Hatchet Ridge Wind Farm
Post-Construction Mortality Monitoring
Comprehensive Three Year Report

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Executive Summary

The Hatchet Ridge Wind Farm (Project) is a 44 turbine wind energy facility located in Shasta County California. In October 2010, Tetra Tech, Inc. (Tetra Tech) was contracted to develop and implement a post-construction mortality monitoring (PCMM) 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. 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 adjust for inherent biases in estimating Project-related fatality rates, avian use surveys in Year One, and a Wildlife Education and Incidental Reporting. In October 2012, the Technical Advisory Committee providing Project oversight and guidance recommended a consecutive third year of the study.

This report presents the results of the third year of monitoring and the overall 3 years of PCMM, and includes a summary of documented fatalities, estimates of searcher efficiency and carcass persistence, and estimated annual fatality rates adjusted for bias for each year. Additionally, observed trends in Project-related fatalities are discussed along with trends relating to Special-Status Species and Groups and sources of study bias.

Specific to Year Three, a total of 51 fatalities were detected during 4 seasons of mortality monitoring. When sorted by search frequency, 38 fatalities (27 birds, 11 bats) were detected during biweekly (2 week interval) searches, 8 fatalities (3 birds, 5 bats) were detected during monthly searches, and 5 fatalities were detected incidentally (3 birds, 2 bats). Fatalities included bird fatalities from 19 species and 2 bird fatalities not identifiable to a species, as well as 18 bat fatalities from 4 species. The avian species groups with the highest number of fatalities include waterfowl (n=13; 25 percent of fatalities) and songbirds (n=9; 17 percent of fatalities). Four raptor fatalities (Special-Status Group: Other Raptors) including red-tailed hawk (n=2), Cooper's hawk (n=1) and great horned owl (Special Status Group: Owls; n=1) were detected during biweekly searches. One raptor fatality, a sharped-shinned hawk, was detected during monthly searches. Seasonal composition of fatalities varied, with the highest number of avian fatalities (n=14) occurring in winter and the highest number of bat fatalities (n=15) occurring in summer. No Special-Status Species (bald eagle, sandhill crane, yellow warbler) were detected.

Year Three searcher efficiency and carcass persistence trials were conducted in each season. Searcher efficiency ranged from 0. 61 (90 percent CI=0.52–0.68) for bats to 0.92 (90 percent CI=0.88–0.96) for large birds. Carcass persistence times ranging from 1.55 days (90 percent CI=1.23–1.87) for bats to 40.80 days (90 percent CI=30.05–59.38) for large birds.

In Year Three fatality estimates were calculated for 5 groups: All birds, non-raptors, large birds, small birds and bats using fatalities detected during the biweekly carcass searches. The annual fatality estimates are presented in Table ES-1. Fatality estimates were not calculated for individual species or species groups with less than 5 fatalities detected (at biweekly searched turbines) due to the estimation model sample size requirement (n≥5).

Over 3 years of monitoring, a total of 98 avian fatalities from 39 species were detected at the Project with 42 avian fatalities not identifiable to species due to the condition of the remains. Estimated annual fatality rates for all birds ranged from 1.93 birds/turbine (90 percent CI=1.49–2.50) to 5.74 birds/turbine (90 percent CI=4.53–7.74). Estimated annual avian fatality rates at the Project were comparable to other reported fatality rate estimates regionally. The majority of avian fatalities were waterfowl in the spring. Waterfowl fatalities at the Project be attributable to these species making localized movements under high wind and/or low visibility conditions. Songbird fatalities were also documented, but at lower rates than other wind facilities. Population-level impacts to the species most commonly detected as fatalities are unlikely due to secure populations of these species. All but one of the identified avian species (European starling) are protected under the MBTA.

A total of 63 bats from 4 species were detected at the Project over the three years of monitoring with 4 fatalities not identifiable to species due to the condition of the remains. Estimated annual bat fatality rates ranged from 5.13 bats/turbine (90 percent CI = 1.92–9.75) to 12.02 bats/turbine (90 percent CI = 6.74–20.85). Estimated annual bat fatality rates at the Project were comparable to other reported fatality rate estimates regionally and were consistent among the years of the study. Bat fatalities were highest during July-September and included hoary, silver-haired, and Brazilian free-tailed bats, as has been found at other wind facilities. Project-related fatalities are unlikely to have population-level impacts for the Brazilian free-tailed bat given their population stability. Limited population data for the hoary and silver-haired bat is available; however, the relatively low number of fatalities detected for these species indicate that population-level impacts are unlikely.

MM BIO-6 Special Status Species and Groups fatalities were detected; however, no bald eagle or sandhill crane fatalities were documented during the 3 years of the study. Fatalities were documented for MM BIO-6 Special-Status Groups Other Raptors (biweekly searched turbines, n=5; monthly searched turbines, n=4), Owls (biweekly searched turbines, n=1) and Special-Status Species Yellow Warbler (biweekly searched turbines, n=1; monthly searched turbines, n=1). Statistically-reliable per turbine annual fatality estimates could not be calculated for these groups or species due to an insufficient sample size ($n \geq 5$); therefore, comparisons against Project-specific thresholds for these species and groups cannot be made.

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

Variable	Value
Study Metrics for Fatality Estimates	
Number of turbines	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[1,2]	
All birds	
Mean fatality rate per turbine per year	2.81(90% CI=1.64–4.36)
Mean fatality rate per MW per year	1.22 (90%CI=0.71–1.90)
Non-raptors	
Mean fatality rate per turbine per year	2.58 (90% CI=1.50–4.04)
Mean fatality rate per MW per year	1.12 (90% CI=0.65–1.76)
Raptors	
Mean fatality rate per turbine per year	-
Mean fatality rate per MW per year	-
Large birds	
Mean fatality rate per turbine per year	1.11 (90% CI=0.79–1.45)
Mean fatality rate per MW per year	0.48 (90% CI =0.34–0.63)
Small birds	
Mean fatality rate per turbine per year	1.70 (90% CI=0.62–3.21)
Mean fatality rate per MW per year	0.74 (90% CI=0.27–1.40)
Bat Fatalities[1]	
Mean fatality rate per turbine per year	9.67 (90% CI=6.57–13.76)
Mean fatality rate per MW per year	4.20 (90% CI=2.86–5.98)

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

[2]Annual fatality estimates provided for groups with a sample size ≥5 detected fatalities.

Table of Contents

List of Tables

List of Figures

Appendices

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 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 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) arranged in a string that extends 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 20 feet ([ft]; 1.5 to 6.1 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). MM BIO-6 also established annual fatality thresholds for 2 California Fully Protected species (1 bald eagle/year and 1 sandhill crane/year), 1 Special-Status Species (0.07 yellow warbler fatalities/turbine/year), and 2 Special-Status Groups (0.35 raptor fatalities/turbine/year (excluding owls), and 0.11 owl fatalities/turbine/year). As part of MM BIO-6, 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 the operating permit, Hatchet Ridge Wind is required to evaluate Project impacts relative to these thresholds as demonstrated by the results of post-construction monitoring. Exceeding established thresholds or other unanticipated impacts to other Special-Status Species 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 was approved by the TAC in 2010 and incorporated 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 incorporated fatality monitoring at all turbines in the form of standardized carcass searches (biweekly and monthly), searcher efficiency and carcass persistence trials to adjust for inherent biases in estimating Project-related fatality rates, avian use surveys in Year One, and a Wildlife Education and Incidental Reporting Program. The two-year study was initiated in late-November 2010. On October 24, 2012, the TAC recommended a third consecutive year of fatality monitoring using the same approved methods and protocols followed in the first two years.

The objectives of this study were to determine species composition of fatalities, determine searcher efficiency and carcass persistence times, assess any spatial and temporal patterns in bird and bat fatalities, calculate annual fatality rates adjusted for bias, and use these estimates to assess compliance with the MM BIO-6 thresholds. This report presents the third year (Year Three) results of post-construction mortality monitoring as well as summarizing the three year comprehensive results of post-construction mortality monitoring at the Project. Additionally, comparisons of Special-Status Species' and Groups' are made among all years of the study.

2 Methods

2.1 Fatality Monitoring

Fatality estimates at wind energy facilities are based on the number of carcasses found during carcass searches conducted under selected operating turbines. Both the duration that a carcass persists on site long enough to be detected by searchers (carcass persistence time), and the ability of searchers to detect carcasses given persistence time (searcher efficiency) can bias the number of carcasses located during standardized searches. Therefore, this post-construction monitoring study included 1) biweekly standardized carcass searches to monitor for fatalities associated with the operation of the Project at half the turbines and 2) monthly standardized carcass searches at the remaining turbines 3) searcher efficiency trials to assess observer efficiency in finding carcasses, and 4) carcass persistence trials to assess site-specific duration that a carcass remains available to searchers. Methods remained consistent among the three years.

Standardized carcass searches at the Project were initiated on December 12, 2010 and continued without interruption through December 12, 2013. Study years were defined as Year One (December 12, 2010–December 11, 2011), Year Two (December 12, 2011–December 15, 2012) and Year Three (December 27, 2012–December 13, 2013). In each year of the study, 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 11).

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. Barotrauma is 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 (approximately every 2 weeks); fatalities detected at biweekly turbines were used for estimating annual fatality rates. The remaining 22 turbines were searched monthly (approximately every 4 weeks; Figure 1). Data from monthly searches were used to supplement fatality data from biweekly searches; these were not used to estimate annual fatality rates. The focus of these additional monthly surveys was on two California Fully Protected species (e.g. bald eagle, sandhill crane) and raptors, all of which are medium- to large-bodied species for which a longer search interval is appropriate.

Biweekly Search Plots

Biweekly search plots were selected to sample turbines evenly along the ridge in order to capture various elevations, vegetation communities, turbine position along the string, and maximize the searchable space within the plot (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 (416 ft x 416 ft). These plots were centered on the turbine and 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 into 4 visibility classes of low, medium, high and non-searchable using a Trimble GeoXT. 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 due to vegetative density 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 surveyed. The amount of non-searchable area varied among search plots. Four plots were fully searchable, 12 had between 0.5 and 10 percent non-searchable area, and 6 had between 10 and 19 percent non-searchable area, for an average of 7.8 percent of all 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 including roads, turbine pads, cleared areas and areas with low vegetation density representing, on average, 36 percent of a given search plot. 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 Handling and Documentation

Tetra Tech's USFWS scientific collecting permit (Number MB163272-1) was issued on April 11, 2011 and was active through March 31, 2013. This permit allowed surveyors to collect Migratory Bird Treaty Act (MBTA)-protected bird carcasses found within the Project area for the duration of the permit. Scientific collecting permits issued by the California Department of Fish and Game to surveyors allowed for the collection of birds in conjunction with a federal scientific collection permit, and bats under California Fish and Game Code Section 1002 and California Code of Regulations Title 14, Section 650.

All fatalities were documented and photographed. Fatalities were identified to species or identified to the highest possible taxonomic level when species identification was not possible due to the condition of the remains. After the USFWS permit expired in March 2013, bird carcasses were documented in-situ and left in place.

Control Plots

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

2.1.2 Incidental Fatalities

When a bird or bat carcass was detected 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. Additionally, all fatalities documented during the initial sweep survey in Year One and during the monthly search interval 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. Approximately 3 searcher efficiency trials were conducted at biweekly searched turbines 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 Project-related bat carcasses were not available) 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 from biweekly search turbines. Each trial included 8 to 10 carcasses from each size category with a maximum of 4 carcasses placed at any given turbine. These carcasses were placed at stratified random locations within selected turbines' search plots. Locations were 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 was not found by searchers and 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 placed for the i^{th} carcass category that are recovered at the end of the trial (i.e. available to be found).

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 can 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). 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 stratified random locations within the selected turbine's search plots. Locations were stratified by searchable and non-searchable area to ensure that searchable areas were represented in proportion to their presence in the search plots. Ten to 15 trial carcasses from each carcass category were utilized per trial; 3-5 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:

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

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

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 2011), 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 $\hat{\tilde{I}}$, 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

The fatality estimates are the result of a bootstrap analysis where each fatality estimate is adjusted based on the bias. For each bootstrap run, turbines are randomly selected from the dataset. When a turbine has associated fatalities, each fatality is adjusted according to detection bias. Then, fatality estimates are generated from the full bootstrap data for selected output categories (i.e., bats, birds) and a corresponding confidence interval is calculated.

Data from the biweekly searched turbines were 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 4 categories: 1) all birds 2) raptors, 3) non-raptors, and 4) 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 rate, a minimum sample size of 5 fatalities of an individual species or species group is required (M. Huso, pers. comm.). Thus, we did not include estimates for MMBIO-6 Special-Status Species or Groups that did not meet this parameter.

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 Three Results

Results from the third year of monitoring are presented in this section although tables and figures show comprehensive results over all three years for comparison. Reports from the first two years of monitoring provide specific seasonal detail (e.g., fatalities by species by season) for Year One and Year Two of the study (Tetra Tech 2012, Tetra Tech 2013).

3.1 Fatality Monitoring

3.1.1 Standardized Carcass Searches

Twenty-six rounds of biweekly carcass searches were conducted at 22 of the 44 turbines in Year Three. Searches were conducted from December 27, 2012 to December 13, 2013 for a total of 570 biweekly searches (Table 1). Due to turbine maintenance, 2 turbines were not surveyed one time each during the 26 rounds of biweekly carcasses searches. Thirteen rounds of monthly carcass searches were conducted at the remaining 22 turbines (286 total monthly searches).

During biweekly searches in Year Three, 38 fatalities (27 birds and 11 bats) were detected (Table 2). Among these fatalities, 15 avian species from 5 species groups were identified (Table 2). Avian species groups detected included waterfowl (n=11), songbirds (n=7), cranes/rails (n=4), raptors (n=4), and swifts/hummingbirds (n=1). The species with the highest number of fatalities were American coot (n=4) and green-winged teal (n= 3). Two or fewer fatalities were detected for each other avian species documented. Additionally, 2 fatalities were identifiable to species group only (unidentified waterfowl; Table 2). Two Special-Status Species or Groups were detected; Other Raptors (n=3) and Owls (n=1). Eleven bats from 3 species were detected, including hoary bat (n=4), silver-haired bat (n=4) and Brazilian free-tailed bat (n=3; Table 2).

During monthly turbine searches in Year Three, 8 fatalities (3 birds and 5 bats) were detected. Among these fatalities, 3 avian species from 3 species groups were identified (Table 3). Species groups detected included waterfowl (n=1), songbirds (n=1), raptors (Special-Status Species Group Other Raptors; n=1; Table 3). Three bat species were detected: hoary bat (n=3) big brown bat (n=1), and silver-haired bat (n=1).

3.1.2 Incidental Finds

Five fatalities (3 birds and 2 bats) were detected incidental to biweekly and monthly searches in Year Three: mountain quail (n=1), house wren (n=1), northern pintail (n=1) and silver-haired bat (n=2; Table 5).

A summary of total avian and bat fatalities for Year Three is presented in Appendix 1.

3.1.3 Spatial and Temporal Distribution of Fatalities

Avian fatalities were distributed throughout the Project in Year Three and include fatalities detected at biweekly search turbines, monthly search turbines and incidentally. Avian fatalities were detected at 16 of 22 biweekly search turbines and at 4 of the 22 monthly search turbines (Figure 2). No turbine had greater than four fatalities detected within its associated search plot. Turbines 15 and 20 were turbines with the highest number of fatalities (n=4 each). No distinct spatial pattern of avian fatality distribution was evident within the Project.

Bat fatalities were also distributed throughout the Project in Year Three. Bat fatalities were detected at 10 of 22 biweekly searched turbines and 4 of 22 monthly searched turbines (Figure 3). Turbine 10 had the highest number of bat fatalities associated with a single turbine (n=3).

Similar to avian fatalities, there was no distinct spatial pattern of bat fatalities within the Project in Year Three.

In Year Three, fatalities at the Project occurred throughout the year. The taxonomic group composition of monthly fatalities varied throughout the year however, the overall monthly totals of avian fatalities had a narrow range of 0–7 (Tables 2–4; Figures 4, 5). The highest number of avian fatalities occurred in spring during the month of March (n=7; Figure 4). Fatalities in this month were comprised of waterfowl (n=4) and cranes/rails (American coot, n=3). Taxonomic groups with the highest number of fatalities (waterfowl, songbirds, raptors) demonstrated little temporal variation by season and month in the number of fatalities detected (Figure 5). Waterfowl and songbirds were detected in each season; waterfowl were detected January–July and in November, while songbirds were detected in January, April, July, October and November. Raptors were detected in 3 seasons including the months of January, , July and August.

Bat fatalities were detected June through October of Year Three. The highest number of bat fatalities occurred in August (n=10), followed by September (n=4; Figure 4). Each other month in which bat fatalities were detected had 2 or fewer bat fatalities detected.

3.2 Searcher Efficiency and Carcass Persistence Trials

Bias correction trials were conducted in each season of Year Three to capture any potential seasonal effects on fatality monitoring. In winter of Year Three, unusually high raw searcher efficiency results (100 percent) and low carcass persistence times (0.98 day for small birds and 0.36 day bats) occurred. This occurrence was likely tied to snowfall just prior searcher efficiency trials and ravens observed feeding on carcass persistence trial carcasses. As these results limited the effective modeling of data, winter searcher efficiency and carcass persistence results from Year Two were used to adjust fatality estimates for Year Three.

Searcher efficiency trials were conducted between January 22 and November 26, 2013. A total of 258 carcasses (84 large birds, 87 small birds, 87 bats) were placed during 11 trials. Two hundred eighty-three carcasses (97 large birds, 94 small birds, 92 bats) were used for analysis. The best fit model indicated searcher efficiency varied by size class (Appendix 2). Searcher efficiency was calculated at 0.61 for bats (90 percent CI=0.52–0.68), 0.69 for small birds (90 percent CI 0.62–0.77) and 0.92 for large birds (90 percent CI=0.88–0.96; Table 5).

Carcass persistence trials were initiated on February 4, April 30, July 22, and October 15 during winter, spring, summer and fall, respectively. A total of 171 trial carcasses were placed (56 large birds, 57 small birds, 58 bat surrogates; Table 6) using results from Year Two winter and Year Three spring, summer and fall trials. The best fit model indicated carcass persistence varied by size class (Appendix 3). Carcass persistence time was calculated at 40.80 days for large birds (90 percent CI=30.05–59.38), 4.34 days for small birds (90 percent CI=3.17–5.69) and 1.55 days for bat surrogates (90 percent CI=1.23–1.87).

3.3 Annual Fatality Estimates

Year Three annual fatality rate estimates are presented for birds and bats including the bird categories of all birds, non-raptors and raptors, small birds and large birds (included for comparison with other projects), and waterfowl. Non-raptors and raptors are included for differentiation between the MMBIO-6 focus group of Other Raptors while waterfowl are included due to the number of fatalities (≥5) detected within the species grouping. Waterfowl fatalities are included in both non-raptor and large bird fatality estimates (Table 7). Table 7 provides fatality estimate for each bird category per turbine, and per Project.

The estimated annual fatality rate for all birds was 2.81 bird fatalities/turbine/year (90 percent CI=1.64–4.36), 1.22 bird fatalities/MW/year (90 percent CI=0.71–1.90), or 124 bird fatalities/Project/year (90 percent CI=73–192).

Although fatalities were detected at biweekly turbines for Special-Status Groups (Other Raptors, n=4; Owls, n=1), no fatality estimates were calculated for these Special-Status Groups. In order to produce a robust estimated annual fatality rate, a minimum sample size of 5 fatalities per category is required (see Section 2.1.5). The minimum sample size requirement was not met by either Special-Status Species Group for which fatalities were detected.

Waterfowl fatalities are estimated at 0.64 fatalities/turbine/year (90 percent CI=0.33–0.97), 0.28 fatalities/MW/year (90 percent CI=0.14–0.42), or 29 fatalities/Project/year (90 percent CI=15–43).

Bat fatalities were estimated at 9.67 bat fatalities/turbine/year (90 percent CI=6.57–13.76), 4.20 bat fatalities/MW/year (90 percent CI=2.86–5.98), or 426 bat fatalities/Project/year (90 percent CI=290–606).

Annual fatality estimates were adjusted for proportion of the large bird, small bird and bat fatality distribution searched as determined by the location of non-searchable areas within each biweekly searched turbine's study plot. Adjusted annual fatality estimates were statistically similar to the non-adjusted fatality estimates presented here as represented by the overlapping confidence intervals of each fatality estimate category. See Appendix 4 for adjusted annual fatality estimates.

4 Discussion

4.1 Bird and Bat Fatalities

Estimated annual fatality rates for all birds at the Project fell in the low to middle range of estimated annual fatality rates from other operational wind energy facilities in California, Oregon and Washington (0.81–12.73 birds per turbine; Enk 2011, Erickson 2007). The estimated avian fatality rate at the Project ranged from 2.81 to 5.47 birds per turbine per year (Table 11). At the time of this report, there are no publically available mortality monitoring studies for wind energy facilities with forested ridge-top habitat in the Western United States; thus, comparisons are made to Western-region facilities. Although fatality estimates from other projects are presented for context, direct comparison of fatality estimates should be approached with caution because the use of different estimators, survey periods, and survey methods creates variable bias (Huso 2011). All but one of the identified avian species (European starling) are protected under the MBTA. Currently, there are no permits for incidental take of migratory birds (Beveridge 2005). USFWS, however, does not usually take action if good faith efforts have been made to minimize impacts, as outlined in their voluntary guidelines (USFWS 2012a).

Spatial distribution of avian fatalities throughout the Project was consistent among years. Fatalities at turbines ranged from 0 to 5 fatalities per turbine in any given year and no individual turbine was identified as a problem turbine (Figures 2, 6, 7, 8).

Avian fatalities were detected throughout the year; however, a peak occurred between March and (Figure 4). This pattern occurred primarily due to an increase in waterfowl fatalities, which contrasts with most studies where waterfowl are not typically documented as a species group with high numbers of fatalities despite high mean use in some locations (Jain 2005, Johnson and Erickson 2011). In all years, waterfowl fatalities were primarily detected after storms moved through the area (Ken Hammon, pers. comm; Figure 5). Strong storm fronts that bring low cloud ceilings with limited visibility and high winds to the area occur most often during this timeframe (NOAA 2014). Studies investigating avian collision risk with wind turbines suggest that the risk of collision can increase under 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 large scale migratory movements. Waterfowl fatalities at the Project be attributable to these species making localized movements under high wind and/or low visibility conditions. Two species, the snow goose and American coot, were the most commonly detected species over all study years (n=10 for each species) and have been as fatalities at other wind energy facilities (Anderson et al. 2005, TRC Environmental 2009). Both species are considered wide-spread and abundant throughout their ranges (NatureServ 2013); thus, Project-related fatalities are not likely to have population-level impacts.

Songbird fatalities comprised 35 percent or less of the fatalities at the Project in contract to the 80 percent of documented songbird fatalities at other projects (Erickson et al. 2001, Johnson et al. 2002, Drewitt and Langston 2006, Strickland and Morrison 2008). Because relatively low numbers of songbird fatalities have occurred at the Project, Project-related impacts to resident and migrating songbird populations are likely to be minimal.

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; however, raptor fatality rates at the Project below levels that allow for fatalities estimates to be derived (n=5).

Nine raptors from five species were detected as fatalities over the course of the three year study: red-tailed hawk (n=4), sharp-shinned hawk (n=2), turkey vulture (n=1), Cooper's hawk (n=1) and great horned owl (n=1, Tables 9–11). This pattern could be due to the low raptor use at the Project (2.4 percent of all birds detected during avian use surveys) or because raptors exhibit collision avoidance behaviors at turbines (Garvin et al. 2011). Fatalities of each of the raptor species found at the Project have been documented at other wind energy facilities (Downes and Gritski 2012, Johnson and Erickson 2011, Stantec 2010, Young 2007). Populations of all of these species are considered secure in California; therefore, fatalities of these species at the Project are unlikely to have population level impacts (Sauer 2012).

Similar to birds, comparison of estimated annual bat fatality rates at wind facilities provides regional context for Project-related impacts. Estimated annual bat fatality rates at the Project range from 5.13 bats/turbine to 12.02 bats/turbine. As mention above, there are no publically available mortality monitoring studies for wind energy facilities with forested ridge-top habitat in the Western United States; thus, comparisons are made to Western-region facilities. Although fatality estimates from other projects are presented for context, direct comparison of fatality estimates should be approached with caution because the use of different estimators, survey periods, and survey methods creates variable bias (Huso 2011).

The ultimate cause(s) behind bat mortality at wind energy facilities is poorly understood. Hypotheses include random collisions with turbines, coincidental collisions such as when turbines occur within migratory corridors and 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 have primarily 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). This same pattern was observed at the Project with migratory tree-roosting species (silver-haired bat and hoary bat) comprising the majority of bat fatalities at the Project and the peak in bat fatalities occurring July – September (Figure 4). The pattern of increased fatalities that coincides with the late summer/fall migration suggests that either there are more bats using the Project at this time and/or they are at a higher risk of collision in the late summer and fall; however, this has not been confirmed (Cryan 2003, Kunz et al. 2007).

Estimated bat fatality rates reported for wind energy facilities in the Pacific Northwest and Intermountain West range from 0.63 to 13.40 bats per turbine. The range of estimated fatality rates for the Project is comparable to the values reported for these reference wind facilities. The highest numbers of bat fatalities reported in the United States are from wind energy facilities located along forested ridges in the East where annual estimated fatality rates have ranged from 20.8 to 69.6 bats per turbine per year (Arnett et al. 2008). As mentioned above for birds, the ability to make comparisons among wind energy facilities is limited due to differences in study length, search interval, species used as trial carcasses, and the formulas used to derive fatality estimates. The ranges of rates among facilities are presented here only to provide a general regional context, and do not accurately reflect differences among facilities in fatality rates.

The Western Bat Working Group (WBWG) provides rankings for bat species found within the western United States in the Regional Bat Species Priority Matrix based on risk of imperilment (WBWG 2007). The WBWG ranks the Brazilian free-tailed bat as the green or low level of concern due to stable populations throughout its range. Additionally, NatureServ ranks the population at the G5 or secure level indicating abundant populations (NatureServe 2014). Based on the reported population stability of the Brazilian free-tailed bat, Project-related fatalities are unlikely to have population-level effects for this species. The hoary bat and silver-haired bat are ranked at the yellow or medium level of concern throughout all regions. The yellow or medium ranking is primarily due to a lack of meaningful information which prevents adequate assessment of their status; therefore, they warrant closer evaluation and more research. Limited population data for the hoary and silver-haired bat are available; however, the relatively low number of fatalities detected for these species indicate that population-level impacts are unlikely..

Spatial distribution of bat fatalities throughout the Project was consistent among years. Fatalities at turbines ranged from 0 to 4 fatalities per turbine and no individual turbine was identified as a problem turbine (Figures 3, 9, 10, 11).

4.2 Mitigation Measure BIO-6 Fatality Thresholds

MM BIO-6 provides fatality thresholds for specific Special-Status Species and Species Groups. No bald eagle or sandhill crane fatalities were detected during the 3 years of monitoring at the Project; thus, fatalities of these species remained below their established thresholds in all years. For the remaining Special-Status Species and Species Groups identified in MMBIO-6 (yellow warbler, Other Raptors, Owls), statistically-reliable per turbine fatality estimates could not be calculated for these groups or species; therefore, comparisons against Project-specific thresholds for these species and groups cannot be made.

4.3 Conclusions

Estimated annual avian fatality rates at the Project were comparable to other reported fatality rate estimates regionally. The majority of avian fatalities were waterfowl in the spring. Waterfowl fatalities at the Project be attributable to these species making localized movements under high wind and/or low visibility conditions. Songbird fatalities were also documented, but at lower rates than other wind facilities. Population-level impacts to the species most commonly detected as fatalities are unlikely due to secure populations of these species. All but one of the identified avian species (European starling) are protected under the MBTA.

Estimated annual bat fatality rates at the Project were comparable to other reported fatality rate estimates regionally. Estimated annual bat fatality rates were consistent among the years of the study. Bat fatalities were highest during July-September and included hoary, silver-haired, and Brazilian free-tailed bats, as has been found at other wind facilities. Limited population data for the hoary and silver-haired bat is available; however, the relatively low number of fatalities detected for these species indicate that population-level impacts are unlikely.

For the MM BIO-6 Special Status Species and Groups, no bald eagle or sandhill crane fatalities were documented and only two MM BIO-6 Special-Status Groups, (Other Raptors and Owls) and one Special-Status Species (yellow warbler) were detected. Statistically-reliable per turbine fatality estimates could not be calculated for these groups or species; therefore, comparisons against Project-specific thresholds for these species and groups cannot be made.

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Tables

Table 1. Hatchet Ridge fatality survey dates.

Survey Season	Survey Period	Year 1 (2010 - 2011)	Year 2 (2011 - 2012)	Year 3 (2012 - 2013)
Winter				
	1	12/12-12/23	12/12-12/14	12/27-1/2
	2	12/27-12/31	12/26-12/29	1/7-1/10
	3	1/10-1/17	1/10-1/13	1/22-1/25
	4	1/25-1/27	1/25-1/27	2/4-2/9
	5	2/7-2/13	2/7-2/9	2/18-2/20
	6	2/22-2/28	2/21-2/23	3/4-3/8
	7	3/7-3/17	3/5-3/9	
Spring				
	7			3/18-3/21
	8	3/22-3/31	3/19-3/22	4/2-4/5
	9	4/4-4/9	4/2-4/7	4/17-4/18
	10	4/19-4/21	4/17-4/18	4/29-5/4
	11	5/3-5/11	4/30-5/4	5/13-5/14
	12	5/19-5/21	5/15-5/16	5/28-5/31
	13	5/30-6/4	5/29-6/1	6/11-6/12
	14	6/13-6/15	6/11-6/14	
Summer				
	14			6/25-6/29
	15	6/27-7/2	6/25-6/30	7/8-7/9
	16	7/12-7/15	7/9-7/15	7/22-7/26
	17	7/25-7/28	7/23-7/29	8/5-8/6
	18	8/8-8/10	8/6-8/7	8/19-8/23
	19	8/22-8/26	8/20-8/24	9/3-9/4
	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)	Year 3 (2012 - 2013)
Fall				
	20			9/14-9/20
	21	9/19-9/23	9/17-9/23	10/1-10/2
	22	10/4-10/8	10/1-10/3	10/14-10/20
	23	10/17-10/21	10/16-10/19	10/31-11/2
	24	11/1-11/5	11/1-11/3	11/11-11/15
	25	11/15-11/18	11/12-11/15	11/25-11/26
	26	11/28-11/30	11/26-11/27	12/9-12/13
	27		12/10-12/14	

Table 2. Summary of avian and bat fatalities found during biweekly searches at Hatchet Ridge from 12/27/2012 to 12/13/2013.

Group Common name	Scientific name	Winter 2012-2013	Spring 2013	Summer 2013	Fall 2013	Total
Waterfowl						
green-winged teal	*Anas crecca*	2	1	0	0	**3**
mallard	*Anas platyrhynchos*	1	0	1	0	**2**
northern shoveler	*Anas clypeata*	0	2	0	0	**2**
American wigeon	*Anas americana*	0	0	0	1	**1**
snow goose	*Chen caerulescens*	1	0	0	0	**1**
unidentified duck		1	0	0	0	**1**
unidentified waterfowl		0	0	1	0	**1**
Waterfowl Total		**5**	**3**	**2**	**1**	**11**
Songbirds						
dark-eyed junco	*Junco hyemalis*	1	0	0	1	**2**
golden-crowned kinglet	*Regulus satrapa*	1	0	0	1	**2**
American robin	*Turdus migratorius*	0	1	0	0	**1**
mountain bluebird	*Sialia currucoides*	0	0	1	0	**1**
ruby-crowned kinglet	*Regulus calendula*	0	1	0	0	**1**
Songbirds Total		**2**	**2**	**1**	**2**	**7**
Cranes/Rails						
American coot	*Fulica americana*	3	1	0	0	**4**
Cranes/Rails Total		**3**	**1**	**0**	**0**	**4**
Raptors						
red-tailed hawk	*Buteo jamaicensis*	0	0	2	0	**2**
Cooper's hawk	*Accipiter cooperii*	1	0	0	0	**1**
great horned owl	*Bubo virginianus*	0	0	1	0	**1**
Raptors Total		**1**	**0**	**3**	**0**	**4**
Swifts/Hummingbirds						
white-throated swift	*Aeronautes saxatalis*	0	0	1	0	**1**
Swifts/Hummingbirds Total		**0**	**0**	**1**	**0**	**1**

Table 2. Summary of avian and bat fatalities found during biweekly searches at Hatchet Ridge from 12/27/2012 to 12/13/2013.

Group Common name	Scientific name	Winter 2012-2013	Spring 2013	Summer 2013	Fall 2013	Total
Bat						
hoary bat	*Lasiurus cinereus*	0	0	2	2	**4**
silver-haired bat	*Lasionycteris noctivagans*	0	1	3	0	**4**
Brazilian free-tailed bat	*Tadarida brasiliensis*	0	0	3	0	**3**
Bat Total		**0**	**1**	**8**	**2**	**11**
Total		**11**	**7**	**15**	**5**	**38**

Table 3. Summary of avian and bat fatalities found during monthly searches at Hatchet Ridge from 12/27/2012 to 12/13/2013.

Group / Common name	Scientific name	Winter 2012-2013	Spring 2013	Summer 2013	Fall 2013	Total
Waterfowl						
green-winged teal	*Anas crecca*	1	0	0	0	**1**
Waterfowl Total		**1**	**0**	**0**	**0**	**1**
Songbirds						
dark-eyed junco	*Junco hyemalis*	1	0	0	0	**1**
Songbirds Total		**1**	**0**	**0**	**0**	**1**
Raptors						
sharp-shinned hawk	*Accipiter striatus*	0	1	0	0	**1**
Raptors Total		**0**	**1**	**0**	**0**	**1**
Bat						
hoary bat	*Lasiurus cinereus*	0	0	3	0	**3**
big brown bat	*Eptesicus fuscus*	0	0	1	0	**1**
silver-haired bat	*Lasionycteris noctivagans*	0	0	1	0	**1**
Bat Total		**0**	**0**	**5**	**0**	**5**
Total		**2**	**1**	**5**	**0**	**8**

Table 4. Summary of avian and bat fatalities found as incidentals at Hatchet Ridge from 12/27/2012 to 12/13/2013.

Group Common name	Scientific name	Winter 2012-2013	Spring 2013	Summer 2013	Fall 2013	Total
Gamebirds						
mountain quail	*Oreortyx pictus*	0	1	0	0	**1**
Gamebirds Total		**0**	**1**	**0**	**0**	**1**
Songbirds						
house wren	*Troglodytes aedon*	0	1	0	0	**1**
Songbirds Total		**0**	**1**	**0**	**0**	**1**
Waterfowl						
northern pintail	*Anas acuta*	1	0	0	0	**1**
Waterfowl Total		**1**	**0**	**0**	**0**	**1**
Bat						
silver-haired bat	*Lasionycteris noctivagans*	0	0	2	0	**2**
Bat Total		**0**	**0**	**2**	**0**	**2**
Total		**1**	**2**	**2**	**0**	**5**

Table 5. Searcher efficiency trial results at Hatchet Ridge with 90% confidence interval (CI), Years 1-3.

Study Year	Carcass Category	Season[1]	Searcher Efficiency	CI	n[2]
Year 1 (2010-2011)	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
Year 2 (2011-2012)	Large bird	Winter	0.93	0.88–0.97	31
		Spring	0.84	0.75–0.93	24
		Summer	0.92	0.70–0.90	25
		Fall	0.96	0.92–0.98	24
	Small bird	Winter	0.73	0.62–0.84	27
		Spring	0.42	0.40–0.65	27
		Summer	0.70	0.59–0.80	27
		Fall	0.82	0.72–0.90	24
	Bat	Winter	0.51	0.50–0.76	21
		Spring	0.30	0.19–0.42	25
		Summer	0.47	0.30–0.60	26
		Fall	0.63	0.50–0.76	21
Year 3 (2012-2013)	Large bird	-	0.92	0.88–0.96	97
	Small bird	-	0.69	0.62–0.77	94
	Bat	-	0.61	0.52–0.68	92

1. SEEF varired by carcass size and season in Year 2 only

2. Number of carcasses used in analysis

Table 6. Carcass persistence at Hatchet Ridge with 90% confidence interval (CI), Years 1–3.

Carcass Category	Year 1 (2011-2012)			Year 2 (2011-2012)			Year 3 (2012-2013)		
	Persistence (days)	CI	n*	Persistence (days)	CI	n*	Persistence (days)	CI	n*
Large Bird	116.00	63.74–254.50	38	97.53	53.25–195.11	50	40.80	30.05–59.38	56
Small Bird	5.60	4.17–7.53	52	8.22	5.41–12.52	54	4.34	3.17–5.69	57
Bat	2.50	1.96–2.95	30	1.89	1.44–2.40	52	1.55	1.23–1.87	58

*Number of carcasses used in analysis

Table 7. Fatality estimates at Hatchet Ridge with 90% confidence interval (CI), Years 1–3.

Carcass Category/Species	Year 1 (2010-2011)					Year 2 (2011-2012)					Year 3 (2012-2013)				
	n[1]	Total Estimate	CI	Per Turbine Estimate	CI	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	11	426	290–606	9.67	6.57–13.76
Birds															-
All birds	48	253	199–341	5.74	4.53–7.74	25	85	66–110	1.93	1.49–2.5	27	124	73–192	2.81	1.64–4.36
Large Bird	19	48	30–69	1.08	0.66–1.57	20	53	35–73	1.20	0.78–1.65	19	49	35–64	1.11	0.79–1.45
Small Bird	29	206	147–290	4.67	3.32–6.57	5	32	13–57	0.72	0.29–1.28	8	75	28–142	1.70	0.62–3.21
Raptor[2]	1	-	-	-	-	0	–	–	–	–	4	-	-	-	-
Non-raptor	47	251	187–337	5.69	4.24–7.66	25	85	66–110	1.93	1.49–2.5	23	114	67–178	2.58	1.50–4.04
Waterfowl	11	28	12–46	0.63	0.25–1.04	15	40	23–59	0.90	0.52–1.33	11	29	15–43	0.64	0.33–0.97
Yellow warbler[2]	1	-	-	-	-	0	-	-	-	-	0	-	-	-	-
Great horned owl[2]	0	-	-	-	-	0	-	-	-	-	1	-	-	-	-

1. Number of fatalities detected

2. Based on modified information (M. Huso, pers. comm.), fatality rates are not estimated for individual species or species groups with <5 fatalities detected due to the modelling constraints of insufficient sample size. Estimated annual fatality rates calculated for species or groups with insufficient sample size are reported in the Year One Annual Report (Tetra Tech 2011).

Table 8. MMBIO-6 annual fatality thresholds for Special-Status Species and Species Groups with Project Fatality Rates, Years 1-3.

Species	California-state or MMBIO-6 Status	Annual Fatality Threshold	Year 1 (2010-2011)		Year 2 (2011-2012)		Year 3 (2012-2013)	
			Number of Individuals detected	Estimated Annual Fatality Rate (fatalities/ turbine)[2]	Number of Individuals detected	Estimated Annual Fatality Rate (fatalities/ turbine)[2]	Number of Individuals detected	Estimated Annual Fatality Rate (fatalities/ turbine)[2]
Bald eagle	Fully Protected	1 individual	0	-	0	-	0	-
Sandhill crane	Fully Protected	1 individual	0	-	0	-	0	-
Other Raptor Species[1]	Species Group of Special Concern	0.35 fatalities/turbine	1	-	0	-	4	-
Yellow warbler[1]	Species of Special Concern	0.07 fatalities/turbine	1	-	0	-	0	-
Owls	Species Group of Special Concern	0.11 fatalities/turbine	0	-	0	-	1	-

1. Estimated fatality rate based on insufficient sample size provided in Year 1 only

2. Fatality estimates provided for species or species groups with sample size of ≥5

Table 9. Summary of avian and bat fatalities found during biweekly searches at Hatchet Ridge,Years 1–3.

Group / Common name	Scientific name	Total Year 1	Total Year 2	Total Year 3	Grand Total
Songbirds					
unidentified songbird		6	0	0	**6**
dark-eyed junco	*Junco hyemalis*	2	1	2	**5**
golden-crowned kinglet	*Regulus satrapa*	1	1	2	**4**
Steller's jay	*Cyanocitta stelleri*	3	0	0	**3**
American robin	*Turdus migratorius*	1	0	1	**2**
ruby-crowned kinglet	*Regulus calendula*	1	0	1	**2**
unidentified kinglet	*Regulus spp.*	2	0	0	**2**
yellow-rumped warbler	*Dendroica coronata*	2	0	0	**2**
bushtit	*Psaltriparus minimus*	1	0	0	**1**
cliff swallow	*Petrochelidon pyrrhonota*	1	0	0	**1**
European starling	*Sturnus vulgaris*	1	0	0	**1**
evening grosbeak	*Coccothraustes vespertinus*	1	0	0	**1**
Lincoln’s sparrow	*Melospiza lincolnii*	1	0	0	**1**
mountain bluebird	*Sialia currucoides*	0	0	1	**1**
red-breasted nuthatch	*Sitta canadensis*	0	1	0	**1**
red-winged blackbird	*Agelaius phoeniceus*	1	0	0	**1**
spotted towhee	*Pipilo maculatus*	0	1	0	**1**
western meadowlark	*Sturnella neglecta*	0	1	0	**1**
yellow warbler	*Dendroica petechia*	1	0	0	**1**
Songbirds Total		25	5	7	**37**
Waterfowl					
unidentified waterfowl		8	2	1	**11**
snow goose	*Chen caerulescens*	0	9	1	**10**

Table 9. Summary of avian and bat fatalities found during biweekly searches at Hatchet Ridge from 11/18/2010 to 12/13/2013.

Group / Common name	Scientific name	Total Year 1	Total Year 2	Total Year 3	Grand Total
northern shoveler	*Anas clypeata*	0	4	2	**6**
green-winged teal	*Anas crecca*	0	0	3	**3**
mallard	*Anas platyrhynchos*	0	0	2	**2**
unidentified goose		2	0	0	**2**
American wigeon	*Anas americana*	0	0	1	**1**
Ross' s goose	*Chen rossii*	1	0	0	**1**
unidentified duck		0	0	1	**1**
Waterfowl Total		11	15	11	**37**
Cranes/Rails					
American coot	*Fulica americana*	3	2	4	**9**
Cranes/Rails Total		3	2	4	**9**
Other					
unidentified bird		4	0	0	**4**
unidentified large bird		0	1	0	**1**
Other Total		4	1	0	**5**
Raptors					
red-tailed hawk	*Buteo jamaicensis*	0	0	2	**2**
Cooper's hawk	*Accipiter cooperii*	0	0	1	**1**
great horned owl	*Bubo virginianus*	0	0	1	**1**
turkey vulture	*Cathartes aura*	1	0	0	**1**
Raptors Total		1	0	4	**5**
Gamebirds					
mountain quail	*Oreortyx pictus*	2	0	0	**2**
Gamebirds Total		2	0	0	**2**

Table 9. Summary of avian and bat fatalities found during biweekly searches at Hatchet Ridge from 11/18/2010 to 12/13/2013.

Group / Common name	Scientific name	Total Year 1	Total Year 2	Total Year 3	Grand Total
Swifts/Hummingbirds					
Vaux's swift	*Chaetura vauxi*	1	0	0	**1**
white-throated swift	*Aeronautes saxatalis*	0	0	1	**1**
Swifts/Hummingbirds Total		1	0	1	**2**
Pigeons/Doves					
mourning dove	*Zenaida macroura*	0	1	0	**1**
Pigeons/Doves Total		0	1	0	**1**
Waterbirds					
unidentified shorebird		1	0	0	**1**
Waterbirds Total		1	0	0	**1**
Woodpeckers					
northern flicker	*Colaptes auratus*	0	1	0	**1**
Woodpeckers Total		0	1	0	**1**
Bat					
silver-haired bat	*Lasionycteris noctivagans*	5	11	4	**20**
hoary bat	*Lasiurus cinereus*	1	4	4	**9**
Brazilian free-tailed bat	*Tadarida brasiliensis*	2	3	3	**8**
unidentified bat		4	0	0	**4**
Bat Total		12	18	11	**41**
Total		**60**	**43**	**38**	**141**

Table 10. Summary of avian and bat fatalities found during monthly searches at Hatchet Ridge, Years 1–3.

Group / Common name	Scientific name	Total Year 1	Total Year 2	Total Year 3	Grand Total
Songbirds					
unidentified songbird		3	0	0	**3**
American robin	*Turdus migratorius*	0	1	0	**1**
dark-eyed junco	*Junco hyemalis*	0	0	1	**1**
golden-crowned kinglet	*Regulus satrapa*	0	1	0	**1**
ruby-crowned kinglet	*Regulus calendula*	0	1	0	**1**
spotted towhee	*Pipilo maculatus*	0	1	0	**1**
Steller's jay	*Cyanocitta stelleri*	1	0	0	**1**
unidentified kinglet	*Regulus spp.*	1	0	0	**1**
Songbirds Total		5	4	1	**10**
Waterfowl					
unidentified waterfowl		4	1	0	**5**
green-winged teal	*Anas crecca*	0	0	1	**1**
northern shoveler	*Anas clypeata*	0	1	0	**1**
snow goose	*Chen caerulescens*	0	1	0	**1**
Waterfowl Total		4	3	1	**8**
Other					
unidentified bird		4	0	0	**4**
Other Total		4	0	0	**4**
Raptors					
red-tailed hawk	*Buteo jamaicensis*	1	1	0	**2**
sharp-shinned hawk	*Accipiter striatus*	1	0	1	**2**
Raptors Total		2	1	1	**4**

Table 10. Summary of avian and bat fatalities found during monthly searches at Hatchet Ridge from 11/18/2010 to 12/13/2013.

Group Common name	Scientific name	Total Year 1	Total Year 2	Total Year 3	Grand Total
Cranes/Rails					
American coot	*Fulica americana*	0	3	0	**3**
Cranes/Rails Total		0	3	0	**3**
Bat					
hoary bat	*Lasiurus cinereus*	1	4	3	**8**
Brazilian free-tailed bat	*Tadarida brasiliensis*	4	0	0	**4**
silver-haired bat	*Lasionycteris noctivagans*	2	1	1	**4**
big brown bat	*Eptesicus fuscus*	0	0	1	**1**
Bat Total		7	5	5	**17**
Total		**22**	**16**	**8**	**46**

Table 11. Summary of avian and bat fatalities found as incidentals at Hatchet Ridge,Years 1–3.

Group Common name	Scientific name	Total Year 1	Total Year 2	Total Year 3	Grand Total
Songbirds					
Brewer's blackbird	*Euphagus cyanocephalus*	**1**	**0**	0	**1**
golden-crowned sparrow	*Zonotrichia atricapilla*	**1**	**0**	0	**1**
house wren	*Troglodytes aedon*	**0**	**0**	1	**1**
yellow warbler	*Dendroica petechia*	**1**	**0**	0	**1**
Songbirds Total		**3**	**0**	1	**4**
Waterfowl					
greater white-fronted goose	*Anser albifrons*	**3**	**0**	0	**3**
northern pintail	*Anas acuta*	**0**	**0**	1	**1**
Waterfowl Total		**3**	**0**	1	**4**
Cranes/Rails					
American coot	*Fulica americana*	**0**	**1**	0	**1**
Cranes/Rails Total		**0**	**1**	0	**1**
Gamebirds					
mountain quail	*Oreortyx pictus*	**0**	**0**	1	**1**
Gamebirds Total		**0**	**0**	1	**1**
Waterbirds					
unidentified grebe		**1**	**0**	0	**1**
Waterbirds Total		**1**	**0**	0	**1**
Bat					
silver-haired bat	*Lasionycteris noctivagans*	**1**	**1**	2	**4**
hoary bat	*Lasiurus cinereus*	**2**	**1**	0	**3**
Brazilian free-tailed bat	*Tadarida brasiliensis*	**1**	**1**	0	**2**
Bat Total		**4**	**3**	2	**9**
Total		**11**	**4**	**5**	**20**

Figures

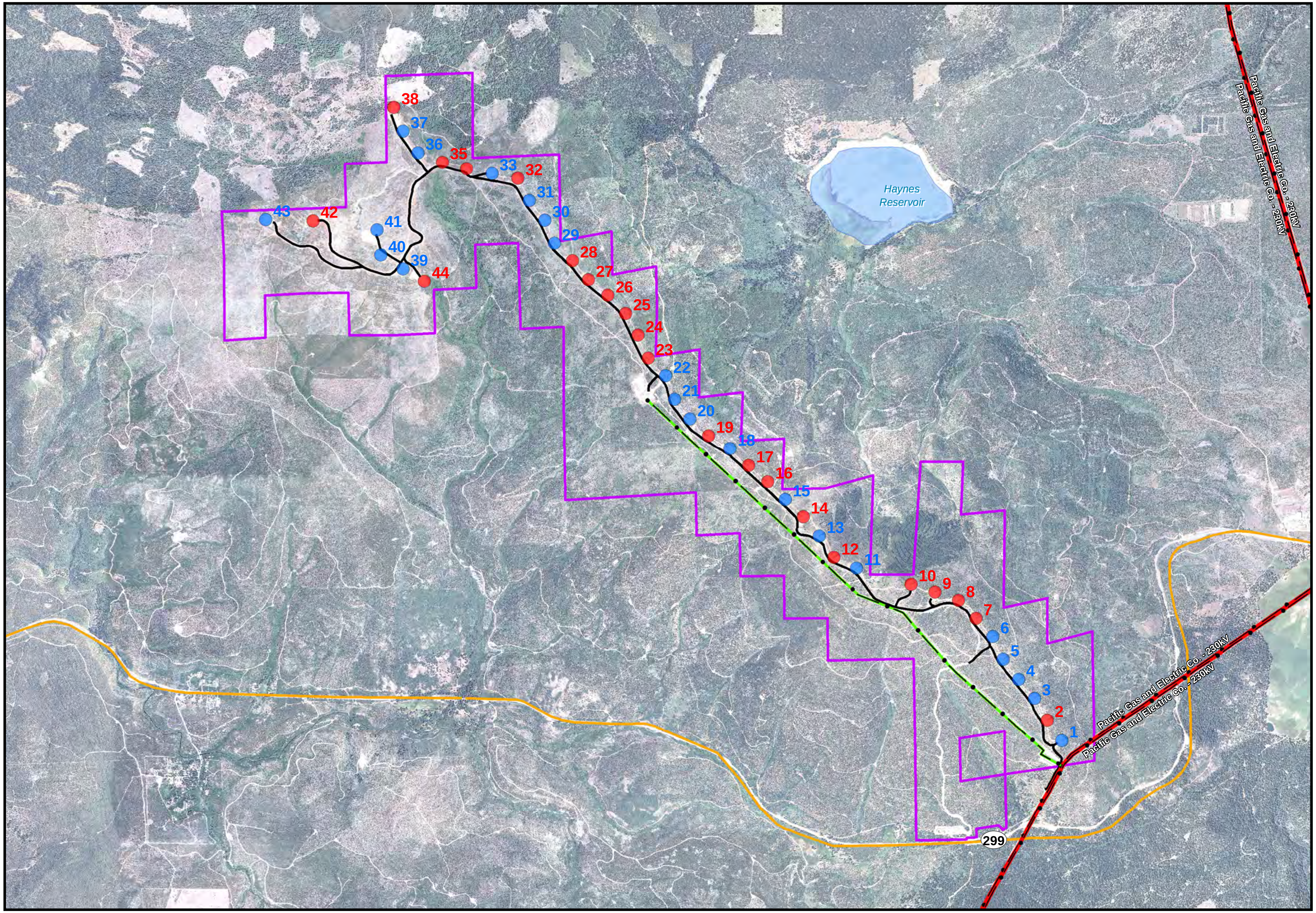

Figure 1

PATTERN ENERGY

Hatchet Ridge

Hatchet Ridge biweekly and monthly fatality search turbines

Shasta County, CA

February 19, 2014

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

Wind Turbine Generator
- Biweekly Search Interval
- Monthly Search Interval

N 1:35,000 WGS84 UTM 10

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

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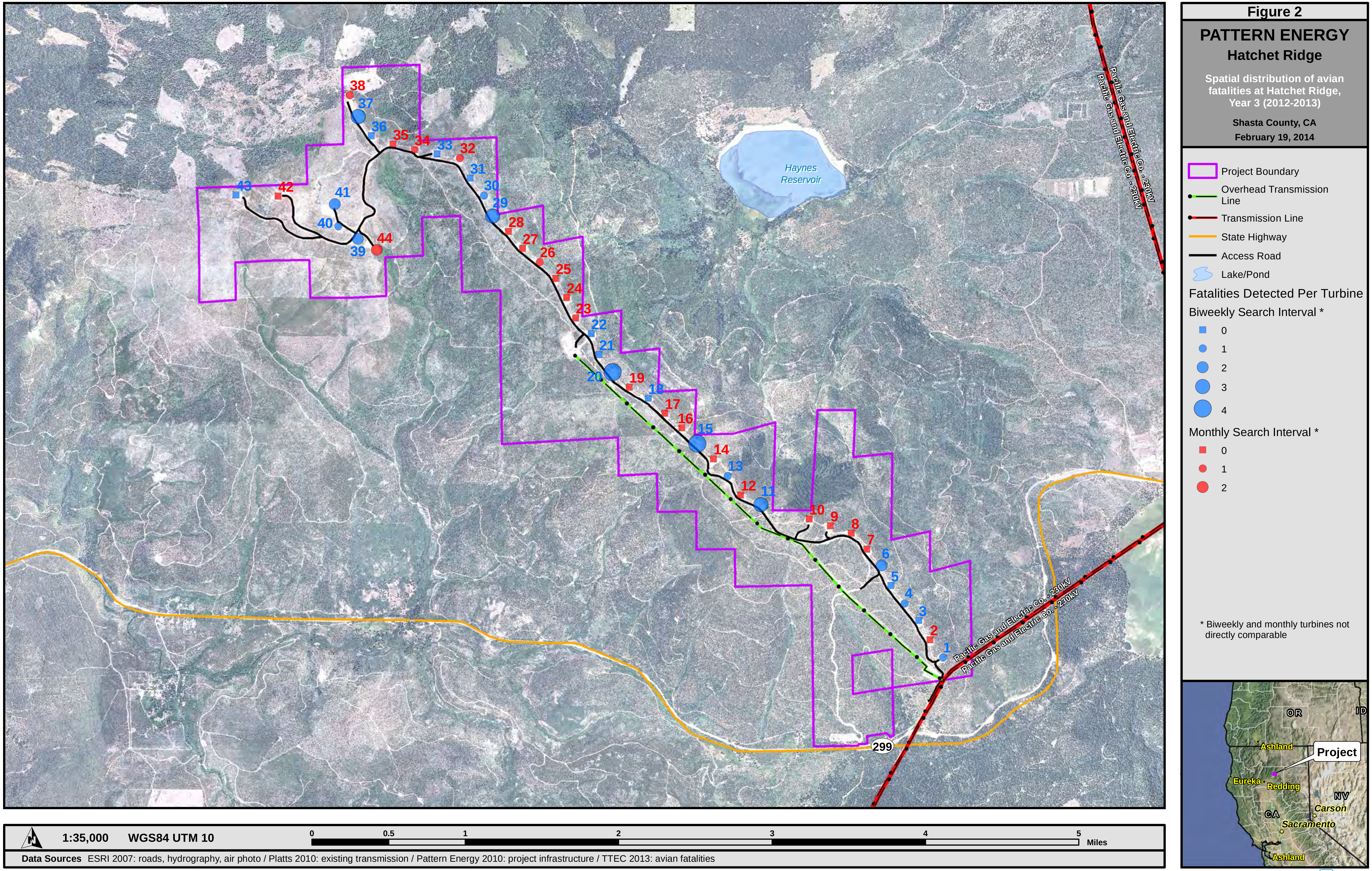

Figure 2

PATTERN ENERGY

Hatchet Ridge

Spatial distribution of avian fatalities at Hatchet Ridge, Year 3 (2012-2013)

Shasta County, CA

February 19, 2014

1:35,000 WGS84 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

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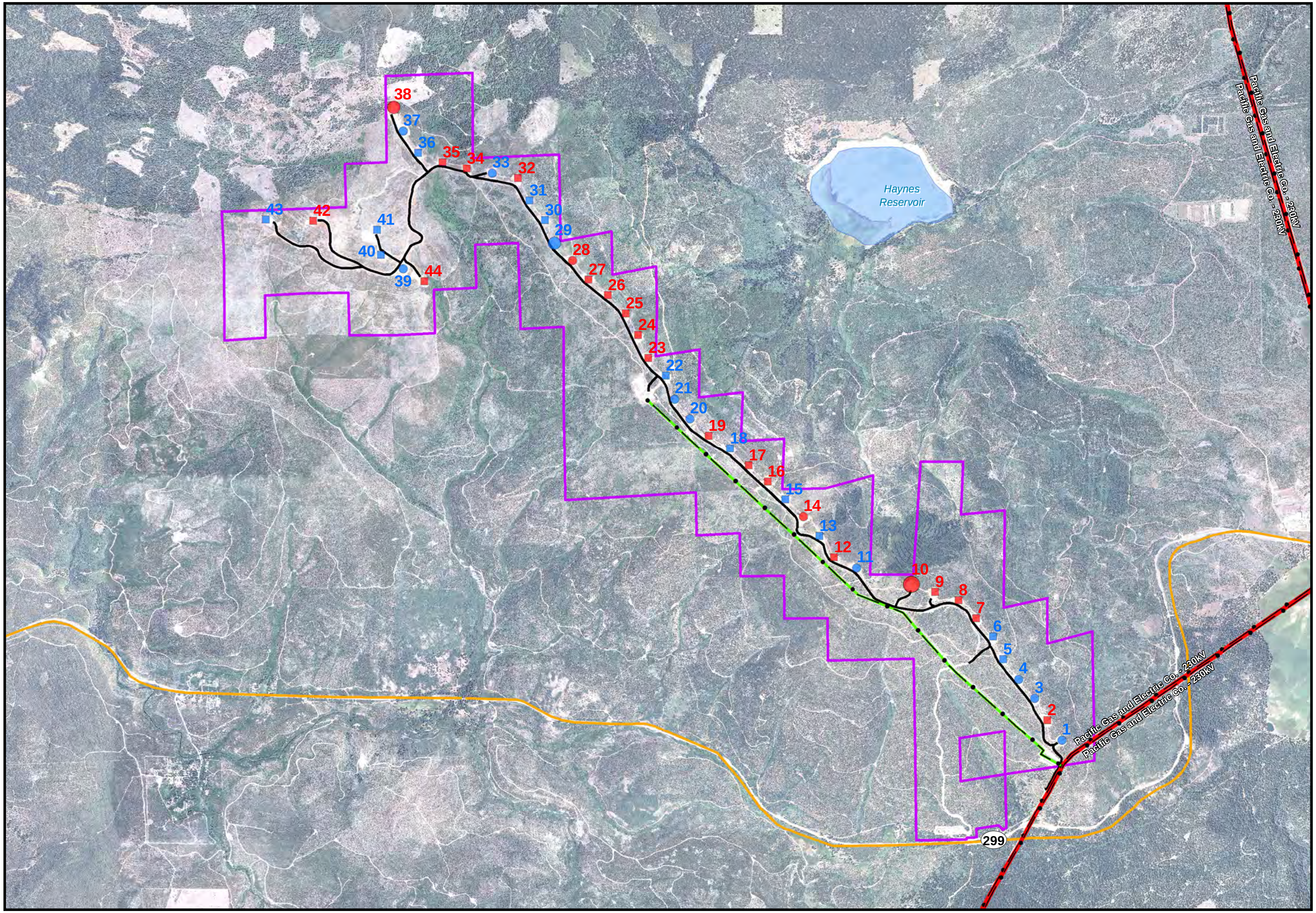
Figure 3

PATTERN ENERGY
Hatchet Ridge

Spatial distribution of bat fatalities at Hatchet Ridge, Year 3 (2012-2013)

Shasta County, CA
February 19, 2014



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

Fatalities Detected Per Turbine

Biweekly Search Interval *
- 0
- 1
- 2

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

* Biweekly and monthly turbines not directly comparable

TETRA TECH

1:35,000 WGS84 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

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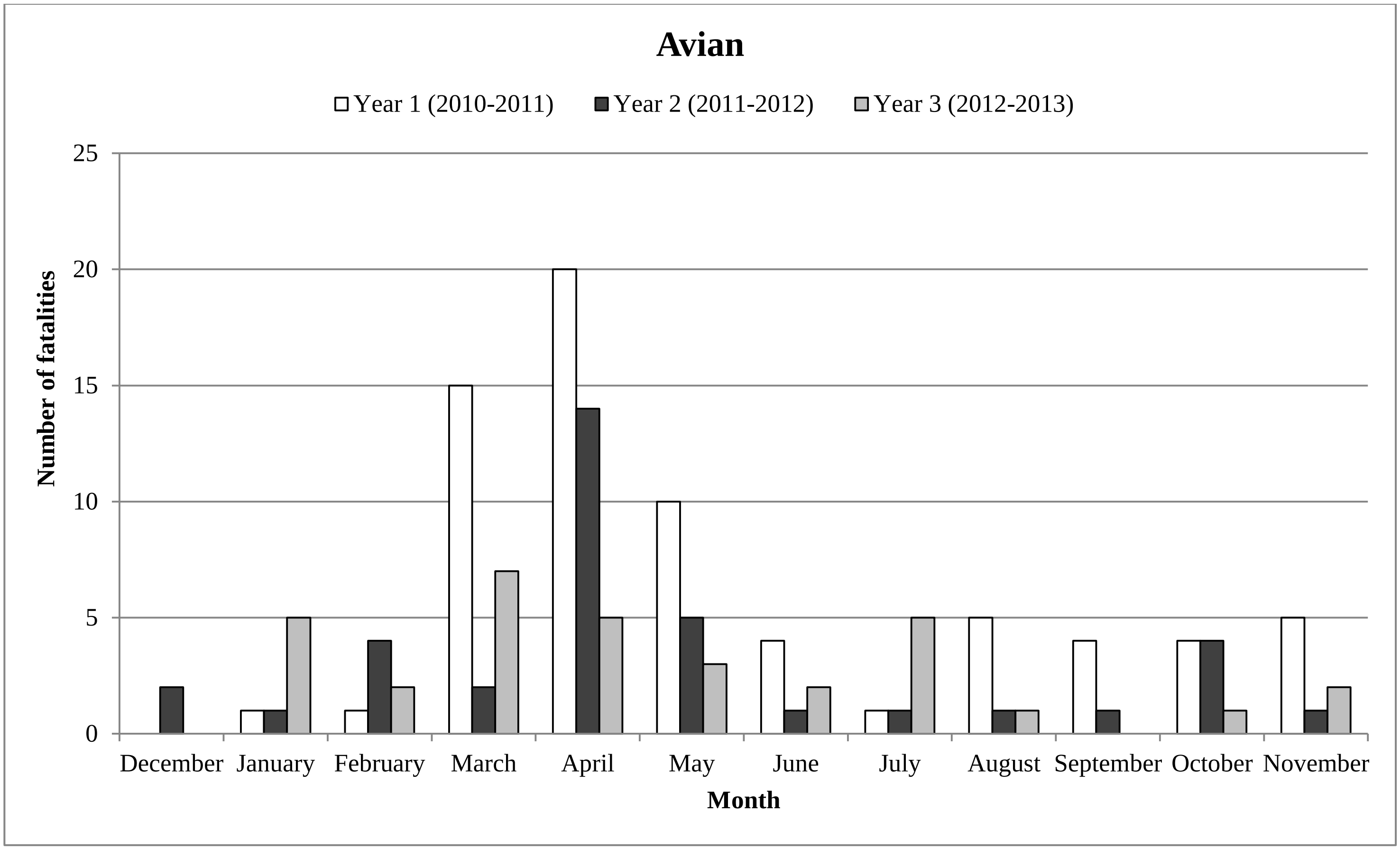
Figure 4. Fatalities found by month at Hatchet Ridge, Years 1–3



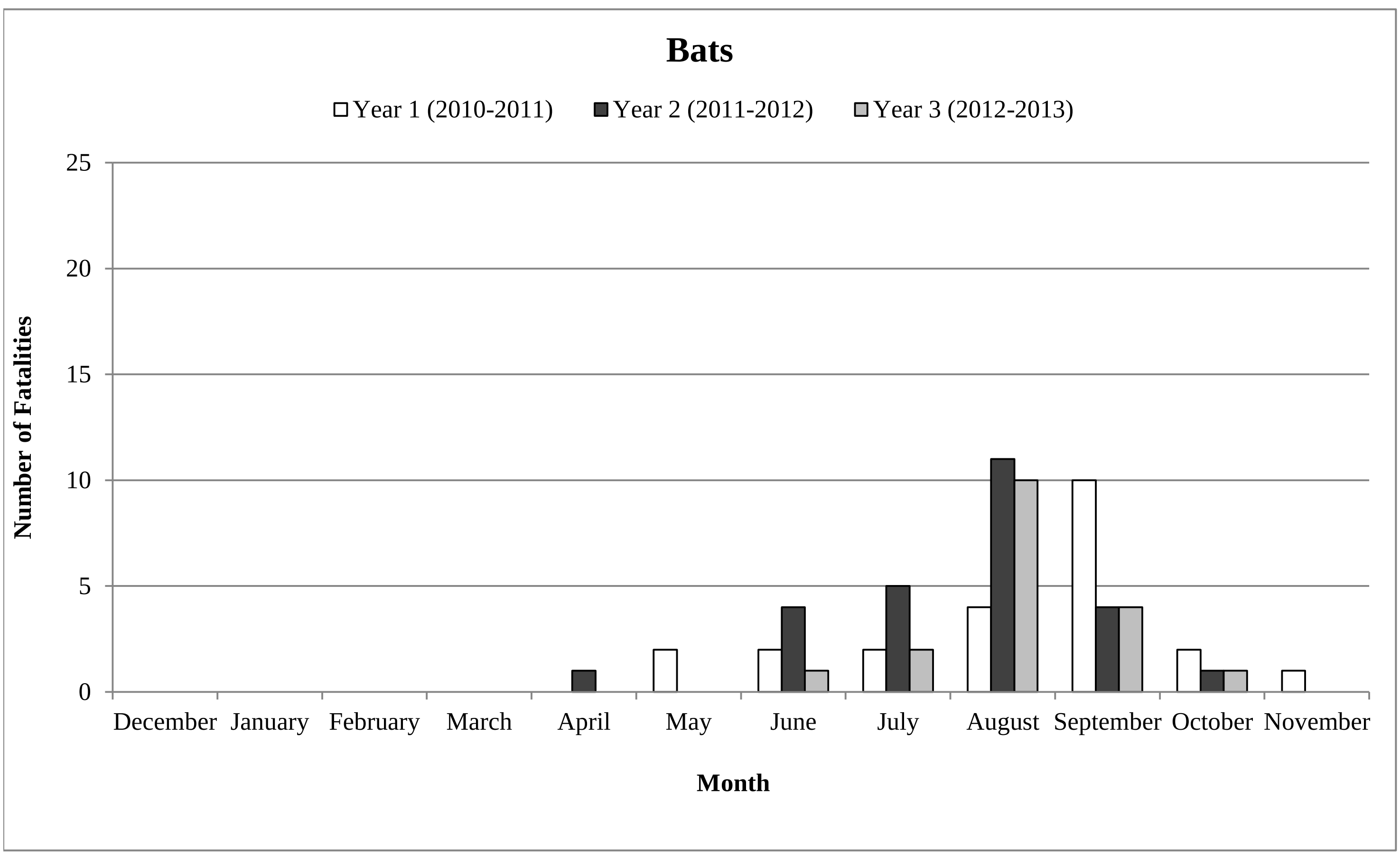
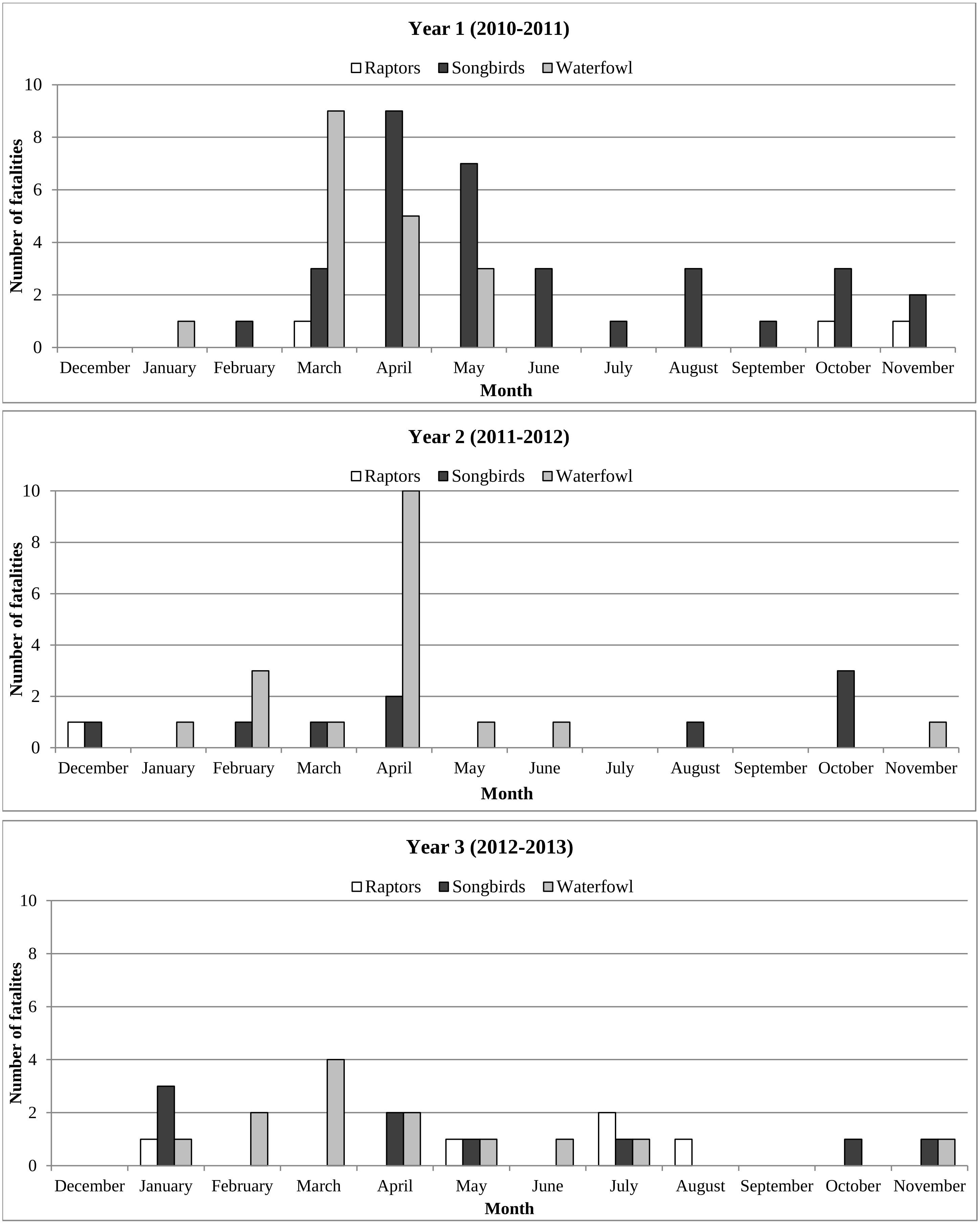


Figure 5. Avian fatalities by group and month at Hatchet Ridge, Years 1–3



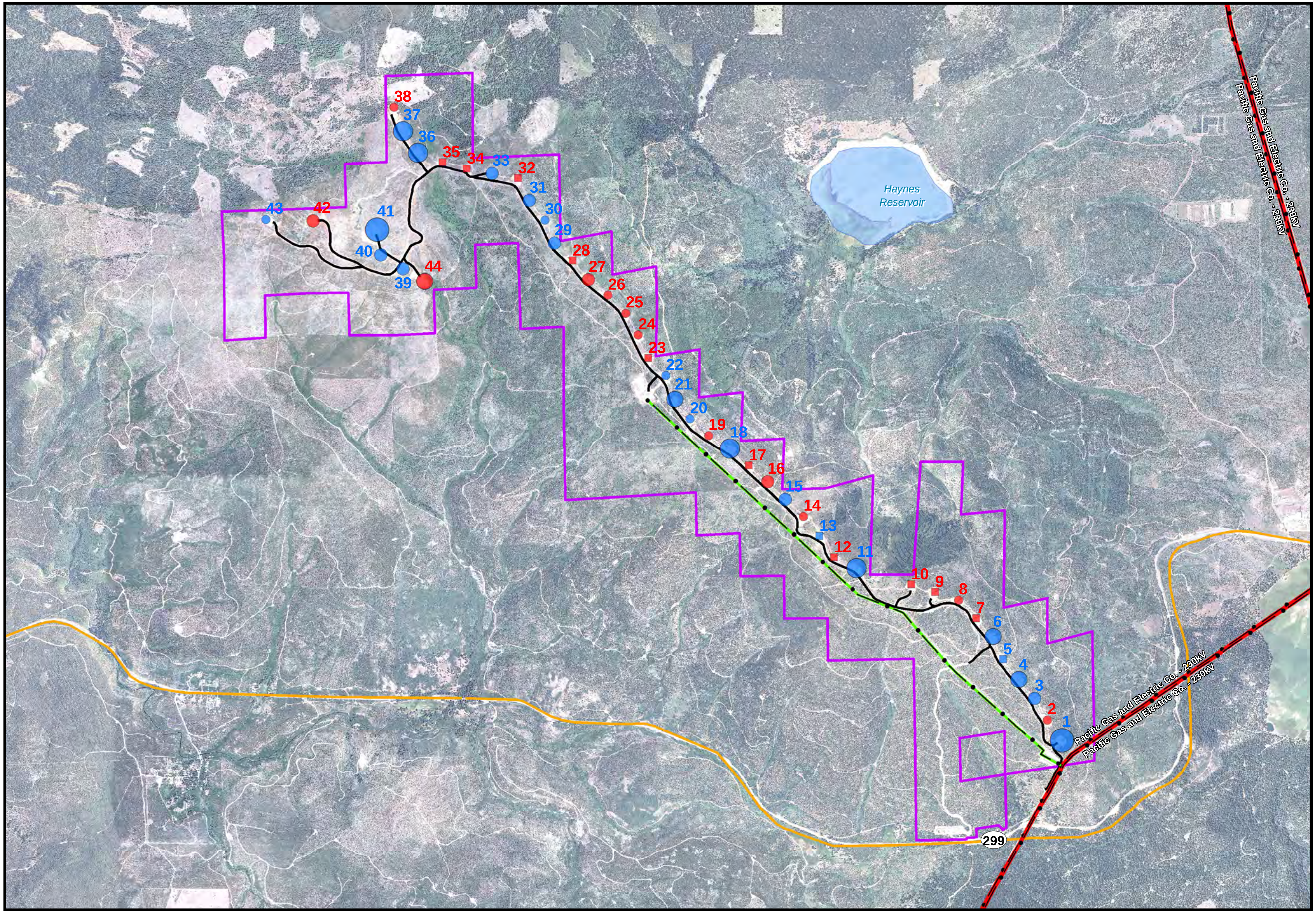


Figure 6

PATTERN ENERGY
Hatchet Ridge

Spatial distribution of avian fatalities at Hatchet Ridge, Year 1 (2010-2011)

Shasta County, CA

February 19, 2014

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

Fatalities Detected Per Turbine

Biweekly Search Interval *

0
1
2
3
4
5

Monthly Search Interval *

0
1
2
3

* Biweekly and monthly turbines not directly comparable

1:35,000 WGS84 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

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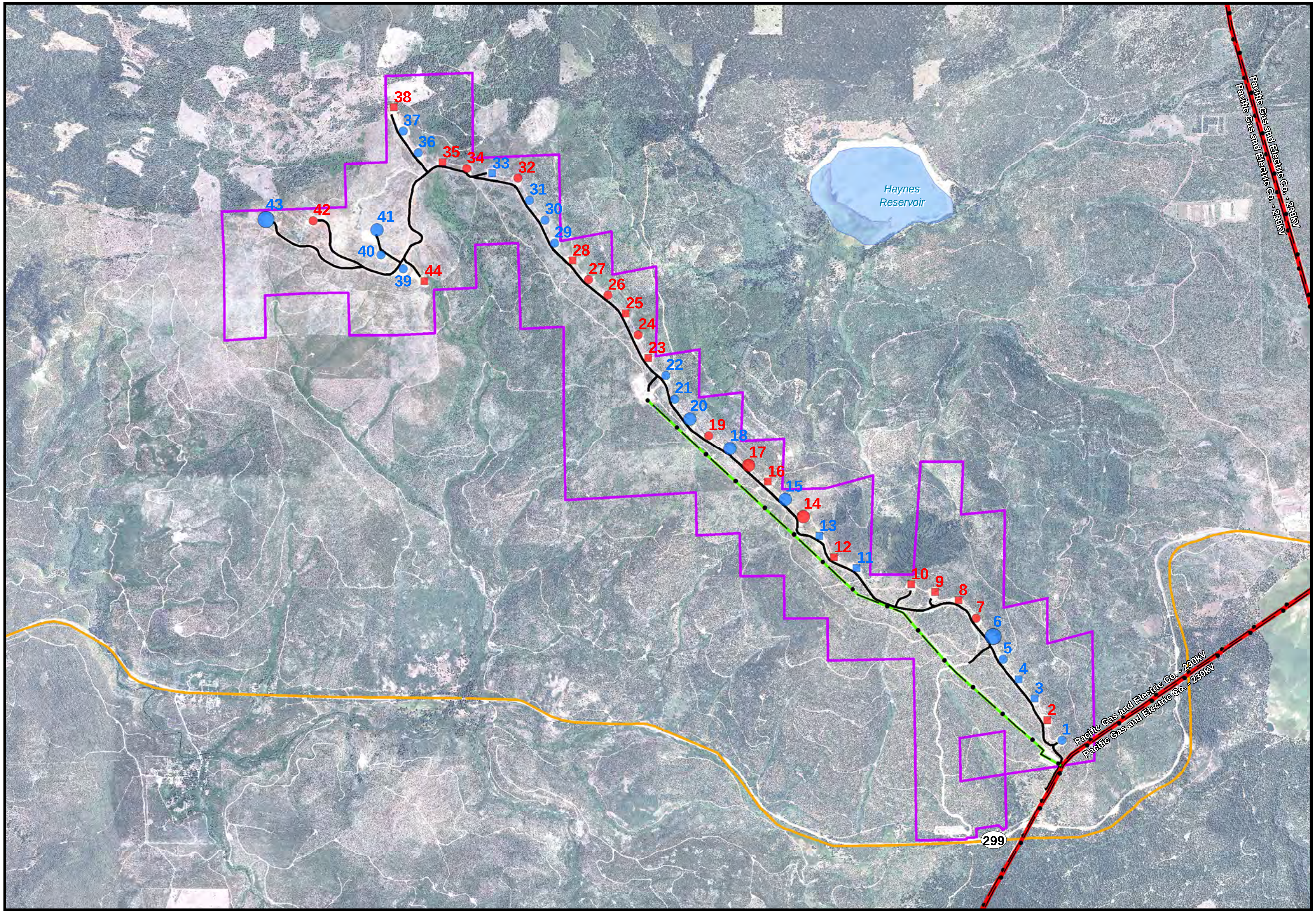
Figure 7

PATTERN ENERGY
Hatchet Ridge

Spatial distribution of avian fatalities at Hatchet Ridge, Year 2 (2011-2012)

Shasta County, CA
February 19, 2014



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

Fatalities Detected Per Turbine

Biweekly Search Interval *
- 0
- 1
- 2
- 3

Monthly Search Interval *
- 0
- 1
- 2

* Biweekly and monthly turbines not directly comparable

N 1:35,000 WGS84 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

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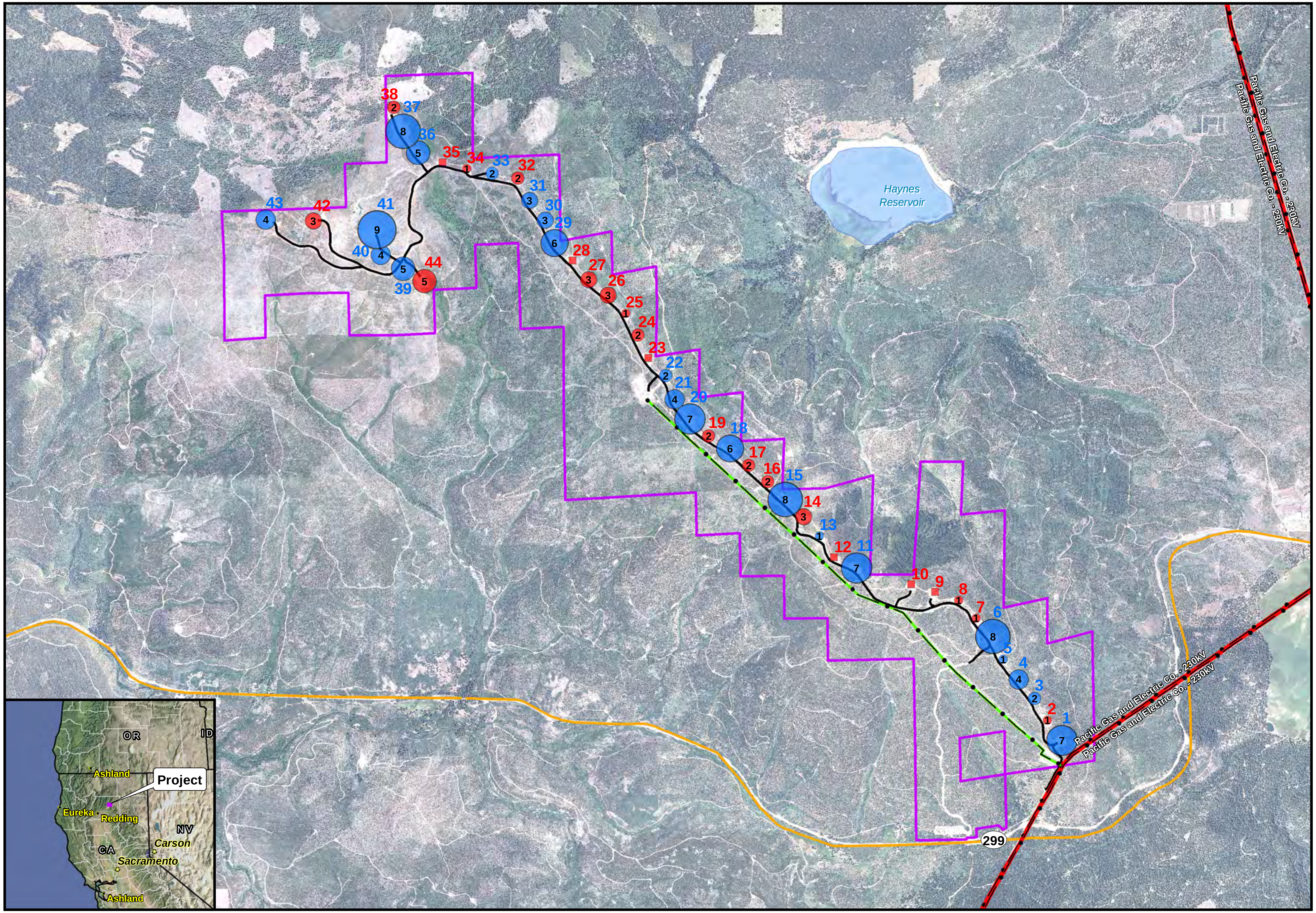

N 1:35,000 WGS84 UTM 10

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 8

PATTERN ENERGY

Hatchet Ridge

Spatial distribution of avian fatalities at Hatchet Ridge, Years 1 -3

Shasta County, CA

February 19, 2014

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

Fatalities Detected Per Turbine

Biweekly Search Interval *

1, 2, 3, 4, 5, 6, 7, 8, 9

Monthly Search Interval *

0, 1, 2, 3, 5

* Biweekly and monthly turbines not directly comparable

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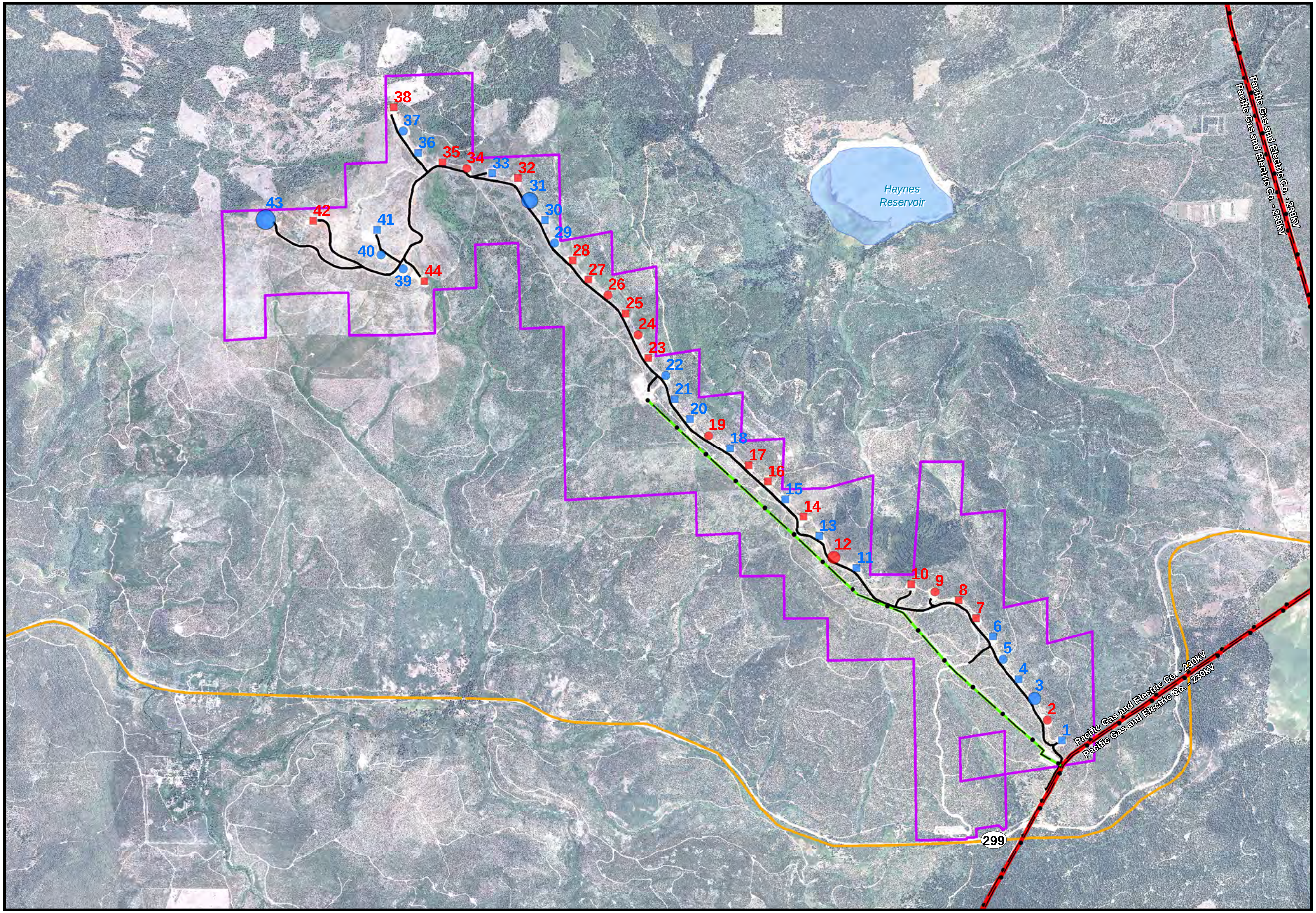

Figure 9

PATTERN ENERGY

Hatchet Ridge

Spatial distribution of bat fatalities at Hatchet Ridge, Year 1 (2010-2011)

Shasta County, CA

February 19, 2014

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

Fatalities Detected Per Turbine

Biweekly Search Interval *

0, 1, 2, 3, 4

Monthly Search Interval *

0, 1, 2

* Biweekly and monthly turbines not directly comparable

1:35,000 WGS84 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: bat fatalities

TETRA TECH EC,INC

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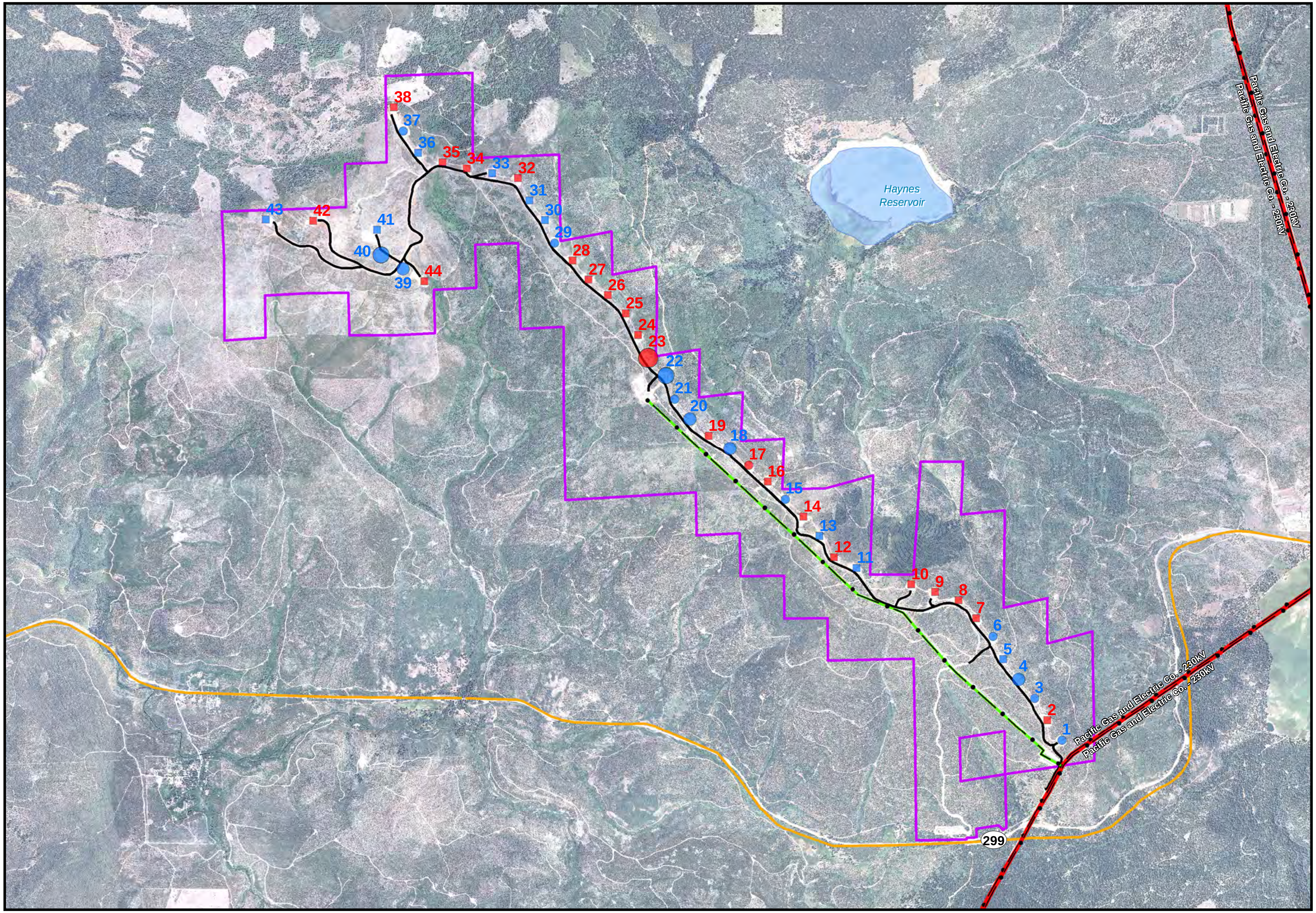

Figure 10

PATTERN ENERGY

Hatchet Ridge

Spatial distribution of bat fatalities at Hatchet Ridge, Year 2 (2011-2012)

Shasta County, CA

February 19, 2014

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

Fatalities Detected Per Turbine

Biweekly Search Interval *

0, 1, 2, 3

Monthly Search Interval *

0, 1, 2, 3, 4

* Biweekly and monthly turbines not directly comparable

1:35,000 WGS84 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

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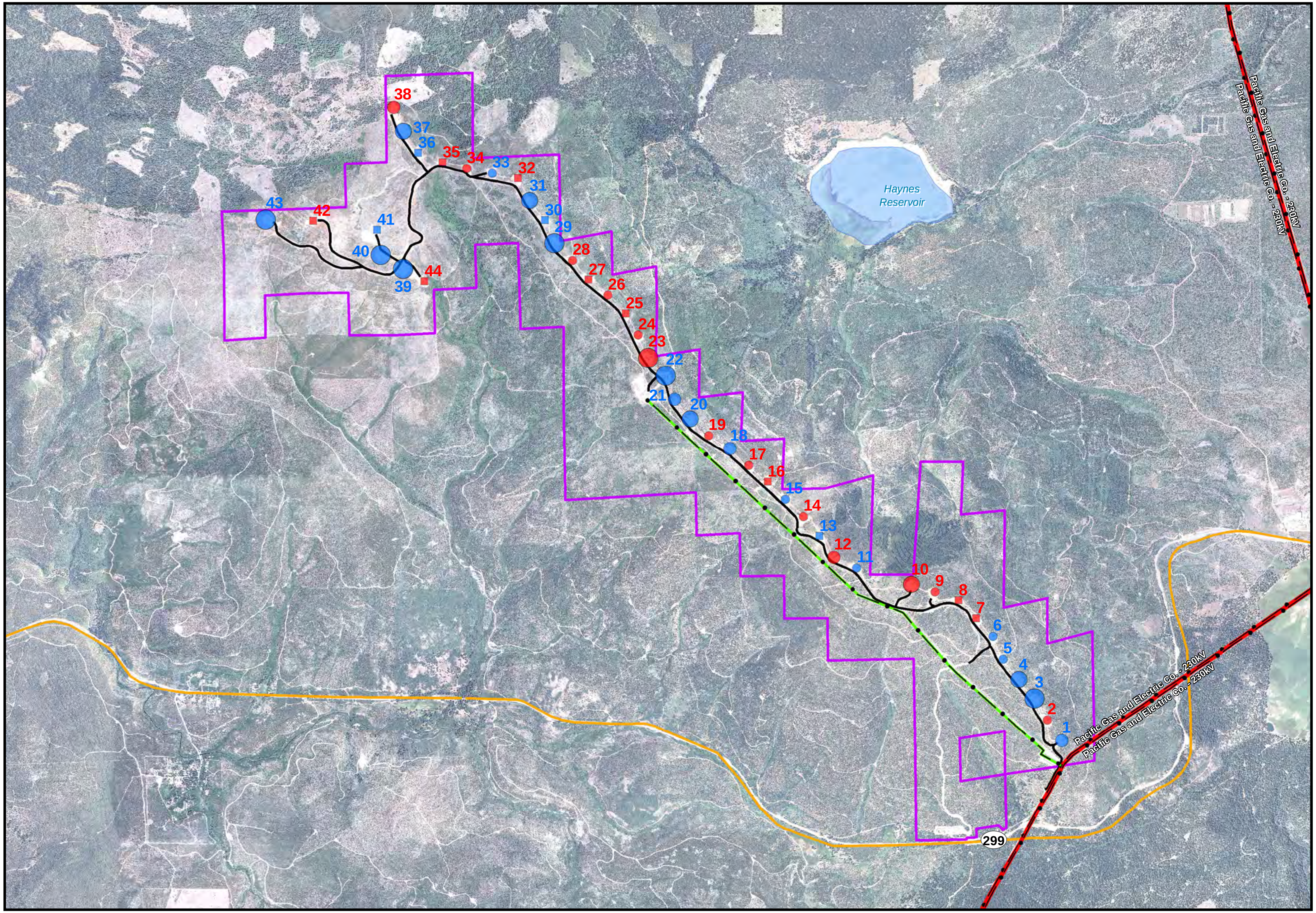

Figure 11

PATTERN ENERGY

Hatchet Ridge

Spatial distribution of bat fatalities at Hatchet Ridge, Years 1-3

Shasta County, CA

February 19, 2014

Project Boundary

Overhead Transmission Line

Transmission Line

State Highway

Access Road

Lake/Pond

Fatalities Detected Per Turbine

Biweekly Search Interval *

0
1
2
3
4

Monthly Search Interval *

0
1
2
3
4

* Biweekly and monthly turbines not directly comparable

1:35,000 WGS84 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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Appendices

Appendix 1. Summary of total bird and bat fatalities detected at the Hatchet Ridge.

Survey Year	**Biweekly Search Fatalities**	**Monthly Search Fatalities**	**Incidental Fatalities**	**Total Fatalities**
Year One (2010 - 2011)				
birds	48	15	7	70
bats	12	7	4	23
Total First	**60**	**22**	**11**	**93**
Year Two (2011 - 2012)				
birds	25	11	1	37
bats	18	5	3	26
Total Second	**43**	**16**	**4**	**63**
Year Three (2012 - 2013)				
birds	27	3	3	33
bats	11	5	2	18
Total third	**38**	**8**	**5**	**51**
Grand Total	**141**	**46**	**20**	**207**

Appendix 2. Akaike Information Criterion (AIC) results for Year 3 searcher efficiency.

Factors	AICc	ΔAICc	k
Size	300.65	0.00	2
Size, Season	306.53	5.88	4
Size, Season, Size*Season	312.70	12.05	3
Season	331.03	30.38	6

Appendix 3. Akaike Information Criterion (AIC) results for Year 3 carcass persistence.

Factors	Distribution	AICc	ΔAICc	k
Size	Exponential	664.54	0.00	2
Size	Weibull	664.89	0.35	2
Size	Log-logistic	667.65	3.11	2
Size	Log-normal	668.16	3.62	2
Size, Season	Exponential	670.11	5.57	4
Size, Season	Log-logistic	670.18	5.64	4
Size, Season	Weibull	670.38	5.84	4
Size, Season, Size*Season	Exponential	674.91	10.37	6
Size, Season, Size*Season	Weibull	676.01	11.47	6
Size, Season	Log-normal	676.01	11.47	4
Size, Season, Size*Season	Log-logistic	677.15	12.61	6
Size, Season, Size*Season	Log-normal	679.77	15.23	6
Season	Log-normal	804.66	140.12	3
Season	Log-logistic	805.46	140.92	3
Season	Weibull	813.24	148.7	2
Season	Exponential	888.23	223.69	3

Appendix 4. Fatality Estimates at Hatchet Ridge with 90% confidence interval (CI) adjusted for proportion of non-searchable area within study plots, Years 1-3.

Carcass Category/Species	Year 1 (2010-2011)					Year 2 (2011-2012)					Year 3 (2012-2013)				
	n[1]	**Total Estimate**	**CI**	**Per Turbine Estimate**	**CI**	**n[1]**	**Total Estimate**	**CI**	**Per Turbine Estimate**	**CI**	**n[1]**	**Total Estimate**	**CI**	**Per Turbine Estimate**	**CI**
Bats	12	231	89–438	5.24	2.03–9.94	18	541	296–905	12.29	6.71–20.57	11	426	290–606	7.10	4.36–11.01
Birds					-										-
All birds	48	275	213–367	6.24	4.85–8.34	25	94	71–110	1.93	1.49–2.5	27	313	192–485	3.06	1.84–4.37
Large Bird	19	54	34–78	1.22	0.78–1.77	20	60	40–83	1.35	0.89–1.88	19	55	40–73	1.24	0.9–1.64
Small Bird	29	221	158–311	5.02	3.61–7.05	5	35	14–62	0.78	0.31–1.4	8	81	31–153	1.82	0.7–3.46
Raptor[2]	1	-	-	-	-	0	-	-	-	-	4	-	-	-	-
Non-raptor	47	272	208–365	6.18	4.73–8.28	25	85	66–110	1.93	1.49–2.5	23	114	67–178	2.80	1.67–4.4
Waterfowl	11	32	14–54	0.71	0.32–1.22	15	40	23–59	0.90	0.52–1.33	11	32	16–48	0.71	0.37–1.09
Yellow warbler[2]	1	-	-	-	-	0	-	-	-	-	0	-	-	-	-
Great horned owl[2]	0	-	-	-	-	0	-	-	-	-	1	-	-	-	-

1. Number of fatalities detected

2. Based on modified information (M. Huso, pers. comm.), fatality rates are not estimated for individual species or species groups with <5 fatalities detected due to the modelling constraints of insufficient