Hatchet Ridge Wind Farm Post-Construction Mortality Monitoring Year One Annual Report

Submitted to:

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Executive Summary

In October 2010, Tetra Tech EC, Inc. (Tetra Tech) was contracted to develop and implement a study plan to monitor Hatchet Ridge Wind Farm (Project) project-related avian and bat fatality rates at the Hatchet Ridge Wind Farm, incorporating methods consistent with the California Energy Commission's California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development (CEC 2007). The study plan includes mortality monitoring at all 44 turbines in the form of standardized carcass searches; searcher efficiency trials and carcass persistence trials to account for inherent bias in estimating Project-related fatality rates; avian use surveys; and a Wildlife Education and Incidental Reporting Program.

This report presents the first-year results of the post-construction mortality monitoring program and avian use surveys; Project-related fatality rates are also estimated based on study results. Additionally, observed trends in Project-related fatalities to Special-Status Species and Species Groups and sources of study bias are addressed.

A total of 95 bird and bat fatalities were detected during the 4 seasons of mortality monitoring. During biweekly (2 week interval) standardized carcass searches at 22 turbines and 3 control plots, 48 bird fatalities and 12 bat fatalities were detected. During monthly standardized carcass searches at 22 turbines, 17 bird fatalities and 7 bat fatalities were detected. Seven bird fatalities and 4 bat fatalities were detected incidentally, 2 of which were detected by means of the Incidental Monitoring Program conducted by operations personnel. Out of all detected fatalities during the study, avian species groups with the highest number of fatalities detected included songbirds (34 fatalities detected, 47 percent of bird fatalities) and waterfowl (18 fatalities detected, 25 percent of bird fatalities). Three raptor fatalities were detected. Additionally, 37 bird fatalities from 20 species and 35 bird fatalities not identifiable to species were detected, while 18 bat fatalities from 3 species and 5 bat fatalities unidentifiable to species were detected but not identifiable to species due to the poor condition of the carcasses. Seasonal composition of fatalities varied, with the highest number of avian fatalities (n=42) occurring in spring and the highest number of bat fatalities occurring in summer (n=10).

Of all documented fatalities found during the biweekly and monthly surveys and as incidental finds, 5 were Special-Status Species or from Special-Status Species Groups. Two yellow warbler fatalities were detected (spring and summer). Three raptors were detected, including a turkey vulture (spring), a red-tailed hawk (fall), and a sharp-shinned hawk (fall). No bald eagle or sandhill crane fatalities were detected during the 4 seasons of monitoring.

Searcher efficiency (SEEF) and carcass persistence estimates varied by carcass category. Searcher efficiency ranged from a low of 60 percent (90% CI: 0.47, 0.71) for bats to a high of 85 percent (90% CI: 0.75, 0.92) for large birds. Carcass persistence estimates were calculated at 2.45 days (90% CI: 1.97, 2.94) for bats, 5.62 days (90% CI: 4.05, 7.46) for small birds, and 116.1 days (90% CI: 70.83, 252.5) for large birds. Carcass category-specific searcher efficiency and carcass persistence rates were used to adjust project specific estimated fatality rates.

Avian point count surveys were conducted at 6 locations once per month in winter 2010-2011, and once every 2 weeks during spring, summer and fall for a total of 132 surveys. Overall mean use varied by season, with the highest mean use occurring in fall (83.33 birds/30 min). Species with the highest mean use were the snow goose (8.89 birds/30 min) and Ross's goose (8.28 birds/30 min); both species were observed only in winter and fall. All other species had a mean use of less than 1.50 birds/30 minutes. Neither the bald eagle nor the sandhill crane was detected during 4 seasons of avian point count surveys, though 1 bald eagle and 1 flock of 18 sandhill cranes were documented incidentally.

Annual fatality rates for the site and per-turbine were estimated for 3 main species groups: raptors, non-raptors, and bats. Based on results of the biweekly standardized carcass searches, searcher efficiency estimates and carcass persistence time estimates, the estimated annual fatality rates at the Hatchet Ridge Wind Farm are 251 non-raptor fatalities per year (5.69 non-raptor fatalities per turbine per year; 90% CI: 4.24-7.66; 2.47 fatalities per MW per year; 90% CI: 1.84-3.33), 3 raptor fatalities per year (0.06 raptor fatalities per turbine per year; 90% CI: 0.05,0.18; 0.03 raptor fatalities per MW per year; 90% CI: 0.02-0.07), and 226 bat fatalities per year (5.13 bat fatalities per turbine per year; 90% CI: 1.94-9.47; 2.23 bats per MW per year; 90% CI; 1.94-9.47).

Annual fatality rates were estimated for Special-Status Species and Species Groups for which Mitigation Measure BIO-6 of the Project's operating permit set annual fatality thresholds. These rates, however, are estimated based on a sample size (n=1) insufficient for accuracy in fatality rate estimation which requires a sample size of 5 or higher (Manuela Huso, pers. comm.). Only the yellow warbler had fatality rates above the established threshold of 0.07 fatalities per turbine per year. Estimated fatality rates for this species are 9 fatalities per year or 0.19 fatalities per turbine per year (90% CI: 0.15-0.62).

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Introduction

Wind energy provides a clean, renewable energy source that is currently in high demand. As the development of wind power generating facilities has increased, so has the need to address potential environmental impacts from those facilities. Birds and bats have been identified as a wildlife group at risk because of collisions or other interactions with wind turbines (Arnett et al. 2007). Estimated avian fatality rates from post-construction mortality monitoring studies at wind energy facilities distributed throughout the country range from approximately 0.5 to 13.9 fatalities/MW/year (Strickland et al. 2011). However, avian fatality rates at most facilities were consistently less than or equal to 3 birds/MW/year (Strickland et al. 2011). Raptors, when analyzed separately from other birds, had fatality rates ranging from 0 to 0.87/MW/year with the highest fatality rates concentrated in California (Strickland 2011). Bat fatalities rates vary by season and location and have been highest at facilities on forested ridges in the eastern region of the United States and lowest in the Rocky Mountain and Pacific Northwest regions (Arnett et al. 2008). Estimated fatalities for these projects range from 53.3 to 0.8 fatalities/MW/year with studies conducted under a variety of protocols, limiting the value of direct project comparison (Strickland et al. 2011). Additionally, recent studies have shown that wind energy facilities constructed in agricultural landscapes may also experience relatively high bat fatality rates (e.g. Gruver 2009, Poulton 2010).

On November 4, 2008, Shasta County certified an Environmental Impact Report (EIR) and approved Use Permit 06-016 for the Hatchet Ridge Wind Farm (Project) owned and operated by Pattern Energy/Hatchet Ridge Wind, LLC (Hatchet Ridge Wind). The 73-acre (29-hectare) Project is located in northeast Shasta County, on Hatchet Mountain, approximately 34 miles (20 kilometers) northeast of Redding, California. Hatchet Ridge Wind completed construction of the approximately 101 megawatt (MW) wind energy project in October 2010. The Project includes 44 2.3-MW Siemens wind turbine generators (turbines) that extends approximately 6.5 miles (4 kilometers) northwest along the ridge of Hatchet Mountain. The Project was constructed in an area managed for commercial timber production; forested habitat primarily consists of ponderosa pine and white fir. This area was replanted in 1993-1994 after the 1992 Fountain Fire; as such, tree height ranges from 5 feet to 15 feet (1.5 to 4.6 meters) tall.

Mitigation Measure BIO-6 (MM BIO-6) of the EIR and Condition 31b of the Use Permit 06-016 (UPC 31b) require the implementation of a post-construction avian and bat mortality monitoring study. Additionally, MM BIO-6 sets forth an annual fatality threshold of one fatality per year for the bald eagle and sandhill crane, both California Fully Protected species. MM BIO-6 also sets forth annual fatality thresholds for 3 Special-Status Species or Groups (other raptors, yellow warbler, and owls) because these species have the potential to be impacted by the Project. Thresholds are set at 0.35 fatalities/turbine for other raptor species, 0.07 fatalities/turbine for the yellow warbler and 0.11 fatalities/turbine for owls. As part of the MM BIO-6 measures, a Technical Advisory Committee (TAC) was created for the Project to provide oversight and guidance with post-construction monitoring and management activities. To maintain compliance with the conditions of their operating permit, Hatchet Ridge Wind must evaluate Project impacts, as demonstrated by the results of post-construction monitoring, relative to these thresholds. Exceedance of these thresholds, or unanticipated impacts to other Special-Status Species, may trigger the TAC to recommend that the Shasta County Planning Director require implementation of additional mitigation.

In October 2010, Tetra Tech EC, Inc. (Tetra Tech) was contracted to develop and implement a 2-year study plan to monitor Project-related avian and bat fatalities and determine fatality rates for these species groups, incorporating methods consistent with the California Energy Commission's California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development (CEC 2007). The study plan incorporates fatality monitoring at all turbines in the form of standardized carcass searches (biweekly and monthly); searcher efficiency trials and carcass persistence trials to account for inherent bias in estimating Project-related fatality rates; avian use surveys; and a Wildlife Education and Incidental Reporting Program. These study elements are described in detail in the study protocol approved by the TAC (Tetra Tech 2011).

This report summarizes the results of the first year of post-construction mortality monitoring at the Project. The objectives of this study are to estimate the bird and bat fatalities associated with the operation of the project, examine spatial and temporal patterns in bird and bat fatalities, examine sources of bias in the study, and contextualize the Project's study results with other projects regionally. This report includes a summary of fatalities documented during the first year of monitoring along with results of searcher efficiency and carcass persistence trials, and estimated fatality rates that incorporate the results of these studies. Avian use survey results are also presented. Finally, a comparison between observed fatalities of Special-Status Species and Species Groups and MM BIO-6 fatality estimate thresholds is made.

Methods

Fatality Monitoring

Wind farm-related fatality estimation is based on the number of carcasses found during carcass searches conducted under operating turbines. Both the ability of searchers to detect carcasses given persistence time (searcher efficiency) and the duration that a carcass persists on site long enough to be detected by searchers (carcass persistence time) can bias the number of carcasses located during standardized searches. Therefore, this post-construction monitoring study includes 1) methods for conducting standardized carcass searches, 2) searcher efficiency trials to assess observer efficiency in finding carcasses, and 3) carcass persistence trials to assess seasonal, site-specific duration that a carcass remains available to be found by searchers.

The fatality monitoring study was initiated in November 2010. Clearance surveys beneath turbines were conducted November 18 to 24, 2010 to remove any fatalities that occurred prior to the study. Standardized carcass searches were initiated on December 12, 2010, with a total of 26 surveys occurring over all 4 seasons. Seasons were defined as winter (December 12, 2010-March 14, 2011), spring (March 15-June 15, 2011), summer (June 16-September 14, 2011), and fall (September 15-December 15, 2011).

Standardized Carcass Searches

In order to maximize coverage of the Project, standardized carcasses searches were completed at all turbines. Twenty-two turbines were searched on a biweekly (2 week) search interval with the remaining 22 searched on a monthly (4 week) search interval (Figure 1).

Biweekly Search Plots

Biweekly search interval turbines were selected to maximize the searchable area available beneath the turbines and sample evenly across the distribution of turbines along the ridge to capture various elevations and vegetation communities and turbine position along the string (Figure 1). Square search plots up to 50 percent of the maximum turbine blade height were established beneath these turbines. Centered on the turbine, search plot size was 127 meters x 127 meters, extending 63.5 meters (208 feet) from the turbines on each side. Linear transects spaced at 6 meter intervals were established within the search plot, with searchers scanning out to 3 meters on both sides of transects.

The vegetative density within each search plot was delineated using a Trimble GeoXT into the 4 visibility class categories of high, medium, low, and non-searchable. Percent vegetative cover was the main criterion for determining visibility class, with 0 to 40 percent vegetative cover delineated as high, 40 to 70 percent cover delineated as medium, greater than 70 percent cover delineated as low, and greater than 70 percent cover but impassible or not walkable was delineated as non-searchable. Percentages of search area that fell into each of 4 categories were then calculated to determine general proportions of each class over all 22 search plots. With the exception of non-searchable area (Tetra Tech 2011), all portions of the search plot were covered. Non-searchable area varied between search plots. Four out of 22 were fully searchable, 12 of 22 had non-searchable area between 0.5 and 10 percent, and 6 out of 22 included non-searchable area between 10 and 19 percent of the search plot, for a total of 7.8 percent of search plots designated non-searchable. Non-searchable areas were generally located in the outer most third of the established search plot

Monthly Search Plots

To supplement fatality data obtained at the turbines searched biweekly, standardized carcass searches were also conducted monthly at the remaining 22 turbines. Square search plots at 75 percent of the turbine-tip height were established beneath these turbines; resulting in a search plot of 190 meters x 190 meters (623 feet x 623 feet) extending 95 meters (312 feet) from the turbines on all sides. The search area for this subset of turbines focused only on cleared and other high visibility areas within the search plot; only high visibility areas were delineated and subsequently searched. Transects spaced 6 meters apart were also established within these search plots. Data from these monthly searches were used to supplement fatality data from biweekly searches because the focus of these additional surveys was on California fully-protected species including the bald eagle and sandhill crane, raptors, and other State fully protected species (all medium- to large-bodied species for which a longer search interval is appropriate) and not intended for statistical analysis.

Control Plots

California Energy Commission guidelines recommend conducting background fatality studies at a control site during the post-construction period to estimate natural mortality due to factors other than wind turbines and related infrastructure (e.g., predation). Background fatality levels, if unaccounted for, may result in an overestimation of collision-related fatalities. Therefore, carcass searches were conducted biweekly at 3 control plots using the same methods outlined above. Control plots were located outside of the turbine search plots, and were spaced to be representative of the southern, central, and northern portions of the Project to capture any background fatality effect that may be correlated with elevation. The control plot locations were centered on the avian point locations of 1, 4 and 6 (Figure 1) and extend out 63.5 m (208 ft) in each direction for a 127 m x 127 m square search plot.

All fatalities were photographed and documented according to the approved protocol (Tetra Tech 2011). Fatalities were identified to species when possible, and when not possible (due to the quantity and condition of the remains), fatalities were identified to the highest possible taxonomic level. An amendment to Tetra Tech's existing USFWS scientific collecting permit (Number MB163272-1) to include the Project was finalized on April 11, 2011, permitting the Tetra Tech team to collect bird and bat carcasses found within the Project area.

Incidental Fatalities

When a bird or bat carcass was found outside of the designated search plot and/or outside of the standardized search period, it was recorded as an incidental fatality. Incidental fatalities were documented with the same level of detail as survey finds, however, they were excluded from statistical analyses. All fatalities documented during the initial sweep survey were considered incidental.

Searcher Efficiency

Searcher efficiency, or the probability that an observer detects a carcass that is available to be found during a search, is used to account for imperfect detection in carcass counts. Searcher efficiency trials were conducted during each season at the 22 turbines searched biweekly and incorporated the assessment of each member of the field staff. Searcher efficiency trials were conducted so that searchers being assessed had no prior knowledge of the trial. Bird carcasses of 2 size classes (large bird and small bird) and bats (or bat surrogates) were used in the trials. For the purposes of analysis, an arbitrary cutoff of 25 centimeters (10 inches) was used to separate birds into the 2 size categories. Species with lengths less than 10 inches (25 centimeters) were considered small birds (e.g., European starling); all other species with lengths greater than or equal to 10 inches (25 centimeters) were considered large birds (e.g., ring-necked pheasant). Mouse carcasses were used as surrogates for bats due to lack of availability of local bat carcasses.

Searcher efficiency trial turbine search plots were randomly selected from the biweekly searched turbine pool. Carcasses from each size class category were placed at randomly generated points within the selected search plots with points being stratified by visibility class (low, moderate, and high) to ensure that all visibility classes were represented in proportion to their presence in the search plots. All trial carcasses were retrieved at the end of each day of the trial; if a trial carcass that was not found by searchers could not be relocated at the end of the trial, it was assumed to have been scavenged and thus unavailable to be found by searchers. Subsequently, these carcasses were not included in the analysis.

Data from SEEF trials were modeled using a logistic regression in order to determine if size influenced searcher efficiency. Carcass size was included as a variable as a larger carcass could be easier to find than smaller carcasses. Season, however, excluded from analysis due to variation in carcass availability in each season limiting the total number of carcasses used per season. Bootstrap estimates of searcher efficiency and 90 percent confidence intervals were calculated using 1000 replicates for each carcass category. The searcher efficiency estimates generated were used in the calculation of fatality rates. The estimated searched efficiency is defined by Huso as:

$$p = \frac{n_i}{k_i}$$

Where n_i is the number of trial carcasses found for the *i*th carcass category, k_i is the number of trial carcasses found for the *i*th carcass category.

Carcass Persistence Time

Carcass persistence, or the number of days a carcass persists in the study area before it is removed, is used to account for inherent bias in fatality reporting due to carcass removal. Carcasses may be removed from the search plot due to scavenging or other means (e.g., decomposition). It is assumed that carcass removal occurs at a constant rate and does not depend on the time since death of the organism. Because carcass persistence is expected to vary with season and carcass size, a 21-day carcass persistence trial was initiated in each season using each of the 3 carcass categories (small bird, large bird, and mice as bat surrogates).

Each carcass persistence trial was conducted over 15 randomly selected turbines. As with SEEF trials, carcasses were placed at randomly generated points within the selected search plots, stratified by visibility class to ensure that all visibility classes were represented in proportion to their presence in the search plots. Three trial carcasses were placed at each turbine with carcass categories represented as available. Carcasses were checked daily until they were no longer detectible or the 21-day trial period was complete. Changes in carcass condition were tracked and documented with photos.

Carcass persistence data falls into the category of survival analysis; a carcass persisting is "surviving" for the purpose of analysis. The persistence time of trial carcasses that survived until the end of the trial period is considered right censored such that the day the carcass is last observed is equal to the end of the trial. However, carcasses not removed by the end of the trial could have persisted longer. Therefore, calculating an average carcass persistence time using all of the data would underestimate persistence because it assumes that surviving carcasses (those that remained until day 21) were removed on the last day of the trial. Therefore, carcass persistence time was estimated by summing the days each trial carcass persisted and dividing by only those carcasses that were removed; the carcasses that were not removed by the end of the trial were excluded from the total in the denominator to produce a more accurate estimate. Consequently, average carcass persistence time can exceed the 21-day trial period.

Data from carcass removal trials were modeled using an interval censored parametric failure time model, which is a type of survival model, in order to determine if size influenced carcass persistence.

We included carcass size as a variable, because larger carcasses might persist longer than small carcasses. Season, again, was excluded as variable because of seasonal carcass availability limiting total number of carcasses places in each season. Bootstrap estimates of carcass persistence time and 90 percent confidence intervals were calculated, using 1000 replicates, by carcass category. These estimates were then used in the calculation of fatality estimates.

The average probability of persistence is defined by Huso (2010) as:

$$r = \frac{\bar{t}\,(1 - e^{-I/\bar{t}})}{min\,(I, I).}$$

where t is the average carcass persistence time, I is the actual search interval and I is the effective search interval (the length of time when 99 percent of the carcasses can be expected to be removed*; I = - log (0.01) * $\bar{t}$).*

Annual Fatality Estimates

Bias related to searcher efficiency and carcass persistence render raw carcass counts unreliable. Fatalities at wind projects are statistically estimated because searcher efficiency is less than 100 percent and often carcass persistence is shorter than the search interval. To estimate fatalities, we used the Huso estimator (Huso 2010), which has been shown to reduce bias in fatality estimates with the following equation: $f_{ijk} = \frac{c_{ijk}}{p_{jk} * r_{jk} * v_{jk}}$

Where:
f_{ijk} is the estimated fatality
i is an arbitrary turbine
j is the arbitrary search interval
k is the arbitrary carcass category
c_{ijk} is the observed number of carcasses
p is the estimated searcher efficiency
r *is the average probability of persistence*
v is the proportion of the interval sampled

r_{jk} is a function of the average carcass persistence time, and the length of the search interval preceeding a carcass being discovered. r_{jk} is calculated using the lower value of I, the actual search interval when a carcass is found or I, the effective search interval, and is estimated through searcher efficieny trials previously described.

v_{jk} is the proportion of the effective search interval sampled where v = min (1, I I).

p_{jk} is the estimated probablity that a carcass in the k^{th} category that is availble to be found will be found during the j^{th} search

p_{jk}, r_{jk}, and v_{jk} are assumed not to differ among turbines but can differ with carcass size and season

The per-turbine number of fatalities was then calculated by summing the estimated number of fatalities in each carcass category during each search for each turbine, and dividing by the effective number of turbines searched.

The Project estimated fatality rates were based upon fatalities detected at turbines searched on a biweekly interval. Fatality rate estimates were calculated on an overall basis, a per-turbine basis and a per-megawatt (MW) basis for 3 categories: 1) raptors, 2) non-raptors, and 3) bats. Estimates were also calculated for large and small birds in order to provide a metric comparable against other studies. Additionally, fatality rate estimates were calculated for Special -Status Species and Species Groups. In order to accurately calculate estimated fatality rates, however, a sample size of $\geq$5 must exist (Manuela Huso, pers.comm). Although estimates are provided for Special-Status Species and Species Groups, they are based on small sample size (<5 fatalities); therefore caution should be used when interpreting those estimates.

Avian Use Surveys

Standard 30-minute avian point count surveys were conducted at 6 locations along the turbine string to assess post-construction avian use of the Project (Figure 1). The surveyor collected data on all birds observed within an 800-m (2,624-feet) radius of the point count location, recording all visual or auditory observations made. The surveyor recorded the following data: species, number of individuals, time of observation, height aboveground, behavior, and flight direction. Additionally, the surveyor estimated flight heights and distances using existing wind turbines, meteorological towers, local transmission lines, and topographic maps for reference. Avian point count survey start times were varied at each location in order to capture avian activity at varying times of the day throughout each season. Surveys were conducted once monthly during winter and twice monthly during all other season. Avian use data were used to calculate mean use (number of birds/30 minutes) for individual species and species groups, and flight heights in relation to the rotor swept area (RSA) for comparison to fatality data.

Results

Fatality Monitoring

Standardized Carcass Searches

Twenty-six rounds of carcass searches were conducted biweekly at 22 of the 44 turbines. Searches were conducted from December 12, 2010 to November 16, 2011 (Table 1) for a total of 572 biweekly searches. Within the dates presented above, thirteen rounds of monthly carcass searches were conducted at the remaining 22 turbines (286 total monthly searches).

During biweekly searches at the Project, 60 fatalities (48 birds and 12 bats) were detected. Among these fatalities, 18 avian species from 7 species groups were identified (Table 2). Avian species groups detected included songbirds (n=25), waterfowl (n=11), waterbirds (n=4), gamebirds (n=2), swifts/hummingbirds (n=1), and raptors (n=1). Species with the highest number of fatalities included Steller's jay (n=3) and American coot (n=3). Nineteen fatalities were identifiable to species group only and 4 were identifiable only as unknown bird due to the poor condition of the remains or a limited amount and/or types of feathers detected (Table 2). Songbirds were the species group with the highest number of fatalities; of the 14 songbird species identified as fatalities at Hatchet, only 4 species were detected more than once: Stellar's jay (n=4), yellow-rumped warbler (n=2), dark-eyed junco (n=2), and American robin (n=2). Two Special-Status Species were detected including turkey vulture (raptor; n=1) and yellow warbler (n=1). Twelve bats from 3 species were detected, including silver-haired bats (n=5), Brazilian free-tailed bats (n=2), and a hoary bat (n=1). Four bats were unidentifiable to species due to the poor condition of the remains.

During monthly turbines searches, 24 fatalities (17 birds and 7 bats) were detected. Among these fatalities, 4 avian species from 3 species groups were identified (Table 3). Species groups detected included songbirds (n=6), waterfowl (n=4), and raptors (n=3). Only 1 species, red-tailed hawk (n=2), had more than 1 fatality. Seven fatalities were identifiable to species group only (unidentified songbird, n=3; unidentified waterfowl, n=4). The remaining fatalities (n = 4) were not identifiable to species group due to the poor condition of the remains or a limited amount and/or type of feathers needed to make a positive identification. Special-Status Species were detected including red-tailed hawk (n=2) and sharp-shinned hawk (n=1). Seven bats from 3 species groups were detected, including Brazilian free-tailed bats (n=4), silver-haired bats (n=2) and a hoary bat (n=1; Table 3).

The 3 control plots searched on a 2-week interval yielded no fatalities. Therefore, for the fatality estimates analysis, fatalities detected within turbine search plots were considered a result of turbine interactions.

Incidental Finds

Eleven fatalities were detected incidentally. Among these fatalities, 4 species groups were identified including songbirds (n=3), waterfowl (n=3), waterbirds (n=1) and bats (n=4; Table 4). One Species of Concern, a yellow warbler, was detected incidentally. Of these 11 incidentally detected fatalities, 2 (unidentified grebe and Brazilian free-tailed bat) were detected through the Incidental Reporting Program established for on-site operations personnel.

Spatial and Temporal Distribution of Fatalities

Avian and bat fatalities were distributed throughout the Project. Avian fatalities were detected at 32 of 44 turbines with the highest proportion of fatalities occurring at either end of the turbine string (Figures 2,3). Five fatalities each were detected at turbines 1 and 41, representing the extreme southeast and northwest sections of the turbine string each. Four or fewer fatalities were detected at all other turbines with fatalities. Bat fatalities were also distributed throughout the Project, with fatalities detected at 16 of 44 turbines (Figure 4). The highest proportion of bat fatalities was detected at the northwest end of the turbine string, with the highest number of fatalities occurring at Turbine 43 (n=4).

Fatalities at the Project occurred in all 4 seasons. The highest number of avian fatalities occurred in spring (n=42) with fatalities detected throughout March 15 to June 15. Similar numbers of avian fatalities occurred in all other seasons (Figure 5). Bat fatalities were detected in higher numbers in summer (n=10) and early fall (n=9), than in spring (n=4). No bat fatalities were detected in winter.

Searcher Efficiency Trials

Searcher efficiency trials were conducted between February 8 and October 18, 2011, with trials encompassing all 4 seasons. A total of 211 carcasses (40 large birds, 121 small birds, 50 mice) were placed during 9 trials. Of the 211 carcasses placed, 206 were recovered and included in analysis. Across all seasons, searchers detected 85 percent of large bird carcasses, 76 percent of small bird carcasses, and 60 percent of bat surrogate (mice) carcasses (Table 5). Carcass size class was the searcher efficiency model used for calculating estimated fatality rates, indicating that size class was an important predictor of searcher efficiency.

Carcass Persistence Trials

Carcass persistence trials were conducted during the spring, summer and fall seasons, with trials initiated May 20, July 25, and October 6 during spring, summer and fall, respectively. Although a trial was initiated during the winter season, snow limited site access and concealed the trial carcasses after day 6 of the trial, rendering the trial incomplete. Additionally, due to limitations in carcass availability, no mice were placed for the spring trial. A total of 120 trial carcasses were placed including 52 small birds, 38 large birds, and 30 bat surrogates (mice) representing the different carcass size classes. Carcass persistence times varied among all size classes (Table 6). The longest observed persistence time overall was for large birds (116 days; 90% CI: 63.74, 254.50). Small birds persisted 5.6 days (99% CI: 4.17, 7.53), and bats persisted 2.5 days (90% CI: 1.96, 2.95). Carcass class size was the carcass persistence model used for calculating fatality rates, indicating that size was an important predictor of carcass persistence.

Fatality Estimates

Annual fatality rate estimates for all turbines at the Project, based on the biweekly survey results are presented for several categories of birds. Bird categories include non-raptors and raptors (included for differentiation between 2 main focus groups of the study), small birds and large birds (included for comparison with other projects), waterfowl (included due to the high mean use of site), and the yellow warbler (included as a Special-Status Species; Table 7).

- Non-raptors had the highest number of estimated fatalities at 251 fatalities/project/year (90% CI: 187, 337), 5.69 fatalities/turbine/year (90% CI: 4.24, 7.66), or 2.47 fatalities/MW/year (90% CI: 1.84, 3.33).
- Small birds had the second highest number of estimated fatalities per year among birds at 206 fatalities/project/year (90 % CI: 147,290), 4.67 fatalities/turbine/year (90% CI: 3.32, 6.57), or 2.03 fatalities/MW/year (90% CI: 1.44, 2.86).
- Large birds were estimated at 48 fatalities/project/year (90% CI: 30, 69), 1.08 fatalities/turbine/year (90% CI: 0.66, 1.57), or 0.47 fatalities/MW/year (90% CI: 0.29, 0.68).

Avian Special-Status Species or Species Groups

- Yellow warbler fatalities are estimated at 9 fatalities/year (90% CI: 7, 28), 0.19 fatalities/turbine/year (90% CI: 0.15, 0.62), or 0.08 fatalities/MW/year (90% CI: 0.06, 0.27). These estimates are based on limited sample size (n=1) and therefore must be interpreted with caution.
- Raptors fatalities are estimated at 3 fatalities/year (90% CI: 3, 8), 0.06 fatalities/turbine/year (90% CI: 0.05, 0.18), or 0.03 fatalities/ MW/year (90% CI: 0.02, 0.07). These estimates are based on a limited sample size (n=1).

Other Avian Groups

- Waterfowl fatalities were estimated at 28 fatalities/project/year (90% CI: 12, 46), 0.63 fatalities/turbine/year (90 %CI: 0.25, 1.04), or 0.27 fatalities/MW/year (90 % CI: 0.11, 0.45).

Bats, as a group, had the second highest number of estimated annual fatalities.

- Bat fatalities were estimated at 226 bat fatalities/year (90% CI: 86, 417), 5.13 bats per turbine/year (90% CI: 1.94, 9.47; Table 7), or 2.23 bats/MW/year (90% CI: 0.84, 4.12).

Avian Use Surveys

Six point count locations were surveyed 23 times throughout 4 seasons for a total of 130 30-minute surveys (Table 8). A total of 3,634 birds were observed over the course of the survey year, with a seasonal breakdown of 360 birds (from 14 species) observed in winter, 444 birds observed in spring (37 species, 5 unidentifiable to species), 330 birds observed in summer (37 species, 10 unidentifiable to species) and 2,500 birds observed in fall (31 species, 4 unidentifiable to species; Table 9). Overall mean use varied by season with highest mean use occurring in fall (83.33 birds/30 min).

The mean use of non-raptors was variable throughout the seasons. Non-raptor mean use was highest in fall (82.67 birds/30 min) and lowest in summer (8.17 birds/30 min; Table 9; Figure 6). The species groups of waterfowl and songbirds were the primary contributors to the mean use values for each season. Waterfowl mean use was highest in fall (67.17 birds/30 min) followed by winter (11.17 birds/ 30 min); songbird mean use was highest in fall (11.40 birds/30 min) followed by spring (8.02 birds/30 min) and summer (7.36 birds/30 min; Table 9). Individual species with highest overall mean use values included snow goose (8.89 birds/30 min), Ross's goose (8.28 birds/30 min), dark-eyed junco (1.48 birds/30 min) and song sparrow (1.25 birds/30 min). Each other species had a mean use of less than 1.00 birds/30 min (Table 9). The yellow warbler, a Species of Concern, was detected in spring and summer, with seasonal mean use values of 0.33 birds/30 min and 0.17 birds/30 min respectively. No bald eagles or sandhill cranes were detected in any season of avian use surveys. Both species, however, were detected incidentally. A single bald eagle was observed on February 9 and 1 flock of 18 sandhill cranes was observed on April 6.

Raptor mean use, also Special-Status Species, was variable throughout the 4 seasons of surveys. Raptor mean use was highest in summer (1.00 birds/20 min), followed by fall (0.67 birds/20 min), spring (0.55

birds/20 min) and lowest in winter (0.33 birds/20 min; Figure 7). Eight raptor species were observed over the 4 survey seasons: turkey vulture (n=35), red-tailed hawk (n=26), northern harrier (n=13), American kestrel (n=4), sharp-shinned hawk (n=3), osprey (n=2), Cooper's hawk (n=2) and merlin (n=1; Table 9). Two raptors observed were not identifiable to species. The turkey vulture and the red-tailed hawk had the highest overall mean use (0.27 birds/30 min and 0.20 birds/30 min, respectively). No owl species were detected in any season of avian use surveys.

Overall mean use by non-raptors and raptors varied by point count location. For non-raptors, overall mean use was highest at point 4 (45.82 birds/30 min), followed by point 3 (43.73 birds/30 min; Figure 7). Overall mean use for raptors was highest at points 6 (1.00 birds/30 min) and 5 (0.91 birds/30 min; Figure 8).

Discussion

The Hatchet Wind Project is one of the first wind projects in California and the Western United States to be built on forested ridge top. As such, this study provides estimated annual fatality rates of Species of Concern for this project (Special-Status Species and Species Groups) which assess compliance with thresholds set under MM-BIO-6 of the operating permit. Additionally, we assess annual estimated fatalities rates in habitat with limited studies on the ecological impacts of wind energy development.

Birds

The prevalence of songbirds among avian fatalities documented at the Project is consistent with trends observed at other wind energy facilities, where approximately 80 percent of avian fatalities documented have been songbirds (Erickson et al. 2001, Johnson et al. 2002, Drewitt and Langston 2006, Strickland and Morrison 2008). Songbird fatalities were predominantly documented during spring, a pattern consistent with other year-round post-construction mortality monitoring studies (Young et al. 2003, Arnett et al. 2007, Gritski et al. 2010). This pattern coincides with songbird mean use values, values which were higher during periods of migration. The majority of songbird fatalities detected were migrant species; the yellow-rumped warbler was the migrant with the highest number of fatalities detected (n=2) and most likely breeds in the area. Other songbird species with multiple fatalities were, Stellar's jay, dark-eyed junco and American robin, are resident species. The dark-eyed junco had the highest mean use of all song bird species during avian surveys conducted pre-construction (West 2007) and post-construction. With the exception of the Stellar's jay, evening grosbeak, and bushtit, species associated with higher-elevation forest communities in the Pacific Northwest, each of the songbird species detected at the Project has been documented as fatalities at other wind energy facilities in North America (Erickson 2004, Kerlinger et al. 2006, Jain, et al. 2007, Drake 2010, Johnson 2011).

Fatality estimates for small birds at the Project (4.67/turbine/year; 90% CI: 3.32, 6.57) fall within the range of reported estimated fatality rates from projects within the Pacific Northwest. Annual estimated fatality rates at facilities with publically available data range from a low of 0.5 small birds/turbine/year to high of 5.75 small birds/turbine/year (Erickson 2000, Gristki 2010). Comparison projects, however, can vary in the data collection, data analysis, and time frame sampled.

Waterfowl are not typically documented as a species group with high numbers of fatalities at operational wind energy facilities despite high mean use in some locations (Jain 2005, Johnson and Erickson 2011). This pattern did not hold for the Project. At Hatchet Ridge, waterfowl represented the avian group with the highest mean use overall and the second highest number of total detected fatalities (n=18). All waterfowl fatalities were detected in March through May (with the exception of 1 detection in January), a time-frame coinciding with spring migration. Weather events inclusive of snow, high winds and dense fog occurred at the Project during this time-frame with fatalities detected after significant weather events. The timing of fatality detection suggests that weather, combined with general waterfowl abundance, plays a role in the occurrence of waterfowl fatalities at the Project.

Conversely to spring, no waterfowl fatalities were detected during the fall migratory season despite the fact that fall had the highest waterfowl mean use (67.17 birds/30 min). However, no major weather events came through the area during the fall time-frame (Ken Hammon, pers. comm) and a considerably higher waterfowl mean use occurred during this season compared to each other season (n=67.17). The higher mean use was primarily attributed to infrequent but large flocks observed flying at high altitudes over the area. These seasonal differences in use, fatalities, and weather patterns support researchers' conclusions that the risk of avian collision can increase with conditions of poor visibility (Desholm and Kahlert 2005) or strong wind (Smallwood 2009).

Waterfowl fatalities may be associated with localized movements during poor weather conditions. The Haynes Reservoir, located approximately 0.6 kilometers (1 mile) to the east of the Project, has congregations of both resident and migrant waterfowl. Migrant and resident waterfowl also move between the Klamath Wildlife Refuge System and the Sacramento Valley. These localized movements are not as likely to be limited by poor weather conditions as are large-scale migratory movements, and thus, waterfowl making these movements may be more susceptible to collision during poor weather conditions.

Raptors are a group of special interest as they appear to be particularly vulnerable to collision due to their propensity to fly at heights similar to a turbine RSA. Strickland et al. (2011) found that 6 percent of reported avian fatalities at North American wind energy facilities were raptors, despite the fact that they are not as abundant as other species groups. Raptors represented 4 percent (n=3) of the total avian fatalities at the Project compared to representing 2.4 percent of all birds detected during avian use surveys. Additionally, the majority of raptor observations were made at the height of the rotor swept area (n=65.9 percent), compared to non-raptors (n=9.5 percent at the height of the RSA). Thus, raptor flight behavior at the Project is similar to general raptor flight behavior and is likely a contributing factor to raptor fatalities at the Project. All 3 of the raptor fatalities reported at the Project are from species that breed locally in the area (turkey vulture, red-tailed hawk and sharp-shinned hawk). The turkey vulture and the red-tailed hawk were the most commonly observed raptors during both pre-construction and post-construction avian use surveys (West 2007). While not commonly detected, the sharp-shinned hawk was present during both pre-construction and post-construction avian use surveys with similar low mean use values in both studies (0.05 and 0.03 birds/30 min, respectively). Each of these species have been reported as fatalities at other wind energy facilities (Stantec 2010, Johnson and Erickson 2011).

The estimated raptor fatalities rates at the Project (0.06 raptors/turbine/year) were comparable to rates of raptor fatalities found regionally. Regional estimated fatality rates from projects in the Pacific Northwest ranged from 0.06 raptors/turbine to 0.49 raptors/turbine (Erickson 2004, Gritski 2010). Comparison projects, however, can vary in the data collection, data analysis, and time frame sampled.

Bats

Most bat fatalities at wind energy facilities have been recorded during late summer to early fall, which coincides with the fall migration period for tree-roosting bats in North America (Cryan 2003, Kunz et al. 2007, Arnett et al. 2008) which are the dominant species found as fatalities during post-construction mortality studies (Kunz et al. 2007, Arnett et al. 2008, Strickland et al. 2011). This pattern of fatalities exists at the Project with the highest proportion of bat fatalities occurring in summer (early August through mid-September) followed by fall (mid-September through mid-October). The migratory tree-roosting species detected as fatalities at the Project included silver-haired bat (n=8) and the hoary bat (n=3).

An alternate fatality pattern emerged, though, for the Brazilian free-tailed bat. Although fatalities of the Brazilian free-tailed bat (n=7) were detected in the same general time frame as the majority of migratory tree-roosting bat species fatalities, 5 of the 7 Brazilian free-tailed bat fatalities were detected within a single survey period covering the dates of September 20-22 with fatalities distributed throughout the turbines. This pulse of fatalities is likely a result of activity related to foraging (e.g. a pulse in insect availability) as opposed to activity relating to migratory movements (Genoways 2000, Rydell 2010). Brazilian free-tailed bats, one of the most studied bat populations in the world, occur in high numbers in the southwestern United States and have made up a high proportion of bat fatalities detected at wind energy facilities in that region of the country. These fatalities are largely attributable to proximity to maternity colonies as opposed to migratory movements (Strickland 2011). Brazilian free-tailed bats in Northern California are uncommon; populations consist of non-migratory residents that engage in local, attitudinally seasonal movements and hibernate in winter (Russell 2005). Fatality patterns of Brazilian free-tailed bats, then, are likely related to foraging behavior suggesting that a temporal pattern to Brazilian free-tailed bat fatalities at the Project is linked to insect availability.

Bat fatality rates are known to vary regionally and locally (Arnett et al. 2008, Baerwald and Barclay 2009) and while the highest bat fatality rates occur at wind projects in the forested mountains in the eastern United States, recent studies suggest that facilities constructed in agricultural landscapes also result in relatively high fatality rates (Strickland et al. 2011). Estimated bat fatality rates at the Project (5.13 bat fatalities/turbine/year; 90% CI=1.94-9.47) are comparable to those reported at wind energy facilities in the Pacific Northwest and California, e.g., Solano County, CA at 3.63 bat fatalities/turbine/year, and Nine Canyon, WA at 3.21 bat fatalities/turbine/year; 90% CI=1.17-5.37). Both facilities however are located within an agricultural landscape. While these projects offer a general comparison for bat fatality rates, these studies vary in the data collection, data analysis, and time frame sampled. Based on limited data directly comparable to the Project, a second year of mortality monitoring at the Project may contribute to further understanding of bat fatality patterns in the forested mountain habitat of the Pacific Northwest.

Mitigation Measure BIO-6 Thresholds

MM BIO-6 provides fatality thresholds for special status species. Exceeding these thresholds, or unanticipated impacts to other special-status species, may trigger the TAC to recommend that the Shasta County Planning Director require implementation of additional mitigation. MM BIO-6 sets fatality thresholds either by the number of fatalities per year or the number of fatalities per turbine per year, depending on the species or species group. For the California fully protected species, bald eagle and sandhill crane, the annual fatality threshold is one fatality per year. For 3 Special-Status Species or Groups, thresholds are set at 0.35 fatalities/turbine for other raptor species, 0.07 fatalities/turbine for the yellow warbler and 0.11 fatalities/turbine for owls (Table 10).

No bald eagle, sandhill crane, or owl fatalities were detected; thus, these species/groups were below their thresholds of 1 fatality per year (eagle and crane) or 0.11 fatalities/turbine/year (owls). Similarly, the calculated annual estimated raptor fatality rate at the Project is 0.06 fatalities/turbine which does not exceed the 0.35 raptor fatalities/turbine threshold (Table 10).

The estimated yellow warbler fatality rate at the Project (0.19 fatalities/turbine) exceeds the per turbine threshold (0.07 fatalities/turbine/year). This value was calculated based on a single fatality found during the biweekly searches and, as such, has low accuracy. Because the threshold was exceeded, the TAC may recommend additional mitigation.

Sources of Study Bias

Fatality estimates at the Project are calculated based upon search plots being established as 100 percent searchable areas; estimates were not corrected for any area not searched within a search plot. Because these types of corrections are dependent on sample size, these adjustments will not be made annually, but will be accounted for after the full 2-year study. Because there is probability that a carcass could land in the non-searchable area of a search plot and thus not be included in the estimate, fatality estimates presented for the Project likely include a downward bias.

Another source of study bias is the surrogate species used for searcher efficiency and carcass persistence trials. The surrogate species used is most variable for bats because local sources of bat carcasses can be difficult to locate. In this study, mice were used as surrogates for bats in both carcass persistence and searcher efficiency trials. Searcher efficiency for bats (mice) was lower than that for small or large birds. Many projects in the Pacific Northwest use small birds as bat surrogates, which affects fatality estimates. Had we used small birds as a bat surrogate, fatality estimates for bats would have been lower based on the longer persistence time of small birds. Additionally, Hale and Karsten (2010) found that using mice as surrogates for bats could significantly affect carcass persistence estimates. In their study, bats persisted on average 3 days longer than mice and these shorter persistence times for mice resulted in an upward bias of fatality estimates (Hale and Karsten 2010). Thus the actual carcass persistence times for bats at the Project may be higher than those calculated and may have resulted in an upward bias of bat fatality rates at the Project.

Search interval can also introduce bias and alter project-level comparisons. Many studies conducted in the Pacific Northwest, and used as comparison projects here, follow a 28 day search interval due to

Energy Facility Siting Council Permitting requirements. However, we found that bat persistence times to be far less than 28 days at the Project. If the carcass persistence times at other projects are comparable, those projects with a 28 day search interval could result in a downward bias of estimated fatality rates.

Conclusions

Of the 5 MMBIO-6 focus species and groups with annual Project fatality thresholds, only the yellow warbler exceeded the threshold set forth. No bald eagle or sandhill crane fatalities were detected, and although a single bald eagle and a small flock of sandhill cranes were observed incidentally, neither species was observed at any point during a full year of avian use surveys. No owls were detected as fatalities. Initial study results, then, suggest limited Project risk to these California Fully Protected Species and Project Special-Status Species Group. Although other raptor fatalities were detected, the estimated annual fatalities for this Special-Status Species group remains below the threshold set forth in MMBIO-6. The estimated annual fatality rate for the yellow warbler, however, exceeds the MMBIO-6 threshold for the first year of the 2 year study.

Estimated avian fatality rates at the Project were comparable to other reported fatality rate estimates in the Pacific Northwest although protocol and terrain or habitats differ between the studies. The avian species reported as fatalities were similar in composition to other reported fatalities at North American wind energy facilities, with the exception of 3 species associated with high elevation forested habitat: Stellar's jay, evening grosbeak, and bushtit. The timing of most fatalities is consistent with spring migration although overall avian mean use was highest in fall, primarily due to large flocks of migrating waterfowl. Waterfowl fatalities however, are likely due to localized movements of birds utilizing the Haynes Reservoir rather than large-scale migratory movements, and are likely influenced by weather events. All but one of the identified avian species (European starling) are protected under the Migratory Bird Treaty Act (MBTA).

Estimated bat fatality rates at the Project were comparable to those reported at wind energy facilities in the Pacific Northwest and in Solano County, CA. Comparison between post-construction mortality monitoring projects are difficult to make due to differences in survey methods (e.g. lengthy of survey, search interval, bat surrogates, transect spacing), and to differences in project location. The higher fatality estimates at the Project could represent actual higher bat use of the area in comparison to other projects in the region or may reflect biases introduced by different survey and statistical methods. Bat fatality rates at the Project were highest during summer and fall and included hoary, silver-haired bats and Brazilian free-tailed bats as the species found as fatalities. Although the species composition and temporal and spatial patterns have been observed at other North American wind energy facilities, the pulse of Brazilian free-tailed bat fatalities could be a pattern unique to the Project and warrants a second year of data before drawing conclusions.

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Table 1. Hatchet Ridge Wind Farm carcasses search dates.

Survey Period	Dates
Winter 2010-2011	
1	12/12-12/23
2	12/27-12/31
3	1/10-1/17
4	1/25-1/27
5	2/7-2/13
6	2/22-2/28
7	3/7-3/17
Spring 2011	
8	3/22-3/31
9	4/4-4/9
10	4/19-4/21
11	5/3-5/7
12	5/19-5/21
13	5/30-6/4
14	6/13-6/15
Summer 2011	
15	6/27-7/2
16	7/12-7/15
17	7/25-7/28
18	8/8-8/10
19	8/22-8/26
20	9/6-9/11
Fall 2011	
21	9/19-9/23
22	10/4-10/8
23	10/17-10/21
24	11/1-11/5
25	11/15-11/18
26	11/28-11/30

Table 2. Summary of avian and bat fatalities found during biweekly searches at Hatchet Ridge Wind Farm from 12/12/2010 to 11/30/2011.

Group / Species	Winter 2010-2011	Spring 2011	Summer 2011	Fall 2011	Total Fatalities
Bat					
silver-haired bat	0	2	2	1	**5**
unidentified bat	0	2	1	1	**4**
Brazilian free-tailed bat	0	0	1	1	**2**
hoary bat	0	0	1	0	**1**
Bat Total	**0**	**4**	**5**	**3**	**12**
Songbirds					
unidentified songbird	0	5	0	1	**6**
Steller's jay	0	2	1	0	**3**
yellow-rumped warbler	1	1	0	0	**2**
unidentified kinglet	0	2	0	0	**2**
dark-eyed junco	1	1	0	0	**2**
yellow warbler	0	0	1	0	**1**
red-winged blackbird	0	1	0	0	**1**
ruby-crowned kinglet	0	1	0	0	**1**
Lincoln’s sparrow	0	0	1	0	**1**
golden-crowned kinglet	0	1	0	0	**1**
evening grosbeak	0	1	0	0	**1**
European starling	0	0	1	0	**1**
cliff swallow	0	0	1	0	**1**
bushtit	0	0	0	1	**1**
American robin	0	1	0	0	**1**
Songbirds Total	**2**	**16**	**5**	**2**	**25**

Table 2. Summary of avian and bat fatalities found during biweekly searches at Hatchet Ridge Wind Farm from 12/12/2010 to 11/30/2011.

Group / Species	Winter 2010-2011	Spring 2011	Summer 2011	Fall 2011	Total Fatalities
Waterfowl					
unidentified waterfowl	3	5	0	0	**8**
unidentified goose	0	2	0	0	**2**
Ross' s goose	0	1	0	0	**1**
Waterfowl Total	**3**	**8**	**0**	**0**	**11**
Waterbirds					
American coot	0	1	0	2	**3**
unidentified shorebird	0	1	0	0	**1**
Waterbirds Total	**0**	**2**	**0**	**2**	**4**
Other					
unidentified bird	0	3	1	0	**4**
Other Total	**0**	**3**	**1**	**0**	**4**
Gamebirds					
mountain quail	0	0	2	0	**2**
Gamebirds Total	**0**	**0**	**2**	**0**	**2**
Swifts/Hummingbirds					
Vaux's swift	0	0	1	0	**1**
Swifts/Hummingbirds Total	**0**	**0**	**1**	**0**	**1**
Raptors					
turkey vulture	0	1	0	0	**1**
Raptors Total	**0**	**1**	**0**	**0**	**1**
Total	**5**	**34**	**14**	**7**	**60**

Table 3. Summary of avian and bat fatalities found during monthly searches at Hatchet Ridge Wind Farm from 12/12/2010 to 11/30/2011.

Group Species	Winter 2010-2011	Spring 2011	Summer 2011	Fall 2011	Total Fatalities
Bat					
Brazilian free-tailed bat	0	0	0	4	**4**
silver-haired bat	0	0	1	1	**2**
hoary bat	0	0	1	0	**1**
Bat Total	**0**	**0**	**2**	**5**	**7**
Songbirds					
unidentified songbird	0	3	0	0	**3**
unidentified kinglet	0	1	0	0	**1**
Steller's jay	0	0	0	1	**1**
American robin					**1**
Songbirds Total	**0**	**4**	**0**	**1**	**6**
Waterfowl					
unidentified waterfowl	3	1	0	0	**4**
Waterfowl Total	**3**	**1**	**0**	**0**	**4**
Other					
unidentified bird	1	2	0	1	**4**
Other Total	**1**	**2**	**0**	**1**	**4**
Raptors					
red-tailed hawk	0	0	0	1	**2**
sharp-shinned hawk	0	0	0	1	**1**
Raptors Total	**0**	**0**	**0**	**2**	**3**
Total	**4**	**7**	**2**	**9**	**24**

Table 4. Summary of avian and bat fatalities found as incidentals at Hatchet Ridge Wind Farm from 11/18/2010 to 11/30/2011.

Group Species	Winter 2010-2011	Spring 2011	Summer 2011	Fall 2011	Total Fatalities
Bat					
hoary bat	0	0	1	0	**1**
silver-haired bat	0	0	1	0	**1**
Brazilian free-tailed bat	0	0	0	1	**1**
unidentified bat	0	0	1	0	**1**
Bat Total	**0**	**0**	**3**	**1**	**4**
Waterfowl					
greater white-fronted goose	0	3	0	0	**3**
Waterfowl Total	**0**	**3**	**0**	**0**	**3**
Waterbirds					
unidentified grebe	0	1	0	0	**1**
Waterbirds Total	**0**	**1**	**0**	**0**	**1**
Songbirds					
Brewer's blackbird	0	0	0	1	**1**
golden-crowned sparrow	0	0	0	1	**1**
yellow warbler	0	1	0	0	**1**
Songbirds Total	**0**	**1**	**0**	**2**	**3**
Total	**0**	**5**	**3**	**3**	**11**

Table 5. Searcher efficiency trial results at Hatchet Ridge Wind Farm with bootstrapped 90% confidence interval (CI).

Carcass Category	Searcher Efficiency	CI	n*
Bat	0.60	0.47–0.71	45
Small bird	0.76	0.69–0.83	121
Large bird	0.85	0.75–0.95	40

* Number of carcasses placed

Table 6. Carcass persistence at Hatchet Ridge Wind Farm with bootstrapped 90% confidence interval (CI).

Carcass Category	Persistence (days)	CI	n*
Bat	2.5	1.96–2.95	30
Small bird	5.6	4.17–7.53	52
Large bird	116.0	63.74–254.5	38

* Number of carcasses placed

[1] Right censoring of persistence data can result in values greater than the 21 day trial.

Table 7. Fatality estimates at Hatchet Ridge Wind Farm with 90% confidence interval (CI).

Carcass Category/Species [1]	n*	Total Estimate	CI	Per Turbine Estimate	CI	Per MW Estimate	CI
Bats	12	226	86-417	5.13	1.94–9.47	2.23	0.84-4.12
Birds							
Small birds	29	206	147-290	4.67	3.32–6.57	2.03	1.44-2.86
Large birds	19	48	30-69	1.08	0.66–1.57	0.47	0.29-0.68
Raptor	1	-	-	0.06	0.05–0.18	0.03	0.02-0.07
Non-raptor	47	251	187-337	5.69	4.24–7.66	2.47	1.84-2.86
Waterfowl	11	28	12-46	0.63	0.25–1.04	0.27	0.11-0.45
Yellow warbler[2]	1	-	-	0.19	0.15–0.62	0.08	0.06-0.27

[*] Number of fatalties found

[1] Categories of small/large bird and raptor/non-raptor are different groupings of bird fatalities

[2] Insufficient sample ($\geq$5) size affects accuracy of estimate

Table 8. Hatchet Ridge Wind Farm point count survey dates.

	Survey Number	Date(s)
Winter 2010-2011		
	1	12/12-12/18
	2	1/10-1/14
	3	2/7-2/11
	4	3/7-3/11
Spring 2011		
	1	3/30-3/31
	2	4/6-4/9
	3	4/21-4/22
	4	5/5-5/7
	5	5/18-5/21
	6	6/3-6/4
	7	6/13-6/14
Summer 2011		
	1	6/27
	2	7/2
	3	7/14
	4	7/25
	5	8/9
	6	8/24
	7	9/11
Fall 2011		
	1	9/21
	2	10/2
	3	10/19
	4	11/5
	5	11/16

Table 9. Avian mean use, by species group, observed during point count surveys at the Hatchet Ridge Wind Farm, 2010-2011.

Species Group Species	Winter 2010-2011			Spring 2011			Summer 2011			Fall 2011			Overall		
	# Birds	# Obs.	Mean Use*	# Birds	# Obs.	Mean Use*	# Birds	# Obs.	Mean Use*	# Birds	# Obs.	Mean Use*	# Birds	# Obs.	Mean Use*
Waterfowl															
snow goose	132	3	5.50	0	0	0.00	0	0	0.00	1042	19	34.73	**1174**	**22**	**8.89**
Ross' s goose	120	2	5.00	0	0	0.00	0	0	0.00	973	18	32.43	**1093**	**20**	**8.28**
Canada goose	16	1	0.67	0	0	0.00	0	0	0.00	0	0	0.00	**16**	**1**	**0.12**
Group Total	**268**	**6**	**11.17**	**0**	**0**	**0.00**	**0**	**0**	**0.00**	**2015**	**37**	**67.17**	**2283**	**43**	**17.30**
Songbirds															
dark-eyed junco	2	1	0.08	73	35	1.74	57	37	1.58	64	21	2.13	**196**	**94**	**1.48**
song sparrow	0	0	0.00	94	93	2.24	63	62	1.75	8	6	0.27	**165**	**161**	**1.25**
mountain chickadee	29	18	1.21	27	19	0.64	31	18	0.86	19	12	0.63	**106**	**67**	**0.80**
bushtit	24	6	1.00	10	4	0.24	11	3	0.31	39	4	1.30	**84**	**17**	**0.64**
mountain bluebird	0	0	0.00	17	13	0.40	4	2	0.11	52	6	1.73	**73**	**21**	**0.55**
American robin	0	0	0.00	9	6	0.21	6	5	0.17	56	12	1.87	**71**	**23**	**0.54**
Steller's jay	9	6	0.38	24	18	0.57	5	5	0.14	16	16	0.53	**54**	**45**	**0.41**
common raven	12	8	0.50	21	15	0.50	3	3	0.08	12	8	0.40	**48**	**34**	**0.36**
lesser goldfinch	0	0	0.00	0	0	0.00	28	9	0.78	18	4	0.60	**46**	**13**	**0.35**
spotted towhee	0	0	0.00	12	12	0.29	15	15	0.42	14	7	0.47	**41**	**34**	**0.31**
yellow-rumped warbler	0	0	0.00	15	10	0.36	1	1	0.03	7	5	0.23	**23**	**16**	**0.17**
yellow warbler	0	0	0.00	14	10	0.33	6	4	0.17	0	0	0.00	**20**	**14**	**0.15**
Nashville warbler	0	0	0.00	0	0	0.00	10	3	0.28	4	2	0.13	**14**	**5**	**0.11**
red-breasted nuthatch	3	3	0.13	4	3	0.10	2	2	0.06	3	3	0.10	**12**	**11**	**0.09**
house finch	0	0	0.00	0	0	0.00	4	3	0.11	8	2	0.27	**12**	**5**	**0.09**
western scrub-jay	0	0	0.00	4	4	0.10	0	0	0.00	6	2	0.20	**10**	**6**	**0.08**
unidentified songbird	0	0	0.00	0	0	0.00	4	2	0.11	4	4	0.13	**8**	**6**	**0.06**
ruby-crowned kinglet	0	0	0.00	3	3	0.07	2	2	0.06	3	2	0.10	**8**	**7**	**0.06**

* Mean use=# birds/30 min.

Table 9. Avian mean use, by species group, observed during point count surveys at the Hatchet Ridge Wind Resource Area, 2010-2011.

Species Group Species	Winter 2010-2011 # Birds	 # Obs.	 Mean Use*	Spring 2011 # Birds	 # Obs.	 Mean Use*	Summer 2011 # Birds	 # Obs.	 Mean Use*	Fall 2011 # Birds	 # Obs.	 Mean Use*	Overall # Birds	 # Obs.	 Mean Use*
western wood-pewee	0	0	0.00	0	0	0.00	0	0	0.00	3	2	0.10	**3**	**2**	**0.02**
red crossbill	0	0	0.00	0	0	0.00	0	0	0.00	3	1	0.10	**3**	**1**	**0.02**
house wren	0	0	0.00	0	0	0.00	1	1	0.03	2	1	0.07	**3**	**2**	**0.02**
Clark’s nutcracker	0	0	0.00	0	0	0.00	3	1	0.08	0	0	0.00	**3**	**1**	**0.02**
winter wren	0	0	0.00	2	2	0.05	0	0	0.00	0	0	0.00	**2**	**2**	**0.02**
western meadowlark	0	0	0.00	2	1	0.05	0	0	0.00	0	0	0.00	**2**	**1**	**0.02**
Say's phoebe	0	0	0.00	0	0	0.00	2	1	0.06	0	0	0.00	**2**	**1**	**0.02**
purple finch	0	0	0.00	2	1	0.05	0	0	0.00	0	0	0.00	**2**	**1**	**0.02**
green-tailed towhee	0	0	0.00	0	0	0.00	2	2	0.06	0	0	0.00	**2**	**2**	**0.02**
Brewer's blackbird	0	0	0.00	2	1	0.05	0	0	0.00	0	0	0.00	**2**	**1**	**0.02**
unidentified warbler	0	0	0.00	1	1	0.02	0	0	0.00	0	0	0.00	**1**	**1**	**0.01**
unidentified swallow	0	0	0.00	0	0	0.00	1	1	0.03	0	0	0.00	**1**	**1**	**0.01**
unidentified flycatcher	0	0	0.00	0	0	0.00	1	1	0.03	0	0	0.00	**1**	**1**	**0.01**
tree swallow	0	0	0.00	0	0	0.00	1	1	0.03	0	0	0.00	**1**	**1**	**0.01**
olive-sided flycatcher	0	0	0.00	0	0	0.00	1	1	0.03	0	0	0.00	**1**	**1**	**0.01**
dusky flycatcher	0	0	0.00	0	0	0.00	1	1	0.03	0	0	0.00	**1**	**1**	**0.01**
Cassin's vireo	0	0	0.00	1	1	0.02	0	0	0.00	0	0	0.00	**1**	**1**	**0.01**
brown creeper	0	0	0.00	0	0	0.00	0	0	0.00	1	1	0.03	**1**	**1**	**0.01**
Group Total	**79**	**42**	**3.29**	**337**	**252**	**8.02**	**265**	**186**	**7.36**	**342**	**121**	**11.40**	**1023**	**601**	**7.75**
Pigeons/Doves															
mourning dove	2	1	0.08	3	2	0.07	2	2	0.06	100	2	3.33	**107**	**7**	**0.81**
rock pigeon	0	0	0.00	0	0	0.00	2	1	0.06	0	0	0.00	**2**	**1**	**0.02**
Group Total	**2**	**1**	**0.08**	**3**	**2**	**0.07**	**4**	**3**	**0.11**	**100**	**2**	**3.33**	**109**	**8**	**0.83**
Raptors															

* Mean use=# birds/30 min.

Table 9. Avian mean use, by species group, observed during point count surveys at the Hatchet Ridge Wind Resource Area, 2010-2011.

Species Group Species	Winter 2010-2011			Spring 2011			Summer 2011			Fall 2011			Overall		
	# Birds	# Obs.	Mean Use*	# Birds	# Obs.	Mean Use*	# Birds	# Obs.	Mean Use*	# Birds	# Obs.	Mean Use*	# Birds	# Obs.	Mean Use*
turkey vulture	1	1	0.04	7	6	0.17	15	15	0.42	12	8	0.40	**35**	**30**	**0.27**
red-tailed hawk	7	6	0.29	5	4	0.12	10	8	0.28	4	4	0.13	**26**	**22**	**0.20**
northern harrier	0	0	0.00	7	7	0.17	4	4	0.11	2	2	0.07	**13**	**13**	**0.10**
American kestrel	0	0	0.00	2	2	0.05	2	2	0.06	0	0	0.00	**4**	**4**	**0.03**
sharp-shinned hawk	0	0	0.00	0	0	0.00	1	1	0.03	2	2	0.07	**3**	**3**	**0.02**
osprey	0	0	0.00	0	0	0.00	2	1	0.06	0	0	0.00	**2**	**1**	**0.02**
Cooper's hawk	0	0	0.00	1	1	0.02	1	1	0.03	0	0	0.00	**2**	**2**	**0.02**
unidentified raptor	0	0	0.00	0	0	0.00	1	1	0.03	0	0	0.00	**1**	**1**	**0.01**
unidentified hawk	0	0	0.00	1	1	0.02	0	0	0.00	0	0	0.00	**1**	**1**	**0.01**
merlin	0	0	0.00	1	1	0.02	0	0	0.00	0	0	0.00	**1**	**1**	**0.01**
Group Total	**8**	**7**	**0.33**	**24**	**22**	**0.57**	**36**	**33**	**1.00**	**20**	**16**	**0.67**	**88**	**78**	**0.67**
Woodpeckers															
northern flicker	2	2	0.08	19	19	0.45	3	3	0.08	15	15	0.50	**39**	**39**	**0.30**
downy woodpecker	1	1	0.04	3	3	0.07	2	2	0.06	3	3	0.10	**9**	**9**	**0.07**
acorn woodpecker	0	0	0.00	3	2	0.07	0	0	0.00	0	0	0.00	**3**	**2**	**0.02**
white-headed woodpecker	0	0	0.00	1	1	0.02	0	0	0.00	0	0	0.00	**1**	**1**	**0.01**
hairy woodpecker	0	0	0.00	1	1	0.02	0	0	0.00	0	0	0.00	**1**	**1**	**0.01**
Group Total	**3**	**3**	**0.13**	**27**	**26**	**0.64**	**5**	**5**	**0.14**	**18**	**18**	**0.60**	**53**	**52**	**0.40**
Gamebirds															
mountain quail	0	0	0.00	30	21	0.71	2	2	0.06	1	1	0.03	**33**	**24**	**0.25**
unidentified quail	0	0	0.00	3	2	0.07	0	0	0.00	0	0	0.00	**3**	**2**	**0.02**
California quail	0	0	0.00	1	1	0.02	0	0	0.00	0	0	0.00	**1**	**1**	**0.01**
Group Total	**0**	**0**	**0.00**	**34**	**24**	**0.81**	**2**	**2**	**0.06**	**1**	**1**	**0.03**	**37**	**27**	**0.28**

* Mean use=# birds/30 min.

Table 9. Avian mean use, by species group, observed during point count surveys at the Hatchet Ridge Wind Resource Area, 2010-2011.

Species Group Species	Winter 2010-2011			Spring 2011			Summer 2011			Fall 2011			Overall		
	# Birds	# Obs.	Mean Use*	# Birds	# Obs.	Mean Use*	# Birds	# Obs.	Mean Use*	# Birds	# Obs.	Mean Use*	# Birds	# Obs.	Mean Use*
Swifts/Hummingbirds															
calliope hummingbird	0	0	0.00	5	5	0.12	14	13	0.39	0	0	0.00	**19**	**18**	**0.14**
Anna's hummingbird	0	0	0.00	2	2	0.05	0	0	0.00	0	0	0.00	**2**	**2**	**0.02**
Group Total	**0**	**0**	**0.00**	**7**	**7**	**0.17**	**14**	**13**	**0.39**	**0**	**0**	**0.00**	**21**	**20**	**0.16**
Waterbirds															
American white pelican	0	0	0.00	10	1	0.24	0	0	0.00	0	0	0.00	**10**	**1**	**0.08**
killdeer	0	0	0.00	2	2	0.05	0	0	0.00	0	0	0.00	**2**	**2**	**0.02**
horned grebe	0	0	0.00	0	0	0.00	1	1	0.03	0	0	0.00	**1**	**1**	**0.01**
Group Total	**0**	**0**	**0.00**	**12**	**3**	**0.29**	**1**	**1**	**0.03**	**0**	**0**	**0.00**	**13**	**4**	**0.10**
Cranes/Rails															
sandhill crane	0	0	0.00	0	0	0.00	0	0	0.00	4	1	0.13	**4**	**1**	**0.03**
Group Total	**0**	**0**	**0.00**	**0**	**0**	**0.00**	**0**	**0**	**0.00**	**4**	**1**	**0.13**	**4**	**1**	**0.03**
Other															
unidentified bird	0	0	0.00	0	0	0.00	3	1	0.08	0	0	0.00	**3**	**1**	**0.02**
Group Total	**0**	**0**	**0.00**	**0**	**0**	**0.00**	**3**	**1**	**0.08**	**0**	**0**	**0.00**	**3**	**1**	**0.02**
Grand Total	**360**	**59**	**15.00**	**444**	**336**	**10.57**	**330**	**244**	**9.17**	**2500**	**196**	**83.33**	**3634**	**835**	**27.53**

* Mean use=# birds/30 min.

Table 10. MMBIO-6 Annual fatality thresholds for Special-Status Species and Species Groups with Hatchet Ridge Wind Farm fatality rates.

Species	Califiornia or MMBIO-6 Status	Fatality Threshold (fatalities/year)	Fatality Threshold (fatalities/turbine)	Hatchet Ridge Estimated Annual Fatality Rate (fatalities/turbine; Year 1)
Bald eagle	Fully Protected	1	-	0
Sandhill crane	Fully Protected	1	-	0
Other raptor species	Species Group of Special Concern	-	0.35	0.06
Yellow warbler	Species of Special Concern	-	0.07	0.19
Owls	Species Group of Special Concern	-	0.11	0

Figure 1

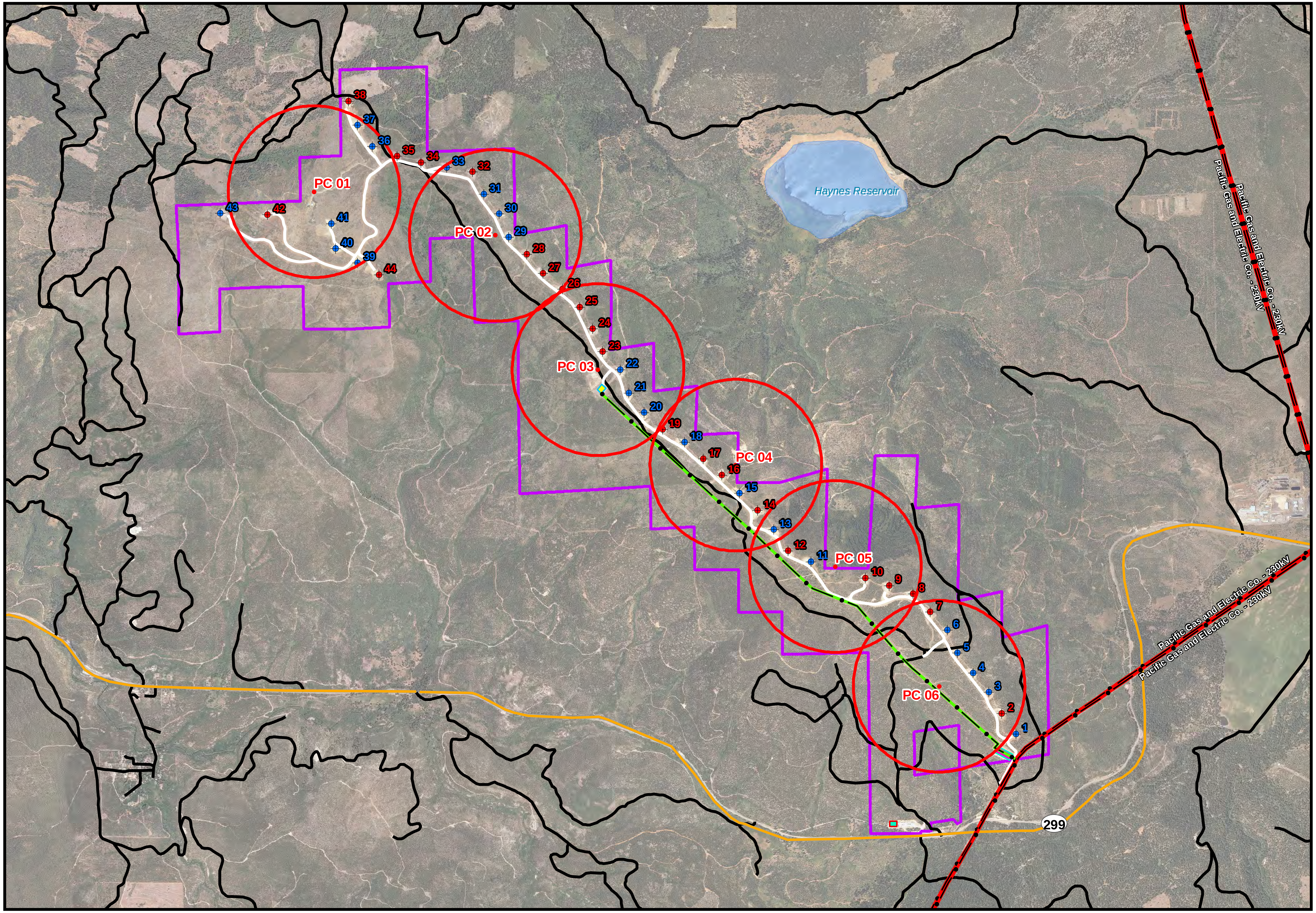
PATTERN ENERGY

Hatchet Ridge

Hatchet Ridge Wind Farm Turbine Layout and Avian Point Count Locations

Shasta County, CA

January 23, 2012



- Project Boundary
- O and M Facility
- Substation
- Switch Yard

Wind Turbine Generator

- 2 Week Search Interval
- Monthly Search Interval
- Overhead Transmission Line
- Transmission Line
- Avian Point Count (12-1-2010)
- Avian Point Count 800m Buffer
- State Highway
- Local Road
- Access Road
- Lake/Pond

1:35,000 NAD 1983 UTM 10

0 1 2 3 4 5 Miles

Data Sources ESRI 2007: roads, hydrography / USDA NAIP 2010: air photo / Platts 2010: existing transmission / Pattern Energy 2010: project infrastructure / TTEC 2010: avain point counts

TETRA TECH EC,INC

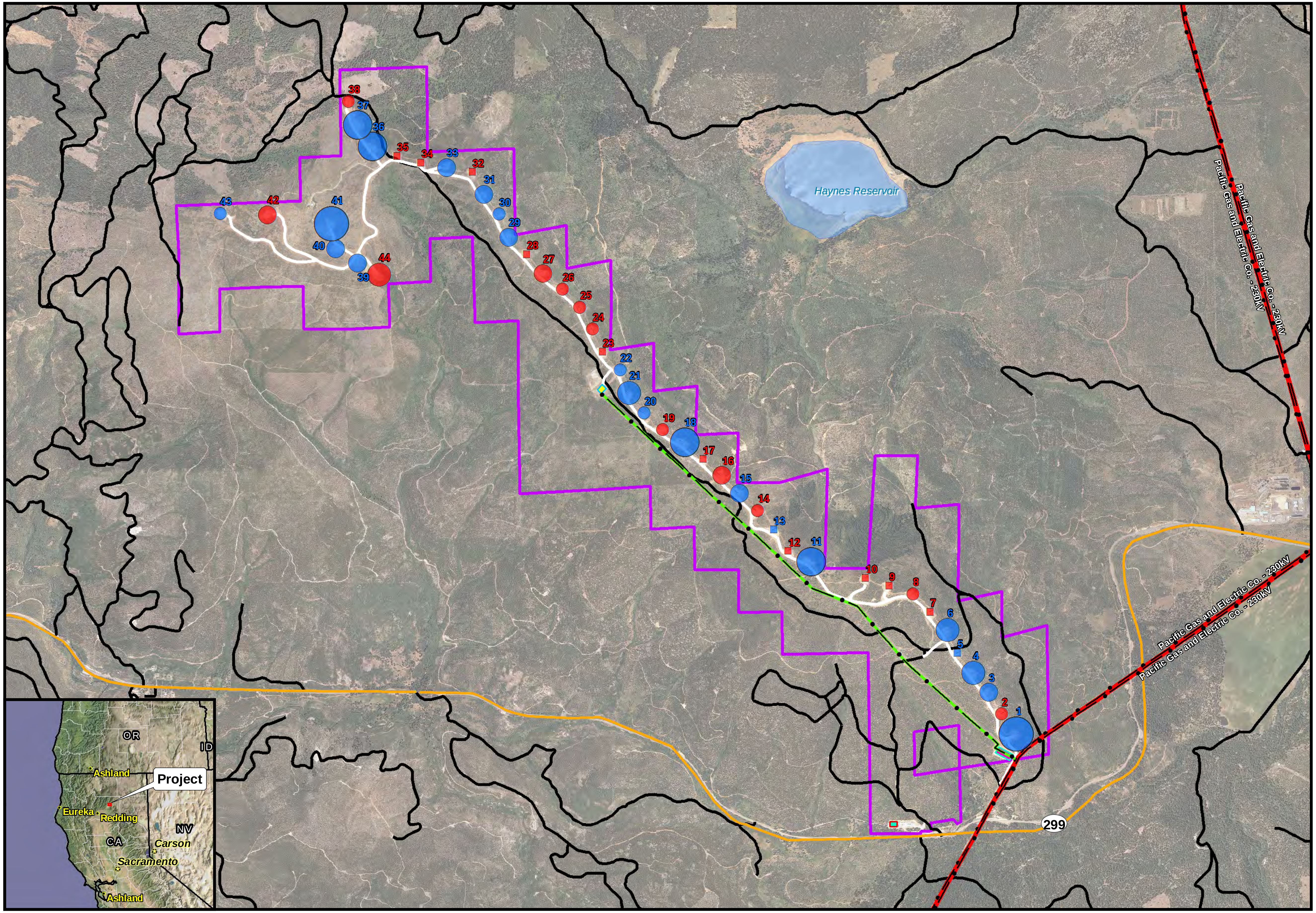


Figure 2

PATTERN ENERGY

Hatchet Ridge

Spatial Distribution of Avian Fatalities at the Hatchet Ridge Wind Farm (November 2010 - December 2011)

Shasta County, CA

January 23, 2012

- Project Boundary
- O and M Facility
- Substation
- Switch Yard
- Overhead Transmission Line
- Transmission Line
- State Highway
- Local Road
- Access Road
- Lake/Pond

Fatalities Detected Per Turbine

2 Week Search Interval

0, 1, 2, 3, 4, 5

Monthly Search Interval

0, 1, 2, 3

1:35,000 NAD 1983 UTM 10

0 1 2 3 4 5 Miles

Data Sources ESRI 2007: roads, hydrography / USDA NAIP 2010: air photo / Platts 2010: existing transmission / Pattern Energy 2010: project infrastructure / TTEC 2010: avain fatalities

TETRA TECH EC,INC

Figure 3

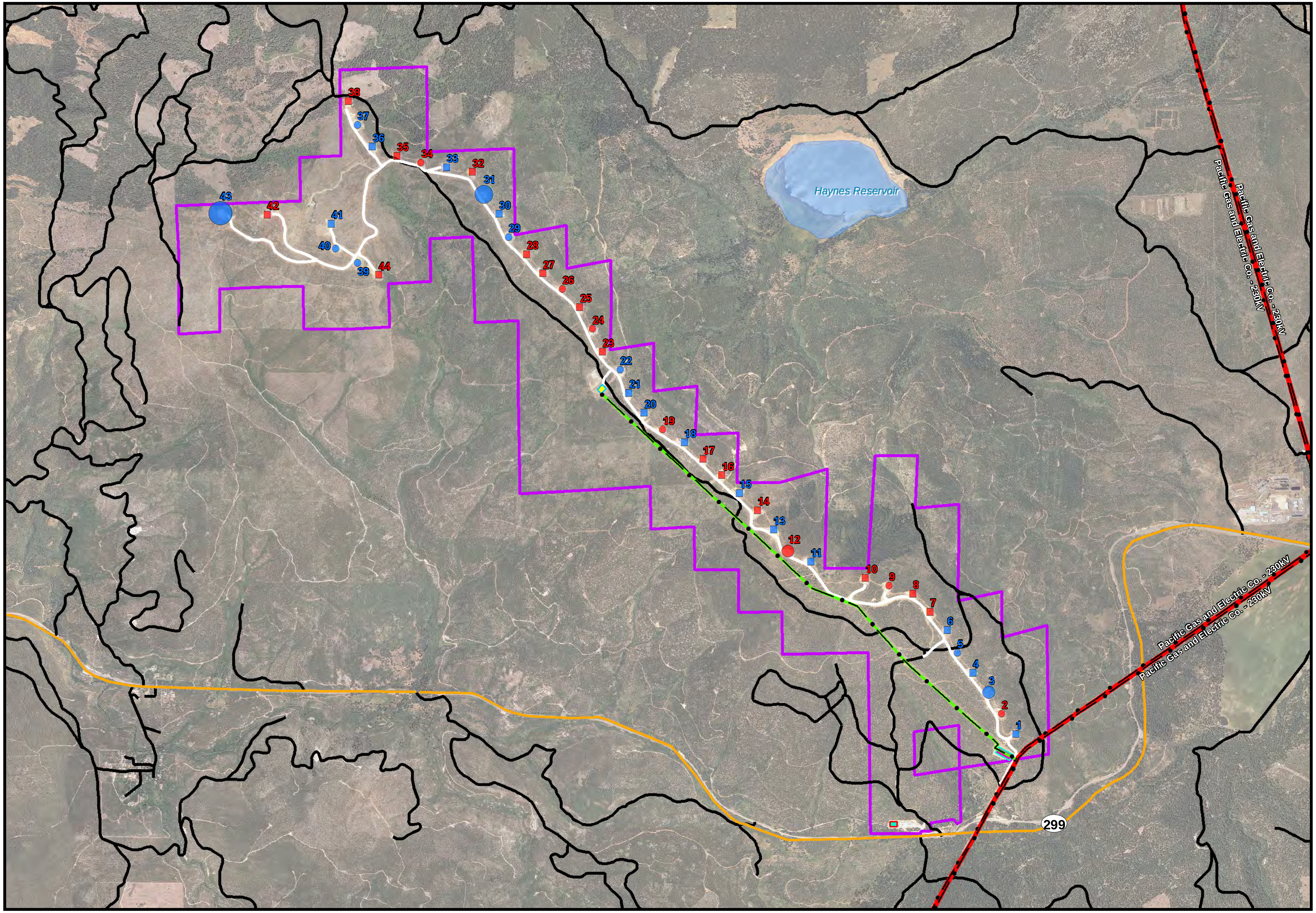
PATTERN ENERGY

Hatchet Ridge

Spatial Distribution of Bat Fatalities at the Hatchet Ridge Wind Farm (November 2010 - December 2011)

Shasta County, CA

January 23, 2012



Data Sources ESRI 2007: roads, hydrography / USDA NAIP 2010: air photo / Platts 2010: existing transmission / Pattern Energy 2010: project infrastructure / TTEC 2010: bat fatalities

Figure 4. Seasonal Distribution of Avian and Bat Fatalities at Hatchet Ridge Wind Farm, November 2010-December 2011.

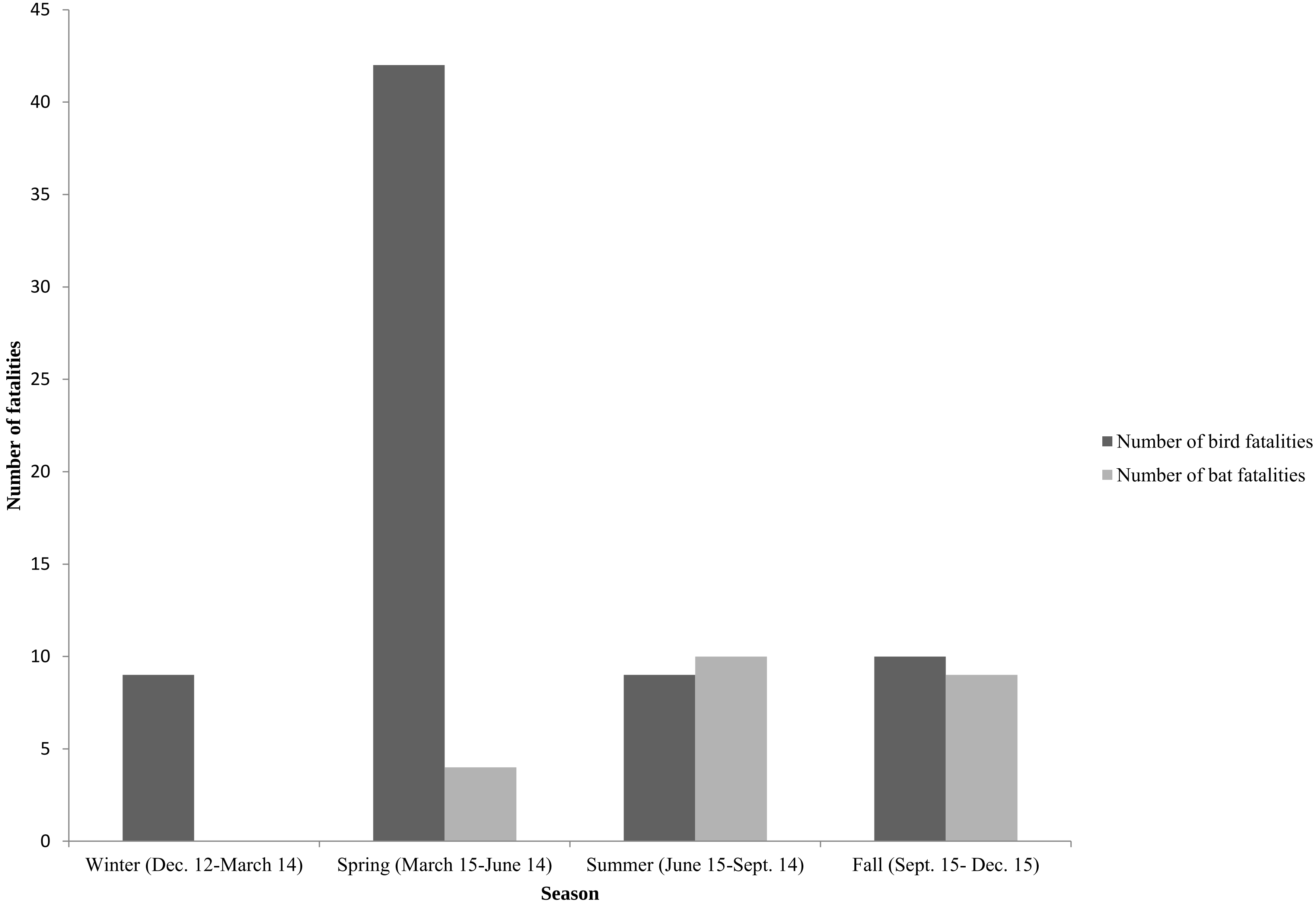
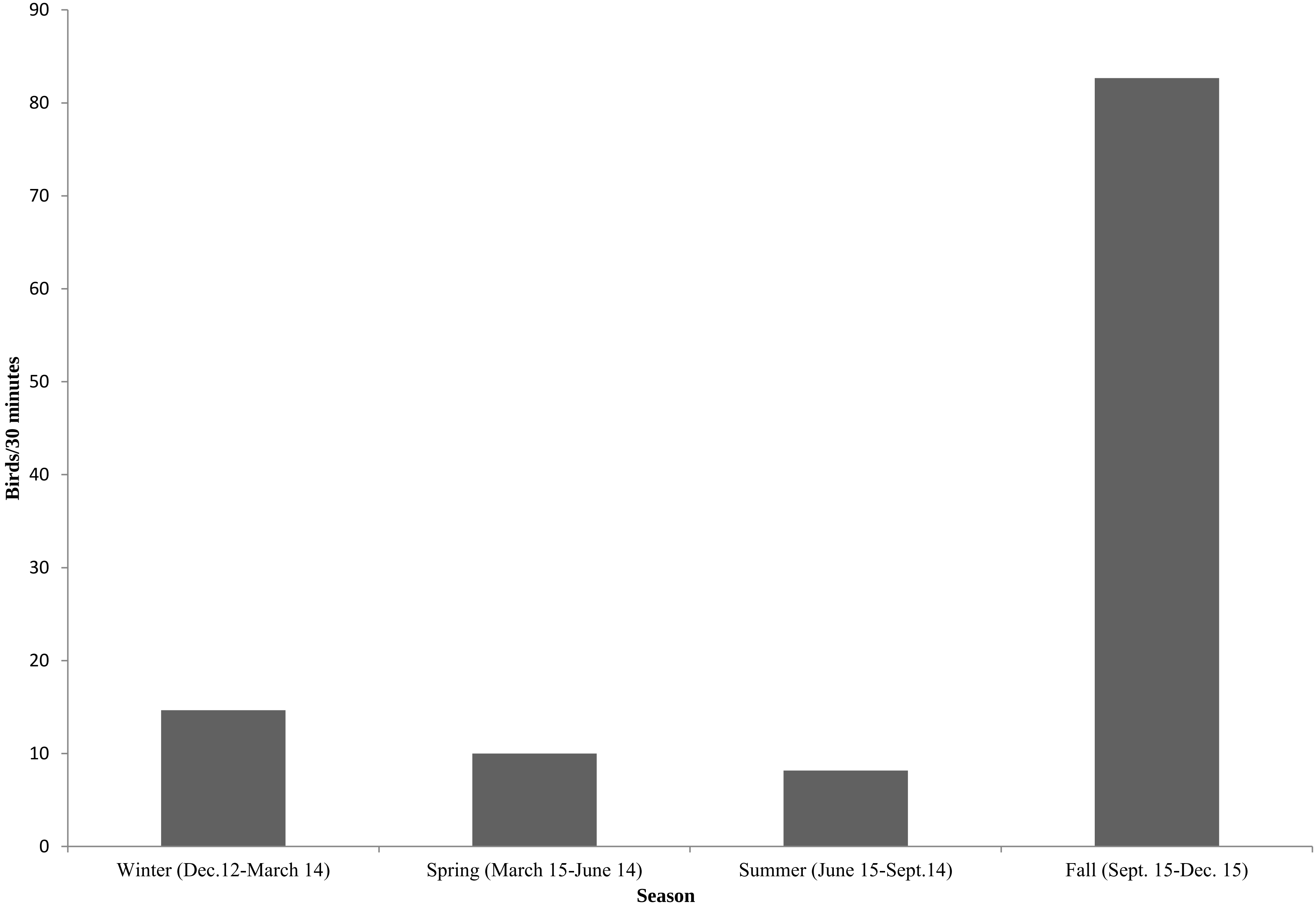


Figure 5. Non-raptor Mean Use by Season at the Hatchet Ridge Wind Farm, 2010-2011.



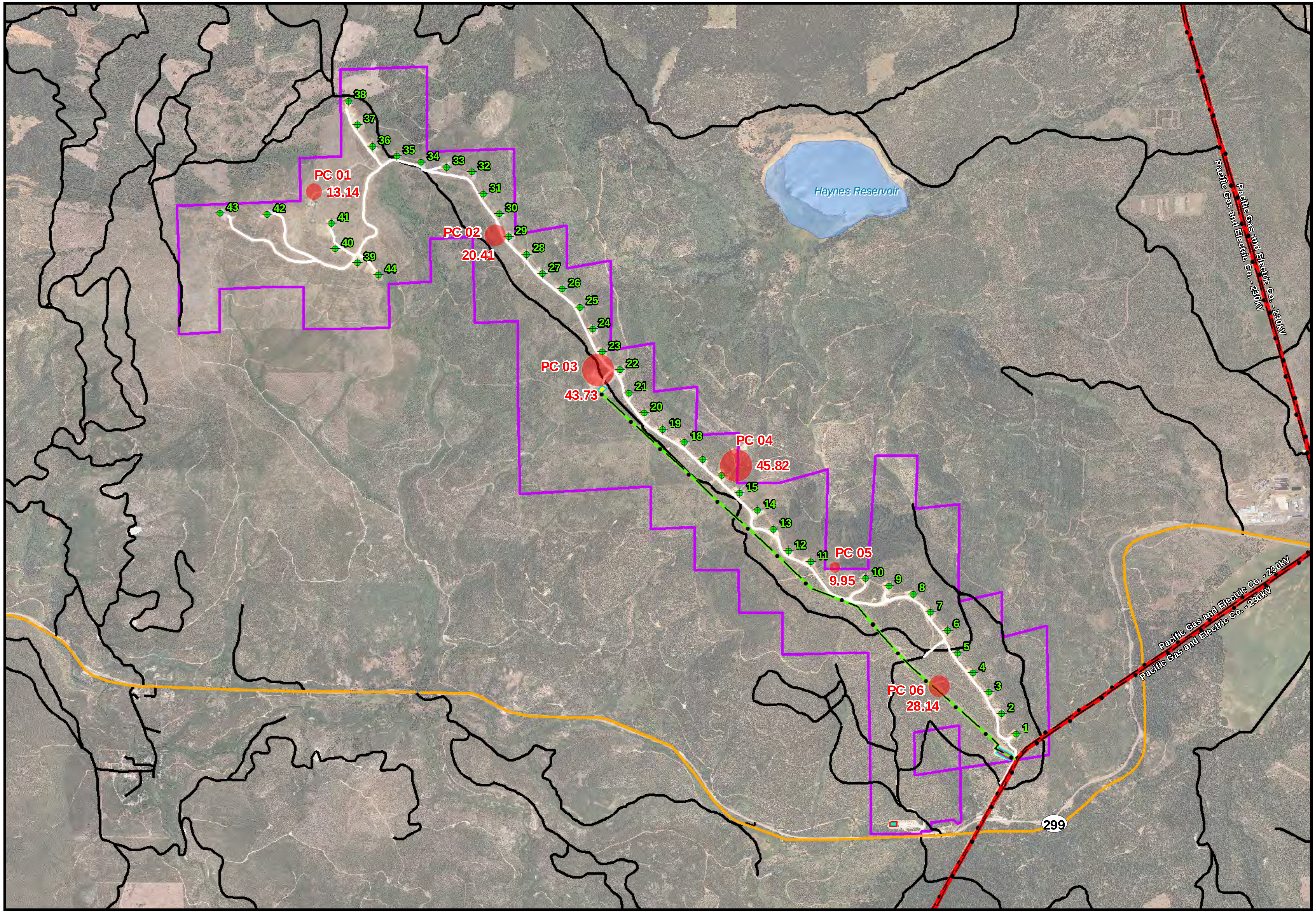


Figure 6

PATTERN ENERGY

Hatchet Ridge

Non-Raptor Mean Use by Point Count Location (December 2010 - November 2011)

Shasta County, CA

January 13, 2012

- Project Boundary
- O and M Facility
- Substation
- Switch Yard
- Wind Turbine Generator
- Overhead Transmission Line
- Transmission Line
- State Highway
- Local Road
- Access Road
- Lake/Pond

Non-Raptors per 30 minutes

- 0.01 - 10.00
- 10.01 - 20.00
- 20.01 - 30.00
- 30.01 - 40.00
- 40.01 - 50.00

1:35,000 NAD 1983 UTM 10

0 1 2 3 4 5 Miles

Data Sources ESRI 2007: roads, hydrography / USDA NAIP 2010: air photo / Platts 2010: existing transmission / Pattern Energy 2010: project infrastructure / TTEC 2012: non-raptor mean use

TETRA TECH EC,INC

P:\GIS_PROJECTS\Pattern_Energy\Hatchet_Ridge\MXDs\PCMM_Report_Jan2012\PatternEnergy_HatchetRidge_PCMMReport_Fig07_NonRaptorMeanUse_11i17_011312 - Last Accessed: 1/13/2012 - Map Scale correct at: ANSI B (17" x 11")

Figure 7. Raptor Mean Use by Season at the Hatchet Ridge Wind Farm, 2010 -2011.

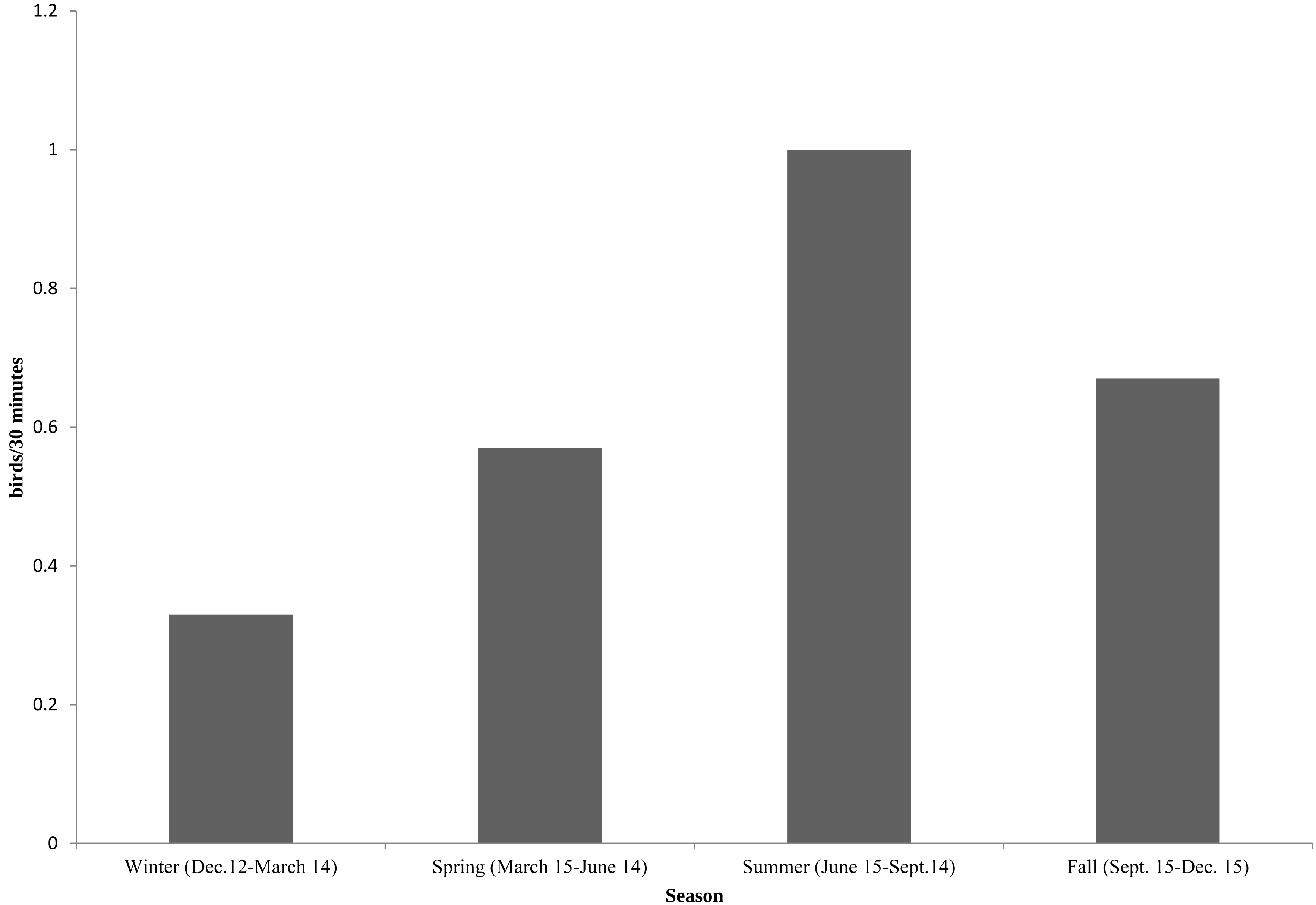


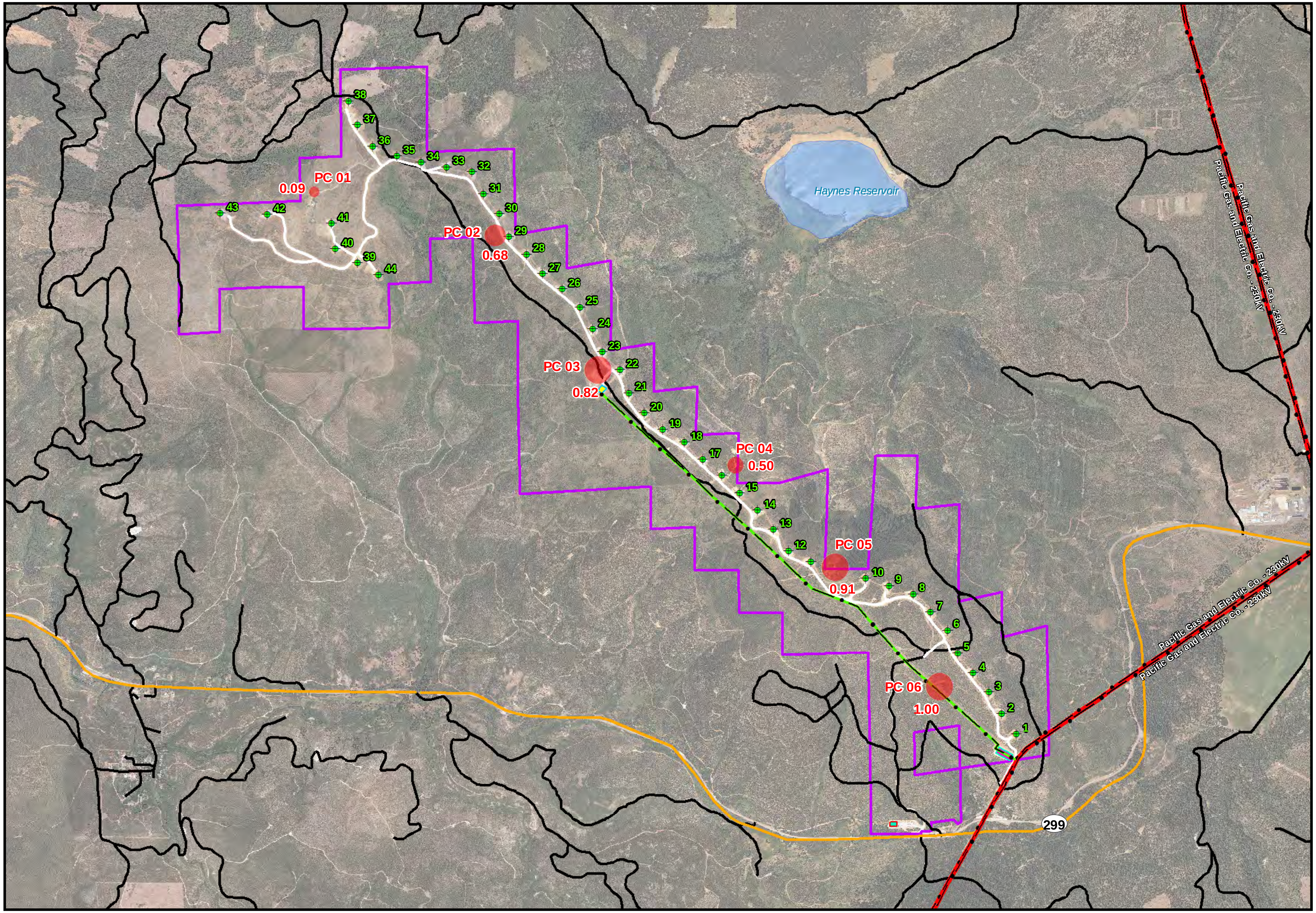
Figure 8

PATTERN ENERGY
Hatchet Ridge

Raptor Mean Use by Point Count Location (December 2010 - November 2011)

Shasta County, CA

January 13, 2012



- Project Boundary
- O and M Facility
- Substation
- Switch Yard
- Wind Turbine Generator
- Overhead Transmission Line
- Transmission Line
- State Highway
- Local Road
- Access Road
- Lake/Pond

Raptors per 30 minutes

- 0.01 - 0.25
- 0.26 - 0.50
- 0.51 - 0.75
- 0.76 - 1.00

1:35,000 NAD 1983 UTM 10

0 1 2 3 4 5 Miles

Data Sources ESRI 2007: roads, hydrography / USDA NAIP 2010: air photo / Platts 2010: existing transmission / Pattern Energy 2010: project infrastructure / TTEC 2012: raptor mean use

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