

Avian Monitoring and Risk Assessment at the Tehachapi Pass Wind Resource Area

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October 2, 1996 - May 27, 1998**

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*State Energy Resources Conservation and
Development Commission
Sacramento, California*

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*Western EcoSystems Technology, Inc.
Cheyenne, Wyoming*



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List of Terms

AWEA	American Wind Energy Association
CEC	California Energy Commission
GIS	Geographical Information System
GPS	Global Positioning System
NREL	National Renewable Energy Laboratory
QA/QC	Quality assurance / quality control
RSA	rotor swept area
TIFF	tag image file format (graphics format)
USFWS	U.S. Fish and Wildlife Service
UTM	Universal Transverse Mercator System
WEST	Western EcoSystems Technology
WRA	Wind Resource Area

Avian Monitoring and Risk Assessment at the Tehachapi Pass Wind Resource Area

Introduction

The early wind energy developments were planned, permitted, constructed, and operated with little consideration for the potential impacts to birds (Anderson et al. 1999). Observations of dead raptors at the Altamont Pass Wind Resource Area (WRA) (Anderson and Estep 1988, Estep 1989, Orloff and Flannery 1992) triggered concerns on the parts of regulatory agencies, environmental/conservation groups, wildlife resource agencies, and wind and electric utility industries about possible impacts to birds from wind energy development.

Bird fatality rates observed at most wind projects are not currently considered significant to individual bird species populations. Although many bird species have observed fatalities, raptors have received the most attention (Anderson and Estep 1988; Anderson et al. 1996a, 1996b, 1997, 1999, 2000; Estep 1989; Howell and Noone 1992; Howell 1995; Hunt 1994; Johnson et al. 2000a, 2000b; Luke and Watts 1994; Martí 1994; Orloff and Flannery 1992, 1996; and Thelander and Rugge 2000). The emphasis on raptors probably emerged for several reasons:

- Raptors appear to be more at risk for collision than other bird groups
- Raptors are symbolic and have emotional value to many Americans
- Raptors are protected under federal and state authorities, including the Federal Migratory Bird Treaty Act, and some are protected by the Bald Eagle Protection Act and Endangered Species Act; thus, companies risk violating the law.

Other WRA studies have documented deaths, primarily of songbirds (Anderson et al. 2000; Erickson et al. 2000, 2001; Higgins et al. 1995; Johnson et al. 1998, 1999, 2000a, 2000b; Orloff and Flannery 1992; Osborn et al. 1996; Pearson 1992; Thelander and Rugge 2000; Winkelman 1994) and waterbirds (Anderson et al. 2000; Erickson et al. 2001; Pearson 1992; Johnson et al. 2000a, 2000b, 2002; Winkelman 1985, 1989, 1990, 1992a, 1992b; Winkelman 1994). Bats also have been killed at wind energy facilities (Anderson et al. 2000; Erickson et al. 2000; Higgins et al. 1995, Johnson et al. 1997, 1998, 1999, 2000a, 2000b, 2003). Generally, bat fatalities have included migratory species, and until recently have not been subject to the degree of concern associated with avian fatalities.

Avian fatalities from human caused sources have been estimated near 1 billion a year in North America alone. Power lines, buildings and windows, communication towers, vehicles and pesticides are estimated to comprise more than 82% of the total mortality. At the current level of development, wind turbines are estimated to comprise less than 0.01% of the total annual avian mortality from human-caused sources (Erickson et al. 2004). Although this proportion is extremely small, potential impacts to species or groups of concern, and proper siting of individual wind projects and turbines within wind projects, still need consideration.

A potential cumulative impact from all sources is still a continued concern, since many bird populations are in decline throughout the United States (USFWS 2002).

The levels of concern about wind turbine impacts on birds will likely remain high until we have a better understanding of the factors related to bird fatality. Studies such as this will hopefully provide valuable information regarding avian use and fatality and help reduce the level of uncertainty with wind energy development.

The primary objective of this study was to estimate and compare bird utilization, fatality rates and collision risk indices among factors such as bird taxonomic groups, turbine types and turbine locations within the operating wind plant in the Tehachapi Pass WRA, in south-central California between October 1996 and May 1998.

Coordination and Funding

California Energy Commission (CEC) staff and Western EcoSystems Technology (WEST, Inc.) personnel worked together on this project. Funding was provided by the California Energy Commission, the National Renewable Energy Laboratory (NREL), and the American Wind Energy Association (AWEA). Cost-sharing funds from NREL were provided starting in late 1996, when this study began at Tehachapi Pass WRA.

Study Area

The Tehachapi Pass WRA is located in south-central California (Figure 1) at elevations of 1,006 to 1,615 m above sea level. The natural vegetative communities are botanically and structurally diverse and complex. The Tehachapi Pass WRA falls within the Sierra Nevada subregion of the California Floristic Province, although it is also influenced by the Great Basin Province and the Desert Province. Plant species found in the Tehachapi Pass WRA are associated with the Sierra Nevada Range to the north, the Mojave Desert to the east, the Great Central Valley to the west, and California's Transverse Range to the south (Sawyer and Keeler-Wolf 1995).

Several wind energy companies operate wind plants in the Tehachapi Pass WRA (Figure 2). We focused on five companies whose wind plants occupy approximately 80% of the developed extent of the WRA. The study area included three distinct geographic locations with operating wind plants:

- The **West Ridge**, which was operated and/or owned by Zond Systems, Inc., at the time of the study
- The **Middle Ridge**, which was predominantly owned and/or operated by Cannon Energy Corporation and FloWind Corporation during the study
- The **East Slope**, which was predominantly owned and/or operated by Foras and SeaWest, Tehachapi, Inc., during the study.

There were approximately 3,300 operational wind turbines within the WRA during this study, approximately 1,200 within the West Ridge and slightly more than 1,000 each within the Middle Ridge and East Slope (Table 2).

The West Ridge is heavily influenced by Central Valley grasslands, the Sierra Nevada foothills, and Sierra Nevada forest ecosystems. This location is the highest in elevation of the three study sites, and is primarily comprised of annual grassland, intersected in several locations by a sub-shrub component, wooded ravines, and seasonal stream/riparian plant communities. There are also areas of north-facing slopes that contain scrub oak chaparral, conifer, and blue oak woodland plant communities. The Middle Ridge occurs at an elevation somewhat lower than the West Ridge. This location contains components of all three major converging floristic regions. The Middle Ridge is a combination of annual and perennial grasslands, with sub-shrubs as common components. There are also small patches of Joshua trees, junipers, willows, and oaks. The East Slope is characteristic of the Desert Province and is predominantly shrubland with a significant component of perennial grasslands. Patches of junipers, Joshua trees, and creosote bushes also occur in this area.

Habitat structure is an important variable for resident and migratory bird species. Most of the vegetation in the WRA is annual and perennial grasslands or grassland with shrub or sub-shrub components. Ground dwelling resident bird species use these habitats for forage and nesting. Many migratory species use it for foraging habitat while passing through the area on their migrations to summer or winter areas. Diurnal and nocturnal resident and migrant species were present in the WRA.

Little is known about nocturnal and migratory bird movements through the Tehachapi area, except that turkey vultures migrate through the area by the thousands each year. Prey does not seem to be a conspicuous contributor to raptor deaths as in Altamont. There are few ground squirrels and small diurnal mammals in the Tehachapi WRA.

The WRA has four distinct seasons. Tehachapi Pass receives approximately 50.8 cm of precipitation from October through April on the West Ridge, which decreases because of rain shadow effects to less than 25.4 cm on the East Slope (Mojave Desert). Snow falls each winter. Temperatures can range from -18°C to 43°C. The WRA is windy much of the year; the predominant wind direction is from the west/northwest in the mid-spring to mid-fall and from the southeast/east during the colder months. The wind is variable, depending on weather fronts. Access within the WRA is by dirt and gravel roads. These roads are often steep, and inclement weather can make them impassible for short periods of time.

Study Objectives and Key Research Questions

The primary objective of this study was to estimate and compare bird utilization, fatality rates, and collision risk indices among factors such as bird taxonomic groups, turbine types, and turbine locations. The key questions addressed to meet this objective include the following:

- Are there any differences in the level of bird activity, called “utilization rate” or “use,” among the factors within the operating wind plant?
- Are there any differences in the rate of bird fatalities among the factors within the operating wind plant?
- Does bird use, fatality rates, or collision risk indices vary according to the geographic location, type, and size of turbine; turbine location; environmental conditions; and/or type of bird; within the operating wind plant?
- How do raptor fatality rates at Tehachapi Pass compare to other wind projects with comparable data?

Methodology Development

The methods used in this study were developed through a collaborative process that included biostatisticians and field methodology experts who represent federal, state, utility, consulting, and environmental organizations. The methods and metrics conform to those suggested in “Studying Wind Energy/Bird Interactions: A Guidance Document” (Anderson et al. 1999).

Study Design

This mensurative study (Hurlbert 1984, Morrison et al. 2001) is designed to provide statistical evidence regarding differences in fatality rates, use and collision risk indices between levels of multiple factors. The true cause of statistically significant differences cannot be determined from this study. Some factors are confounded. For example, the West Ridge area had no large tubular towers when studied and the highest fatality rates when compared to the other two areas. Therefore, geographic location is confounded with turbine type, and significant differences observed may be a result of location or turbine type. The basic experimental design is a stratified random design, with geographic location, turbine types, turbine sizes, and tower types used in defining strata.

Permanent Site Selection

In all, 201 permanent sample sites were selected (Table 2) for the location of carcass searches and bird use surveys. Each site included 1–11 turbines; 637 turbines were sampled. Sites were selected within all geographic locations (West Ridge, Middle Ridge, and East Slope) and were located at operational turbines. A stratified random sampling method was used to select the sample sites. Within each region to be sampled, turbines of the same type were assigned sequential numbers.

Turbine type consisted of six stratum:

- Large tubular turbine (horizontal axis turbine >26 m rotor diameter on tubular tower)
- Small tubular turbine (horizontal axis turbine <26 m rotor diameter on tubular tower)
- Large lattice turbine (horizontal axis turbine >26 m rotor diameter on lattice tower)
- Small lattice turbine (horizontal axis turbine <26 m rotor diameter on lattice tower)
- Windwall turbine
- Vertical axis turbine.

At least 19 turbines of a particular type were selected randomly within each region, if that particular type had been built in a particular region. When a selected turbine was found to be non-operational, the next closest turbine or a different turbine — using the previously mentioned sampling methods — was selected.

Starting April 1, 1997, 30 additional end-row turbine sample sites were selected to provide information on end-row versus mid-row comparisons. The additional end-row turbine sites were randomly selected from all available end-row turbines. Stratification was conducted according to turbine type. Six turbines were randomly selected from all the available end-row turbines of each turbine type. Available end-row turbines included those that were not previously chosen as permanent samples or scavenging study sites. The latter criterion resulted from concern that a scavenging site may become attractive to scavengers because of the large food source and could result in higher scavenging rates of wind turbine fatalities. There was no limit on how close a new end-row turbine could be to a previously chosen permanent sample or a scavenging study site.

The sample design resulted in the following number of turbines and turbine types for the center turbine for each permanent study site (Table 3): 30 large tubular turbines; 42 small tubular turbines; 46 large lattice turbines; 27 small lattice turbines; 26 small windwall turbines; and 30 vertical axis turbines. More specifically, the design resulted in the selection of 25 large lattice turbines, 27 small lattice turbines, and 26 windwalls at West Ridge, 21 large lattice turbines, 23 small lattice turbines, and 30 vertical axis turbines at Middle Ridge, and 30 large lattice turbines and 19 small lattice turbines at East Slope. The permanent sample sites were sampled four or five times in random order from 2 October 1996 to 27 May 1998; the additional end-row turbines were sampled starting April 1, 1997.

The carcass search plot was defined as a 50-m radius circular area centered on the selected turbine, and the bird use plot was defined as variable circular plot centered at the selected turbine. The search plot could contain more than one turbine. The permanent site search plots covered approximately 400 acres or 14% of the total search area (approximately 3,000 acres) as determined by a 50-m buffer of all turbines in the WRA.

Each permanent and end-row sample site was classified into one of three row position classifications: end-row, mid-row, and discontinuous. We used the distance D , defined as the average distance following the general contour of the topography, between turbines within the same row to determine the row position for each sample site. The following definitions were used:

End-row: A turbine at the “end” of a row that is within three rotor diameters ($3D$) of a turbine on one side of it, but greater than $3D$ from any other turbine. For a turbine that is approximately $2D$ – $3D$ from its closest turbine to be considered an end-row turbine, it must follow the general contour or line of the row.

Mid-row: A turbine within a row that is no more than $3D$ (or 100 m in the case of a wind-wall turbine) from the next closest turbine in either direction within the row.

Discontinuous: One or two turbines that are not within 3D of a third turbine of the same turbine type. D in these cases would be approximately equal to the average distance between turbines of the same model within a row within that company area. Alternatively, a turbine is considered discontinuous if it is part of a row and is approximately 2D–3D from the closest turbines in either direction of the row, but does not follow the general contour/line or configuration.

Observer Detection Efficiency Study Site Selection

Observer detection trials were conducted to estimate the probability a carcass present in a search plot would be found during a search. Nine observer detection efficiency study sites were selected subjectively according to the two primary criteria: (1) the bulk of each site had to be representative of the vegetative cover in the WRA; and (2) the sites had to be in an area that was large enough to accommodate three observer detection efficiency study sites within approximately 200 m of one another. Six grassland sites and three sub-shrub sites were selected. Observers conducted searches at each site.

Scavenging Study Site Selection

Near-Turbine Sites

Scavenger detection trials were conducted to estimate the length of time a carcass would remain in the WRA before being removed by scavenging. Stratification for selection of near-turbine carcass placement sites for the scavenging bias trials was conducted by geographic location. Each location was further stratified into five regions of equal size (area) or equal number of turbines. Four turbine locations were randomly selected in each region. Each turbine thus had an equal chance of being selected.

Each trial carcass was generally placed 50 m from its respective chosen turbine at an angle perpendicular to the general angle of the turbine row.

Away-From-Turbine Sites along Roads

Some trial carcasses were placed at least 0.4 km away from turbines, along lightly to moderately used roads. For carcass placement, unpaved roads away from wind turbines were driven, and trial carcasses were put out at every 0.32 km or 0.48 km interval of the road. Each available site along a driven road was used unless a site was inappropriate because of atypical vegetation or unacceptable proximity to turbines or main roads. The carcass was placed 50 m from the road at an angle approximately perpendicular to the road and a stake or pinflag was placed 10 m in a magnetic north direction from the carcass. Another pinflag was placed along the opposite side of the road from where each trial carcass was placed.

Methods

Geographical Information System

Characteristics of the Tehachapi WRA study area were mapped using a Geographical Information System (GIS). Digital topographic maps (1:24,000) from the U.S. Geological Survey were used as base maps. These maps contained topographic information, roads, watercourses, and various other physical features. Aerial photographs of the study area were scanned into the computer in tag image file format (TIFF) and included as a GIS layer. The aerial photographs were used to identify additional features such as roads, power lines, wind turbines, and buildings not found on the base map layer. Vegetation types were outlined on the aerial photographs and confirmed by comparing the vegetation at selected ground locations with the photo-interpreted types. The vegetation types for the study area were then digitized to create a vegetation layer. Universal Transverse Mercator System (UTMs) coordinates were obtained for all turbines with a Global Positioning System (GPS) handheld unit. The UTM coordinates collected at each turbine were used to create another GIS layer that contained turbine locations. Other turbine information was attributed to each turbine in the GIS database, such as turbine manufacturer, turbine height, rotor swept area/volume, and type of tower. The GIS layers were created using Arc/Info, ArcView, and DIMPLE remote-sensing image analysis software.

Vegetation Types Classification

Vegetation types (Sawyer and Keeler-Wolf 1995) were identified on the ground and on aerial photographs and transferred to a GIS information layer. The information was used to analyze habitat influence on bird use and other parameters. The vegetation type within 50 m of each carcass search plot center was documented, including the vegetative structure and dominant (e.g., highest percent cover overstory) and as many as two sub-dominant plant species. Four vegetation structures were identified for the Tehachapi Pass WRA: (1) grass, (2) sub-shrub, (3) large shrub, and (4) wooded. Plant groups and species within each structure are presented in Table 1.

Bird Utilization Count

Bird utilization counts were conducted from 8:00 a.m. to 12:00 p.m. for 20 months from 2 October 1996 through 27 May 1998. Each sample site was visited approximately every 6-7 weeks, and each visit consisted of two 5-minute consecutive utilization counts. Observations consisted of continuous counts of birds detected visually or audibly at any distance during the 5-minute intervals for a circular plot with the site turbine located at the plot center.

Data collected during each site visit consisted of both site and observation information. Site information included site number, observer, date, starting and ending times, and applicable weather (precipitation, fog, cloud cover, temperature, wind speed and direction, and background sound levels). Observation information included the utilization count number, starting time, a unique observation number, species, number of individuals, estimated

distance from observer at initial sighting, estimated closest distance to observer, behavior or activity (e.g., flying, perching, soaring, hunting, foraging, height above ground, and behavior if the bird approached the turbine [i.e., within ≤ 50 m of the turbine]), and the type and operational status of the closest turbine to the observation. Additionally, for all observations, flight height was recorded to the nearest meter when the bird (or group of birds) was first observed and when or if they entered within 50 m of a turbine. Avoidance behavior (e.g., flaring, other avoidance behavior, perching) was also characterized and recorded. Comments or unusual observations were recorded in the comment section of the data form.

Carcass Searches

The objective of the carcass searches was to document bird fatalities. At each permanent site, one carcass search was conducted quarterly, and four or five searches were conducted at each site during the study. Circular plots with a radius of 50 m centered at each sample site (turbine) were systematically searched. The intensity of each search was vegetation dependent and typically took 30 minutes to 2 hours (i.e. searching short grassland was quicker than searching thick shrubby areas).

Data collected during each carcass search included a unique carcass number, site, date, observer, species, sex, and age when possible, time, condition (e.g., intact, scavenged, feather spot), cause of death (when possible), description of injury(ies), identification of and distance to nearby structures, distance to closest turbine, classification of closest turbine (i.e., mid-row and end-row), and distance to plot center. Comments that describe the characteristics of the carcass and indicate the cause of death or other pertinent information were also recorded. All carcasses discovered were photographed as found, plotted on a detailed map of the study area that showed the location of the wind turbines and associated facilities such as power lines and towers, and collected for species verification.

Observer Detection Efficiency Study

Circular plots 100 m in diameter were identified with pinflags placed at the north, east, south, and west edges. An individual, not conducting searches as a part of the trial, placed small and large bird carcasses and carcass parts at randomly selected locations within the plot. All placements were documented and then compared with the observer's findings to determine the proportion of small and large carcasses or carcass parts detected by each observer.

Scavenging Bias Trials

For each scavenging trial, 60 brown chickens and 60 chick carcasses were used to simulate large and small bird carcasses for scavenging rate comparisons near turbines and at different distances from turbines. Three independent scavenging bias trials were conducted using a total of 315 carcasses. The scavenging bias trials were conducted on 2-3 August 1996, 9-10 December 1996, and 8-9 April 1997. As many as 40 chicken and chick carcasses (20 each) were placed in each geographic location. In each location, 10 chickens and 10 chicks were placed at near-turbine sites, and 10 of each were placed at away-from-turbine locations, more than 0.4 km away from the nearest turbines. Because of constraints on readily accessible

away-from-turbines sites, the goal of 20 away-from-turbine sites was not attainable at each geographic location. Because we used carcasses that were not representative of the bird species that were observed as fatalities, this information was primarily used to describe relative differences in scavenging by study area or vegetation.

Statistical Analysis Methods

Bird Use

Bird activity was described by calculating utilization rates. We defined utilization rate as the number of observations of birds divided by the number of utilization counts (surveys). Only birds visually observed within 200 m of the site center were considered in the calculation of mean utilization rates. Observations of birds only heard and not seen were not used in the calculation of mean utilization rates because turbine and wind noise often mask bird calls. This ensured that turbine or wind noise would not bias bird use estimates in developed WRA compared to undeveloped areas.

Observed Bird Fatality Rates

Bird fatality rate is defined as the number of unique bird carcasses found on each plot per search (50 m radius of focal turbine):

$$\text{bird fatality rate} = \frac{\text{number of fatalities}}{\text{number of searches}}$$

Because searches are conducted quarterly, the fatality rate used in the comparative analyses represents the observed number of fatalities per 3-month period per sample site. This fatality rate could be multiplied by four to come up with an observed annual fatality rate per search plot unadjusted for scavenging and search efficiency biases, with each search plot typically containing one or more turbines. An annual per turbine fatality rate was calculated by adjusting the annual fatality rate per search plot to account for the effective area of the wind project that was searched (14% of the total search area within 50 m of turbine strings) and the interval between searches (approximately 90 days). Each search plot on average effectively covered the area around 2.2 turbines. Therefore, the annual fatality rate was calculated by:

$$\text{annual per turbine fatality rate} = \frac{4}{2.2} (\text{no. fatalities per search})$$

where the factor 4 adjusts the search period to a year period and the 2.2 factor adjusts for the fact each plot effectively samples 2.2 turbines on average.

Bird Collision Risk Index

We defined an index to collision risk as the fatality rate divided by the utilization rate. For example, considering only birds observed within 200 m of the site center, the overall bird risk for the Tehachapi Pass WRA is:

$$\text{bird risk index} = \frac{\text{fatality rate}}{\text{utilization rate}}$$

Bird utilization rates and bird fatality can increase proportionately without changing the bird collision risk index. An increase or decrease in fatality, however, with no change in use causes an increase or decrease in the risk index. Similarly, an increase or decrease in use with no change in fatality causes a decrease or increase in the risk index. The bird risk index can therefore be used to compare differences for variables of interest (i.e., geographic location, taxonomic group, turbine density, row location, rotor swept area/volume, turbine size, turbine styles, and turbine type) while accounting for observed differences in use and fatality rates associated with individual values of each variable. This index is a relative number that can range from zero to a large number and is used for comparing levels of other factors such as turbine type. It should not be construed as an absolute measure of collision risk. The numerator represents a fatality rate (number of fatalities/3-month period/site). The denominator represents the number of birds observed per 5-minute period. To equate the risk index to a more direct measure of the likelihood of collision per bird observation near wind turbines, the index would need to be divided by the number of 5-minute periods within the 3-month search interval. For example, a risk index of 1.0 from the equation above can loosely be interpreted in the following way: one fatality is estimated to occur in a 3-month period for every 10,800 bird observations (90 days in 3-month interval times 120 5-minute daylight periods per day) within 200 m of the turbine during that 3-month period. Detection biases associated with bird observations and detection and scavenging biases for fatalities would affect the risk measure.

Comparison Factors and Analyses

The primary analysis variables considered in comparing use, fatality rates, and the collision risk index are listed in Table 3. For each metric (except rotor swept area [RSA]) and variable of interest, 95% confidence intervals were calculated. The null hypothesis of “no difference” was tested at two-tailed α -level of 0.10 by investigating the overlap of the confidence intervals. Given the high variability in field data of this sort, we discuss statistically significant differences and trends in the data that are supported by consistent patterns across several comparisons. Linear regression was used to investigate the relationship between the fatality or collision risk rates and the RSA (RSA of turbine sampled and RSA within the 50-m plot). Logistic regression was also used to investigate the relationship between the presence of at least one carcass at a site and the RSA (RSA of turbine sampled and RSA within the 50-m plot).

There are other factors that may be important, which we did not attempt to model. Cause of the differences is not inferred from the statistical analyses because of the observational nature of the study and the possibility of confounding factors. Professional judgment and trends in the data are the primary methods we use to interpret pattern and to make inferences regarding the results.

Scavenging Bias Trials

Scavenging rates by season and vegetation type are described by calculating the proportion of birds removed after 8 days and the estimated mean time until removal. Given the limited

nature of these data (few trials, limited species of trial carcass), they were used only to describe the characteristics of scavenging rates, and general comparisons of rates of factors such as season.

Observer Detection Bias Trials

The observer detection probability was estimated by:

$$p = \frac{\text{\#of carcasses detected}}{\text{\#of carcasses placed}}$$

Given the limited nature of these data (few trials), they were used only to describe the relative efficiency of the searches and general comparisons of detection rates and the influence of factors such as season.

Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) measures were used during all stages of the project including field training, data collection, field form completeness, data entry, data analysis, and report preparation. Field forms were created, and lists of variables documented and defined for each research study. A detailed protocol (standard operating procedure) was prepared for bird utilization counts, carcass searches, scavenging bias trials, and observer detection trials. These protocols helped maintain a high level of precision and consistency in data collection.

Field personnel were trained in all field collection methods. A computerized database was created to store and retrieve field data. Personnel experienced in data entry using a pre-defined format to make subsequent data analysis more efficient entered data from field forms into electronic data files. Printouts of the entered data were compared with the completed and previously checked field forms to verify the accuracy of the data entries. All data entry errors were corrected.

At the end of the study, the complete database was sent to statistical personnel for additional QA/QC and data analysis. Anomalies or inconsistencies were resolved with field staff and changes were made where necessary with the proper documentation. Results of data analysis were compared for accuracy during all stages against hand-calculations and other methods of calculation.

Results

General Avian Use, Frequency Occurrence, and Species Composition

A total of 3,318 5-minute bird utilization counts, including 1,404 at West Ridge, 992 at Middle Ridge, 922 at East Slope, and 829 carcass searches were completed in Tehachapi Pass WRA from 2 October 1996 to 27 May 1998. During the utilization counts and other observations, 47 unique species were documented in 2,882 sightings of 6,380 individuals

(Table 4). Appendix A contains a list of the bird species observed during bird utilization surveys.

For all three geographic locations combined, 25 species were observed during spring (1 March - 15 April), 28 during summer (16 April - 30 September), 25 during fall (1 October - 15 December), and 20 during winter (16 December - 28/29 February) (Table 5). The greatest number of species observed at Middle Ridge occurred during summer (20), at West Ridge also during summer (17), and at East Slope during fall (13). West Ridge tended to have a higher number of species present throughout the year, followed by East Slope. Middle Ridge showed the largest differences in numbers of species observed between seasons.

Avian use (mean number of individuals per survey) across all three geographic locations was highest in the spring (1.61), followed by fall (1.55), winter (1.20), and summer (0.93). The highest use occurred at West Ridge in spring (2.36), and the lowest use was recorded at East Slope in summer (0.35) (Tables 5 and 6).

Avian richness (mean number of species per survey) across all three geographic locations was highest in the spring (1.26), followed by fall (1.25), summer (1.20), and winter (1.16). Both the highest and lowest estimates of avian richness occurred at East Slope during spring (1.38) and summer (1.04), respectively (Table 5).

Avian Use by Bird Group

Raptor use was generally higher during fall and winter and slightly lower during spring and summer (Table 6). Corvid abundance was highest during spring and lowest during summer and fall. Passerine abundance was highest during fall and lowest during summer with similar values for spring and winter (Table 6). Passerines had the highest mean use recorded at East Slope during fall (1.65 birds/survey). There were no raptors observed during winter at East Slope. Raptor use was also lowest in the summer at East Slope.

Avian Use by Species

Overall, the most abundant avian species, based on mean number per 5-minute utilization survey, during the spring, summer, and winter was the common raven, with the horned lark being the most abundant species during the fall (Table 7). At West Ridge the common raven was the most abundant species year round. At Middle Ridge the most abundant species was the common raven during summer and winter, the European starling during spring, and the white-crowned sparrow during fall. At East Slope the most abundant species was the European starling during spring, the common raven during summer, the horned lark during fall, and the western meadowlark during winter.

The most frequently occurring avian species throughout the year was the common raven, followed by the western meadowlark in spring, fall, and winter, and the horned lark during summer (Table 8). At West Ridge the common raven was the most frequently occurring species throughout the year, followed by the western meadowlark during spring and winter, and the scrub jay during summer and fall. At Middle Ridge the common raven was again the

most frequently occurring species throughout the year, followed by the loggerhead shrike during summer and winter, and the western meadowlark during spring and fall. At East slope the common raven was the most frequently occurring species in spring, summer, and winter, and the horned lark was the most frequently occurring species during fall.

The red-tailed hawk was the most commonly observed raptor species (Table 4), accounting for more than 60% of the observations, followed by the American kestrel (15%). Other raptor species observed included the golden eagle (3 detections), northern harrier (2), sharp-shinned hawk (2), ferruginous hawk (2), and prairie falcon (1).

Avian Flight Height Characteristics

Flight height characteristics were calculated by taxonomic groups and geographic locations (Table 9). The overall mean flight height of bird groups for the Tehachapi Pass WRA was 22.27 m. Overall, flight heights were highest for raptors (53.58 m), followed by corvids (28.34 m), other birds (26.17 m), and passerines (7.38 m); Middle Ridge followed the same pattern. At West Ridge the pattern was similar except other birds were observed slightly higher than corvids. At East Slope, mean flight heights were highest for corvids, followed by raptors, other birds and passerines. The highest mean flight height was observed at West Ridge (26.19 m), followed by Middle Ridge (18.35 m) and East Slope (15.62 m). The higher average flight heights at West Ridge may be a result of the topographic diversity as well as the higher raptor use at this location.

Avian Perching Behavior

Considering all birds, most observations of perched individuals were on vegetation (39.6%) or the ground (18.1%, Table 10). Power lines were the most common structure used as a perch (11.9%). Other structure types with at least 5% of the perched bird observations were small tubular turbines (9.5%), lattice turbines (6.7%), and meteorological towers (5.0%). No birds were observed perching on tall tubular turbines.

A total of 40 perching events were documented for raptors (Table 10). Power lines (poles and conductors, 27.5%) and meteorological towers (wires and towers, 22.5%) comprised 50% of the perched raptor observations. Large and small lattice turbines comprised 20% of the observations, and vertical axis turbines comprised 10% (both guy and tower observations). Two raptors were observed perching on small tubular turbines, and no raptors were observed perching on large tubular turbines. Nearly all perching events were on non-operating turbines.

Avian Fatality Counts and Composition

One hundred and twenty-seven bird fatalities representing 27 species were identified during the study period in the Tehachapi Pass WRA (Table 11, Table 12, and Appendix B). Seventy-five of 127 fatalities were found on search plots. In addition, one long-eared bat (*Myotis evotis*) with a fresh wound to the body was found dead 3 m from a turbine at West Ridge during a carcass search.

Of the 75 fatalities found on search plots, the most commonly found avian group was other birds (40.0%, mostly unidentified birds) followed by raptors (34.7%), passerines (20.0%), and corvids (5.3%). These dead birds were found 0–50 m (mean = 20.4 m) away from the closest turbine. When the closest structure was a turbine, dead birds were found 0–50 m (mean = 16.8 m) away from the turbine.

Forty-four of the 127 fatalities (34.6%) were raptors (Table 11). Raptor species with the most fatalities were the red-tailed hawk (14), great horned owl (13), and American kestrel (9). Other raptor fatalities consisted of the common barn owl (2) and one each of the following: the ferruginous hawk, prairie falcon, long-eared owl, flammulated owl, an unidentified buteo, and an unidentified raptor. Only two corvid species suffered fatalities, the common raven (8) and scrub jay (2), which represented 7.9% of the total. Twenty-seven of the fatalities (21.3%) were passerines. Passerine species with the most fatalities were the western meadowlark (6), horned lark (3), European starling (3), white-crowned sparrow (2), and dark-eyed junco (2). Other passerine fatalities consisted of one each of the chipping sparrow, Brewer's blackbird, hermit thrush, rock wren, yellow-rumped warbler, loggerhead shrike, and unidentified sparrow in addition to four unidentified passerine fatalities. Other birds comprised 46 (36.3%) of the fatalities. Other bird species with fatalities included the rock dove (11), mourning dove (6), red-shafted flicker (3), greater roadrunner (2), chukar (2), and California quail (2). Twenty fatalities remained unidentified to taxonomic group and were grouped in the other bird category. These were typically feather spots.

Seventy of the 127 fatalities (55.1%) were feather spots, 31 (24.4%) consisted of feathers and/or bones, 13 (10.2%) were intact and 12 (9.5%) were dismembered. Seventy-five of the 127 bird fatalities (59.1%) were found during scheduled carcass searches. The remaining fatalities were found by observers as they conducted other study activities or by power company employees (Appendix B). Only fatalities found during scheduled carcass searches were used to estimate fatality rates.

Fatalities were observed at 54 (27%) of the 201 sites monitored. The largest number of fatalities observed at any one site was four (sites Z18, Z36, Z44), with three fatalities observed at each of two sites, two fatalities at nine sites, one fatality at 39 sites, and no fatalities at the remaining sites. Based on the 75 fatalities observed at these sites, we would expect approximately 28% of the sites to have at least one fatality under a random distribution, which suggests there was no large distinctive clustering of fatalities at a few turbines. However, factors such as scavenging and the relatively small sample of turbines compared to the total number of turbines in the wind site could mask a clustering effect.

Turbines were the closest structure that could have caused the fatality for 97 of the 127 fatalities (76.4%). Turbines were the first or second closest structure for 118 fatalities (92.9%). Dead birds were found 0–350 m (mean = 25.1 m) away from the closest turbine. When the closest structure was a turbine, dead birds were found 0–75 m (mean = 16.9 m) away from the turbine. Thirty-six (28.3%) of the 127 fatalities were found <10 m from a turbine, 34 (26.8%) from 10 m to ≤ 20 m, 14 (11.0%) from 20 m to ≤ 30 m, 19 (15.0%) from 30 m to ≤ 40 m, 16 (12.6%) from 40 m to ≤ 50 m, and 7 (5.5%) were ≥ 50 m from a turbine.

Eight fatalities (6.3%) were associated with structures other than turbines as the two closest structures. Other structures located closest (<40 m) to the dead birds were distribution lines (7), meteorological towers (6), transmission lines (6), other human-made structures (4), main roads traveled >56.3 kph (3), fences (2), and telephone lines (1). When considering only the standardized carcass search data, there is a strong negative relationship between distance from turbine and the proportion of fatalities observed, which suggests the 50- radius plot is sufficient to document most wind turbine fatalities (Figure 3).

Cause of death could not be determined for 111 (86.6%) of the 127 fatalities because of their conditions, which were influenced by the long intervals between searches. Of the 16 fatalities for which cause of death could be determined, 12 (75.0%) resulted from collisions with turbines, two (12.5%) from electrocution, and one each (6.3%) resulted from a collision with a vehicle and a collision with a wire. One collision with a structure was observed. A western meadowlark was observed colliding with the wire of a guyed meteorological tower. The bird flew away after being approached and was not included in the carcass list.

Geographic Location

Most of the 127 avian fatalities occurred at West Ridge (91), followed by East Slope (19) and Middle Ridge (16). One additional passerine fatality was located between Middle Ridge and East Slope. Raptor fatalities were proportionately higher at East Slope (9 of 19 or 47.4%) than at West Ridge (32 of 91 or 35.2%) or Middle Ridge (three of 16 or 18.8%) (Table 11). Corvids were consistently the lowest fatality group overall and at each geographical location. Passerines were higher proportionately at Middle Ridge (7 of 16 or 43.8%) and East Slope (6 of 19 or 31.6%) than at West Ridge (13 of 91 or 14.3%).

Standardized Bird Utilization, Fatality Rates and Risk Index Comparisons

In this section, comparisons of bird utilization rates, fatality rates, and the risk index are made between the primary analysis factors. Bird utilization rates are compared for general analysis categories such as seasons, taxonomic groups, and geographic locations. Fatality rates and the risk index are compared for all variables except season, because searches were done quarterly and the actual season the fatality occurred could not always be determined, especially for feather spots and non-fresh carcasses. For fatality rates and the risk index, we focused on total birds and raptors.

Seasons

Bird Utilization. Mean utilization rates and 95% confidence intervals by taxonomic groups were calculated for each season (Table 13). These are depicted graphically in Figures 4-8.

In every season, use was highest for passerines, followed by corvids, other birds, and raptors (Table 13). There were some differences in the observed proportions of use by groups between seasons. The highest total use was observed during spring (1.61 birds/survey). The lowest total use was observed during summer (0.93). Spring use was significantly ($p < 0.10$)

higher than summer use, however not significantly different from fall (1.55) or winter (1.20) use.

Taxonomic Groups

Bird Utilization. The mean utilization rate by all birds over the entire Tehachapi Pass WRA was 1.25 birds/survey. Mean utilization rates by taxonomic groups were calculated (Table 13) and are depicted graphically in the top portion of Figure 9. Overall, use was highest for passerines (0.82 birds/survey), followed by corvids (0.32), other birds (0.09), and raptors (0.03). Use by raptors was lower (although not statistically significant) than other birds and was significantly ($p < 0.10$) lower than corvids and passerines. Corvids had significantly ($p < 0.10$) higher use than raptors and other birds, and significantly ($p < 0.10$) lower use than passerines. Use by passerines was significantly ($p < 0.10$) higher than use by any other taxonomic group. Other birds had significantly ($p < 0.10$) lower use than either corvids or passerines and higher, but not statistically significant different use ($p > 0.10$) than raptors.

Fatality. Total bird fatality over the entire Tehachapi Pass WRA was 0.086 carcasses/survey. Fatality by taxonomic groups is presented in Table 14. These are depicted graphically in the middle section of Figure 9. Fatality was highest for other birds (0.034 carcasses/survey; mostly unidentified feather spots), followed by raptors (0.027), passerines (0.017), and corvids (0.008). Fatality of corvids was significantly ($p < 0.10$) lower than fatality of other birds and lower (although not statistically significant) than fatality of raptors. There were no other significant differences in fatality between taxonomic groups.

Risk Index. The average risk index by taxonomic groups was calculated (Table 15) and is depicted graphically in the bottom section of Figure 9.

The total bird risk index over the entire Tehachapi Pass WRA was 0.070. Risk was highest for raptors (0.836 carcasses/bird use unit), followed by other birds (0.406), corvids (0.025), and passerines (0.021) (Table 15). Risk for raptors was significantly ($p < 0.10$) higher than for corvids and passerines; however, raptor risk was not significantly different from risk for other birds. Corvids and passerines both had significantly ($p < 0.10$) lower risk index than other birds; however, they were not significantly different from one another.

Geographic Location

Bird Utilization. Mean utilization rates by taxonomic groups were calculated for each geographic location within the study area (Table 13). These are depicted graphically in the top sections of Figures 10 - 14.

Similar patterns of use were observed at all locations. Use was highest for passerines (0.82), followed by corvids (0.32), other birds (0.09), and raptors (0.03) (Table 13). There were some differences in the observed proportions of use by groups in different locations. The highest total use was observed at West Ridge (1.64 birds/survey). Lower use was observed at East Slope (1.08); however, this difference was not significant. Total use at Middle Ridge

(0.95) was significantly ($p < 0.10$) lower than West Ridge; however, it was not significantly different from East Slope.

Raptors showed similar use at both West Ridge (0.04 birds/survey) and Middle Ridge (0.04); however, this group had significantly ($p < 0.10$) lower use at East Slope (0.01). The highest use for corvids was observed at West Ridge (0.51). Significantly ($p < 0.10$) lower use was observed at Middle Ridge (0.25) and significantly ($p < 0.10$) lower use was again observed at East Slope (0.11). Passerines showed no significant difference in use between West Ridge (0.94), Middle Ridge (0.61), and East Slope (0.92) ($p > 0.10$). There were no significant differences in use between West Ridge (0.15), Middle Ridge (0.05), and East Slope (0.04) for other birds ($p > 0.10$).

Fatality. Mean fatality by taxonomic groups was calculated for each geographic location (Table 14) and is depicted graphically in the middle sections of Figures 10 - 14.

Overall, West Ridge had the highest bird fatality (0.145 carcasses/survey), followed by Middle Ridge (0.053) and East Slope (0.041) (Table 14). Fatality at West Ridge was significantly ($p < 0.10$) higher than fatality at either Middle Ridge or East Slope.

Patterns of fatality varied across geographic location. For West Ridge, fatality was very similar for raptors (0.056) and other birds (0.057). Lower fatality was observed for passerines (0.025); however, this difference was not significant ($p > 0.10$). Corvid fatality (0.008) was significantly ($p < 0.10$) lower than either raptor or other bird fatality; however, corvid fatality was not significantly different from passerine fatality. For Middle Ridge, fatality was highest for other birds (0.024), followed by corvids (0.014), passerines (0.009), and raptors (0.006). None of the observed fatality rates by taxonomic group were significantly different among groups. For East Slope, similar mortalities were observed for raptors (0.012), passerines (0.016), and other birds (0.012). No corvid fatalities were observed at East Slope.

Raptors had significantly ($p < 0.10$) higher fatality at West Ridge (0.056 carcasses/survey) than either Middle Ridge (0.006) or East Slope (0.012). Raptor fatality at Middle Ridge was not significantly different than fatality at East Slope. A chi-squared test revealed that there was a significant difference between the proportion of raptor fatalities found at the geographic locations ($\chi^2 = 19.55$, $df = 2$, $p = 0.0001$). The highest fatality for corvids was observed at Middle Ridge (0.014); however, fatality was not significantly different at Middle Ridge than that observed at West Ridge (0.008) or East Slope (0). Passerines showed no significant differences in fatality between West Ridge (0.025), Middle Ridge (0.009), and East Slope (0.016). The highest fatality was observed for other birds at West Ridge (0.057). Lower fatality was observed at Middle Ridge (0.024) and significantly ($p < 0.10$) lower fatality was observed at East Slope (0.012). There was no significant difference in fatality between Middle Ridge and East Slope for other birds ($p > 0.10$).

Risk Index. The average risk index by taxonomic groups was calculated for each geographic location (Table 15), and is depicted graphically in the bottom sections of Figures 10 – 14.

Overall, West Ridge had the highest bird risk index (0.090 carcasses/bird use unit), followed by Middle Ridge (0.056) and East Slope (0.038) (Table 15). Patterns of the risk index for individual groups of birds varied across geographic location. For West Ridge, raptors had the highest risk index (1.421 carcasses/bird use unit). A lower risk index was observed for other birds (0.403) and a significantly ($p < 0.10$) lower risk index was observed for corvids (0.015) and passerines (0.026). The other bird risk index was also significantly ($p < 0.10$) higher than risk index observed for both corvids and passerines. Corvid and passerine risk were not significantly different from one another ($p > 0.10$). For Middle Ridge, the risk index was highest for other birds (0.487), followed by raptors (0.156), corvids (0.055), and passerines (0.015). None of the observed risk index estimates by taxonomic group were significantly different from one another. For East Slope, the risk index was highest for raptors (1.187), followed by other birds (0.279), and passerines (0.018). No corvid fatalities were observed at East Slope therefore, the risk index calculated for corvids was zero. Despite the large differences in mean risk index estimates there were no significant differences observed by taxonomic group for East Slope ($p > 0.10$).

Raptors had a significantly ($p < 0.10$) higher risk index at West Ridge (1.421 carcasses/bird use unit) than Middle Ridge (0.156). The risk for raptors at East Slope (1.187) was not significantly different than either West Ridge or Middle Ridge. The highest risk index for corvids was observed at Middle Ridge (0.055); however, risk was not significantly different at Middle Ridge than that observed for West Ridge (0.015). The risk index was zero for corvids at East Slope because no corvid fatalities were detected at that location.

Passerines showed no significant differences in the risk index between West Ridge (0.026), Middle Ridge (0.015), and East Slope (0.018). The highest risk index observed for other birds was at Middle Ridge (0.487). A lower risk index was observed at both West Ridge (0.403) and East Slope (0.279). There were no significant differences in the risk index by location for other birds ($p > 0.10$).

Turbine Size

Fatality rates and the risk index for large (≥ 26 m rotor diameter) and small (< 26 m rotor diameter) turbines are standardized only to a per turbine basis. Fatality and risk are expected to be higher for larger turbines because of their larger rotor diameter. Comparisons on a per rotor swept area basis are found in those sections below.

Fatality. Without adjusting for RSA, large turbines had a slightly higher bird fatality rate (0.085/search) than small turbines (0.071), although the difference was not statistically significant based on the confidence intervals ($p > 0.10$, Figure 15). A chi-squared test of raptor fatality rates at the large and small turbines was also not significant ($\chi^2 = 0.34$, $df = 1$, $p = 0.5580$) (Figure 16). Within all taxonomic groups, except passerines, the fatality rate at large turbines was higher than at small turbines, although none of the differences were statistically significant. The influence of more than a single turbine in a plot could affect the results of this study. Additional information regarding this is in the Rotor Swept Area and Turbine Density sections.

Within the West Ridge there are only lattice structures. Comparisons of bird fatality rates of the turbines in the West Ridge show slightly higher all bird and raptor fatality rates at larger turbines compared to smaller turbines (Figures 17 and 18), but the differences were not statistically significant. Rotor swept area of the larger turbines in this comparison are two to three times larger than the rotor swept area of the smaller turbines, and therefore, estimates on a rotor swept area equivalence basis are lower for the large turbines.

Risk Index. Without adjusting for RSA, larger turbines had a higher bird risk index (0.072) than smaller turbines (0.053), although the difference was not statistically significant ($p > 0.10$, Figure 15). The raptor risk index was slightly higher for small turbines (0.968 versus 0.807), but was not statistically significant. Within the West Ridge, there are only lattice structures, and these comparisons are discussed in the Turbine Types section.

Turbine Types

Fatality. Overall, fatality rates were highest for windwall turbines (0.131/search) followed by large lattice turbines (0.123), small lattice turbines (0.109), vertical axis turbines (0.083), small tubular turbines (0.048), and large tubular turbines (0.027). Confidence intervals for all estimates overlapped, which indicates no statistically significant differences (Figure 19). There was a similar pattern for raptors. The highest fatality rate occurred with windwall turbines (0.069), followed by large lattice turbines (0.045), small lattice turbines (0.027), and small tubular turbines (0.019). Large tubular and vertical axis turbines had no observed raptor fatalities. None of the differences were statistically significant (Figure 20). It is important to note that no raptors were observed at the large tubular towers, and that these towers are in the East Slope area, which had very low raptor use. A chi-squared test comparing fatality rates of only tubular and lattice towers was significant ($\chi^2 = 4.64$, $df = 1$, $p = 0.0312$, Figure 20).

Within the West Ridge, only lattice structures exist. Overall fatality rates for the large lattice structures were nearly twice the rate of the small lattice turbines (0.20 versus 0.12), but the difference was not statistically significant. Passerine fatality rates were slightly higher for larger turbines (0.037–0.030) and not statistically significant. Raptor fatality rates were nearly three times higher at the large lattice turbines than at the small lattice turbines; again the difference was not statistically significant (Figure 18). This large difference may be explained primarily by the higher raptor utilization rate at the large lattice sites compared to raptor use at the small lattice sites (see Risk Index section below). Within the Middle Ridge, the three turbine types sampled included vertical axis turbines, large lattice turbines, and small tubular turbines. The highest overall fatality rate occurred at VAT turbines (0.083/search) followed by small tubular turbines (0.035) and large lattice turbines (0.031). The same pattern was observed for raptors and passerines.

Risk Index. Overall, the average risk index was highest for windwall turbines (0.107), followed by large lattice turbines (0.102), vertical axis turbines (0.070), small tubular turbines (0.060) small lattice turbines (0.049), and large tubular turbines, although confidence intervals for all estimates overlapped and indicated no statistically significant differences (Figure 19). The raptor risk index was highest at windwall turbines (3.176),

followed by small tubular turbines (1.021), small lattice turbines (0.917), large lattice turbines (0.879), with no raptor fatalities and subsequently 0 for an estimate of the risk index at the large tubular and vertical axis turbines (Figure 20). No raptor carcasses were found at the large tubular towers and these towers are in the East Slope area, which had very low raptor use.

Within the West Ridge, the mean overall risk index was highest for the large lattice turbines followed by windwall turbines (0.107) and small lattice turbines (0.052). The mean raptor risk index was highest for the windwall turbines followed by very similar estimates for large lattice turbines and small lattice turbines. The mean passerine risk index was highest for large lattice turbines (0.050) followed by small lattice turbines (0.020), and wind wall turbines (0.013).

Row Location

Fatality. Overall, mean fatality rates at mid-row sites were twice as high as fatality rates at end-row sites, but not quite significantly different (Figure 21). For raptors, the mean fatality rate at mid-row sites was three times higher than at end row sites (Figure 22). A chi-squared test revealed that there was a significant difference between the proportion of fatalities found at the different row locations ($\chi^2 = 5.10$, $df = 2$, $p = 0.0779$). This pattern is likely partially explained by the fact that mid-row sites often have other turbines within 50 m in both directions, while end-row turbines often have other structures in only one direction.

This same pattern was apparent at the West Ridge. Although this pattern is likely partially explained by the influence of more turbines, possibly causing fatality at the mid-row permanent site location, the result that end-row turbines showed higher fatality at Altamont Pass WRA was not apparent in this study.

Risk Index. Patterns in relationships between row location and the risk index were similar to those for fatality, but again not significantly different. The estimate of risk for mid-row turbines was greater than for end row turbines (Figures 21 and 22).

Turbine Density

Fatality. Overall mean fatality rates increased with increasing turbine densities, with high turbine density fatality rates of 0.136, followed by medium density (0.075), low density (0.066), and very low density (one turbine within 100 m) (0.029); none of the differences were statistically significant (Figure 23). This gradient trend was also apparent for raptors (Figure 24), but again with no significant differences. A chi-squared test revealed a significant difference between the proportion of fatalities found at the different turbine densities ($\chi^2 = 14.30$, $df = 3$, $p = 0.0025$).

Risk. Overall risk when considering all groups showed a somewhat similar gradient trend with the highest risk at high density turbine plots (0.117) and the lowest risk at plots with one turbine within 50 m (0.015). This difference was statistically significant ($p < 0.10$).

Rotor Swept Area

Fatality. Overall mean fatality rates did not increase or decrease consistently as the rotor swept area (RSA) of the permanent site turbine or the combined RSA of the turbines within the search plots increased (Figures 25 and 27). A similar result was observed for raptors (Figures 26 and 28). A chi-squared test revealed no significant difference between the proportion of raptor fatalities found at the different RSA of the center turbine of each plot ($\chi^2 = 2.04$, $df = 3$, $p = 0.5650$). The chi-squared test for RSA for the entire search plots revealed a significant difference between the proportion of raptor fatalities found ($\chi^2 = 8.23$, $df = 3$, $p = 0.0408$). Slope coefficients for linear regression analyses of the fatality rates against the RSA of an individual turbine and of the RSA of all turbines within 50 m of the center of the permanent site for all birds and raptors were not significantly different than zero ($p > 0.10$).

Risk Index. The overall risk index when considering all groups showed no consistent pattern as RSA for the turbines and RSA for the sites increased. The highest risk for RSA for the center turbine occurred in the 573-616 category (0.078) and the lowest risk occurred in the 1195 category (0.033), but this difference was not statistically significant ($p > 0.10$). The highest risk for RSA for the site occurred in the 1301-1900 category (0.109) and the lowest risk occurred in the 801-1300 category (0.042). Again, this difference was not statistically significant ($p > 0.10$). Slope coefficients for linear regression analyses of the risk rates against the RSA of an individual turbine and of the rotor swept area of all turbines within 50 m of the center of the permanent site for all birds and raptors were not significantly different than zero ($p > 0.10$).

Observer Detection Rates

Two observer efficiency experiments were conducted: one on 20–22 August 1996 and one on 28–30 April 1997. A total of 407 birds were placed in the field for observers to either detect or not detect. Estimates of the probability of an observer detecting an available carcass or part by experiment, size (small and large), and vegetation (small shrubs and grass), as well as across experiments and overall detection rates are found in Table 16. No significant differences in probability of detection estimates were observed during the first experiment for any of the comparisons. During the second study, small birds and parts of birds were significantly less detectable than large birds in both vegetation types. The two vegetation types were not significantly different from one another for small and large birds, because of tall green grass in all vegetation types.

Overall, observers detected 73% of the carcasses/parts placed in the field. Large carcasses/parts were detected 84% of the time in small shrub vegetation, and 81% in grass vegetation. Small carcasses/parts were detected 66% of the time in small shrub vegetation, and 60% in grass vegetation. Overall, small birds/parts were significantly less detectable than large birds for both vegetation types ($p < 0.10$). There were no significant differences in detectability between the vegetations for either small or large birds/parts.

Scavenging Rates

Three scavenging experiments were conducted, one on 2 and 3 August 1996, one on 9 and 10 December 1996, and one on 8 and 9 April 1997. A total of 315 carcasses were used to estimate scavenging rates (Table 17). Primary analysis variables compared include placement (within 50 m from turbines versus ≥ 400 m from turbines), season, study area, carcass size (small and large), and carcass color (cryptic versus non-cryptic). Overall, 96% of the carcasses were removed 8 days after placement (excludes carcasses available after day 4 that were not checked). The estimated proportion of fatalities removed by day 8 varied little by the primary analysis variables. The mean time to removal estimate was less than 3.20 days, with an overall average of 2.62 days (95% confidence interval [2.35, 2.89]).

Proximity to Turbines

The mean removal time for carcasses near turbines was higher than away from turbines (2.89 days versus 2.31 days), but not quite significantly different ($p > 0.10$) based on overlapping 95% confidence intervals (Table 17).

Geographic Location

The mean removal time was lowest in the West Ridge area (2.17 days), followed by Middle Ridge (2.70 days) and East Ridge (3.03 days). None of the means were significantly different based on the confidence intervals, although the confidence intervals overlapped only slightly between the West Ridge and East Slope ($0.10 < p < 0.15$).

Season

Mean removal time was lowest during the August trial (2.20 days), followed by April (2.55 days) and December (3.13 days). The difference between August and December is considered statistically significant ($p < 0.10$).

Size of Carcass

Mean removal time was significantly lower for large carcasses (2.12) compared with small carcasses (3.10 days, $p < 0.10$). This may be partially attributable to the fact that most of the large carcasses were much more visible to ravens and raptors or diurnal predators.

Color

Mean removal time was higher for cryptic colored carcasses (2.97 days) compared with non-cryptic colored carcasses (2.45 days), although this difference was not statistically significant ($p > 0.10$).

Annual Fatality Estimates

This study was not specifically designed to provide standardized estimates of avian fatalities and the wide interval between searches (90 days) leads to a high level of uncertainty in the fatality estimates. The unknown impact scavenging has on the fatality estimates could greatly impact the fatality estimates. With these obvious caveats in mind, the unadjusted estimate of raptor fatalities for the wind resource area is 0.047 per turbine per year. The average nameplate output of the turbines in our sample was 0.19 kW yielding an estimate of 0.25 raptor fatalities per MW per year unadjusted for searcher efficiency bias and 0.3 per MW per year adjusted for searcher efficiency bias.

Discussion, Conclusions, and Recommendations

Raptors appear to be more susceptible to collision with turbines than other birds at Tehachapi Pass, a pattern also observed at Altamont Pass (Thelander et al. 2003). Fatality rates and the risk index are clearly higher for raptors than the other bird groups. Flight height characteristics support this result, because a large majority of raptors observed were within the typical heights of turbine rotors. Many studies of avian use at wind projects (e.g., Anderson et al. 2004; Johnson et al. 2000a, 2000b; Thelander et al. 2003; Young et al. 2003) have documented raptors flying consistently at rotor swept heights of wind turbines, while resident passerines observed during the day were typically observed at lower flight heights. Flight height characteristics alone do not necessarily equate to risk, and do not account for avoidance behaviors of birds. Fatality composition from newer wind projects outside California show a much lower percentage of raptors, and more passerines, including apparent nocturnal migrants (Erickson et al. 2002).

Raptor use is the clearest factor related to raptor fatality at Tehachapi Pass. West Ridge had the highest raptor use and by far the highest fatality rates; Middle Ridge had moderate raptor use and moderate fatality rates and East Slope had very low raptor use and very low raptor fatality rates. At a macro scale, raptor use of a site still appears to be one of the most important factors that can be easily measured and is generally related to risk of collision. At this large wind site, there were differences in raptor use geographically that could be measured and were related to fatality rates. These results support the collection of baseline data in diverse and large wind projects for use in estimating locations of least impact.

When controlling for raptor use by calculating the risk index, very few differences (statistical differences or patterns) in the effects of turbine characteristics were apparent. The statistical power for detecting these differences is low as a result of confounding of variables and relatively low fatality rates. There was a pattern of higher fatality rates at larger turbines, but when the fatality rates and collision risks were adjusted by rotor swept area (RSA) or turbine density, those differences were reduced, and in some cases the fatality rates for smaller turbines on a RSA equivalence basis were higher than for the larger turbines. These patterns do not suggest higher raptor fatality rates on a per rotor swept area equivalence basis for larger turbines. Some studies have suggested a lower raptor fatality rate for larger turbines on a per rotor swept area basis. Howell (1997) examined differences in fatality rates between

56-100 lattice and KVS-33 lattice turbines at Altamont Pass and Montezuma Hills. The overall fatality rates for the 56-100 downwind turbines on a per turbine basis were higher than the 33 m rotor diameter, suggesting in this case, that mortality was not related to rotor swept area. Other studies at Altamont have suggested a higher golden eagle fatality rate for the 56-100 turbines compared to other turbine types (Hunt 2002), possibly because of the closer proximity of the blades to the ground and the foraging behavior of golden eagles (i.e., they often forage within 3 m of the ground).

Most studies at new generation wind projects do not have different size turbines in the same WRA, greatly limiting the ability to infer differences in impacts among turbine sizes. Studies in Minnesota (Johnson et al. 2002) suggest there may be some relationship between the rotor swept area and fatality. Rotor swept area for larger turbines on the site (using 47-m rotor diameter) is approximately two times the area for a smaller 33- turbine on the site, and all bird fatality rates were estimated to be approximately three times higher for the larger turbine type. Most of the observed differences could be attributed to a higher rate of passerine casualties at the larger turbines, although the differences were not statistically significant. Other factors such as differences in habitat and avian use could also have been a factor in these differences.

Taller turbines may impact more nocturnal migrating birds that typically fly at altitudes much higher than small older generation turbines. While there have been numerous single fatality events recorded at communication structures that document several hundred avian fatalities in one night, there have been only two events reported, both reasonably small, at U.S. wind generation facilities. Fourteen nocturnal migrating passerines were found dead at two turbines during a single night at the Buffalo Ridge, Minnesota, Windplant during spring migration. Approximately 25-30 nocturnal migrating passerines were observed at three turbines and a lighted substation at the Backbone Mountain, West Virginia, facility following one or two nights of foggy weather. Strong evidence suggests the sodium vapor lamps at the substation were the primary attractant, and few migrant fatalities were found after the lights on the substation were turned off.

Many reports and studies have suggested that turbines on lattice towers may be associated with higher fatality rates than comparable tubular tower turbines (Curry and Kerlinger 2000; Hunt 2002; Orloff and Flannery 1996; Rugge 2001) because of the increased perching opportunities on horizontal lattice towers, which are thought to increase the number of fatalities. In this study, tubular towers have lower estimated fatality rates than lattice towers in general, but the true cause of the difference cannot be determined. Geographic location is highly confounded with tower type, since all turbines studied in the West Ridge were lattice and all turbines studied in the Middle Ridge were tubular and highest raptor use and fatality occurred in the West Ridge. Recent studies by Thelander et al. (2003) showed higher fatality rates at tubular towers, although turbine size differences between lattice and tubular towers were not taken into account. Our study and the recent studies at the Altamont suggest that tower type is not likely to be related to collision risk at sites where perch sites are abundant. However, our data do suggest a higher rate of perching behavior by raptors and small birds on small and large lattice turbines, and small tubular turbines compared to tall tubular turbines, with most perching occurring on turbines not operating. Similar results have been

observed by Thelander (personal communications), where nearly all the perching occurred on turbines that were not operational. Perching structures for raptors and other large birds are very abundant at large older wind projects like the Altamont Pass, Tehachapi Pass, and San Geronio, with overhead lines and non-operational turbines. It is plausible that presence of structures such as lattice turbines and overhead lines that provide perches for raptors and other birds at sites where perch sites are limited could increase use of the sites and lead to higher mortality, although this has not been tested.

Fatalities were observed at 54 of the 201 sites monitored. The largest number of fatalities observed at any one site was four. Based on the 75 fatalities observed at these sites, we would expect approximately 28% of the sites to have at least one fatality under a random distribution. This pattern of no distinctive clustering of fatality locations at a particular turbine suggests there is no single site sampled that has a very high fatality rate compared to the other sites sampled. A similar result was observed at Altamont Pass (Thelander et al. 2003) where the number of fatalities at turbines was similar to a random distribution. However, factors such as scavenging and the relatively small sample of turbines compared to the total number of turbines in the wind site could mask potential differences. This does not imply that factors such as location of turbine or turbine string are not related to fatality rates.

There were apparent differences in collision risk among different avian groups. Ravens and turkey vultures had low fatality and relatively high use, suggesting they are not very susceptible to collisions. This was also observed at Altamont (Orloff and Flannery 1992, 1996). Red-tailed hawks, great horned owls, and American kestrels appeared to show the highest risk of collision.

We did not attempt to make estimates of annual bird fatality estimates for the developed Tehachapi Pass WRA because of the extremely high uncertainty surrounding the long search intervals (90 days) and the unknown impact of scavenging rates. We did report unadjusted annual raptor per turbine and per MW fatality estimates, because the corrections for large birds for scavenging and searcher efficiency have been much less than for small birds. Studies at the Altamont and San Geronio have presented unadjusted rates using reasonably similar methods. This study suggested an estimate of 0.04 raptors per turbine per year or 0.20 raptor fatalities per MW per year. Unadjusted estimates from recent studies at the Altamont Pass was 0.10 raptors per turbine per year and 1 – 1.23 raptors per MW per year. Unadjusted estimates from studies of 56-100 turbines at Montezuma Hills were 0.05 per turbine per year, or 0.50 per MW per year (Howell 1997). Raptor use (including Vultures) at Tehachapi Pass is estimated to be much less than at the Altamont Pass and Montezuma Hills, but higher than San Geronio (Erickson et al. 2002). The West Ridge, where the highest raptor fatality rates were observed at Tehachapi Pass WRA, was estimated to be approximately half the estimate from the Altamont Pass.

In future studies at Tehachapi Pass, we would recommend additional scavenging trials be conducted, and using bird species that are more representative of the species/groups found in the area. If raptors are the target of the research, raptors should be used in the trials. We would also recommend that searches be conducted more frequently. Initial scavenging studies should be used to direct how often a plot is to be searched. Estimating scavenging

rates is vital in estimating fatality rates (Erickson et al. 2000). It is less vital in a study like this when comparing indices among levels of several factors. We did need to assume similar average scavenging rates among the levels of the factors studied (e.g., geographic location). The estimated scavenging rates are higher than those recorded at several other wind projects (Morrison 2002), but may be influenced by the species used (chickens). At the newly constructed Vansycle windplant located primarily in wheat fields, small carcasses lasted on average 15.0 days, and large carcasses lasted on average greater than the search interval of 28 days (Erickson et al. 2000). At the Buffalo Ridge Windplant, small carcasses persisted on average 4.7 days, whereas small birds at Foote Creek Rim persisted 12.2 days. Some other scavenging studies have observed high rates of scavenging such as those estimated at Tehachapi. Wobeser and Wobeser (1992) reported that nearly 80% (79.2) of the chicks placed in a mixed grazed pasture were removed within 24 hours. In France, Pain (1991) estimated duck carcasses lasted an average of 1.5 days in open vegetations, whereas those concealed by vegetation or those in water lasted 3.3–7.6 days. In one orchard, scavengers removed all 25 of the placed carcasses within 24 hours, with lower rates in the other orchards studied.

The scavenging bias trials in our study were limited because of their relatively small sample size and the species of birds used (chickens). It is also believed scavengers may use scent and visual clues to locate trial carcasses, which inflates scavenging rates above rates for actual wind turbine carcasses. The observer detection trials were limited in scope and sample size.

This was not a manipulative experiment, but an observational study (Hurlbert 1984, Morrison et al. 2001) designed to provide statistical evidence regarding differences in fatality rates, use, and collision risk between levels of factors such as geographic location, turbine size, and tower type. Actual cause of statistical differences or consistent patterns in the results cannot be statistically determined from this study. For example, differences in raptor fatality rates were observed between the West Ridge and the East Slope. These differences may be a result of factors not controlled for. In a true manipulative experiment, random assignment of treatments (e.g., turbine type) to experiment units (plots) would have provided stronger inferences towards cause of differences. Although this is important to acknowledge, it is also important to acknowledge that nearly all studies at wind projects and most field studies in general are observational studies with no control over assignment of treatments (e.g., tower type) to experimental units. In observational studies, professional opinion based on patterns observed in the data, and knowledge of the subject matter, are used to make conclusions. Confirming patterns from other studies conducted at other wind sites strengthens our knowledge.

Most fatality studies (e.g., Orloff and Flannery 1992, Thelander et al. 2003, Erickson et al. 2003) are designed to estimate fatality rates for the wind project, and searches of turbines are usually conducted on a much more frequent interval (e.g., weekly, twice monthly) than the interval used in our study. We would recommend much higher search frequency (e.g., monthly or twice monthly at a minimum) and a larger sample size. In addition, at sites where turbines within strings are closer together than two times the fatality plot search radius, we would recommend searching entire turbine strings, and not individual turbines.

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Table 1. Vegetation Types Documented during Phase I Studies at Tehachapi Pass Wind Resource Area, 2 October 1996 to 27 May 1998 (Based on Vegetation Observed Within 50 m of the Sample Site Center)

Vegetation Structure	Dominant Group/Species
Grass	California Annual Grassland Desert Needlegrass
Sub-Shrub	Saltbush (<i>Atriplex</i> spp.) Brittlebush California Buckwheat Mormon Tea (<i>Ephedra</i> spp.) Interior Goldenbush Rabbit Brush
Large Shrub	California Juniper Joshua Tree
Wooded	Foothill Pine (pinyon, grey pine) Oak Woodland (scrub oak, canyon live oak)
	Other (described in comments)

Table 2. Description of Turbines within the Tehachapi Pass WRA and the Turbines Selected to Be Studied (Approximately 95% of the Turbines Within the WRA were Documented)

Model	Tower Type	Tower Height (m)	# blades	Height (m) of Swept Areas		Rotor /Blade Length(m)	RSA ^a m ²	# in WRA	# of Sample Sites ^b
				max	min				
West Ridge									
Vesta V15	SLT	25.4	3	33.9	18.9	7.2	184	463	24
Vesta V17	SLT	14.7	3	24.2	7.2	8.2	227	639	29
Vesta V17E	SLT	25.4	3	35.8	17	9.1	278	13	1
Vesta V27	LLT	28.4	3	41.3	14.3	12.8	573	87	24
percentage of search area = 14%							subtotal	1202	78
Middle Ridge									
Cannon 250	LTT	42.7	3	62.2	23.2	19.5	1195	3	0
Micon 250	LTT	42.7	3	54.7	30.7	12	452	3	0
Vestas V39	LTT	42.7	3	62.2	23.2	19.5	1195	28	21
Micon 108	STT	24.4	3	33.4	15.4	8.5	283	141	7
Nordtank 150	STT	25.9	3	35.4	16.4	9	254	102	3
Nordtank 65-75	STT	24.4	3	32.7	16.1	8.3	216	388	13
EHD Prototype	VAT	57.6	3	nc	nc	nc	nc	1	0
FloWind 17	VAT	28.1	2	nc	nc	nc	nc	161	10
FloWind 19	VAT	30.8	2	nc	nc	nc	nc	176	20
percentage of search area = 14%							subtotal	1003	74
East Slope									
Danwind 160	STT	32	3	43	21	11	415	91	0
Micon 108	STT	23.8	3	33.3	14.3	9	254	251	15
Mitsubishi 250A	LTT	26	3	38	14	12	531	20	0
Mitsubishi 250B	LTT	32	3	45	19	13	616	340	14
Mitsubishi 250C	LTT	32	3	45	19	13	616	300	16
Nordtank 150	STT	26	3	36	16	10	346	62	4
percentage of search area = 14%							subtotal	1064	49
percentage of search area = 14%							Total	3269	201

^a Rotor swept area

^b All sample sites included multiple turbines.

Table 3. Sample Sizes for Each Factor Used in Comparison of Fatality Rates, Use, and Collision Risk

Measure/Category	Overall		West Ridge		Middle Ridge		East Slope	
	n	%	n	%	n	%	n	%
Geographic Location	201		78		74		49	
Turbine Type								
LLT	45	22.4	24	30.8	21	28.4	0	0.0
slt	28	13.9	28	35.9	0	0.0	0	0.0
LTT	30	14.9	0	0.0	0	0.0	30	61.2
stt	42	20.9	0	0.0	23	31.1	19	38.8
VAT	30	14.9	0	0.0	30	40.5	0	0.0
ww	26	12.9	26	33.3	0	0.0	0	0.0
Turbine Size								
Large	75	37.3	24	30.8	21	28.4	30	61.2
Small	70	34.8	28	35.9	23	31.1	19	38.8
Turbine Style								
Lattice	73	36.3	52	66.7	21	28.4	0	0.0
Tubular	72	35.8	0	0.0	23	31.1	49	100.0
Row Position								
End-row	41	20.4	21	26.9	10	13.5	10	20.4
Mid-row	116	57.7	55	70.5	22	29.7	39	79.6
Discontinuous	14	7.0	2	2.6	12	16.2	0	0.0
Not Applicable (VAT)	30	14.9	0	0.0	30	40.5	0	0.0
Density								
One	37	18.4	2	2.6	34	45.9	1	2.0
Low	120	59.7	41	52.6	31	41.9	48	98.0
Medium	26	12.9	17	21.8	9	12.2	0	0.0
High	18	9.0	18	23.1	0	0.0	0	0.0
Rotor Swept Area								
177	24	11.9	24	30.8	0	0.0	0	0.0
216	13	6.5	0	0.0	13	17.6	0	0.0
227	29	14.4	29	37.2	0	0.0	0	0.0
278	1	0.5	1	1.3	0	0.0	0	0.0
284	25	12.4	0	0.0	10	13.5	15	30.6
346	4	2.0	0	0.0	0	0.0	4	8.2
573	24	11.9	24	30.8	0	0.0	0	0.0
616	30	14.9	0	0.0	0	0.0	30	61.2
1066	10	5.0	0	0.0	10	13.5	0	0.0
1195	21	10.4	0	0.0	21	28.4	0	0.0
1281	20	10.0	0	0.0	20	27.0	0	0.0

Table 4. Number of Groups and Individuals of Avian Groups Observed during Bird Utilization Surveys at Tehachapi Pass Wind Resource Area, 2 October 1996 to 27 May 1998

Species	# Groups	# Det.	% Group Composition	% Overall Composition
Raptors				
Red-Tailed Hawk	106	119	60.10	1.87
Unidentified Raptor	30	32	16.16	0.50
American Kestrel	29	30	15.15	0.47
Unidentified Buteo	5	5	2.53	0.08
Golden Eagle	2	3	1.52	0.05
Northern Harrier	2	2	1.01	0.03
Sharp-Shinned Hawk	2	2	1.01	0.03
Unidentified Falcon	2	2	1.01	0.03
Ferruginous Hawk	1	1	0.51	0.02
Prairie Falcon	1	1	0.51	0.02
Unidentified Accipiter	1	1	0.51	0.02
Subtotal	181	198	100.00	3.10
Corvids				
Common Raven	1067	1702	87.33	26.68
Scrub Jay	161	197	10.11	3.09
Common Raven/American Crow	27	50	2.57	0.78
Subtotal	1255	1949	100.00	30.55
Passerines				
Horned Lark	171	819	25.88	12.84
Unidentified Passerine	340	773	24.42	12.12
Western Meadowlark	233	427	13.49	6.69
European Starling	106	264	8.34	4.14
Dark-Eyed Junco	52	212	6.70	3.32
White-Crowned Sparrow	27	146	4.61	2.29
Brewer's Blackbird	9	132	4.17	2.07
Loggerhead Shrike	84	88	2.78	1.38
Unidentified Swallow	3	63	1.99	0.99
Unidentified Swift	1	50	1.58	0.78
Unidentified Sparrow	14	35	1.11	0.55
House Finch	11	34	1.07	0.53
Plain Titmouse	22	26	0.82	0.41
Cactus Wren	22	23	0.73	0.36
California Towhee	10	13	0.41	0.20

Table 4. (continued)

Species	# Groups	# Det.	% Group Composition	% Overall Composition
Lark Sparrow	8	10	0.32	0.16
Yellow-Rumped Warbler	5	9	0.28	0.14
Rock Wren	6	6	0.19	0.09
Western Bluebird	4	6	0.19	0.09
Western Kingbird	2	3	0.09	0.05
House/Purple Finch	2	3	0.09	0.05
Sage Sparrow	3	3	0.09	0.05
Cliff Swallow	1	3	0.09	0.05
Unidentified Wren	3	3	0.09	0.05
American Robin	2	3	0.09	0.05
Unidentified Finch	2	2	0.06	0.03
Rufous-Crowned Sparrow	1	2	0.06	0.03
Northern Mockingbird	2	2	0.06	0.03
Unidentified Hummingbird	2	2	0.06	0.03
Black-Throated Sparrow	1	1	0.03	0.02
Yellow-Breasted Chat	1	1	0.03	0.02
Bewick's Wren	1	1	0.03	0.02
Subtotal	1151	3165	100.00	49.61
Other				
Unidentified Bird	243	578	54.12	9.06
Turkey Vulture	19	404	37.83	6.33
California Quail	8	43	4.03	0.67
Rock Dove	7	23	2.15	0.36
Greater Roadrunner	7	7	0.66	0.11
Chukar	3	4	0.37	0.06
Mourning Dove	1	2	0.19	0.03
Unidentified Duck	1	1	0.09	0.02
Band-Tailed Pigeon	1	1	0.09	0.02
Downy Woodpecker	1	1	0.09	0.02
Ladder-Backed Woodpecker	1	1	0.09	0.02
Nuttall's Woodpecker	1	1	0.09	0.02
Red-Shafted Flicker	1	1	0.09	0.02
Unidentified Woodpecker	1	1	0.09	0.02
Subtotal	295	1068	100.00	16.74
Total	2882	6380	100.00	100.00

Table 5. Avian Abundance and Richness by Season during Phase I Utilization Surveys at Tehachapi Pass Wind Resource Area, 2 October 1996 to 27 May 1998. (Calculated Based on Observations within 200 m of Site Center)

Season	Study Area			
	Overall	West Ridge	Middle Ridge	East Slope
Spring				
No. Species	25	13	14	10
Mean No. / Survey ^a	1.61	2.36	0.95	1.32
Mean No. Species / Survey	1.26	1.17	1.24	1.38
Summer				
No. Species	28	17	20	11
Mean No. / Survey ^a	0.93	1.46	0.72	0.35
Mean No. Species / Survey	1.20	1.23	1.23	1.04
Fall				
No. Species	25	16	16	13
Mean No. / Survey ^a	1.55	1.61	1.25	1.77
Mean No. Species / Survey	1.25	1.29	1.21	1.19
Winter				
No. Species	20	15	8	8
Mean No. / Survey ^a	1.20	1.75	0.44	1.09
Mean No. Species / Survey	1.16	1.12	1.08	1.29

^a Mean No. / Survey defined as the mean number of individuals observed per 5-minute utilization survey.

Table 6. Mean Abundance, Percent Composition, and Percent Frequency of Occurrence of Avian Groups Observed during Phase I Utilization Surveys at Tehachapi Pass Wind Resource Area, 2 October 1996 to 27 May 1998 (Calculated Based on Observations within 200 m of Site Center)

Group	Mean Abundance				% Composition				% Frequency of Occurrence			
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
Overall												
Raptors	0.02	0.02	0.04	0.03	1.0	2.4	2.5	2.7	1.6	2.0	3.5	2.2
Corvids	0.49	0.27	0.26	0.33	30.3	28.6	17.0	27.4	20.8	14.9	16.5	17.4
Passerines	0.86	0.59	1.14	0.79	53.5	63.1	73.8	65.6	31.2	21.6	22.2	17.0
Other	0.24	0.05	0.10	0.05	15.2	5.9	6.7	4.3	2.7	3.6	3.4	1.7
Total	1.61	0.93	1.55	1.20	100	100	100	100				
West Ridge												
Raptors	0.02	0.04	0.04	0.05	0.9	2.4	2.7	2.9	2.1	2.9	3.9	3.3
Corvids	0.82	0.47	0.45	0.48	34.7	32.5	27.9	27.4	31.1	25.3	27.1	23.2
Passerines	0.94	0.88	1.00	1.15	39.6	60.3	62.4	65.7	21.1	22.5	20.4	14.7
Other	0.58	0.07	0.11	0.07	24.7	4.8	6.9	4.0	2.6	3.7	3.9	2.2
Total	2.36	1.46	1.61	1.75	100	100	100	100				
Middle Ridge												
Raptors	0.01	0.02	0.05	0.03	0.7	3.1	3.9	6.6	0.7	2.2	4.6	2.3
Corvids	0.24	0.16	0.22	0.23	25.2	23.0	17.8	52.6	10.0	9.9	14.4	13.4
Passerines	0.68	0.46	0.84	0.17	71.3	64.8	67.2	39.5	28.7	25.0	19.9	8.7
Other	0.03	0.07	0.14	0.01	2.8	9.2	11.0	1.3	2.0	4.9	3.6	0.6
Total	0.95	0.72	1.25	0.44	100	100	100	100				
East Slope												
Raptors	0.02	<0.01	0.02	0	1.5	0.9	1.1	0	2.0	0.3	2.0	0
Corvids	0.31	0.06	0.04	0.16	23.7	16.4	2.4	14.7	18.7	4.3	3.6	10.9
Passerines	0.95	0.27	1.65	0.86	72.2	77.6	93.2	78.7	46.7	16.5	27.1	31.9
Other	0.03	0.02	0.06	0.07	2.5	5.2	3.3	6.7	3.3	1.8	2.3	2.2
Total	1.32	0.35	1.77	1.09	100	100	100	100				

Table 7. Five Most Abundant Avian Species (Based on Mean Number per Five-Minute Utilization Survey) Observed during Phase I Utilization Surveys at Tehachapi Pass Wind Resource Area, 2 October 1996 to 27 May 1998 (Calculated Based on Observations within 200 m of Site Center)

Study Area		Season					
		Spring		Summer		Fall	
Species	Use	Species	Use	Species	Use	Species	Use
Overall							
Common Raven	0.44	Common Raven	0.23	Horned Lark	0.41	Common Raven	0.32
European Starling	0.23	Horned Lark	0.19	Common Raven	0.22	European Starling	0.19
Unidentified Swallow	0.12	Brewer's Blackbird	0.10	Dark-Eyed Junco	0.14	Western Meadowlark	0.16
Western Meadowlark	0.11	Western Meadowlark	0.05	Western Meadowlark	0.14	Unidentified Swift	0.09
Horned Lark	0.06	Scrub Jay	0.04	White-Crowned Sparrow	0.12	Dark-Eyed Junco	0.08
West Ridge							
Common Raven	0.72	Common Raven	0.38	Common Raven	0.37	Common Raven	0.47
Unidentified Swallow	0.32	Horned Lark	0.30	Dark-Eyed Junco	0.22	European Starling	0.28
Scrub Jay	0.11	Brewer's Blackbird	0.22	Western Meadowlark	0.21	Western Meadowlark	0.21
Western Meadowlark	0.06	Scrub Jay	0.09	Horned Lark	0.16	Unidentified Swift	0.18
European Starling	0.05	Western Meadowlark	0.05	Scrub Jay	0.07	Dark-Eyed Junco	0.14
Middle Ridge							
European Starling	0.24	Common Raven	0.16	White-Crowned Sparrow	0.29	Common Raven	0.23
Common Raven	0.24	Horned Lark	0.16	Common Raven	0.21	Loggerhead Shrike	0.08
Horned Lark	0.09	Loggerhead Shrike	0.05	Horned Lark	0.18	Dark-Eyed Junco	0.06
Dark-Eyed Junco	0.05	Western Meadowlark	0.05	Western Meadowlark	0.08	Red-Tailed Hawk	0.02
Lark Sparrow	0.05	European Starling	0.03	California Quail	0.07	American Kestrel	0.01
Western Meadowlark	0.05						

Table 7. (continued)

Study Area		Season					
Spring		Summer		Fall		Winter	
Species	Use	Species	Use	Species	Use	Species	Use
East Slope							
European Starling	0.43	Common Raven	0.06	Horned Lark	1.00	Western Meadowlark	0.28
Common Raven	0.29	Horned Lark	0.06	Dark-Eyed Junco	0.14	European Starling	0.23
Western Meadowlark	0.22	Western Meadowlark	0.05	Western Meadowlark	0.09	Common Raven	0.16
Horned Lark	0.10	European Starling	0.03	White-Crowned Sparrow	0.06	Horned Lark	0.14
Loggerhead Shrike	0.06	Cactus Wren	0.03	Common Raven	0.04	White-Crowned Sparrow	0.06

Table 8. Five Most Frequently Occurring Avian Species during Phase I Utilization Surveys at Tehachapi Pass Wind Resource Area, 2 October 1996 to 27 May 1998 (Calculated Based on Observations within 200 m of Site Center)

Study Area		Season					
		Spring		Summer		Fall	
Species	%	Species	%	Species	%	Species	%
Overall							
Common Raven	19.0	Common Raven	12.1	Common Raven	13.4	Common Raven	16.7
Western Meadowlark	8.6	Horned Lark	4.2	Western Meadowlark	4.0	Western Meadowlark	3.8
European Starling	6.7	Western Meadowlark	3.4	Dark-Eyed Junco	2.5	Loggerhead Shrike	2.9
Loggerhead Shrike	3.3	Scrub Jay	2.7	Scrub Jay	2.5	European Starling	2.7
Horned Lark	2.7	Loggerhead Shrike	2.4	Horned Lark	2.4	Red-Tailed Hawk	1.2
West Ridge							
Common Raven	27.9	Common Raven	18.8	Common Raven	21.1	Common Raven	22.1
Western Meadowlark	6.3	Scrub Jay	6.3	Scrub Jay	5.6	Western Meadowlark	3.7
Scrub Jay	3.2	Horned Lark	5.7	Western Meadowlark	4.4	Dark-Eyed Junco	1.8
European Starling	2.6	Western Meadowlark	3.1	Dark-Eyed Junco	3.5	Plain Titmouse	1.8
Red-Tailed Hawk	2.1	European Starling	1.4	Red-Tailed Hawk	2.1	Red-Tailed Hawk	1.8
Middle Ridge							
Common Raven	10.0	Common Raven	9.6	Common Raven	13.1	Common Raven	12.8
Western Meadowlark	5.3	Loggerhead Shrike	4.7	Western Meadowlark	3.9	Loggerhead Shrike	5.8
Loggerhead Shrike	4.7	Western Meadowlark	4.1	Red-Tailed Hawk	3.3	Red-Tailed Hawk	1.2
European Starling	4.0	Horned Lark	3.3	Horned Lark	2.6	American Kestrel	1.2
Horned Lark	3.3	European Starling	1.6	Loggerhead Shrike	2.0	Greater Roadrunner	0.6

Table 8. (Continued)

Study Area		Season							
		Spring		Summer		Fall		Winter	
Species	%	Species	%	Species	%	Species	%		
East Slope									
Common	16.7	Common	4.3	Horned Lark	3.6	Common	10.9		
Raven		Raven				Raven			
European	14.7	Western	3.0	Western	3.6	European	8.7		
Starling		Meadowlark		Meadowlark		Starling			
Western	14.7	Cactus Wren	2.7	Common	2.9	Western	8.7		
Meadowlark				Raven		Meadowlark			
Loggerhead	6.0	Horned Lark	2.7	Loggerhead	2.6	Loggerhead	5.1		
Shrike				Shrike		Shrike			
Horned Lark	5.3	Loggerhead	2.1	Dark-Eyed	2.0	Cactus Wren	2.9		
		Shrike		Junco					
				White-	2.0				
				Crowned					
				Sparrow					

Table 9. Flight Height Characteristics by Avian Group Observed during Phase I Utilization Surveys at Tehachapi Pass Wind Resource Area, 2 October 1996 to 27 May 1998

Study Area Group	# Flocks Flying	# Birds Flying	Mean Flight Height (m)	% Flying	% in Height (m) Categories			
					< 10	10 – 35	36 – 60	> 60
Overall								
Raptors	130	146	53.58	73.7	6.8	40.4	29.5	23.3
Corvids	952	1510	28.34	77.5	23.1	42.6	21.1	13.1
Passerines	703	1891	7.38	59.7	69.2	25.6	1.5	3.7
Other	158	484	26.17	45.3	25.2	27.9	7.0	39.9
Total	1943	4031	22.27	63.2	44.4	32.8	10.5	12.3
West Ridge								
Raptors	91	105	54.23	86.8	5.7	36.2	32.4	25.7
Corvids	664	1100	28.92	81.1	22.7	39.6	24.1	13.5
Passerines	270	1119	8.07	69.3	67.6	24.0	2.5	5.8
Other	95	385	31.74	44.4	21.0	21.6	8.1	49.4
Total	1120	2709	26.19	68.4	40.4	30.5	13.2	15.9
Middle Ridge								
Raptors	27	29	64.37	51.8	6.9	48.3	20.7	24.1
Corvids	159	225	24.94	62.7	30.7	44.9	13.8	10.7
Passerines	182	320	5.66	51.9	75.0	25.0	0.0	0.0
Other	27	50	19.00	39.1	40.0	52.0	4.0	4.0
Total	395	624	18.35	53.8	53.0	35.4	6.3	5.3
East Slope								
Raptors	12	12	24.33	57.1	16.7	58.3	25.0	0.0
Corvids	129	185	29.50	79.1	16.2	57.8	12.4	13.5
Passerines	251	452	7.89	48.4	68.8	29.9	0.2	1.1
Other	36	49	16.86	67.1	42.9	53.1	2.0	2.0
Total	428	698	15.62	55.3	52.1	39.4	4.0	4.4

Table 10. Characteristics of Perching Locations

Perch Type	All Birds		Raptors	
	n	%	n	%
Large Lattice Turbine	11	1.9	5	12.5
Small Lattice Turbine	28	4.9	3	7.5
Small Tubular Turbine	49	8.5	2	5.0
Large Tubular Turbine	0	0.0	0	0.0
Vertical Axis Turbine (Wire or Turbine)	16	2.8	4	10.0
Meteorological Tower (Wire or Tower)	29	5.0	9	22.5
Powerline/Pole/Conductor	69	12.0	11	27.5
Fence	20	3.5	0	0.0
Ground	105	18.3	0	0.0
Vegetation	230	40.0	4	10.0
Other	18	3.1	2	5.0
Subtotal	575	100.0	40	100.0

Table 11. Number of avian Fatalities Observed during This Study at Tehachapi Pass Wind Resource Area, 2 October 1996 to 27 May 1998

Study Area / Group	Total Fatalities			Carcass Search Fatalities		
	#	% Composition		#	% Composition	
		overall	within area		overall	within area
Overall						
Raptors	44	34.6	n/a	26	34.7	n/a
Corvids	10	7.9	n/a	4	5.3	n/a
Passerines	27	21.3	n/a	15	20.0	n/a
Other	46	36.2	n/a	30	40.0	n/a
Subtotal	127	100.0	n/a	75	100.0	n/a
West Ridge						
Raptors	32	25.2	35.2	21	28.0	38.2
Corvids	9	7.1	9.9	3	4.0	5.5
Passerines	13	10.2	14.3	9	12.0	16.4
Other	37	29.1	40.7	22	29.3	40.0
Subtotal	91	71.7	100.0	55	73.3	100.0
Middle Ridge						
Raptors	3	2.4	18.8	2	2.7	20.0
Corvids	1	0.8	6.3	1	1.3	10.0
Passerines	7	5.5	43.8	2	2.7	20.0
Other	5	3.9	31.3	5	6.7	50.0
Subtotal	16	12.6	100.0	10	13.3	100.0
East Slope						
Raptors	9	7.1	47.4	3	4.0	30.0
Corvids	0	0.0	0.0	0	0.0	0.0
Passerines	6	4.7	31.6	4	5.3	40.0
Other	4	3.1	21.1	3	4.0	30.0
Subtotal	19	15.0	100.0	10	13.3	100.0

Table 12. Composition of Avian Fatalities Observed during Phase I Study Period at Tehachapi Pass Wind Resource Area, 2 October 1996 to 27 May 1998

Avian Group / Species	Number of Fatalities	Percent of Fatalities
Raptors		
Red-Tailed Hawk	14	11.0
Great Horned Owl	13	10.2
American Kestrel	9	7.1
Common Barn Owl	2	1.6
Unidentified Raptor	1	0.8
Unidentified Buteo	1	0.8
Prairie Falcon	1	0.8
Long-Eared Owl	1	0.8
Flammulated Owl	1	0.8
Ferruginous Hawk	1	0.8
Corvids		
Common Raven	8	6.3
Scrub Jay	2	1.6
Passerines		
Western Meadowlark	6	4.7
Unidentified Passerine	4	3.1
European Starling	3	2.4
Horned Lark	3	2.4
White-Crowned Sparrow	2	1.6
Dark-Eyed Junco	2	1.6
Hermit Thrush	1	0.8
Yellow-Rumped Warbler	1	0.8
Unidentified Sparrow	1	0.8
Rock Wren	1	0.8
Loggerhead Shrike ^a	1	0.8
Brewer's Blackbird	1	0.8
Chipping Sparrow	1	0.8
Other		
Unidentified Bird	20	15.7
Rock Dove	11	8.7
Mourning Dove	6	4.7
Red-Shafted Flicker	3	2.4
Chukar	2	1.6
Greater Roadrunner	2	1.6
California Quail	2	1.6
Total	127	100.0

^a located between Middle Ridge and East Slope.

Table 13. Mean Use Observed during Phase I Utilization Surveys at Tehachapi Pass Wind Resource Area, 2 October 1996 to 27 May 1998 (Calculated Based on Observations Within 200 m of Site Center: lcl = 95% Lower Confidence Limit, ucl = 95% Upper Confidence Limit; lcl Values Less Than Zero were Set to Zero)

Study Area	Season														
	Overall			Spring			Summer			Fall			Winter		
	mean	lcl	ucl	mean	lcl	ucl	mean	lcl	ucl	mean	lcl	ucl	mean	lcl	ucl
Overall															
Raptors	0.03	0.02	0.04	0.02	0.01	0.03	0.02	0.01	0.03	0.04	0.03	0.05	0.03	0.01	0.06
Corvids	0.32	0.27	0.36	0.49	0.38	0.60	0.27	0.22	0.31	0.26	0.22	0.31	0.33	0.26	0.40
Passerines	0.82	0.66	0.97	0.86	0.59	1.14	0.59	0.39	0.79	1.14	0.82	1.47	0.79	0.47	1.11
Other	0.09	0.04	0.13	0.25	0	0.58	0.06	0.04	0.08	0.10	0.05	0.16	0.05	0.01	0.09
Total	1.25	1.08	1.42	1.61	1.17	2.05	0.93	0.73	1.14	1.55	1.21	1.89	1.20	0.87	1.54
West Ridge															
Raptors	0.04	0.02	0.06	0.02	0	0.04	0.04	0.02	0.05	0.04	0.02	0.07	0.05	0.01	0.10
Corvids	0.51	0.43	0.59	0.82	0.59	1.05	0.48	0.38	0.57	0.45	0.36	0.54	0.48	0.34	0.61
Passerines	0.94	0.68	1.21	0.94	0.33	1.55	0.88	0.42	1.34	1.01	0.65	1.36	1.15	0.50	1.79
Other	0.15	0.04	0.26	0.58	0	1.45	0.07	0.03	0.11	0.11	0.03	0.19	0.07	0	0.14
Total	1.64	1.34	1.94	2.36	1.31	3.42	1.46	0.99	1.93	1.61	1.23	1.98	1.75	1.08	2.41
Middle Ridge															
Raptors	0.04	0.02	0.06	0.01	0	0.02	0.02	0.01	0.04	0.05	0.02	0.08	0.03	0	0.06
Corvids	0.25	0.18	0.31	0.24	0.10	0.38	0.17	0.11	0.22	0.22	0.15	0.29	0.23	0.14	0.33
Passerines	0.61	0.43	0.79	0.68	0.32	1.05	0.46	0.33	0.60	0.84	0.45	1.22	0.17	0.04	0.31
Other	0.05	0.02	0.08	0.03	0	0.06	0.07	0.03	0.10	0.14	0.02	0.26	0.01	0	0.02
Total	0.95	0.75	1.15	0.95	0.55	1.35	0.72	0.57	0.87	1.25	0.80	1.70	0.44	0.28	0.60
East Slope															
Raptors	0.01	0.00	0.02	0.02	0	0.04	0.00	0	0.01	0.02	0.00	0.04	0		
Corvids	0.11	0.07	0.14	0.31	0.18	0.45	0.06	0.03	0.09	0.04	0.02	0.07	0.16	0.07	0.25
Passerines	0.92	0.50	1.33	0.95	0.69	1.22	0.27	0.18	0.37	1.65	0.73	2.57	0.86	0.45	1.26
Other	0.04	0.01	0.08	0.03	0.00	0.06	0.02	0.00	0.03	0.06	0.01	0.11	0.07	0	0.17
Total	1.08	0.67	1.49	1.32	1.02	1.62	0.35	0.26	0.45	1.77	0.85	2.69	1.09	0.66	1.52

Table 14. Mean Fatality Observed during Phase I Utilization Surveys at Tehachapi Pass Wind Resource Area, 2 October 1996 to 27 May 1998 (Calculated Based on Fatalities Found during Scheduled Carcass Searches: lcl = 95% Lower Confidence Limit; ucl = 95% Upper Confidence Limit; lcl Values Less Than Zero were Set to Zero)

Study Area/Group	mean	lcl	ucl
Overall			
Raptors	0.027	0.016	0.038
Corvids	0.008	0	0.018
Passerines	0.017	0.008	0.026
Other	0.034	0.019	0.050
Total	0.086	0.061	0.111
West Ridge			
Raptors	0.056	0.031	0.080
Corvids	0.008	0	0.016
Passerines	0.025	0.001	0.041
Other	0.057	0.029	0.085
Total	0.145	0.099	0.192
Middle Ridge			
Raptors	0.006	0	0.015
Corvids	0.014	0	0.040
Passerines	0.009	0	0.024
Other	0.024	0	0.053
Total	0.053	0.012	0.095
East Slope			
Raptors	0.012	0	0.026
Corvids	0		
Passerines	0.016	<0.001	0.032
Other	0.012	0	0.026
Total	0.041	0.015	0.067

Table 15. Mean Risk Observed During Phase I Utilization Surveys at Tehachapi Pass Wind Resource Area, 2 October 1996 to 27 May 1998 (calculated based on observations of use within 200 m of site center and fatalities found during scheduled carcass searches: lcl = 95% Lower Confidence Limit; ucl = 95% Upper Confidence Limit; lcl Values Less than Zero were Set to Zero)

Study Area	mean	lcl	ucl
Overall			
Raptors	0.836	0.395	1.277
Corvids	0.025	0	0.058
Passerines	0.021	0.009	0.033
Other	0.406	0.125	0.686
Total	0.070	0.047	0.092
West Ridge			
Raptors	1.421	0.547	2.294
Corvids	0.015	0	0.032
Passerines	0.026	0.008	0.044
Other	0.403	0.046	0.761
Total	0.090	0.058	0.123
Middle Ridge			
Raptors	0.156	0	0.390
Corvids	0.055	0	0.163
Passerines	0.015	0	0.039
Other	0.487	0	1.137
Total	0.056	0.012	0.101
East Slope			
Raptors	1.187	0	2.800
Corvids	0	0	0.036
Passerines	0.018	0	0.036
Other	0.279	0	0.651
Total	0.038	0.010	0.065

Table 16. Results of the Searcher Efficiency Trials at Tehachapi by Size of Carcass and Vegetation Type

Size of Carcass/ Part	Vegetation Type	Estimated Probability of Detection	Std. Error	N- trials	N Carcasses/ Parts	95% C.I. LL	95% C.I. UL
STUDY 1 (August 1996)							
Small	Small shrubs	0.75	0.078	12	36	0.59	0.91
Small	Grass	0.72	0.079	12	32	0.56	0.88
Large	Small shrubs	0.82	0.058	12	44	0.70	0.93
Large	Grass	0.70	0.052	12	64	0.60	0.81
STUDY 2 (April 1997)							
Small	Small shrubs	0.59	0.071	12	44	0.47	0.71
Small	Grass	0.56	0.054	24	87	0.46	0.67
Large	Small shrubs	0.86	0.055	12	36	0.77	0.95
Large	Grass	0.92	0.033	12	64	0.86	0.99
Overall							
Small	Small shrubs	0.66	0.055	24	80	0.57	0.75
Small	Grass	0.60	0.044	36	119	0.53	0.68
Large	Small shrubs	0.84	0.040	24	80	0.77	0.90
Large	Grass	0.81	0.040	36	128	0.75	0.88
Overall		0.73	0.022	60	407	0.68	0.77

Table 17. Results of the Scavenging Trials at Tehachapi Pass by Size of Carcass and Vegetation Type

Comparisons	N	Proportion Carcasses Removed by Day 8	Removal Time (days)		95% Confidence Intervals	
			Mean	Se	LL	UL
Proximity to turbines						
Near turbines	170	0.95	2.890	0.20	2.49	3.29
>400 m from turbines	145	0.97	2.307	0.17	1.96	2.65
Geographic Area						
Zond (West Ridge)	115	0.95	2.172	0.19	1.79	2.55
Cannon/Flowind (Middle Ridge)	91	0.98	2.701	0.25	2.20	3.20
SeaWest (East Ridge)	109	0.96	3.030	0.25	2.52	3.54
Season/Experiment						
Aug-96	114	0.96	2.195	0.19	1.81	2.58
Dec-96	108	0.94	3.134	0.26	2.61	3.66
Apr-97	93	0.98	2.548	0.23	2.09	3.01
Size						
Small	161	0.94	3.101	0.21	2.68	3.53
Large	154	0.99	2.120	0.15	1.81	2.43
Color						
Non-cryptic	210	0.97	2.446	0.16	2.13	2.76
Cryptic	105	0.95	2.971	0.25	2.47	3.48
Overall	315	0.96	2.621	0.13	2.35	2.89

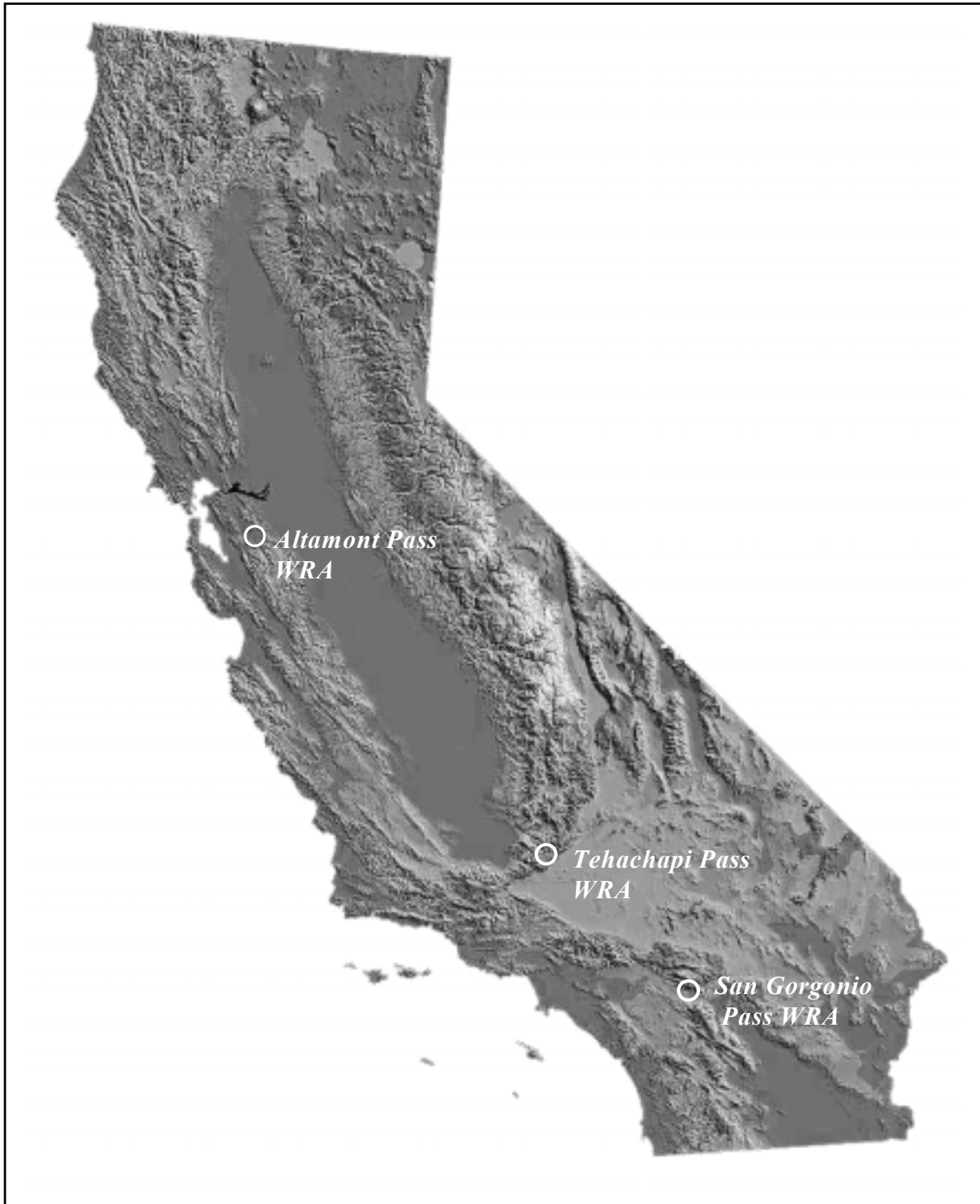


Figure 1. Major developed wind resources areas (WRA) of California

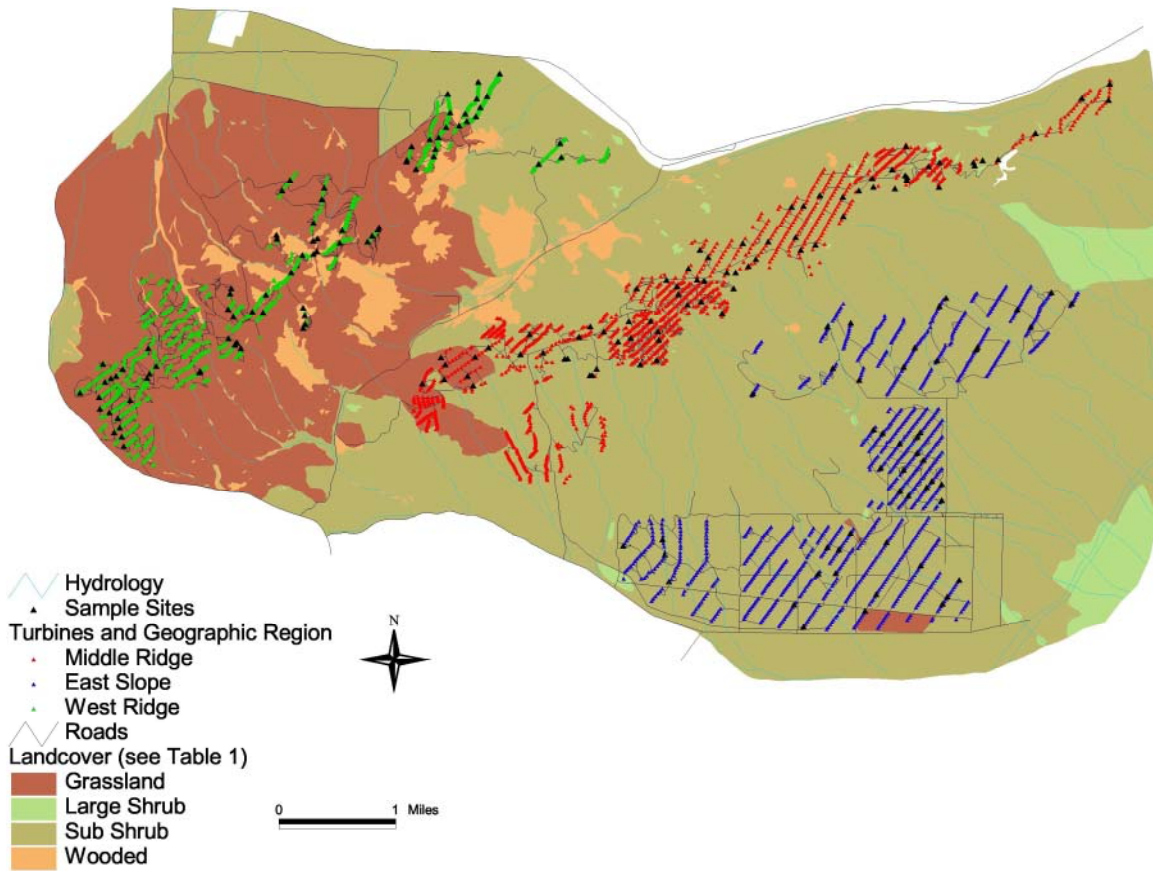


Figure 2. Location of geographic regions and sample site locations at Tehachapi

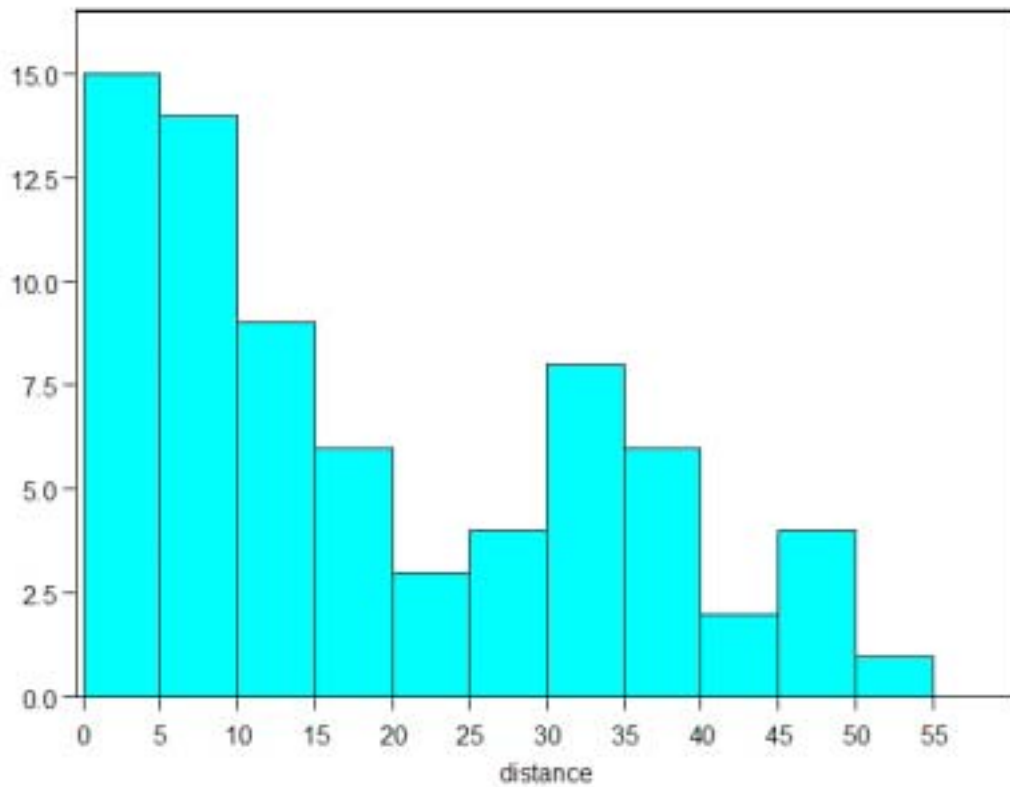


Figure 3. Horizontal distribution of dead birds surrounding the closest turbine observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, calculated without regard to other structures and whether the turbine is the closest structure

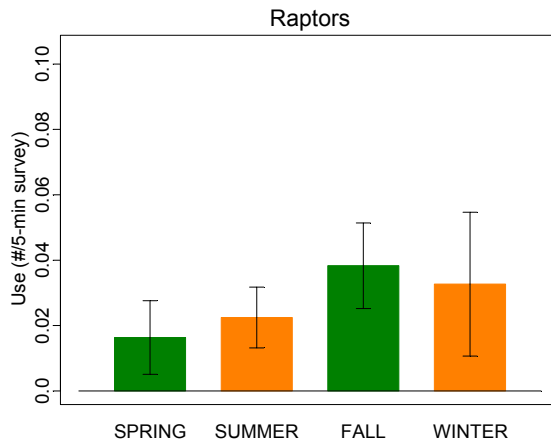


Figure 4. Raptor mean use by season observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

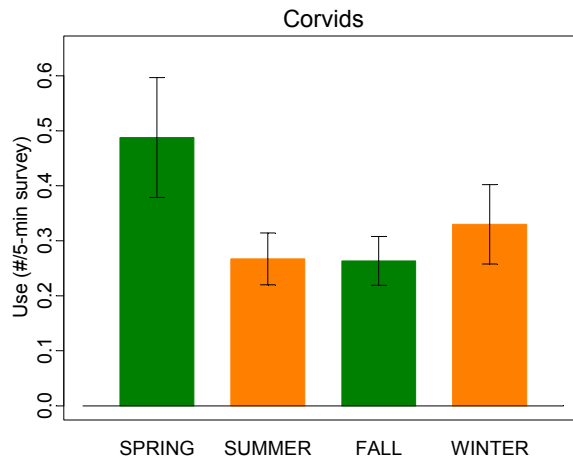


Figure 5. Corvid mean use by season observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

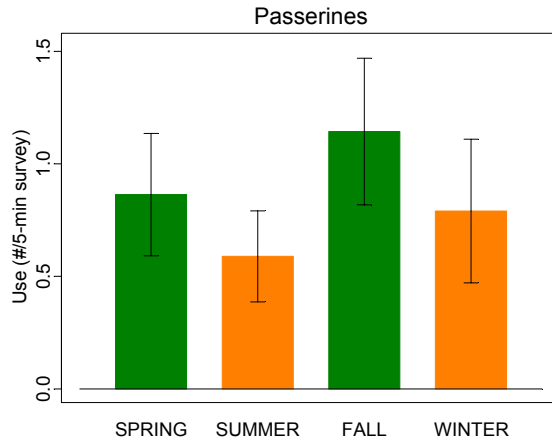


Figure 6. Passerine mean use by season observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

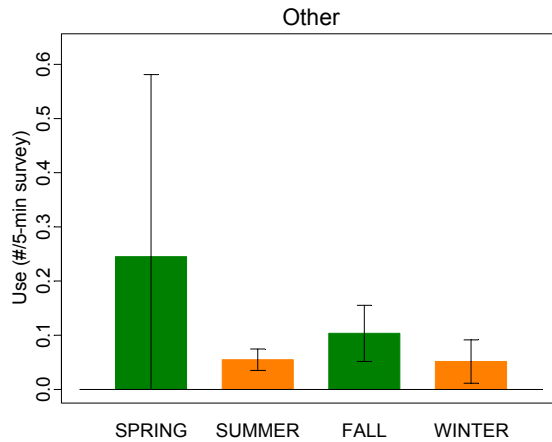


Figure 7. Other bird mean use by season observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

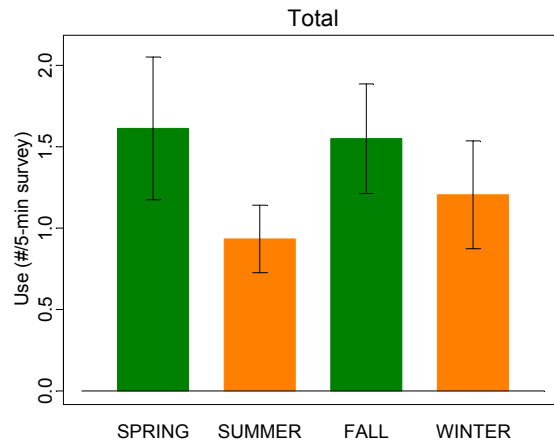


Figure 8. Total bird mean use by season observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

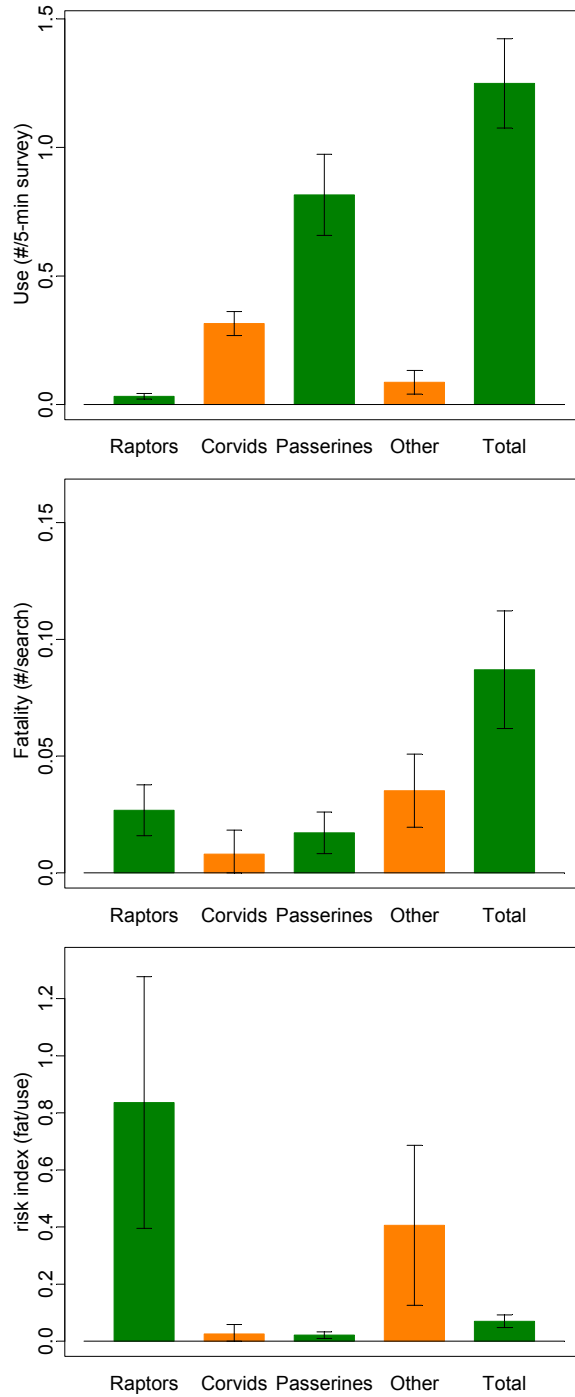


Figure 9. Mean use, fatality rate, and the risk indices by taxonomic group observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

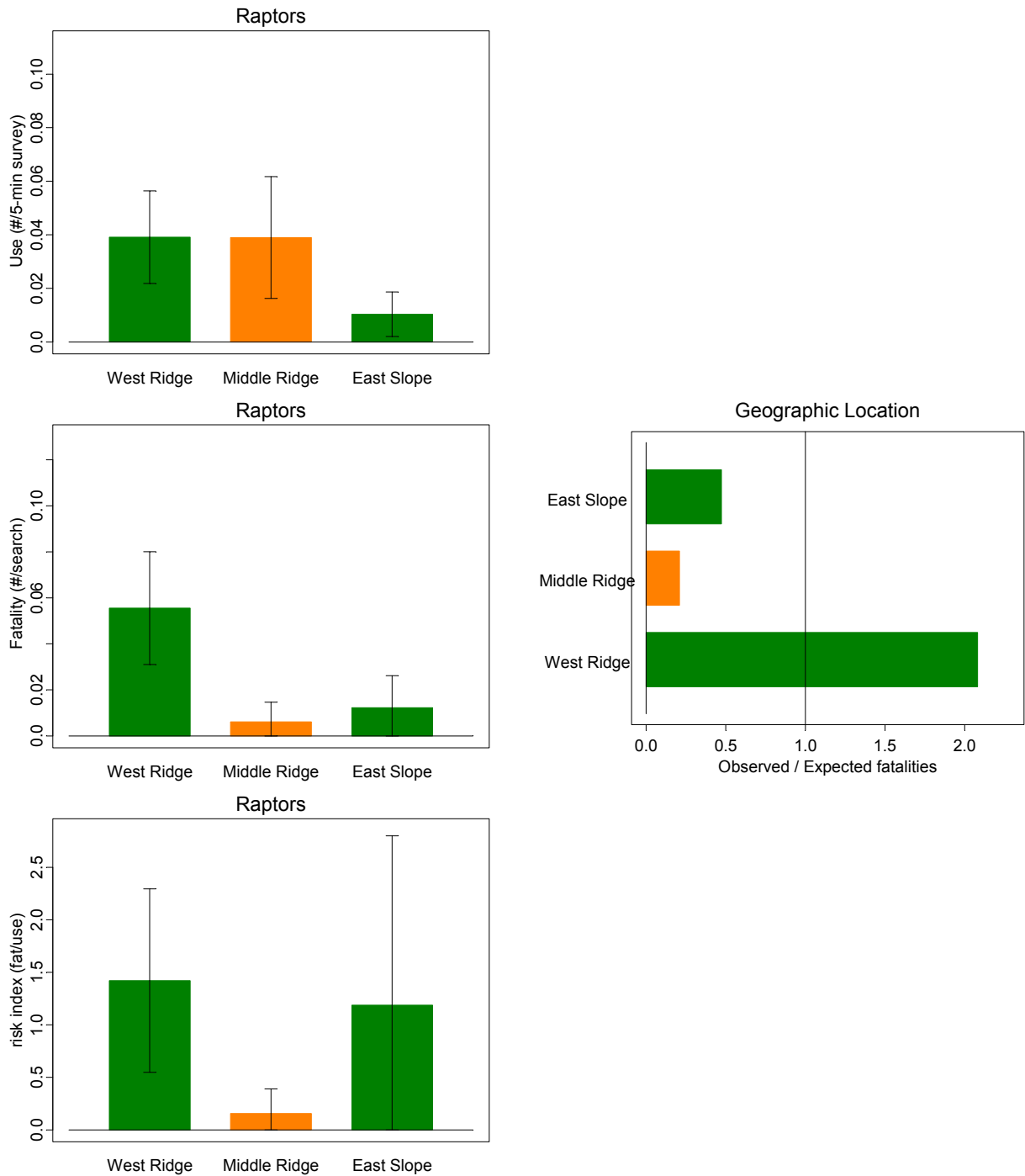


Figure 10. Raptor mean use, fatality rate, observed/expected fatalities, and the risk indices by geographic location observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

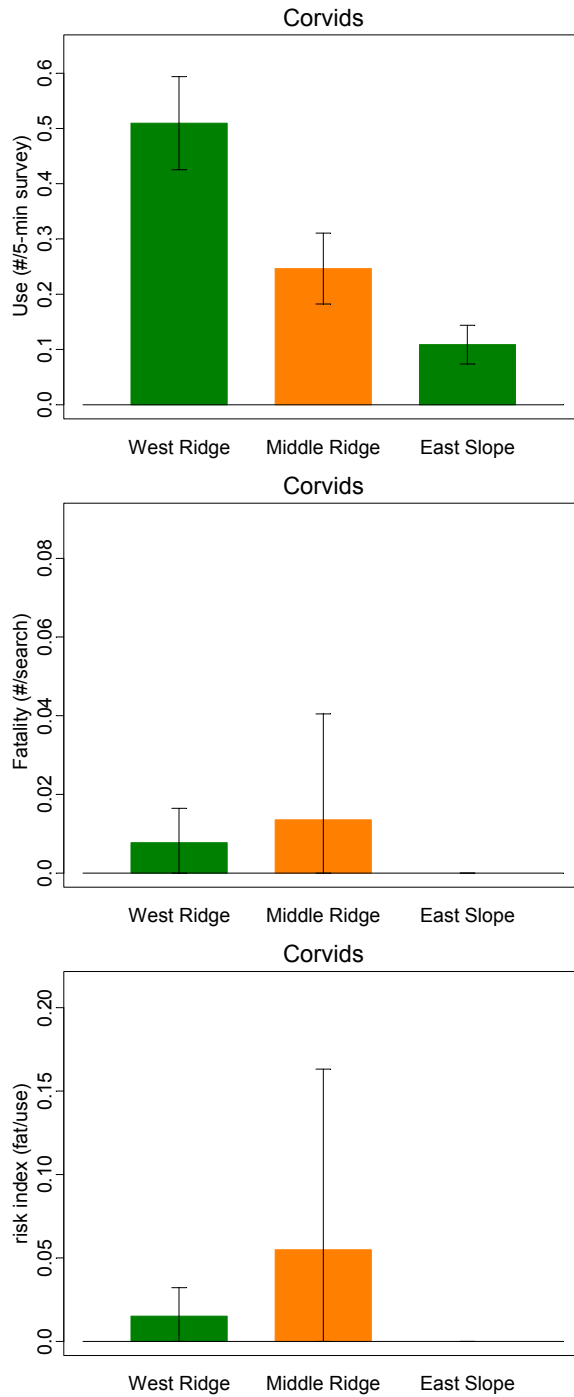


Figure 11. Corvid mean use, fatality rate, and the risk indices by geographic location observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

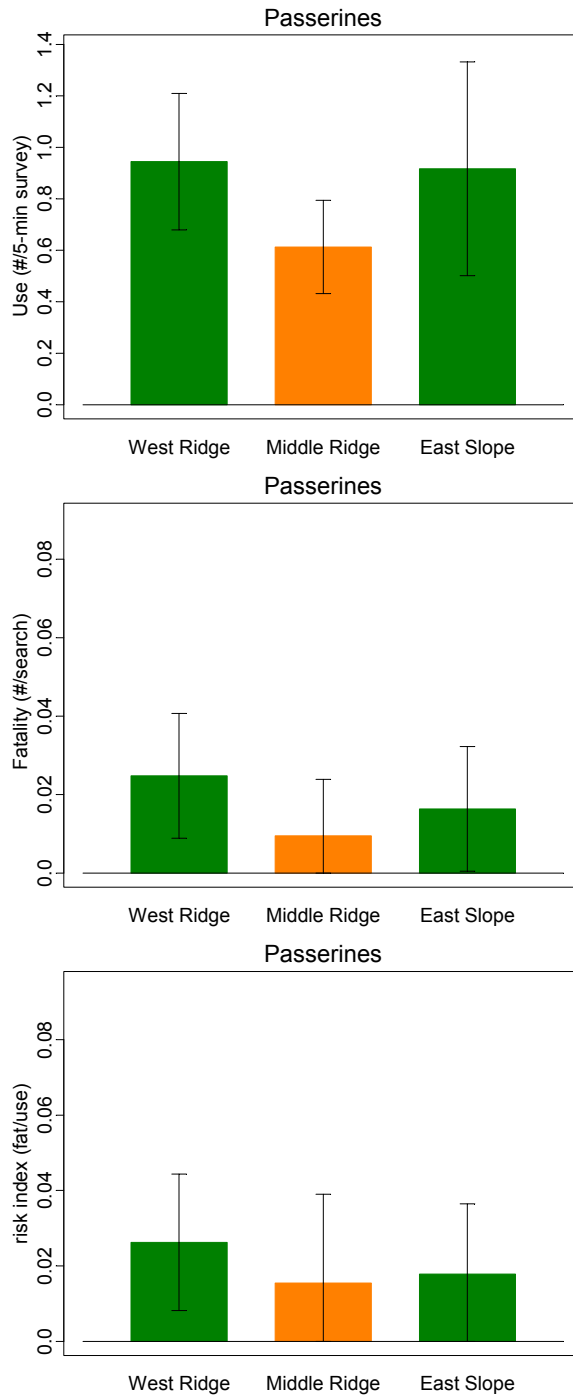


Figure 12. Passerine mean use, fatality rate, and the risk indices by geographic location observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

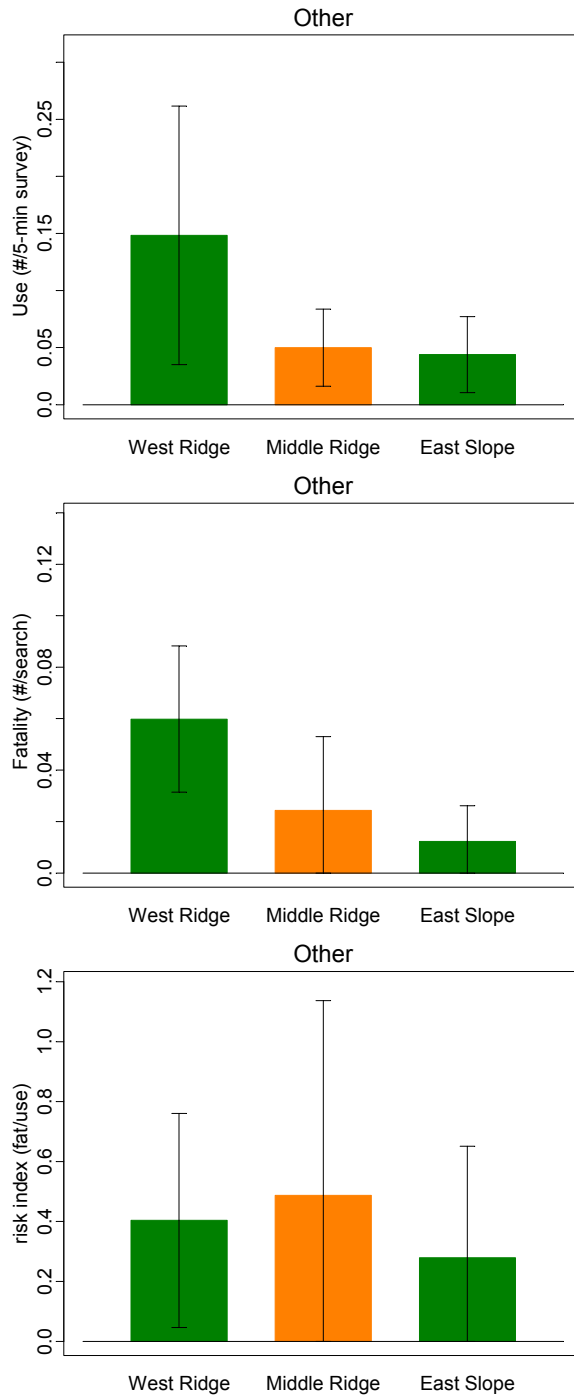


Figure 13. Other bird mean use, fatality rate, and the risk indices by geographic location observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

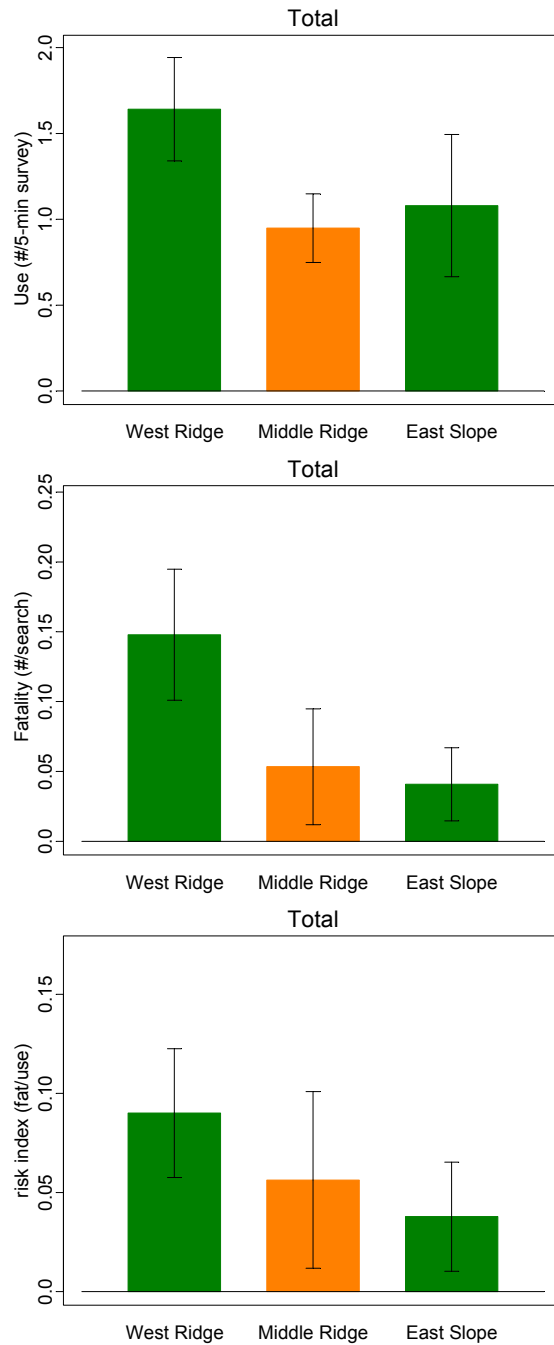


Figure 14. Total bird mean use, fatality rate, and the risk indices by geographic location observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

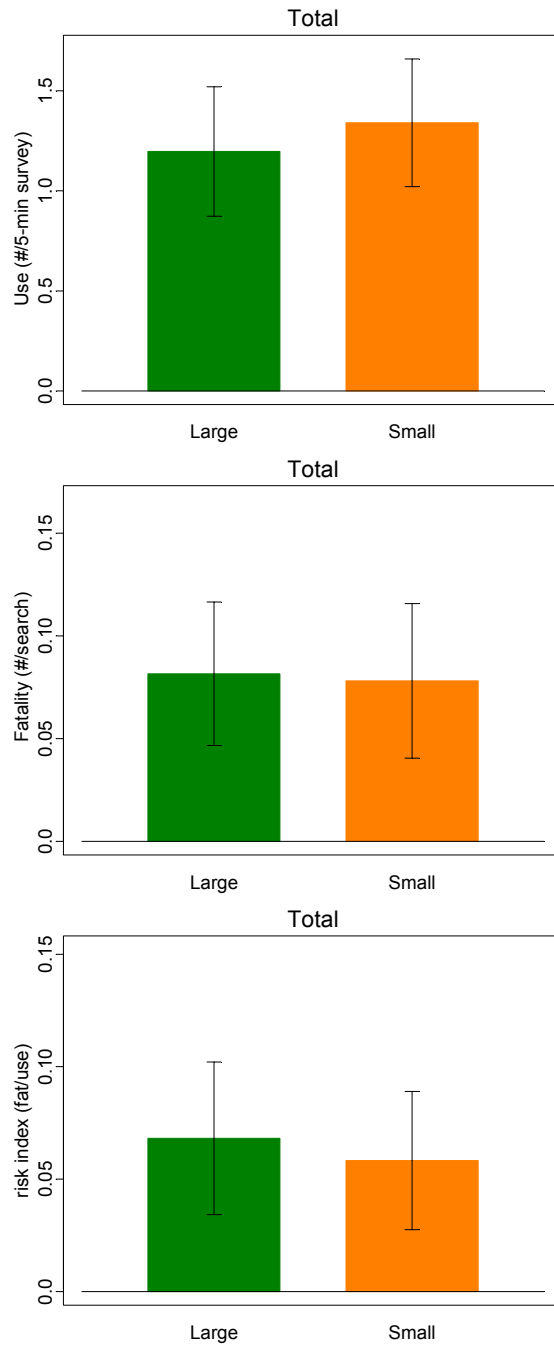


Figure 15. Total bird mean use, fatality rate, and the risk indices by size of turbine (large and small) observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

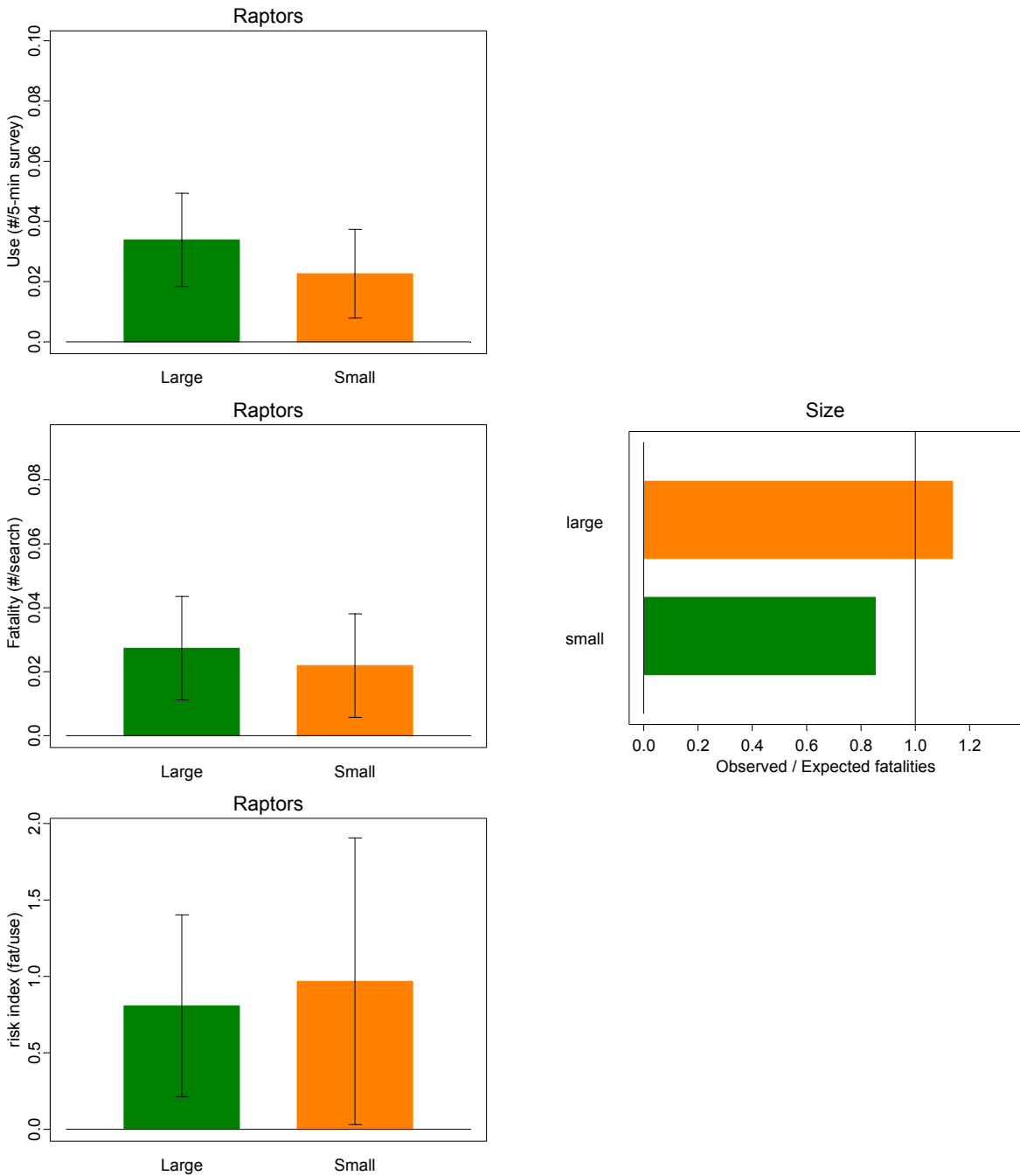


Figure 16. Raptor mean use, fatality rate, observed/expected fatalities, and the risk indices by size of turbine (large and small) observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

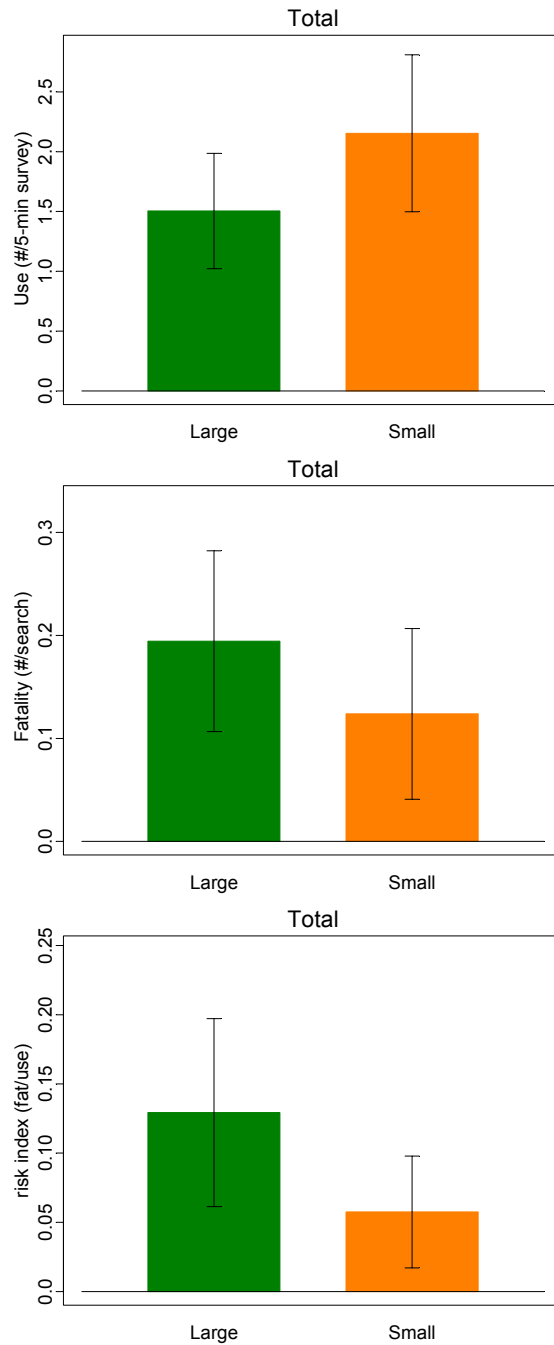


Figure 17. Total bird mean use, fatality rate, and the risk indices by size of turbine (large and small) observed within the West Ridge during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

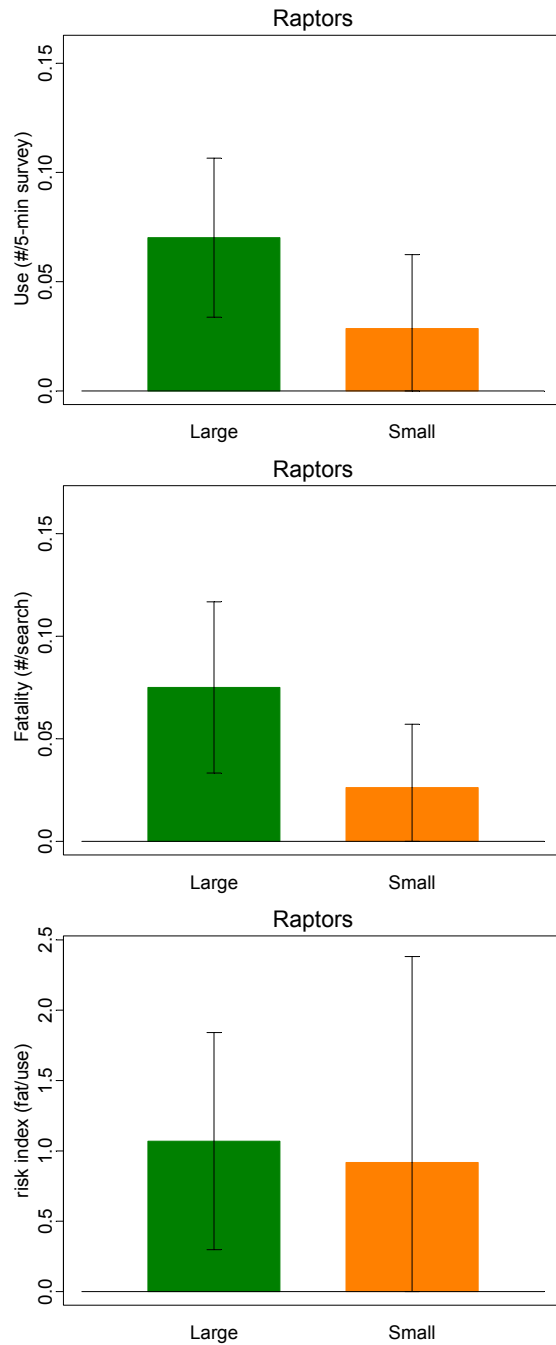


Figure 18. Raptor mean use, fatality rate, observed/expected fatalities, and the risk indices by size of turbine (large and small) observed within the West Ridge during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

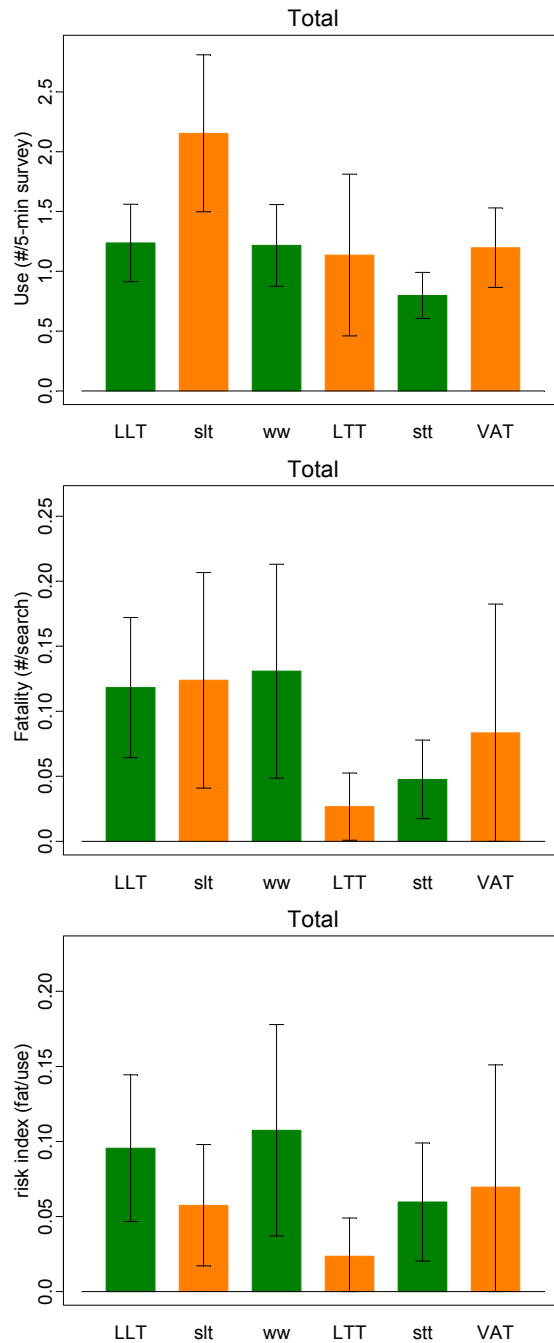


Figure 19. Total bird mean use, fatality rate, and the risk indices by turbine type observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

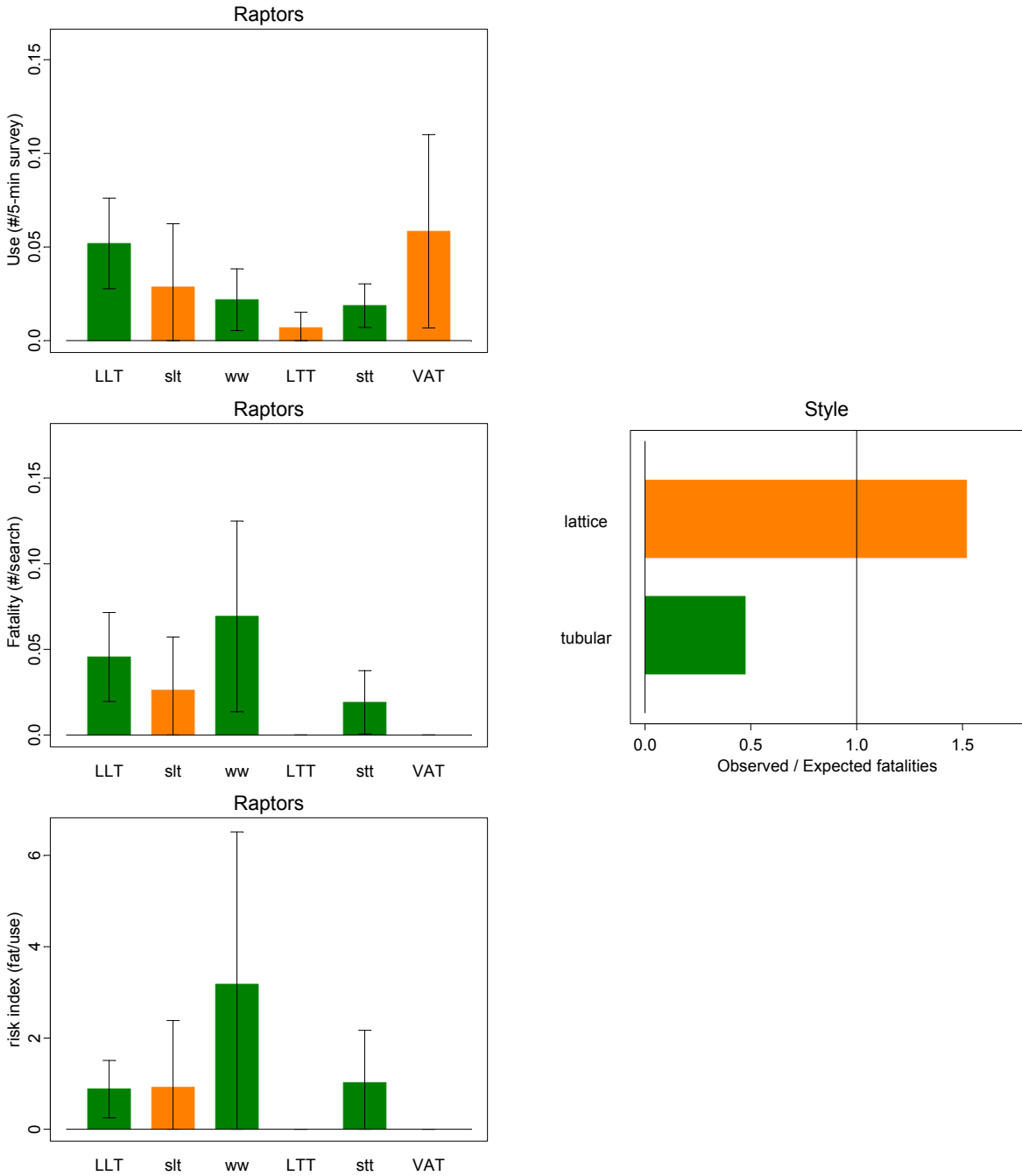


Figure 20. Raptor mean use, fatality rate, observed/expected fatalities, and the risk indices by turbine type observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

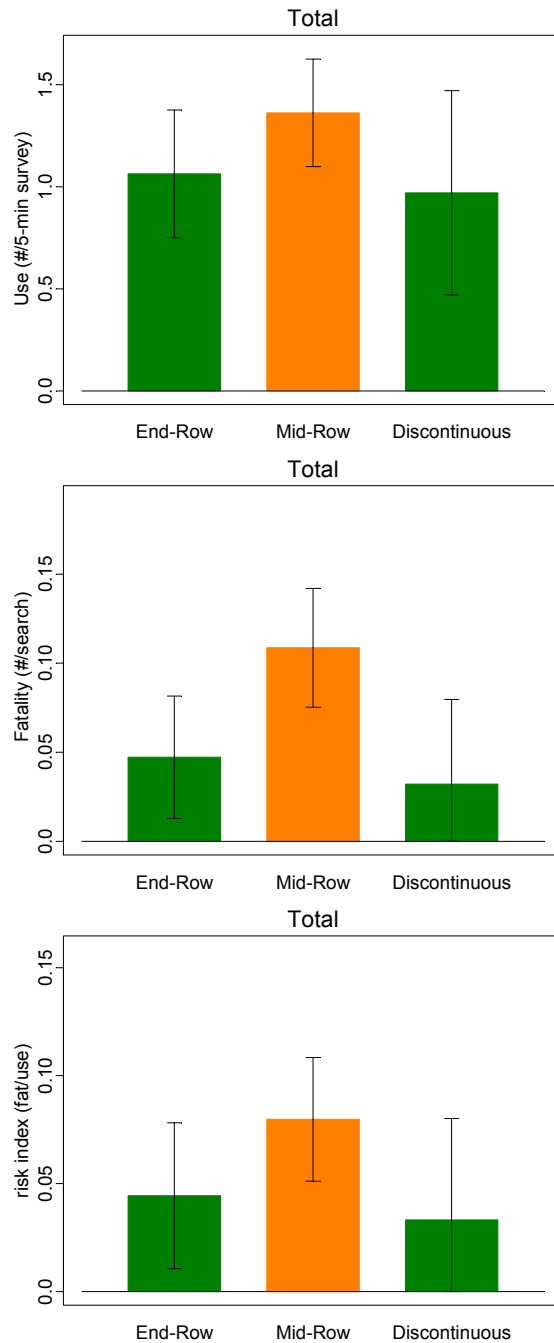


Figure 21. Total bird mean use, fatality rate, and the risk indices by row location observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

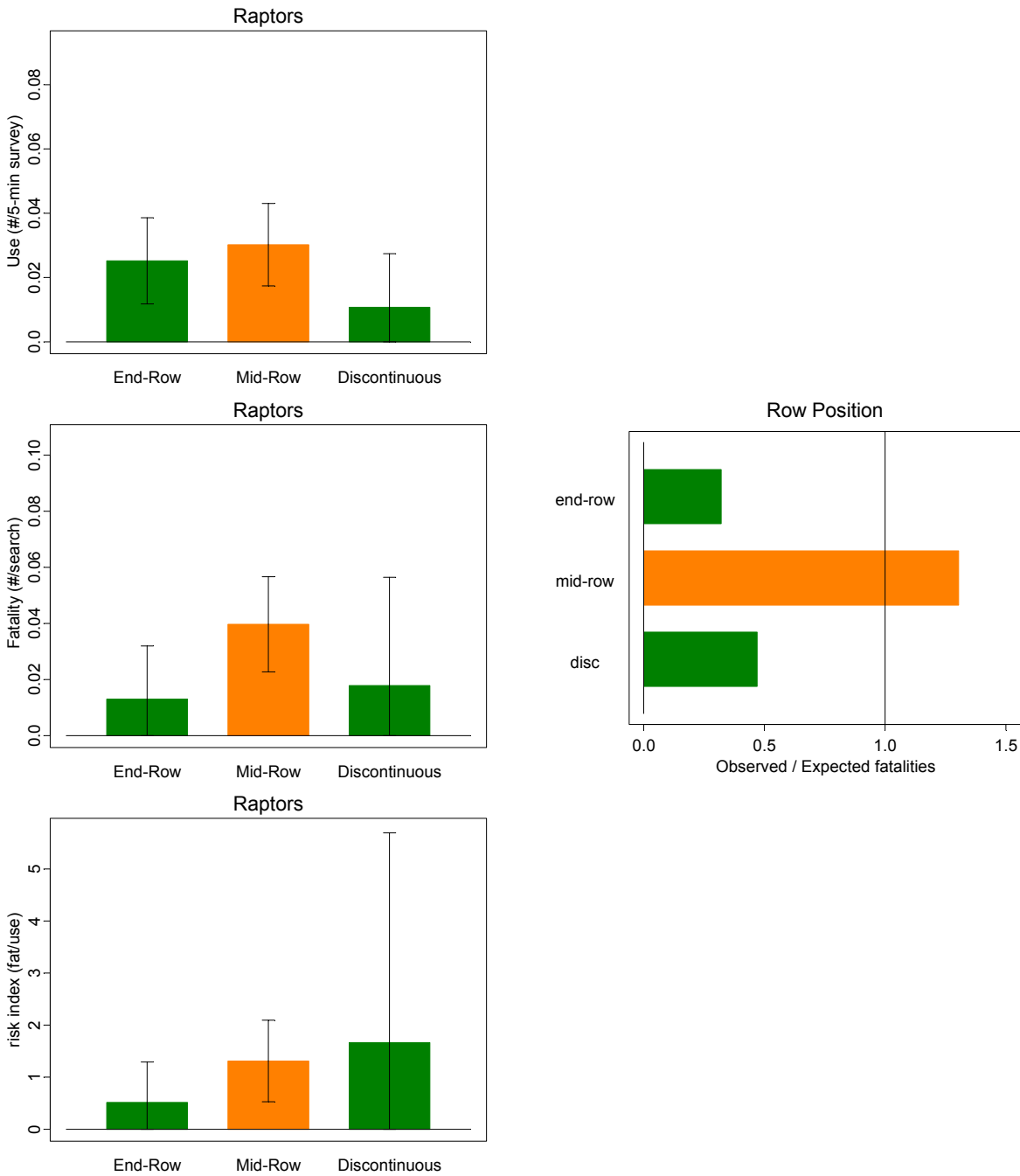


Figure 22. Raptor mean use, fatality rate, observed/expected fatalities, and the risk indices by row location observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

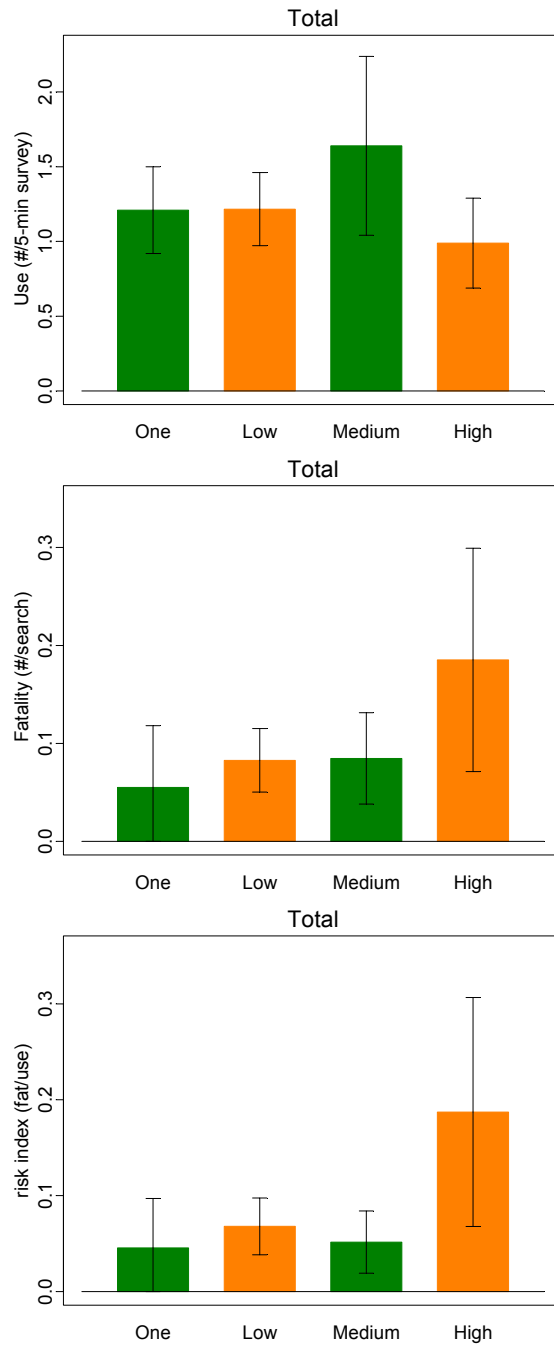


Figure 23. Total bird mean use, fatality rate, and the risk indices by turbine density observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

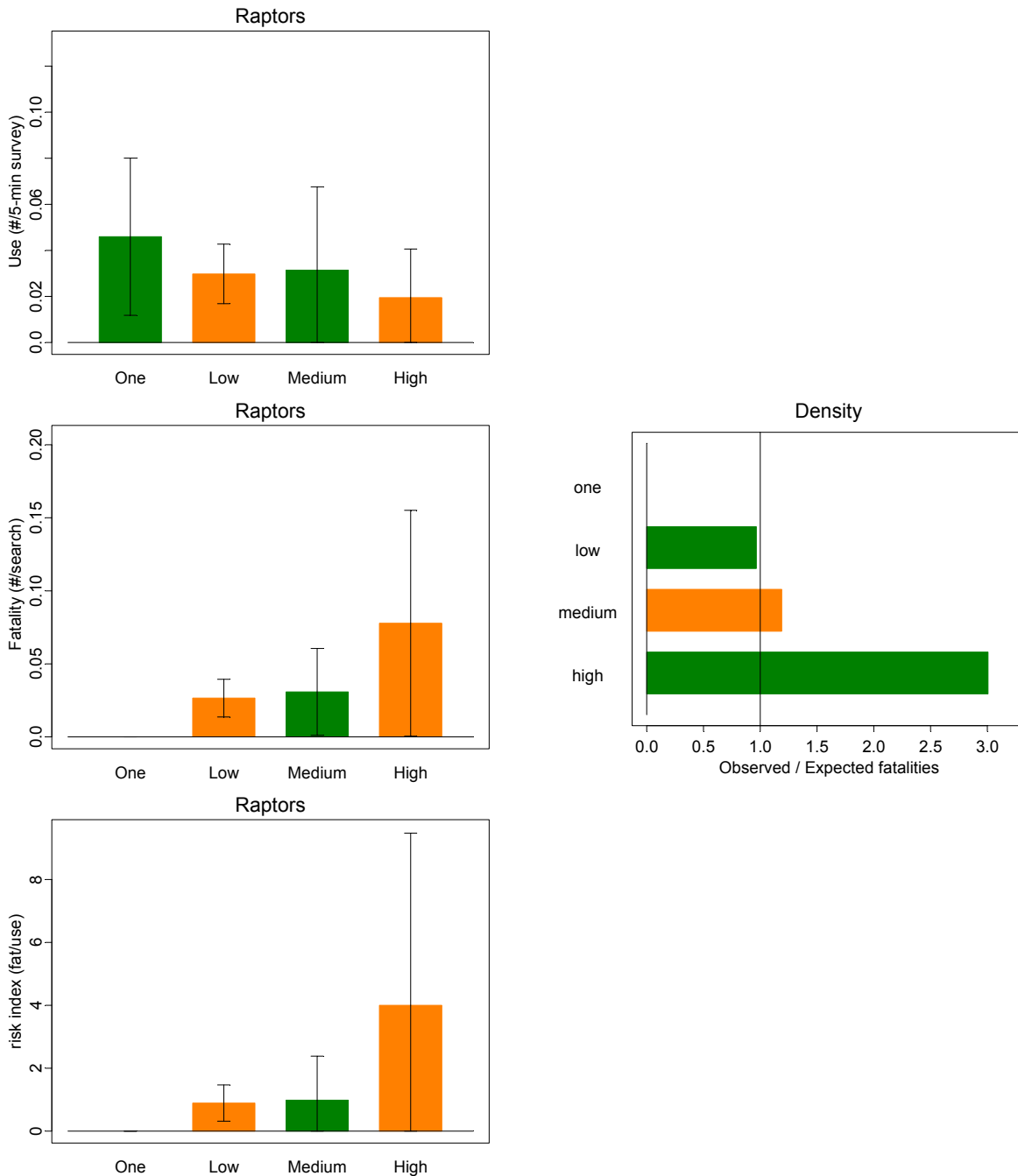


Figure 24. Raptor mean use, fatality rate, observed/expected fatalities, and the risk indices by turbine density observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

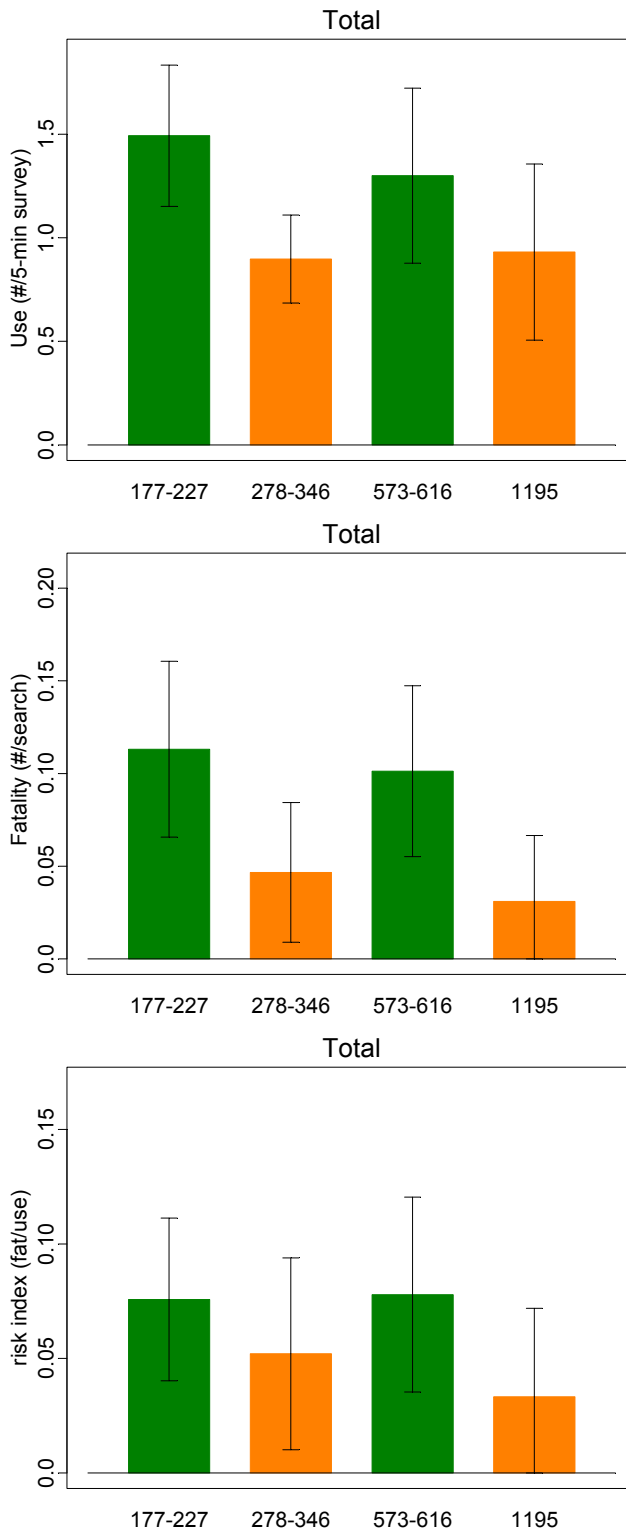


Figure 25. Total birds mean use, fatality rate, and the risk indices by rotor swept area of turbine observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

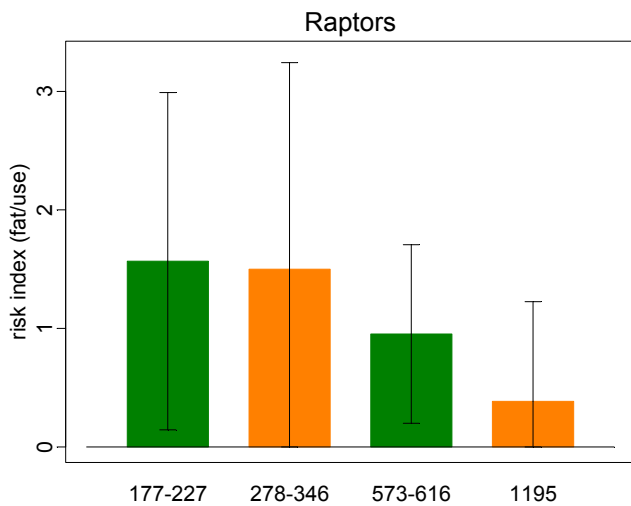
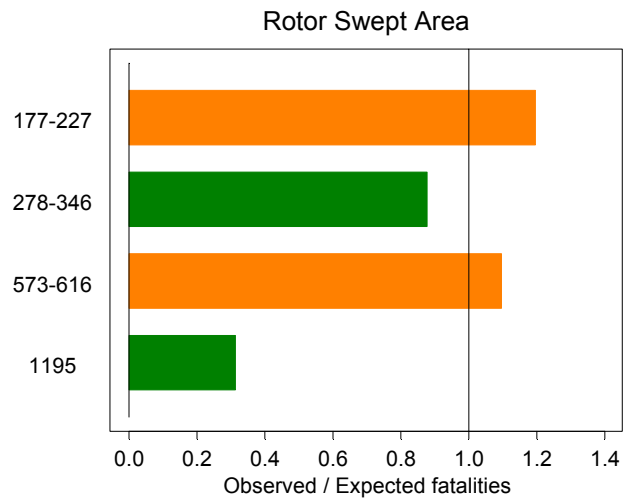
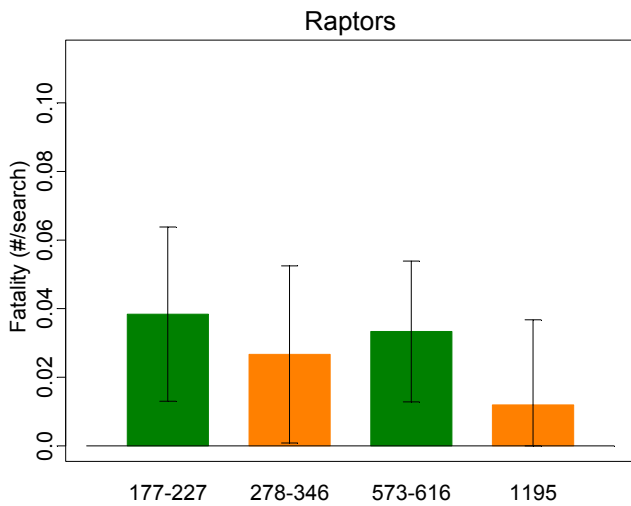
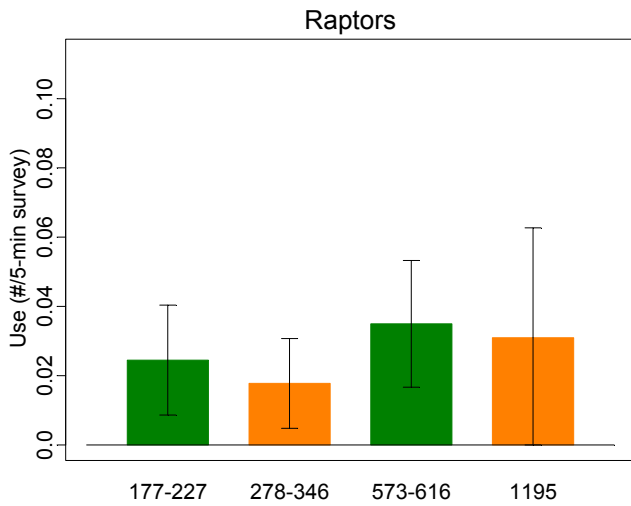


Figure 26. Raptor mean use, fatality rate, observed/expected fatalities, and the risk indices by rotor swept area of turbine observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

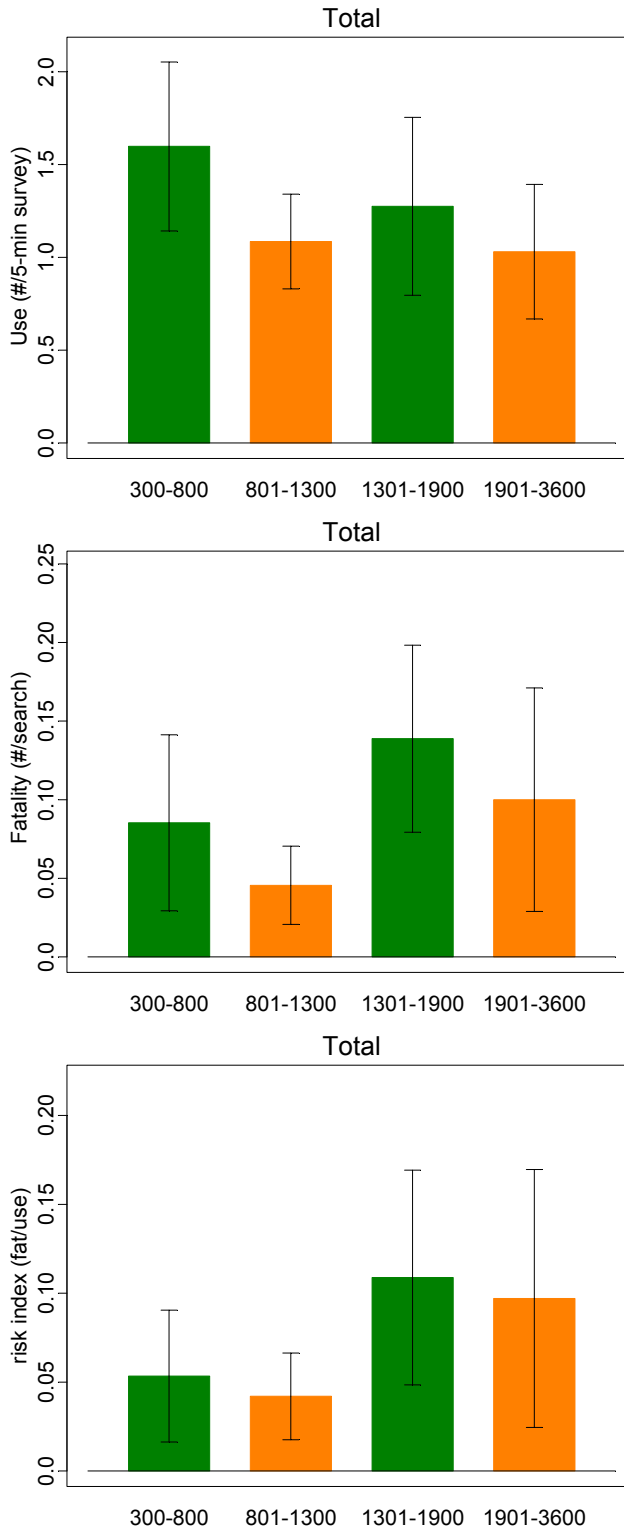


Figure 27. Total birds mean use, fatality rate, and the risk indices by total rotor swept area of search plot observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

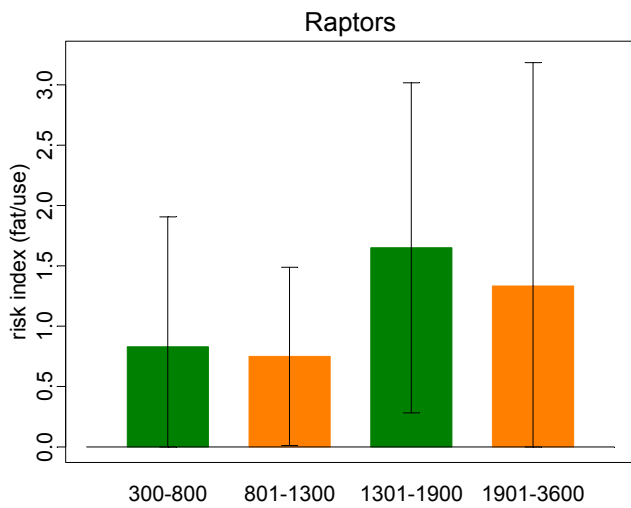
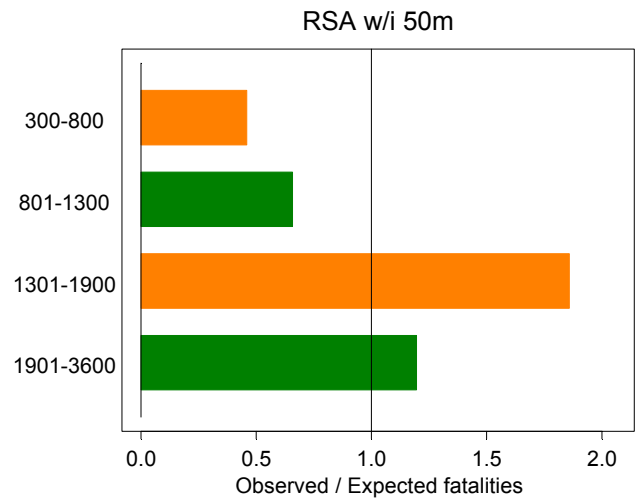
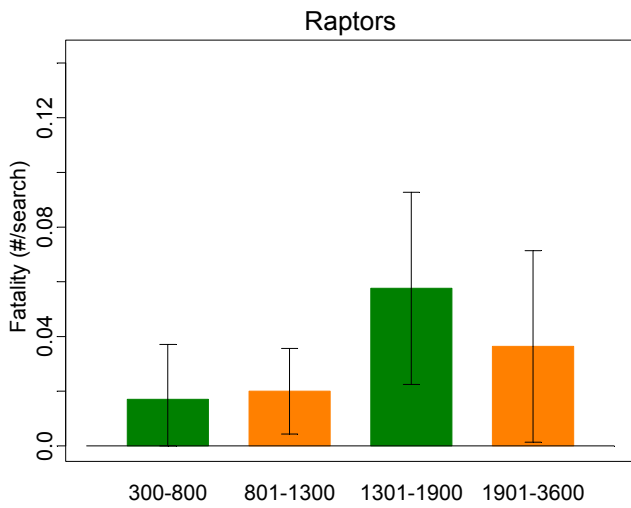
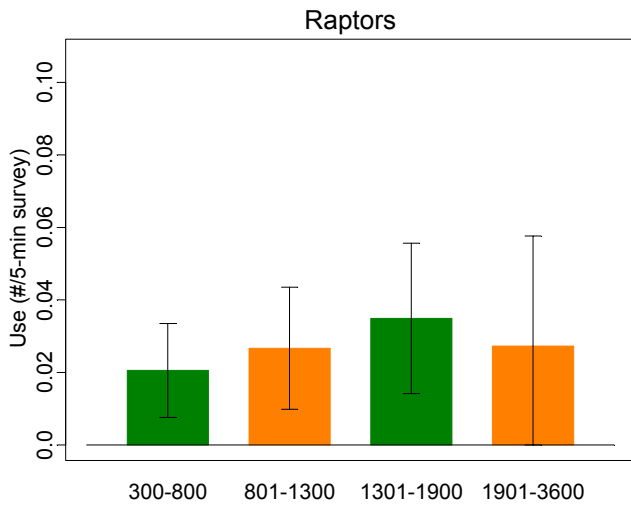


Figure 28. Raptor mean use, fatality rate, observed/expected fatalities, and the risk indices by total rotor swept area of search plot observed during Phase I studies at Tehachapi Pass, Wind Resource Area, 2 October 1996 to 27 May 1998, mean use calculated based on observations within 200 m of site center

Appendix

Appendix A. List of Birds Observed During This Study at Tehachapi Pass Wind Resource Area, 2 October 1996 to 27 May 1998

Taxonomic Group	Common Name	Scientific Name
<i>Raptors</i>		
	Northern Harrier	<i>Circus cyaneus</i>
	Sharp-shinned Hawk	<i>Accipiter striatus</i>
	Red-tailed Hawk	<i>Buteo jamaicensis</i>
	Ferruginous Hawk	<i>Buteo regalis</i>
	Golden Eagle	<i>Aquila chrysaetos</i>
	Prairie Falcon	<i>Falco mexicanus</i>
	American Kestrel	<i>Falco sparverius</i>
<i>Corvids</i>		
	Scrub Jay	<i>Aphelocoma californica</i>
	Common Raven	<i>Corvus corax</i>
<i>Passerines</i>		
	Western Kingbird	<i>Tyrannus verticalis</i>
	Horned Lark	<i>Eremophila alpestris</i>
	European Starling	<i>Sturnus vulgaris</i>
	Western Meadowlark	<i>Sturnella neglecta</i>
	Brewer's Blackbird	<i>Euphagus cyanocephalus</i>
	House Finch	<i>Carpodacus mexicanus</i>
	Lark Sparrow	<i>Chondestes grammacus</i>
	White-Crowned Sparrow	<i>Zonotrichia leucophrys</i>
	Dark-Eyed Junco	<i>Junco hyemalis</i>
	Black-Throated Sparrow	<i>Amphispiza bilineata</i>
	Sage Sparrow	<i>Amphispiza belli</i>
	Rufous-Crowned Sparrow	<i>Aimophila ruficeps</i>
	California Towhee	<i>Pipilo crissalis</i>
	Cliff Swallow	<i>Petrochelidon pyrrhonota</i>
	Loggerhead Shrike	<i>Lanius ludovicianus</i>
	Yellow-Rumped Warbler	<i>Dendroica coronata</i>
	Yellow-Breasted Chat	<i>Icteria virens</i>
	Northern Mockingbird	<i>Mimus polyglottos</i>
	Cactus Wren	<i>Campylorhynchus brunneicapillus</i>
	Rock Wren	<i>Salpinctes obsoletus</i>
	Bewick's Wren	<i>Thryomanes bewickii</i>
	Plain Titmouse	<i>Baeolophus inornatus</i>
	American Robin	<i>Turdus migratorius</i>
	Western Bluebird	<i>Sialia mexicana</i>
	Unidentified Hummingbird	
	Unidentified Swift	

Appendix A (continued)

Taxonomic Group	Common Name	Scientific Name
<i>Other</i>		
	Unidentified Duck	
	Band-Tailed Pigeon	<i>Columba fasciata</i>
	Rock Dove	<i>Columba livia</i>
	Mourning Dove	<i>Zenaida macroura</i>
	California Quail	<i>Callipepla californica</i>
	Chukar	<i>Alectoris chukar</i>
	Turkey Vulture	<i>Cathartes aura</i>
	Greater Roadrunner	<i>Geococcyx californianus</i>
	Downy Woodpecker	<i>Picoides pubescens</i>
	Ladder-Backed Woodpecker	<i>Picoides scalaris</i>
	Nuttall's Woodpecker	<i>Picoides nuttallii</i>
	Red-Shafted Flicker	<i>Colaptes auratus</i>

Appendix B. Fatalities found during carcass searches at Tehachapi Pass Wind Resource Area, 2 October 1996 to 27 May 1998.
LLT = large lattice turbine; LTT = large tubular turbine; slt = small lattice turbine; stt = small tubular turbine; VAT = two-blade vertical axis turbine; ww = small windwall turbine

Species	Geographic Location	Site ^a	Date	Condition	Distance from closest turbine (m)	Closest Structure	Comments
Unidentified Passerine	East Slope	S02	10/2/96	Feather spot	29	LTT	Many grey/brown fthrs. Approx 5 brown/grey flight fthrs w/ thin white fringe.
Red-Tailed Hawk	West Ridge		10/4/96	Dismembered	11	ww	Strong odor. flies on body. upper body gone. fthrs, bone, & dry flesh remain.
Common Barn Owl	East Slope	S04	10/7/96	Feather spot	23	stt	Feathers scattered over area 23 m @ 334 deg. from E13.
Unidentified Passerine	West Ridge	Z03	10/8/96	Feather spot	19	slt	Estimated time since death. (>100 body feathers & >15 flight feathers).
Rock Dove	West Ridge	Z03	10/8/96	Feather spot	9	slt	12 Feather dispersed along top (1.5 m high) of dirt rd side brim; along 3-m area.
Chukar	Middle Ridge	C03	10/8/96	Feather spot	15	stt	Numerous feathers found scattered over approx. a 15-m ² area..
Red-Tailed Hawk	West Ridge		10/14/96	Feather spot	13	LLT	Found 14 m from 32-4 between in & 32-3. Coll. 2 blood and many body feathers.
Rock Wren	West Ridge	Z18	10/29/96	Feather spot	10	ww	Found 15 remiges and 10 downy feathers in a shrub while looking for fat. #8.
American Kestrel	West Ridge	Z18	10/29/96	Feather spot	12	ww	Found 10 tail feathers and several body feathers on ledge east of 4-36 & 4-37.
Great Horned Owl	West Ridge	Z18	10/29/96	Feather spot and/or bones	0	ww	Found many wing & body feathers around the bases of 4-35, 4-36, & 4-37.
Red-Tailed Hawk	West Ridge	Z48	11/1/96	Feather spot	5	LLT	Feathers w/in 50 m radius of perm. Study site Z48 as was found on 2/11/97 & 8/28/97.
Common Raven	Middle Ridge	C22	11/4/96	Feather spot	46	distribution line	Feather spot (approx. >25 flight feathers), area about 3 m x 4 m.
Great Horned Owl	Middle Ridge	C21	11/4/96	Feather spot and/or bones	50	stt	Feather spot approx. 1 m ² (approx. 30 flight feathers & 1 bone fragment). 50 m @ 256 deg. from 9-20B.

Species	Geographic Location	Site ^a	Date	Condition	Distance from closest turbine (m)	Closest Structure	Comments
Unidentified Bird	West Ridge	Z22	11/6/96	Feather spot and/or bones	11	ww	Just bones. Old, partially buried. Vertebrae, leg, wing, pelvis.
Red-Shafted Flicker	West Ridge	Z22	11/6/96	Feather spot	20	ww	Many feathers.
Red-Tailed Hawk	East Slope	S03	11/14/96	Dismembered	11	LTT	Fresh kill a day or 2 at most. Head & lft wing sheared off.
White-Crowned Sparrow	Middle Ridge		11/15/96	Intact	35	other human-made structure	Cannon maint. office. Body fresh & somewhat warm. Possibly slammed into building.
Dark-Eyed Junco	Middle Ridge	C16	12/2/96	Intact	49	distribution line	Carcass shows no signs of trauma, but numerous small feathers on buckwheat found.
Horned Lark	East Slope		12/14/96	Intact	10	stt	Fnd 10 m from turb. base road; not hit by car. Most likely turbine kill - head crushed.
Common Barn Owl	Middle Ridge	C35	12/16/96	Feather spot	30	LTT	Fthrs very weathered. Poss scavenged coyote scat near fthrs apprx 10 flgt fth
European Starling	Middle Ridge	C21	1/21/97	Dismembered	1	stt	Fresh kill, likely w/in 24hrs. Decapitated near base of neck.
Western Meadowlark	Middle Ridge	C39	1/23/97	Feather spot	14	stt	Fthr spot of aprox. 1 m ² area; >30 ft. fthrs, >100 body fthrs.
Unidentified Bird	West Ridge	Z42	1/29/97	Feather spot and/or bones	1	LLT	45 m from study center 22-7 LLT. One femur and 2 tibiotarsus.
Unidentified Bird	West Ridge	Z50	2/5/97	Intact	5	slt	Flight fthrs and partial skeleton (see data sheet). Fthrs weathered. 12-31-97.
Red-Tailed Hawk	West Ridge	Z52	2/21/97	Feather spot	40	ww	Found some feathers within and some outside the search site.
Great Horned Owl	West Ridge	Z60	2/24/97	Feather spot	2	ww	Cursory search. One fthr collected for species verification. Numerous widely scattered fthrs.
Red-Tailed Hawk	West Ridge	Z01	3/5/97	Intact	3	LLT	Numerous bones incl. complete rt. wing w/ flgt fthrs @ tip (6 indiv. fthrs).
Scrub Jay	West Ridge		3/10/97	Feather spot	7	LLT	Numerous body feathers and 6-10 flight feathers.

Species	Geographic Location	Site ^a	Date	Condition	Distance from closest turbine (m)	Closest Structure	Comments
Rock Dove	West Ridge	Z04	3/10/97	Feather spot	45	LLT	Numerous fthr (>100) scattered along side of rd & slopes.
Unidentified Bird	West Ridge	Z14	3/24/97	Feather spot and/or bones	7	LLT	Found legs, pelvic bone and a few ribs. Old & weathered.
Great Horned Owl	West Ridge	Z18	3/27/97	Dismembered	6	slt	Scavenged poss. by ravens: two carcass parts - wing and rest of body. Skull cap present but rest gone.
Chukar	Middle Ridge	C17	3/27/97	Dismembered	37	distribution line	Rt. wing, loose wing, tail, & body feathers. Fatality may have been recent.
Red-Tailed Hawk	West Ridge	Z21	4/1/97	Feather spot and/or bones	4	LLT	2 bone frags.
Loggerhead Shrike	Middle Ridge ²		4/14/97	Intact	350	main road > 35 mph	Bird was hit by a vehicle at 20 mph coming down Cannon main entrance road.
Great Horned Owl	West Ridge		4/18/97	Intact	4	LLT	Observed during dead bird search at Permanent Site #Z27, LLT #27-13.
White-Crowned Sparrow	Middle Ridge		4/23/97	Intact	200	main road > 35 mph	Body was intact; bird might have been dead for 2-3 days; only eyes eaten by ants.
Red-Shafted Flicker	Middle Ridge	C25B	5/13/97	Feather spot	1	VAT	Found body fthrs & several retrices.
Mourning Dove	East Slope	S39	5/28/97	Feather spot	17	other human-made structure	Clusters of feathers found over square meter area. Some still had skin attached.
Common Raven ³	West Ridge		6/3/97	Intact	15	main road > 35 mph	Found alongside main road, broken tailbone, no leg func, taken to rehab, died 6/5/97.
Great Horned Owl	East Slope	S42	6/9/97	Feather spot	30	stt	Group of primaries stuck together; several other wing feathers only had shafts left.
Unidentified Passerine	West Ridge	Z44	6/13/97	Feather spot	38	slt	Scattered fthrs (8 x 1 m area) in veg. along dirt road.
Mourning Dove	West Ridge	Z44	6/13/97	Feather spot	9	slt	Area of scatt. feathers was 29 m long & 1 m wide in veg. along dirt road.

Species	Geographic Location	Site ^a	Date	Condition	Distance from closest turbine (m)	Closest Structure	Comments
Mourning Dove	Middle Ridge	C48	6/17/97	Feather spot	6	stt	Found 50+ feathers, mostly along side of rd. or on rd. berm. Appears semi-recently graded.
Western Meadowlark	West Ridge	Z06	7/10/97	Feather spot and/or bones	11	slt	Found frag. of head and feathers alongside some breast skin-had yell. feath.
Red-Tailed Hawk	West Ridge		7/14/97	Feather spot	20	slt	Feathers along both sides of road at about 307 deg. from V136. Feathers fresh.
American Kestrel	West Ridge		7/16/97	Feather spot	40	slt	9 L. Wing feathers and several body feathers (good cond.) 54 m from site Z12 (V102 at 336 deg).
Red-Tailed Hawk	West Ridge	Z17	7/18/97	Dismembered	9	LLT	Found rt. wing, fthr spot, and pelvis & 2 partial legs in 3 places & fthrs. Scattered in area.
California Quail	Middle Ridge	C23	7/24/97	Feather spot	36	transmission line	Found feather spot; >50 feathers in a 10 X 5 area 36 m from site turb.
Unidentified Bird	West Ridge	Z66	7/29/97	Feather spot and/or bones	7	LLT	Found talons- tried to ID spp.. Might be ACCI or PRFA. Also leg bones.
Unidentified Bird	West Ridge	Z64	8/6/97	Feather spot and/or bones	49	LLT	Found 1 humerus and 2 bone frags.
Common Raven	West Ridge		8/8/97	Feather spot	19	ww	About 19 m from turb. 19-5. Found about 20 remiges and some body feathers.
Unidentified Bird	West Ridge	Z27	8/12/97	Feather spot and/or bones	36	transmission line	Compared bones to GHOW-looks more like RTHA. Found coracoid, humerus, tibiotarsus. Also found tattered feathers.
Long-Eared Bat	West Ridge	Z23	8/12/97	Intact	3	slt	Found w/ fresh wound.
Great Horned Owl	West Ridge	Z28	8/13/97	Feather spot	3	ww	Feathers were around base of 6-43. Mostly body and down feathers.
Mourning Dove	East Slope	S26	8/18/97	Feather spot	38	fence	Found feather spot 38M @ 120 deg. from turb. K1.

Species	Geographic Location	Site ^a	Date	Condition	Distance from closest turbine (m)	Closest Structure	Comments
Common Raven	West Ridge	Z36	8/20/97	Feather spot	30	LLT	Feathers found. Looks like large bird. Body fthrs. >50 scattered semiplumes & other coverts.
Great Horned Owl	West Ridge	Z36	8/20/97	Feather spot and/or bones	47	meteorological tower	Partial wing collected, plus additional feathers. Both flight feathers and coverts collected.
Unidentified Bird	West Ridge		8/20/97	Feather spot and/or bones	35	fence	Found while doing a search @17-75; pneumatic femur, tibiotarsus, & tarsometatarsus.
Brewer's Blackbird	West Ridge	Z36	8/20/97	Feather spot	3	LLT	15 wing feathers (primaries and secondaries) and 20 body feathers collected.
American Kestrel	West Ridge	Z38	8/25/97	Feather spot	28	slt	Feather spot (>100 body and >6 flight feathers); scattered along both sides of road.
Rock Dove	West Ridge	Z44	8/27/97	Feather spot	49	other human-made structure	Found feathers 2 m from a dirt road & 32 m from barbed wire fence.
California Quail	West Ridge	Z46	8/28/97	Feather spot	4	ww	Mainly flight & body fthrs. Lg conc at base of 5-72 & some by 5-73. >50 fthrs & few diff fthrs.
Western Meadowlark	East Slope	S42	9/3/97	Feather spot and/or bones	3	stt	Found some of both wings and many wing and body feathers. Found 2 leg bones.
Unidentified Bird	West Ridge	Z21	9/3/97	Feather spot and/or bones	7	LLT	Fnd pieces of humerus, coracoid attach to sca-pula piece, during cnt 50 m from 22-16 @22-15.
American Kestrel	West Ridge	Z57	9/9/97	Feather spot	1	LLT	Fthrs were dispersed, but one area had high concentration, approx. 40 m from site at 20 deg.
Chipping Sparrow	Middle Ridge		9/10/97	Intact	55	transmission line	Skull cracked on back with hole. Dessicated inside cranium. Wing injury dorsal to rt. wing.
Great Horned Owl	West Ridge	Z02	9/23/97	Feather spot and/or bones	19	ww	Found some bones, part on one wing.

Species	Geographic Location	Site ^a	Date	Condition	Distance from closest turbine (m)	Closest Structure	Comments
Rock Dove	West Ridge		9/23/97	Feather spot	11	transmission line	Feathers strewn a long distance from near 3-24 toward 5-84.
Great Horned Owl	West Ridge	Z46	9/23/97	Feather spot and/or bones	5	ww	Strewn over a mod. area, many fthrs, part of lt wing, rt talon, lt talon att. to pelvis & vertebra.
Rock Dove	West Ridge	Z03	9/26/97	Feather spot	15	slt	Found many flight and body feathers. One clump of feathers had a skin partial at tip.
Mourning Dove	West Ridge	Z02	9/30/97	Feather spot	2	ww	Fthr spot found at NE corner of base of 3-28. fthr area approx 1 ft ² @ 13 deg from ctr.
American Kestrel	West Ridge	Z06	10/1/97	Feather spot	14	slt	The few greyish coverts and tail feathers indicated that this individual was a male.
American Kestrel	West Ridge	Z08	10/7/97	Feather spot	8	ww	Fthr spot: 5 m X 3 m; >30 wing & tail fthrs. Some fthrs weathered and/or with broken shafts.
Unidentified Bird	West Ridge		10/16/97	Feather spot	60	distribution line	Found 4 remiges with a few coverts still attached to piece of ulna. Passerine-sized bird.
Western Meadowlark	East Slope	S16	10/20/97	Feather spot	16	stt	Feather spot (>100 contour & some flight feathers) in 5 m X 3 m area. 43 m from site turbine.
Unidentified Bird	West Ridge	Z23	10/22/97	Feather spot and/or bones	3	slt	Keel was found. Also found 6 ribs attached to different pieces of the sternum.
Western Meadowlark ^d	West Ridge		10/22/97	Not applicable	93	meteorological tower	Saw it hit guywire of MET. Landed nearby. As I approached, it flushed & flew away, flew fine.
Common Raven	West Ridge		10/23/97	Dismembered	14	slt	Most of ft. forearm & seconds, some radius & ulna expsd, distal gone, blood fresh @trauma.
Unidentified Passerine	East Slope	S20	10/23/97	Feather spot	40	LTT	Feather spot around juniper.

Species	Geographic Location	Site ^a	Date	Condition	Distance from closest turbine (m)	Closest Structure	Comments
European Starling	West Ridge	Z24	10/23/97	Feather spot	21	LLT	Feather spot, 1-3 m from side of dirt road to turbine. >100 body feathers & <15 ft feathers.
Hermit Thrush	West Ridge		10/24/97	Intact	15	other human-made structure	Fresh kill, blood was fresh and neck was loose. Eyes are gone.
Great Horned Owl	West Ridge		10/27/97	Dismembered	30	slt	Partial rt. wing (below hum.) with some prim. att. rad. & uln. expsd, no mscl, skin or fthrs. lg. fthr spot both side rd.
Common Raven	West Ridge	Z58	10/28/97	Feather spot	0	ww	Found several body and flt feathers in area around site Z58; main clump 41 m from 17-46.
Unidentified Bird	East Slope	S21	10/28/97	Feather spot and/or bones	30	LTT	Bone has marks as if sm mammal had gnawed on it.
Rock Dove	West Ridge	Z27	10/29/97	Feather spot	33	transmission line	Fthrs scattered along base of slope between 27-13 and 27-14. 6 remiges & 13 other feathers.
Yellow-Rumped Warbler	West Ridge	Z27	10/29/97	Feather spot	33	transmission line	8 retrices and 3 contour-type fthrs at base of slope between 27-13 and 27-14 in 1 m ² area.
Rock Dove	West Ridge	Z03	10/30/97	Feather spot	3	slt	Feathers spread from 3 m away from turbine to 35 m away. Found during util count.
Flammulated Owl	West Ridge	Z70	10/30/97	Feather spot	10	slt	Fthrs collected = 100+ (includes 12+ remiges).
Red-Tailed Hawk	West Ridge	Z33	10/31/97	Dismembered	14	LLT	Coll pair of wings and other fthrs. Flesh on wings vry fresh, wings flex., torso devoured.
Dark-Eyed Junco	Middle Ridge		11/6/97	Feather spot	59	meteorological tower	Found sev. flt. and body fthrs 59 m from site C62 & 9m from guywire of MET - likely coll.
Unidentified Bird	West Ridge	Z34	11/7/97	Feather spot and/or bones	14	ww	Large raptor-sized sternum approx. 14 m from 18-27 @ 290 deg.

Species	Geographic Location	Site ^a	Date	Condition	Distance from closest turbine (m)	Closest Structure	Comments
Greater Roadrunner	West Ridge	Z36	11/11/97	Feather spot and/or bones	25	meteorological tower	Feather area was at edge of main access rd - maybe hit by vehicle.
Unidentified Raptor	West Ridge		11/17/97	Feather spot	75	ww	Feather spot of >65 contour feathers. 100M @ 227 DEG. FROM 6-65.
Common Raven	West Ridge		11/19/97	Feather spot	1	ww	Found 12 ft feathers and 5 body feathers 17 m from turb. 16-48 near base of a rabbitbrush.
American Kestrel	West Ridge	Z39	11/20/97	Feather spot	0	LLT	Found approx. 70 body feathers and 2 remiges at base of turb. 23-3.
Scrub Jay	West Ridge	Z39	11/20/97	Feather spot	7	LLT	Found 10 ft. feathers and 3 coverts just outside base of turb. #23-3.
Rock Dove	West Ridge	Z44	12/1/97	Feather spot and/or bones	46	slt	Found >70 body & flight feathers & 3 bone frags in an area 57 m from turb. #V265 (Z44).
Unidentified Bird	West Ridge		12/2/97	Feather spot and/or bones	40	slt	Left and right femurs 51 m from V209. It femur had hole in end.
Red-Tailed Hawk	East Slope		12/3/97	Dismembered	26	distribution line	Found dead by S.W. emp. in AM on ground next to D-Line pole; had electric burn on rt talon.
Great Horned Owl	East Slope		12/3/97	Intact	26	distribution line	Found dead on platform of D-Line pole in AM by S.W. emp. No obvious signs of electrocution.
Long-Eared Owl	East Slope	S34	12/4/97	Feather spot	39	stt	Approx. 100 body fthrs. Parts of bill found in fthr area. 39 m from D28 @ 100 deg.
European Starling	West Ridge		12/4/97	Intact	30	meteorological tower	Found lying on back, wings folded, tail slightly splayed, legs extended, no sign of injury, fresh.
Unidentified Bird	West Ridge	Z60	12/20/97	Feather spot and/or bones	15	ww	At 3 main areas: talons, leg bones, coracoids, scapulae, partial vertebral col, 1 rib, & hum.
Unidentified Buteo	West Ridge	Z54	12/29/97	Feather spot and/or bones	28	LLT	Old & weathered raptor skull 28 m from 22-1; no feathers or other bird bones.

Species	Geographic Location	Site ^a	Date	Condition	Distance from closest turbine (m)	Closest Structure	Comments
Rock Dove	West Ridge	Z03	12/31/97	Feather spot and/or bones	27	slt	>150 fthrs (remiges, retrices, & body fthrs). Femur, radius, & ulna cleaned of all flesh.
American Kestrel	West Ridge	Z63	12/31/97	Feather spot	3	ww	Found at least 20 (probably more) body fthrs around base of 5-116.
Western Meadowlark	West Ridge	Z76	12/31/97	Feather spot	32	LLT	>200 ft. & body feathers beneath a clump of pines and amidst tumbleweeds.
Horned Lark	East Slope	S02	1/6/98	Feather spot	18	LTT	>500 body & ft. fthrs in 1 large fthr spot, some may still be there.
Red-Tailed Hawk	East Slope	S05	1/6/98	Feather spot	12	LTT	Found 7 remiges, 14 add'l wing coverts and a few body fthrs. Several remiges - broken tips.
Ferruginous Hawk	East Slope	S02	1/6/98	Feather spot	43	meteorological tower	23 body fthrs inside circle & 32 outside.1.
Unidentified Bird	West Ridge	Z02	1/8/98	Feather spot and/or bones	26	meteorological tower	Possible TUVU/GOEA bones. Keel, part of pect girdle, 2 vertebrae & other bones near 3-28.
Mourning Dove	West Ridge	Z12	1/21/98	Feather spot	31	slt	5 Right remiges (probably all primaries) & 7 small UNID fthrs collected.
Rock Dove	West Ridge	Z65	1/26/98	Feather spot	46	telephone line	28 weathered flight fthrs (includes remiges, retrices, & <5 coverts).
Red-Tailed Hawk	West Ridge		1/27/98	Dismembered	10	ww	Pair of wings & adult rufous tail. Gnawed bones. Flexible skin w/ sticky, very red blood.
Great Horned Owl	East Slope	S16	2/5/98	Feather spot	47	distribution line	4 remiges from same wing. Also found 2 smaller fthrs. 2 pieces of fthrs, and 1 rachis tip.
Greater Roadrunner	East Slope	S17	2/5/98	Feather spot	41	LTT	Approx 100 fthrs, inc. 8 retrices, 22 remiges, and numerous wing coverts & contour fthrs.
Red-Shafted Flicker	West Ridge	Z20	2/5/98	Feather spot	21	slt	Feather spot, 25 wing & tail feathers & 7 contour feathers.

Species	Geographic Location	Site ^a	Date	Condition	Distance from closest turbine (m)	Closest Structure	Comments
Red-Tailed Hawk	West Ridge	Z23	2/27/98	Dismembered	13	slt	Found femur, tibiota, lt wing, ruf. tail fthrs. may have missed some fthrs. prob scav by birds.
Horned Lark	West Ridge	Z30	3/4/98	Feather spot and/or bones	17	LLT	Approx 50 contour feathers & 7 brown remiges.
Unidentified Bird	West Ridge	Z33	3/4/98	Feather spot and/or bones	26	LLT	7 withered remiges att., 11 brkn shfts of remiges att. to hum. w/ ends of coracoid & scapula att.
Unidentified Sparrow	West Ridge	Z37	3/11/98	Feather spot	17	ww	>100 body feathers (many downy) & approx 12 remiges.
American Kestrel	West Ridge	Z36	3/23/98	Feather spot	6	LLT	Believe most larger fthrs coll, some small fthrs might still be present.
Unidentified Bird	West Ridge	Z36	3/23/98	Feather spot and/or bones	13	LLT	Found old humerus, probably from raptor.
Prairie Falcon	Middle Ridge	C48	3/24/98	Feather spot	18	stt	4 retrices (2 attached together by dried skin). Each w/ dried skin at end of each quill).
Unidentified Bird	West Ridge	Z49	4/9/98	Feather spot and/or bones	46	ww	Old bleached sternum (probably RAPT, possibly GHOW/RTHA).
Unidentified Bird	West Ridge		4/23/98	Feather spot and/or bones	31	slt	Fragmented withered bones outside of search area of site Z53. Prob. at least 1 humerus or femur.
Common Raven	West Ridge		4/23/98	Feather spot	11	ww	Feathers old & withered. About 15 flt fthrs (mostly primaries) w/in 1.5-m area. Large black feathers.

^a Null value for site indicates fatality found outside of permanent sites.

^b West of Sea West - area between Cannon and Sea West.

^c Found alive but later died from injuries.

^d Observed alive - flew away apparently unharmed.

REPORT DOCUMENTATION PAGE

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14. ABSTRACT (Maximum 200 Words) Observations of dead raptors at the Altamont Pass Wind Resource Area triggered concerns on the parts of regulatory agencies, environmental/conservation groups, wildlife resource agencies, and wind and electric utility industries about possible impacts to birds from wind energy development. Bird fatality rates observed at most wind projects are not currently considered significant to individual bird species populations. Although many bird species have observed fatalities, raptors have received the most attention. The primary objective of this study was to estimate and compare bird utilization, fatality rates, and collision risk indices among factors such as bird taxonomic groups, turbine types, and turbine locations within the operating wind plant in the Tehachapi Pass WRA, in south-central California between October 1996 and May 1998.						
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