Puget Sound Energy
Hopkins Ridge Wind Project Phase 1
Post-Construction Avian and Bat Monitoring
First Annual Report

January - December 2006

Prepared for:

Puget Sound Energy
153 E. Main St.
Dayton, Washington 99328

and the

Hopkins Ridge Wind Project
Technical Advisory Committee
Columbia County, Washington

Prepared by:

David P. Young, Jr., Wallace P. Erickson, Jay D. Jeffrey,
and Victoria K. Poulton
Western **E**co**S**ystems **T**echnology, Inc.
Cheyenne, Wyoming, & Walla Walla, Washington

WEST, Inc.

March 28, 2007

EXECUTIVE SUMMARY

The Hopkins Ridge Wind Project is located in the rolling hills south and west of the Tucannon River and northeast of Dayton, Columbia County, Washington. Phase I of the wind project consists of 83 Vestas 1.8 MW turbines with a total nameplate capacity of approximately 150 MW. Due to concern over potential impacts from the wind project development, Puget Sound Energy with the assistance of a Technical Advisory Committee developed a post-construction study plan to monitor impacts to birds and bats over a minimum of two years. The first year of monitoring surveys were conducted on the site between January and December 2006.

The primary objective of the monitoring study is to estimate the number of avian and bat casualties attributable to collisions with wind turbines and meteorological towers for the entire project on an annual basis. The monitoring study consists of four components: (1) standardized carcass searches of selected turbines or turbine strings to measure observed casualty rates; (2) searcher efficiency trials to estimate the percentage of carcasses found by searchers; (3) carcass removal trials to estimate the length of time that a carcass remains in the field for possible detection; and (4) a Wildlife Incident Reporting and Handling System for wind project personnel to handle and report casualties found in the project area incidentally to the study.

Carcass searching surveys took place at 41 turbines and two permanent met towers. Search plots were 180 meters on a side (90 meter radius from the tower turbine) and centered on the turbine. Surveyors walked parallel transects within the search plot spaced approximately 6-12 meter apart while scanning the ground for fatalities or injured birds or bats. Standardize searches of all selected turbines and the met towers (43 plots) were conducted once every four week (28 day) period. During the spring and fall migration periods, a sub-set of 22 of the selected turbines were searched once a week.

A total of 865 plot searches were conducted over the one year monitoring study period (January-December 2006). Thirty-eight bird fatalities comprised of 17 identified species and two unidentified species were found and 19 bat fatalities comprised of four species and one unidentified bat were found. Bird fatalities were found near 25 different turbines; bat fatalities were found near 14 different turbines. The average distance of bird casualties to the nearest turbine was 45 meters; the average distance of bat casualties to the nearest turbine was 26 meters. No bird or bat carcasses were found that were attributed to the met towers.

Passerines comprised 60% and upland gamebirds comprised 18% of the avian fatalities. Ring-necked pheasant and European starling, two introduced species, were the most common bird fatalities with seven (18%) each. Horned lark was the most common native species with six (15%) fatalities. Including the unknown passerines as possible migrants, approximately 61% of the passerines were considered resident and 39% were likely migrants; 26% of all avian fatalities found were considered nocturnal migrants. Three species of raptors, American kestrel (3), northern harrier (1) and Cooper's hawk (1) were found. No Federal or State Threatened or Endangered species were found during the study. Fatality rate was highest in the winter (37%), followed by the spring (26%), summer (21%) and fall (16%). No increase in fatalities was observed during the spring and fall migration seasons. There was no strong concentration of

avian fatalities within the search plots. One turbine (T59) had four fatalities and three turbines (T17, T28, T74) had three fatalities. Most turbine searches produced no fatalities.

Bat fatalities were found between April 28 and October 26, 2006. Thirteen (68%) of the bat fatalities occurred during the months of August or September, which is considered the fall migration season for bats. Five (26%) occurred during the spring and one fatality was found in July. Silver-haired bat comprised 63% and hoary bat 21% of the bat fatalities. One little brown bat, one big brown bat, and one unidentified bat made up the remainder of the bat fatalities. There did not appear to be any strong concentrations of bat fatalities within the search plots.

Overall fatality estimates were calculated by adjusting for carcass removal and observer detection bias. The estimated number of all bird fatalities per turbine per year was 2.21 and the lower and upper 90% confidence limits around this estimate were 1.64 and 2.92. The estimated number of small bird fatalities per turbine per year with 90% confidence limits was 1.45 (0.93, 21.4) and large bird fatalities per turbine per year was 0.76 (0.42, 1.17). European starling and ring-necked pheasant were the most commonly observed fatalities with an estimated fatality rate of 0.37 per turbine per year. Excluding starlings (a non-protected species) and ring-necked pheasant (an introduced non-native species), the overall estimate and 90% confidence limits are approximately 1.47 (0.98, 2.02) bird fatalities per turbine per year. Ten fatalities were found which were considered nocturnal migrants; the estimated number of nocturnal migrant fatalities per turbine per year was 0.82 (0.38, 1.44).

Adjustments for carcass removal and observer detection bias for bats were made using the estimates for small birds. The estimated number of bat fatalities per turbine per year and associated 90% confidence limits was 1.13 (0.69, 1.71).

Fatality estimates for birds and bats from the study are similar to other wind projects in the region. All fatalities found were assumed to be wind project related so the estimate of avian mortality is an over-estimate of actual wind project mortality. In order to compare Hopkins Ridge to other wind projects with different turbines, the fatality rates were standardized on a per MW capacity basis. For Hopkins Ridge the estimate was 1.23 birds per MW per year. This estimate was lower than the nearby Combine Hills (2.56 bird fatalities per MW) and Stateline (2.90 fatalities per MW) projects, and the overall average for new generation wind projects in the U.S of 3.1 fatalities per MW. The Hopkins Ridge bat fatality rate of 0.63 per MW capacity per year is also lower than Combine Hills (1.88 per MW) and Stateline, (1.70 per MW), and the average rate for new generation wind projects in the west and mid-west of 2.10 per MW.

Species composition for bird and bat fatalities was similar to composition at other wind projects in the Pacific Northwest with horned lark making up the majority of the native avian fatalities and silver-haired bat the majority of bat fatalities. When grouped together, upland gamebirds were also common fatalities. The raptor fatality rate was slightly higher than other regional wind projects and similar to what would be predicted based on pre-project estimated use defined as the number of raptors observed per 20-minute survey. The estimated fatality rate for nocturnal migrants fell within the range of other wind projects studied in the Pacific Northwest. No difference in fatality rate was found between lit and un-lit turbines.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

STUDY PARTICIPANTS

Western EcoSystems Technology

David Young	Project Manager, Wildlife Biologist
Jay Jeffrey	Field Project Manager, Wildlife Biologist
Wallace Erickson	Statistician
Kimberly Bay	Data Supervisor and Statistician
Victoria Poulton	GIS Technician
Jamey P. Eddy	Data Technician and Trial Bird Provider
Jerry Baker	Field Technician
Adam Hannuksela	Field Technician
Denise Tonn	Field Technician
Levi Hicks	Field Technician
Patrick Migas	Field Technician
Jay Llewellyn	Field Technician

REPORT REFERENCE

Young, Jr., D.P., W.P. Erickson, J.D. Jeffrey, K. Bay, and V. Poulton. 2006. Puget Sound Energy, Hopkins Ridge Wind Project Phase 1, Post-Construction Avian and Bat Monitoring, First Annual Report, Janary-December 2006. Technical report prepared for Puget Sound Energy, Dayton, Washington and the Hopkins Ridge Technical Advisory Committee, Columbia County, Washington. Prepared by Western EcoSystems Technology, Inc., Cheyenne, Wyoming and Walla Walla, Washington.

ACKNOWLEDGEMENTS

A number of individuals from different and varied organizations were instrumental in the completion of the first year of monitoring the Puget Sound Energy Hopkins Ridge Wind Project, Phase 1. Clark Posey, Columbia County; Tom Schirm, Washington Department of Fish and Wildlife; Diane Petrula, U.S. Fish and Wildlife Service; Mike Denny, Blue Mountain Audubon; Terry Bruegmann, Don Howard, Dan McKinley, and Raymond DeRuw, Landowners and Landowner Representatives; and Paul Smith, Puget Sound Energy served on the Technical Advisory Committee and provided comments, suggestions, guidance, and methods for improving the studies. Mike Denny and Shirley Muse, Blue Mountain Audubon, provided early comments in the overall development of biological resource studies for the Hopkins Ridge Project Area and have been active participants in renewable energy project review throughout the region.

RES Americas, Inc. and Puget Sound Energy provided funding for the field studies both pre- and post-construction and access to the Hopkins Ridge facility. Scott Piscitello, RES Americas and Anne Walsh, PSE, have served as outstanding project managers administering pre- and post-construction studies throughout the Hopkins Ridge project development. On-site personnel, Paul Smith and Miranda Bowen were helpful in safety instruction, access, storage, and other logistical considerations for the study. All the landowners in the Hopkins Ridge project deserve recognition for their support and cooperation in allowing safe, secure, and trouble-free property access.

1.0 INTRODUCTION

Puget Sound Energy (PSE) is implementing a two year (24 month) operational (post-construction) monitoring study of the Hopkins Ridge Wind Project, Phase 1 to study the impacts of the development on birds and bats. The Hopkins Ridge Wind Project is located in the rolling hills south and west of the Tucannon River and northeast of Dayton, Washington in Columbia County. Phase I of the wind project consists of 83 Vestas 1.8 MW turbines and two permanent meteorological (met) towers for a total generation capacity of approximately 150 MW.

The first year of monitoring surveys were conducted on the site between January and December 2006. Data was collected according to a detailed monitoring protocol developed in cooperation with the Hopkins Ridge Wind Project Technical Advisory Committee (Young *et al*. 2005). The protocol for the monitoring study is similar to protocols used at other wind projects in the region including the Vansycle Project, Umatilla County, Oregon (Erickson *et al*. 2000); the Stateline project in Oregon and Washington (FPL *et al.* 2001); the Nine Canyon project Benton County, Washington (Energy Northwest *et al.* 2002); and the Combine Hills Turbine Ranch, Umatilla County, Oregon (Young *et al.* 2003a).

The overall objective of the monitoring study is to estimate the annual number of avian and bat casualties (fatalities and injured birds/bats) attributable to collisions with wind turbines and meteorological towers for the entire project. The study consists of four components:

1) Standardized carcass searches of selected turbines or turbine strings in a rectangular plot centered on the turbine;
2) Searcher efficiency trials to estimate the percentage of carcasses found by searchers;
3) Carcass removal trials to estimate the length of time that a carcass remains in the field for possible detection; and
4) A Wildlife Incident Reporting and Handling System (WIRHS) for wind project personnel to handle and report casualties found in the project incidentally to the study.

The WIRHS is part of the long-term wind project monitoring. Wildlife casualties found incidentally to the monitoring study by wind project personnel or others are handled under the WIRHS protocol (Young *et al.* 2005). Casualties found by wind project personnel during the first year of study within search plots were included in the overall dataset.

Columbia County requested a Technical Advisory Committee (TAC) be convened to provide guidance and oversight of the Hopkins Ridge Wind Project monitoring studies. The TAC is intended to provide a neutral forum to formulate and review monitoring studies and data; facilitate collaboration among project stakeholders (owners, landowners, agencies, conservation organizations, interested individuals); and make recommendations to the Columbia County Board of Adjustment for changes to the monitoring studies. The TAC membership includes representatives from: Columbia County, the Washington Department of Fish and Wildlife, the U.S. Fish and Wildlife Service, the Audubon Society, participating landowners, the project owner (PSE), and other interested parties.

1.1 Study Area and Project Description

The Hopkins Ridge Wind Project area is within the Columbia Basin physiographic province (ecoregion) and immediately adjacent to the northernmost reach of the Blue Mountains subprovince (Franklin and Dyrness 1988). This dual land platform consists of incised rivers, extensive plateaus and ridges, and basaltic outcrops and cliffs. The Hopkins Ridge Wind Project area abuts the transition zone between grassland/shrub-steppe and coniferous vegetation zones. The Tucannon River corridor borders the proposed development area to the north and east. The project area ranges in elevation from approximately 1600 to 3400 feet.

Dominant vegetation of the Hopkins Ridge project area is either a mix of steppe types (grassland steppe) or dryland agriculture. The majority of the site is dryland agriculture (cropland) planted in wheat or peas. Some areas of Conservation Reserve Program (CRP) land occur mainly in the northwest part of the project area with a few small parcels scattered elsewhere. Steppe types are primarily grass dominated areas with predominantly native bunchgrasses [Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Agropyron spicatum*)] and exotic annuals such as the introduced cheatgrass (*Bromus tectorum*), or areas with small isolated patches of shrubs or shrub thickets of sagebrush (*Artemisia spp.*) and rabbitbrush (*Chrysothamnus spp.*). Stands of deciduous trees and riparian wetlands of various sizes exist along the Willow Creek corridor as well as in the nearby Tucannon River floodplain.

The wind project consists of 83 Vestas V80 wind turbines, rated at 1.8 MW each. Turbines are mounted on 67 m (221 ft) tubular steel towers. The rotor diameter of the three-bladed turbines is 80 m (264 ft), resulting in a rotor swept area (RSA) of approximately 5026.5 m^2. The maximum height above ground to the top of the RSA is approximately 107 m (351 ft). The minimum height above ground to the bottom of the RSA is 27 m (89 ft). The wind turbines operate at wind speeds from approximately 10-90 kilometers per hour (kph) (~8-56 mph), at a relatively constant speed of approximately 15.5 revolutions per minute (rpm).

Forty-one of the wind turbines are lit with FAA recommended strobe lighting. Turbines located at the end of turbine strings are lit, and roughly every third or fourth turbine within turbine strings that have more than five turbines in the string are also lit. Each lit turbine is equipped with a ORGA Aviation Lighting L303-864/865 Medium Intensity Dual Red/White Strobe Obstruction Light System. The light is a white strobe during the day (~40 flashes per minute), and red flashing at night (~20 flashes per minute).

2.0 METHODS

A detailed study plan with sampling protocols was developed for the monitoring studies (Young *et al.* 2005) and was based largely on previous studies, permit requirements, and recommendations of the WDFW and USFWS. In order to provide comparable data and results, the protocol was similar to other previously studied wind projects in Washington and Oregon.

The avian and bat fatality study consisted of four components: (1) standardized carcass searches to measure observed fatality rates; (2) searcher efficiency trials to measure searcher bias; (3) carcass removal trials to measure removal bias; (3) and the WIRHS. There are three scenarios under which casualties may be found in the wind project: (1) during the standardized searches for the study; (2) while observers are on-site but not conducting a standardized search; and (3) by wind plant personnel or others on site for other purposes such as turbine maintenance. The reporting and handling methods for wind plant personnel discoveries is addressed by the WIRHS (Young *et al*. 2005). All casualties that were located within the standardized turbine and met tower search plots whether incidentals or during a designated search were included in the data set under the assumption that the incidental finds would have been found during standardized searches.

All casualties located within areas surveyed, regardless of species, were recorded and a cause of death determined, if possible, based on field inspection of the carcass. For carcasses where the cause of death is not apparent, the assumption that the fatality was a wind turbine or met tower collision casualty was made for the analysis. This approach leads to an overestimate of the true number of wind plant-related fatalities.

2.1 Search Plots and Sample Size

Rectangular plots around selected turbines and the met towers were searched for carcasses. The Phase I portion of Hopkins Ridge has a total of 83 turbines and two permanent met towers. Approximately 50% of the structures, 41 turbines and the two met towers, were sampled during the study by trained biologists once every 28-day (4-week) period. Search plots encompassed between 2 and 5 turbines. Based on the wind project layout, turbines were grouped into strings of 2, 3, 4 or 5 turbines (Figure 1). The search effort was spread throughout the wind project by choosing approximately, every other turbine group (strings of 2-5) for surveys.

Turbine plots were 180 m on a side (90 m from the turbine) and centered on the turbine. Studies at wind plants with other large turbines, Klondike in Sherman County Oregon (Johnson *et al*. 2002), and Combine Hills, Umatilla County, Oregon (Young *et al*. 2005) indicate nearly all fatalities are found within the area that is roughly equivalent to the height of the turbine. The survey plots for the met towers were 120 m on a side (60 m from the tower), also roughly equivalent to the height of the tower.

During the first year of sampling, standardize searches of all 43 plots were conducted once every 28-day period. During the spring and fall migration seasons[1], the search effort was increased at a sub-set of 22 of the selected turbines to once a week (Figure 1). The first year of study was the first year post construction (January –December 2006) and consisted of 13 search intervals for the 43 plots (turbines plus met towers) and 16 additional searches of the 22 turbine sub-set.

2.2 Standardized Searches

The objective of the standardized carcasses searches was to systematically search a portion of the wind project for avian and bat casualties that were attributable to collision with turbines or met towers. Personnel trained in proper search techniques conducted the carcass searches. Parallel transects were set approximately 6-12 meters apart, depending on habitat (e.g., open bareground versus thick grassland or crop) in the search plots and searchers walked at a rate of approximately 45-60 meters a minute along each transect taking approximately 45 to 90 minutes

[1] The spring migration season was defined as March 15-May15 and the fall migration season was from August 15-October 31.

to search each turbine plot. Searchers scanned the area on both sides of the transect out to approximately 5-6 meters for casualties as they walked.

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

- Intact - a carcass that was completely intact, not badly decomposed, and showed no sign of being fed upon by a predator or scavenger.
- Scavenged - an entire carcass, which showed signs of being fed upon by a predator or scavenger, or a portion(s) of a carcass in one general location (e.g., wings, skeletal remains, portion of a carcass, etc.), or a carcass that was heavily infested by insects.
- Feather Spot - 10 or more feathers or 2 or more primaries at one location indicating an avian fatality had been there.

All carcasses found were labeled with a unique number, bagged and frozen for future reference. For all casualties found, data recorded included species, sex and age when possible, date and time collected, GPS location, condition (intact, scavenged, feather spot), and any comments that were relevant or may indicate cause of death. All casualties located were photographed as found.

Casualties found outside the formal search area by carcass search technicians were treated following the above protocol as closely as possible. Casualties found in non-search areas (e.g., near a turbine not included in the search area) were coded as incidental discoveries and were documented in a similar fashion as those found during standard searches. Casualties found by maintenance personnel and others not conducting the formal searches were documented using the WIRHS.

2.3 Searcher Efficiency Trials

The objective of the searcher efficiency trials was to estimate the percentage of casualties that were found by searchers. Searcher efficiency trials were conducted each season in the same areas (plots) carcass searches occurred. Personnel conducting carcass searches did not know when trials were conducted or the location of the detection carcasses. During each season and within two major habitat types (cultivated agriculture and grassland), approximately 8 carcasses of birds of two different size classes[2] were placed in the search area during the search period, for a total of approximately 64 searcher efficiency trial carcasses for the entire year. A minimum of two dates were used each season for a minimum total of 8 trial dates.

Trial carcasses were placed at random locations within areas being searched prior to the carcass search on the same day. Carcasses were generally placed in a random posture by tossing the carcass to one side to simulate a turbine fatality. Each trial carcass was discreetly marked so that it could be identified as a study carcass after it was found. The number and location of the detection carcasses found during the carcass search was recorded and the number of carcasses available for detection during each trial was determined immediately after the trial by the person responsible for distributing the carcasses.

[2] Carcass used for searcher efficiency trials included non-native/non-protected and commercially available species. Small carcasses were house sparrows, hatchling mallards, hatchling pheasants, and European starlings; large carcasses were rock doves and hen mallards.

Searcher efficiency was estimated by major habitat type (cultivated agriculture and grassland), carcass size (small and large), and season. Estimates of searcher efficiency were used to adjust the total number of carcasses found for those missed by searchers, correcting for detection bias.

2.4 Carcass Removal Trials

The objective of carcass removal trials was to estimate the average length of time a carcass remains in the study area and is available to be detected. Carcass removal includes removal by predation or scavenging, or other means such as being plowed into a field. Carcass removal trials were conducted during each season near the carcass search plots (e.g., near a turbine that is not included in the standard search plots) and within two major habitat types (cultivated agriculture and grassland). Approximately 8 carcasses of birds of two different size classes (same as searcher efficiency birds) were placed in the field, for a total of approximately 64 removal trial carcasses for the entire year. Removal trials were spread throughout the year to incorporate the effects of varying weather, climatic conditions, farming practices, and scavenger densities.

Removal trial birds were not placed in the standardized search plots to minimize the chance of confusing a trial bird with a true casualty. Turbines not included in the standardized searches were selected for the removal trials and trial carcasses were randomly located in a similar size plot to the search plots around the turbine. Carcasses were generally placed in a random posture to simulate a turbine fatality. Personnel conducting carcass searches monitored the trial birds over a 40 day period. In general carcasses were checked every day for the first 4 days, and then on day 7, day 10, day 14, day 20, day 30 and day 40. Trial carcasses were marked discreetly for recognition by searchers and other personnel. Experimental carcasses were left at the location until the end of the 40-day period and any evidence of the carcasses remaining was removed.

Carcass removal was estimated by major habitat type (cultivated agriculture and grassland), carcass size (small and large), and season. Estimates of carcass removal were used to adjust the total number of carcasses found for those removed from the study area, correcting for removal bias.

2.5 Statistical Methods for Fatality Estimates

The estimate of the total number of wind turbine-related fatalities was based on three components: 1) observed number of carcasses, 2) searcher efficiency expressed as the proportion of trial carcasses found by searchers, and 3) removal rates expressed as the length of time a carcass remains in the study area and is available for detection by searchers.

2.5.1 Observed Number of Carcasses

The average number of carcasses detected per turbine or meteorological tower is:

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

where c_i is the number of carcasses detected at turbine i for the period of study, and k is the number of turbines searched. The estimated variance is calculated using the usual sample variance formula:

$$v(\bar{c}) = \frac{1}{k}\left[\frac{\sum_{i=1}^{k}(c_i - \bar{c})^2}{k-1}\right].$$

The variance of the total number of carcasses observed ($\hat{C}$) is calculated by:

$$v(\hat{C}) = k^2 * v(\bar{c}).$$

2.5.2 Estimation of Observer Detection Rates
Searcher efficiency is expressed as p, which is simply the proportion of trial carcasses found by searchers. The variance of the estimate, v(p), is calculated by the formula:

$$v(p) = \frac{p(1-p)}{d}$$

where d is the total number of carcasses placed for possible detection.

2.5.3 Estimation of Carcass Removal
Carcass removal is expressed the length of time a carcass remains in the study area before it is removed and no longer available for detection. Mean carcass removal time is expressed as $\bar{t}$, the average length of time a carcass remains at the site before it is removed:

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

where ti is the number of days trial carcass i stays in the study area and s is the number of carcasses used in the scavenging trials.

The sample variance, $v(\bar{t})$ is calculated using the variance of a mean formula:

$$v(\bar{t}) = \frac{1}{s}\left[\frac{\sum_{i=1}^{k}(t_i - \bar{t})^2}{s-1}\right].$$

2.5.4 Estimation of Facility-Related Fatality Rates
The estimate of the total number of avian or bat carcasses by species or groups of species (e.g., raptors, passerines), is comprised of the three components discussed above: 1) the estimated total number of carcasses detected per turbine for the study period and associated variance, 2) the estimate and associated variance for the searcher efficiency rate, and 3) the estimate and associated variance for the mean length of time the carcass remains in the study area before it is removed. Fatality estimates were calculated for: all birds, small birds, large birds, raptors, nocturnal migrants, and bats.

The estimated total number of carcasses for the project, m, for the time period of study one year, is calculated by:

$$m = \frac{N * I * C}{k * \bar{t} * p}$$

where N is the total number of turbines in the project, k is the number of turbines sampled, I is the interval between searches in days, C is the total number of carcasses detected for the period of study, $\bar{t}$ is the mean length of time the carcass remains in the study area before it is removed, and p is the observer detection rate. The variance and confidence intervals were estimated using bootstrapping techniques for estimating variance of small samples (Manly 1997, Barnard 2000). Bootstrapping is a computer simulation technique that uses iterative sampling of the data to calculate point estimates, variances, and confidence intervals for complicated test statistics. For each iteration (or bootstrap), the plots were sampled with replacement, trial carcasses were sampled with replacement, and $\bar{c}$, $\bar{t}$, p, and m were calculated. A total of 5,000 bootstrap iterations were used. The reported estimates are the means of the 5,000 bootstrap estimates. The standard deviation of the bootstrap estimates is the estimated standard error. The lower 5^{th}, and upper 95^{th} percentiles of the 5,000 bootstrap estimates are estimates of the lower limit and upper limit of 90% confidence intervals.

3.0 RESULTS

The fatality estimates are based on one full year of the study from January 6 to December 23, 2006. A total of 865 plot searches were conducted over the one year monitoring study period (January-December 2006). Thirty-four (34) bird fatalities of 11 species and two unidentified passerine species were located during standardized searches and an additional four fatalities of four species were found incidentally outside of designated search plots. Nineteen (19) bat fatalities of four species were found during the standardized searches and an additional two bat fatalities of one species were found incidentally outside of designated search plots. Bird fatalities were found near 25 different turbines; bat fatalities were found near 14 different turbines. The maximum number of bird fatalities found at any one turbine was four fatalities found closest to turbine number 59 (Figure 2); the maximum number of bat fatalities found at any one turbine was three found closest to turbine 100 (Figure 2). The vast majority of the plot searches produced no fatalities. The average distance of bird casualties (n=38) to the nearest turbine was 45 meters; the average distance of bat casualties (n=21) to the nearest turbine was 26 meters. No bird or bat carcasses were found that were attributed to the met towers.

3.1 Bird Fatalities

Ring-necked pheasant and European starling, two introduced species, were the most common avian fatality with seven (18%) each (Table 1). Horned lark (6) and American kestrel (3) were the most common native species. The remainder of the species only had one fatality each (Table 1). Passerines comprised approximately 60% of the fatalities (23). Including the unknown birds as possible migrants, approximately 39% (9) of the passerines were considered migrants and 61% (14) were considered residents. Three species of raptors were found during the study American kestrel (3), Cooper's hawk (1), and northern harrier (1). None of the birds found were listed as Federal or State Threatened or Endangered species. Upland gamebirds (all ring-necked pheasant) comprised approximately 18% (7) of the avian fatalities.

Based on the date of recovery (season) and species, ten of the avian fatalities were considered nocturnal migrants: nine passerines and one American coot. The remainder of the passerines were either horned larks, which are year-round residents of the project area, or were found during the breeding season and are common summer or year-round residents of the area (e.g., American goldfinch, black-billed magpie, northern flicker).

Fatalities were found throughout the year, but rates were highest in the winter (35%), followed by the spring (26%), summer (21%) and lowest in the fall (16%). There was no evident increase in avian mortality during the spring and fall migration seasons (Figure 3). When considering all bird fatalities, there did not appear to be any strong localization in casualties (see Figure 2). There were some local concentrations (e.g., turbines 28 and 59) but it appears as if the three European starlings found around turbine 28 were attributable to one event, as they were all found during the same search.

3.2 Bat Fatalities

Four species of bats fatalities were found. Silver-haired bat comprised 63% (12) and hoary bat 21% (4) of the fatalities (Table 1). None of the bats are Federal or State Threatened or Endangered species.

Bat fatalities were observed between April 28 and October 26, 2006, although due to the carcass condition of bats found in October it was suspected that they had died earlier in the fall season (Figure 3). There did not appear to be any strong concentrations of bat fatalities within the facility (see Figure 2). The majority the bat fatalities (67%) were found during the fall migration period for hoary and silver-haired bats with the greatest number of bat fatalities found in September (Figure 3).

3.3 Search Efficiency Trials

Searcher efficiency trials were conducted between February 11 and December 13, 2006. A total of 31 large bird trial carcasses and 32 small bird trial carcasses were used in detection trials (Table 2). The trial carcasses were placed throughout the year to account for varying weather and habitat conditions. Overall, observers detected approximately 67% of the large bird carcasses and 53% of the small bird carcasses. Detection rates for large and small birds were similar in agriculture and grassland primarily because much of the grassland in the project area is in CRP which tended to have tall grass similar to agricultural fields in wheat or beans.

3.4 Carcass Removal Trials

The carcass removal trials were conducted between February 11 and December 13, 2006. A total of 32 large bird carcasses and 32 small bird carcasses were placed in the field and monitored over 40-day periods. For large birds the mean removal time was estimated at approximately 19.9 days. The lower and upper 90% confidence limits around this estimate were 15.5 and 25.0. For small birds the mean removal time and 90% confidence limits were 26.6 days (18.8, 36.5) (Figure 4). For large birds, half (median) of the carcasses remained until day 16 of the trial, and for small birds one half remained until day 17 of the trial.

3.5 Adjusted Fatality Estimates

Fatality estimates, standard errors, and confidence intervals were calculated for: (1) all birds – with and without introduced species, (2) small birds, (3) large birds, (4) raptors (5) nocturnal migrant birds, and (6) bats (Table 4). The fatality estimates are adjusted based on the corrections for carcass removal and observer detection biases. Based on the average number of days between searches, the estimated average probability a small bird casualty would remain until a scheduled search and would be found and the 90% confidence limits around this probability were 0.41 (0.29, 0.45). The estimated average probability a large bird casualty will remain until a scheduled search and will be found and the 90% confidence limits were 0.41 (0.30, 0.50).

3.5.1 Small Birds

Twenty-five (24) small bird fatalities were found during the standardized searches. The estimated number of small bird fatalities per turbine per year and associated 90% confidence limits was 1.45 (0.93, 2.14) (Table 4).

3.5.2 Large Birds

Eleven large bird fatalities[3] were found during the study. The estimated number of large bird fatalities per turbine per year and associated 90% confidence limits for the first year of study was 0.76 (0.42, 1.17) (Table 4).

3.5.3 All Birds

The fatality estimate for all birds was obtained by summing the estimates for small and large birds. The estimated number of all bird fatalities per turbine per year and associated 90% confidence limits for the first year of study is 2.21 (1.64, 2.92) (Table 6). European starlings, which are not protected under the Migratory Bird Treaty Act, and ring-necked pheasant, a non-native introduced species, were included in this estimate. By excluding starlings and pheasants, the estimate is approximately 1.47 (0.98, 2.02) bird fatalities per turbine per year.

3.5.4 Raptors

Four raptors of three species were found during the standardized carcass searches. The estimated number of raptors per turbine per year and associated 90% confidence limits for the first year of study was 0.25 (0.09, 0.46) (Table 4).

3.5.5 Nocturnal Migrants

Based on date of find and species, ten casualties were found which were considered nocturnal migrants – one American coot and nine passerines. The estimated number of nocturnal migrant fatalities per turbine per year and associated 90% confidence limits for first year of study was 0.82 (0.38, 1.44) (Table 6).

3.5.6 Bats

Adjustments for carcass removal and observer detection bias for bats were made using the estimates for small birds. The estimated number of bat fatalities per turbine per year and associated 90% confidence limits for first year of study was 1.13 (0.69, 1.71) (Table 4).

[3] Large birds were considered all upland gamebirds, raptors, corvids, and waterbirds.

3.6 Lighting Effects and Turbine Location Effects

Because of the very low number of observed avian nocturnal migrant fatalities (10) and bats (19) the effect of turbine lights on avian mortality could not be calculated with high levels of confidence. For nocturnal migrant birds the observed number of fatalities for lit turbines (6) was slightly higher than unlit turbines (4). This difference was not statistically significant ($t = -0.996$, $df = 39$, p-value = 0.3253, not statistically different) suggesting that turbine lighting did not attract nocturnal migrants. For bats the fatalities at lit turbines (7) was lower than unlit turbines (11). This difference was not statistically significant ($t = 0.847$, $df = 39$, p-value = 0.4024, not statistically different) suggesting that turbine lighting did not attract bats.

4.0 SUMMARY/DISCUSSION

The Hopkins Ridge Phase 1 Wind Project is located in the Columbia Basin physiographic province, a region with extensive wind power development. Umatilla County, Oregon and Walla Walla County, Washington roughly 50 miles southwest of Hopkins Ridge are home to three utility scale wind projects: the Vansycle wind plant (24 MW), the Stateline Wind Project (300 MW), and the Combine Hills Turbine Ranch (41 MW). In addition the Nine Canyon Wind Project in Benton County, Washington, and the Klondike Wind Project, Sherman County, Oregon, while further west also occur in the Columbia Basin and have been monitored using similar protocols. A sixth project, Condon, is located in Gilliam County, Oregon, but has not undergone rigorous monitoring studies[4]. Monitoring studies have occurred at these wind projects within the last seven years providing a relatively contemporary pool of data for comparison. Studies at the Hopkins Ridge Wind Project were designed to provide comparable results and utilized information gained from the nearby Stateline and Combine Hills studies.

The overall study design incorporates several assumptions or factors that affect the results of the fatality estimates. First, all bird casualties found within the standardized search plots during the study were included in the analysis. One carcass was found incidentally within a search plot during other activities on-site and it was assumed that this carcass would have been found during a scheduled carcass search. Second, it was assumed that all carcasses found during the study were due to collision with wind turbines. True cause of death is unknown for most of the fatalities. It is possible that some of the ring-necked pheasant fatalities were caused by predators (e.g., raptors, fox) and some of the other casualties may have been due to farming activity or vehicles on county/project roads. It is likely that some of the casualties included in the data pool were due to natural causes (background mortality[5]). The effect of these assumption is that the analysis provides a conservative estimate (an over estimate) of mortality due to the wind plant.

[4] Monitoring at the Condon wind project took place for less than one year in 2003 (Fishman 2003). Three bird fatalities, including one rough-legged hawk, and no bats were located during the study. No searcher efficiency or carcass removal trials were conducted.

[5] A few wind project studies have provided information on background mortality. During a four-year study at Buffalo Ridge, Minnesota, 2,482 fatality searches were conducted on study plots without turbines to estimate reference mortality in the study area. Thirty-one (31) avian fatalities comprising 15 species were found (Johnson *et al.* 2000). Reference mortality for this study was estimated to average 1.1 fatalities per plot per year.

Some pre-project carcass searches were conducted at a proposed wind project in Montana (Harmata *et al.* 1998). Three bird fatalities were found during 8 searches of 5 transects, totaling 17.61 km per search. On average, approximately 1.8 km of transect is searched within every 180 m diameter turbine plot. Therefore, the amount of

No adjustments were made for fatalities possibly occurring outside of the rectangular plot boundaries. Plot boundaries were established a minimum distance of 90 m from the turbines. Because the search plots were rectangular in shape, the maximum distance to a turbine within a search plot was 127 m at the corners. Also, because observers search both sides of a transect out to 5-6 m, the effective surveyed distance from a turbine is 100 m (90 m plus 5 m on either end). The search plot distance for this study was selected based on results of other studies (Higgins *et al.* 1996, Erickson *et al.* 2004a, Young *et al.* 2003, Young *et al*. 2005) where a distance equal to approximately the height of the turbines appeared to capture a very large percentage of fatalities. Based on the distribution of fatalities as a function of distance from turbines (Figure 5), a small percentage of bird fatalities possibly fell outside the search plots and may have been missed. This factor would lead to an underestimate of bird fatality rates. However, again it is unknown if the fatalities detected at greater than 90m (2) were actual turbine collision fatalities. The distribution of bat fatalities at Hopkins Ridge (see Figures 2 and 5) and at other sites (e.g., Erickson *et al.* 2004a, Young *et al.* 2003c, Kerlinger and Kerns 2004) suggest bat casualties fall closer to turbines than bird casualties. No bat carcasses were found beyond 61 m from a turbine and it is unlikely that many bats fell outside the effective search area.

During the monitoring study the Hopkins Ridge wind project was subject to curtailment of generation during the period from May 26 to October 24, 2006. During this time between 18 and 38 turbines were paused for various periods of time, curtailing the overall wind project production. Analysis of the curtailment dates and turbines indicated that a total of 71 plot searches were conducted at paused turbines or approximately 10% of all searches. While a turbine is paused it continues to rotate during windy conditions. For the Vestas V80 turbines at Hopkins Ridge, the typical rotation speed while they are generating electricity is between 15.5 and 16.8 rpm. While they are paused the turbines are allowed to freewheel (pinwheel) so they continue to turn at lower rpms but do not generate electricity. Rotation speed (rpms) for freewheeling turbines is variable depending on the wind speed but does not exceed 15.5 rpm. Freewheeling turbines are still considered a risk to birds and bats because they are allowed to spin freely. Also during the period of curtailment, four carcasses were found at paused turbines indicating that they do pose a risk to some degree. For these reasons no adjustments were made to the analysis to try and account for paused versus normally operating turbines.

The overall bird fatality rate calculated for Hopkins Ridge (2.21 per turbine per year) falls within the range of estimates reported for Stateline (1.93), Vansycle (0.63), and Combine Hills (2.56) (Erickson *et al*. 2004a, Erickson *et al.* 2000, Young *et al*. 2006) and is slightly higher than the average bird fatality rates reported for new generation wind projects in the U.S. (2.11 per turbine per year, Erickson *et al.* 2004b). However, fatality estimates on a per turbine basis may be misleading when comparing different wind energy projects since turbine sizes vary among projects. For example, the Vestas V80 turbines at Hopkins Ridge are 1.8 MW turbines with a rotor swept area of approximately 5026 $m^{2.}$ This is quite a bit larger than the Mitsubishi MWT-1000A 1.0 MW turbines at Combine Hills with a rotor swept area of approximately 2961 m^2 or

transect searched at the Montana site per search was equivalent to searching approximately 9 turbines at Hopkins Ridge. The background estimate for observed mortality would be approximately 0.33 per turbine plot per year, unadjusted for scavenging and searcher efficiency.

The background mortality information from Minnesota and Montana suggest that the estimates of bird mortality include some avian fatalities not related to turbine collision, and this factor alone would lead to an over-estimate of true avian collision mortality for the study.

the Stateline project with Vestas V-47 0.66 kW turbines with a rotor swept area of approximately 1735 m^2. Fatality estimates for smaller turbines may be less per turbine than for larger turbines, however, it would take more small turbines to generate the same amount of electricity. In an effort to account for differences in turbine size, the fatality rates standardized to a per MW basis can be compared. For Hopkins Ridge with 1.8 MW turbines, the estimate for all birds drops to 1.23 birds per MW per year which is lower than Stateline, 2.92 fatalities per MW per year; Combine Hills, 2.56 fatalities per MW per year; and the overall average for new generation wind projects in the U.S of 3.05 fatalities per MW (Erickson *et al.* 2004b).

The overall bat fatality rate for Hopkins Ridge (1.13 per turbine per year) is similar to the per turbine estimate for Stateline (1.12 per year), Combine Hills (1.88) and the average bat fatality rate reported for western and mid-western wind projects in the U.S. (1.40 per turbine per year, Johnson *et al*. 2004). On a per MW basis, the Hopkins Ridge estimate (0.63 bats per MW per year) is lower than the Stateline (1.70) and Combine Hills (1.88) estimates and below the average rate for new generation wind projects in the west and mid-west of 2.10 per MW per year. Bat fatality estimates at new projects are more variable than bird estimates, with the highest estimates occurring at sites in the east (Nicholson 2003, Kerlinger and Kerns 2004, Arnett 2005). Based on these comparisons, bird and bat mortality at Hopkins Ridge is similar and slightly lower than other newer generation wind projects studied in the Pacific Northwest and U.S. in general.

4.1 Species Composition

Species composition for bird casualties was similar to composition at other sites in the Pacific Northwest. When species were group taxonomically, passerines (60%) and upland gamebirds (18%) were the groups with the most fatalities. Horned lark made up a large proportion of the passerine fatalities similar to other wind projects in agricultural and short-grass settings, although at Hopkins Ridge there were more European starlings found. Non-native avian species were included in the analysis so that results would be comparable to other studies of regional wind projects. However, starlings and pheasants, two non-native introduced species made up approximately 37% of all avian fatalities. Eliminating these from the data pool substantially reduced the avian mortality estimates for Hopkins Ridge.

Raptor mortality (0.14 per MW) was slightly higher than the Stateline wind project (0.09) and Nine Canyon wind project (0.05) on a per MW basis (Erickson *et al.* 2004a, Erickson *et al.* 2003). Pre-project raptor use estimates (defined as the number observed per 20-minute survey) for Hopkins Ridge (0.64) were also slightly higher than Stateline (0.41) and Nine Canyon (0.44). Assuming raptor mortality is correlated with raptor use of a site, it would be predicted that Hopkins Ridge would have slightly higher raptor mortality.

Species composition for bats was almost identical to other Pacific Northwest projects with only four species found: silver-haired bat, hoary bat, little brown bat, and big brown bat. Three silver-haired bat fatalities were found in April or May which could be considered the spring migration period for bats and four were found in June or July, the summer period. These numbers were higher than the Stateline and Combine Hills project where only one and three bat fatalities were found respectively during the spring and summer periods. However, overall bat mortality is lower at Hopkins Ridge on a per turbine and per MW basis. As confirmed by numerous other monitoring studies throughout the U.S., the majority of bat fatalities were found in the late summer and early fall during the time period when both silver-haired and hoary bats are migrating (Cryan *et al*. 2004). Fatality rates at Hopkins Ridge and other projects in the Pacific Northwest and Midwest are much lower than estimates from recently studied wind projects in the East (Kerlinger and Kerns 2004, Nicholson 2003, Arnett 2005).

4.2 Nocturnal Migrants and Lighting

Tall lighted structures are suspected of attracting nocturnal migrating birds, especially during inclement weather (Kerlinger 2000). There has been concern expressed that lighting wind turbines may increase the risk of collision fatalities for birds and bats if they are attracted to the lights. Typically not every turbine in a wind project is lit, however, and to date, results have generally shown no effect from lighting (see Erickson *et al*. 2004, Arnett 2005, Young *et al*. 2006). Lighting at other structures like communication towers is typically different than lighting at wind turbines. Communication towers may have more than one light on a tower and therefore, cumulatively may have a stronger attraction (Kerlinger 2003). Wind turbines have only one location for the light on top of the nacelle.

The number of potential nocturnal avian migrants (10) and bats (19) observed during the study were generally too few for a meaningful analysis on the potential effects of lit versus unlit turbines; however, fatality rates for lit turbines and unlit turbines were compared. Observed bat fatality rates were higher at unlit turbines (11) compared to lit turbines (7), but nocturnal migrant birds were slightly higher at lit turbines (6) than unlit turbines (4). Neither difference was statistically significant suggesting that, during the study, lighting did not appear to influence mortality. Similar results have been found at the Stateline wind project (Erickson *et al*. 2004a), the Nine Canyon wind project (Erickson *et al.* 2003), and the Combine Hills project (Young *et al*. 2006), which have the same lighting characteristics (red-flashing at night). It appears as if FAA required lighting on turbines does not influence the risk of bird or bat mortality associated with wind turbines.

5.0 REFERENCES

Anthony, E.L.P. 1988. Age determination in bats. Pages 47-58 in T. H. Kunz, editor. Ecological and behavioral methods for the study of bats. Smithsonian Institution, Washington, D.C., USA.

Arnett, E.B, W.P. Erickson, J. Kerns, and J. Horn. 2005. Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines. Prepared for the Bats and Wind Energy Cooperative, March 2005.

Beason, R. C. 1995. Horned Lark (*Eremophila alpestris*). *In* The Birds of North America, No. 195 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.

Cryan, P.M., M.A Bogan, R.O. Rye, G.P. Landis, and C.L. Kester. 2004. Stable hydrogen isotope analysis of bat hair as evidence for seasonal molt and long-distance migration. Journal of Mammalogy 85(5):995-1001.

Energy Northwest, W. Erickson, G. Johnson, and K. Kronner. 2002. Avian and Bat Monitoring Plan for the Nine Canyon Wind Project. April 2002. Energy Northwest, Richland, Washington.

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

Erickson, W.P., G.D. Johnson, and D.P. Young. 2004b. Summary of anthropogenic causes of bird mortality. Proceedings of the 2002 International Partner's in Flight Conference, Monterrey, California.

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

Erickson, W.P., G.D. Johnson, M.D. Strickland, and K. Kronner. 2000. Avian and bat mortality associated with the Vansycle Wind Project, Umatilla County, Oregon: 1999 study year. Technical Report prepared by WEST, Inc. for Umatilla County Department of Resource Services and Development, Pendleton, Oregon. 21pp.

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

FPL Energy Vansycle LLC. W.P. Erickson and K. Kronner. 2001. Avian and bat monitoring plan for the Washington portion of the Stateline Wind Project. Technical Report prepared for Walla Walla Regional Planning Department. May, 2001.

Gill, J.P. 2000a. Baseline breeding bird survey of the Dun Law wind farm. Report to Renewable Energy Systems Ltd. By Environmentally Sustainable Systems, Edinburgh.

Gill, J.P. 2000b. Changes in breeding birds at Dun Law wind farm, 1999-2000. Report to Renewable Energy Systems Ltd. By Environmentally Sustainable Systems, Edinburgh.

Harmata, A.R., K. M. Podruzny, and J. R. Zelenak. 1998. Avian use of Norris Hill Wind Resource Area, Montana. NREL/SR-500-23822.

Higgins, K. F., R. G. Osborn, C. D. Dieter and R. E. Usgaard. 1996. Monitoring of seasonal bird activity and mortality at the Buffalo Ridge Wind Resource Area, Minnesota, 1994-1995. Completion Report for the Research Period May 1, 1994 – December 31, 1995. Unpublished Report prepared for Kenetech Windpower, Inc. by the South Dakota Cooperative Fish and Wildlife Research Unit, Brookings, SD. 84pp.

Johnson, G.D., W.P. Erickson, and M.D. Strickland. 2004. Overview of available bat mortality studies at wind energy projects. Proceedings of the National Avian-Wind Power Planning Meeting V. November 2004. National Wind Coordinating Committee.

Johnson, G.D., W.P. Erickson, and J. White. 2003b. Avian and bat mortality at the Klondike, Oregon Phase I Wind Plant. Technical report prepared for Northwestern Wind Power by WEST, Inc.

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

Johnson, G. D., W. P. Erickson, M. D. Strickland, M. F. Shepherd and D. A. Shepherd. 2000. Avian monitoring studies. Buffalo Ridge, Minnesota Wind Resource Area, 1996-1999, results of a 4-year study. Technical Report prepared for Northern States Power Co., Minneapolis, MN. 212 pp.

Kerlinger P. and J. Kerns. 2004. A study of bird and bat collisions at the Mountaineer Wind Energy Facility, Tucker County, West Virginia. Prepared for FPL Energy and the Mountain Wind Energy Center Technical Review Committee.

Kerlinger, P. 2003. FAA and Lighting. Presentation at the NWCC Biological Significance Workshop. November 17-18, 2003. Washington D,C.

Kerlinger, P. 2000. Avian mortality at communication towers: a review of recent literature, research, and methodology. Unpublished report prepared for the U.S. Fish and Wildlife Service, Office of Migratory Bird Management. http://migratorybirds.fws.gov/issues/towers/review.pdf

Ketzenberg, C., Exo, K.-M., Reichenbach, M., & Castor, M. (2002) Einfluss von Windkraftanlagen auf brütende Wiesenvögel. *Natur und Landschaft* 77: 144-153.

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

Manly, B.F.J. 1997. Randomization, Bootstrap and Monte Carlo Methods in Biology. 2nd edition. Chapman and Hall, New York. Pp 399.

Nicholson, C.P. 2003. Buffalo Mountain Windfarm bird and bat mortality monitoring report: October 2001 – September 2002. Tennessee Valley Authority, Knoxville.

Racey, P. A. 1988. Reproductive assessment in bats. Pages 31–46 *in* T. H. Kunz, editor. Ecological and behavioral methods for the study of bats. Smithsonian Institution, Washington, D.C., USA.

Shaffer, J.A. and D. Johnson. 2003. Influence of wind generators on grassland breeding birds. Annual report 2003. U.S. Geological Survey. Northern Prairie Wildlife Research Center. Jamestown, North Dakota.

Barnard, D. 2000. Statistical properties of an avian fatality estimator. MS Thesis, Statistics Department, University of Wyoming.

Reynolds, R.T., J.M. Scott, and R.A. Nussbaum. 1980. A Variable Circular-Plot Method for Estimating Bird Numbers. Condor 82(3): 309-313.

Young, Jr., D.P., J.D. Jeffrey, W.P. Erickson, K.J. Bay, and V.K. Poulton. 2006. Eurus Combine Hills Turbine Ranch Phase 1 Post Construction Wildlife Monitoring First Annual Report February 2004 – February 2005. Prepared for Eurus Energy America Corporation and Combine Hills Technical Advisory ttee, Umatailla County, Oregon. Prepared by: Western EcoSystems Technology, Inc., Cheyenne, Wyoming and Walla Walla, Washington, February 21, 2006.

Young, Jr., D.P., W.P. Erickson, J.P. Jeffrey, and V.K. Poulton. 2005. Avian and Bat Monitoring Study Plan Puget Sound Energy Hopkins Ridge Wind Project Phase 1, Columbia County Washington. Prepared for: Puget Sound Energy, Dayton, Washington. Western EcoSystems Technology Inc. Cheyenne, Wyoming and Walla Walla, Washington, November 21, 2005

Young, Jr., D.P., W.P. Erickson, J.D. Jeffrey, K. Bay, and M. Bourassa. 2003a. Avian and Sensitive Species, Baseline Study Plan and Final Report, Eurus Combine Hills Turbine Ranch, Umatilla County, Oregon. Technical Report for Eurus Energy America Corporation and Aeropower Services, Inc. Prepared by: Western EcoSystems Technology, Inc., Cheyenne, Wyoming.

Young, Jr., D.P., W.P. Erickson, R.E. Good, M.D. Strickland, and G.D. Johnson. 2003c. Final Report, Avian and Bat Mortality Associated with the Initial Phase of the Foote Creek Rim Windpower Project, Carbon County, Wyoming. November 3, 1998 – June 2002. Technical report prepared by WEST, Inc. for Pacificorp, Inc. Portland, Oregon; SeaWest Windpower, Inc, San Diego, California; and Bureau of Land Management, Rawlins, Wyoming. January 10, 2003.

Table 1. Summary of avian and bat fatality composition based on carcasses found during standardized searches and incidentally in the project area.

Species	Total	% Comp.
European starling	7	18.42
ring-necked pheasant[b,c]	7	18.42
horned lark[b]	6	15.79
American kestrel[b]	3	7.89
American coot	1	2.63
American goldfinch	1	2.63
black-billed magpie	1	2.63
Cooper's hawk	1	2.63
dark-eyed junco	1	2.63
golden-crowned kinglet	1	2.63
golden-crowned sparrow	1	2.63
gray catbird[a]	1	2.63
northern flicker	1	2.63
northern harrier	1	2.63
Townsend's warbler	1	2.63
unidentified bird	1	2.63
unidentified empidonax	1	2.63
white-crowned sparrow	1	2.63
yellow-rumped warbler	1	2.63
Avian Subtotal	**38**	**100.00**
silver-haired bat[a, b]	12	63.16
hoary bat	4	21.05
big brown bat	1	5.26
little brown bat	1	5.26
unidentified bat	1	5.26
Bat Subtotal	**19**	**100.00**

[a] Observed at a search turbine but not during a scheduled search.
[b] Observed at a non-search turbine.

Table 2. Results of Searcher Efficiency Trials.

	Grassland		Agriculture	
	Large Birds			
Season	# Placed	% Found	# Placed	% Found
Winter	4	50	7	100
Spring	4	100	0	
Summer	4	50	8	37.5
Fall	4	0	0	
Total	16	50.0	15	66.7
	Small Birds			
Season	# Placed	% Found	# Placed	% Found
Winter	3	66.7	9	55.6
Spring	4	75	0	
Summer	4	25	8	50
Fall	4	0	0	
Total	15	40	17	52.9

Table 3. Mortality estimates for birds and bats associated with the first year of monitoring of the Hopkins Ridge Wind Project, Phase 1.

			90% Confidence Limits	
	Estimate	se	ll	ul
Searcher Efficiency Rates				
Large Birds	0.58	0.09	0.42	0.71
Small Birds	0.47	0.09	0.33	0.63
Mean Carcass Removal Times (days)				
Large Birds	19.92	2.92	15.46	25.04
Small Birds	26.63	5.45	18.81	36.49
Available and Detection Probabilities				
Large Birds	0.41	0.06	0.30	0.50
Small Birds	0.41	0.08	0.29	0.54
Fatality Estimates (#/turbine/yr)				
Small Birds	1.45	0.38	0.93	2.14
Large Birds	0.76	0.23	0.42	1.17
All Birds	2.21	0.40	1.64	2.92
Raptors	0.25	0.11	0.09	0.46
Nocturnal Migrants	0.82	0.33	0.38	1.44
Bats	1.13	0.32	0.69	1.71
Fatality Estimates (#/MW/yr)				
Small Birds	0.80	0.21	0.52	1.19
Large Birds	0.42	0.13	0.23	0.65
All Birds	1.23	0.22	0.91	1.62
Raptors	0.14	0.06	0.05	0.25
Nocturnal Migrants	0.46	0.18	0.21	0.80
Bats	0.63	0.18	0.38	0.95

Figure 1. Project Location and Study Area Map

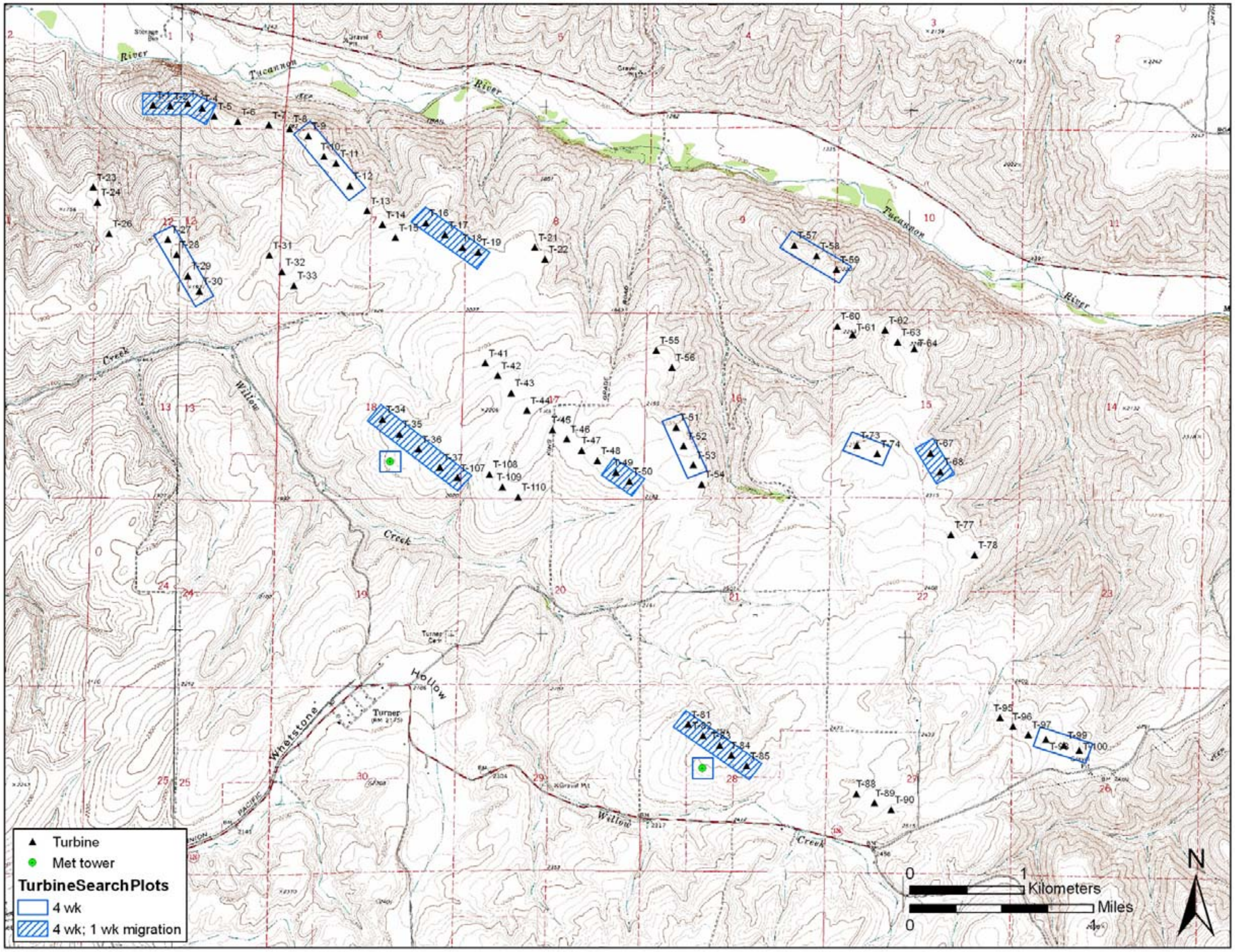


Figure 2. Carcass Search Plots and Distribution of Carcasses Found During the Study

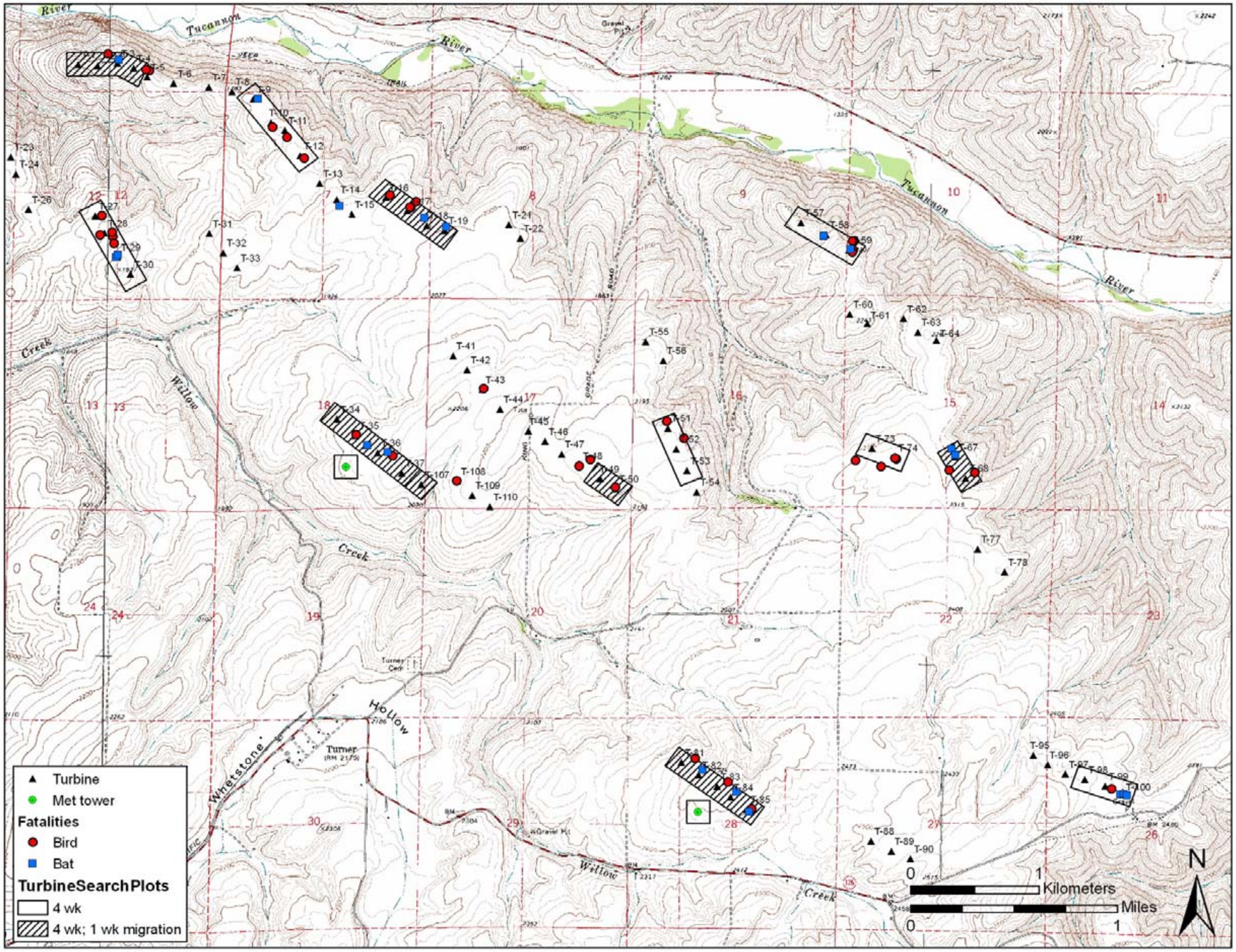
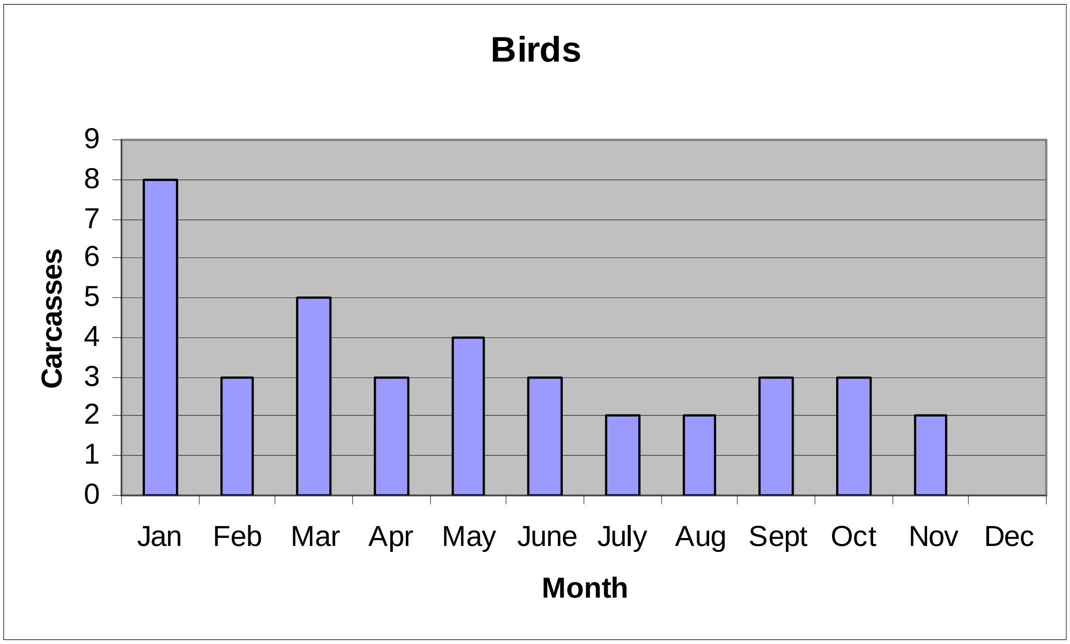


Figure 3. Seasonal Distribution of Carcass Discovery Over the One Year Study Period.



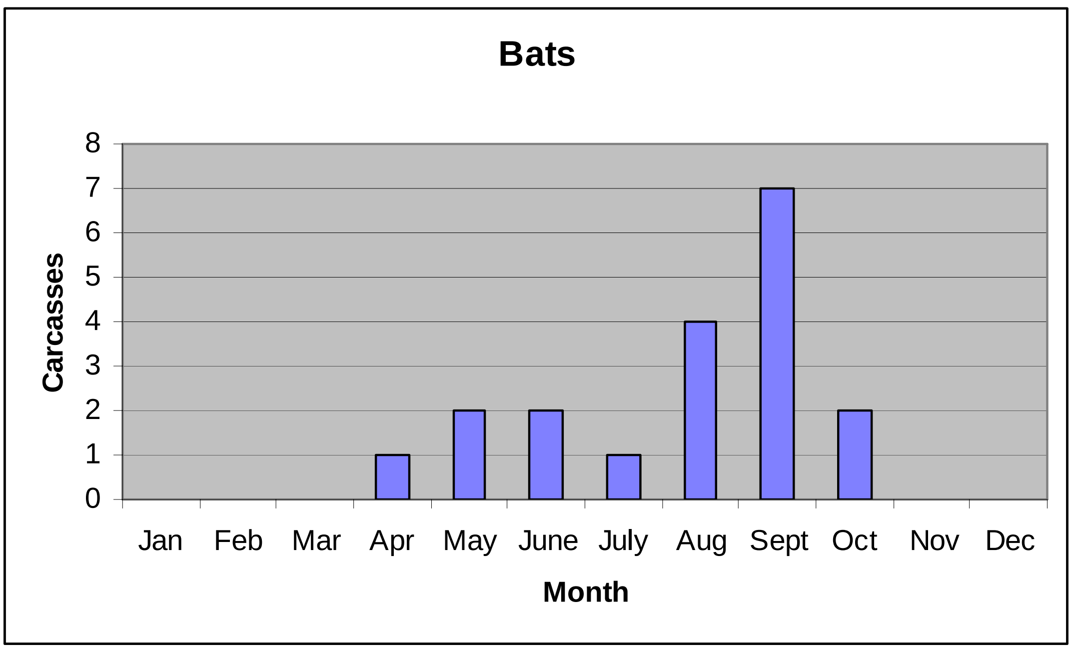


Figure 4. Carcass Removal Rates for Large and Small Birds.

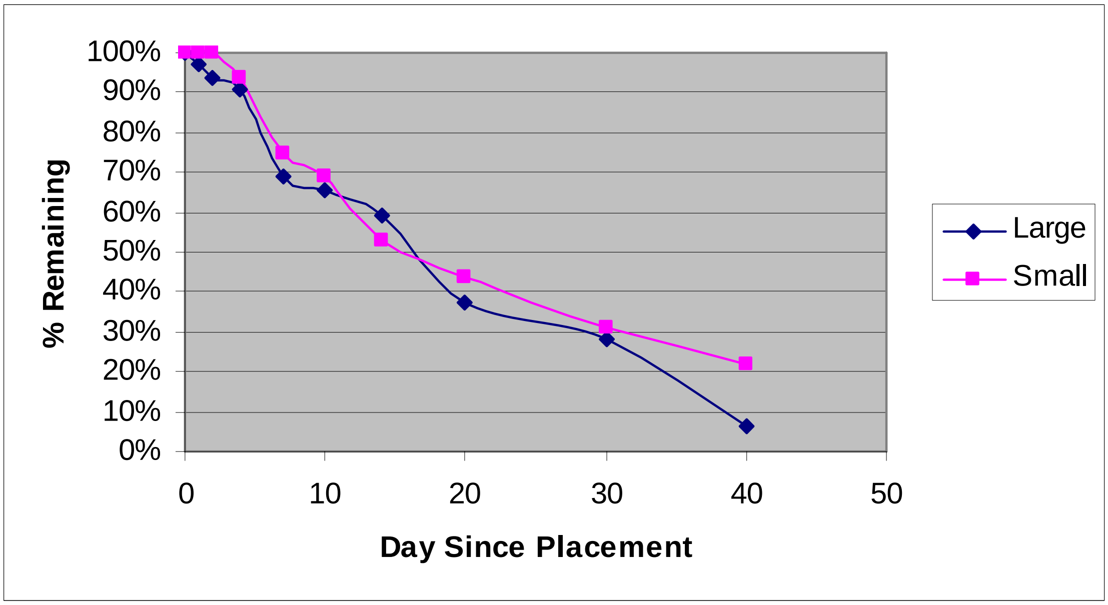
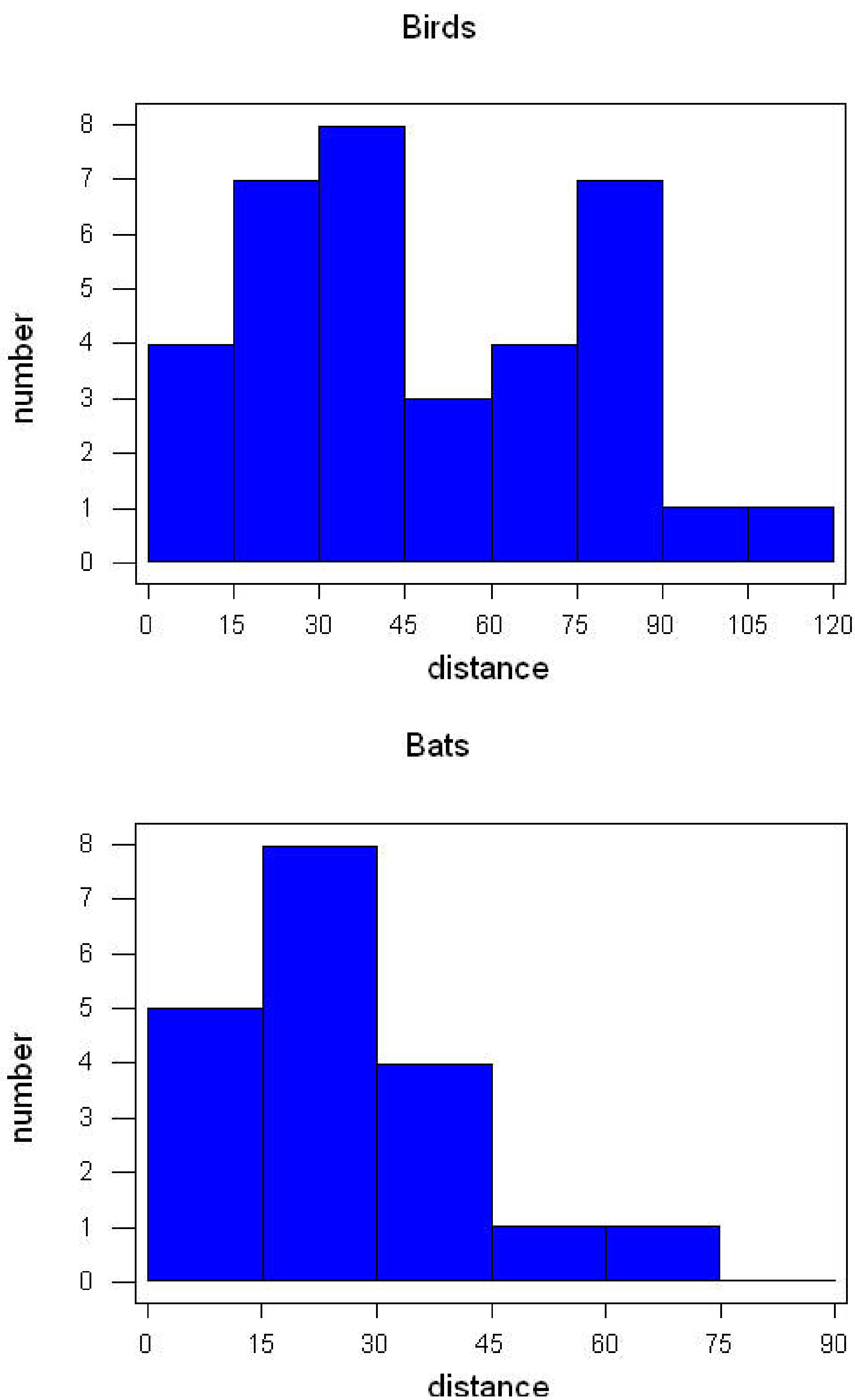


Figure 5. Distribution of Carcasses as a Function of Distance (m) from Turbine.



APPENDIX A
TURBINES AND MET TOWERS SAMPLED DURING STANDARDIZED SEARCHES

Turbine ID	Dominant Habitat[6]	Turbine Position[7]	FAA Light
1	GS	E	Y
2	GS	M	N
3	GS	M	N
4	GS	M	Y
9	CRP	M	N
10	CRP	M	Y
11	CRP	M	N
12	CRP	M	N
16	CRP	E	Y
17	CRP	M	N
18	CRP	M	N
19	CRP	E	Y
27	CRP	E	Y
28	CRP	M	N
29	CRP	M	N
30	CRP	E	Y
34	AG	E	Y
35	AG	M	N
36	AG	M	N
37	AG	M	Y
49	AG	M	N
50	AG	E	Y
51	AG	E	Y
52	AG	M	N
53	AG	M	N
57	CRP/GS	E	Y
58	CRP/GS	M	N
59	CRP/GS	E	Y
67	CRP/AG	E	N
68	CRP/AG	E	Y
73	AG	E	N
74	AG	E	Y
81	AG	E	Y
82	AG	M	N
83	AG	M	Y
84	AG	M	N
85	AG	E	Y
98	AG	M	N
99	AG	M	N
100	AG	M	Y
107	AG	E	N
East Met	AG		
West Met	AG		

[6] AG=agriculture (winter wheat, stubble, plowed), GS=grassland, CRP= Conservation Reserve Program fields
[7] E=end-row, M=mid-row.

APPENDIX B
LIST OF AVIAN FATALITIES OBSERVED DURING HOPKINS RIDGE PHASE 1 MONITORING, JANUARY 6 - DECMBER 23, 2006

	Date	Species	Nearest Turbine	Distance from tower	FAA Lit?
1	1/14/2006	black-billed magpie	27	78	Y
2	1/14/2006	ring-necked pheasant	27	64	Y
3	1/16/2006	ring-necked pheasant	11	53	N
4	1/16/2006	ring-necked pheasant	12	22	N
5	1/17/2006	ring-necked pheasant	68	115	Y
6	1/18/2006	horned lark	4	16	Y
7	1/19/2006	northern harrier	59	84	Y
8	1/20/2006	ring-necked pheasant	59	85	Y
9	2/8/2006	European starling	28	43	N
10	2/8/2006	European starling	28	65	N
11	2/8/2006	European starling	28	42	N
12	3/1/2006	European starling	85	13	Y
13	3/3/2006	American goldfinch	4	25	Y
14	3/5/2006	dark-eyed junco	51	56	N
15	3/29/2006	European starling	37	37	Y
16	3/30/2006	European starling	83	69	Y
17	4/6/2006	European starling	73	11	N
18	4/18/2006	horned lark	2	103	N
19	4/27/2006	ring-necked pheasant	109	12	N
20	5/11/2006	yellow-rumped warbler	81	80	Y
21	5/12/2006	unidentified *Empidonax*	68	82	Y
22	5/18/2006	American kestrel	35	15	N
23	5/25/2006	gray catbird	74	36	Y
24	6/1/2006	horned lark	99	37	N
25	6/23/2006	horned lark	74	1	Y
26	6/26/2006	American kestrel	43	13	N
27	7/10/2006	northern flicker	17	7	N
28	7/24/2006	horned lark	59	30	Y
29	8/17/2006	American kestrel	50	15	Y
30	8/29/2006	Townsend's warbler	49	50	N
31	9/6/2006	horned lark	16	34	Y
32	9/18/2006	white-crowned sparrow	17	78	N
33	9/20/2006	golden-crowned sparrow	59	33	Y
34	10/3/2006	American coot	17	15	N
35	10/15/2006	Cooper's hawk	10	29	Y
36	10/15/2006	golden-crowned kinglet	74	10	Y
37	11/14/2006	ring-necked pheasant	52	78	N
38	11/14/2006	Unidentified bird	49	68	N

APPENDIX C
LIST OF BAT FATALITIES OBSERVED DURING HOPKINS RIDGE PHASE 1 MONITORING,JANUARY 6 - DECMBER 23, 2006

	Date	Species	Nearest Turbine	Distance from tower	FAA Lit?
1	4/28/2006	silver-haired bat	67	57	N
2	5/3/2006	silver-haired bat	100	12	Y
3	5/17/2006	silver-haired bat	14	14	N
4	6/8/2006	hoary bat	29	19	N
5	6/12/2006	silver-haired bat	59	15	Y
6	7/5/2006	silver-haired bat	37	10	Y
7	8/21/2006	hoary bat	82	35	N
8	8/24/2006	hoary bat	9	25	N
9	8/28/2006	big brown bat	19	22	Y
10	8/29/2006	silver-haired bat	3	61	N
11	9/5/2006	silver-haired bat	85	38	Y
12	9/20/2006	silver-haired bat	58	21	N
13	9/21/2006	silver-haired bat	29	21	N
14	9/23/2006	hoary bat	100	42	Y
15	9/26/2006	silver-haired bat	18	13	N
16	9/28/2006	silver-haired bat	67	6	N
17	9/28/2006	unidentified bat	36	29	N
18	10/18/2006	little brown bat	100	18	Y
19	10/26/2006	silver-haired bat	82	30	N