outside of standardized searches were coded as incidental discoveries and documented using the same protocol as for those found during standard searches.

Table 1: Schedule for Carcass Searches

Search	Dates	Number of Plots	Interval
1	March 15–June 1	16	7 days
2	March	31	28 days
3	April	31	28 days
4	May	31	28 days
5	June	31	28 days
6	July	31	28 days
7	August 1–October 31	16	7 days
8	August	31	28 days
9	September	31	28 days
10	October	31	28 days
11	November	31	28 days
12	December	31	28 days
13	January	31	28 days
14	February	31	28 days

3.3 Searcher Efficiency Trials

Searcher efficiency trials were conducted during regularly scheduled carcass search surveys. Personnel conducting the carcass searches were unaware which surveys contained planted carcasses. One trial was held during winter (March) and four trials each were held during spring and fall migrations for a total of 109 planted carcasses, comprising 54 small and 55 large birds. Carcasses were of non-native/non-protected or commercially available species such as house sparrows, European starlings, rock pigeons, bobwhite quail, mallards ducks or hen pheasants. A few native songbirds were collected under a salvage permit and were used in the efficiency trials as permitted by United States Fish and Wildlife Service (USFWS) permit MB737207-0, authorization G.

All carcasses were placed at random locations within search areas before the plot was searched on the same day the search was conducted. Carcasses were placed in a variety of postures to simulate a range of conditions. For example, birds were placed in exposed postures (tossed randomly to one side to simulate a bird after it was killed from impacting a structure) and hidden behind grass clumps and shrubs to simulate injured birds.

Each trial carcass was discreetly marked so it could be identified as a study carcass after it was found. For each trial carcass, the species, position of the bird, habitat around the carcass, and whether it was found during the survey were recorded. After the completion of an efficiency trial, the personnel who placed the carcasses attempted to retrieve all carcasses not found by the searchers. Searcher efficiency was estimated by carcass size (large or small). Small birds were bobwhite quail size or smaller (no more than 170 grams (6 ounces)); large birds were pheasant hen size or larger (more than 170 grams (6 ounces)).

3.4 Carcass Removal Trials

Carcass removal trials estimated the length of time before scavengers removed a carcass in order to adjust the number of carcasses found for those that were removed between surveys. Removal trials began at the same time as carcass search studies.

During each of the survey periods (winter, spring migration, summer, fall migration), carcasses of large and small birds were placed within 80 meters of randomly selected turbines that were not part of the regular surveys (Figure 1). A total of 60 removal trials were conducted between October 2009 and October 2010; 8 during the winter, 12 during spring migration, 24 during the summer, and 16 during fall migration. As with searcher efficiency trials, the carcasses were placed in a variety of postures to simulate a range of conditions. Legally obtained, fresh game birds and house sparrows were used. House sparrow carcasses were used to simulate bat carcasses.

Carcass removal trial birds were monitored over a 40-day period according to the following schedule: carcasses were checked every day for the first four days, and then on days 7, 10, 14, 20, 30, and 40. This schedule varied slightly depending on site weather conditions and coordination with other survey work. Carcasses were marked discreetly (for example, with dark electrical tape around one or both legs) for recognition by searchers and other personnel. Experimental carcasses were left undisturbed until the end of the carcass removal trial, at which point any remaining evidence of the carcasses was removed.

3.5 Statistical Methods

Estimates of facility-related fatalities are based on:

1. The observed number of carcasses found during standardized searches throughout the monitoring period for which the cause of death is either unknown or probably facility-related.
2. Removal rates expressed as the estimated length of time a carcass is expected to remain in the study area and be available for detection by the searchers as estimated from the removal trials.
3. Searcher efficiency expressed as the proportion of planted carcasses found by searchers during searcher efficiency trials.

Fatality estimates are provided for six categories: 1) all birds, 2) small birds, 3) large birds, 4) raptors, 5) likely nocturnal migrants, and 6) bats. The number of avian and bat fatalities attributable to the operation of the facility, based on the number of avian and bat fatalities found at the facility site whose death was unknown or appears related to facility operation, are reported.

3.5.1 Definition of Variables

The following variables are used in the equations below:

c_i The number of carcasses detected at plot *i* for which the cause of death is unknown or attributed to the facility.

$\bar{c}$ The average number of carcasses observed per turbine.

n The number of search plots.

k The number of turbines and meteorological towers searched.

s The number of carcasses used in removal trials.

s_c The number of carcasses in removal trials remaining in the study area after 30 days.

SE Standard error (square of the sample variance of the mean).

t_i The time (in days) a carcass remains in the study area during the removal trials.

$\bar{t}$ The mean time (in days) a carcass remains in the study area during the removal trials.

d The total number of carcasses placed during searcher efficiency trials.

p The proportion of carcasses found by searchers during the efficiency trials.

I The mean interval between standardized carcass searches, in days.

A Proportion of the area surrounding a turbine included in the search plot.

$\hat{\pi}$ The estimated probability that a carcass is both available to be found during a search and that it is found, as determined by the removal trials and the searcher efficiency trials.

m The estimated mean number of fatalities per turbine, adjusted for removal and searcher efficiency bias.

3.5.2 Observed Number of Carcasses

The estimated mean number of carcasses ($\bar{c}$) found per turbine adjusted for area searched is:

$$\bar{c} = \frac{\sum_{i=1}^{n} c_i}{k \cdot A}$$

3.5.3 Estimation of Carcass Removal Rates

Carcass removal time ($\bar{t}$) is the mean length of time a carcass remains in the study area:

$$\bar{t} = \frac{\sum_{i=1}^{s} t_i}{s - s_c}$$

3.5.4 Estimation of Searcher Efficiency Trials

Searcher efficiency rates are expressed as *p,* the proportion of trial carcasses that are found by searchers in the searcher efficiency trials. These rates were estimated by carcass size, large or small.

3.5.5 Estimation of Facility Related Fatality Rates

The estimated per turbine fatality rate (*m*) is calculated by:

$$m = \frac{\bar{c}}{\hat{\pi}}$$

Where $\bar{c}$ is the mean number of birds found per turbine adjusted for search area and $\hat{\pi}$ is the probability that a carcass located within the search plot will be encountered, calculated as a combination of the likelihood that a carcass will be available (i.e. not removed by scavengers before the search) and the probability that is found given that is available.

$\hat{\pi}$ is calculated as follows:

$$\hat{\pi} = \frac{\bar{t} \cdot p}{I} \cdot \left[\frac{\exp\left({}^{I}/_{\bar{t}} \right) - 1}{\exp\left({}^{I}/_{\bar{t}} \right) - 1 + p} \right]$$

This formula has been independently verified by Shoenfeld (2004). The final reported estimates of *c, t, p,* $\hat{\pi}$, and *m* and 90 percent confidence intervals for these estimates were calculated using bootstrapping (Manly 1997). Bootstrapping is a useful technique for calculating variances and confidence intervals for data that is not normally distributed. Bootstrapping randomly re-samples the dataset to create new datasets. For this analysis, a total of 5,000 new datasets were generated by re-sampling the original data with replacement, with each of the 5,000 new datasets having the same sample size as the original. The 90% confidence intervals were determined by generating a sample mean for each of the 5,000 datasets and using the lower 5^{th} and upper 95^{th} percentiles of the 5,000 sample means as the lower and upper limits of the confidence intervals. All analyses were run in program R (R Development Core Team 2010).

3.6 Pronghorn Antelope and Greater Sage-Grouse Displacement Study

The objective of the displacement studies for the greater sage-grouse and pronghorn antelope was to determine the degree of avoidance or reduction in habitat use by these species due to the presence of WTGs. Pellet counts for pronghorn antelope were conducted at all turbines located within the crucial winter range for the pronghorn. Pellet counts for greater sage-grouse were conducted at every turbine in habitats dominated by sagebrush.

The pellet count study consisted of counting pellets at six plots at each of the turbines located within suitable habitat. Twenty-four (24) turbines were within the crucial winter range for the pronghorn; therefore, 144 plots were surveyed for pronghorn pellets. Based on habitat mapping of the project area, greater sage-grouse pellet plots were placed along transects at turbines with tall or dense stands of sagebrush that provide greater sage-grouse nesting, brood rearing, or winter habitat. Turbines in areas devoid of sagebrush or with low densities of sagebrush were not sampled.

At each turbine selected, the six plots were established using a systematic sample between 10 and 100 meters away from the turbine, perpendicular to the access road. Each plot was approximately 15 meters apart and marked with wire flags. The location was recorded using a GPS. All pellet groups within a 2-meter radius of each point were enumerated and then removed from the plot. Surveys were conducted twice a year, beginning in October 2009 and again in May and October of 2010. Surveys will continue for up to a total of three years with sampling in May/June and October/November.

For reference data, six plots were established at 25 random points in an area of similar topography and vegetation as the turbines, but at least one mile from the nearest turbine. Sampling methods were identical to those at the turbine plots.

To compare differences in pellet count density between the wind turbine sites and the reference sites, 95% confidence intervals were calculated using bootstrapping for each sampling period and group.

4.0 Findings and Results

4.1 Standardized Carcass Searches

A total of 51 carcasses were found between 14 October 2009 and 31 October 2010. The mean distance from turbine to carcass location was 51 m. Of these 51 carcasses, 26 were of bird species and 25 were of bat species. Forty-two of the carcasses were found during the 723 individual plot searches; the remaining nine were incidental finds. Only the 42 carcasses found during standardized surveys were used in calculating estimates of fatality rates but incidental finds are included here for the purpose of identifying overall species composition of tower kills. For birds, the 26 carcasses were comprised of 14 species with nine carcasses that could not be identified down to the species level (Table 2). All 14 species are protected under the Migratory Bird Treaty Act (MBTA). A bald eagle was found on April 28, 2010 by wind farm personnel and was reported to the USFWS the same day. A golden eagle was found on Sept 3, 2010 and was reported to the USFWS the same day. Bald eagles and golden eagles are protected under the Bald Eagle and Golden Eagle Protection Act; in addition, bald eagles are listed as a species of special concern by the Wyoming Game and Fish Department (Native Species Status 2). None of the other species found were listed as species of special concern at the federal or state level.

For bats, the 25 carcasses were comprised of three species with three carcasses not identifiable down to the species level (Table 2). All three bat species are listed as species of special concern by the Wyoming Game and Fish Department; the western small-footed bat as Native Species Status 3 and hoary and silver-haired bats as Native Species Status 4.

Table 2. Species Composition of Birds and Bats Found Between 14 October 2009 and 31 October 2010 (Numbers in parentheses indicate incidental finds).

Species	Total	Composition
Birds		
Bald eagle (*Haliaeetus leucocephalus*)	0 (1)	4%
Cliff swallow (*Petrochelidon pyrrhonota*)	1	4%
Common nighthawk (*Chordeiles minor*)	1	4%
Dark-eyed junco (*Junco hyemalis*)	1	4%
Golden eagle (*Aquila chrysaetos*)	0 (1)	4%
Gray catbird (*Dumetella carolinensis*)	1	4%
Hermit thrush (*Catharus guttatus*)	1	4%
Horned lark (*Eremophila alpestris*)	4 (2)	23%
Lesser goldfinch (*Spinus psaltria*)	1	4%
Mallard (*Anas platyrhynchos*)	0 (1)	4%
Raptor, most likely northern harrier (*Circus cyaneus*)	0 (1)	4%
Red-tailed hawk (*Buteo jamaicensis*)	1 (1)	8%
Swainson's thrush (*Catharus ustulatus*)	0 (1)	4%
Vesper Sparrow (*Pooecetes gramineus*)	1	4%
Unknown hummingbird	0 (1)	4%
Unknown passerine	3	12%
Unknown waterfowl	2	8%
Subtotal birds	17 (9)	100%
Bats		
Hoary bat (*Lasiurus cinereus*)	15	60%
Silver-haired bat (*Lasionycteris noctivagans*)	6	24%
Western small-footed bat (*Myotis ciliolabrum*)	1	4%
Unknown bat	3	12%
Subtotal bats	25	100%
Total Carcasses	42 (9)	

For birds, based on the timing of the finds and habitat preferences of these species, the hawks, eagles, mallard, horned larks, and vesper sparrow were probable breeders in the area; the remaining birds were likely migrants passing through the area. All but four of the 26 bird carcasses were found during the spring and fall migration periods.

Table 3. Number of Birds and Bats Found per Month, from October 2009 to October 2010 (Numbers in parentheses indicate incidental finds).

Species Group	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	Total
Raptors	0	0	0	0	0	0	1 (1)	0 (1)	0	0 (1)	0	0 (1)	0	1 (4)
Passerines	0	0	0	0	0	0	1	5 (2)	1	0	2	2 (1)	2	13 (3)
Other birds	1	0	0	0	0	0	0	0 (1)	0	1	1 (1)	0	0	3 (2)
All birds	1	0	0	0	0	0	2 (1)	5 (4)	1	1 (1)	3 (1)	2 (2)	2	17 (9)
Bats	0	0	0	0	0	0	0	0	1	0	11	12	1	25
Total Carcasses	1	0	0	0	0	0	2 (1)	5 (4)	2	1 (1)	14 (1)	14 (2)	3	42 (9)

Over the one-year period, the estimated mean number of carcasses ($\bar{c}$) found per turbine adjusted for area searched was 0.54 birds/turbine and 0.81 bats/turbine.

4.2 Searcher Efficiency Trials

Small birds were less likely to be found during searcher efficiency trials than large birds. Small birds were detected 44% of the time (90% CI 34-55%), whereas large birds were detected 81% of the time (90% CI 71-89%).

4.3 Carcass Removal Trials

Small birds were also somewhat more likely to be scavenged sooner than large birds (Figure 2). For small birds, the mean length of time a carcass remained on the site was 19.6 (90% CI 14.3-24.8) days; for large birds the mean length of time a carcass remained on the site was 25.2 (90% CI 20.5-29.7) days.

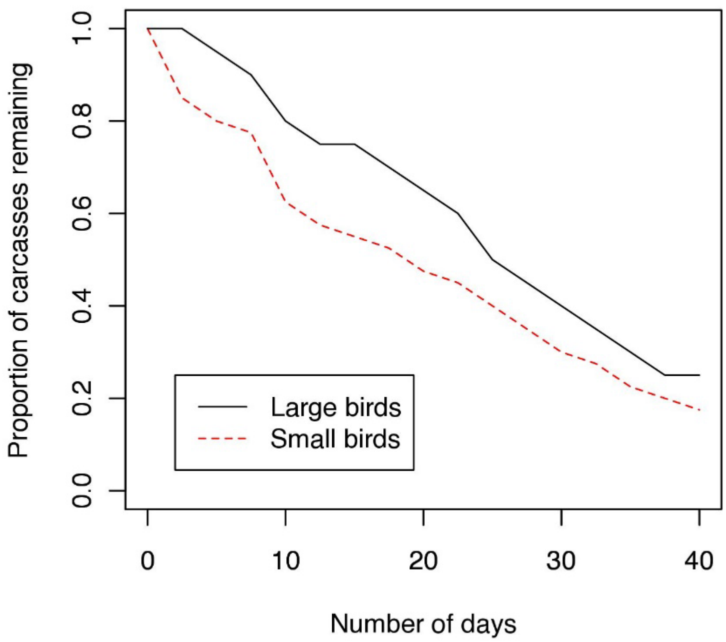

Figure 1. The Proportion of Carcasses Remaining by Exposure Days in the Field During the 2010 Trials.

4.4 Fatality Estimates

For birds, the estimated overall fatality rate for the one-year period between 1 November 2009 and 31 October 2010 was 1.13 (90% CI 0.19-2.22) birds/turbine. For raptors the estimated fatality rate for the year-long period was 0.04 (90% CI 0.00-0.11) birds/turbine. Small birds (0.95 birds/turbine 90% CI 0.19-1.75) had higher annual fatality rates than large birds (0.18 birds/turbine 90% CI 0.00-0.47) but this difference was not statistically significant. Seasonally, the highest fatality rates occurred during spring migration, with an estimated rate of 0.59 (90% CI 0.06-1.09) birds/turbine.

Table 4. Estimated Fatality Rates (individuals/turbine), by Group, for Fall (14 October to 31 October 2009), Winter (1 November 2009 to 14 March 2010), Spring (15 March to 31 May 2010), Summer (1 June to 31 July 2010), and Fall (1 August to 31 October 2010). Annual fatality rate (animals/turbine) given for 1 November 2009 to 31 October 2010.

Group	Species Group	Fall	Winter	Spring	Summer	Fall	Annual Rate
Birds	Raptors	0.00	0.00	0.05	0.00	0.00	0.04
	All large birds	0.07	0.00	0.13	0.05	0.00	0.18
	All small birds	0.00	0.00	0.46	0.10	0.39	0.95
	All birds	0.07	0.00	0.59	0.15	0.39	1.13
Bats	All bats	0.00	0.00	0.00	0.10	1.60	1.70

For the sake of comparison to other studies, which are generally given in terms of the number of animals killed per megawatt (MW) per year, the overall number of predicted fatalities was 0.75 birds/MW/year and 1.13 bats/MW/year.

4.5 Pronghorn Antelope and Greater Sage-Grouse Displacement Study

Pellet counts were lower near turbines than at reference sites for pronghorn antelopes but this difference was only statistically significant for the first two of the three surveys. The mean count at surveys adjacent to turbines was significantly lower than reference surveys in October 2009 (0.20 pellets/count, 95% CI 0.13-0.27, at turbines vs. 0.39 pellets/count, 95% CI 0.30-0.48 at reference surveys) and in May 2010 (0.12, 95% CI 0.06-0.18, pellets/count at turbines vs. 0.36, 95% CI 0.26-0.48, pellets/count at reference surveys) but not in October 2010 (0.19 pellets/count, 95% CI 0.12-0.27, at turbines vs. 0.27 pellets/count, 95% CI 0.18-0.40 at reference surveys; Figure 2). Habitat was disturbed (exposed soil) during October 2009 at 33% of the pellet survey sites near turbines whereas none of the reference sites were disturbed.

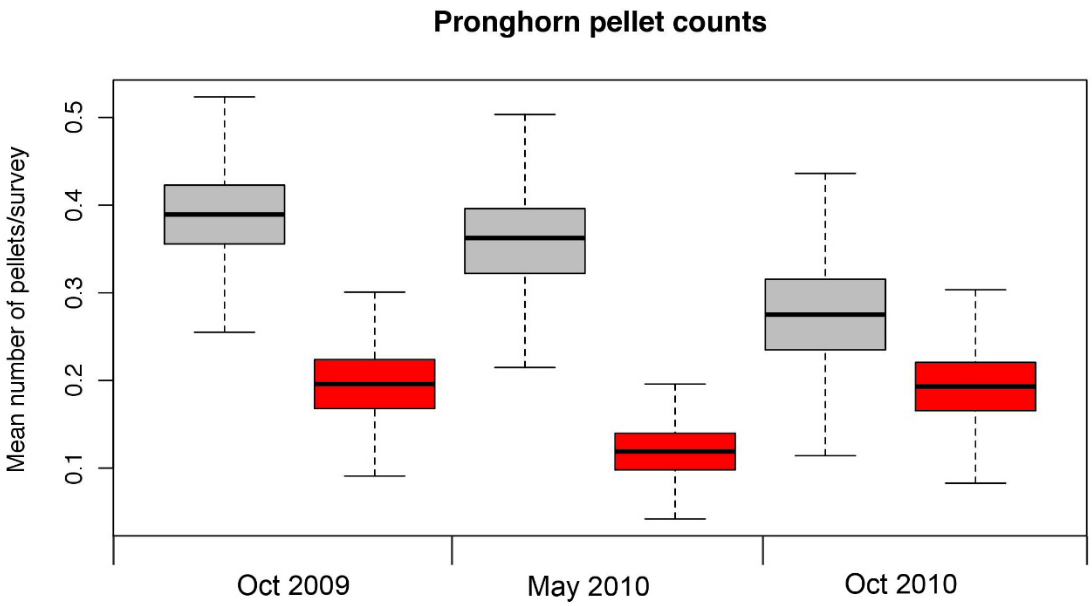

Figure 2. Bootstrapped Data of Pronghorn Antelope Pellet Counts at Reference (grey) and Turbine (red) Sites Collected During October 2009, May 2010, and October 2010 (Black line indicates median value, box indicate 25% and 75% percentiles, and whiskers indicate data range).

Greater sage-grouse pellets occurred at very low densities at both turbine and reference sites. The pellet counts for sage-grouse were slightly lower at turbine sites than at reference sites, but this difference was not statistically significant in October 2009 (0.01 pellets/count, 95% CI 0.00-0.02, at turbines vs. 0.04 pellets/count, 95% CI 0.01-0.07, at reference surveys), May 2010 (0.00 pellets/count, 95% CI 0.00-0.00, at turbines vs. 0.01 pellets/count, 95% CI 0.00-0.02, at reference surveys), or October 2010 (0.01 pellets/count, 95% CI 0.00-0.02, at turbines vs. 0.03 pellets/count, 95% CI 0.01-0.05, at reference surveys; Figure 3).

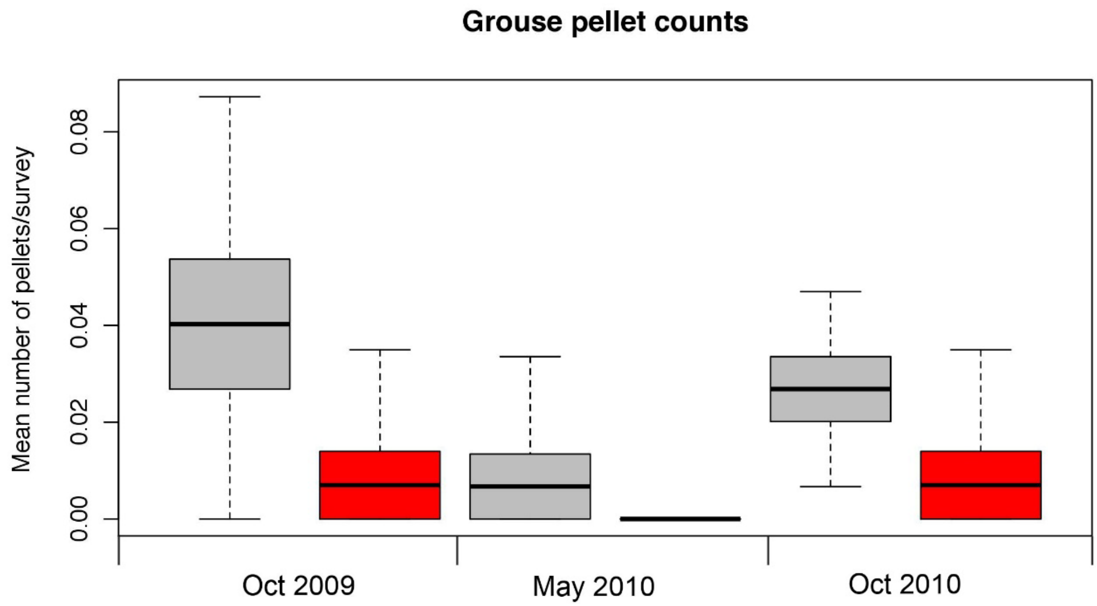

Figure 3. Bootstrapped Data of Greater Sage-Grouse Pellet Counts at Reference (grey) and Turbine (red) Sites Collected During October 2009, May 2010, and October 2010 (Black line indicates median value, box indicates 25% and 75% percentiles, and whiskers indicate data range).

5.0 Summary and Conclusions

The estimated rate of bird fatalities (0.75 birds/MW/year) was in the lower range of comparable estimates of wildlife fatalities at other wind farms. For wind energy projects in Montana, Washington, Wyoming, Iowa, Nebraska, and Oregon, bird fatality has ranged from 0.95 to 2.76 birds/MW/year (Erickson et al. 2003, Johnson et al. 2003, Young et al. 2003, Young et al. 2006, Derby et al. 2007, TRC Environmental Corporation 2008, and Jeffery et al. 2009). Fatality rates in this study were higher for small birds (0.63 birds/MW) than for large birds (0.12 birds/MW) over the one-year period, with the majority of carcasses for both small and large birds found during spring and fall migration. Passerines are known to comprise the majority of fatalities at wind energy facilities with newer designs, with the peak of fatalities occurring during seasonal migration (Erickson 2004) when migrating passerines generally fly between 91-610 meters, thereby placing low-flying migrants at risk of collision (Morrison 2006). In addition, male grassland birds that engage in aerial displays during courtship, such as the vesper sparrow and horned lark, may also be at risk of colliding with rotor blades during the breeding season (IDNR 2007, Kingsley and Whittam 2003). Two individuals of a species with a federally protected status, a bald eagle and a golden eagle (The Bald and Golden Eagle Protection Act), were found during the study outside of scheduled searches and were not included in the statistical analysis.

The estimated bat fatality rate was also on the low end of the range of comparable studies with an estimated fatality rate of 1.13 bats/MW/year. Bat fatality estimates for wind power facilities in western states and mid-western states are typically lower than in eastern states (Kunz et al. 2007), For wind energy projects in Montana, Washington, Wyoming, Iowa, Nebraska, and Oregon, bat fatality has ranged from 0.8 to 8.93 bats/MW/year (Erickson et al. 2003, Johnson et al. 2003, Young et al. 2003, Young et al. 2006, Derby et al. 2007, TRC Environmental Corporation 2008, and Jeffery et al. 2009). Similarly to what we observed in this study, bat fatalities in western states are typically highest from July-October, with most of the fatalities attributed to hoary and silver-haired bats.

The pellet count data suggested habitat disturbance near turbines and/or displacement by pronghorns from turbine sites. The apparent avoidance of turbine sites by pronghorns observed in this study was likely in part due to habitat disturbance at the turbine survey sites, with 33% of the turbine sites disturbed whereas none of the reference sites were disturbed. Although all three surveys had lower pellet counts at turbine than at reference sites, in the most recent survey (October 2010) this difference was not statistically significant, suggesting a decrease in displacement over time. Walter et al. (2006) found that elk in Oklahoma were displaced from the wind development area immediately after construction; displacement gradually decreased but was still elevated above pre-construction levels. However, although displacement and some loss of habitat was apparent, elk were not adversely affected by wind-power development as determined by home range size and dietary analysis (Walter et al. 2006).

Sage grouse pellet counts were low at both the reference and turbine survey plots, possibly due to the marginal quality of habitat at the surveyed sites. The survey plots were located in habitat characterized by short grasses and sparse sagebrush that was unlikely to be high quality habitat for this species (Schroeder et al. 1999). Sage grouse pellet counts were lower at turbine plots, but this difference was not statistically significant for any of the surveys.

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Second Annual Report

High Plains and McFadden Ridge I Wind Energy Facility Avian and Bat Fatality Survey and Pronghorn Antelope and Greater Sage Grouse Displacement Assessment

Prepared for:

PacifiCorp Energy
1407 West North Temple, Suite 310
Salt Lake City, UT 84116

Prepared by:

John McCreight and Sarah Lehnen
Enercon Services, Inc.
6525 N. Meridian Ave, Suite 400
Oklahoma City, OK 73116

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1.0 Introduction

PacifiCorp Energy (PacifiCorp) has developed two (2) wind energy facilities near Rock River, in Albany County, Wyoming. The High Plains Wind Energy Facility (HPWEF) consists of 66 General Electric Company (GE) 1.5-megawatt (MW) wind turbine generators (WTG) with a nameplate output of 99 MW. The McFadden Ridge I Wind Energy Facility (MRIWEF) consists of 19 WTGs with a nameplate output of 28.5 MW. Each of the 1.5 MW turbines consists of an 80-meter tall tubular steel tower, an 82-meter diameter rotor, and a nacelle that houses the generator, transformer, and power trains. The towers have a base diameter of 4.5 meters and a top diameter of 2.5 meters. The rotors consist of three 41-meter long composite blades. Infrastructure to support the combined 85 WTGs includes transformers, an operation and maintenance (O&M) building, underground electric cable, fiber optic communication cable, WTG access roads, two (2) permanent 60-meter tall meteorological towers (MET), approximately five (5) miles of overhead power lines, and a supervisory control and data acquisition (SCADA) system.

The primary objective of this monitoring study is to estimate the avian and bat collision mortality at these facilities. The secondary objective is to examine pronghorn antelope (*Antilocapra americana*) and greater sage-grouse (*Centrocercus urophasianus*) displacement as assessed by pellet counts. This report conveys the results of avian and bat monitoring at both HPWEF and MRIWEF from 14 October 2009 through 31 October 2011, and pellet counts collected during October 2009, May 2010, October 2010, May 2011, and October 2011. Avian and bat monitoring involved five activities:

1. Standardized carcass searches at turbine and MET locations;
2. Search efficiency trials to estimate the proportion of carcasses found by searchers;
3. Carcass removal trials to estimate the length of time a carcass remains at the survey sites available for detection;

4. Statistical analysis to adjust fatality estimates for searcher efficiency and carcass removal rates and to calculate a 90% confidence interval (CI) of the number of avian and bat fatalities associated with the wind energy facilities; and
5. Implementation of PacifiCorp's Wildlife Incident Reporting and Handling System (WIRHS) for wind project personnel. All avian and bat casualties found are handled under the WIRHS protocol, which is part of the long-term wind project monitoring (Young et al. 2005).

2.0 Study Area

The study area is located within the Laramie Basin subset of the Wyoming Basin ecoregion. The ecoregion is a broad arid intermontane basin interrupted by hills and low mountains. The Wyoming Basin ecoregion, which is nearly encompassed by forest-covered mountains, is drier than the northwestern Great Plains to the northeast. Additionally, the ecoregion does not have the extensive cover of pinion-juniper woodland found in the Colorado Plateau to the south. Major industries in this region include natural gas and petroleum fields, and coal, trona, bentonite, clay, and uranium mining (Chapman et al. 2004). The Laramie Basin is a wide intermontane valley consisting predominantly of mixed-grass prairie. Potential natural vegetation includes needle-and-thread grass, western wheatgrass, blue grama, Indian ricegrass, and other mixed-grass species. Although some riparian areas are present within the subset, it is generally drier than the sub-irrigated high valleys (Chapman et al. 2004).

This wind energy project is located in southeastern Wyoming in Albany County, five (5) miles southwest of Rock River and two (2) miles east of McFadden. The wind farm encompasses over 4,400 hectares of private and state-owned land, most of which is ranchland. Vegetation is dominated by native grasses and sagebrush on rolling hills. Elevation ranges from approximately 2,100 to 2,300 meters above mean sea level. Turbines and MET towers are located in Sections 1 & 3, Township 19 North, Range 77 West; Sections 24, 25, 26, 27, 33, 34, & 35, Township 20 North, Range 77 West; and Section 30, Township 20 North, Range 76 West.

3.0 Methodology

3.1 Search Plots

The two wind energy facilities have a combined eighty-five (85) turbines and two (2) MET towers. Approximately one-third (29) of the turbines and both MET towers were surveyed for carcasses. These turbines were searched year-round every 28 days. During the remainder of the 2009 fall migration (the surveys began 14 October 2009), 2010 and 2011 spring migrations (15 March to 1 June), and 2010 and 2011 fall migrations (1 August to 31 October) half of the turbines (15) and one of the MET towers were searched every seven (7) days. The search effort was spread throughout the entire study area by selecting turbines for sampling using a systematic design with a random start. The 160-meter-by-160-meter search plots were centered on each of the included turbines (plots extended 80 meters on each side of the turbine). For MET towers, the search plots were 120-meters-by-120-meters (60 meters on each side of the tower).

3.2 Standardized Carcass Searches

The two wind energy facilities were systematically searched for avian and bat casualties. Two trained personnel conducted the carcass searches, walking at a rate of approximately 45 to 60 meters per minute along each transect, depending upon terrain. The two searchers walked 6 to 10 meters apart, depending upon habitat type (closer in thick brush), while scanning an area approximately 3 to 5 meters wide on either side for carcasses as they walked. Prior to initiating the standardized carcass searches, all selected turbines and MET towers were searched to remove any carcasses found.

The condition of each carcass found was recorded using the following categories:

- **Intact**: A completely intact carcass, with little decomposition, and no indication of being fed upon by a predator or scavenger.
- **Scavenged**: An entire carcass that has been fed upon by a predator or scavenger. A scavenged carcass could also be a portion(s) of a carcass at a single location (e.g., wings, skeletal remains, etc.), or a carcass heavily infested by insects.

- **Feather Spot**: Ten or more feathers at a single location indicating predation or scavenging.

For each carcass found, searchers recorded species, sex and age when possible, date and time collected, global positioning system (GPS) location, condition (intact, scavenged, feather spot), and comments indicating cause of death. Data were entered into an Excel spreadsheet. All casualties were photographed as found and plotted on a detailed map of the study area. Carcasses were labeled with a unique number, placed in a bag with the data sheet, and frozen for future reference and possible necropsy.

Any carcasses found by wind farm personnel or outside of standardized searches were coded as incidental discoveries and documented using the same protocol as for those found during standard searches.

Table 1: Schedule for Carcass Searches

Search	Dates	Number of Plots	Interval
1	March 15–June 1	16	7 days
2	March	31	28 days
3	April	31	28 days
4	May	31	28 days
5	June	31	28 days
6	July	31	28 days
7	August 1–October 31	16	7 days
8	August	31	28 days
9	September	31	28 days
10	October	31	28 days
11	November	31	28 days
12	December	31	28 days
13	January	31	28 days
14	February	31	28 days

3.3 Searcher Efficiency Trials

Searcher efficiency trials were conducted during regularly scheduled carcass search surveys. Personnel conducting the carcass searches were unaware which surveys contained planted carcasses. One trial was held during winter (March 2010) and four trials each were held during spring 2010, fall 2010, spring 2011, and fall 2011 migrations for a total of 181 planted carcasses, comprising 91 small and 90 large birds. Carcasses were of non-native/non-protected or commercially available species such as house sparrows, European starlings, rock pigeons, bobwhite quail, mallard ducks, or hen pheasants. A few native songbirds were collected under a salvage permit and were used in the efficiency trials as permitted by United States Fish and Wildlife Service (USFWS) permit MB737207-0, authorization G.

All carcasses were placed at random locations within search areas before the plot was searched on the same day the search was conducted. Carcasses were placed in a variety of postures to simulate a range of conditions. For example, birds were placed in exposed postures (tossed randomly to one side to simulate a bird after it was killed from impacting a structure) and hidden behind grass clumps and shrubs to simulate injured birds.

Each trial carcass was discreetly marked so it could be identified as a study carcass after it was found. For each trial carcass, the species, position of the bird, habitat around the carcass, and whether it was found during the survey were recorded. After the completion of an efficiency trial, the personnel who placed the carcasses attempted to retrieve all carcasses not found by the searchers. Searcher efficiency was estimated by carcass size (large or small). Small birds were bobwhite quail size or smaller (no more than 170 grams (6 ounces)); large birds were pheasant hen size or larger (more than 170 grams (6 ounces)).

3.4 Carcass Removal Trials

Carcass removal trials estimated the length of time before scavengers removed a carcass in order to adjust the number of carcasses found for those that were removed between surveys. Removal trials began at the same time as carcass search studies. During each of the survey periods (winter, spring migration, summer, fall migration), carcasses of large and small birds were placed within 80 meters of randomly selected turbines that were not part of the regular surveys (Figure 1). A total of 76 removal trials were conducted between October 2009 and October 2011; 8 during the winter, 28 during spring migration, 24 during the summer, and 16 during fall migration. As with searcher efficiency trials, the carcasses were placed in a variety of postures to simulate a range of conditions. Legally obtained, fresh game birds were used to simulate large bird carcasses and house sparrows were used to simulate small bird and bat carcasses.

Carcass removal trial birds were monitored over a 40-day period according to the following schedule: carcasses were checked every day for the first four days, and then on days 7, 10, 14, 20, 30, and 40. This schedule varied slightly depending on site weather conditions and coordination with other survey work. Carcasses were marked discreetly (for example, with dark electrical tape around one or both legs) for recognition by searchers and other personnel. Experimental carcasses were left undisturbed until the end of the carcass removal trial, at which point any remaining evidence of the carcasses was removed.

3.5 Statistical Methods

Estimates of facility-related fatalities are based on:

1. The observed number of carcasses found during standardized searches throughout the monitoring period for which the cause of death is either unknown or probably facility-related.
2. Removal rates expressed as the estimated length of time a carcass is expected to remain in the study area and be available for detection by the searchers as estimated from the removal trials.
3. Searcher efficiency expressed as the proportion of planted carcasses found by searchers during searcher efficiency trials.

Fatality estimates are provided for six categories: 1) all birds, 2) small birds, 3) large birds, 4) raptors, and 5) bats. The number of avian and bat fatalities attributable to the operation of the facility, based on the number of avian and bat fatalities found at the facility site whose death was unknown or appears related to facility operation, are reported.

3.5.1 Definition of Variables

The following variables are used in the equations below:

c_i The number of carcasses detected at plot *i* for which the cause of death is unknown or attributed to the facility.

$\bar{c}$ The average number of carcasses observed per turbine.

n The number of search plots.

k The number of turbines and meteorological towers searched.

s The number of carcasses used in removal trials.

s_c The number of carcasses in removal trials remaining in the study area after 30 days.

SE Standard error (square of the sample variance of the mean).

t_i The time (in days) a carcass remains in the study area during the removal trials.

$\bar{t}$ The mean time (in days) a carcass remains in the study area during the removal trials.

d The total number of carcasses placed during searcher efficiency trials.

p The proportion of carcasses found by searchers during the efficiency trials.

I The mean interval between standardized carcass searches, in days.

A Proportion of the area surrounding a turbine included in the search plot.

$\hat{\pi}$ The estimated probability that a carcass is both available to be found during a search and that it is found, as determined by the removal trials and the searcher efficiency trials.

m The estimated mean number of fatalities per turbine, adjusted for removal and searcher efficiency bias.

3.5.2 Observed Number of Carcasses

The estimated mean number of carcasses ($\bar{c}$) found per turbine adjusted for area searched is:

$$\bar{c} = \frac{\sum_{i=1}^{n} c_i}{k \cdot A}$$

3.5.3 Estimation of Carcass Removal Rates

Carcass removal time ($\bar{t}$) is the mean length of time a carcass remains in the study area:

$$\bar{t} = \frac{\sum_{i=1}^{s} t_i}{s - s_c}$$

3.5.4 Estimation of Searcher Efficiency Trials

Searcher efficiency rates are expressed as *p,* the proportion of trial carcasses that are found by searchers in the searcher efficiency trials. These rates were estimated by carcass size, large or small.

3.5.5 Estimation of Facility Related Fatality Rates

The estimated per turbine fatality rate (*m*) is calculated by:

$$m = \frac{\bar{c}}{\hat{\pi}}$$

Where $\bar{c}$ is the mean number of birds found per turbine adjusted for search area and $\hat{\pi}$ is the probability that a carcass located within the search plot will be encountered, calculated as a combination of the likelihood that a carcass will be available (i.e. not removed by scavengers before the search) and the probability that is found given that is available.

$\hat{\pi}$ is calculated as follows:

$$\hat{\pi} = \frac{\bar{t} \cdot p}{I} \cdot \left[\frac{\exp\left({}^{I}/_{\bar{t}} \right) - 1}{\exp\left({}^{I}/_{\bar{t}} \right) - 1 + p} \right]$$

This formula has been independently verified by Shoenfeld (2004). The final reported estimates of *c, t, p,* $\hat{\pi}$, and *m* and 90 percent confidence intervals for these estimates were calculated using bootstrapping (Manly 1997). Bootstrapping is a useful technique for calculating variances and confidence intervals for data that is not normally distributed. Bootstrapping randomly re-samples the dataset to create new datasets. For this analysis, a total of 5,000 new datasets were generated by re-sampling the original data with replacement, with each of the 5,000 new datasets having the same sample size as the original. The 90% confidence intervals were determined by generating a sample mean for each of the 5,000 datasets and using the lower 5th and upper 95th percentiles of the 5,000 sample means as the lower and upper limits of the confidence intervals. All statistical analyses were run in program R 2.13.0 (R Development Core Team 2011).

3.6 Pronghorn Antelope and Greater Sage-Grouse Displacement Study

The objective of the displacement studies for the greater sage-grouse and pronghorn antelope was to determine the degree of avoidance or reduction in habitat use by these species due to the presence of WTGs. Pellet counts for pronghorn antelope were conducted at all turbines located within the crucial winter range for the pronghorn. Pellet counts for greater sage-grouse were conducted at every turbine in habitats dominated by sagebrush.

The pellet count study consisted of counting pellets at six plots at each of the turbines located within suitable habitat. Twenty-four (24) turbines were within the crucial winter range for the pronghorn; therefore, 144 plots were surveyed for pronghorn pellets. Based on habitat mapping of the project area, greater sage-grouse pellet plots were placed along transects at turbines with tall or dense stands of sagebrush that provide greater sage-grouse nesting, brood rearing, or winter habitat. Turbines in areas devoid of sagebrush or with low densities of sagebrush were not sampled.

At each turbine selected, the six plots were established using a systematic sample between 10 and 100 meters away from the turbine, perpendicular to the access road. Each plot was approximately 15 meters apart and marked with wire flags. The location was recorded using a GPS. All pellet groups within a 2-meter radius of each point were enumerated and then removed from the plot. Surveys were conducted twice a year, during May and October, beginning in October 2009 and continuing through October

2011. Surveys will continue for up to a total of three years with sampling in May/June and October/November of each year.

For reference data, six plots were established at 25 random points in an area of similar topography and vegetation as the turbines, but at least one mile from the nearest turbine. Sampling methods were identical to those at the turbine plots.

To compare differences in pellet count density between the wind turbine sites and the reference sites, 95% confidence intervals were calculated using bootstrapping for each sampling period and group.

4.0 Findings and Results

4.1 Standardized Carcass Searches

A total of 87 bird and bat carcasses were found between 14 October 2009 and 31 October 2011. Sixty-three of the 87 carcasses were found during the **1,067** scheduled individual plot searches; the remaining 24 were incidental finds. Of these 87 carcasses, 47 were of bird species and 40 were of bat species. Only the 63 carcasses found during standardized surveys were used in the estimation of fatality rates but incidental finds are included here for the purpose of identifying overall species composition of tower kills. For birds, the 47 carcasses were comprised of 21 species with nine carcasses that could not be identified down to the species level (Table 2). All 21 species are protected under the Migratory Bird Treaty Act (MBTA). A bald eagle was found on April 28, 2010 by wind farm personnel and was reported to the USFWS the same day. Two golden eagles were found, one on September 3, 2010 and a second on May 25, 2011; both were reported to the USFWS the same day. A greater sage-grouse was found on September 4, 2011 and was reported to PacifCorp the same day. Bald eagles and golden eagles are protected under the Bald Eagle and Golden Eagle Protection Act and the MBTA; the greater sage-grouse is protected by the MBTA and is a candidate for protection under the Endangered Species Act. In addition, both the bald eagle and greater sage-grouse are listed as a species of special concern by the Wyoming Game and

Fish Department (Native Species Status 2). None of the bird species found were listed as threatened or endangered and no birds other than the bald eagle and greater sage-grouse were listed as species of special concern in Wyoming.

For bats, the 40 carcasses were comprised of three species with four carcasses not identifiable down to the species level (Table 2). All three bat species are listed as species of special concern by the Wyoming Game and Fish Department; the western small-footed bat as Native Species Status 3 and hoary and silver-haired bats as Native Species Status 4.

Table 2. Species Composition of Birds and Bats Found Between 14 October 2009 and 31 October 2011 (numbers in parentheses indicate incidental finds).

Species	Total	Composition
Birds		
American kestrel (*Falco sparverius*)	0 (1)	2.1%
American robin (*Turdus migratorius*)	1	2.1%
American wigeon (*Anas americana*)	0 (1)	2.1%
bald eagle (*Haliaeetus leucocephalus*)	0 (1)	2.1%
blue-winged teal (*Anas discors*)	1	2.1%
cliff swallow (*Petrochelidon pyrrhonota*)	1	2.1%
common nighthawk (*Chordeiles minor*)	1 (1)	4.3%
dark-eyed junco (*Junco hyemalis*)	1	2.1%
golden eagle (*Aquila chrysaetos*)	0 (2)	4.3%
gray catbird (*Dumetella carolinensis*)	1	2.1%
greater-sage grouse (*Centrocercus urophasianus*)	1	2.1%
hermit thrush (*Catharus guttatus*)	1	2.1%
horned lark (*Eremophila alpestris*)	8 (3)	23.4%
lesser goldfinch (*Spinus psaltria*)	1	2.1%
mallard (*Anas platyrhynchos*)	0 (1)	2.1%
Raptor, most likely northern harrier (*Circus cyaneus*)	0 (1)	2.1%
red-tailed hawk (*Buteo jamaicensis*)	2 (2)	8.5%
savannah sparrow (*Passerculus sandwichensis*)	1	2.1%
Swainson's hawk (*Buteo swainsoni*)	1	2.1%

Species	Total	Composition
Swainson's thrush (*Catharus ustulatus*)	0 (1)	2.1%
unknown bird	4 (1)	10.6%
unknown hummingbird	0 (1)	2.1%
unknown waterfowl	2 (1)	6.4%
vesper sparrow (*Pooecetes gramineus*)	2 (1)	6.4%
Subtotal birds	29 (18)	100.0%
Bats		
hoary bat (*Lasiurus cinereus*)	18 (3)	52.5%
silver-haired bat (*Lasionycteris noctivagans*)	11 (3)	35.0%
western small-footed bat (*Myotis ciliolabrum*)	1	2.5%
unknown bat	4	10.0%
Subtotal bats	34 (6)	100.0%
Total Carcasses	63 (24)	

Based on the timing of the finds and habitat preferences of these species, the hawks, eagles, mallard, American wigeon, horned larks, and vesper sparrows were probable breeders in the area; the remaining birds and all of the bats were likely migrants passing through the area. All but five of the 47 bird carcasses were found during the spring and fall migration periods and all but three of the 40 bat carcasses were found during the fall migration period.

Table 3. Number of Birds and Bats Found by Species and Month from October 2009 to October 2011.

	2009			2010												2011									
species	oct	nov	dec	jan	feb	mar	apr	may	june	july	aug	sept	oct	nov	dec	jan	feb	mar	apr	may	june	july	aug	sept	oct
Birds																									
American kestrel																							1		
American robin																			1						
American wigeon																				1					
bald eagle							1																		
blue-winged teal																								1	
cliff swallow									1																
common nighthawk											1												1		
dark-eyed junco								1																	
golden eagle												1								1					
gray catbird								1																	
greater-sage grouse																								1	
hermit thrush													1												
horned lark							1	3			1	1	1						1	2		1			
lesser goldfinch												1													
mallard								1																	
northern harrier										1															
red-tailed hawk							1	1											1				1		
savannah sparrow																								1	
Swainson's hawk																							1		
Swainson's thrush								1																	
unknown hummingbird											1														
unknown waterfowl	1									1										1					
unknown small bird											1	1								2					1
vesper sparrow								1												1					1
All birds	1	0	0	0	0	0	3	9	1	2	4	4	2	0	0	0	0	0	3	8	0	1	4	3	2

	2009			2010												2011									
species	oct	nov	dec	jan	feb	mar	apr	may	june	july	aug	sept	oct	nov	dec	jan	feb	mar	apr	may	june	july	aug	sept	oct
Bats																									
hoary bat											11	4									1		5		
silver-haired bat												5	1							1			3	4	
small-footed bat									1																
unknown bat												3													1
All bats	0	0	0	0	0	0	0	0	1	0	11	12	1	0	0	0	0	0	0	1	1	0	8	4	1

Over the duration of the study to date (14 October 2009 to 31 October 2011), the estimated mean number of carcasses ($\bar{c}$) found adjusted for area searched was 0.62 birds/MW and 0.73 bats/MW.

4.2 Searcher Efficiency Trials

Small birds were less likely to be found during searcher efficiency trials than large birds. Small birds were detected 52% of the time (90% CI 44-62%), whereas large birds were detected 82% of the time (90% CI 73-91%).

4.3 Carcass Removal Trials

Small birds were also somewhat more likely to be scavenged sooner than large birds, although this difference was not significant (Figure 1). For small birds, the mean length of time a carcass remained on the site was 16.5 (90% CI 11.6-21.6) days; for large birds the mean length of time a carcass remained on the site was 20.3 (90% CI 15.0-25.4) days.

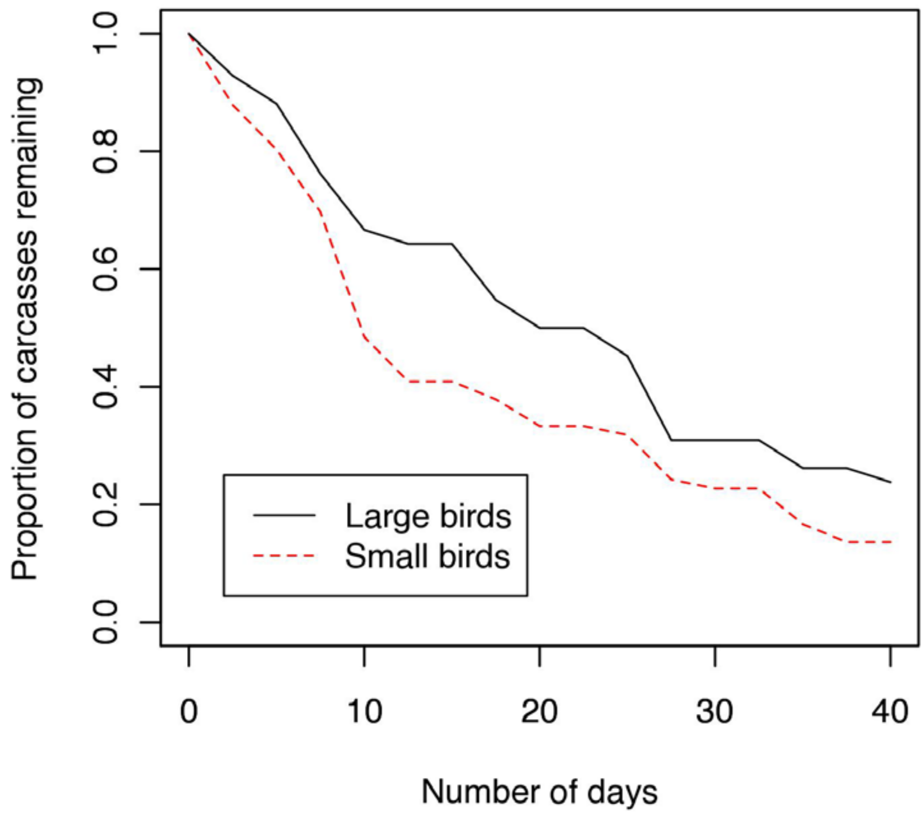

Figure 1. The Proportion of Carcasses Remaining by Exposure Days in the Field During the 2010 and 2011 Trials.

4.4 Fatality Estimates

For birds, the estimated fatality rate for the duration of the study to date (14 October 2009 to 31 October 2011) was 1.33 (90% CI 0.53-2.77) birds/MW. Seasonally, the highest fatality rates for birds occurred during migration periods, particularly spring migration, with an estimated fatality rate of 0.31 birds/MW during spring 2010, 0.24 birds/MW during fall 2010, 0.32 birds/MW during spring 2011, and 0.24 birds/MW during fall 2011 (Table 4).

For bats, the estimated overall fatality rate for the duration of the study was 1.39 bats/MW (90% CI 0.85-2.16). Seasonally, by far the highest fatality rate occurred during the three-month period of fall migration during 2010 with an estimated rate of 0.98

bats/MW. There was a second, much lower peak in bat fatality rates during fall migration in 2011 with an estimated rate of 0.32 bats/MW.

Table 4. Estimated Fatality Rates (individuals/MW), by Group, for Fall (1 August to 31 October), Winter (1 November to 14 March), Spring (15 March to 31 May), and Summer (1 June to 31 July) for Fall 2009 through Fall 2011. The mean annual fatality rate (animals/MW) is given for 1 November 2009 to 31 October 2011.

		2009	2010				2011				
Group		fall[1]	winter	spring	summer	fall	winter	spring	summer	fall	mean annual rate
birds	raptors	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.05	0.04
	large birds	0.05	0.00	0.02	0.04	0.00	0.00	0.00	0.00	0.18	0.12
	small birds	0.00	0.00	0.29	0.06	0.24	0.00	0.32	0.06	0.06	0.52
	all birds	0.05	0.00	0.31	0.10	0.24	0.00	0.32	0.06	0.24	0.64
bats	all bats	0.00	0.00	0.00	0.06	0.98	0.00	0.03	0.00	0.32	0.70

[1] Fall 2009 (14 to 31 October 2009) was a partial season period.

Fatality rates were similar for the first and second year of the study for birds but not for bats (Table 5). For birds, there were an estimated 0.65 (90% CI 0.25-1.34) birds/MW killed during the first year of the study versus 0.63 (90% CI 0.18-1.30) birds/MW killed during the second year of the study. For bats, however, the estimated fatality rate was significantly lower during the second year; there were an estimated 1.04 (90% CI 0.77-1.57) bats/MW killed during the first year of the study versus only 0.35 (90% CI 0.08-0.59) bats/MW killed during the second year.

Table 5. Estimated Annual Fatality Rates (individuals/MW), by Group and Year (Year 1=1 November 2009 to 31 October 2010, Year 2 = 1 November 2010 to 31 October 2011). The fatality rate (animals/MW) for the study period is given for 14 October 2009 to 31 October 2011. Numbers in parentheses indicate 90% confidence intervals.

Group		Year 1	Year 2	Study period
birds	raptors	0.02 (0.00-0.07)	0.05 (0.00-0.10)	0.07 (0.00-0.17)
	large birds	0.06 (0.00-0.18)	0.18 (0.10-0.45)	0.29 (0.10-0.77)
	small birds	0.59 (0.25-1.16)	0.44 (0.18-0.85)	1.04 (0.43-2.00)
	All birds	0.65 (0.25-1.34)	0.63 (0.18-1.30)	1.33 (0.53-2.77)
bats	All bats	1.04 (0.77-1.57)	0.35 (0.08-0.59)	1.39 (0.85-2.16)

4.5 Pronghorn Antelope and Greater Sage-Grouse Displacement Study

Pellet counts were lower near turbines than at reference sites for pronghorn antelopes but this difference was only statistically significant for the first two of the five surveys. The mean count at surveys adjacent to turbines was significantly lower than reference surveys in October 2009 (0.20 pellets/count, 95% CI 0.13-0.27, at turbines vs. 0.39 pellets/count, 95% CI 0.30-0.48 at reference surveys) and in May 2010 (0.12, 95% CI 0.06-0.18, pellets/count at turbines vs. 0.36, 95% CI 0.26-0.48, pellets/count at reference surveys) but not in October 2010 (0.19 pellets/count, 95% CI 0.12-0.27, at turbines vs. 0.27 pellets/count, 95% CI 0.18-0.40 at reference surveys), May 2011 (0.19 pellets/count, 95% CI 0.13-0.26, at turbines vs. 0.22 pellets/count, 95% CI 0.15-0.29 at reference survey) or October 2011 (0.11 pellets/count, 95% CI 0.06-0.17, at turbines vs. 0.18 pellets/count, 95% CI 0.12-0.24 at reference surveys; Figure 2). Habitat was disturbed (exposed soil) during the October 2009 surveys at 33% of the pellet survey sites near turbines whereas none of the reference sites were disturbed during this period.

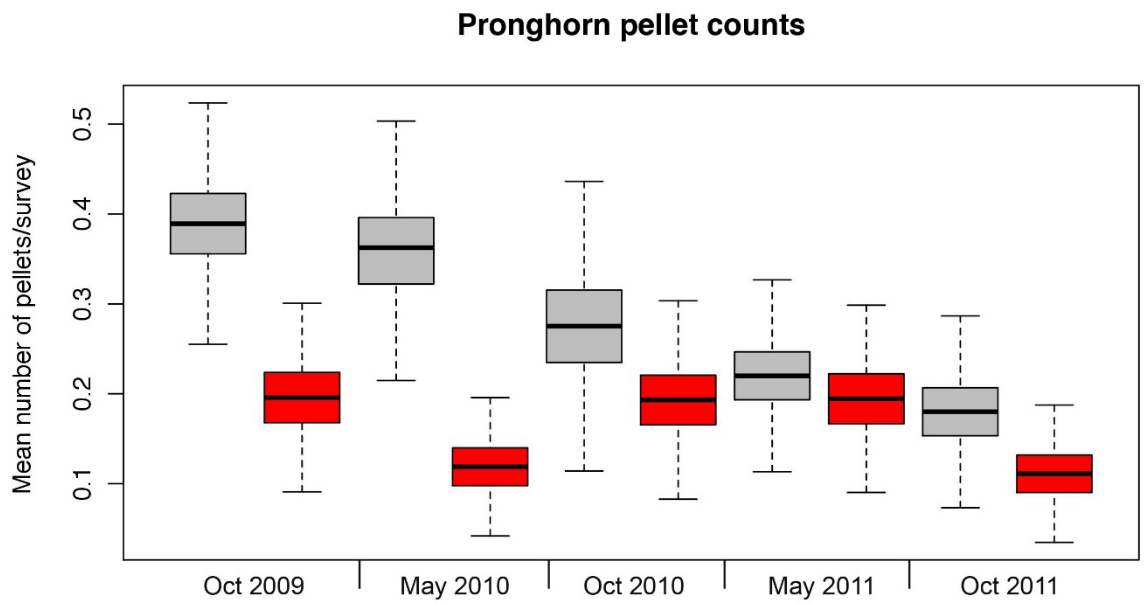

Figure 2. Bootstrapped Data of Pronghorn Antelope Pellet Counts at Reference (grey) and Turbine (red) Sites Collected During October 2009, May 2010, October 2010, May 2011, and October 2011 (Black line indicates median value, box indicate 25% and 75% percentiles, and whiskers indicate data range).

Greater sage-grouse pellets occurred at very low densities at both turbine and reference sites. The pellet counts for sage-grouse were slightly lower at turbine sites than at reference sites during four of the five surveys, but this difference was not statistically significant for any survey. In October 2009 there were 0.01 pellets/count (95% CI 0.00-0.02) at turbines vs. 0.04 pellets/count (95% CI 0.01-0.07) at reference points, in May 2010 there were 0.00 pellets/count (95% CI 0.00-0.00) at turbines vs. 0.01 pellets/count (95% CI 0.00-0.02) at reference points, in October 2010 there were 0.01 pellets/count (95% CI 0.00-0.02) at turbines vs. 0.03 pellets/count (95% CI 0.01-0.05) at reference points, in May 2011 there were 0.00 pellets/count (95% CI 0.00-0.00) at both turbine and reference points, and in October 2011 there were 0.00 pellets/count (95% CI 0.00-0.00) at turbines vs. 0.01 pellets/count (95% CI 0.00-0.02) at reference points (Figure 3).

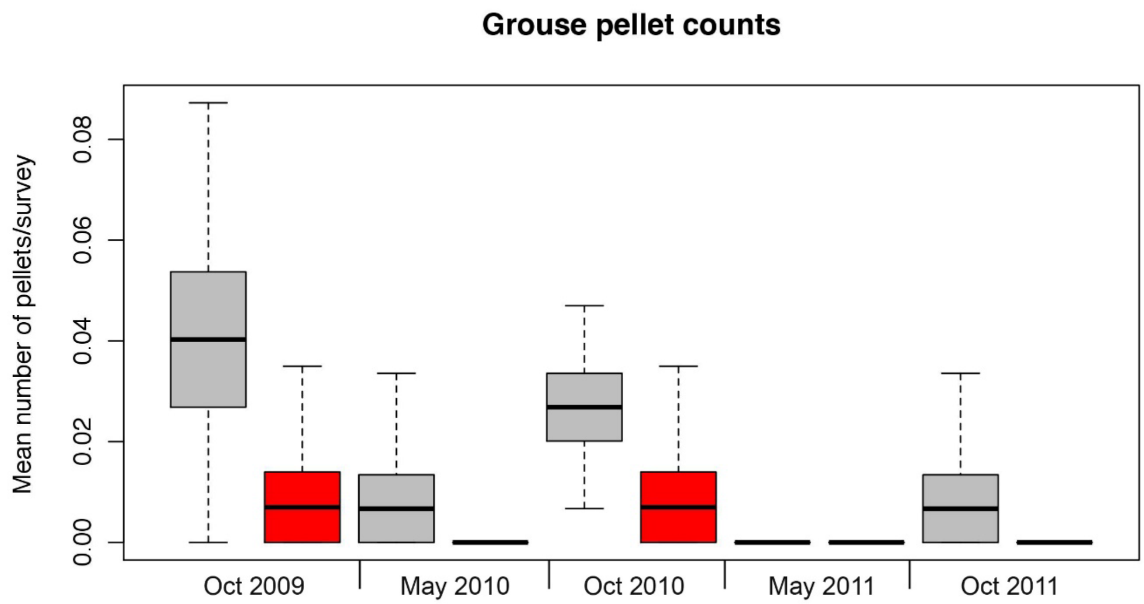

Figure 3. Bootstrapped Data of Greater Sage-Grouse Pellet Counts at Reference (grey) and Turbine (red) Sites Collected During October 2009, May 2010, October 2010, May 2011, and Oct 2011 (Black line indicates median value, box indicates 25% and 75% percentiles, and whiskers indicate data range).

5.0 Summary and Conclusions

The mean estimated annual bird fatality rate of 0.64 birds/MW/year at the High Plains and McFadden Ridge I wind energy project was lower than the average bird fatality rate (1.78 birds/MW/year; Johnson and Stephens 2010) documented in a review of 21 studies of wind facilities in western North America. The estimated bird fatality rate was also lower than the range observed in similar studies; for wind energy projects in Montana, Washington, Wyoming, Iowa, Nebraska, and Oregon, bird fatality has ranged from 0.95 to 2.76 birds/MW/year (Erickson et al. 2003, Johnson et al. 2003, Young et al. 2003, Young et al. 2006, Derby et al. 2007, TRC Environmental Corporation 2008, and Jeffery et al. 2009). Fatality rates in this study were higher for small birds (0.52 birds/MW/year) than for large birds (0.12 birds/MW/year), with the majority of carcasses for both small and large birds found during spring and fall migrations. The most common bird species found was the horned lark (23.4% of birds found), which is consistent with other studies of western wind facilities (horned larks comprised 21.8% of 1,247 fatalities in a review of 21 wind facilities; Johnson and Stephens 2010). Passerines are known to comprise the majority of fatalities at wind energy facilities with newer designs, with the peak number of fatalities occurring during seasonal migration (Erickson 2004). Passerines generally fly between 91-610 meters during migration, thereby placing low-flying birds at risk of collision (Morrison 2006). In addition, male grassland birds that engage in aerial displays during courtship, such as the vesper sparrow and horned lark, may also be at risk of colliding with rotor blades during the breeding season (IDNR 2007, Kingsley and Whittam 2003). Three individuals of species with a federally protected status, a bald eagle and two golden eagles (The Bald and Golden Eagle Protection Act), were found during the study. Because none of these three birds were found during scheduled searches, they were not included in the statistical analysis and thus these deaths are not reflected in the fatality estimates for raptors.

The estimated bat fatality rate of 0.70 bats/MW/year at the High Plains and McFadden Ridge I wind energy project was lower than the average bat fatality rate (2.13 bats/MW/year; Johnson and Stephens 2010) documented in a review of 21 studies of wind facilities in western North America. Similarly, the estimated bat fatality rate was lower than the range observed in similar studies; for wind energy projects in Montana, Washington, Wyoming, Iowa, Nebraska, and Oregon, bat fatality has ranged from 0.8 to 8.93 bats/MW/year (Erickson et al. 2003, Johnson et al. 2003, Young et al. 2003, Young et al. 2006, Derby et al. 2007, TRC Environmental Corporation 2008, and Jeffery et al. 2009). In concordance to what we observed in this study, bat fatalities at wind facilities in western states are typically highest from mid July through September (Johnson 2005). Also consistent with study findings at other western wind facilities, hoary and silver-haired bats were the most common bat fatalities at the High Plains and McFadden Ridge I wind energy project. Of the over 2,000 bat fatalities reported from studies of 21 wind facilities in western North America, the hoary bat comprised 55.9% of the carcasses and the silver-haired bat comprised 33.1% of the carcasses (Johnson and Stephens 2010); in this study, the hoary bat comprised 52.5% of the bat carcasses and the silver-haired bat comprised 35.0% of the bat carcasses. Hoary and silver-haired bats are migratory, tree-dwelling species. Based on the timing of fatalities for these species, combined with the lack of forest cover near the study location that could potentially provide habitat for resident bats, the bats were likely fall migrants passing through the area. Bat fatalities at most wind energy facilities in North America are comprised primarily of migrants (Johnson 2005, Arnett et al. 2008).

Estimated bat fatality rates were significantly lower during fall 2011 (0.32 bats/MW, 90% CI 0.08-0.54) than during fall 2010 (0.98 bats/MW, 90% CI 0.77-1.39). It is not known what caused this decrease. Bats are known to have the highest activity rates and thus be the most susceptible to turbine strikes on nights with low (3-5 m/s or 7-11 mph) wind speeds (Arnett et al. 2011).

The pellet count data suggested habitat disturbance near turbines and/or displacement by pronghorns from turbine sites during late 2009 and early 2010 with the level of disturbance declining over time. The apparent avoidance of turbine sites by pronghorns observed in this study was likely in part due to habitat disturbance at the turbine survey sites, with 33% of the turbine sites disturbed whereas none of the reference sites were disturbed. Although all five surveys had lower pellet counts at turbine than at reference plots, in the most recent three surveys (October 2010, May 2011, and October 2011) this difference was not statistically significant. Walter et al. (2006) found that elk in Oklahoma were displaced from the wind development area immediately after construction; displacement gradually decreased but was still elevated above pre-construction levels. However, although displacement and some loss of habitat was apparent, elk in the Walter et al. (2006) study were not adversely affected by wind-power development as determined by home range size and dietary analysis.

Sage grouse pellet counts were lower at turbine plots in four of the five surveys but this difference was not statistically significant for any of the surveys. Sage grouse pellet counts were counted in low numbers at both the reference and turbine survey plots, possibly due to the marginal quality of habitat at the surveyed sites. The survey plots were located in habitat characterized by short grasses and sparse sagebrush, areas that are likely to be low quality habitat for this species (Schroeder et al. 1999).

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PACIFICORP ENERGY
A DIVISION OF PACIFICORP

Final Report

High Plains and McFadden Ridge I Wind Energy Facility Avian and Bat Fatality Survey and Pronghorn Antelope and Greater Sage Grouse Displacement Assessment

Prepared for:

PacifiCorp Energy
1407 West North Temple, Suite 310
Salt Lake City, UT 84116

Prepared by:

John McCreight and Sarah Lehnen
Enercon Services, Inc.
6525 N. Meridian Ave, Suite 400
Oklahoma City, OK 73116

November 16, 2012

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1.0 Introduction

PacifiCorp Energy (PacifiCorp) has developed two (2) wind energy facilities near Rock River, in Albany County, Wyoming. The High Plains Wind Energy Facility (HPWEF) consists of 66 General Electric Company (GE) 1.5-megawatt (MW) wind turbine generators (WTG) with a nameplate output of 99 MW. The McFadden Ridge I Wind Energy Facility (MRIWEF) consists of 19 WTGs with a nameplate output of 28.5 MW. Each of the 1.5 MW turbines consists of an 80-meter tall tubular steel tower, an 82-meter diameter rotor, and a nacelle that houses the generator, transformer, and power trains. The towers have a base diameter of 4.5 meters and a top diameter of 2.5 meters. The rotors consist of three 41-meter long composite blades. Infrastructure to support the combined 85 WTGs includes transformers, an operation and maintenance (O&M) building, underground electric cable, fiber optic communication cable, WTG access roads, two (2) permanent 60-meter tall meteorological towers (MET), approximately five (5) miles of overhead power lines, and a supervisory control and data acquisition (SCADA) system.

The primary objective of this monitoring study is to estimate the avian and bat collision mortality at these facilities. The secondary objective is to examine pronghorn antelope (*Antilocapra americana*) and greater sage-grouse (*Centrocercus urophasianus*) displacement as assessed by pellet counts. This report conveys the results of avian and bat monitoring at both HPWEF and MRIWEF from 14 October 2009 through 31 October 2012, and pellet counts collected during October 2009, May 2010, October 2010, May 2011, October 2011, May 2012, and October 2012. Avian and bat monitoring involved five activities:

1. Standardized carcass searches at turbine and MET locations;
2. Search efficiency trials to estimate the proportion of carcasses found by searchers;

3. Carcass removal trials to estimate the length of time a carcass remains at the survey sites available for detection;
4. Statistical analysis to adjust fatality estimates for searcher efficiency and carcass removal rates and to calculate a 90% confidence interval (CI) of the number of avian and bat fatalities associated with the wind energy facilities; and
5. Implementation of PacifiCorp's Wildlife Incident Reporting and Handling System (WIRHS) for wind project personnel. All avian and bat casualties found are handled under the WIRHS protocol, which is part of the long-term wind project monitoring (Young et al. 2005).

2.0 Study Area

The study area is located within the Laramie Basin subset of the Wyoming Basin ecoregion. The ecoregion is a broad arid intermontane basin interrupted by hills and low mountains. The Wyoming Basin ecoregion, which is nearly encompassed by forest-covered mountains, is drier than the northwestern Great Plains to the northeast. Additionally, the ecoregion does not have the extensive cover of pinion-juniper woodland found in the Colorado Plateau to the south. Major industries in this region include natural gas and petroleum fields, and coal, trona, bentonite, clay, and uranium mining (Chapman et al. 2004). The Laramie Basin is a wide intermontane valley consisting predominantly of mixed-grass prairie. Potential natural vegetation includes needle-and-thread grass, western wheatgrass, blue grama, Indian ricegrass, and other mixed-grass species. Although some riparian areas are present within the subset, it is generally drier than the sub-irrigated high valleys (Chapman et al. 2004).

This wind energy project is located in southeastern Wyoming in Albany County, five (5) miles southwest of Rock River and two (2) miles east of McFadden. The wind farm encompasses over 4,400 hectares of private and state-owned land, most of which is ranchland. Vegetation is dominated by native grasses and sagebrush on rolling hills. Elevation ranges from approximately 2,100 to 2,300 meters above mean sea level.

Turbines and MET towers are located in Sections 1 & 3, Township 19 North, Range 77 West; Sections 24, 25, 26, 27, 33, 34, & 35, Township 20 North, Range 77 West; and Section 30, Township 20 North, Range 76 West.

3.0 Methodology

3.1 Search Plots

The two wind energy facilities have a combined eighty-five (85) turbines and two (2) MET towers. Approximately one-third (29) of the turbines and both MET towers were surveyed for carcasses. These turbines were searched year-round every 28 days. During the remainder of the 2009 fall migration (the surveys began 14 October 2009), 2010, 2011, and 2012 spring migrations (15 March to 1 June), and 2010, 2011, and 2012 fall migrations (1 August to 31 October) half of the turbines (15) and one of the MET towers were searched every seven (7) days. The search effort was spread throughout the entire study area by selecting turbines for sampling using a systematic design with a random start. The 160-meter-by-160-meter search plots were centered on each of the included turbines (plots extended 80 meters on each side of the turbine). For MET towers, the search plots were 120-meters-by-120-meters (60 meters on each side of the tower).

3.2 Standardized Carcass Searches

The two wind energy facilities were systematically searched for avian and bat casualties. Two trained personnel conducted the carcass searches, walking at a rate of approximately 45 to 60 meters per minute along each transect, depending upon terrain. The two searchers walked 6 to 10 meters apart, depending upon habitat type (closer in thick brush), while scanning an area approximately 3 to 5 meters wide on either side for carcasses as they walked. Prior to initiating the standardized carcass searches, all selected turbines and MET towers were searched to remove any carcasses found.

The condition of each carcass found was recorded using the following categories:

- **Intact**: A completely intact carcass, with little decomposition, and no indication of being fed upon by a predator or scavenger.
- **Scavenged**: An entire carcass that has been fed upon by a predator or scavenger. A scavenged carcass could also be a portion(s) of a carcass at a single location (e.g., wings, skeletal remains, etc.), or a carcass heavily infested by insects.
- **Feather Spot**: Ten or more feathers at a single location indicating predation or scavenging.

For each carcass found, searchers recorded species, sex and age when possible, date and time collected, global positioning system (GPS) location, condition (intact, scavenged, feather spot), and comments indicating cause of death. Data were entered into an Excel spreadsheet. All casualties were photographed as found and plotted on a detailed map of the study area. Carcasses were labeled with a unique number, placed in a bag with the data sheet, and frozen for future reference and possible necropsy.

Any carcasses found by wind farm personnel or outside of standardized searches were coded as incidental discoveries and documented using the same protocol as for those found during standard searches.

Table 1: Schedule for Carcass Searches

Search	Dates	Number of Plots	Interval
1	March 15–June 1	16	7 days
2	March	31	28 days
3	April	31	28 days
4	May	31	28 days
5	June	31	28 days
6	July	31	28 days
7	August 1–October 31	16	7 days
8	August	31	28 days
9	September	31	28 days
10	October	31	28 days

Search	Dates	Number of Plots	Interval
11	November	31	28 days
12	December	31	28 days
13	January	31	28 days
14	February	31	28 days

3.3 Searcher Efficiency Trials

Searcher efficiency trials were conducted during regularly scheduled carcass search surveys. Personnel conducting the carcass searches were unaware which surveys contained planted carcasses. One trial was held during winter (March 2010) and five trials each were held during spring 2010, fall 2010, spring 2011, fall 2011, spring 2012, and fall 2012 migrations for a total of 287 planted carcasses, comprising 138 small and 149 large birds. Carcasses were of non-native/non-protected or commercially available species such as house sparrows, European starlings, rock pigeons, bobwhite quail, mallard ducks, or hen pheasants. A few native songbirds were collected under a salvage permit and were used in the efficiency trials as permitted by United States Fish and Wildlife Service (USFWS) permit MB737207-0, authorization G.

All carcasses were placed at random locations within search areas before the plot was searched on the same day the search was conducted. Carcasses were placed in a variety of postures to simulate a range of conditions. For example, birds were placed in exposed postures (tossed randomly to one side to simulate a bird after it was killed from impacting a structure) and hidden behind grass clumps and shrubs to simulate injured birds.

Each trial carcass was discreetly marked so it could be identified as a study carcass after it was found. For each trial carcass, the species, position of the bird, habitat around the carcass, and whether it was found during the survey were recorded. After the completion of an efficiency trial, the personnel who placed the carcasses attempted to retrieve all carcasses not found by the searchers. Searcher efficiency was estimated by carcass size (large or small). Small birds were bobwhite quail size or smaller (no more than 170 grams (6 ounces)); large birds were pheasant hen size or larger (more than 170 grams (6 ounces)).

3.4 Carcass Removal Trials

Carcass removal trials estimated the length of time before scavengers removed a carcass in order to adjust the number of carcasses found for those that were removed between surveys. Removal trials began at the same time as carcass search studies. During each of the survey periods (winter, spring migration, summer, fall migration), carcasses of large and small birds were placed within 80 meters of randomly selected turbines that were not part of the regular surveys (Figure 1). A total of 122 removal trials were conducted between 14 October 2009 and 31 October 2012; 8 during the winter, 58 during spring migration, 24 during the summer, and 56 during fall migration. As with searcher efficiency trials, the carcasses were placed in a variety of postures to simulate a range of conditions. Legally obtained, fresh game birds were used to simulate large bird carcasses and house sparrows were used to simulate small bird and bat carcasses.

Carcass removal trial birds were monitored over a 40-day period according to the following schedule: carcasses were checked every day for the first four days, and then on days 7, 10, 14, 20, 30, and 40. This schedule varied slightly depending on site weather conditions and coordination with other survey work. Carcasses were marked discreetly (for example, with dark electrical tape around one or both legs) for recognition by searchers and other personnel. Experimental carcasses were left undisturbed until the end of the carcass removal trial, at which point any remaining evidence of the carcasses was removed.

3.5 Statistical Methods

Estimates of facility-related fatalities are based on:

1. The observed number of carcasses found during standardized searches throughout the monitoring period for which the cause of death is either unknown or probably facility-related.
2. Removal rates expressed as the estimated length of time a carcass is expected to remain in the study area and be available for detection by the searchers as estimated from the removal trials.
3. Searcher efficiency expressed as the proportion of planted carcasses found by searchers during searcher efficiency trials.

Fatality estimates are provided for six categories: 1) all birds, 2) small birds, 3) large birds, 4) raptors, and 5) bats. The number of avian and bat fatalities attributable to the operation of the facility, based on the number of avian and bat fatalities found at the facility site whose death was unknown or appears related to facility operation, are reported.

3.5.1 Definition of Variables

The following variables are used in the equations below:

c_i The number of carcasses detected at plot *i* for which the cause of death is unknown or attributed to the facility.

$\bar{c}$ The average number of carcasses observed per turbine.

n The number of search plots.

k The number of turbines and meteorological towers searched.

s The number of carcasses used in removal trials.

s_c The number of carcasses in removal trials remaining in the study area after 30 days.

SE Standard error (square of the sample variance of the mean).

t_i The time (in days) a carcass remains in the study area during the removal trials.

$\bar{t}$ The mean time (in days) a carcass remains in the study area during the removal trials.

d The total number of carcasses placed during searcher efficiency trials.

p The proportion of carcasses found by searchers during the efficiency trials.

I The mean interval between standardized carcass searches, in days.

A Proportion of the area surrounding a turbine included in the search plot.

$\hat{\pi}$ The estimated probability that a carcass is both available to be found during a search and that it is found, as determined by the removal trials and the searcher efficiency trials.

m The estimated mean number of fatalities per turbine, adjusted for removal and searcher efficiency bias

3.5.2 *Observed Number of Carcasses*

The estimated mean number of carcasses ($\bar{c}$) found per turbine adjusted for area searched is:

$$\bar{c} = \frac{\sum_{i=1}^{n} c_i}{k \cdot A}$$

3.5.3 *Estimation of Carcass Removal Rates*

Carcass removal time ($\bar{t}$) is the mean length of time a carcass remains in the study area:

$$\bar{t} = \frac{\sum_{i=1}^{s} t_i}{s - s_c}$$

3.5.4 *Estimation of Searcher Efficiency Trials*

Searcher efficiency rates are expressed as *p,* the proportion of trial carcasses that are found by searchers in the searcher efficiency trials. These rates were estimated by carcass size, large or small.

3.5.5 *Estimation of Facility Related Fatality Rates*

The estimated per turbine fatality rate (*m*) is calculated by:

$$m = \frac{\bar{c}}{\hat{\pi}}$$

Where $\bar{c}$ is the mean number of birds found per turbine adjusted for search area and $\hat{\pi}$ is the probability that a carcass located within the search plot will be encountered, calculated as a combination of the likelihood that a carcass will be available (i.e. not removed by scavengers before the search) and the probability that is found given that is available.

$\hat{\pi}$ is calculated as follows:

$$\hat{\pi} = \frac{\bar{t} \cdot p}{I} \cdot \left[\frac{\exp\left(^{I}/_{\bar{t}}\right) - 1}{\exp\left(^{I}/_{\bar{t}}\right) - 1 + p} \right]$$

This formula has been independently verified by Shoenfeld (2004). The final reported estimates of *c, t, p*, $\hat{\pi}$, and *m* and 90 percent confidence intervals for these estimates were calculated using bootstrapping (Manly 1997). Bootstrapping is a useful technique for calculating variances and confidence intervals for data that is not normally distributed. Bootstrapping randomly re-samples the dataset to create new datasets. For this analysis, a total of 5,000 new datasets were generated by re-sampling the original data with replacement, with each of the 5,000 new datasets having the same sample size as the original. The 90% confidence intervals were determined by generating a sample mean for each of the 5,000 datasets and using the lower 5^{th} and upper 95^{th} percentiles of the 5,000 sample means as the lower and upper limits of the confidence intervals. All statistical analyses were run in program R 2.13.0 (R Development Core Team 2011).

3.6 Pronghorn Antelope and Greater Sage-Grouse Displacement Study

The objective of the displacement studies for the greater sage-grouse and pronghorn antelope was to determine the degree of avoidance or reduction in habitat use by these species due to the presence of WTGs. Pellet counts for pronghorn antelope were conducted at all turbines located within the crucial winter range for the pronghorn. Pellet counts for greater sage-grouse were conducted at every turbine in habitats dominated by sagebrush.

The pellet count study consisted of counting pellets at six plots at each of the turbines located within suitable habitat. Twenty-four (24) turbines were within the crucial winter range for the pronghorn; therefore, 144 plots were surveyed for pronghorn pellets.

Based on habitat mapping of the project area, greater sage-grouse pellet plots were placed along transects at turbines with tall or dense stands of sagebrush that provide greater sage-grouse nesting, brood rearing, or winter habitat. Turbines in areas devoid of sagebrush or with low densities of sagebrush were not sampled.

At each turbine selected, the six plots were established using a systematic sample between 10 and 100 meters away from the turbine, perpendicular to the access road. Each plot was approximately 15 meters apart and marked with wire flags. The location was recorded using a GPS. All pellet groups within a 2-meter radius of each point were enumerated and then removed from the plot. Surveys were conducted twice a year, during May and October, beginning in October 2009 and continuing through October 2012.

For reference data, six plots were established at 25 random points in an area of similar topography and vegetation as the turbines, but at least one mile from the nearest turbine. Sampling methods were identical to those at the turbine plots.

To compare differences in pellet count density between the wind turbine sites and the reference sites, 95% confidence intervals were calculated using bootstrapping for each sampling period and group.

4.0 Findings and Results

4.1 Standardized Carcass Searches

A total of 112 bird and bat carcasses were found between 14 October 2009 and 31 October 2012. Eighty-six of the 112 carcasses were found during the 1,647 scheduled individual plot searches; the remaining 26 were incidental finds. Of these 112 carcasses, 60 were of bird species and 52 were of bat species. Only the 86 carcasses found during standardized surveys were used in the estimation of fatality rates but incidental finds are included here for the purpose of identifying overall species composition of turbine kills. For birds, the 60 carcasses were comprised of 23 species with 13 carcasses that could not be identified down to the species level (Table 2). All 23 of the species other than the European starling are protected under the Migratory Bird Treaty Act (MBTA). Four eagles were found during the study. A bald eagle was found on April 28, 2010 and three golden eagles were found, one on September 3, 2010, one on May 25, 2011, and one on August 21, 2012. All four eagles were reported to the USFWS on the day they were found. A greater sage-grouse was found on September 4, 2011 and was reported to PacifCorp the same day. Bald eagles and golden eagles are protected under the Bald Eagle and Golden Eagle Protection Act and the MBTA; the greater sage-grouse is protected by the MBTA and is a candidate for protection under the Endangered Species Act. In addition, both the bald eagle and greater sage-grouse are listed as a species of special concern by the Wyoming Game and Fish Department (Native Species Status 2). None of the bird species found were listed as threatened or endangered and no birds other than the bald eagle and greater sage-grouse were listed as species of special concern in Wyoming.

For bats, the 52 carcasses were comprised of five species with four carcasses not identifiable down to the species level (Table 2). All five bat species are listed as species of special concern by the Wyoming Game and Fish Department; the western small-footed bat as Native Species Status 3, the hoary, silver-haired, and little brown bats as Native Species Status 4, and the eastern red bat as Native Species Status Unknown.

Table 2. Species Composition (% Comp.) of Birds and Bats Found Between 14 October 2009 and 31 October 2012 (numbers in parentheses indicate incidental finds). Abbreviations used in Table 3 are also listed.

Abv.	Species	Total	% Comp
	Birds		
AMKE	American kestrel (*Falco sparverius*)	1 (1)	3.3%
AMRO	American robin (*Turdus migratorius*)	1	1.7%
AWPE	American white pelican (*Pelecanus erythrorhynchos*)	0 (1)	1.7%
AMWI	American wigeon (*Anas americana*)	0 (1)	1.7%
BAEA	bald eagle (*Haliaeetus leucocephalus*)	0 (1)	1.7%
BWTE	blue-winged teal (*Anas discors*)	1	1.7%

Abv.	Species	Total	% Comp
CLSW	cliff swallow (*Petrochelidon pyrrhonota*)	1	1.7%
CONI	common nighthawk (*Chordeiles minor*)	1	1.7%
DEJU	dark-eyed junco (*Junco hyemalis*)	1	1.7%
GOEA	golden eagle (*Aquila chrysaetos*)	1 (2)	5.0%
GRCA	gray catbird (*Dumetella carolinensis*)	1	1.7%
EUST	European starling (*Sturnus vulgaris*)	1	1.7%
FEHA	ferruginous hawk (*Buteo regalis*)	0 (1)	1.7%
GSHA	greater-sage grouse (*Centrocercus urophasianus*)	1	1.7%
HETH	hermit thrush (*Catharus guttatus*)	1	1.7%
HOLA	horned lark (*Eremophila alpestris*)	12 (3)	25.0%
LEGO	lesser goldfinch (*Spinus psaltria*)	1	1.7%
MALL	mallard (*Anas platyrhynchos*)	0 (1)	1.7%
NOHA	Raptor, most likely northern harrier (*Circus cyaneus*)	0 (1)	1.7%
RTHA	red-tailed hawk (*Buteo jamaicensis*)	2 (2)	6.7%
SASP	savannah sparrow (*Passerculus sandwichensis*)	1	1.7%
SWHA	Swainson's hawk (*Buteo swainsoni*)	1	1.7%
SWTH	Swainson's thrush (*Catharus ustulatus*)	0 (1)	1.7%
UNBI	unknown bird	7 (1)	13.3%
UNHU	unknown hummingbird	0 (1)	1.7%
UNWA	unknown waterfowl	3 (1)	6.7%
VESP	vesper sparrow (*Pooecetes gramineus*)	3 (1)	6.7%
	Subtotal birds	41 (19)	100.0%
	Bats		
ERBA	Eastern red bat (*Myotis lucifugus*)	1	1.9%
HOBA	hoary bat (*Lasiurus cinereus*)	26 (4)	57.7%
LBBA	little brown bat (*Myotis lucifugus*)	1	1.9%
SHBA	silver-haired bat (*Lasionycteris noctivagans*)	12 (3)	28.8%
WSFB	western small-footed bat (*Myotis ciliolabrum*)	1	1.9%
UNBA	unknown bat	4	7.7%
	Subtotal bats	45 (7)	100%
	Total Carcasses	86 (26)	

Based on the timing of the finds and habitat preferences of these species, the hawks, eagles, mallard, American wigeon, horned larks, and vesper sparrows were probable breeders in the area; the remaining birds and all of the bats were likely migrants passing through the area. For birds, 93.3 % (56 out of 60) of bird carcasses were found during the spring and fall migration periods with roughly equal numbers (mean of 9.7 carcasses found during spring vs. mean of 9.0 carcasses found during fall) found during spring and fall. For bats, 92.3% (48 out of 52) of bat carcasses were found during the fall migration period.

Table 3. Number of Birds and Bats Found by Species and Month from October 2009 to October 2012.

	2009			2010												2011												2012									
Species	oct	nov	dec	jan	feb	mar	apr	may	june	july	aug	sept	oct	nov	dec	jan	feb	mar	apr	may	june	july	aug	sept	oct	nov	dec	jan	feb	mar	apr	may	june	july	aug	sept	oct
Birds																																					
AMKE																							1								1						
AMRO																			1																		
AMWI																				1																	
BAEA							1																														
BWTE																								1													
CLSW									1																												
CONI											1												1														
DEJU								1																													
GOEA												1								1															1		
EUST																																			1		
FEHA								1																												1	
GRCA								1																													
GSGR																								1													
HETH													1																								
HOLA							1	3			1	1	1						1	2		1										2			2		
LEGO												1																									
MALL								1																													
NOHA										1																											
RTHA							1	1											1				1														
SASP																								1													
SWHA																							1														
SWTH								1																													
UNHU											1																										
UNWA	1									1										1												1					
UNBI											1	1								2					1						1	1			1		

	2009			2010												2011												2012									
	oct	nov	dec	jan	feb	mar	apr	may	june	july	aug	sept	oct	nov	dec	jan	feb	mar	apr	may	june	july	aug	sept	oct	nov	dec	jan	feb	mar	apr	may	june	july	aug	sept	oct
VESP								1												1					1										1		
All birds	1	0	0	0	0	0	3	9	1	2	4	4	2	0	0	0	0	0	3	8	0	1	4	3	2	0	0	0	0	0	2	4	0	0	7	1	0
Bats																																					
ERBA																																				1	
HOBA											11	4										1	5												9		
LBBA																																			1		
SHBA												5	1								1		3	4										1			
WSFB									1																												
UNBA												3													1												
All bats	0	0	0	0	0	0	0	0	1	0	11	12	1	0	0	0	0	0	0	0	1	1	8	4	1	0	0	0	0	0	0	0	0	1	10	1	0

Over the duration of the study (14 October 2009 to 31 October 2012), the estimated mean number of carcasses ($\bar{c}$) found adjusted for area searched was 0.94 birds/MW and 1.03 bats/MW.

4.2 Searcher Efficiency Trials

Small birds were significantly less likely to be found during searcher efficiency trials than large birds. Small birds were detected 53.8% of the time (90% CI 42.3-64.3%), whereas large birds were detected 83.9% of the time (90% CI 75.0-91.1%).

4.3 Carcass Removal Trials

Small birds were also more likely to be scavenged sooner than large birds, although this difference was not significant (Figure 1). For small birds, the mean length of time a carcass remained on the site was 16.7 (90% CI 11.4-22.2) days; for large birds the mean length of time a carcass remained on the site was 19.8 (90% CI 14.4-25.3) days.

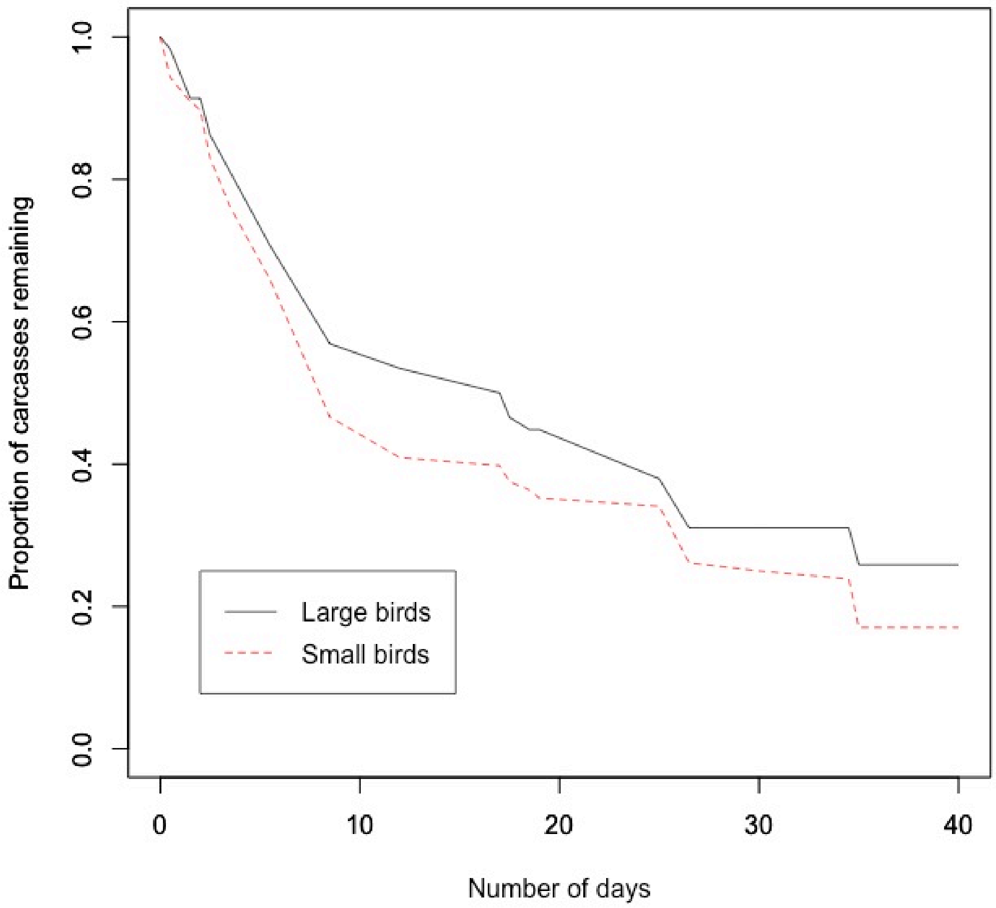

Figure 1. The Proportion of Carcasses Remaining by Exposure Days in the Field During the 2010, 2011, and 2012 Trials.

4.4 Fatality Estimates

For birds, the estimated fatality rate for the duration of the study (14 October 2009 to 31 October 2012) was 1.62 (90% CI 0.47-3.64) birds/MW (Table 4). Seasonally, the highest fatality rates for birds occurred during migration periods, with an estimated fatality rate of 0.30 birds/MW during spring 2010, 0.24 birds/MW during fall 2010, 0.25 birds/MW during spring 2011, 0.30 birds/MW during fall 2011, 0.18 birds/MW during spring 2012, and 0.17 birds/MW during fall 2012 (Table 5).

For bats, the estimated overall fatality rate for the duration of the study was 1.56 bats/MW (90% CI 0.86-2.97). Seasonally, by far the highest fatality rate occurred during the three-month period of fall migration during 2010 with an estimated rate of 0.95 bats/MW. There were subsequent, lower peaks in bat fatality rates during fall migrations in 2011 and 2012 with an estimated rate of 0.31 bats/MW and 0.24 bats/MW, respectively.

Table 4. Estimated Annual Fatality Rates (individuals/MW/YR), by Group and Year (Year 1=1 November 2009 to 31 October 2010, Year 2 = 1 November 2010 to 31 October 2011, Year 3 = 1 November 2011 to 31 October 2012). The fatality rate (animals/MW) for the study period is given for 14 October 2009 to 31 October 2012. Numbers in parentheses indicate 90% confidence intervals.

Group	Year 1	Year 2	Year 3	Study period
raptors	0.02 (0.00 – 0.31)	0.05 (0.00 -0.13)	0.06 (0.00 – 0.29)	0.14 (0.00 – 0.73)
large birds	0.07 (0.00 – 0.31)	0.13 (0.00 – 0.29)	0.09 (0.00 – 0.39)	0.32 (0.00 - 0.99)
small birds	0.60 (0.23 – 1.32)	0.44 (0.09 – 0.73)	0.27 (0.11 – 0.60)	1.30 (0.47 – 2.65)
All birds	0.67 (0.23 -1.64)	0.56 (0.09 – 1.01)	0.36 (0.11 – 0.99)	1.62 (0.47 - 3.64)
All bats	1.01 (0.72 – 1.64)	0.33 (0.10 -0.66)	0.21 (0.05 – 0.67)	1.56 (0.86 -2.97)

Fatality rates did not vary significantly among years for birds among the three years of the study but fatality rates were lower for bats during years two and three than for year one (Table 4). There were estimated fatality rates of 0.67 (90% CI 0.19-2.04) birds/MW during the first year of the study, 0.56 (90% CI 0.14-1.87) birds/MW during the second year of the study, and 0.36 (90% CI 0.11-0.99) birds/MW during the third year of the study. For bats, the estimated fatality rate was significantly lower during the second and third years than the first year; there were estimated fatality rates of 1.01 (90% CI 0.72-1.64) bats/MW during the first year of the study versus only 0.33 (90% CI 0.10-0.66) bats/MW during the second year and 0.21 (90% CI 0.05-0.67) bats/MW during the third year.

Table 5. Estimated Fatality Rates (individuals/MW), by Group, for Fall (1 August to 31 October), Winter (1 November to 14 March), Spring (15 March to 31 May), and Summer (1 June to 31 July) for Fall 2009 through Fall 2012. The mean annual fatality rate (mean ann. rate; animals/MW/YR) is given for 1 November 2009 to 31 October 2012.

	2009	2010				2011				2012				
	fall[1]	winter	spring	summer	fall	winter	spring	summer	fall	winter	spring	summer	fall	Mean ann. rate
raptors	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.04	0.00	0.02	0.05
large birds	0.04	0.00	0.02	0.05	0.00	0.00	0.00	0.00	0.13	0.00	0.06	0.00	0.02	0.10
small birds	0.00	0.00	0.28	0.08	0.24	0.00	0.25	0.06	0.12	0.00	0.12	0.00	0.15	0.43
all birds	0.04	0.00	0.30	0.12	0.24	0.00	0.25	0.06	0.25	0.00	0.18	0.00	0.17	0.53
all bats	0.00	0.00	0.00	0.06	0.95	0.00	0.03	0.00	0.30	0.00	0.00	0.06	0.15	0.52

[1] Fall 2009 (14 to 31 October 2009) was a partial season period.

4.5 Pronghorn Antelope and Greater Sage-Grouse Displacement Study

Pellet counts were lower near turbines than at reference sites for pronghorn antelopes but this difference was only statistically significant for the first two of the six surveys. The mean count at surveys adjacent to turbines was significantly lower than reference surveys in October 2009 (0.20 pellets/count, 95% CI 0.13-0.27, at turbines vs. 0.39 pellets/count, 95% CI 0.30-0.48 at reference surveys), May 2010 (0.12, 95% CI 0.06-0.18, pellets/count at turbines vs. 0.36, 95% CI 0.26-0.48, pellets/count at reference surveys) and October 2012 (0.05 pellets/count, 95% CI 0.02-0.08, at turbines vs. 0.15 pellets/count, 95% CI 0.10-0.20 at reference surveys) but not in October 2010 (0.19 pellets/count, 95% CI 0.12-0.27, at turbines vs. 0.27 pellets/count, 95% CI 0.18-0.40 at reference surveys), May 2011 (0.19 pellets/count, 95% CI 0.13-0.26, at turbines vs. 0.22 pellets/count, 95% CI 0.15-0.29 at reference survey) , October 2011 (0.11 pellets/count, 95% CI 0.06-0.17, at turbines vs. 0.18 pellets/count, 95% CI 0.12-0.24 at reference surveys), or May 2012 (0.06 pellets/count, 95% CI 0.03-0.10, at turbines vs. 0.15 pellets/count, 95% CI 0.10-0.21 at reference surveys; Figure 2). Habitat was disturbed (exposed soil) during the October 2009 surveys at 33% of the pellet survey sites near turbines whereas none of the reference sites were disturbed during this period.

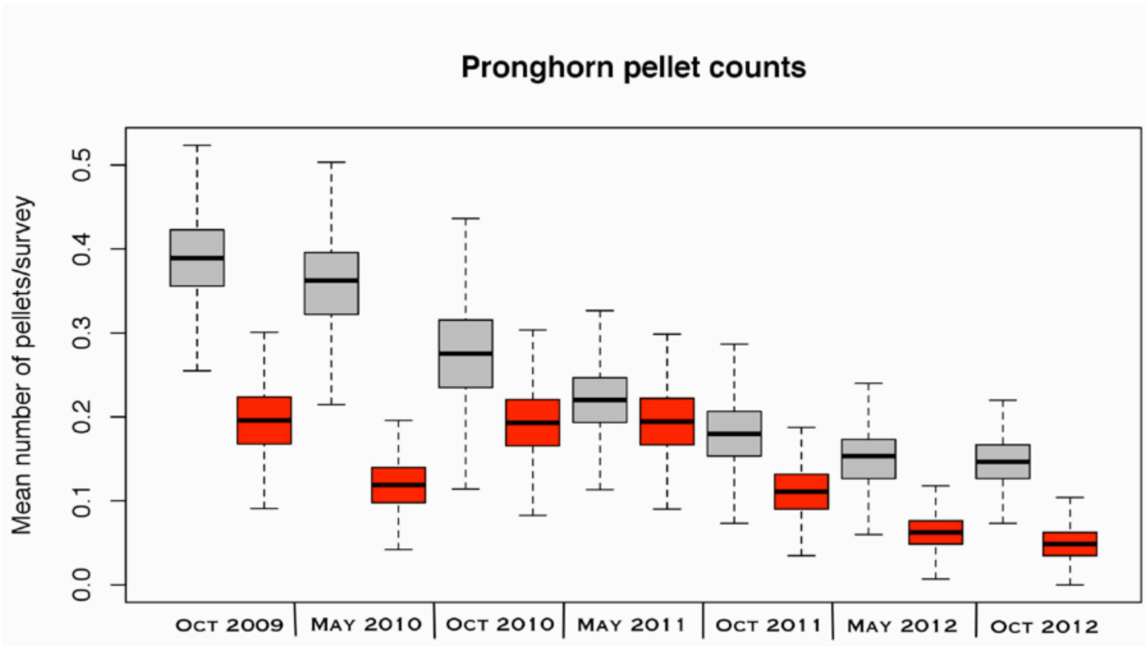

Figure 2. Bootstrapped Data of Pronghorn Antelope Pellet Counts at Reference (grey) and Turbine (red) Sites Collected During October 2009, May 2010, October 2010, May 2011, October 2011, May 2012, and October 2012 (Black line indicates median value, box indicate 25% and 75% percentiles, and whiskers indicate data range).

Greater sage-grouse pellets occurred at very low densities at both turbine and reference sites. The pellet counts for sage-grouse were slightly lower at turbine sites than at reference sites during four of the five surveys, but this difference was not statistically significant for any survey. In October 2009 there were 0.01 pellets/count (95% CI 0.00-0.02) at turbines vs. 0.04 pellets/count (95% CI 0.01-0.07) at reference points, in May 2010 there were 0.00 pellets/count (95% CI 0.00-0.00) at turbines vs. 0.01 pellets/count (95% CI 0.00-0.02) at reference points, in October 2010 there were 0.01 pellets/count (95% CI 0.00-0.02) at turbines vs. 0.03 pellets/count (95% CI 0.01-0.05) at reference points, in May 2011 there were 0.00 pellets/count (95% CI 0.00-0.00) at both turbine and reference points, in October 2011 there were 0.00 pellets/count (95% CI 0.00-0.00) at turbines vs. 0.01 pellets/count (95% CI 0.00-0.02) at reference points , and in May and October 2012 there were 0.00 pellets/count (95% CI 0.00-0.00) at both turbines and reference points (Figure 3).

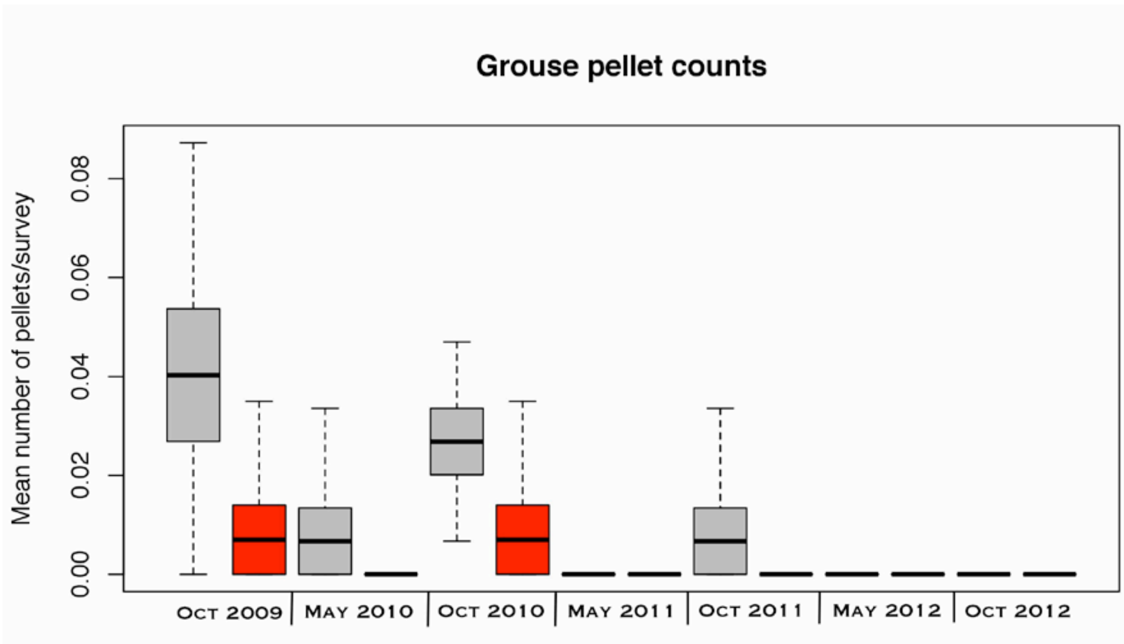

Figure 3. Bootstrapped Data of Greater Sage-Grouse Pellet Counts at Reference (grey) and Turbine (red) Sites Collected During October 2009, May 2010, October 2010, May 2011, October 2011, May 2012, and October 2012 (Black line indicates median value, box indicates 25% and 75% percentiles, and whiskers indicate data range).

5.0 Summary and Conclusions

The mean estimated annual bird fatality rate of 0.53 birds/MW/year at the High Plains and McFadden Ridge I wind energy facility was lower than the average bird fatality rate (1.78 birds/MW/year; Johnson and Stephens 2010) documented in a review of 21 studies of wind facilities in western North America. The estimated annual bird fatality rate was also lower than the range observed in similar studies; for wind energy projects in Montana, Washington, Wyoming, Iowa, Nebraska, and Oregon, bird fatality has ranged from 0.95 to 2.76 birds/MW/year (Erickson et al. 2003, Johnson et al. 2003, Young et al. 2003, Young et al. 2006, Derby et al. 2007, TRC Environmental Corporation 2008, and Jeffery et al. 2009). Fatality rates in this study were higher for small birds (0.43 birds/MW/year) than for large birds (0.10 birds/MW/year), with the majority of carcasses for both small and large birds found during spring and fall migrations. The most common bird species found in this study was the horned lark (25.0% of birds found), which is consistent with other studies of western wind facilities (horned larks comprised 21.8% of 1,247 fatalities in a review of 21 wind facilities; Johnson and Stephens 2010). Passerines are known to comprise the majority of fatalities at wind energy facilities with newer designs, with the peak number of fatalities occurring during seasonal migration (Erickson 2004). Passerines generally fly between 91-610 meters during migration, thereby placing low-flying birds at risk of collision (Morrison 2006). In addition, male grassland birds that engage in aerial displays during courtship, such as the vesper sparrow and horned lark, may also be at risk of colliding with rotor blades during the breeding season (IDNR 2007, Kingsley and Whittam 2003). Four individuals of species with a federally protected status, a bald eagle and three golden eagles (The Bald and Golden Eagle Protection Act), were found during the study. Only one of these four birds was found during a scheduled carcass search so estimates of fatality rates may underrepresent the risk to these birds.

The estimated bat fatality rate of 0.52 bats/MW/year at the High Plains and McFadden Ridge I wind energy project was lower than the average bat fatality rate (2.13 bats/MW/year; Johnson and Stephens 2010) documented in a review of 21 studies of wind facilities in western North America. Similarly, the estimated bat fatality rate was lower than the range observed in similar studies; for wind energy projects in Montana, Washington, Wyoming, Iowa, Nebraska, and Oregon, bat fatality has ranged from 0.8 to 8.93 bats/MW/year (Erickson et al. 2003, Johnson et al. 2003, Young et al. 2003, Young et al. 2006, Derby et al. 2007, TRC Environmental Corporation 2008, and Jeffery et al. 2009). In concordance to what we observed in this study, bat fatalities at wind facilities in western states are typically highest from mid July through September (Johnson 2005).

Also consistent with study findings at other western wind facilities, hoary and silver-haired bats were the most common bat fatalities at the High Plains and McFadden Ridge I wind energy project. Of the over 2,000 bat fatalities reported from studies of 21 wind facilities in western North America, the hoary bat comprised 55.9% of the carcasses and the silver-haired bat comprised 33.1% of the carcasses (Johnson and Stephens 2010); in this study, the hoary bat comprised 57.7% of the bat carcasses and the silver-haired bat comprised 28.8% of the bat carcasses. Hoary and silver-haired bats are migratory, tree-dwelling species. Based on the timing of fatalities for these species and the lack of forest cover near the study location that could potentially provide habitat for resident bats, these bats were likely migrants passing through the area. Bat fatalities at most wind energy facilities in North America are comprised primarily of migrants (Johnson 2005, Arnett et al. 2008).

Estimated bat fatality rates were significantly lower during fall 2011 (0.30 bats/MW, 90% CI 0.10-0.52) and fall 2012 (0.15 bats/MW, 90% CI 0.05-0.34) than during fall 2010 (0.95 bats/MW, 90% CI 0.72-1.32). It is not known what caused this decrease. Bats are known to have the highest activity rates and thus be the most susceptible to turbine strikes on nights with low (3-5 m/s or 7-11 mph) wind speeds (Arnett et al. 2011). It is possible local weather conditions during fall 2010 led to higher fatality rates during this period.

The pellet count data suggested habitat disturbance near turbines and/or displacement by pronghorns from turbine sites during late 2009 and early 2010 with the level of disturbance declining over time. The apparent avoidance of turbine sites by pronghorns observed in this study was likely in part due to habitat disturbance at the turbine survey sites, with 33% of the turbine sites disturbed whereas none of the reference sites were disturbed. Although all seven surveys had lower pellet counts at turbine than at reference plots, in four out of five of the most recent surveys (October 2010, May 2011, October 2011, May 2012) this difference was not statistically significant. Walter et al. (2006) found that elk in Oklahoma were displaced from the wind development area immediately after construction; displacement gradually decreased but was still elevated above pre-construction levels. However, although displacement and some loss of habitat was apparent, elk in the Walter et al. (2006) study were not adversely affected by wind-power development as determined by home range size and dietary analysis.

Sage grouse pellet counts were lower at turbine plots in four of the six surveys but this difference was not statistically significant for any of the surveys. Sage grouse pellet counts were counted in low numbers at both the reference and turbine survey plots, possibly due to the marginal quality of habitat at the surveyed sites. The survey plots were located in habitat characterized by short grasses and sparse sagebrush, areas that are likely to be low quality habitat for this species (Schroeder et al. 1999).

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