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

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March 2013

TTCES-PTLD 2013 129

Executive Summary

In October 2010, Tetra Tech, Inc. (Tetra Tech) was contracted to develop and implement a study plan which incorporated methods consistent with the California Energy Commission's California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development (CEC 2007), to monitor project-related avian and bat fatality rates for Hatchet Ridge Wind Farm (Project), a 44 turbine wind energy facility in Northern California. The study plan included 2 years of mortality monitoring at all 44 turbines in the form of standardized carcass searches (biweekly and monthly monitoring); searcher efficiency trials and carcass persistence trials were also incorporated into the study design to account for inherent bias in estimating Project-related fatality estimates.

This report presents the first and second year (Year One, Year Two) results of the post-construction mortality monitoring program, and includes a summary of documented fatalities, estimates of searcher efficiency and carcass persistence, and estimated fatality rates adjusted for bias. Additionally, observed trends in Project-related fatalities to Special-Status Species and Groups and sources of study bias are discussed.

In Year Two, a total of 63 fatalities were detected during 4 seasons of mortality monitoring; with 43 fatalities detected during biweekly searches, 16 fatalities during monthly searches, and 4 incidental fatalities. Detected fatalities included 25 bird and 18 bat fatalities during biweekly (2 week interval) standardized carcass searches at 22 turbines, and 11 bird and 5 bat fatalities during monthly searches at the remaining 22 turbines. In addition to the fatalities found during biweekly and monthly searches, 1 bird and 3 bat fatalities were incidentally detected. The avian species groups with the highest number of fatalities include waterfowl (n=18; 28 percent of bird fatalities) and songbirds (n=9; 14 percent of bird fatalities). One raptor fatality, a red-tailed hawk, was detected during monthly searches. Fatalities encompassed 34 bird fatalities from 14 species and 3 bird fatalities not identifiable to a species, as well as 26 bat fatalities from 3 species. Seasonal composition of fatalities varied, with the highest number of avian fatalities (n=20) occurring in spring and the highest number of bat fatalities occurring in summer (n=18).

No Special-Status Species (bald eagle or sandhill crane) were detected. However, 1 red-tailed hawk, from the Special-Status Species Groups (other raptors) was detected during monthly searches.

Searcher efficiency and carcass persistence trials were conducted during each survey season. A total of 12 searcher efficiency trials were conducted with 3 trials per season. Searcher efficiency ranged from 0.30 (90% CI=0.19–0.42) for bats in spring to 0.96 (90% CI=0.92–0.98) for large birds in fall. Carcass persistence trials were initiated on January 9, April 12, June 25 and September 17, 2012. Persistence values ranged from 1.89 days (90% CI=1.44-2.94) for bats to 97.53 days (90% CI=53-195) for large birds.

Annual fatality rates per-turbine and for the site were estimated for 5 groups: bats, non-raptors, large birds, small birds, and raptors, using fatalities detected during the biweekly standardized carcass searches. The annual fatality estimates were 12.02 bat fatalities/turbine/year (90% CI=6.74-20.85) or 529 bat fatalities/Project/year (90% CI=297-918); 1.93 non-raptor fatalities/turbine/year (90% CI=1.49-

2.50) or 85 non-raptor fatalities/Project/year (90% CI=66-110); 1.2 large bird fatalities/ turbine/year (90% CI=0.78-1.65) or 77 large bird fatalities/Project/year (905 CI=37-133); and 0.72 small bird fatalities/ turbine/year (90% CI=0.52-1.33) or 40 small bird fatalities/Project/year (90% CI=23-59). No raptor fatalities were detected during the biweekly searches; therefore, no estimated annual fatality rate for raptors is presented for Year Two.

No fatalities of any Special-Status Species and Species Groups for which Mitigation Measure BIO-6 (MM BIO-6) of the Project's operating permit set annual fatality thresholds were detected in Year Two, with the exception of a single raptor detected incidentally at monthly searched turbines. Therefore, no estimated annual fatality rates are provided for these species or species groups. However, when averaged over both years of the study, the resulting estimated annual fatality rate for the yellow warbler is 0.09 fatalities/ turbine/year (90% CI=0.07-0.27), a rate that exceeds the annual threshold set forth for this species in MM BIO-6 of the Shasta County approved Environmental Impact Report. This is based on a single fatality detected in Year One.

Table ES-1. Post-construction Fatality Monitoring Summary, Year Two

Variable	Value
Study Metrics for Fatality Estimates	
Turbine number	44
Turbines searched[1]	22
Turbine specifications	Siemens 2.3 MW Hub height: 80 m (263 feet) Rotor diameter: 94 m (308 feet) Maximum blade tip height (MBTH): 127 m (416 feet)
Turbine search plot size	127 m x 127 m
Study period	Annual (Spring, Summer, Fall, Winter)
Search interval	14 days in all seasons
Bird Fatalities[1]	
Non-raptors	
Mean fatality rate per turbine per year	1.93 (90% CI=1.49-2.5)
Mean fatality rate per MW per year	0.83 (90% CI=0.95-1.09)
Raptors	
Mean fatality rate per turbine per year	-
Mean fatality rate per MW per year	-
Large birds	
Mean fatality rate per turbine per year	1.2 (90% CI=0.78-1.65)
Mean fatality rate per MW per year	0.52 (90% CI =0.34-0.72)
Small birds	
Mean fatality rate per turbine per year	0.72 (90% CI=0.29–1.28)
Mean fatality rate per MW per year	0.31 (90% CI=0.13-0.56)
Bat Fatalities[1]	
Mean fatality rate per turbine per year	12.02 (90% CI=6.74-20.85)
Mean fatality rate per MW per year	5.22 (90% CI=2.93 to 9.06)

[1]Includes only fatalities detected at turbines searched during biweekly standardized carcass searches

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1 Introduction

Wind energy provides a clean, renewable energy source. 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 wildlife groups at risk because of collisions or other interactions with wind turbines (Erickson et al. 2001, Drewitt and Langston 2006, Arnett et al. 2007, 2008). 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/megawatt (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 are an avian group with particular susceptibility to collisions with turbines (Kikuchi 2008), and fatality rates ranged from 0 to 0.87 raptor fatalities/MW/year, with the highest fatality rates concentrated in California (Strickland et al. 2011). Bat fatality rates vary by season and location and have been highest at facilities on forested ridges in the eastern region of the United States (range 15.3 – 53.3 fatalities/MW/year) and lowest in the Rocky Mountain and Pacific Northwest regions (range 0.7 – 3.4 fatalities/MW/year; Arnett et al. 2008). However, some recent studies have shown that wind energy facilities constructed in agricultural landscapes may also experience relatively high bat fatality rates (e.g., Gruver et al. 2009, Poulton 2010). Bat mortality associated with wind facilities has been reported throughout the United States (Kunz et al. 2007, Arnett et al. 2008), and is predominantly composed of migratory tree-roosting bats (Arnett et al. 2008).

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 101 MW wind energy project in October 2010. The Project includes 44 2.3-MW Siemens wind turbine generators (turbines) that extend approximately 6.5 miles (4 kilometers) northwest along the ridgeline of Hatchet Mountain. The Project was constructed in an area managed for commercial timber production primarily consisting of ponderosa pine and white fir. This area was replanted in 1993-1994 after the 1992 Fountain Fire, and tree height ranges from 5 to 15 feet ([ft]; 1.5 to 4.6 meters [m]) 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 (SCDRM 2007). Additionally, MM BIO-6 has annual fatality thresholds of 1 fatality per year for the bald eagle and the sandhill crane, both California Fully Protected species. MM BIO-6 dictates annual fatality thresholds for 3 Special-Status Species /Groups : thresholds are 0.35 fatalities/turbine/year for other raptors (excluding owls), 0.11 fatalities/turbine for owls, and 0.07 fatalities/turbine/year for the yellow warbler. As part of the MM BIO-6 measures, a Technical Advisory Committee (TAC) was created for the Project to provide oversight and guidance of the 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. Exceeding established thresholds or other 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, 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 groups. The study plan, approved by the TAC in 2010, incorporated methods consistent with the California Energy Commission's California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development (CEC 2007). Additionally, the study plan incorporated fatality monitoring at all turbines in the form of standardized carcass searches (biweekly and monthly), searcher efficiency and carcass persistence trials to account for inherent biases in estimating Project-related fatality rates, avian use surveys in Year One, and a Wildlife Education and Incidental Reporting Program.

This report summarizes the results of the first 2 years of post-construction mortality monitoring at the Project. The objectives of this study were to ensure project compliance with MM BIO-6 through determining species composition of fatalities and estimating the annual fatality rates of bird and bat fatalities associated with the operation of the Project, to examine spatial and temporal patterns in bird and bat fatalities and to examine sources of bias in the study. Study results for both years are included in this report, and are inclusive of estimated annual fatality rates adjusted for bias. Additionally, a comparison between observed fatalities of Special-Status Species and Species Groups and MM BIO-6 fatality estimate thresholds is made for both years of the study.

2 Methods

2.1 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 included 1) standardized carcass searches to monitor for fatalities associated with the operation of the Project, 2) searcher efficiency trials to assess observer efficiency in finding carcasses, and 3) carcass persistence trials to assess site-specific duration that a carcass remains detectable to searchers. Methods remained consistent between study years.

The fatality monitoring study for Year Two was initiated on December 12, 2012 with no interruption of the biweekly monitoring schedule that commenced with Year One. A total of 27 surveys were conducted over 4 seasons with seasons defined as winter (December 12–March 14), spring (March 15–June 15), summer (June 16–September 14), and fall (September 15–December 15).

2.1.1 Standardized Carcass Searches

The objective of the standardized carcass searches was to systematically search turbine locations for avian and bat fatalities that are attributable to collisions; or in the case of bats, also due to barotrauma (defined as tissue damage to the lungs that results from the rapid air-pressure reduction near moving turbine blades [Baerwald et al. 2008, Rollins et al. 2012]). In order to maximize coverage of the Project, standardized carcasses searches were completed at all turbines. Twenty-two turbines were searched biweekly (2 week survey period); fatalities detected at biweekly turbines were used for estimating annual fatality rates. The remaining 22 turbines were searched monthly (4 week survey period) (Figure 1); data from 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 California Fully Protected species (all medium- to large-bodied species for which a longer search interval is appropriate).

Biweekly Search Plots

Biweekly search plots were selected to maximize the searchable area beneath the turbines and sample turbines evenly along the ridge, when established, in order to capture various elevations, vegetation communities, and turbine position along the string (Figure 1). The search area extended 63.5 m (208 ft) from the turbine on each side to create a square plot 127 m x 127 m (208 ft x 208 ft) centered on the turbine that covered 50 percent of the maximum turbine blade height (MBTH). Linear transects spaced at 6 m (19.7 ft) intervals were established within the search plot, with searchers scanning out to 3 m (9.8 ft) on each side of the transects while walking at a rate of approximately 45-60 m (147.6-196.9 ft) per minute.

The vegetative density within each search plot was delineated, using a Trimble GeoXT, into 4 visibility classes: low, medium, high and non-searchable. Percent vegetative cover was the main criterion for determining visibility class, with 0 to 40 percent vegetative cover delineated as high visibility, 41 to 70 percent cover delineated as medium visibility, greater than 70 percent cover delineated as low visibility, and greater than 70 percent cover, and impassible or not walkable was delineated as non-searchable. Percentages of search area that fell into each of the 4 classes were then calculated 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 plots were fully searchable, 12 had non-searchable area between 0.5 and 10 percent, and 6 had non-searchable area between 10 and 19 percent, for a total of 7.8 percent of search plots designated as 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 MBTH were established beneath these turbines; resulting in a search plot of 190 m x 190 m (623 ft x 623 ft) extending 95 m (312 ft) from the turbines on all sides. The search area for this subset of turbines was limited to high visibility areas. Transects spaced 6 m apart were also utilized within these search plots. Fatalities detected within these search plots were considered supplementary data only and therefore excluded from the statistical analysis.

Fatality Documentation

All fatalities were photographed and documented. Fatalities were identified to species when possible or identified to the highest possible taxonomic level when species identification was not possible due to the condition of the remains. Tetra Tech's existing USFWS scientific collecting permit (Number MB163272-1) was finalized on April 11, 2011 permitting the staff to collect MBTA-protected bird carcasses found within the Project area while surveyor permits with California Department of Fish and Game allowed for the collection of birds and bats under California Fish and Game Code Section 1002 and California Code of Regulations Title 14, Section 650).

Control Plots

Control plots were established in Year One of the study to determine levels of background mortality in the area. Biweekly searches of these plots in Year One yielded no background mortality. Consequently, it was determined that background mortality likely had a negligible effect on study results. As a result, control plots were not surveyed in Year Two. Therefore, all fatalities documented within search plots were attributed to turbine strikes without adjustment for background mortality.

2.1.2 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 and during the monthly searches were considered incidental.

2.1.3 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 searches. Twelve searcher efficiency trials were conducted at the 22 turbines searched biweekly within each season to account for changes in the vegetation conditions. These trials incorporated the assessment of each member of the field staff and were conducted by an independent third party (tester). 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 mice as bat surrogates when bat carcasses were not available from the project) were used in the trials. For the purposes of analysis, an arbitrary cutoff of 25 centimeters (cm; 10 inches [in]) was used to separate birds into size categories. Species with lengths less than 25 cm were considered small birds (e.g., European starling); all other species with lengths greater than or equal to 25 cm were considered large birds (e.g., ring-necked pheasant).

Trial turbines were randomly selected. For each trial, 8 to 10 carcasses from each size category were utilized with no more than 3 carcasses placed at any given turbine. These carcasses were placed at randomly generated points within the selected turbines' search plots with points stratified by visibility class (low, moderate, and high) to ensure that all visibility classes were represented in proportion to their presence within the study area. All trial carcasses were retrieved by the end of each trial day; 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 searcher efficiency trials were modeled using a logistic regression to determine if carcass size or season influenced searcher efficiency. Carcass size was included as a variable because a larger carcass might be easier to find and season was included as seasonal changes in vegetation might affect the ability to find a carcass. To determine the variable(s) that influenced searcher efficiency, model selection was based on the Akaike information criterion (AIC). The AIC is a measure of the “relative goodness of fit” of a statistical model and is used to select the best model (i.e., to identify if carcass size and/or season impacted searcher efficiency). The model with the lowest AIC value was considered to best explain the variance in searcher efficiency and estimates generated from this model were used in the calculation of fatality rates. Models that had an AIC value that differed by 2 or more were not considered to adequately explain variations in searcher efficiency. Bootstrap estimates of searcher efficiency and 90 percent confidence intervals (CI) were calculated, using 1000 replicates, for each season and carcass category (large bird, small bird, and bat).

The estimated searched efficiency is defined by Huso (2010) as:

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

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.

2.1.4 Carcass Persistence Time

Carcass persistence time, or the number of days a carcass persists in the study area before it is removed, is used to account for removal bias. 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 conducted each season using carcasses of varying size classes (large bird, small bird, and bat surrogates). Mice were used as surrogates for bats.

Persistence trials were conducted at 10-15 randomly selected turbines from the subset of turbines searched monthly. Carcasses were placed at randomly generated points within the selected turbine’s search plots, stratified by visibility class to ensure that visibility classes were represented in proportion to their presence in the search plots. Fifteen trial carcasses from each carcass category were utilized per trial; 3 carcasses were placed at each turbine. 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.

Data from carcass persistence trials were modeled using an interval censored parametric failure time model, which is a type of survival model, to determine if size or season influenced carcass persistence. We included carcass size as a variable, as larger carcasses might persist longer, and we included season, as seasonal changes in scavengers or other factors might affect persistence time. Four distributions were included in the analysis: exponential, Weibull, log-logistic, log-normal. Model selection was based on AIC values similar to that of searcher efficiency. Bootstrap estimates of carcass persistence time and 90 percent confidence intervals were calculated, using 1000 replicates, by season and by carcass category.

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

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

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

The persistence time of trial carcasses that survived until the end of the trial period is right censored in 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 would incorrectly assume that carcasses that "survived" until the end of the trial were scavenged on the last day of the trial. Carcass persistence time is obtained by summing the days each trial carcass persisted and dividing by only those carcasses that were scavenged; thus the carcasses that were not scavenged by the end of the trial are excluded from the denominator when obtaining the average persistence time. Consequently, average carcass persistence time can exceed the 21-day trial period.

2.1.5 Annual Fatality Estimates

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: $\hat{f}_{ijk} = \frac{c_{ijk}}{\hat{p}_{jk} * \hat{r}_{jk} * \hat{v}_{jk}}$

Where:
$\hat{f}_{ijk}$ 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
$\hat{p}$ is the estimated searcher efficiency
$\hat{r}$ is the average probability of persistence
$\hat{v}$ is the proportion of the interval sampled

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

$\hat{v}_{jk}$ is the proportion of the effective search interval sampled where $\hat{v}$ = min (1, $\tilde{I}/I$).

$\hat{p}_{jk}$ 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

$\hat{p}_{jk,}$ $\hat{r}_{jk,}$ and $\hat{v}_{jk}$ are assumed not to differ among turbines but can differ with carcass size and season

Data from the biweekly searched turbines was extrapolated to all turbines at the Project.

Annual estimated fatality rates were calculated on a per turbine basis, per MW basis, and over all turbines 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. In order to accurately calculate estimated fatality rates, a sample size greater than or equal to 5 must exist (M. Huso, pers. comm.). Caution should be used when interpreting estimates for any taxonomic group or individual species with a small sample (e.g., less than 5 fatalities). Fatality rate estimates are only calculated for those species or species groups with 1 or more fatalities detected at turbines searched biweekly; thus, in the case of special-status species for which no fatalities were detected at biweekly turbines, a fatality estimate is not provided.

Similar to Year One, estimated annual fatality rates presented in this report are not adjusted for the proportion of non-searchable area present within biweekly search plots in order for comparable results between study years. Upon completion of a third year of fatality data, estimated annual fatality rates will be adjusted for the proportion of non-searchable area within the biweekly search plots for each of the 3 years; both adjusted-for and unadjusted estimated annual fatality rates will be presented in the final report.

Variation in the fatality estimate results from 2 major components: variance in the fatalities detected among turbines (sample variance) and variance in the modeled fatality estimate (model variance) arising from variance in the detection bias parameters (probability in detection and probability of persistence). Fatalities occur as discrete counts (i.e., they occur as whole numbers) and the more turbines that are searched the lower the sample variance. This occurs because extreme values (i.e., a high number of fatalities at 1 turbine) have more influence on the fatality estimate and the confidence interval when the sample of turbines is small than when it is large. If the sample size was increased and no additional extreme values were found, the influence of the extreme value would be minimized. However, if the variation found for the sample of turbines is representative of the full project, then the variation would be similar if all turbines are sampled. Variation in detection bias (i.e., natural variation in carcass persistence time) also influences the fatality estimate because variability in the detection bias parameters is included in the fatality modeling. In other words, the higher the variability in carcass persistence time, the higher the variability in the fatality estimates. This natural variation cannot be controlled; however, increasing sample size of trial carcasses and minimizing the difference between the search interval and carcass persistence time can increase the precision in the estimate of detection bias. Given that the estimates are calculated on a per-turbine basis, the natural variation in the number of fatalities among turbines will likely have a larger effect on the confidence interval of the fatality estimate compared to the variance in the detection bias parameters (M. Huso, pers. comm.).

3 Year Two Results

3.1 Fatality Monitoring

3.1.1 Standardized Carcass Searches

Twenty-seven rounds of carcass searches were conducted biweekly at 22 of the 44 turbines. Searches were conducted from December 12, 2011 to December 14, 2012 for a total of 594 biweekly searches (Table 1). Fourteen rounds of monthly carcass searches were conducted at the remaining 22 turbines (308 total monthly searches). The results of fatality searches as each turbine subset are presented in Tables 2-5.

During biweekly searches at the Project, 43 fatalities (25 birds and 18 bats) were detected (Table 2). Among these fatalities, 10 avian species from 6 species groups were identified (Table 2). Two fatalities were identifiable to species group only and 1 was identifiable only as unknown large bird due to the limited amount and types of feathers detected (Table 2). Avian species groups detected included songbirds (n=5), waterfowl (n=15), waterbirds (n=2), woodpeckers (n=1), and pigeons/doves (n=1). Waterfowl was the species group with the highest number of fatalities. Individual species with the highest number of fatalities included snow geese (n=9), American coot (n=3) and northern shoveler (n=2). One fatality was detected for each other avian species documented. Eighteen bats from 3 species were detected, including silver-haired bat (n=11), hoary bat (n=4) and Brazilian free-tailed bat (n=3; Table 2,).

During monthly turbine searches, 16 fatalities (11 birds and 5 bats) were detected. Among these fatalities, 8 avian species from 4 species groups were identified (Table 3). Species groups detected included songbirds (n=4), waterfowl (n=3), waterbirds (n=3), and raptors (n=1; Table 3). Only 1 species, the American coot, had more than 1 fatality (n=3). One fatality was identifiable to species group only (unidentified waterfowl). A single fatality (red-tailed hawk) categorized as a Special-Status Species Groups (Other Raptors) for the Project was detected. Five bats from 2 species were detected, including hoary bat (n=4) and silver-haired bat (n=1).

3.1.2 Incidental Finds

Four fatalities (1 bird and 3 bats) were detected incidentally to biweekly and monthly searches. Specifically, 1 American coot, 1 hoary bat, 1 silver-haired bat, and 1 Brazilian free-tailed bat were found (Table 4).

3.1.3 Spatial and Temporal Distribution of Fatalities

Avian and bat fatalities were distributed throughout the Project in Year Two. Avian fatalities were detected at 26 of 44 turbines; no turbine had greater than 4 fatalities and no distinct pattern of fatality distribution was evident (Figure 2). Three avian fatalities were detected at turbine 43, representing the extreme northwest section of the turbine string and 3 were also detected at turbine 6, representing the southern portion. Bat fatalities were also distributed throughout the Project, with fatalities detected at 14 of 44 turbines (Figure 3).

Fatalities at the Project occurred throughout the year and varied in composition of taxonomic group. Fatalities were detected in every month of Year Two with the exception of December 2012 and were relatively low. The highest number of avian fatalities, although low, occurred in spring during the month of April (n=13; Figure 4), and were predominately comprised of waterfowl (Figure 5). The second highest number of fatalities occurred in May (n=5; Figure 4) and were predominately comprised of waterbirds (Figure 5). Each other month had 4 or fewer avian fatalities. Songbird fatalities were highest in October (n=3) while the only raptor fatality detected occurred in December 2011 (Figure 5).

Bat fatalities were detected in April and in June through October of Year Two, with species composition varying by month. The highest number of bat fatalities occurred in August (n=9), followed by July (n=5) and June (n=4; Figure 4). Each other month in which bat fatalities were detected had 3 or fewer bat fatalities. Fatalities were predominately silver-haired bats in July and August, while hoary bat fatalities peaked in August, but occurred in June and October (Figure 6). Brazilian free-tailed bats were detected in September (n=2) and June (n=1; Figure 6).

3.2 Searcher Efficiency Trials

Searcher efficiency trials were conducted in each season. Trials were conducted between January 9 and November 16 with 3 trials occurring in all 4 seasons. A total of 331 carcasses (106 large birds, 112 small birds, 113 bats) were placed during 12 trials. Of the 331 carcasses placed, 311 were recovered and included in analysis. Based on AIC analysis, the best fit searcher efficiency model included both size class and season, indicating that both of these parameters were an important predictor of searcher efficiency (Appendix 1). Searcher efficiency ranged from 0.30 (90% CI=0.19-0.42) for bats in spring to 0.96 (90% CI=0.92-0.98) for large birds in fall (Table 6b).

3.3 Carcass Persistence Trials

Carcass persistence trials were also conducted in each season. Trials initiated January 9, April 12, June 25, and September 17 during winter, spring, summer and fall, respectively. A total of 156 trial carcasses were placed with a minimum of 50 for each class size (including mice as bat surrogates; Table 7). Based on AIC analysis, carcass size class was the best fit carcass persistence model, Carcass persistence times were rom 97.53 days for large birds (90% CI=53.25-195.11) 8.22 days for Small birds (90% CI=5.41-12.52)and 1.89 days for bat surrogates (90% CI=1.44-2.40).

3.4 Annual Fatality Estimates

Year Two annual fatality rate estimates at the Project are presented for bats and several categories of birds in order of highest to lowest annual fatality estimate.

Bats, as a group, had the highest number of estimated fatalities for the project (Table 8).

- Bat fatalities were estimated at 12.02 bat fatalities/turbine/year (90% CI=6.74-20.85), 5.22 bat fatalities/MW/year (90% CI=2.93-9.06), or 529 bat fatalities/Project/year (90% CI=297-918; Table 8).

Bird categories include non-raptors and raptors (included for differentiation between the 2 main focus groups of the study), small birds and large birds (included for comparison with other projects), and waterfowl (included due to the high mean use of site). Waterfowl fatalities are accounted for in both non-raptor and large bird fatality estimates.

- Non-raptors were estimated at 1.93 fatalities/turbine/year (90% CI=1.49-2.50), 0.83 fatalities/MW/year (90% CI=0.65-1.09), or 85 fatalities/Project/year (90% CI=66-110).
- Large birds were estimated at 1.2 fatalities/turbine/year (90% CI=0.78-1.65), 0.52 fatalities/MW/year (90% C=0.34-0.72), or 53 fatalities/Project/year (90 % CI=35-73).
- Small birds were estimated at 0.72 fatalities/turbine/year (90% CI=0.29-1.28), 0.31 fatalities/MW/year (90% CI=0.13-0.55), or 32 fatalities/Project/year (90% CI=13-57).

Avian Special-Status Species/Groups

- No Special-Status species or species groups were detected during biweekly searched turbines (Table 9).
- The average estimated annual fatality rate for the yellow warbler over both years of the study is 0.09 fatalities/turbine/year (90% CI=0.07-0.27) or 8 fatalities/Project/year (90% CI=7-24).
- No raptors were detected at turbines searched biweekly in Year Two. One raptor fatality was detected at monthly searched turbines; per study design, the fatality was not included in the statistical analysis.

Other Avian Groups

- Waterfowl fatalities are estimated at 0.90 fatalities/turbine/year (90 % CI=0.52-1.33), 0.39 fatalities/MW/year (90 % CI=0.11-0.45), or 40 fatalities/Project/year (90% CI=23-59).

4 Discussion

4.1 Mitigation Measure BIO-6 Thresholds

MM BIO-6 provides fatality thresholds for special status species/groups. 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. In Year Two of post-construction monitoring at the Project, no Special-Status Species or individuals from Special-Status Species groups were detected as fatalities, with the exception of a single raptor detected during monthly searches. Monthly searches were conducted to detect special status species but are excluded from the fatality estimates due to differences in search methodology. No bald eagle or sandhill crane fatalities were detected in Year Two; as a result, these species remain below the fatality threshold of 1 fatality each per year. Additionally, other raptor species and yellow warbler and owls fall below each of the thresholds set respectively, as no fatalities of these species were detected at biweekly searched turbines during Year Two (Table 9).

Similarly, no bald eagle, sandhill crane, or owl fatalities were detected in Year One; thus, these species/groups remain below their established thresholds in both years of the study. Additionally, other raptors fell below the threshold of 0.35 fatalities/year in both years of the study (Section 4.3.2). The estimated yellow warbler fatality rate at the Project in Year One was 0.19 fatalities / turbine/year (90% CI=0.15-0.62) which exceeded the per turbine threshold (0.07 fatalities/turbine/year). When results from both years are pooled, the average annual fatality estimate for yellow warblers is 0.09 yellow warbler fatalities/turbine/year (90% CI=0.07-0.27), a value above the annual fatality threshold established for this species. It is important to note that this value was calculated based on a single fatality detected over 2 years; given the small sample size, the accuracy of this fatality estimate is questionable.

4.2 Bats

The ultimate cause behind bat mortality at wind energy facilities is poorly understood and has been hypothesized as due to random collisions with turbines, coincidental collisions such as when turbines occur within migratory corridors, or collisions that occur as a result of bats being attracted to turbines (Kunz et al. 2007, Horn et al. 2008, Ellison 2012). The majority of bat fatalities at North American wind energy facilities are migratory, tree-roosting bats (i.e., silver-haired bats, hoary bats, and red bats; Kunz et al. 2007, Arnett et al. 2008, Strickland et al. 2011) and bat fatalities primarily have been documented during late summer to early fall, a time period that coincides with fall migration (Cryan 2003, Kunz et al. 2007, Arnett et al. 2008). Migratory tree roosting species (silver-haired bat and hoary bat) comprised the majority of bat fatalities at the Project. The highest proportion of bat fatalities occurred July - September, a temporal pattern consistent with other wind energy facilities (Arnett et al. 2008; Figure 6).

The species composition of bat fatalities detected at the Project remained consistent between study years. Bat fatalities were comprised of 3 species; 2 tree-roosting species, the silver-haired bat (n=8 and n=13, Year One and Year Two; Tables 2, 3, 4) and the hoary bat (n=3 and n=9, Year One and Year Two; Tables 2, 3, 4), and 1 non-migratory, cavity roosting species, Brazilian free-tailed bat (n=7 and n= 4, Year One and Year Two, Tables 2, 3, 4). The Project area provides suitable roosting and foraging habitat for tree-roosting bat species in the forested and low vegetative land cover than can be found on site. Further, migrating individuals may use the forested areas surrounding the Project as stopover habitat during migration. In general, migratory bats tend to move along linear landscape features that connect habitats, such as horizontal forest features (e.g., forest edges), vertical forest features (e.g., between forest canopy structures), or riparian corridors (Hayes and Gruver 2000, Downs and Racey 2006, Furmankiewicz and Kucharska 2009). These habitat features are present within the Project and vicinity.

Annual fatality rates for bats at the Project in Year Two were estimated to be 12.02 bats/turbine/year (90% CI=6.74-20.85) compared with 5.13 bats/ turbine/ year in Year One (90% CI=1.92-9.75). The overlapping confidence intervals suggest no statistical differences among years. Variability among years could be driven by differences by weather, food availability, timing of migration, bat population size, or other factors (Horn et al. 2008). Annual fatality rates, are influenced by the biases used to adjust the fatality estimates. Surrogate species used for searcher efficiency and carcass persistence trials offer a source of study bias. In this study, mice were used as surrogates for bats in carcass persistence trials when bat carcasses were not in pristine condition and some searcher efficiency trials when bat carcasses were unavailable. Using mice as surrogates for bat estimates can result in an increased estimate in fatality rates because mice do not persist as long as bats (Hale and Karsten 2010).

There are no publicly available post-construction studies at wind facilities with forested ridge tops in the Western U.S. and the closest regional studies for comparison in the Pacific Northwest contain agricultural or sagebrush steppe habitat but with differences in the composition of the bat community. Additionally, studies conducted in the Columbia Plateau Ecoregion in Oregon and Washington used small birds as surrogates for bats (e.g., Young et al. 2007, Jeffrey et al. 2009, Gritski et al. 2010) rather than solely bats or mice as a surrogate, as were used at the Project. The choice of surrogates used for bats in carcass persistence trials has been shown to have implications on the fatality estimate (Hale and Karsten 2010). Publicly available mortality monitoring studies for wind energy facilities in California are limited. Although bat fatalities of similar species composition were detected at 3 California projects with publicly available data, only 1 project in Solano County provides an annual fatality estimate for bats of 3.63 bats/ turbine/year (Kerlinger et al. 2006). No confidence interval was presented for this estimate which limits meaningful comparison to the Project. Additionally, there are important differences between the Solano County wind energy facility and the Project in location, habitat, methodology, and fatality estimation. Due to the lack of comparable projects, estimated annual fatality rates for the Project should be contextualized by the study year rather than the relativity to other projects.

4.3 Birds

Most native, migratory birds are protected under the Migratory Bird Treaty Act (MBTA) of 1918. No permitting scheme for the incidental take of migratory birds during otherwise lawful activities currently exists (Beveridge 2005). As such, there is no permitting framework (i.e., incidental take permits) that allow a wind company to protect itself from liability at wind facilities; however, the USFWS does not usually take action if good faith efforts have been made to minimize impacts.

4.3.1 Non-Raptors

The estimated annual fatality rate for non-raptors is highest among all avian groups at the Project in both years of the study (251 non-raptor fatalities/Project/year (90% CI=187-337) in Year One and 85 non-raptors fatalities/Project/year (90% CI=66-110) in Year Two. Fatality estimates for the non-raptor avian group are rarely presented in other fatality studies; thus direct comparison to other projects for this group is not possible.

4.3.1.1 Waterfowl

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); however, waterfowl were common fatalities in both years of the study. Annual Project-related fatalities for waterfowl were estimated at0.63 waterfowl fatalities/turbine/year (90% CI=0.25-

1.04) in Year One and 0.90 waterfowl fatalities/turbine/year (90% CI=0.52-1.33) in Year Two. In both years, waterfowl fatalities were detected primarily during the spring season after significant weather events moved through the area (Ken Hammon, Pers. Comm; Table 2; Figure 5). Strong storm fronts in the area occur most often in the spring, supporting this relationship (NOAA 2013).

Studies investigating avian collision risk with wind turbines suggest that the risk of collision can increase with conditions of poor visibility (Desholm and Kahlert 2005) or strong winds (Smallwood and Thelander 2009). Additionally, Sugimoto (2011) determined that localized movements of waterfowl are not as likely to be limited by poor weather conditions as are large scale migratory movements. Waterfowl fatalities at the Project may be associated with windy conditions or localized movements of waterfowl during poor weather conditions rather than the large-scale movement of migrating waterfowl.

The American coot (taxonomic group: waterbirds) was also detected as a fatality at the Project in both years of the study (n=3 in Year One, n=5 in Year Two; Tables 2, 3). This species utilizes habitats similar to waterfowl and demonstrates similar localized-movement flight patterns as waterfowl, including an increase in low elevation flight to clear obstacles such as trees (Brisbin and Mowbray 2002). Thus, this species is likely susceptible to fatalities under the same conditions as waterfowl at the Project.

4.3.1.2 Small birds

Migrant passerines are found more often in post-construction mortality monitoring compared to other groups of birds (Arnett et al. 2007, Erickson et al. 2007). At newer generation wind energy facilities outside of California, approximately 80 percent of documented fatalities have been songbirds, with as much as 50 percent of them being nocturnal migrants (Erickson et al. 2001, Johnson et al. 2002, Drewitt and Langston 2006, Strickland and Morrison 2008). Although this pattern was consistent with avian fatalities detected at the Project in Year One (Figure 5), the pattern did not hold for avian fatalities detected in Year Two as songbirds accounted for only 14 percent of Year Two fatalities compared to 47 percent in Year One. In Year Two, songbird fatalities were detected in low numbers during the spring (n=2) and fall (n=3) migration periods (Table 2) and songbird species documented as fatalities are individuals of resident species that breed in the area. These low numbers of resident breeders may be partially attributed to the hypothesis that locally breeding songbirds may experience lower mortality rates than migrants because many of these species tend not to fly at turbine heights during the breeding season (Drewitt and Langston 2008). Additionally, resident species are not engaging in long distance migratory flight often associated with turbine- related fatalities, which may account for the relatively low number of resident songbird fatalities throughout the study year. During 2010-2011 avian point-count studies conducted at the Project, less than 1 percent of the flying songbirds were observed flying at the height of the RSA, suggesting that resident species and diurnal migrant species observed at the Project are a low risk of collision (Tetra Tech 2012). Additionally, environmental conditions can cause annual variation in migratory pathways of nocturnal migrants leading to potential annual variation in the temporal and spatial use of the Project area by these species

Fatality estimates for small birds at the Project fall within the range of reported estimated fatality rates for small birds from projects within California and the Pacific Northwest. In Year One, the annual estimated fatality rate for small birds was 4.67 fatalities/turbine/year. The annual estimated fatality rate in Year Two for small birds is 0.72 fatalities/turbine/year (90% CI=0.29-1.28), both of which fall within range of reported annual estimated fatality rates at facilities publicly available data [(0.5 to 5.75 small birds/turbine/year (Erickson et al. 2000, Gristki 2010)}. These comparison projects, however, are based on a range of habitats with agriculture as the primary land use and vary in the methods with respect to the data collection, data analysis, and time-frame sampled. Thus, estimated annual fatality rates for other projects are presented for context only and the value of direct comparison is limited.

4.3.2 Raptors

Raptors are an avian 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. During fatality monitoring at the Project, raptors represented 1.6 percent (n=1) of the total avian fatalities in Year Two and 4 percent (n=3) of total avian fatalities in Year One. The low proportion of raptor fatalities at the Project might, in part, be attributable to low raptor use of the Project as raptors represented 2.4 percent of all birds detected during avian use surveys conducted concurrently with fatality monitoring in Year One (Tetra Tech 2012). Additionally, Garvin et al. (2011) documented that some raptor species, despite high-risk flight behavior, demonstrate collision avoidance behavior when observed flying within the RSA at operational wind energy facilities. The only raptor fatality detected in Year Two, a red-tailed hawk, is a resident species and local breeder which was commonly detected during Year One avian studies. Red-tailed hawk fatalities have been documented at other wind energy facilities (Johnson and Erickson 2011, Stantec 2010).

Raptors are a Special-Status Species Group for the Project. In Year One, the annual fatality rate for raptors was estimated at 0.06 raptors/turbine/year (90%CI = 0.05-0.16) In Year Two, an annual raptor fatality rate was not estimated for the Project as no raptor fatalities were detected at turbines searched biweekly. The protocol established for fatality monitoring at the Project incorporated the monthly searched study plots to provide supplementary fatality data on large birds (e.g., raptors and cranes) while the estimated annual fatality rates are based only on fatalities detected at turbines searched biweekly. The single detection of the red-tailed hawk fatality at a monthly searched turbine is indicative that the established study design and protocol for the Project are meeting the desired results, which were to ensure that large birds would be found throughout the Project rather than being limited to the turbines sampled. Regional fatality estimates from projects in the Pacific Northwest range from 0.06 to 0.49 raptors/turbine/year (Erickson et al. 2004, Gritski et al. 2010). These comparison projects, however, vary in the study design, data analysis, habitat, and time-frame sampled. Thus, estimated annual fatality rates for other projects are presented for context only; the value of direct comparison is limited and results from other projects are presented for context only.

4.4 Conclusions

No MM BIO-6 focus species and groups with annual Project fatality thresholds were detected in Year Two of fatality monitoring at the project with the exception of a single raptor fatality, detected incidentally. Although no yellow warbler fatalities were detected in Year Two, the average estimated annual fatality rate of 0.09 yellow warblers/turbine/year over 2 study years exceeds the MM BIO-6 threshold of 0.07 yellow warblers /turbine per year set forth for this species. However, this rate is based on a single yellow warbler fatality detected in Year One, the small sample size limits the accuracy of the estimated fatality rate, and the confidence interval overlaps with the threshold value.

When compared to other wind energy facilities in California, estimated bat fatality rates at the Project could represent actual higher bat use in comparison to other projects in the region or may reflect biases introduced by different survey and statistical methods between studies such as length of survey, search interval, surrogates, transect spacing, and project location. In both years of the study, bat fatality rates at the Project were highest during July - September and included hoary, silver-haired, and Brazilian free-tailed bats as the species found as fatalities. The species composition and temporal patterns at the Project have been observed at other North American wind energy facilities. The small number of detections of Brazilian free-tailed bat fatalities observed in Year One was not repeated in Year Two.

Estimated avian fatality rates at the Project were comparable to other reported fatality rate estimates in the Pacific Northwest, although as mentioned above, the comparisons reflect differences in study methods as well as project-related differences. The avian species reported as fatalities were similar in composition to other reported fatalities at North American wind energy facilities and included songbirds, waterfowl, waterbirds, among other species groups. Estimated waterfowl fatalities rates were similar between years and may be influenced by limited turbines visibility during weather events. All but 1 of the identified avian species (European starling, Year One) are protected under the MBTA.

In October 2012, the TAC approved a consecutive Year Three of fatality monitoring at the Project to begin in December 2012. This third year of mortality monitoring at the Project will contribute to further understanding of bat and bird fatality patterns in the forested mountain habitat of California.

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Table 1. Hatchet Ridge fatality survey dates.

Survey Season	Survey Period	Year 1 (2010 - 2011)	Year 2 (2011 - 2012)
Winter			
	1	12/12-12/23	12/12-12/14
	2	12/27-12/31	12/26-12/29
	3	1/10-1/17	1/10-1/13
	4	1/25-1/27	1/25-1/27
	5	2/7-2/13	2/7-2/9
	6	2/22-2/28	2/21-2/23
	7	3/7-3/17	3/5-3/9
Spring			
	8	3/22-3/31	3/19-3/22
	9	4/4-4/9	4/2-4/7
	10	4/19-4/21	4/17-4/18
	11	5/3-5/11	4/30-5/4
	12	5/19-5/21	5/15-5/16
	13	5/30-6/4	5/29-6/1
	14	6/13-6/15	6/11-6/14
Summer			
	15	6/27-7/2	6/25-6/30
	16	7/12-7/15	7/9-7/15
	17	7/25-7/28	7/23-7/29
	18	8/8-8/10	8/6-8/7
	19	8/22-8/26	8/20-8/24
	20	9/6-9/11	9/4-9/5

Table 1. Hatchet Ridge fatality survey dates.

Survey Season	Survey Period	Year 1 (2010 - 2011)	Year 2 (2011 - 2012)
Fall			
	21	9/19-9/23	9/17-9/23
	22	10/4-10/8	10/1-10/3
	23	10/17-10/21	10/16-10/19
	24	11/1-11/5	11/1-11/3
	25	11/15-11/18	11/12-11/15
	26	11/28-11/30	11/26-11/27
	27		12/10-12/14

Table 2. Summary of avian and bat fatalities found during searches at Hatchet Ridge from 11/18/2010 to 12/14/2012.

Group / Common name	Scientific name	Winter 2010-2011	Winter 2011-2012	Spring 2011	Spring 2012	Summer 2011	Summer 2012	Fall 2011	Fall 2012	Total Year 1	Total Year 2
Songbirds											
unidentified songbird		0	0	5	0	0	0	1	0	**6**	**0**
Steller's jay	*Cyanocitta stelleri*	0	0	2	0	1	0	0	0	**3**	**0**
dark-eyed junco	*Junco hyemalis*	1	1	1	0	0	0	0	0	**2**	**1**
yellow-rumped warbler	*Dendroica coronata*	1	0	1	0	0	0	0	0	**2**	**0**
unidentified kinglet	*Regulus spp.*	0	0	2	0	0	0	0	0	**2**	**0**
golden-crowned kinglet	*Regulus satrapa*	0	0	1	1	0	0	0	0	**1**	**1**
yellow warbler	*Dendroica petechia*	0	0	0	0	1	0	0	0	**1**	**0**
western meadowlark	*Sturnella neglecta*	0	0	0	1	0	0	0	0	**0**	**1**
spotted towhee	*Pipilo maculatus*	0	0	0	0	0	0	0	1	**0**	**1**
red-winged blackbird	*Agelaius phoeniceus*	0	0	1	0	0	0	0	0	**1**	**0**
ruby-crowned kinglet	*Regulus calendula*	0	0	1	0	0	0	0	0	**1**	**0**
red-breasted nuthatch	*Sitta canadensis*	0	0	0	0	0	1	0	0	**0**	**1**
Lincoln's sparrow	*Melospiza lincolnii*	0	0	0	0	1	0	0	0	**1**	**0**
evening grosbeak	*Coccothraustes vespertinus*	0	0	1	0	0	0	0	0	**1**	**0**
European starling	*Sturnus vulgaris*	0	0	0	0	1	0	0	0	**1**	**0**
cliff swallow	*Petrochelidon pyrrhonota*	0	0	0	0	1	0	0	0	**1**	**0**
bushtit	*Psaltriparus minimus*	0	0	0	0	0	0	1	0	**1**	**0**
American robin	*Turdus migratorius*	0	0	1	0	0	0	0	0	**1**	**0**
Songbirds Total		**2**	**1**	**16**	**2**	**5**	**1**	**2**	**1**	**25**	**5**
Waterfowl											
unidentified waterfowl		3	2	5	0	0	0	0	0	**8**	**2**
snow goose	*Chen caerulescens*	0	3	0	6	0	0	0	0	**0**	**9**
northern shoveler	*Anas clypeata*	0	0	0	4	0	0	0	0	**0**	**4**
unidentified goose		0	0	2	0	0	0	0	0	**2**	**0**

Table 2. Summary of avian and bat fatalities found during searches at Hatchet Ridge from 11/18/2010 to 12/14/2012.

Group / Common name	Scientific name	Winter 2010-2011	Winter 2011-2012	Spring 2011	Spring 2012	Summer 2011	Summer 2012	Fall 2011	Fall 2012	Total Year 1	Total Year 2
Ross' s goose	*Chen rossii*	0	0	1	0	0	0	0	0	**1**	**0**
Waterfowl Total		**3**	**5**	**8**	**10**	**0**	**0**	**0**	**0**	**11**	**15**
Waterbirds											
American coot	*Fulica americana*	0	0	1	1	0	0	2	1	**3**	**2**
unidentified shorebird	*Unidentified Shorebird*	0	0	1	0	0	0	0	0	**1**	**0**
Waterbirds Total		**0**	**0**	**2**	**1**	**0**	**0**	**2**	**1**	**4**	**2**
Other											
unidentified bird		0	0	3	0	1	0	0	0	**4**	**0**
unidentified large bird		0	0	0	0	0	1	0	0	**0**	**1**
Other Total		**0**	**0**	**3**	**0**	**1**	**1**	**0**	**0**	**4**	**1**
Gamebirds											
mountain quail	*Oreortyx pictus*	0	0	0	0	2	0	0	0	**2**	**0**
Gamebirds Total		**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**2**	**0**
Woodpeckers											
northern flicker	*Colaptes auratus*	0	0	0	1	0	0	0	0	**0**	**1**
Woodpeckers Total		**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**
Swifts/Hummingbirds											
Vaux's swift	*Chaetura vauxi*	0	0	0	0	1	0	0	0	**1**	**0**
Swifts/Hummingbirds Total		**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**
Raptors											
turkey vulture	*Cathartes aura*	0	0	1	0	0	0	0	0	**1**	**0**
Raptors Total		**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**
Pigeons/Doves											
mourning dove	*Zenaida macroura*	0	0	0	0	0	1	0	0	**0**	**1**
Pigeons/Doves Total		**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**

Table 2. Summary of avian and bat fatalities found during searches at Hatchet Ridge from 11/18/2010 to 12/14/2012.

Group / Common name	Scientific name	Winter 2010-2011	Winter 2011-2012	Spring 2011	Spring 2012	Summer 2011	Summer 2012	Fall 2011	Fall 2012	Total Year 1	Total Year 2
Bat											
silver-haired bat	*Lasionycteris noctivagans*	0	0	2	2	2	9	1	0	**5**	**11**
Brazilian free-tailed bat	*Tadarida brasiliensis*	0	0	0	1	1	1	1	1	**2**	**3**
hoary bat	*Lasiurus cinereus*	0	0	0	2	1	1	0	1	**1**	**4**
unidentified bat		0	0	2	0	1	0	1	0	**4**	**0**
Bat Total		**0**	**0**	**4**	**5**	**5**	**11**	**3**	**2**	**12**	**18**
Total		**5**	**6**	**34**	**19**	**14**	**14**	**7**	**4**	**60**	**43**

Table 3. Summary of avian and bat fatalities found during monthly searches at Hatchet Ridge from 11/18/2010 to 12/14/2012.

Group / Common name	Scientific name	Winter 2010-2011	Winter 2011-2012	Spring 2011	Spring 2012	Summer 2011	Summer 2012	Fall 2011	Fall 2012	Total Year 1	Total Year 2
Waterfowl											
unidentified waterfowl		3	0	1	1	0	0	0	0	**4**	**1**
snow goose	*Chen caerulescens*	0	0	0	0	0	0	0	1	**0**	**1**
northern shoveler	*Anas clypeata*	0	0	0	1	0	0	0	0	**0**	**1**
Waterfowl Total		**3**	**0**	**1**	**2**	**0**	**0**	**0**	**1**	**4**	**3**
Songbirds											
unidentified songbird		0	0	3	0	0	0	0	0	**3**	**0**
unidentified kinglet	*Regulus spp.*	0	0	1	0	0	0	0	0	**1**	**0**
Steller's jay	*Cyanocitta stelleri*	0	0	0	0	0	0	1	0	**1**	**0**
spotted towhee	*Pipilo maculatus*	0	0	0	0	0	0	0	1	**0**	**1**
ruby-crowned kinglet	*Regulus calendula*	0	1	0	0	0	0	0	0	**0**	**1**
golden-crowned kinglet	*Regulus satrapa*	0	0	0	0	0	0	0	1	**0**	**1**
American robin	*Turdus migratorius*	0	1	0	0	0	0	0	0	**0**	**1**
Songbirds Total		**0**	**2**	**4**	**0**	**0**	**0**	**1**	**2**	**5**	**4**
Raptors											
sharp-shinned hawk	*Accipiter striatus*	0	0	0	0	0	0	1	0	**1**	**0**
red-tailed hawk	*Buteo jamaicensis*	0	1	0	0	0	0	1	0	**1**	**1**
Raptors Total		**0**	**1**	**0**	**0**	**0**	**0**	**2**	**0**	**2**	**1**
Other											
unidentified bird		1	0	2	0	0	0	1	0	**4**	**0**
Other Total		**1**	**0**	**2**	**0**	**0**	**0**	**1**	**0**	**4**	**0**
Cranes/Rails											
American coot	*Fulica americana*	0	0	0	3	0	0	0	0	**0**	**3**
Cranes/Rails Total		**0**	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**3**

Table 3. Summary of avian and bat fatalities found during montly searches at Hatchet Ridge from 11/18/2010 to 12/14/2012.

Group / Common name	Scientific name	Winter 2010-2011	Winter 2011-2012	Spring 2011	Spring 2012	Summer 2011	Summer 2012	Fall 2011	Fall 2012	Total Year 1	Total Year 2
Bat											
Brazilian free-tailed bat	*Tadarida brasiliensis*	0	0	0	0	0	0	4	0	**4**	**0**
silver-haired bat	*Lasionycteris noctivagans*	0	0	0	0	1	1	1	0	**2**	**1**
hoary bat	*Lasiurus cinereus*	0	0	0	0	1	4	0	0	**1**	**4**
Bat Total		**0**	**0**	**0**	**0**	**2**	**5**	**5**	**0**	**7**	**5**
Total		**4**	**3**	**7**	**5**	**2**	**5**	**9**	**3**	**22**	**16**

Table 4. Summary of avian and bat fatalities found as incidentals at Hatchet Ridge from 11/18/2010 to 12/14/2012.

Group / Common name	Scientific name	Winter 2010-2011	Winter 2011-2012	Spring 2011	Spring 2012	Summer 2011	Summer 2012	Fall 2011	Fall 2012	Total Year 1	Total Year 2
Waterfowl											
greater white-fronted goose	*Anser albifrons*	0	0	3	0	0	0	0	0	**3**	**0**
Waterfowl Total		**0**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**3**	**0**
Waterbirds											
unidentified grebe		0	0	1	0	0	0	0	0	**1**	**0**
American coot	*Fulica americana*	0	0	0	1	0	0	0	0	**0**	**1**
Waterbirds Total		**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**1**
Songbirds											
yellow warbler	*Dendroica petechia*	0	0	1	0	0	0	0	0	**1**	**0**
golden-crowned sparrow	*Zonotrichia atricapilla*	0	0	0	0	0	0	1	0	**1**	**0**
Brewer's blackbird	*Euphagus cyanocephalus*	0	0	0	0	0	0	1	0	**1**	**0**
Songbirds Total		**0**	**0**	**1**	**0**	**0**	**0**	**2**	**0**	**3**	**0**
Bat											
Brazilian free-tailed bat	*Tadarida brasiliensis*	0	0	0	0	0	0	1	1	**1**	**1**
silver-haired bat	*Lasionycteris noctivagans*	0	0	0	0	1	1	0	0	**1**	**1**
hoary bat	*Lasiurus cinereus*	0	0	0	0	1	1	0	0	**1**	**1**
unidentified bat		0	0	0	0	1	0	0	0	**1**	**0**
Bat Total		**0**	**0**	**0**	**0**	**3**	**2**	**1**	**1**	**4**	**3**
Total		**0**	**0**	**5**	**1**	**3**	**2**	**3**	**1**	**11**	**4**

Table 5. Summary of fatalities detected at the Hatchet Ridge.

Survey Year	Biweekly Search Fatalities	Monthly Search Fatalities	Incidental Fatalities	Total Fatalities
Year One (2010-2011)				
Bird	48	15	7	70
Bat	12	7	4	23
Total	**60**	**22**	**11**	**93**
Year Two (2011-2012)				
Bird	25	11	1	37
Bat	18	5	3	26
Total	**43**	**16**	**4**	**63**
Grand Total	**103**	**38**	**15**	**156**

Table 6a. Searcher efficiency trial results in Year One with bootstrapped 90% confidence interval (CI).

Carcass Category	Searcher Efficiency[1]	CI	n[2]
Large bird	0.85	0.75–0.95	40
Small bird	0.76	0.69–0.83	121
Bat	0.60	0.47–0.71	45

1. Searcher Efficiency presented as an annual estimate due to limited seasonal sample size
2. Number of carcasses used in analysis

Table 6b. Searcher efficiency trial results in Year Two with 90% confidence interval (CI).

Carcass Category	Season	Searcher Efficiency	CI	n[1]
Large Bird	Spring	0.84	0.75–0.93	24
Small Bird	Spring	0.42	0.40–0.65	27
Bat	Spring	0.30	0.19–0.42	25
Large Bird	Summer	0.92	0.70–0.90	25
Small Bird	Summer	0.70	0.59–0.80	27
Bat	Summer	0.47	0.30–0.60	26
Large Bird	Fall	0.96	0.92–0.98	24
Small Bird	Fall	0.82	0.72–0.90	24
Bat	Fall	0.63	0.50–0.76	21
Large Bird	Winter	0.93	0.88–0.97	31
Small Bird	Winter	0.73	0.62–0.84	27
Bat	Winter	0.51	0.39–0.64	30

1. Number of carcasses used in analysis

Table 7. Carcass persistence at Hatchet Ridge with 90% confidence interval (CI).

Carcass Category	2011			2012		
	Persistence (days)[1]	CI	n[2]	Persistence (days)[1]	CI	n[2]
Large Bird	116	63.74–254.50	38	97.53	53.25–195.11	50
Small Bird	5.60	4.17–7.53	52	8.22	5.41–12.52	54
Bat	2.50	1.96–2.95	30	1.89	1.44–2.40	52

1. Right censoring of persistence data can result in values greater than the 21 day trial.
2. Number of carcasses placed

Table 8. Fatality estimates at Hatchet Ridge with 90% confidence interval (CI).

Carcass Category/Species	2011					2012				
	n[1]	Total Estimate	CI	Per Turbine Estimate	CI	n[1]	Total Estimate	CI	Per Turbine Estimate	CI
Bats	12	226	332–686	5.13	1.92–9.75	18	529	297–918	12.02	6.74–20.85
Birds										
Large Bird	19	48	30–69	1.08	0.66–1.57	20	53	35–73	1.20	0.78–1.65
Small Bird	29	206	147–290	4.67	3.32–6.57	5	32	13–57	0.72	0.29–1.28
Raptor[2]	1	3	3–8	0.06	0.05–0.18	0	–	–	–	–
Non-raptor	47	251	187–337	5.69	4.24–7.66	25	85	66–110	1.93	1.49–2.5
Waterfowl	11	28	12–46	0.63	0.25–1.04	15	40	23–59	0.90	0.52–1.33
Yellow warbler[2]	1	9	7–28	0.19	0.15–0.62	0	–	–	–	–

1. Number of fatalities found
2. Insufficient estimate sample size for accuracy of fatality estimate for observed species group (n < 5)

Table 9. MMBIO-6 annual fatality thresholds for Special-Status Species and Species Groups with Hatchet Ridge fatality rates for Years One and Two

Species	Califiornia or MMBIO-6 Status	Fatality Threshold (fatalities/year)	Fatality Threshold (fatalities/turbine)	Hatchet Ridge Estimated Annual Fatality Rate (fatalities/turbine; Year 1)	Hatchet Ridge Estimated Annual Fatality Rate (fatalities/turbine; Year 2)	Hatchet Ridge Averge Estimated Annual Fatality Rate (fatalities/turbine)
Bald eagle	Fully Protected	1	-	-	-	-
Sandhill crane	Fully Protected	1	-	-	-	-
Other raptor species[1]	Species Group of Special Concern	-	0.35	0.06	-	0.06
Yellow warbler[1]	Species of Special Concern	-	0.07	0.19	-	0.09
Owls	Species Group of Special Concern	-	0.11	-	-	-

1. Fatalities detected and used in estimated fatality rate in Year One only

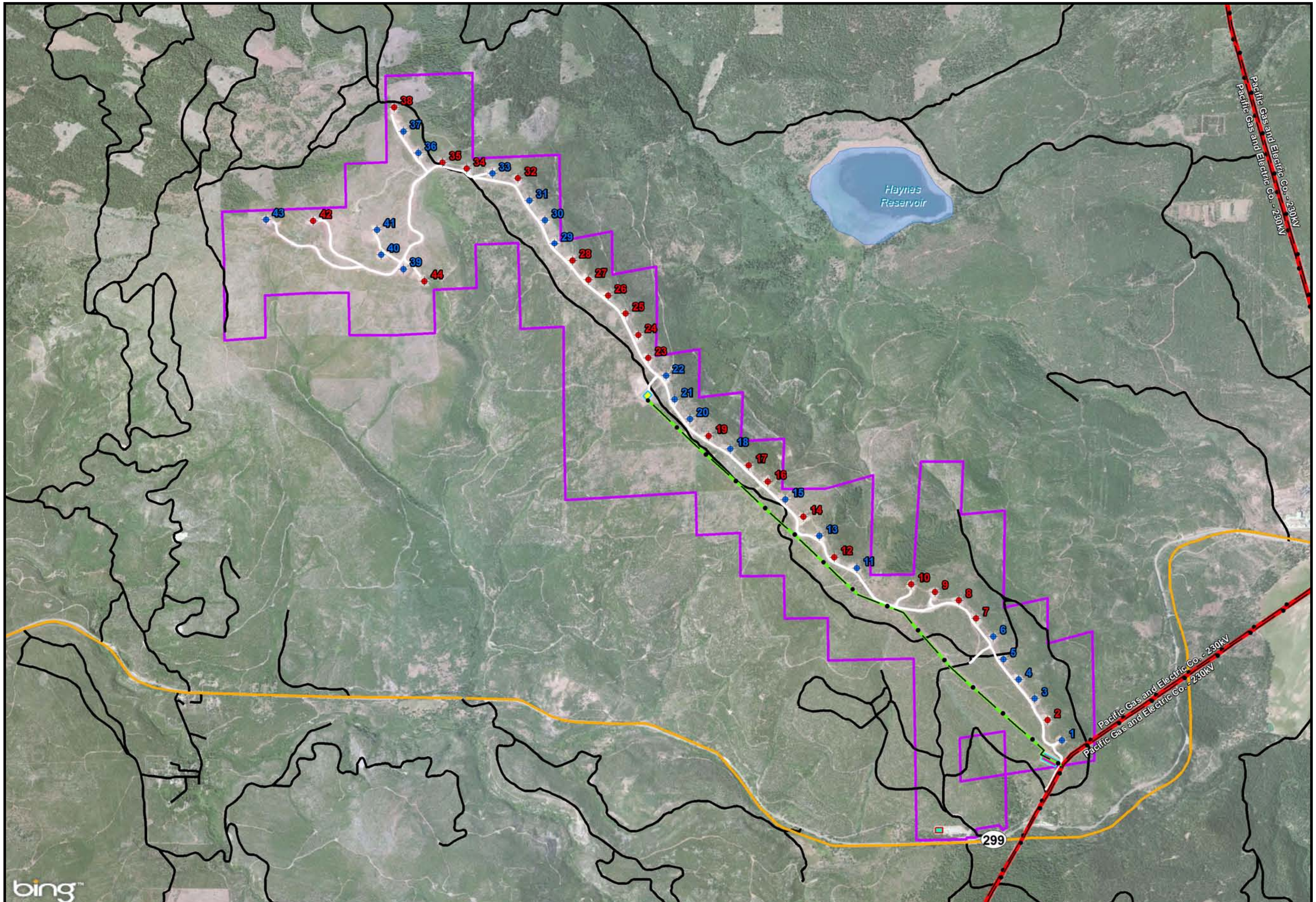

Figure 1

PATTERN ENERGY

Hatchet Ridge

Hatchet Ridge Wind Farm Biweekly and Monthly Fatality Search Turbines

Shasta County, CA

January 2, 2013

Project Boundary

Wind Turbine Generator

- Biweekly Search Interval
- Monthly Search Interval

O and M Facility

Substation

Switch Yard

Overhead Transmission Line

Transmission Line

State Highway

Local Road

Access Road

Lake/Pond

1:35,000 NAD 1983 UTM 10

0 0.5 1 2 3 4 5 Miles

Data Sources ESRI 2007: roads, hydrography, air photo / Platts 2010: existing transmission / Pattern Energy 2010: project infrastructure

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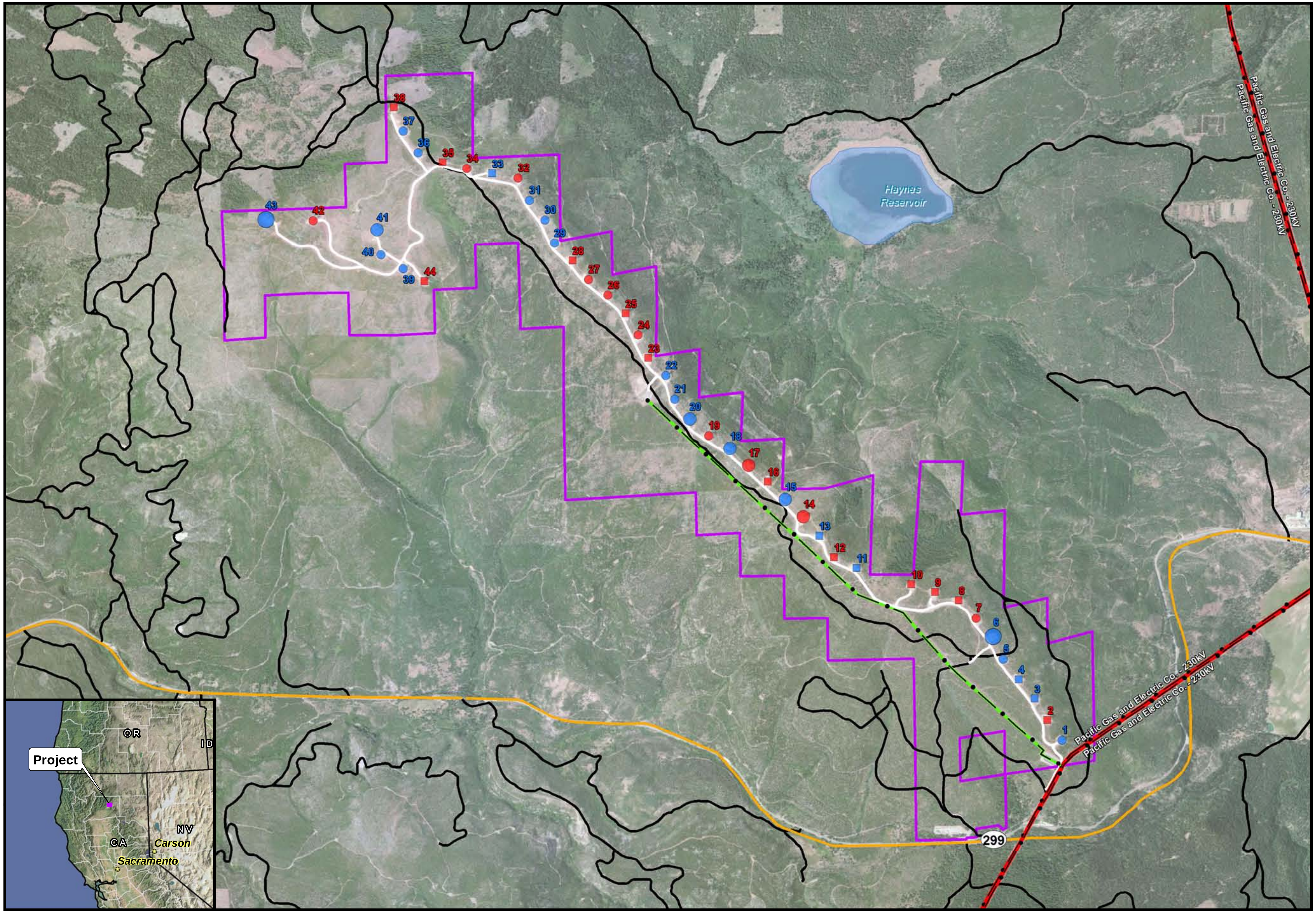

Figure 2

PATTERN ENERGY

Hatchet Ridge

Spatial Distribution of Avian Fatalities at the Hatchet Ridge Wind Farm (December 2011 - December 2012)

Shasta County, CA

February 25, 2013

- Project Boundary
- Overhead Transmission Line
- Transmission Line
- State Highway
- Local Road
- Access Road
- Lake/Pond

Fatalities Detected Per Turbine

Biweekly Search Interval

- 0
- 1
- 2
- 3

Monthly Search Interval

- 0
- 1
- 2

1:35,000 NAD 1983 UTM 10

0 0.5 1 2 3 4 5 Miles

Data Sources ESRI 2007: roads, hydrography, air photo / Platts 2010: existing transmission / Pattern Energy 2010: project infrastructure / TTEC 2013: avian fatalities

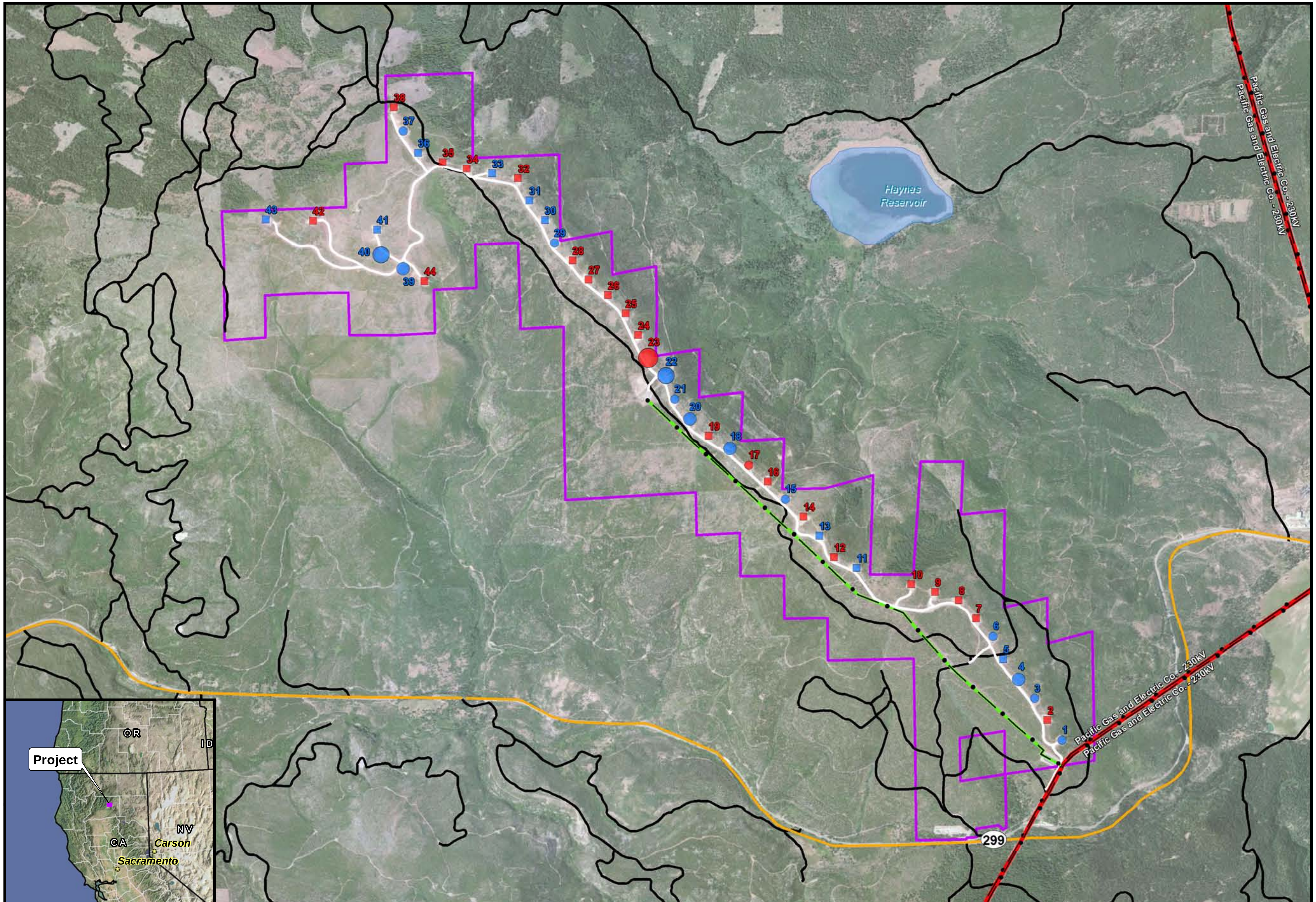

Figure 3

PATTERN ENERGY

Hatchet Ridge

Spatial Distribution of Bat Fatalities at the Hatchet Ridge Wind Farm (December 2011 - December 2012)

Shasta County, CA

February 25, 2013

- Project Boundary
- Overhead Transmission Line
- Transmission Line
- State Highway
- Local Road
- Access Road
- Lake/Pond

Fatalities Detected Per Turbine

Biweekly Search Interval

0
1
2
3

Monthly Search Interval

0
1
2
3
4

1:35,000 NAD 1983 UTM 10

0 0.5 1 2 3 4 5 Miles

Data Sources ESRI 2007: roads, hydrography, air photo / Platts 2010: existing transmission / Pattern Energy 2010: project infrastructure / TTEC 2013: bat fatalities

TETRA TECH

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Figure 2

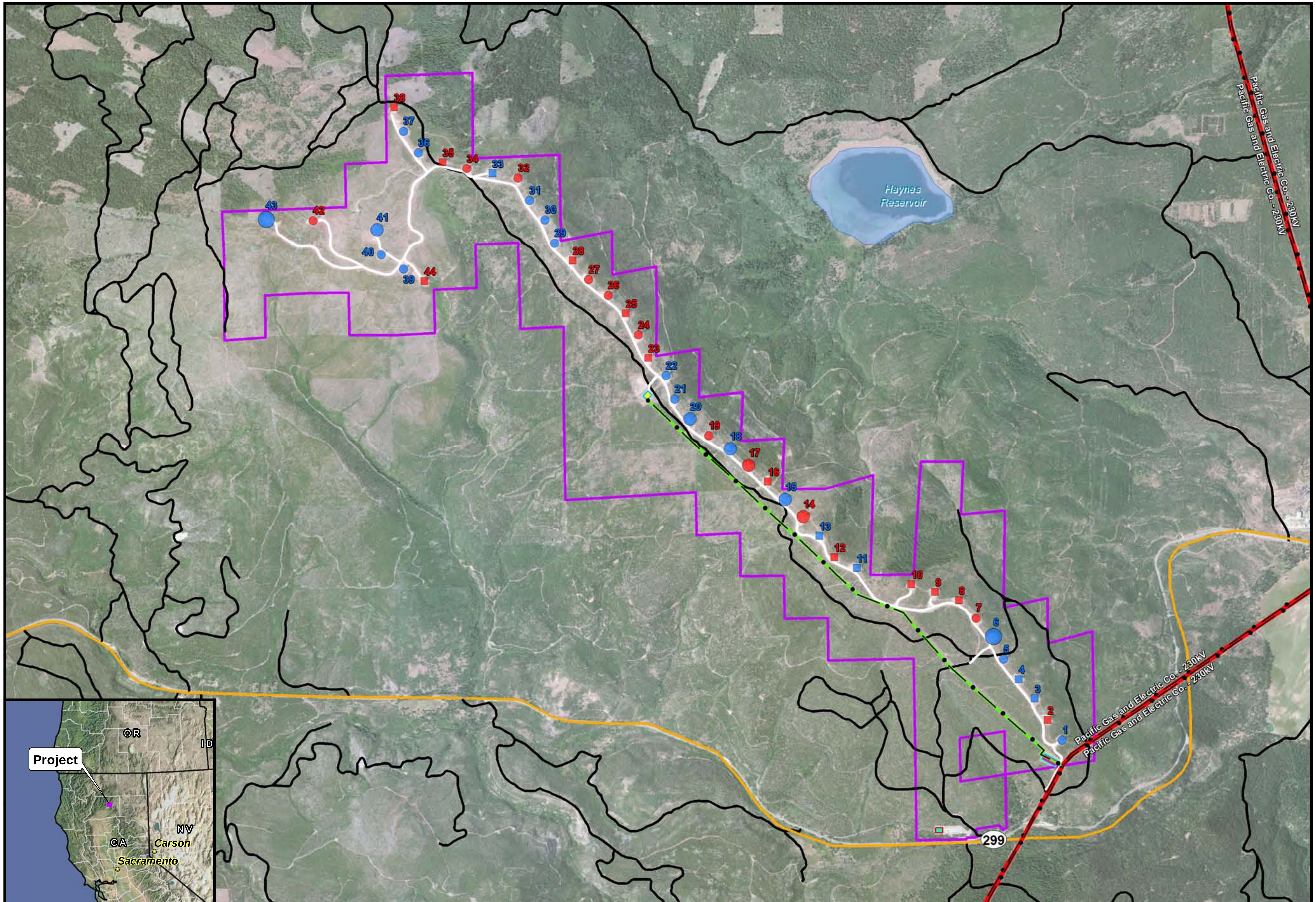
PATTERN ENERGY

Hatchet Ridge

Spatial Distribution of Avian Fatalities at the Hatchet Ridge Wind Farm (December 2011 - December 2012)

Shasta County, CA

January 11, 2013



- 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

Biweekly Search Interval

- 0
- 1
- 2
- 3

Monthly Search Interval

- 0
- 1
- 2

N

1:35,000 NAD 1983 UTM 10

0 0.5 1 2 3 4 5 Miles

Data Sources ESRI 2007: roads, hydrography, air photo / Platts 2010: existing transmission / Pattern Energy 2010: project infrastructure / TTEC 2013: avian fatalities

TETRA TECH

Figure 3

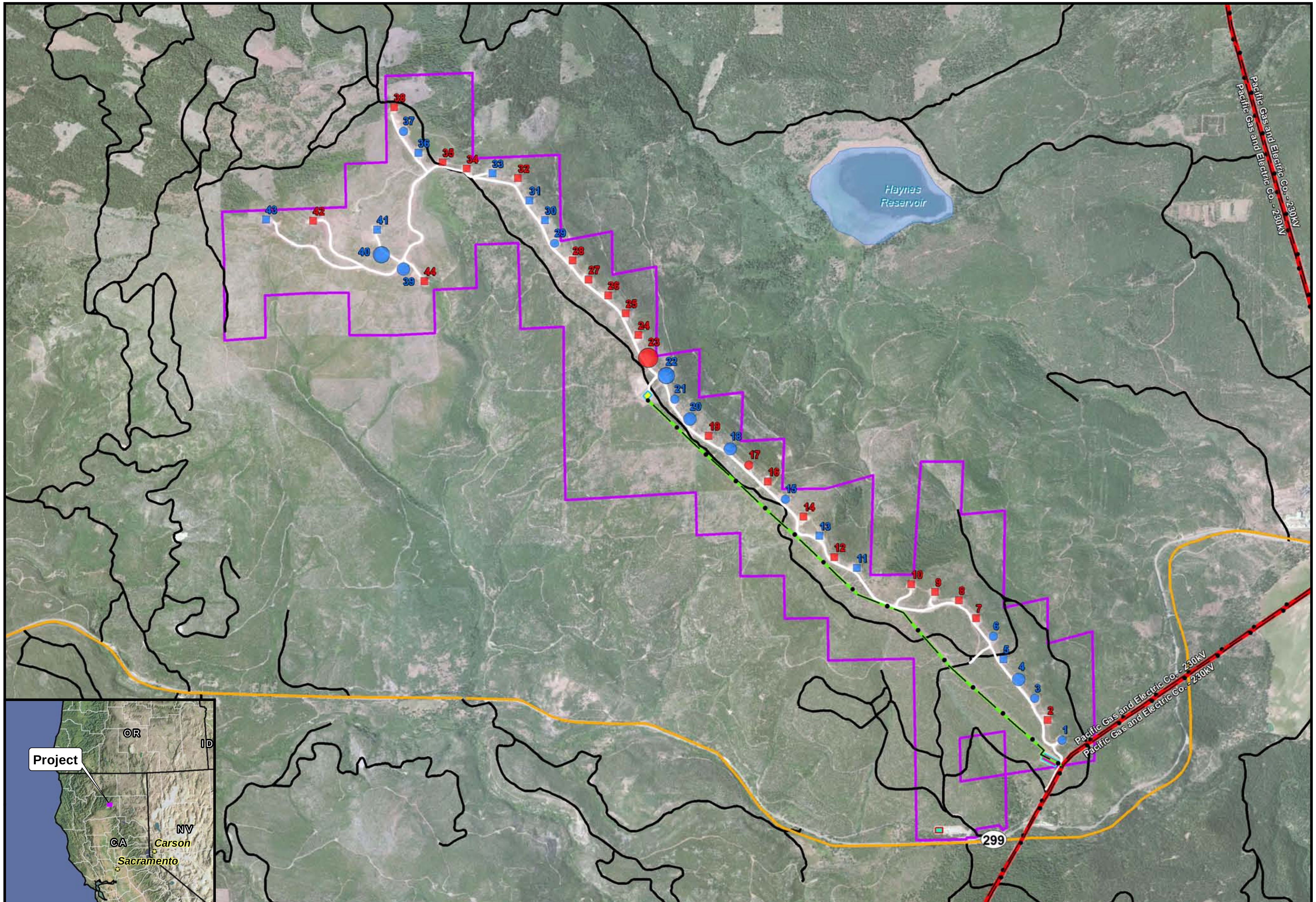
PATTERN ENERGY

Hatchet Ridge

Spatial Distribution of Bat Fatalities at the Hatchet Ridge Wind Farm (December 2011 - December 2012)

Shasta County, CA

January 11, 2013



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

Biweekly Search Interval
- 0
- 1
- 2
- 3

Monthly Search Interval
- 0
- 1
- 2
- 3
- 4

1:35,000 NAD 1983 UTM 10

0 0.5 1 2 3 4 5 Miles

Data Sources ESRI 2007: roads, hydrography, air photo / Platts 2010: existing transmission / Pattern Energy 2010: project infrastructure / TTEC 2013: bat fatalities

TETRA TECH

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Figure 4. Search fatalities found by month at Hatchet Ridge

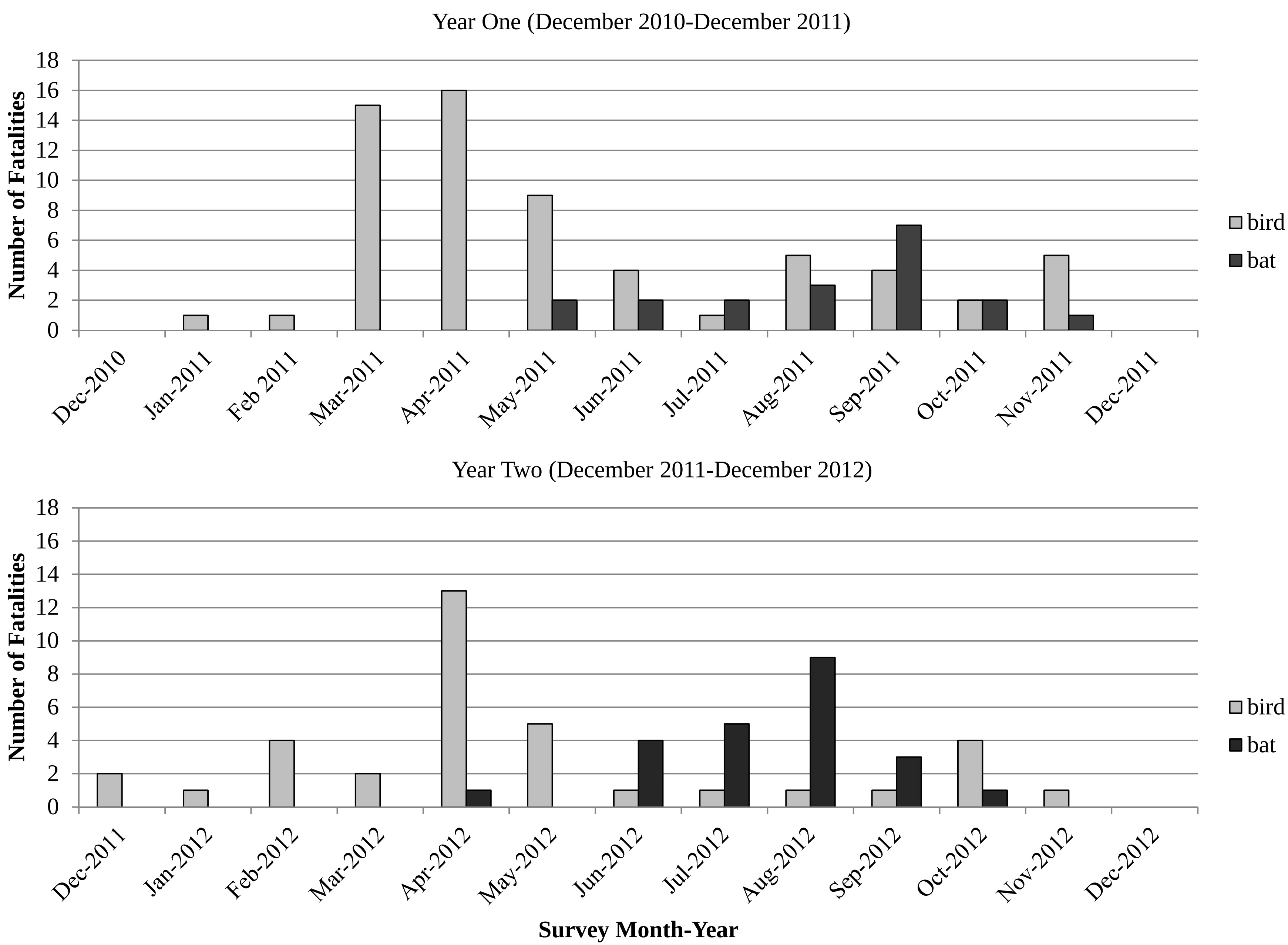
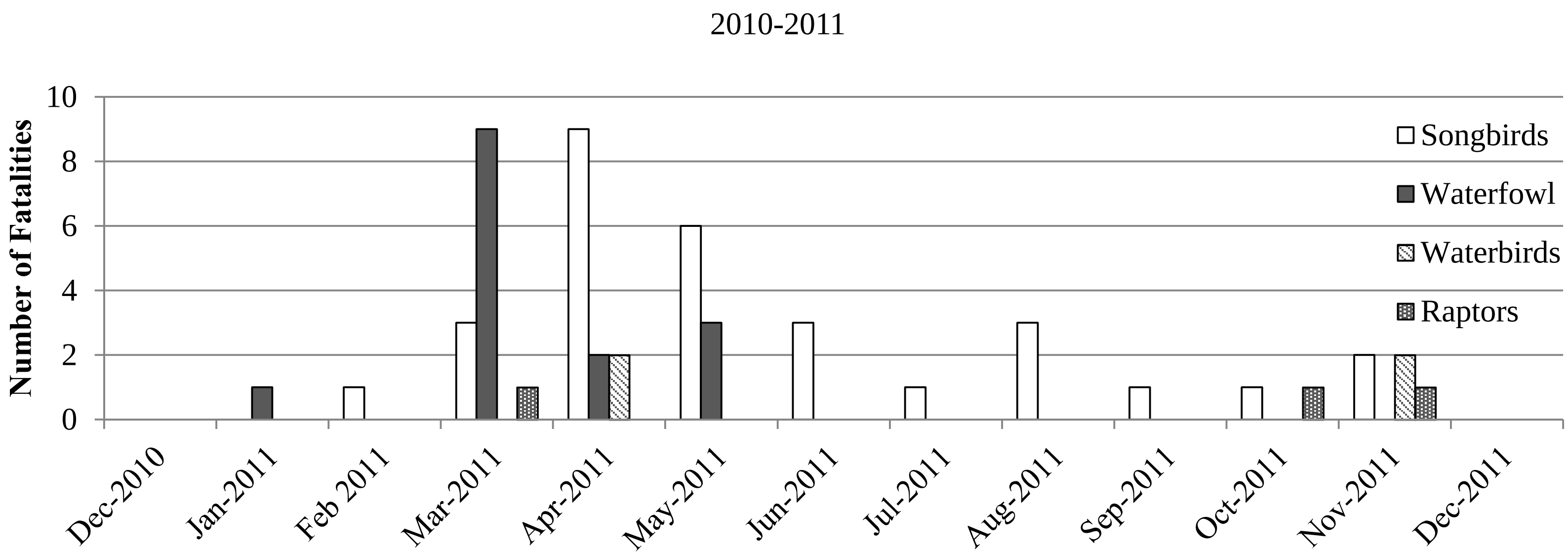


Figure 5. Avian fatalities by month at Hatchet Ridge Wind Farm



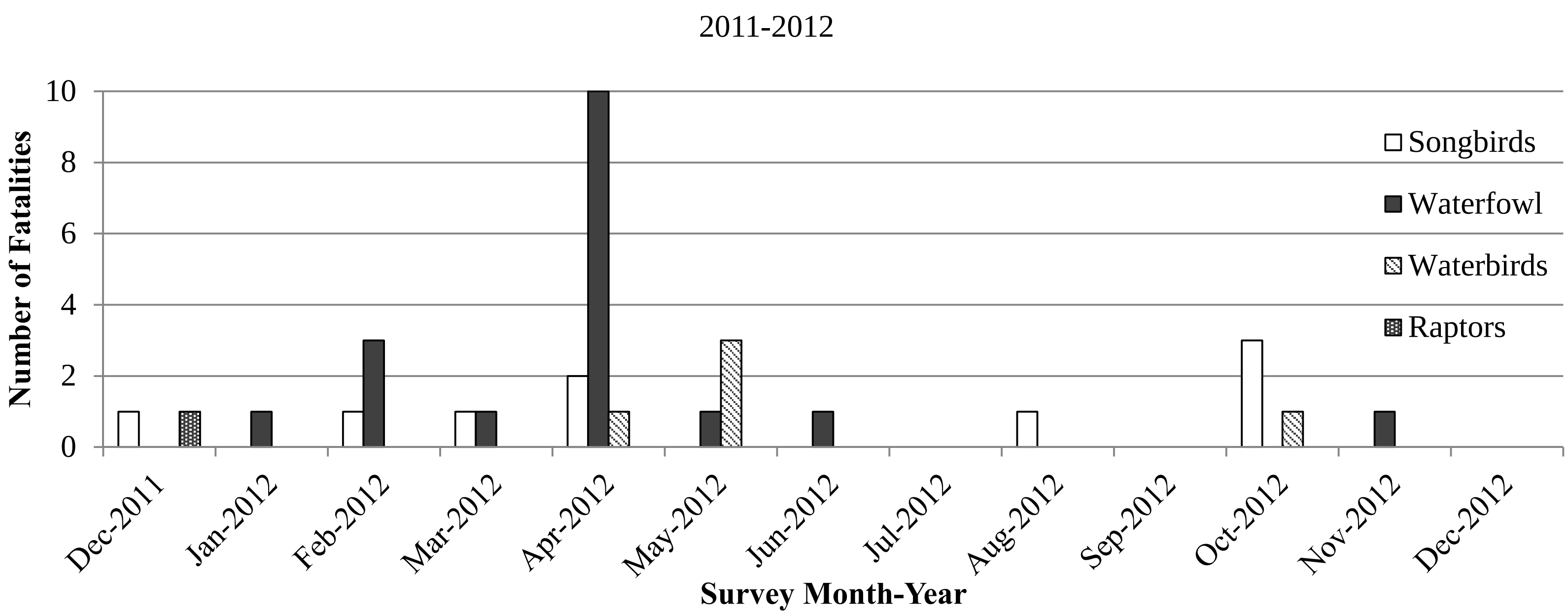
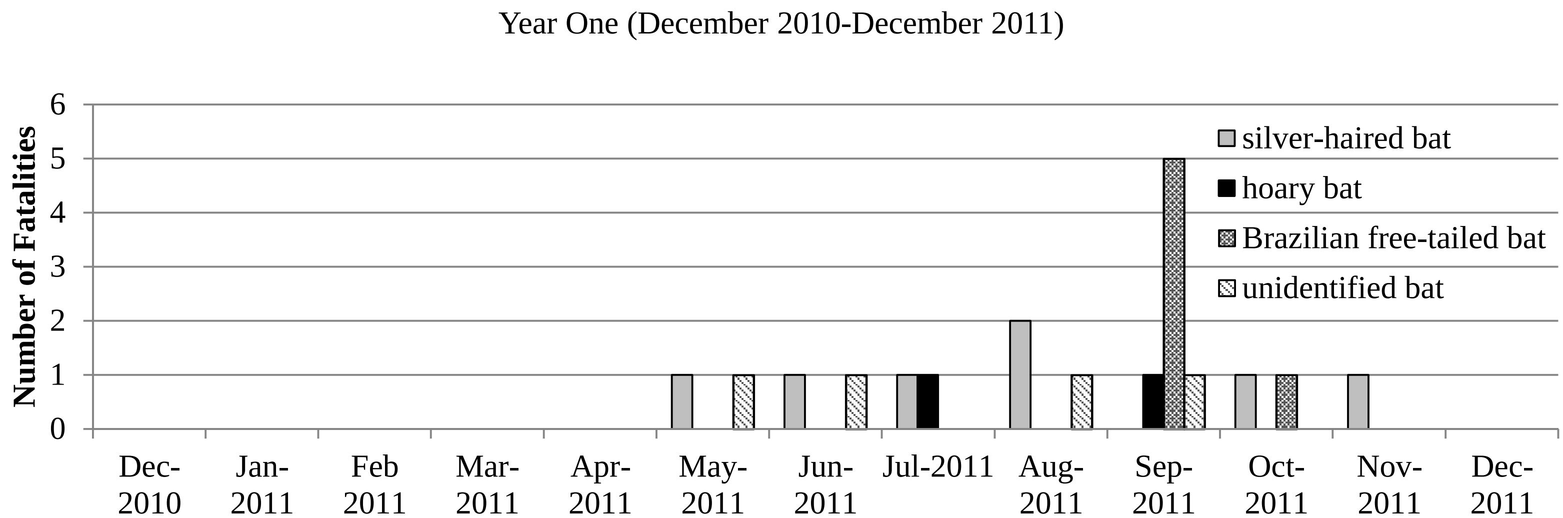
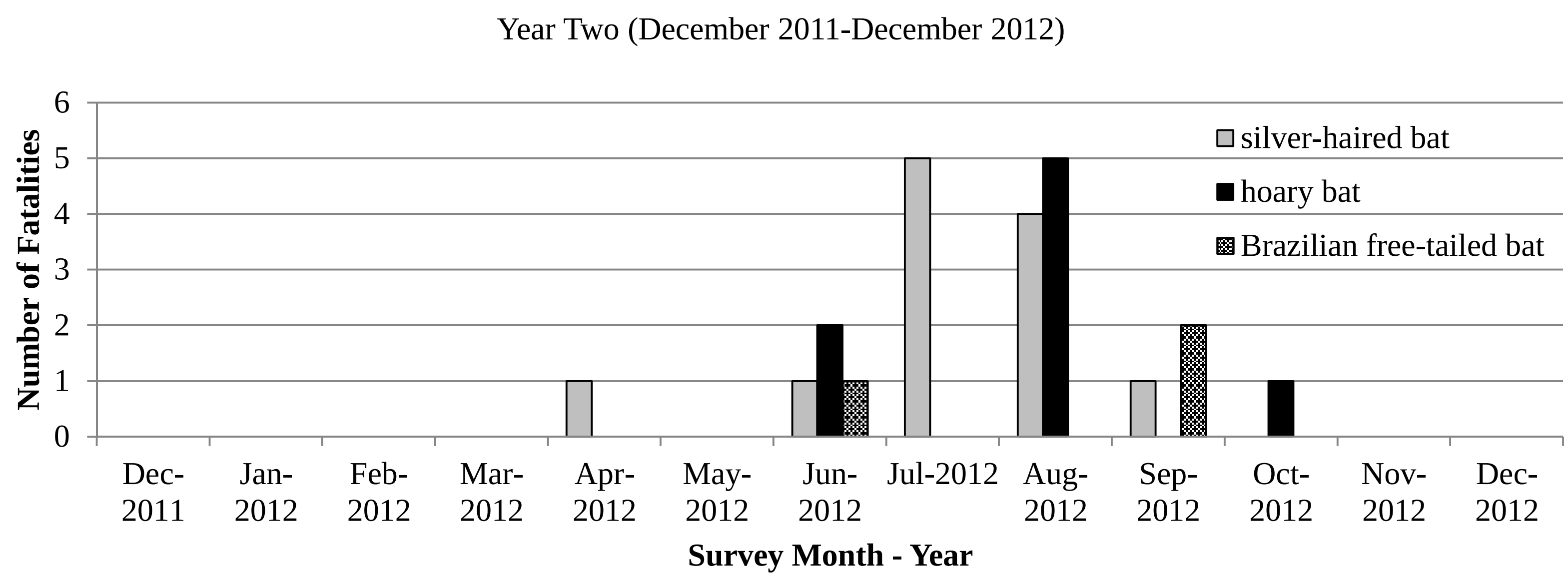


Figure 6. Monthly distribution of bat fatalities by species at Hatchet Ridge





Appendix 1. Akaike Information Criterion (AIC) results for Year 2 searcher efficiency.

Factors	AICc	ΔAICc	k
Size, Season	330.36	0.00	4
Size	336.77	6.41	2
Size, Season, Size*Season	340.22	9.86	4
Season	377.99	47.63	2

Appendix 2. Akaike Information Criterion (AIC) results for Year 2 carcass persistence.

Factors	Distribution	AICc	ΔAICc	k
Size	Weibull	552.62	0.00	2
Size, Season	Weibull	556.17	3.55	4
Size, Season, Size*Season	Weibull	557.12	4.50	6
Size, Season	Log-logistic	560.37	7.75	4
Size	Log-logistic	560.48	7.86	2
Size	Log-normal	560.48	7.86	2
Size, Season, Size*Season	Log-normal	562.62	10.00	6
Size, Season, Size*Season	Log-logistic	562.85	10.23	6
Size, Season	Log-normal	562.87	10.25	4
Size, Season, Size*Season	Exponential	567.00	14.38	6
Size, Season	Exponential	568.88	16.26	4
Season	Log-normal	630.36	77.74	3
Season	Log-logistic	631.88	79.26	3
Season	Weibull	644.22	91.60	3
Season	Exponential	721.56	168.94	3