Nine Canyon Wind Power Project
Avian and Bat Monitoring Report

September 2002 – August 2003

Prepared for:

Nine Canyon Technical Advisory Committee
Energy Northwest

Prepared by:

Wally Erickson
WEST, Inc.
2003 Central Ave.
Cheyenne, WY 82001

and

Karen Kronner and Bob Gritski
Northwest Wildlife Consultants, Inc.
815 NW 4th Street
Pendleton, Oregon 97801

October 2003

Executive Summary

We conducted studies of bird and bat mortality at the Nine Canyon Wind Energy Project located in Benton County, Washington. Fatality searches were conducted between September 2002 and August 2003, with a search conducted approximately every two weeks during spring, summer and fall (March – October), and once a month during the winter (November – February). A total of 19 searches were conducted at each of the 37 Nine Canyon turbines and the one unguyed permanent meteorological tower. Experimental trials were conducted to estimate searcher efficiency and carcass removal (scavenging, etc.). Mean searcher efficiency was 44% for small-sized casualties and 78% for large-sized casualties. These rates are very similar to those observed from on-going monitoring at the Stateline Wind Power Project located approximately 12 miles southeast of Nine Canyon. Mean carcass removal time, the average time it takes for a scavenger or other measure to remove a carcass, was estimated to be approximately 11 days for small birds and 33 days for large-sized birds. The carcass removal rates are higher at Nine Canyon than at Stateline. The observed number of fatalities and the results of the experimental bias trials were used to estimate mortality. Thirty-six bird and 27 bat fatalities for which collision with turbines or vehicles could not be ruled out, were found within or very near the search plots. Some of these may not have been killed by turbines or vehicles, but are conservatively included. Horned larks comprised 47% of the fatalities, ring-necked pheasants comprised 14% of the fatalities and western meadowlarks comprised 6% of the fatalities. No other individual species was documented more than once. Two raptor fatalities (American kestrel and short-eared owl) were discovered within the search plots. Estimated mortality was 3.59 bird and 3.21 bat fatalities per turbine per year. Cause of fatalities could have been strikes with turbine towers or blades, collision vehicles traveling along project roads or other non-project related causes. When standardized to the area swept by rotors of the individual turbines, per turbine fatality estimates are within the range observed at other wind projects in the west and mid-west. These results provide an estimate of the mortality expected at the Nine Canyon Wind Power Project or at future wind developments with similar characteristics.

PARTICIPANTS

Personnel	Duties
Western EcoSystems Technology	
Wallace Erickson	Project Manager, TAC Coordinator and Statistician
Kimberly Bay	Data Technician
Sean Morrison	Field Technician
Nancy LaFramboise	Field Technician
Nicholas Griffin	Field Technician
Northwest Wildlife Consultants Inc.	
Karen Kronner	Project Biologist, Field Project Manager for NWC
Bob Gritski	Team Leader, Field Supervisor and Field Biologist
Laurie Ness	Assistant Team Leader and Field Biologist
Jerry Baker	Field Technician
Julie Miller	Field Technician
Jane Holmes	Field Technician
Cindy Wood	Field Technician
Michele Talley	Field Technician
Lorie Emert	Field Technician
Riley Hall	Field Technician

Report Reference:

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.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

INTRODUCTION

The Nine Canyon Wind Project (referred to as the "Project") developed by Energy Northwest consists of 37 1.3-MW Bonus turbines on privately owned land in Benton County, Washington (Figure 1). The conditional use permit for the project, granted by the county on June 7, 2001, required, among other items, the development and implementation of an avian and bat monitoring program ("the Monitoring Plan") for the operations phase. The monitoring program follows the protocol document "Avian and Bat Monitoring Plan for the Nine Canyon Wind Project". Operational monitoring for the Nine Canyon Wind Project began in September 2002, and the first year of monitoring was completed at the end of August 2003.

Avian and bat fatality monitoring for the Project consisted of the following components: 1) fatality monitoring involving standardized carcass searches, scavenging and searcher efficiency trials, and a protocol for handling and reporting of fatalities and injured wildlife found by maintenance personnel, and 2) formation of a Technical Advisory Committee comprised of stakeholders for review of monitoring protocols and results, and discussion of mitigation measures (if needed), and for making recommendations to Benton County, the permitting agency. Mitigation measures already agreed upon include a $75 per turbine per year fee for the life of the project for benefits to shrub-steppe and grassland habitats and associated wildlife species potentially impacted by the project. This fund is managed by Washington Department of Fish and Wildlife.

The number of avian and bat fatalities attributable to the Project was estimated based on the number of avian and bat fatalities found within the search plots whose death appeared to be related to the facility. 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 (observer detection) bias. For carcasses where the cause of death was not apparent, the fatality was conservatively attributed to the facility. This report contains results from a full year of monitoring.

STUDY AREA AND PROJECT DESCRIPTION

The Project is located approximately 5 miles south of the town of Finley. Turbines are located at elevations ranging from approximately 380 – 594 m (1250 – 1950 feet) above sea level. The Project is located within the Columbia Basin Physiographic Province. The original vegetation of the project area was a 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 cultivated wheat fields, grazed shrub-steppe, and Conservation Reserve Program (CRP) grasslands (Figure 2).

Wind turbines at the facility are Bonus 1.3 MW three-bladed horizontal axis turbines mounted on a 60 m (200 feet) tubular tower (Figure 3). The rotor diameter of the turbine is approximately 62 m (203 feet) so the rotor swept area ranges from 29 m to 91 m (95 to 299 feet) above ground level. There are 37 turbines in the facility. Fifteen of the turbines are equipped with FAA required airplane warning lights[1]. Turbine towers within a string are approximately 150 m (492 feet) apart. We also monitored the permanent meteorological tower, an unguyed lattice structure approximately 60 m (200 feet) in height (Figure 4).

Thirty-one of the 37 turbines are located in wheat fields, and the remaining 6 (T-22, T-23, T-34, T-35, T-36 and T-37) are located in CRP grassland. Small areas of grassland/shrub steppe habitats exist within the northern portion of search plots along string B (T-1 through T-6).

FIELD METHODS

The fatality monitoring study began once all the turbines were constructed and operational (early September). The following dates were used to define seasons: (1) spring migration (March 16 - May 15); (2) breeding season (May 16-August 15); (3) fall migration (August 16-October 31) and (4) winter (November 1-March 15).

Standardized Carcass Searches

Personnel trained in proper search techniques conducted the carcass searches at the turbines and the permanent meteorological tower. Boundaries of rectangular plots were delineated along each turbine string. All areas within a minimum of 90-m from turbines were searched[2]. Transects were set at 6 m (20 feet) apart, and searchers walked at a rate of approximately 45 to 60 m (148 to 197 feet) a minute along each transect searching both sides out to 3 m (10 feet) for casualties (Johnson *et al*. 1993). Search area and speed were adjusted by habitat type. It took approximately 1.5 to 2 hours to search each turbine depending on the habitat type. Searches were conducted twice monthly in the spring, summer and fall and once monthly in the winter, resulting in 19 searches at each of the 37 turbines. A complete round of searches (all turbines searched) took approximately 4 to 5 days to complete, depending on the number of searchers.

The condition of each carcass found was recorded using the following condition categories: (1) Intact – a completely intact carcass that is not badly decomposed, and showing no sign of being fed upon by a predator or scavenger; (2) Scavenged – an entire carcass which shows signs of being fed upon by a

[1] white strobe lights during the day, and red pulsating lights at night
[2] the search area was expanded from 70 m (230 feet) to 90 m (295 feet) in November 2002

predator or scavenger, or a portion(s) of a carcass in one location (e.g., wings, skeletal remains, legs, pieces of skin, etc.), and (3) Feather Spot - 10 or more feathers, or two primary feathers at one location indicating predation or scavenging.

All carcasses found were uniquely labeled, bagged and frozen for future reference and possible necropsy. A copy of the data sheet for each carcass was stored with the carcass at all times. Data recorded included species, sex and age (when possible), date and time collected, location, condition, and any comments that may indicate cause of death. All casualties were photographed as found. Casualties or fatalities found incidentally and not during formal searches were documented using a wildlife incidental reporting system (see next section). When non-study personnel discovered wildlife carcasses, a biologist was contacted to identify and collect the casualty. Appropriate wildlife salvage permits were obtained from the Washington Department of Fish and Wildlife and the U.S. Fish and Wildlife Service.

Energy Northwest's Wildlife Reporting and Handling System for Incidental Fatality and Injured Bird Discoveries

Energy Northwest'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 (Energy Northwest 2003). 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.

Any carcass discovered by maintenance personnel was recorded, photographed and reported to the designated Primary Respondent. The Primary Respondent contacted a Project Biologist to have the fatality identified and collected.

Experimental Searcher Efficiency Trials

Searcher efficiency studies were conducted throughout the year in the carcass search areas. Estimates of searcher efficiency were used to adjust the number of carcasses found, correcting for detection bias. Search personnel did not know when efficiency trials were to be conducted. Before the beginning of a standardized carcass search, observer detection trial carcasses were placed at random locations. Each carcass was discretely 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. Each carcass was discretely secured to its location to discourage removal by scavengers. The number and location of the detection carcasses found during the carcass search were recorded. The number of carcasses available for detection during each trial was verified immediately after the trial to ensure that between the time they were placed and the carcass search on that day no carcasses were removed by scavengers. Carcasses not found by the searcher were removed following the carcass search effort for that day.

Nine searcher efficiency trials were conducted (trial dates 2002: September 26, October 22, December 16; trial dates 2003: February 19, April 7, May 6, June 24, July 8, August 7). Outcome (detected or not detected) was determined for 34 small and 37 large sized carcasses placed in the field prior to carcass searches. Carcasses used to represent large birds included ring-necked pheasant, great horned owl, red-tailed hawk (*Buteo jamaicensis*), Canada goose, mallard, rock dove, and barn owl. Carcasses used to represent small birds and bats included coturnix quail, house sparrow, American robin, white-crowned sparrow, killdeer, silver-haired bat (*Lasionycterus noctivagans*), warbling vireo (*Vireo gilvus*), juvenile ring-necked pheasant and red-winged blackbird.

Experimental Carcass Removal Trials

Experimental carcass removal trials were conducted throughout the year near the carcass search plots using planted carcasses. 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. 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.

Two trials were conducted each season (start dates 2002: Sept 23, Dec 16; start dates 2003: January 13, March 19, April 7, May 19, June 23, August 18). Eight carcasses, 4 large and 4 small, were used in each trial, for a total of 32 small and 32 large carcasses for the entire trial. Carcasses were placed in the field (day 0) and typically checked on days 1, 2, 3, 4, 7, 14, 20, and 30. At the end of the 30-day period any remaining carcasses or feathers were removed.

Carcasses used to represent medium to large birds included ring-necked pheasant (*Phasianus colchicus*), ring-billed gull (*Larus delawarensis*), American kestrel (*Falco sparverius*), mallard (*Anas platyrhynchos*), rock dove (*Columba livia*), great horned owl (*Bubo virginianus*), Canada goose (*Branta canadensis*), gray partridge (*Perdix perdix*), and barn owl (*Tyto alba*). Carcasses used to represent small birds and bats included juvenile ring-necked pheasant, western meadowlark (*Sturnella neglecta*), red-winged blackbird (*Agelaius phoeniceus*), song sparrow (*Melospiza melodia*), mourning dove (*Zenaida macroura*), horned lark (*Eromophila alpestris*), cliff swallow (*Petrochelidon pyrrhonota*), white-crowned sparrow (*Zonotrichia leucophrys*), American robin (*Turdus migratorius*), coturnix quail (*Coturnix coturnix*), house sparrow (*Passer domesticus*), killdeer (*Charadrius vociferous*), northern rough-winged swallow (*Stelgidopteryx serripennis*), red-breasted nuthatch (*Sitta canadensis*), house finch (*Carpodacus mexicanus*) and vesper sparrow (*Pooecetes gramineus*).

Raptor Nest Monitoring

Three historic raptor nests near the project were checked for occupancy on June 22 and 23, 2003.

STATISTICAL METHODS

Observed Number of Carcasses

The observed fatality rate was expressed as the mean number of carcasses ($\bar{c}$) observed per turbine per year.

Estimation of Searcher Efficiency Rates

Searcher efficiency rates are expressed as *p,* the proportion of trial carcasses that are detected by searchers.

Estimation of Carcass Removal Rates

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: $\bar{t} = \frac{\sum_{i=1}^{s} t_i}{s - s_c}$, where t_i is the removal time of the ith carcass, s is the number of carcasses used in the trials, and s_c is the number of carcasses remaining at day 30 of the trial.

This estimator is the maximum likelihood estimator assuming the removal times follow an exponential distribution and there is right-censoring of data (Barnard 2000). In our application, any trial carcasses still remaining at 30 days were collected, yielding censored observations at 30 days.

Estimation of Facility-Related Fatality Rates

We estimate the facility-related fatality rates by dividing the observed number of fatalities by an estimate of the probability a casualty is available to be picked up during a fatality search (probability it is not removed by a scavenger or by other methods), and is observed (probability of detection). This estimator (m_1) has been applied at other wind facilities, and was the estimator proposed in the Stateline Protocols (FPL Energy *et al.*, 2001, Oregon Energy Facility Siting Council 2001 and 2002) and the Nine Canyon Protocol. The estimated per turbine annual fatality rate (m_1) is calculated by:

$$m_1 = \frac{\bar{c}}{\hat{\pi}_1},$$

where

$$\hat{\pi}_1 = \begin{cases} \frac{\bar{t} \cdot p}{I} & \text{if } I > \bar{t} \\ p & \text{if } I \le \bar{t} \end{cases},$$

p is the estimated searcher efficiency rate, $\bar{t}$ is the estimated carcass removal time, and I is the average interval between searches (approximately 19 days).

We calculated fatality estimates for 1) all birds, 2) small birds, 3) large birds, 4) raptors, and 5) bats. The final reported estimate of m_1 and associated standard errors and 90% confidence intervals were calculated using bootstrapping (Manly 1997).

Statistical Comparisons of Observed Mortality

Observed bird and bat mortality (unadjusted for biases) was compared among several factors for the purpose of understanding whether these factors influenced the mortality rates. Factors included:

1) Juxtaposition within the Project (String A, String B and String C);
2) Juxtaposition within a string (end row versus mid-row);
3) Lighting (lit versus unlit turbines);

Means and limits of 95% confidence intervals for levels of each factor were presented in graphs.

RESULTS

Bird Casualties

No casualties of federal or state-listed species were found during the study. Thirty-eight avian casualties representing 13 species[3] were found within search plots during the study (Table 1). Six casualties were non-native species. One heavily scavenged avian carcass (rough-legged hawk) was found a long distance (200 m) from the turbines, and was excluded from the analysis. Two of the 38 casualties were flightless young found away from the roads, and were therefore not considered collision fatalities. Only the remaining 36 were used in subsequent analyses. Eight of the 36 fatalities were intact, 13 were dismembered and scavenged, and the remaining 15 were feather spots. No fatalities were observed at the permanent meteorological tower. The thirty-six fatalities were observed at 21 different turbines (Table 2, Figure 5). The maximum number of fatalities observed during this period nearest any one turbine was 3 (Turbines 2, 4, 16 and 37). Two fatalities were found at 7 different turbines, and one fatality was observed at 10 different turbines. It was assumed that the fatalities occurred at the turbine nearest the carcass.

The most common fatality was horned lark (17 fatalities, 47% of total), which is a very common resident bird (Figure 6). Horned larks are also the most common fatality observed at the Stateline Wind Project, which is located approximately 12 miles southeast of the Nine Canyon Wind Project area (Erickson *et al*. 2003). Ring-necked pheasant (5 fatalities, 14% of total) and western meadowlark (2 fatalities, 6% of total) were the only other species with multiple fatality records. All five ring-necked pheasant casualties were feather spots. Two of the five feather spots were found at a potential roost site, which suggests they may not have been fatalities. Other fatalities found were one American kestrel, European starling (*Sturnus vulgaris*), great blue heron (*Ardea herodias*), red-breasted nuthatch, ruby-crowned kinglet (*Regulus calendula*), short-eared owl (*Asio flammeus*), spotted towhee (*Pipilo maculates*), Virginia rail (*Rallus limicola*), winter wren (*Troglodytes troglodytes*), and yellow-rumped warbler (*Dendroica coronata*). There were also two unidentified passerine feather spots observed within search plots.

The winter wren, yellow-rumped warbler, spotted towhee, ruby-crowned kinglet, and red-breasted nuthatch were most likely migrants. Virginia rails are found year-round in the Tri-Cities area in wetland habitats. It is unclear whether the rail was migrating through the project area, or a local resident that was moving between suitable habitat. There is no suitable habitat for this species near the project site. The American kestrel found in the middle of November had been heavily scavenged and scattered suggesting it was possibly dragged by farm equipment. The short-eared owl was intact. The average

[3] 13 identifiable species and four unidentified passerine feather spots

distance from turbines to fatalities was 50 m (164 feet). Bird casualties were discovered during all but two search periods (late July and early August, Figure 7).

Bat Casualties

Twenty-seven dead bats were found during the study (Table 3). Silver-haired bat (15) and hoary bat (*Lasiurus cinereus*) (12) were the only two species observed. Both these species are likely migrants at this project site. Twenty of the bat fatalities were found during the period August 5 through October 24, during the apparent fall migration period for these bat species. Seven of the fatalities were found from May 6 through July 8 (Figure 7). These 27 fatalities were observed at 18 different turbines (Table 2, Figure 5). The maximum number of fatalities observed at any one turbine was 3 (Turbine 24). The average distance from turbines to fatalities was 29 m (95 feet).

Experimental Searcher Efficiency Bias Trials

The estimated observer detection rate was 44% for small birds (n=34), and 78% for medium to large birds (n=37).

Experimental Carcass Removal Bias Trials

Some evidence of scavenging of trial carcasses was often documented a day after the carcasses were placed in the field, although removal of the carcass typically did not occur on this first day. On average, small carcasses lasted approximately 11 days before they were removed (n=32), with 94% of trial carcasses removed at day 30 of the trial (Figure 8). Large carcasses averaged approximately 33 days before they were removed (n=32), with 57% removed at the end of the trial period (day 30).

Fatality Estimates

Fatality estimates, standard errors and 90% confidence intervals for (1) all birds, (2) small birds, (3) large birds, (4) raptors, and (5) bats are found in Table 4.

Small Birds

Twenty-eight small bird fatalities were found on search plots during the monitoring period. The estimated average probability a small bird casualty remained until a scheduled search was initiated (monthly or every 2 weeks) and was found was 0.246. The estimated number of small bird fatalities per turbine per year for the Nine Canyon Wind Power Project is 3.31 (1.75, 5.51)[4]. We estimate an average of

[4] upper and lower limits of 90% confidence intervals (bootstrapping)

122 small bird fatalities each year for the 37 wind turbines.

Large Birds

Eight large birds were found on search plots during the monitoring period. The estimated average probability a large bird casualty remained until a scheduled search and was found was 0.780. The estimated number of large bird fatalities per turbine per year for the Nine Canyon Wind Power Project is 0.28 (0.11, 0.48). We estimate an average of 10 large bird fatalities each year for the 37 wind turbines.

All Birds

The all bird fatality estimate was obtained by summing the estimates for small and large birds. Based on the 36 bird casualties found on the search plots, we estimate 3.59 bird fatalities occur per turbine per year (2.03, 5.78) for the Nine Canyon Wind Power Project. We estimate an average of 133 bird fatalities each year for the 37 wind turbines.

Raptors

Among of the eight large bird casualties discovered on standardized search plots were two raptors. We estimate 0.065 raptor fatalities occur per turbine per year (0.054, 0.148) for the Nine Canyon Wind Power Project. We estimate an average of 3 raptor fatalities each year for the 37 wind turbines.

Bats

Twenty-seven bat fatalities were observed on search plots during the study. We estimate 3.21 bat fatalities occur per turbine per year (1.71, 5.37) for the Nine Canyon Wind Power Project. We estimate an average of 119 bat fatalities each year for the 37 wind turbines.

Raptor Nest Monitoring

Three historically active nests of raptor species of interest (Swainson's hawk and ferruginous hawk) exist within approximately four miles of the Nine Canyon Project. The nearest historic ferruginous hawk nest is located approximately 3 miles southeast of the project. This nest site was not active in 2000, 2001 and 2002. The site was used by common ravens in 2003. Another historic ferruginous hawk nest is located approximately 3.8 miles southwest of the project. This site was occupied by ferruginous hawks in 2001 and 2002 before operation began and again in 2003 during operations of the wind project. One historic Swainson's hawk nest is located along Beck Rd. and approximately 1.8 miles from Nine Canyon wind turbines. This nest site was occupied by Swainson's hawks in 2001 and 2002 and again in 2003.

SUMMARY/DISCUSSION

With the exception of the two flightless young, all bird casualties observed within the search plots were included in the fatality estimates. There were no other casualties where the cause of death could be definitively attributed to factors not related to the wind facility, although true cause of death is unknown for most of the fatalities. Some of the fatalities may have been killed by means not associated with wind facility operations (e.g., kills by raptors or other predators). A maintenance person reported hitting a pheasant with a vehicle near a turbine where a pheasant fatality was found during a search around the same time. Two other pheasant feather spots were found near a potential roost site and may have been predator kills, excessive molting or were injured birds. Several of the horned lark fatalities are suspected to be vehicle kills occurring along turbine string roads and not wind turbine strikes, given the locations of the finds (e.g., recently fledged juveniles near or along the road). TAC members previously agreed that all fatalities would be attributable to the wind project operations (inclusive of turbine strikes and vehicle impacts) unless cause of death not related to the operations could be determined.

There is likely some background[5] mortality that is included in the fatality rate estimates. To the best of our knowledge, reference or background mortality has been estimated only once during baseline studies of new wind projects. During a four-year study at Buffalo Ridge (MN), 2,482 fatality searches were conducted on study plots without turbines to estimate reference mortality in the study area, and 31 avian fatalities comprised of 15 species were found (Johnson *et al.* 2002). Reference mortality consisted of eight upland gamebirds, seven doves, five sparrows, three waterfowl, three raptors, two blackbirds, one waterbird, one shorebird, and one unidentified bird. The exact cause of death of many birds found in reference plots could not be determined; however, most birds appeared to have been killed by predators or vehicles. Reference mortality was estimated to average 1.1 per plot per year, compared to 0.98, 2.27 and 4.45 fatalities per turbine search plot per year in the Phase 1, 2 and 3 wind plants, respectively (Johnson *et al.* 2002). These numbers indicate that estimates of turbine mortality likely include some fatalities not related to project operations.

Although background mortality is likely one of the largest sources of bias in the bird estimates, other factors may have caused an overestimate of the number of fatalities. Searcher efficiency trials are conducted with intact carcasses, while some of the casualties were found as feather spots or scattered body parts. These feather spots sometimes involve numerous feathers spread over a large area, and are therefore likely easier to detect than an intact carcass. If this bias exists, it would contribute to an underestimate of bird detection rates and an overestimate of fatality rates. Carcasses found incidentally[6]

[5] fatalities that were caused by factors unrelated to the Wind Project (e.g., predator kills, farm equipment collisions)
[6] not found during formal searches

(approximately 6% of total bird finds) were included in the calculation of fatality estimates, also possibly contributing to an overestimate of the fatality rates. These fatalities may or may not have been found during scheduled searches. One other possible negative bias in the estimate relates to the carcass search plot area. The average distance from a turbine to a bird fatality was 50 m (164 feet). We searched out a minimum distance of 90 m (295 feet) to each turbine, but given the distribution of fatalities as a function of distance to turbine, a small percentage of fatalities may have landed outside the search plots (Figure 9). This bias appears to be extremely small for bats, since only one fatality was observed more than 50 m (164 feet) from a turbine.

Approximately 50% of the bird fatalities were horned larks, a very common yearlong resident songbird within the project and the geographic area that comprised over 50% of the bird observations from pre-construction point counts at the Nine Canyon Project (Erickson *et al*. 2001). Five pheasants feather spots were found and were included in the fatality estimates, although some of these feather spots may not have been casualties. If they were casualties and not excessive molting at roost sites, we also believe wind turbines were likely not the cause of death. One of the pheasants founds was apparently killed by a maintenance vehicle. We believe vehicles (part of wind plant operations) or raptors were the probable cause of death for the other pheasant fatalities. Two western meadowlark fatalities were also found, and western meadowlarks were the 2nd most commonly observed species observed during pre-construction point counts (Erickson *et al*. 2001). No other individual species was documented more than once as a fatality. One European starling, which is not protected under the Migratory Bird Treaty Act (MBTA), was included in the fatality estimate.

Comparisons of fatality rates among wind projects should account for factors such as operation time of the wind project, rotor swept area of the turbines, and nameplate power output of the turbines. When adjusted fatality rates are standardized to 3000 m^2 rotor swept area or to 1 MW of nameplate power output, bird and bat fatality rates at Nine Canyon are in the range of observed at other new generation wind projects (Table 5).

Studies at the Foote Creek Rim Wind Project (Young *et al*. 2003) showed 3 to 4 times higher per structure fatality rates at the guyed meteorological towers compared to the wind turbines. The higher fatality rates were likely caused by the wires associated with the structure. In response to those results, Energy Northwest agreed to use an unguyed meteorological tower, and no fatalities were observed at this structure.

We compared observed fatality rates among levels of three primary factors, juxtaposition of turbines within a turbine string, juxtaposition of turbine strings within the wind project and lighting of turbines. These were not experiments, so cause of significant differences cannot be inferred from this observation data. No statistically significant differences in fatality rates were observed for any of the factors (Figures 10-12). Observed fatality rates for birds and bats combined were very similar comparing end row turbines to mid-row turbines. One earlier study of raptor mortality suggested higher mortality rates for end row turbines (Orloff and Flannery 1992 and 1996), but other more recent studies have suggested higher raptor mortality rates at mid-row turbines (Anderson *et al.* 2000).

Tall structures that are lighted are suspected of attracting nocturnal migrating birds, especially during inclement weather (Kerlinger 2000). High intensity continuously lit red lights are believed to be more of an attractant than other types, although very few studies have investigated this. We investigated whether the annual observed fatality rates tended to differ for lit turbines compared to unlit turbines. Observed fatality rates at lit turbines were higher than at unlit turbines for passerines and lower at lit turbines for bats, although none of the differences were statistically significant ($p>0.10$). These observed differences in fatality rates were not consistent with observed differences from monitoring of the Stateline Wind Project (Erickson *et al.* 2003).

ACKNOWLEDGEMENTS

We would like to thank Energy Northwest Energy for funding and other support for this project. We would also like to thank the Blair and the Bateman families for their cooperation. We want to acknowledge the field personnel who conducted the carcass searches, often under very difficult environmental conditions (see page ii for the list of project participants).

REFERENCES

Anderson, R.L., D. Strickland, J. Tom, N. Neumann, W. Erickson, J. Cleckler, G. Mayorga, G. Nuhn, A. Leuders, J. Schneider, L. Backus, P. Becker and N. Flagg. 2000. Avian monitoring and risk assessment at Tehachapi Pass and San Gorgonio Pass wind resource areas, California: Phase 1 preliminary results. Proceedings of the National Avian-Wind Power Planning Meeting 3:31-46. National Wind Coordinating Committee, Washington, D.C.

Barnard, D. 2000. Statistical properties of an avian fatality estimator. Thesis, University of Wyoming, Laramie, Wyoming, USA.

Erickson, W.P., J. Jeffrey, K. Kronner, and K. Bay. 2003. Stateline Wind Project Wildlife Monitoring Annual Report, Results for the Period July 2001 – December 2002. Technical report submitted to FPL Energy, the Oregon Office of Energy, and the Stateline Technical Advisory Committee.

Erickson, W.P., E. Lack, M. Bourassa, K. Sernka, and K. Kronner. 2001. Wildlife baseline study for the Nine Canyon Wind Project. Technical report prepared for Energy Northwest.

Energy Northwest. 2003. Nine Canyon Wind Project Wildlife Reporting And Handling System. Technical Manual.

FPL Energy Inc., 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.

Franklin, J. F. and C. T. Dyrness. 1973 (1988 reprint with new bibliographic supplement). Natural Vegetation of Oregon and Washington. Oregon State University Press, Corvallis, OR. 452 pp.

Johnson, G.D., W.P. Erickson, and J. White. 2003. 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., H.O. Krueger, and R.T. Balcomb. 1993. Effects on wildlife of Brace® 10G applications to corn in south-central Iowa. Environmental Toxicology and Chemistry 12:1733-1739.

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.

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

Oregon Energy Facility Siting Council. 2001. Final Order for the Stateline Wind Facility. September 2001. Attachment A. Stateline Wind Project: Oregon Wildlife Monitoring Plan.

Oregon Energy Facility Siting Council. 2002. Final Order on Stateline Amendment #1. May 17, 2002. Attachment A. Stateline Wind Project: Oregon Wildlife Monitoring Plan.

Orloff, S. and A. Flannery. 1992. Wind turbine effects on avian activity, habitat use, and mortality in Altamont Pass and Solano County Wind Resource Areas, 1989-1991. Final Report to Alameda, Costra Costa and Solano Counties and the California Energy Commission by Biosystems Analysis, Inc., Tiburon, CA.

Orloff, S. and A. Flannery. 1996. A continued examination of avian mortality in the Altamont Pass Wind Resource Area. Final Report to the California Energy Commission by Biosystems Analysis, Inc., Tiburon, CA.

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

Table 1. Bird fatalities found within carcass search plots at the Nine Canyon Wind Project for the one-year monitoring period.

Sequence ID	Structure ID	Alternate Structure ID	Date Collected	Species	Distance (m)
1	T-21	C0801	9/8/2002	horned lark	15
2	T-37	C0905	9/9/2002	Virginia rail	34
3	T-16	B0701	9/10/2002	ring-necked pheasant	69
4	T-16	B0701	9/10/2002	ring-necked pheasant	73
5	T-22	A0101	9/26/2002	horned lark	40
6	T-7	B0403	10/9/2002	horned lark	9
7	T-33	C0901	10/22/2002	winter wren	65
8	T-35	C0903	11/18/2002	American kestrel	14
9	T-37	C0905	12/16/2002	European starling	39
10	T-18	B0703	1/14/2003	horned lark	20
11	T-16	B0701	1/14/2003	western meadowlark	18
12	T-18	B0703	1/14/2003	yellow-rumped warbler	61
13	T-36	C0904	2/17/2003	great blue heron	118
14	T-2	B0302	2/21/2003	horned lark	20
15	T-1	B0301	2/21/2003	ring-necked pheasant	103
16	T-12	B0602	3/18/2003	spotted towhee	101
17	T-22	A0101	3/19/2003	horned lark	52
18	T-2	B0302	3/19/2003	unidentified passerine	42
19	T-25	A0202	3/20/2003	horned lark	42
20	T-31	C0804	4/7/2003	short-eared owl	59
21	T-12	B0602	4/7/2003	unidentified passerine	65
22	T-27	A0204	4/10/2003	horned lark	35
23	T-14	B0604	4/22/2003	horned lark	53
24	T-5	B0401	4/24/2003	horned lark	46
25	T-3	B0303	4/24/2003	ruby-crowned kinglet	99
26	T-27	A0204	5/8/2003	horned lark	24
27	T-4	B0304	5/22/2003	horned lark	24
28	T-4	B0304	5/22/2003	horned lark	39
29	T-35	C0903	6/4/2003	ring-necked pheasant	74
30	T-9	B0405	6/5/2003	horned lark	29
31	T-5	B0401	6/6/2003	horned lark	23
32	T-2	B0302	6/6/2003	horned lark	75
33	T-07	B0403	7/23/2003	western meadowlark	99
34	T-20	B0705	8/4/2003	red-breasted nuthatch	57
35	T-37	C0905	8/19/2003	ring-necked pheasant	69
36	T-04	B0304	8/22/2003	horned lark	9

Table 2. Distribution of observed bird and bat fatalities among turbines.

Turbine	All Fatalities	All Birds	Passerines	Nocturnal Migrants	Raptors	Bats
String B						
T-1	1	1	0	0	0	0
T-2	3	3	3	0	0	0
T-3	2	1	1	1	0	1
T-4	3	3	3	0	0	0
T-5	2	2	2	0	0	0
T-6	0	0	0	0	0	0
T-7	2	2	2	0	0	0
T-8	2	0	0	0	0	2
T-9	3	1	1	0	0	2
T-10	0	0	0	0	0	0
T-11	1	0	0	0	0	1
T-12	3	2	2	1	0	1
T-13	2	0	0	0	0	2
T-14	1	1	1	0	0	0
T-15	0	0	0	0	0	0
T-16	3	3	0	0	0	0
T-17	1	0	2	0	0	1
T-18	3	2	1	1	0	1
T-19	0	0	0	0	0	0
T-20	1	1	1	1	0	0
String A						
T-22	3	2	2	0	0	1
T-23	2	0	0	0	0	2
T-24	3	0	0	0	0	3
T-25	1	1	1	0	0	0
T-26	0	0	0	0	0	0
T-27	4	2	2	0	0	2
T-28	1	0	0	0	0	1
String C						
T-21	1	1	1	0	0	0
T-29	0	0	0	0	0	0
T-30	1	0	0	0	0	1
T-31	1	1	0	0	1	0
T-32	0	0	0	0	0	0
T-33	2	1	1	1	0	1
T-34	1	0	0	0	0	1
T-35	2	2	0	0	1	0
T-36	3	1	0	0	0	2
T-37	5	3	2	1	0	2
Grand Total	63	36	28	6	2	27

Table 3. Bat fatalities found within carcass search plots at the Nine Canyon Wind Project for the one year monitoring period.

Sequence ID	Structure ID	Alternate Structure ID	Date Collected	Species	Distance(m)
1	T-33	C0901	9/8/2002	silver-haired bat	31
2	T-18	B0703	9/9/2002	silver-haired bat	6
3	T-36	C0904	9/9/2002	hoary bat	28
4	T-17	B0702	9/10/2002	silver-haired bat	14
5	T-11	B0601	9/10/2002	silver-haired bat	30
6	T-28	A0205	9/23/2002	silver-haired bat	9
7	T-30	C0803	9/23/2002	silver-haired bat	30
8	T-37	C0905	9/23/2002	silver-haired bat	26
9	T-8	B0404	9/25/2002	silver-haired bat	48
10	T-13	B0603	9/25/2002	silver-haired bat	35
11	T-23	A0102	9/26/2002	hoary bat	8
12	T-24	A0201	9/26/2002	hoary bat	29
13	T-24	A0201	9/26/2002	hoary bat	25
14	T-37	C0905	10/8/2002	hoary bat	30
15	T-23	A0102	10/11/2002	silver-haired bat	17
16	T-27	A0204	10/17/2002	silver-haired bat	10
17	T-24	A0201	10/24/2002	hoary bat	38
18	T-9	B0405	5/6/2003	silver-haired bat	48
19	T-9	B0405	5/21/2003	hoary bat	93
20	T-22	A0101	5/22/2003	silver-haired bat	15
21	T-34	C0902	6/4/2003	hoary bat	11
22	T-3	B0303	6/6/2003	silver-haired bat	48
23	T-36	C0904	6/20/2003	hoary bat	32
24	T-8	B0404	7/8/2003	silver-haired bat	12
25	T-12	B0602	8/5/2003	hoary bat	42
26	T-13	B0603	8/20/2003	hoary bat	30
27	T-27	A0204	8/21/2003	hoary bat	25

Table 4. Observed number of birds and bats and adjusted fatality rate estimates for the Nine Canyon Wind Project.

		# fatalities per turbine per year				# fatalities in Wind Project per year			
Group	# found	mean	se[a]	ll[b]	ul[c]	Total	se	ll	ul
all birds	36	3.59	1.20	2.03	5.78	133	44	75	214
small birds	28	3.31	1.20	1.75	5.51	122	44	65	204
large birds	8	0.28	0.12	0.11	0.48	10	4	4	18
raptors	2	0.065	0.046	0.054	0.148	3	2	2	5
bats	27	3.21	1.16	1.71	5.37	119	43	63	199

[a] standard error of mean
[b] lower limit of a 90% confidence interval about the mean
[c] upper limit of a 90% confidence interval about the mean

Table 5. Comparison of fatality rates standardized to rotor swept area (3000 m^2) or nameplate power output (1 MW) for several wind projects.

	Project Size		Turbine Characteristics			Fatality Rates			
						Birds		Bats	
Wind Power Project	# turbines	Nameplate Output (MW)	RD[a] (m)	RSA[b] (m^2)	Nameplate Output (MW)	#/ 3000 m^2 RSA	#/ MW	#/ 3000 m^2 RSA	#/ MW
Stateline, OR/WA	454	300	47	1735	0.66	2.9	2.6	1.6	1.4
Vansycle, OR	38	25	47	1735	0.66	1.1	1.0	1.3	1.1
Klondike, OR	16	24	65	3318	1.5	1.3	0.9	1.0	0.8
Nine Canyon, WA	37	48	62	3019	1.3	3.6	2.8	3.2	2.5
Foote Creek Rim, WY	69	48	43	1452	0.7[c]	3.5	2.4	2.1	1.4
Wisconsin	31	20	47	1735	0.66	2.2	2.0	7.4	6.5
Buffalo Ridge, MN	353	212	44	1488	0.6[d]	5.6	4.7	4.0	3.3

[a] rotor diameter
[b] rotor swept area
[c] an approximately average turbine output based on the two different sizes of turbines in operation at the time of study
[d] an approximately average turbine output based on the three different sizes of turbines in operation at the time of study,

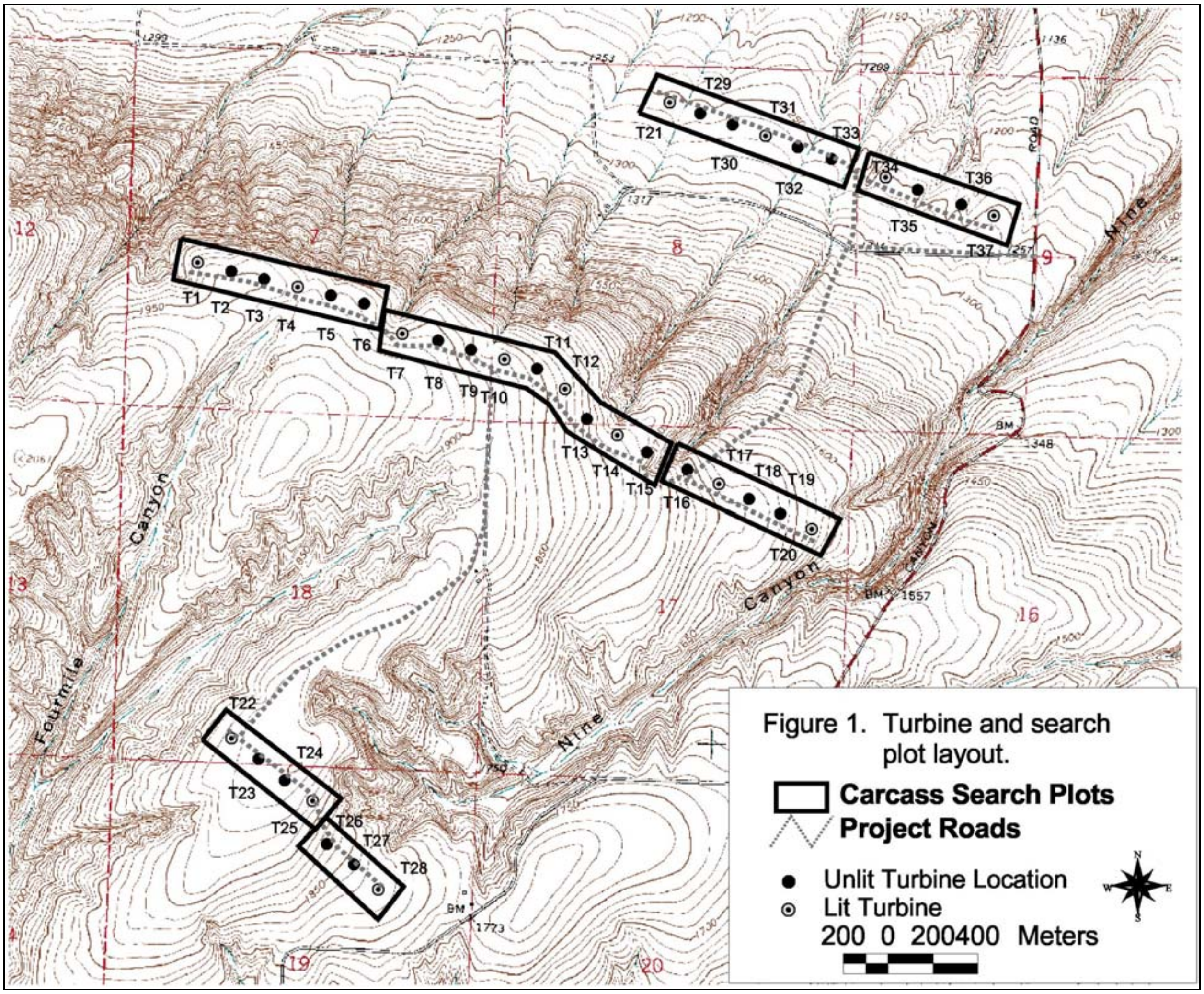


Figure 1. Turbine and search plot layout.

Figure 2. Aerial photograph of the Nine Canyon Wind Project.

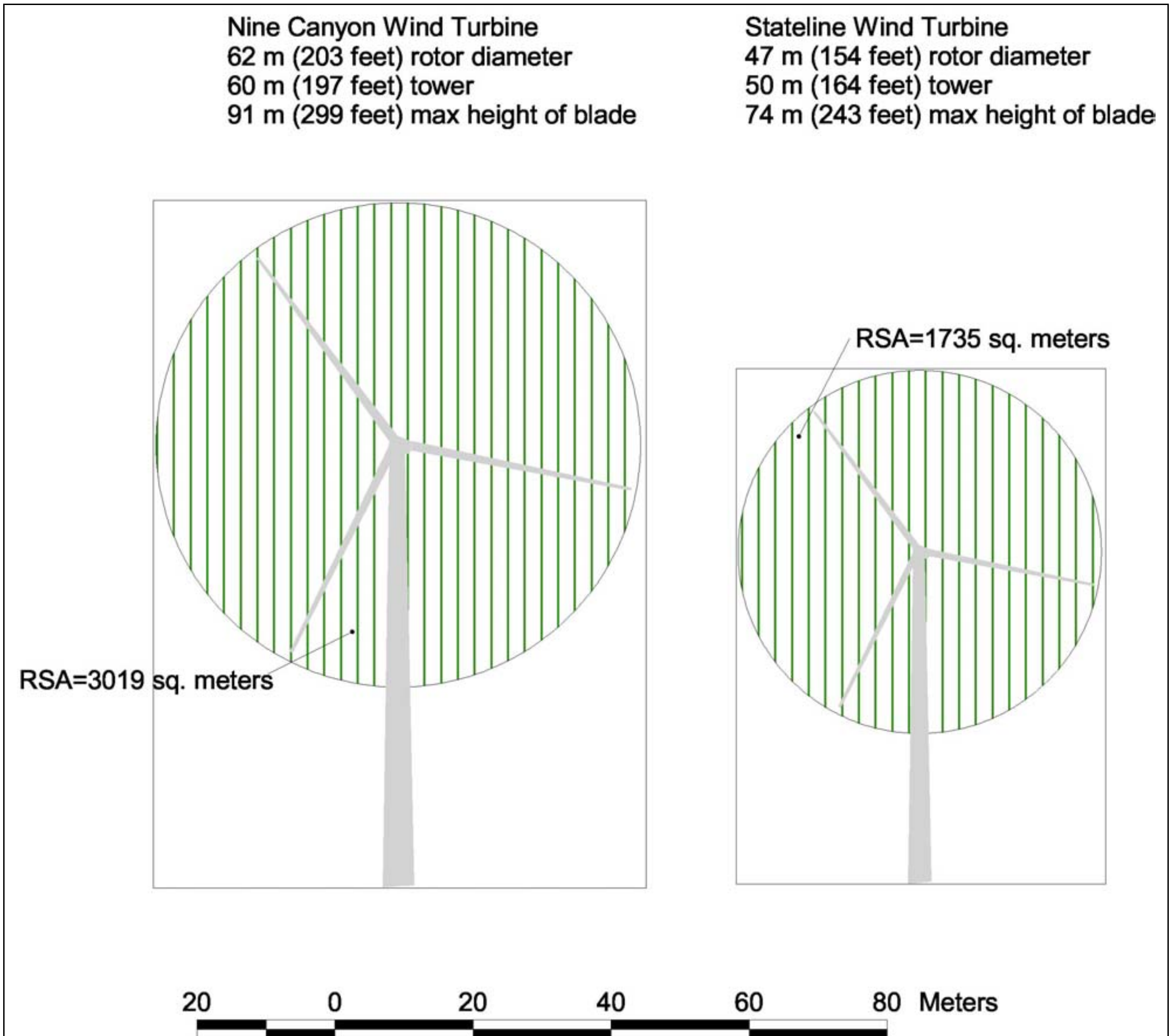


Figure 3. Illustration of differences in size between the Nine Canyon 1.3 MW turbines and the Stateline 660 kW turbines.

Figure 4. Lattice unguyed meteorological tower at the Nine Canyon Wind Project.

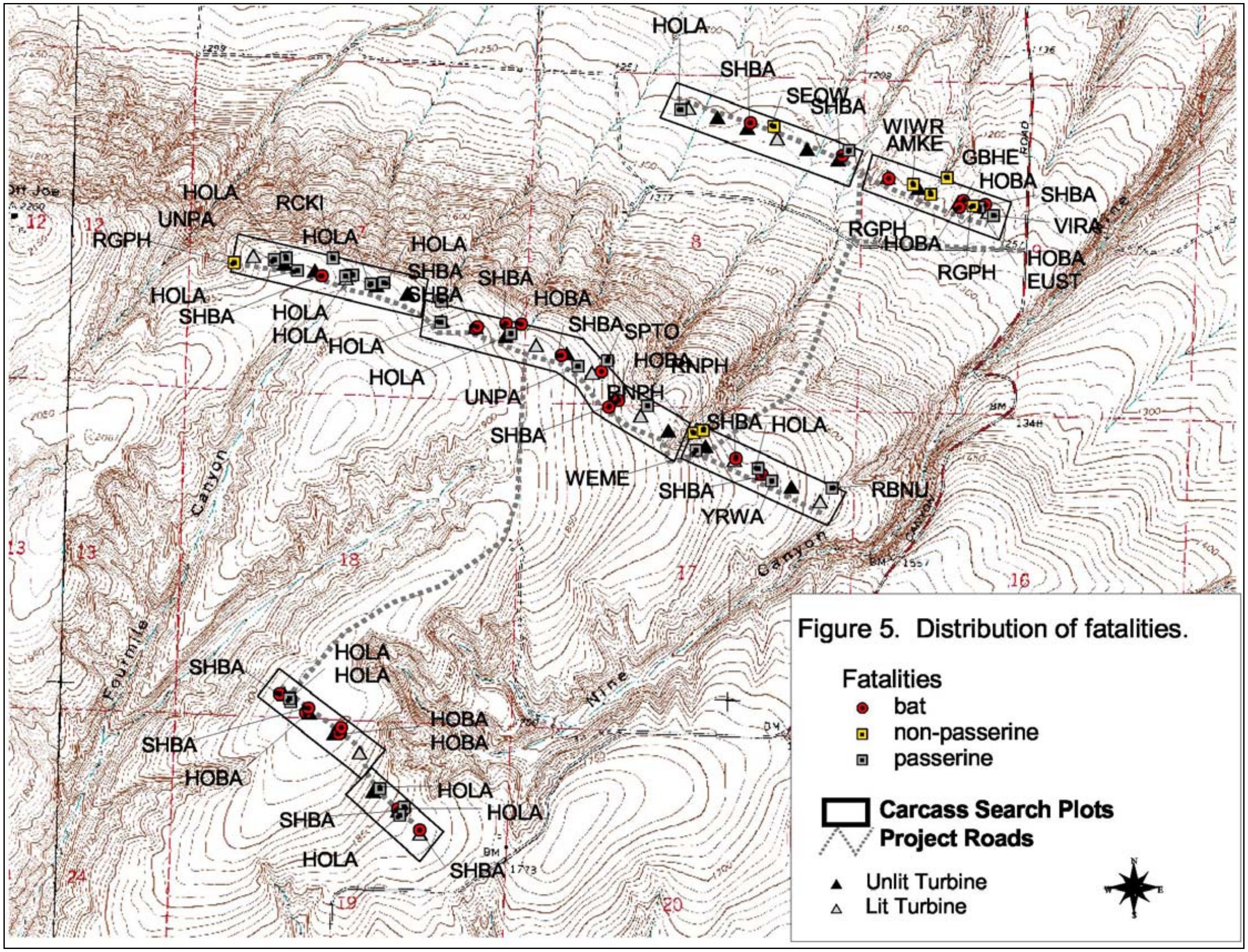


Figure 5. Distribution of fatalities.

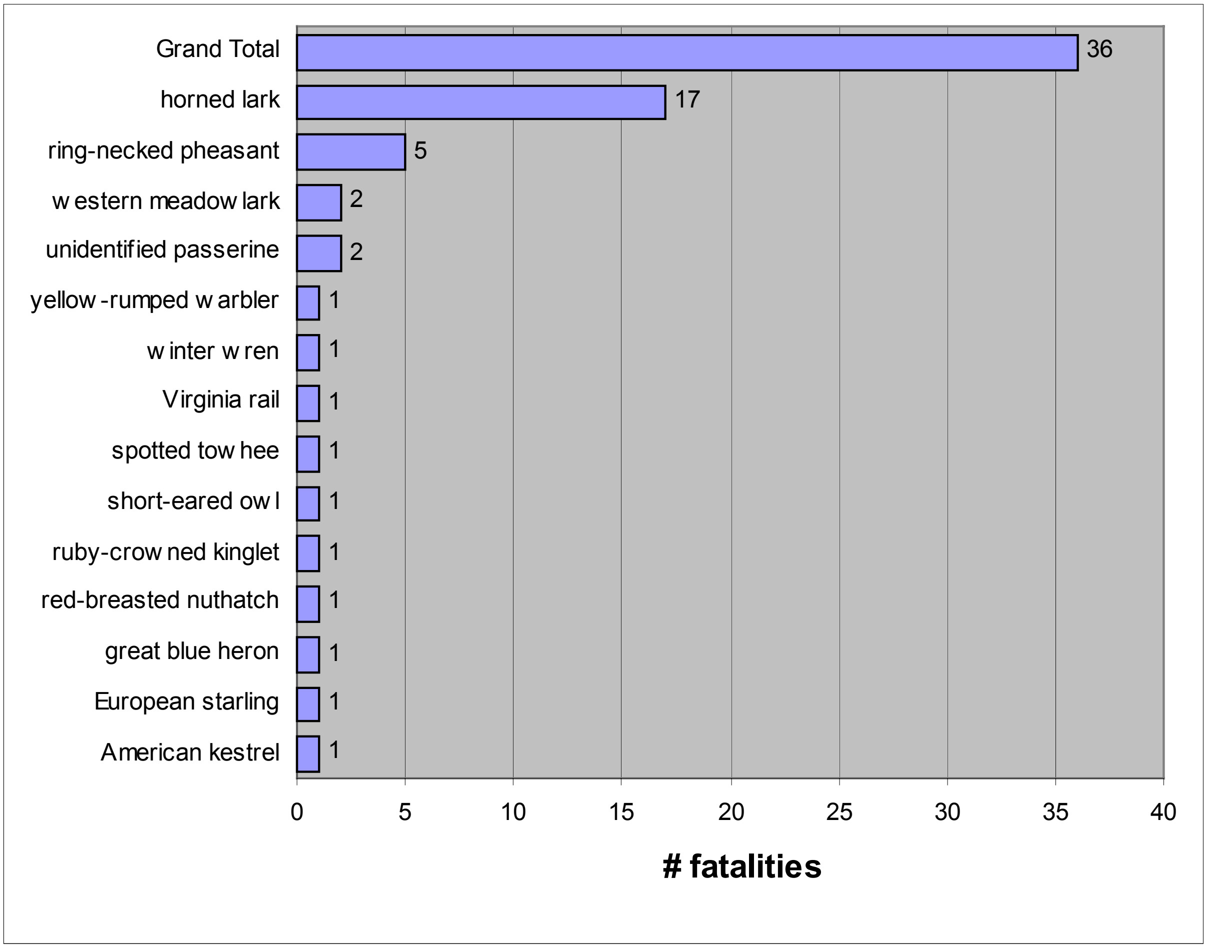
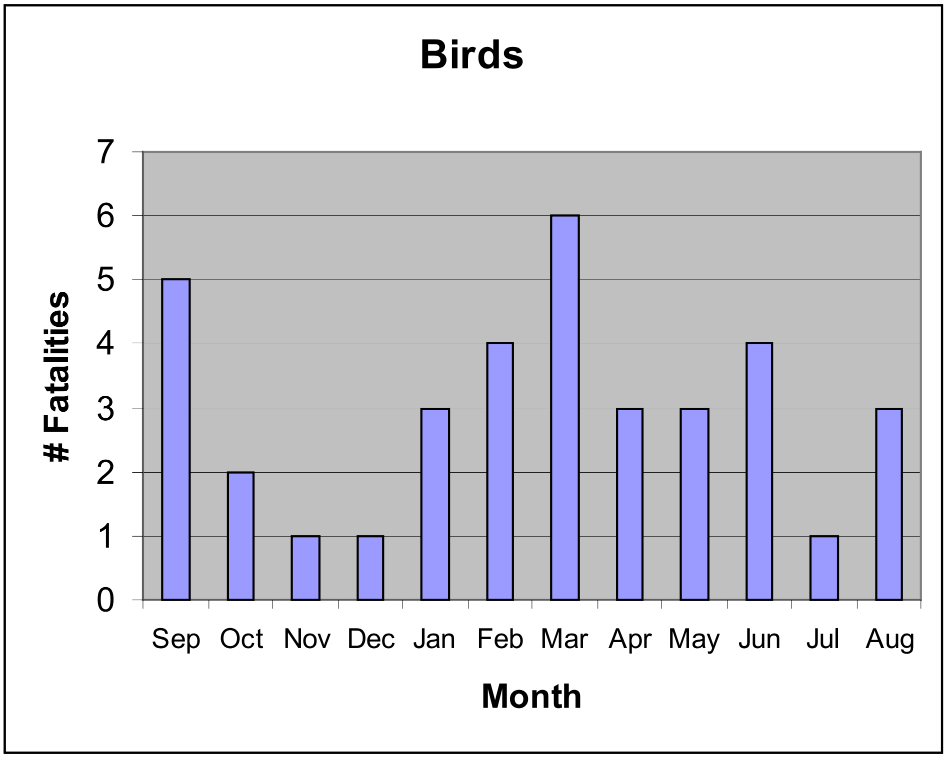


Figure 6. Number of fatalities by species.



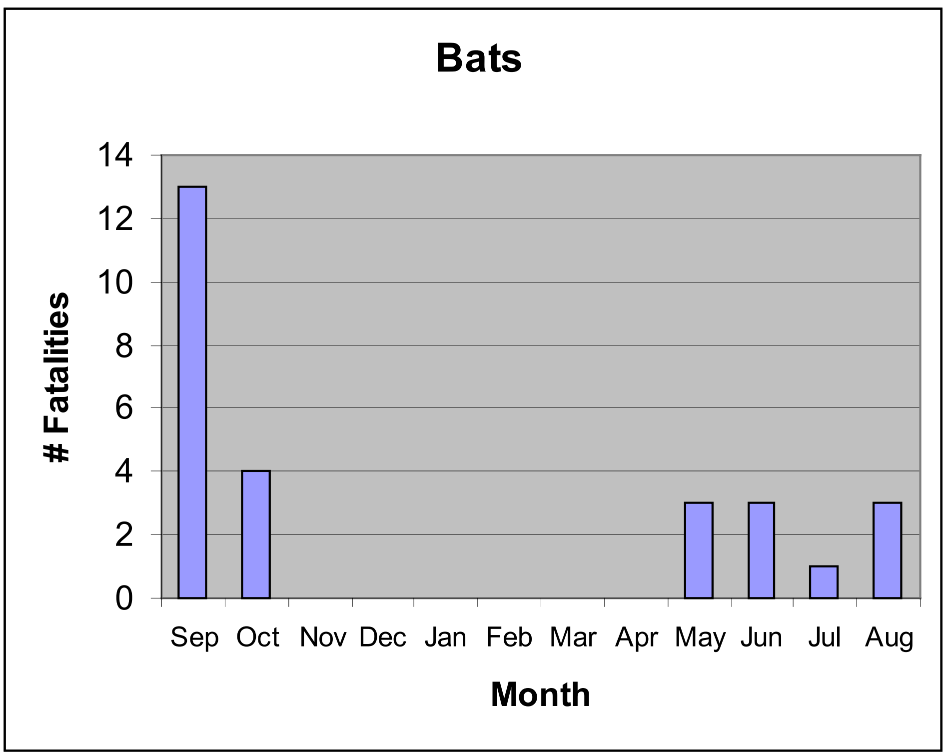


Figure 7. Timing of bird and bat mortality (September 2002 – August 2003)

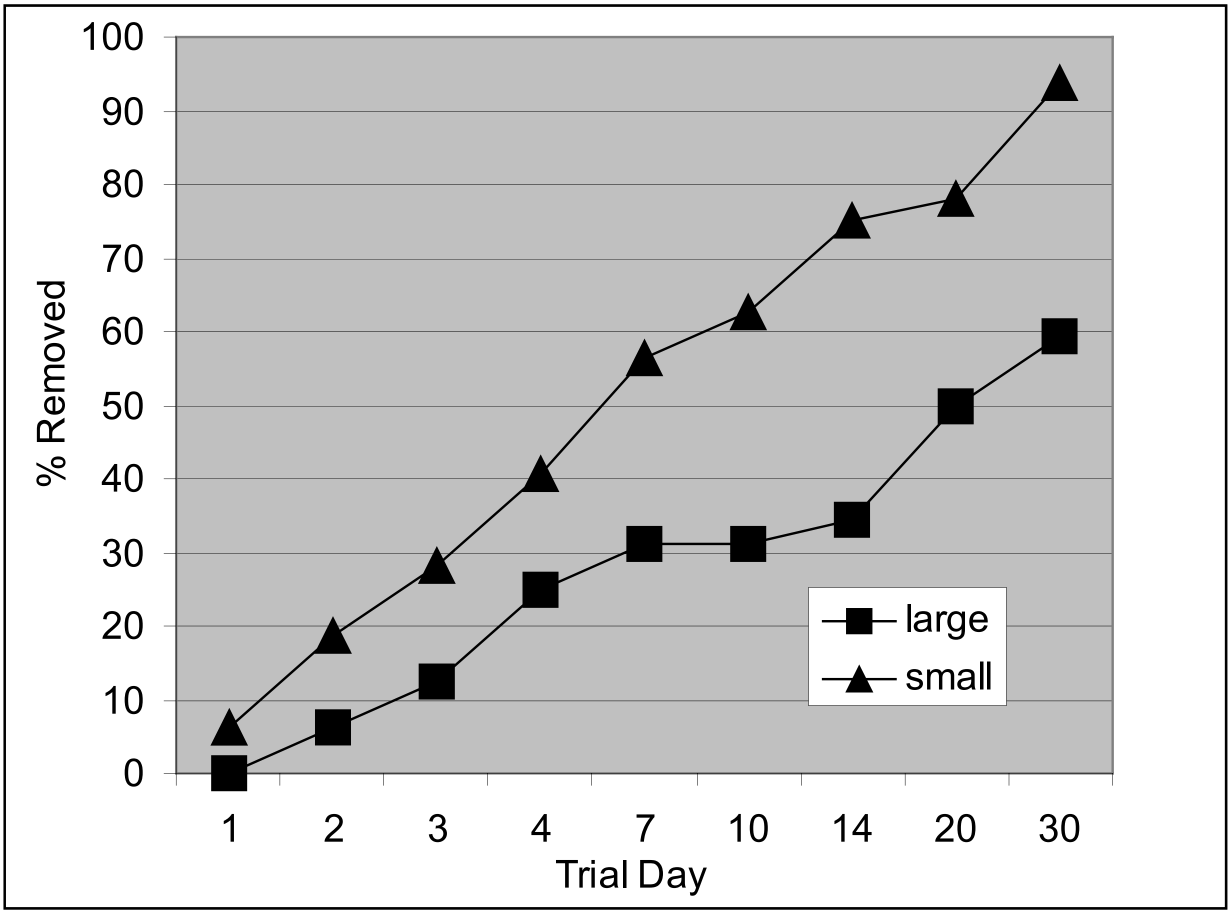


Figure 8. Carcass removal rates by size class of trial carcasses.

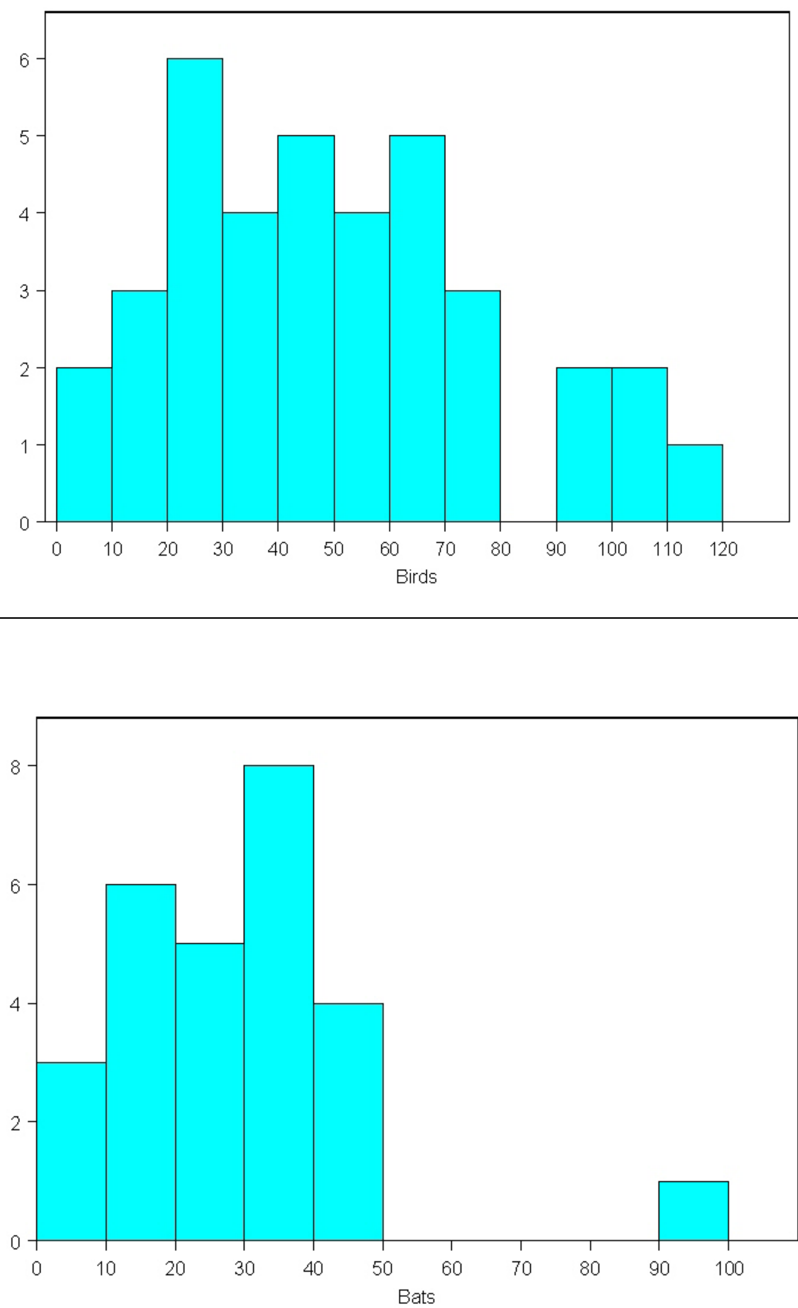


Figure 9. Distribution of distances (m) fatalities were observed from turbines.

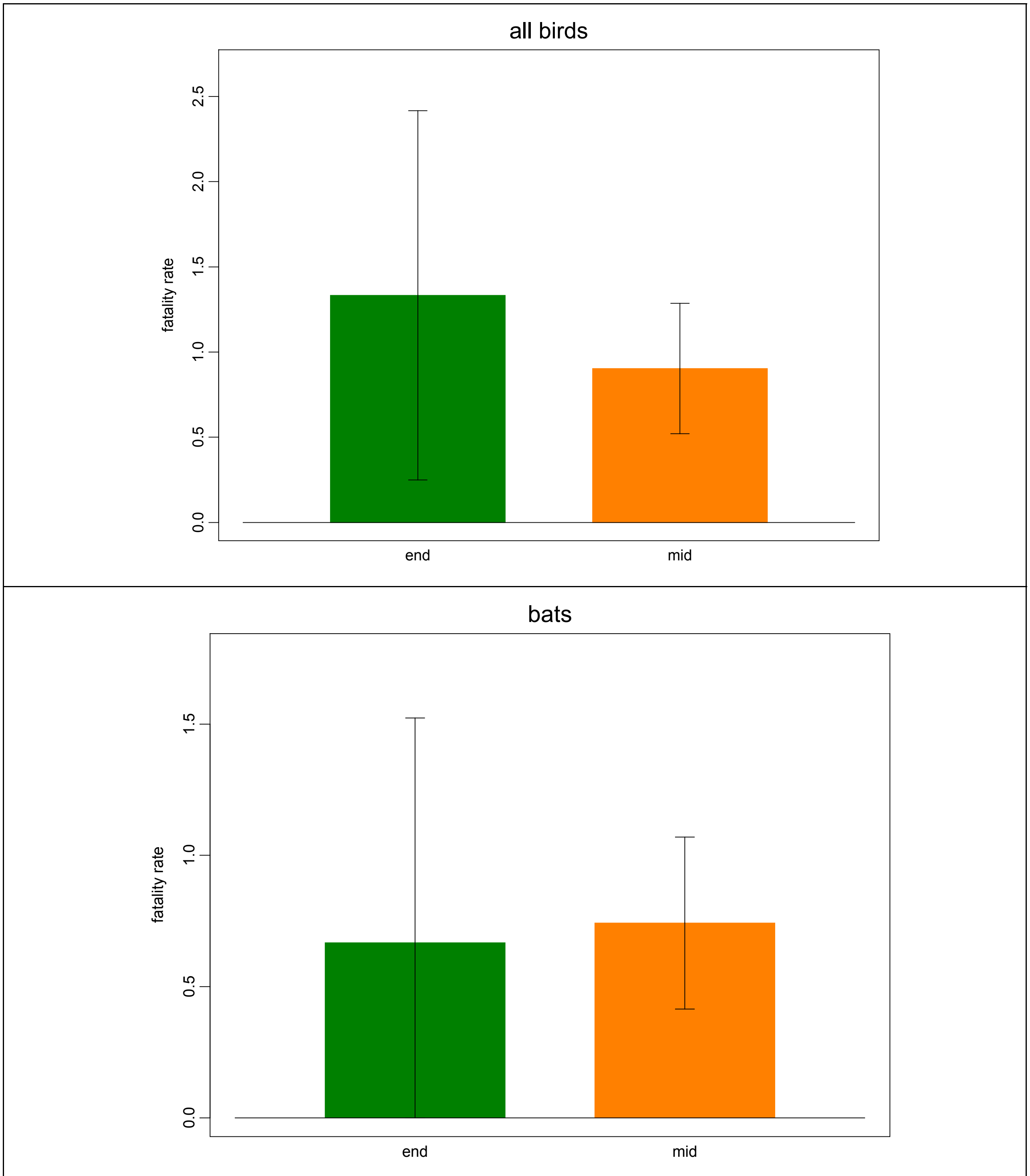
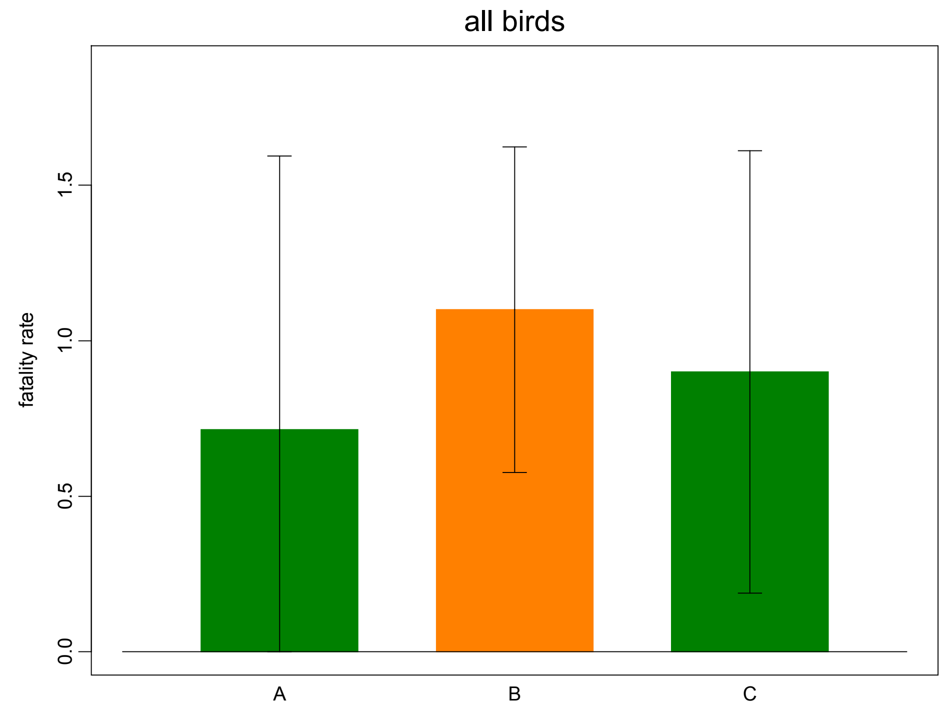


Figure 10. Observed fatality rates and 95% confidence intervals for all birds and bats at end row and mid-row turbines.



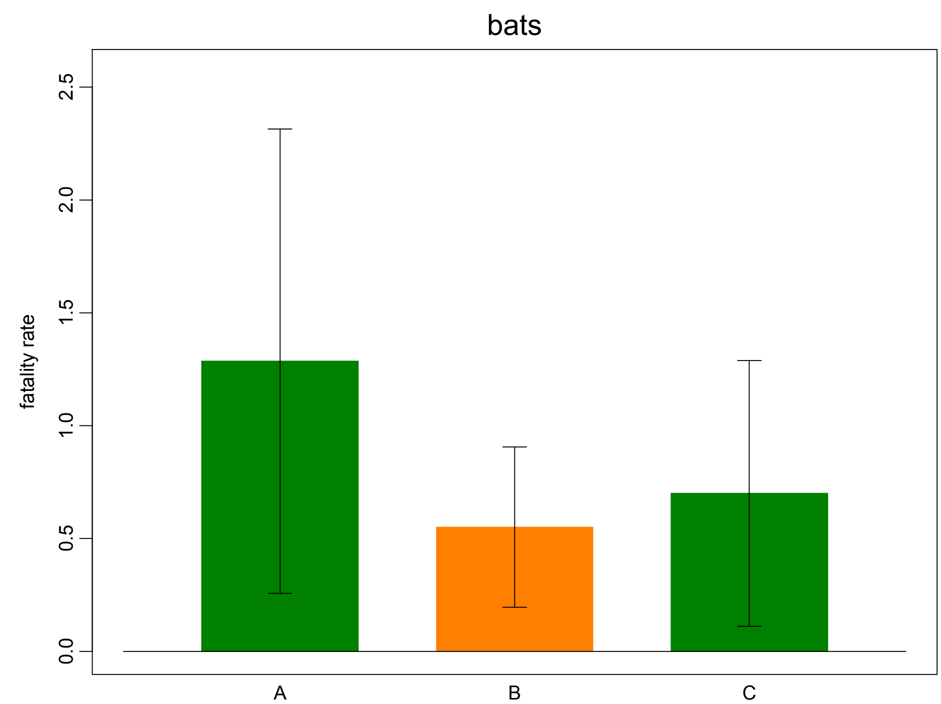


Figure 11. Observed fatality rates and 95% confidence intervals for all birds and bats at strings A, B and C.

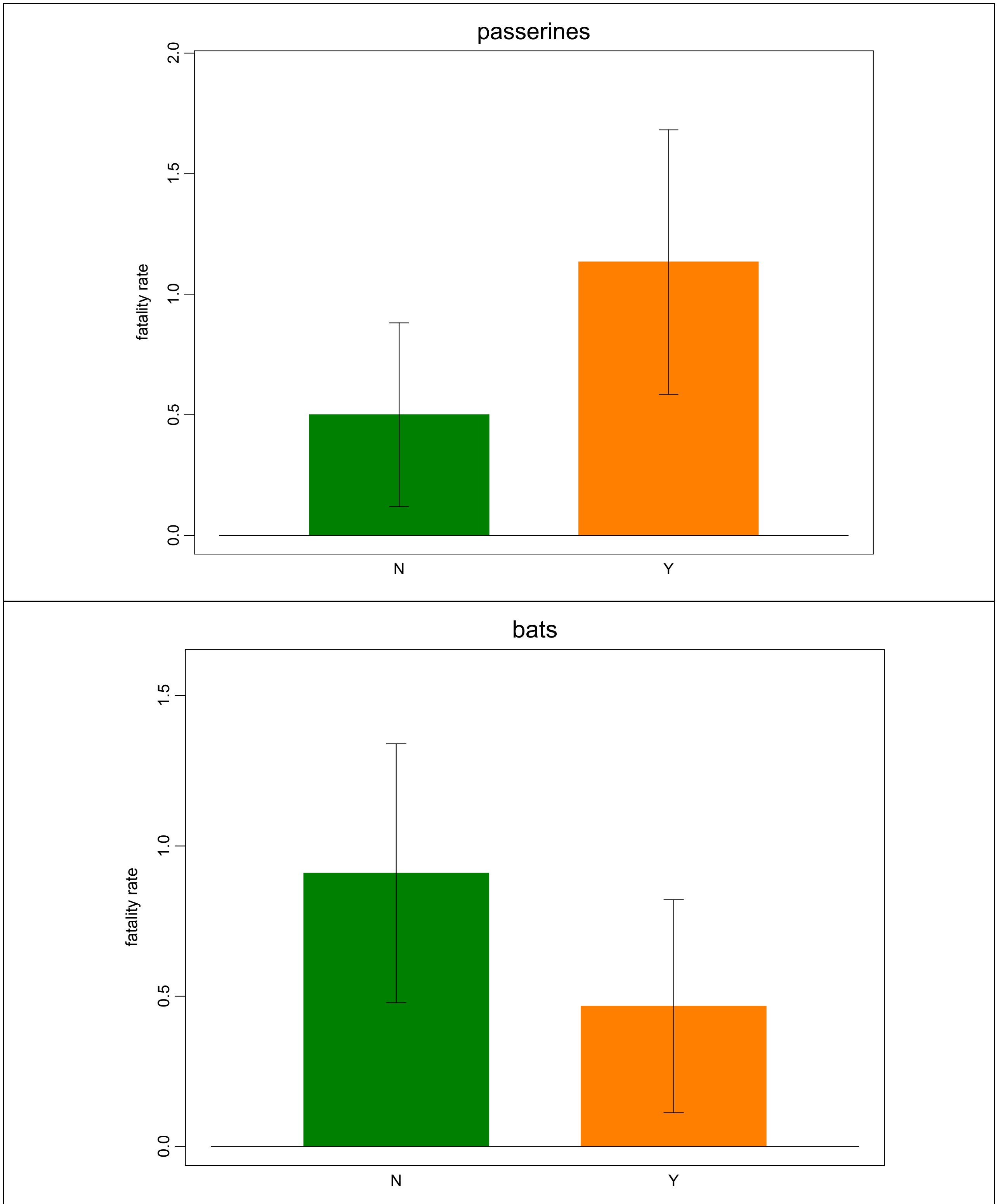


Figure 12. Observed fatality rates and 95% confidence intervals for all birds and bats at lit (Y) and unlit (N) turbines.

APPENDIX A

NINE CANYON TECHNICAL ADVISORY COMMITTEE

Voting Membership

Primary

Daniel Porter
Energy Northwest
PO Box 968 (MD-1035)
Richland, WA 99352-0968
509-372-5531
dwporter@energy-northwest.com

Alternate

David Kobus
Energy Northwest
PO Box 968 (Mail Drop 1035)
Richland, WA 99352-0968
509-372-5087
drkobus@energy-northwest.com

Primary

Paul LaRiviere
WDFW, Habitat Management
2620 North Commercial Avenue
Pasco, WA 99301
509 545-2014
fax: 509 545-2229
larivpel@dfw.wa.gov

Alternate

Mike Livingston
WDFW
2620 North Commercial Avenue
Pasco, WA 99301
livinmfl@dfw.wa.gov

Primary

Skip Stonesifer
US Fish & Wildlife Service
215 Melody Lane Suite 119
Wenatchee, WA 98801
509-665-3508
skip_stonesifer@fws.gov

Primary

Richard Leaumont (LCBAS)
9016 Sunset Trail
Pasco, WA 99301-1675
509-547-4815
leaumont@owt.com

Alternate

Tom Clarke
Lower Columbia Basin Audubon
PO Box 1900
Richland, WA 99353
509-588-3362
bclarke@scregems.org

Primary

Jan Blair
121 South Wamba Rd.
Prosser, WA 99350
509-786-3411

Alternate

Gail, Jeff or Jerry Blair

Primary

Wendell Bateman
6029 W. Quinalt Ave.
Kennewick, WA 99336
509-783-2202
batman1@gte.net

Alternate

Pearl, Larry or Lynn Bateman

Distribution - Nine Canyon TAC Advisory Members

Wally Erickson
WEST, Inc.
2003 Central Ave.
Cheyenne, WY 82001
307-634-1756
werickson@west-inc.com

Karen Kronner
Northwest Wildlife Consultants, Inc.
815 NW 4th St.
Pendleton, OR 97801
541-278-2987
kronner@oregontrail.net

Phillip Knudsen
USFWS Law Enforcement
14852 NE 95th St.
Redmond, WA 98052
425-883-8122
Philip_Knudsen@fws.gov

Michael Shuttleworth
Benton County Planning Dept.
PO Box 910, 1002 Dudley Ave.
Prosser, WA 99350
509-786-5612
mike_shuttleworth@co.benton.wa.us

Bill LaFramboise
Energy Northwest
PO Box 968 (Mail Drop PE24)
Richland, WA 99352-0968
509-377-4679
wllaframboise@energy-northwest.com

Carl Van Hoff
Energy Northwest
PO Box 968 (Mail Drop PE05)
Richland, WA 99352-0968
509-372-5565
cvanhoff@energy-northwest.com