Avian and Bat Mortality During the First Year of Operation at the Klondike Phase I Wind Project, Sherman County, Oregon

DRAFT

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INTRODUCTION AND BACKGROUND

Wind has been used to commercially produce energy in the U.S. since the early 1970's (American Wind Energy Association [AWEA] 1995). Recent advances in wind turbine technologies have reduced costs associated with wind power production, improving the economics of wind energy development (Hansen *et al.* 1992). Wind power produced in the United States in 2001 was comparable in price to conventional power produced using natural gas (AWEA 2001). Commercial wind energy plants have been constructed in 26 states (Anderson *et al.* 1999, AWEA 2002a), and total wind power capacity in the United States increased from 10 megawatts (MW) in 1981 to 4,261 MW in 2001, which is enough to supply the electricity needs of approximately 3.2 million homes (AWEA 2002b). Over 2000 MW of new wind projects have been proposed for 2003 (AWEA 2002c). To date, most wind power development in the U.S. has occurred in California and Texas, but greater than 90% of the wind power potential in the U.S. exists within the Midwestern and western states (Weinberg and Williams 1990).

Although development of renewable energy sources is generally considered environmentally friendly, wind power development has been associated with the deaths of birds colliding with turbines and other wind plant structures, especially in California (Erickson *et al.* 2001). Bat collision mortality has also recently become an issue at some wind plants (Johnson 2003). As a result of these concerns, state and federal agencies have required monitoring of many new wind development areas to assess the extent of and potential for avian and bat collision mortality.

In January 2001, Northwestern Windpower completed development of a 16 turbine 24-megawatt (MW) wind plant on private land in Sherman County, Oregon (Figure 1). A one-year baseline study was conducted at this site prior to wind plant development to assess the potential for bird, bat and sensitive species impacts (Johnson *et al.* 2002a).

The Monitoring Plan used for this study was developed in response to the Sherman County conditional use permit conditions, and through input from both the Oregon Department of Fish and Wildlife and the Central Oregon Audubon Society (COAS). Components of the monitoring study included: (1) fatality monitoring using standardized carcass searches, scavenging and searcher efficiency trials, and a protocol for handling and reporting of fatalities and injured wildlife found by maintenance personnel, (2) a ground survey of existing raptor nests identified during 2001 helicopter surveys within three miles of project features, and (3) formation of a Technical Advisory Committee (TAC) made of stakeholders for review of monitoring protocols and results and mitigation measures and making recommendations to Sherman County, which retains jurisdiction over the Monitoring Plan. The monitoring study was conducted for one full year. The protocol for the fatality monitoring study was similar to protocols used at the Vansycle Wind Plant in northeastern Oregon (Erickson *et al.* 2000), the Stateline Wind Plant in Oregon and Washington (FPL *et al.* 2001), the Buffalo Ridge Wind Plant in southwestern Minnesota (Johnson *et al.* 2000a), and the SeaWest Wind Plant in Wyoming (Johnson *et al.* 2000b).

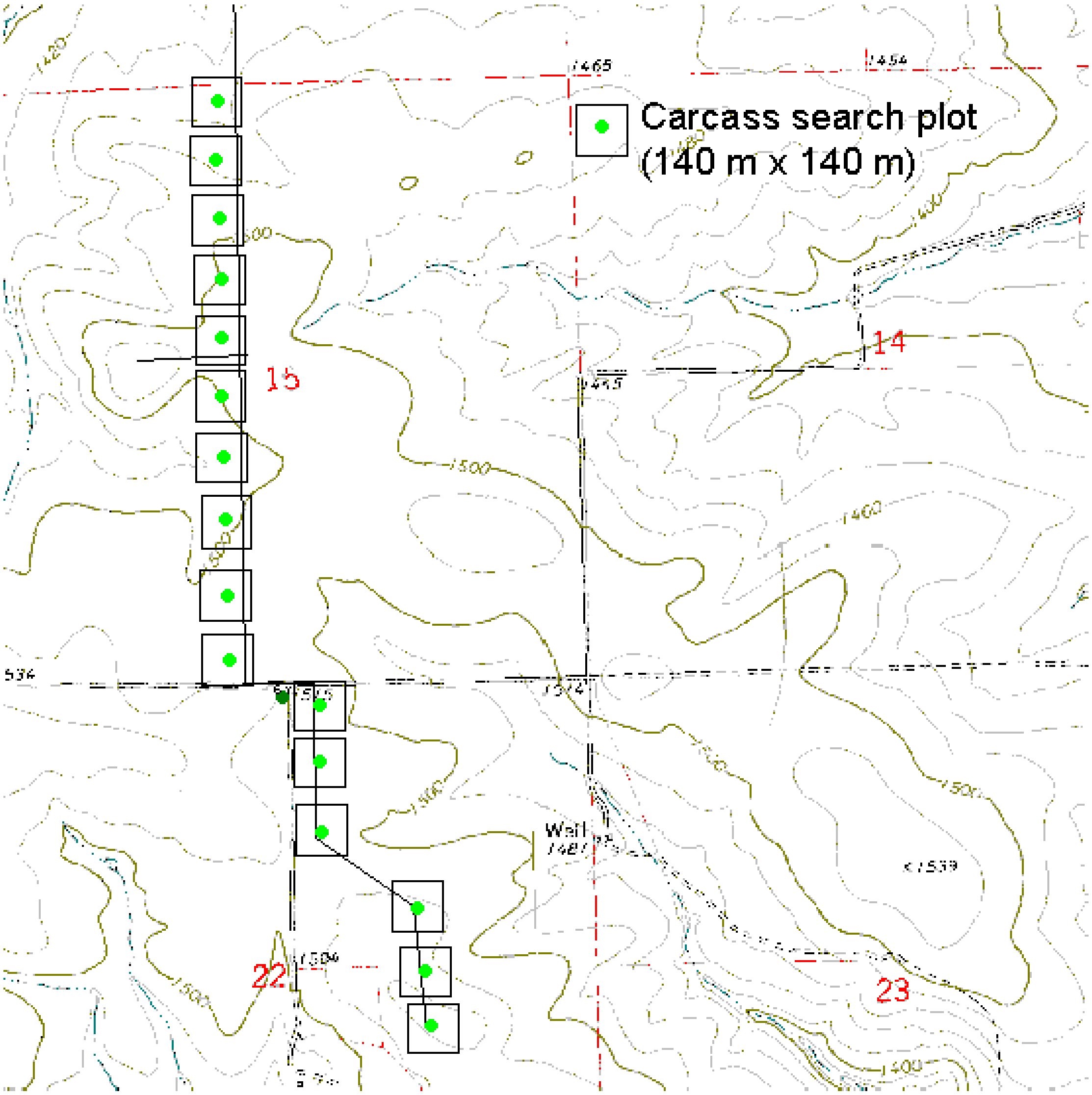

Figure 1. Carcass search plots for the Klondike Wind Project.

STUDY AREA

The Project area is within the Columbia Basin Physiographic Province. The study area (referred to herein as the "Project area") is 3 miles directly east of Wasco and approximately 7.5 miles south of the Columbia River. The initial Project consists of 16 turbines placed in Sections 10, 15 and 22, Township 1 N, Range 18 E (Figure 1). The turbines are 1.5-megawatt Enron turbines with rotor-swept heights of approximately 30 to 100 m above ground.

The original vegetation of this area was the bluebunch wheatgrass-Idaho fescue zonal association, which was predominately grassland and shrub-steppe with deciduous riparian forest and scrub along drainages (Franklin and Dyrness 1973). Agriculture and livestock grazing have converted the area to a mosaic of grazed shrub-steppe, Conservation Reserve Program ("CRP") fields, and cultivated wheat fields. CRP fields are areas that had previously been farmed, but have been seeded to grasslands for a minimum of 10 years to reduce soil erosion. Most of the Project area is cultivated wheat. Minor habitat types in the vicinity include wooded drainages and woodlots associated with abandoned and occupied farmsteads. Thirteen of the 16 turbines in the first phase were placed within wheat fields and the remaining three (turbines 11-13) were placed within a narrow strip of CRP.

METHODS

The fatality monitoring phase of the study began once all the turbines were constructed and operational. The primary objective of the fatality studies was to estimate the number of avian and bat fatalities attributable to wind turbine collisions for the entire Project. The study was conducted for one full year. The study consisted of four components: 1) standardized carcass searches, 2) an incidental casualty and injured bird reporting system, 3) scavenging/carcass removal trials; and, 4) searcher efficiency trials. Other operations-related bird and bat fatalities may occur such as meteorological (met) tower collisions and vehicle strikes. The study included searches of the permanent met tower and reporting of other fatalities and injured animals that were discovered incidental to conducting other tasks.

The number of avian and bat fatalities attributable to the Project was estimated based on the number of avian and bat fatalities found in the Project area whose death appeared to be related to the Project. All carcasses located within areas surveyed, regardless of species, were recorded. An estimate of the total number of avian and bat mortalities within the search areas was made by adjusting for "removal bias" (scavenging) and searcher efficiency bias. For carcasses where the cause of death was not apparent, the fatality was conservatively attributed to the Project.

We used the following dates to define seasons for this study:

Spring Migration	March 16 – May 15
Summer/Breeding	May 16-August 15
Fall Migration	August 16-October 31
Winter	November 1-March 15

The first search was conducted within one week after the date all turbines become operational (commercially producing electricity) to clear the plots of evidence of old carcasses and document fatalities that may have occurred during the testing and early operational phase. Subsequent searches were conducted at intervals of approximately 28-30 days. A total of 13 searches were conducted at each turbine and the one permanent met tower during the monitoring year.

Standardized Carcass Searches

Personnel trained in proper search techniques conducted the carcass searches. Boundaries of square plots 140 m on a side and centered on the turbine were delineated (Figure 1). The areas within these plots that were within the lease boundaries of the project were searched by walking parallel transects. Studies at the Vansycle Wind Plant (Erickson *et al.* 2000), the Buffalo Ridge Wind Plant (Johnson *et al.* 2002, 2003, Higgins *et al.* 1996) and the Foote Creek Rim Wind Plant

(Johnson *et al.* 2000b) indicate nearly all fatalities are found in this area, with a large majority of carcasses found within 40 meters of the turbine. Transects were initially set at 6 meters apart in the area to be searched, and searchers walked at a rate of approximately 45-60 meters a minute along each transect searching both sides out to five meters for casualties (Johnson *et al.* 1993). Search area and speed were adjusted by habitat type after evaluation of the first searcher efficiency trial. It took approximately 45 to 90 minutes to search each turbine depending on the habitat type.

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

- Intact – a carcass that is completely intact, is not badly decomposed, and shows no sign of being fed upon by a predator or scavenger.
- Scavenged – an entire carcass which shows signs of being fed upon by a predator or scavenger, or a portion(s) of a carcass in one location (e.g., wings, skeletal remains, legs, pieces of skin, etc.).
- Feather Spot - 10 or more feathers at one location indicating predation or scavenging.

All carcasses found were labeled with a unique number, bagged and frozen for future reference and possible necropsy. A copy of the data sheet for each carcass was maintained, bagged and frozen with the carcass at all times. For all casualties found, data recorded included species, sex and age when possible, date and time collected, location, condition (e.g., intact, scavenged, feather spot), and any comments that may indicate cause of death. All casualties were photographed as found.

Casualties or fatalities found by maintenance personnel and others not conducting the formal searches were documented using a wildlife incidental reporting system. When carcasses of animals were discovered by non-study personnel, a Project Biologist was contacted to identify and collect the casualty. Personnel involved in searches received training prior to working in the wind plant. Appropriate wildlife salvage permits were obtained from the Oregon Department of Fish and Wildlife and the U.S. Fish and Wildlife Service.

Northwestern Wind Power's Wildlife Reporting and Handling System for Incidental Fatality and Injured Bird Discoveries

Northwestern Wind Power's Wildlife Reporting and Handling System (WRHS) is a monitoring program for reporting and handling avian and bat casualties or injured wildlife found by maintenance personnel. Construction and maintenance personnel were trained in the methods. This monitoring program includes reporting of carcasses discovered incidental to construction and maintenance operations. This system will be in place for the life of the project.

Carcass Removal Trials

Carcass removal studies were conducted during each season near the carcass search plots. Estimates of carcass removal were used to adjust carcass counts for removal bias. Carcass removal includes removal by predation or scavenging, or removal by other means such as being plowed into a field.

Carcass removal trials were spread throughout the year to account for changes in weather, climatic conditions, farming practices, and scavenger densities. The planted carcasses were located randomly within the carcass removal trial plots. Carcass removal trial plots were located outside the carcass search areas to avoid confusing trial carcasses with actual wind plant related fatalities.

For each trial, eight carcasses of birds of two size classes (four small, and four medium to large) were distributed within two habitat types (CRP grassland and cultivated agriculture). There were eight trials, resulting in 64 trial carcasses used in carcass removal studies for the monitoring year. Small carcasses (i.e., house sparrows, western meadowlark) were used to simulate passerines and rock doves, chukars and mallards were used to simulate medium to large birds such as raptors, game birds and waterfowl. Carcasses were checked for a period of 28 days to determine removal rates. They were checked every day for the first 4 days, and then on Day 7, Day 14, Day 21, and Day 28. At the end of the 28-day period any remaining birds were removed.

Searcher Efficiency Trials

Searcher efficiency studies were conducted in the same areas carcass searches occurred. Trials were conducted throughout the year. Searcher efficiency was estimated by major habitat type (CRP grassland and cultivated agriculture), size of carcass and season. Estimates of searcher efficiency were used to adjust the number of carcasses found, correcting for detection bias.

Personnel conducting searches did not know when trials were scheduled to be conducted. Before the beginning of a standardized carcass search, observer detection trial carcasses were placed at random locations. Each carcass was discreetly marked so that it could be identified as an efficiency trial carcass after it was found. The number and location of the trial carcasses found during the carcass search were recorded. The number of efficiency trial carcasses available for detection during each trial was determined immediately after the trial by the person responsible for distributing the carcasses. Approximately eight carcasses were used during each trial. Carcasses of birds of two different size classes (same classes as in removal studies) were placed in the search area throughout the search period for the searcher to either detect or not detect, resulting in 72 searcher efficiency trial carcasses over the entire year. Small brown birds (house sparrows) were used to simulate bat carcasses.

Statistical Methods

The estimate of the total number of wind facility-related fatalities was based on:

(1) Observed number of carcasses found during standardized carcass searches.
(2) Searcher efficiency expressed as the proportion of planted carcasses found by searchers
(3) Non-removal rate expressed as the length of time a carcass is expected to remain in the study area and be available for detection by the searchers

The following variables and their symbols are used in the equations in the following sections:

c_i the number of carcasses detected at plot i for a study period of one year
n the number of search plots
k the number of turbines searched
$\bar{c}$ the observed average number of carcasses per turbine per year
s the number of carcasses used in removal trials

s_c — the number of carcasses in removal trials that lasted 28 days or longer before being removed

se — abbreviation for standard error, which is the square of the sample variance of the mean

t_i — the time (days) a carcass remains in the study area before it is removed

$\bar{t}$ — the average time (days) a carcass remains in the study area before it is removed

d — the total number of carcasses placed in searcher efficiency trials

p — the estimated proportion of searcher efficiency trial carcasses found by searchers

N — the total number of turbines in the facility

I — the average interval between searches in days

$\hat{p}_i$ — the estimated probability a carcass is available to be found during a search and is found

m_i — the estimated annual number of fatalities, adjusted for removal and observer detection bias

Observed Number of Carcasses

The estimated average number of carcasses ($\bar{c}$) observed per turbine per year is:

$$\bar{c} = \frac{\sum_{i=1}^{n} c_i}{k}. \qquad (1)$$

The final estimate of $\bar{c}$ and its standard error were calculated using bootstrapping (Manly 1997). Bootstrapping is a computer simulation technique that is useful for calculating point estimates, variances and confidence intervals for complicated test statistics. For each iteration of the bootstrap, the 16 plots were sampled with replacement, and $\bar{c}$ was calculated. A total of 5000 bootstrap iterations were used. The reported estimate is the mean of the 5000 bootstrap estimates. The standard deviation of the bootstrap estimates of $\bar{c}$ is the estimated standard error of $\bar{c}$ (se($\bar{c}$)).

Estimation of Carcass Removal

Estimates of carcass removal were used to adjust carcass counts for removal bias. Mean carcass removal time ($\bar{t}$) is the average length of time a carcass remains at the site before it is removed:

$$\bar{t} = \frac{\sum_{i=1}^{s} t_i}{s - s_c}. \qquad (2)$$

This estimator is the maximum likelihood estimator assuming the removal times follow an exponential distribution and there is right-censoring of data. In our application, any trial carcasses still remaining at 28 days were collected, yielding censored observations at 28 days.

The final estimate of $\bar{t}$, the estimated standard error, and 90% confidence limits were calculated using bootstrapping. For each iteration of the bootstrap, the removal times for the trial birds were sampled with replacement, and $\bar{t}$ was calculated. A total of 5000 bootstrap iterations were used. The standard deviation of the bootstrap estimates of $\bar{t}$ is the estimated standard error of $\bar{t}$ (se ($\bar{t}$)). Removal rates were estimated by carcass size (small and large) and season.

Estimation of Searcher Efficiency

Searcher efficiency rates were expressed as *p*, the proportion of trial carcasses that were detected by searchers. The standard error (square of variance) and 90% confidence limits were calculated by bootstrapping. A total of 5000 bootstrap iterations were used. Searcher efficiency rates were estimated by carcass size and season.

Estimation of the Total Number of Facility-Related Fatalities

To calculate the total number of facility-related fatalities, the actual number of fatalities found was divided by an estimate of the probability a casualty was available to be picked up during a fatality search (probability it was not removed by a scavenger), and was observed (probability of detection). The estimated total number of annual facility-related fatalities (*m*) is calculated by:

$$m_2 = \frac{N * \bar{c}}{\hat{p}_2} \qquad (3)$$

where $\hat{p}_2$ is calculated assuming the carcass removal times (t_I) follow an exponential distribution.

We calculated fatality estimates for (1) small birds, (2) large birds, (3) all birds and (4) bats. The final reported estimates of *m* and associated standard errors and 90% confidence intervals were calculated using bootstrapping (Manly 1997) based on a computer program written in SAS.

Raptor Nest Surveys

Active raptor nests (Swainson's hawk, red-tailed hawk and great horned owl) documented within 3 miles of the turbine strings during the 2001 helicopter surveys were visited from the ground during the breeding season in 2002 to determine activity and reproduction.

RESULTS

Birds

Eight fatalities comprised of seven species of birds were found associated with operational wind turbines during the study (Table 1). No fatalities were found at the meteorological tower during the study. Of the eight turbine fatalities, six were passerines and two were Canada geese. The passerines included European starling, brown-headed cowbird, house wren, golden-crowned kinglet, ruby-crowned kinglet, and dark-eyed junco. No raptor mortalities were found during the study.

Five of the fatalities were intact and three were scavenged. All passerine fatalities were found during scheduled fatality searches; the two geese were found by maintenance personnel and were not found during a scheduled search by study personnel. Dead birds were found from 1 m to 72 m away from turbines, and the mean distance was 31 m. Based on the distribution of bird fatalities surrounding turbines, the plot size established for searching was adequate to detect all fatalities (see Gauthreaux 1996).

Inclement weather did not appear to be related to any of the passerine mortalities. Weather was likely a factor in the two Canada goose collision fatalities. Both birds were fresh and it had been foggy and rainy during the previous 24-hour period. Inclement weather has also been identified as a contributing factor in avian collisions with other obstacles, including power lines, buildings, and communications towers (Estep 1989, Howe *et al*. 1995). Nine of the 16 turbines have FAA airplane warning lights that flash white during the day and red after dark. Presence of Federal Aviation Administration (FAA) lighting on turbines did not appear to be related to mortality; only one of the eight birds (the European starling) was found at a lighted turbine.

Table 1. Avian and bat fatalities associated with Phase 1 of the Klondike Wind Plant, February 2002 through February 2003.

Date	Species	Age	Sex	Turbine	Habitat	Condition	Found during Search?	Distance from turbine	Direction from turbine
Birds									
2/14/02	European Starling	A	U	T5	Plowed	Intact	Yes	33	92
8/09/02	Brown-headed Cowbird	J	U	T15	Plowed	Intact	Yes	72	278
8/24/02	House Wren	A	U	T10	Wheat Stubble	Scavenged	Yes	37	250
10/06/02	Golden-crowned Kinglet	A	U	T8	Wheat Stubble	Intact	Yes	19	245
10/18/02	Ruby-crowned Kinglet	A	U	T15	Plowed	Intact	Yes	55	250
11/02/02	Dark-eyed Junco	A	U	T2	Turbine Pad	Intact	Yes	29	236
12/28/02	Canada Goose	A	U	T10	Turbine Pad	Scavenged	No	1	360
12/28/02	Canada Goose	A	U	T10	Turbine Pad	Scavenged	No	3	360
Bats									
5/18/02	Silver-haired Bat	A	U	T13	Fallow	Intact	Yes	30	229
6/17/02	Unidentified *Myotis*	A	U	T15	Plowed	Intact	Yes	8	90
6/29/02	Unidentified *Myotis*	A	U	T6	Turbine Pad	Scavenged	Yes	10	245
9/09/02	Hoary Bat	A	U	T11	CRP	Scavenged	Yes	27	234
9/16/02	Hoary Bat	A	U	T15	Turbine Road	Scavenged	No	15	45
9/20/02	Hoary Bat	A	U	T3	Plowed	Intact	Yes	15	300

Three of the dead birds were found on turbine pads, three were found in plowed fields, and two were found in wheat stubble. Timing of the mortality suggests that the European starling and brown-headed cowbird were local residents. Based on the species, date found, and habitat, the other four passerines were likely fall migrants. Most of these birds were likely nocturnal migrants that collided with turbines at night.

There was some correlation between the species of turbine fatalities and the turbine exposure index we developed based on observations during the baseline study (Johnson *et al*. 2002a) in that Canada goose had the highest predicted risk of any species in the area. There was little relationship between the exposure index and species of passerine mortalities. This was expected because the exposure index was developed using data on avian abundance and flight behavior collected during daylight hours, which likely differ substantially from abundance and flight behavior of nocturnal migrants.

Bats

Six dead bats were found during the study (Table 1), including three hoary bats, one silver-haired bat, and two unidentified *Myotis* species that were too decomposed to allow for positive identification. All three hoary bat fatalities were found in September, the silver-haired bat was found in May and the two unidentified *Myotis* bats were found in June. All but one of the bats were located during scheduled fatality searches. Three of the bats were intact and three were scavenged. Virtually all scavenging of bat carcasses was done by insects. Two of the bats were found on the turbine pad or access road, two were found in plowed fields, one was found in CRP and one was found in a fallow field. Distances bats were found from turbines ranged from 8 m to 30 m, with an average of 17.5 m. Based on distribution of bat fatalities surrounding turbines, the search plot was more than adequate to detect all bat fatalities associated with turbines (Gauthreaux 1996).

With the exception of silver-haired bat, which is a species of special concern in Oregon, the identified species of bats found associated with turbines appear to be relatively common in the state. As was the case for songbirds, inclement weather did not appear to be related to bat mortality. One bat was found following a rainstorm but the other five apparently collided with turbines under clear weather conditions. Presence of FAA lighting did not appear to be related to bat fatality rates, as three bats were found at lighted and three were found at unlit turbines.

Fatality Search Biases

Searcher Efficiency

During the study, 72 birds were placed for searcher efficiency trials, divided equally among small and large birds (Table 2). Searcher efficiency remained fairly consistent between seasons and varied by size class of bird. For all habitats combined, 75% of the small birds and 92% of the large birds were detected. The overall detection rate for all bird size classes and habitats combined was 83%. Detection rates were higher than most other studies because of the habitat conditions surrounding turbines. Throughout the study, the gravel turbine pads were surrounded by plowed agricultural fields or wheat stubble because wheat crops were not produced adjacent to the turbines. As a result, visibility was excellent within the search plots throughout the study.

Table 2. Number of birds detected during searcher efficiency trials.

		Large Birds			**Small Birds**	
Season	# Placed	# Found	%Found	# Placed	# Found	% Found
Fall	4	4	100	4	3	75
Winter	12	9	75	12	8	67
Spring	4	4	100	4	3	75
Summer	16	16	100	16	13	81
Overall	36	33	92	36	27	75

Carcass Removal Rates

Sixty-four bird carcasses were used for scavenger removal trials during the study. The mean length of time that carcasses remained in the study area prior to removal was 14.2 days for small and 19.9 days for large carcasses. After seven days in the field, 81% of the large and 59% of the small carcasses remained. By Day 28, 22% of the large and 16% of the small carcasses remained (Figure 2). Potential scavengers observed during the baseline study included raptors, turkey vultures, common ravens, gulls, coyotes and badgers. During summer, the main cause of small carcass removal was scavenging by insects, primarily maggots and carrion beetles.

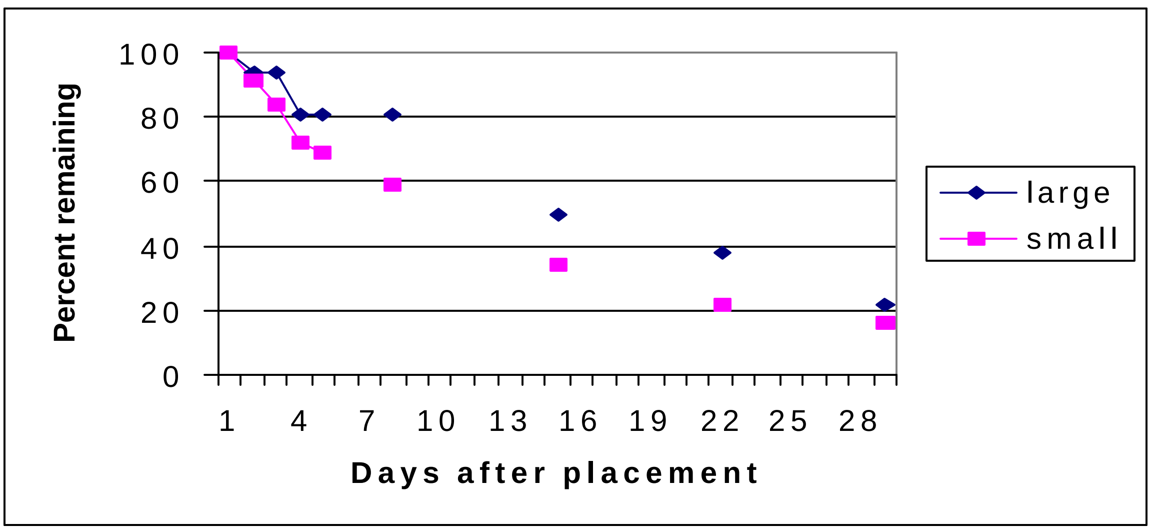

Figure 2. Mean proportion of bird scavenger trial carcasses available for detection over the 28-day interval between carcass searches.

Estimation of the Number of Turbine-Related Fatalities

Birds

Estimated total avian mortality over the one-year study period for the entire windplant was 4 (90% confidence interval [CI] = 2 – 12) large birds, of which none were raptors, and 19 (90% CI = 7 - 34) small birds, for a total of 23 birds (Table 3). The mean number of birds killed per turbine over the 1-year study period was estimated to be 0.26 (90% CI = 0.13 – 0.75) large birds and 1.16 (90% CI = 0.41 – 2.11) small birds, for a total of 1.42 birds per turbine per year.

Bats

Estimated total bat mortality over the one-year study period was 19 (90% CI = 7 - 34) (Table 3). The mean number of bats killed per turbine over the 1-year study period was estimated to be 1.16 (90% CI = 0.41 – 2.12).

Table 3. Annual fatality rate estimates

Group	Number of Fatalities found	Total Mortality Estimate	90% Confidence Interval	No. fatalities per turbine per year	90% Confidence Interval
Small birds	6	18.6	6.5 – 33.7	1.16	0.41 – 2.11
Large birds	2	4.1	2 – 12.0	0.26	0.13 – 0.75
Bats	6	18.6	6.5 – 33.9	1.16	0.41 – 2.12

Raptor Nest Occupancy Near the Wind Plant

Five active raptor nests (2 red-tailed hawk, 2 Swainson's hawk, 1 great horned owl) were documented within 3 miles of the Phase I wind plant during aerial surveys in 2001. The status of these nests was checked on May 8, 2002. The red-tailed hawk nest located about 2.5 miles north of the Phase I turbine string in the NW NW SW of Section 34, T2N R18E was active. The other red-tailed hawk nest located about 1.75 miles east of the turbine strings in the NW NW SW of Section 12, T1N R18E was not active. The great horned owl nest located 1.6 miles east of the turbine strings in the SE NE NE of Section 14, T1N, R18E did not appear to be active. The Swainson's hawk nest located about 3 miles west of the turbine strings in the SE SW SE of Section 19, T1N R18E was apparently not active. The nest closest to the turbine string was a Swainson's hawk nest located 0.25 miles northwest of the turbine strings in the SE NE SW of Section 10, T1N R18E. This nest was active on May 8, 2002 (a Swainson's hawk was incubating eggs on that date). In addition to being within 0.25 miles of the turbine string, this nest was also within 0.25 miles of the access road and O&M facility for the Phase I project.

DISCUSSION

Our data suggest that wind plant-related avian mortality at Klondike is low and involves both resident birds and nocturnal migrant passerines. Mortality of resident breeding birds appears very low, involves common species, and would not likely have any population consequences within the area. The only species with more than one casualty (Canada goose) was found to be very abundant in the area during the baseline study. Over a 1-year period, 4,845 individuals were observed flying over the project area, mostly in the winter. The Canada goose collision fatality rate is very low in view of the large number of birds using the area, and would not have any population consequences. The nocturnal migrant passerine fatalities all occurred in the fall.

The estimated collision rates for all bird species at Klondike are among the lowest of any wind plant studied in the U.S. (Table 4). Only the Vansycle, Oregon windplant (25 MW facility owned and operated by FPL Energy), which is located in a similar wheat farming setting, has lower bird collision rates than Klondike. Klondike is also one of the few wind plants studied where no raptor fatalities were documented. Furthermore, the rotor swept area of each 1.5 MW GE turbine (3848 m^2) at the Klondike facility is approximately 2.3 times larger than the rotor swept area of the 660 kW Vestes turbine (1661 m^2) at the Vansycle facility. Therefore, fatality rates on a per rotor swept area equivalence basis are nearly identical for the two wind projects.

Table 4. Estimated avian collision fatality rates at U.S. wind plants

Wind Resource Area	# raptors/turbine/year	# birds/turbine/year	Reference
Klondike, OR	0	1.42	This study
Vansycle, OR	0	0.63	Erickson *et al*. 2000
Buffalo Ridge, MN	0.002	2.83	Johnson *et al*. 2000a
Foote Creek Rim, WY	0.036	1.75	Johnson *et al*. 2000b Young *et al*. 2003
Altamont, CA	0.007-0.100 (mean=0.048)	--	Howell and Didonato 1991 Orloff and Flannery 1992 Thelander 2000
Montezuma Hills, CA	0.048	--	Howell and Noone 1992
San Gorgonio, CA	0.01	2.31	McCrary *et al*. 1986
Wisconsin	0	1.29	Howe *et al*. 2002
Buffalo Mountain, TN	0	7.7	Nicholson 2003

Table 5. Estimated bat collision fatality rates at U.S. wind plants.

Wind Resource Area	Bat mortalities per turbine per year	Reference
Klondike, OR 16 turbines	1.2	This study
Buffalo Ridge, MN 281 turbines	2.0	Johnson *et al*. 2003a&b
Northeastern Wisconsin 31 turbines	4.3	Howe *et al*. 2002
Foote Creek Rim, WY 105 turbines	1.3	Johnson *et al*. 2000b, Young *et al*. 2003, Gruver 2002
Buffalo Mountain, TN 3 turbines	28.5	Nicholson 2003
Vansycle, OR 38 turbines	0.7	Erickson *et al*. 2000

The estimated bat collision rate at Klondike is slightly higher than other regional windplants including the Vansycle, Oregon wind plant; however, it is lower than most other wind plants studied across the U.S. (Table 5). On a per rotor swept area equivalence basis, the bat collision rate at the Klondike wind project is less than at the Vansycle wind project. Results of the post-construction monitoring indicate that avian and bat fatality rates are minimal, and that the windplant has apparently not resulted in displacement of breeding raptors.

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