POST-CONSTRUCTION BIRD AND BAT STUDIES at the SHILOH II WIND PROJECT, LLC Solano County, California

Final Report

December 2012
(Revised June 2013)

Prepared for:

EDF Renewable Energy, Inc.
(f.k.a enXco)

Prepared by:
CURRY & KERLINGER, LLC

Paul Kerlinger, Ph.D.
Richard Curry, Ph.D.
Aaron Hasch
John Guarnaccia
Daniel Riser-Espinoza

Curry and Kerlinger, LLC
1734 Susquehannock Drive
McLean, VA. 22101
703-821-1404, fax-703-821-1366
RCA1817@aol.com

Executive Summary

This report details the results of a three-year (2009-2012) study of post-construction fatalities and avian use (abundance and behavior) at the Shiloh II Wind Project, LLC (hereafter, Shiloh II). The Shiloh II project is located in the Montezuma Hills Wind Resource Area (MHWRA) in Solano County, California. Owned by EDF Renewable Energy, Inc. (f.k.a. enXco) and operating since 2008, Shiloh II has 75 wind turbines, each with a nameplate capacity of 2.0 MW.

Standardized carcass searches were conducted weekly at a different subset of 25 turbines each year so that, over a three-year period, all 75 turbines were searched. Weekly observations at six observation points (OPs) distributed throughout the Shiloh II footprint were also conducted to examine how birds were distributed and used the airspace at Shiloh II while turbines were operating. In addition, an annual raptor nesting survey was conducted.

A total of 3,894 standardized turbine searches conducted during the three-year study found 301 carcasses of which 120 (40%) were of bats and 181 (60%) were of birds. Mexican Free-tailed Bat and Hoary Bat made up 95% of bat fatalities, and carcasses of Western Red Bat made up the other 5%. Bird fatalities were distributed among 45 species, but 50% of carcasses were of five species: Red-tailed Hawk (25 carcasses), Western Meadowlark (22), American Kestrel (15), Red-winged Blackbird (15) and Horned Lark (12). More than one-half of bird species recorded were represented by one or two carcasses.

Special-status species recorded in Shiloh II searches included the California-threatened Black Rail (two carcasses) and the following California Special-Concern species: Northern Harrier (two carcasses), Vaux's Swift (one carcass), Loggerhead Shrike (one carcass), Yellow Warbler (one carcass), and Western Red Bat (six carcasses).

When adjusted for searcher efficiency (Se) and scavenger removal (Sr), bat mortality at Shiloh II averaged 3.3 bats/MW/year, while bird mortality was about 25% less, averaging 2.5 birds/MW/year. Adjusted bird mortality was distributed as follows: small birds, 57%; medium birds, 28%; and large birds, 15%. When raptor mortality was considered separately, it was found to range from one raptor at every five turbines in year 1 to nearly two raptors at each turbine in year 3. The three-year average was about one raptor per turbine per year. The increase in raptor fatalities correlated with an increase in raptor abundance.

When the rate of fatalities at individual turbines was examined for outliers, none was found. In other words, there was no evidence that particular turbines killed many more bats or birds than the rest. Nonetheless, bat fatalities were consistently greater at turbines with 68.5-m hub heights than at turbines with 78.0-m hub heights, presumably because shorter turbines swept airspace closer to the ground where bats migrated or foraged. Aviation obstruction lighting appeared to have no effect on fatalities.

The density distribution of bat and bird carcass by distance from turbines conformed to a negative exponential distribution In other words, the density of carcasses for birds and bats declined dramatically from turbines out to distances of ~40-60 m. In addition, the effort to find

bat and bird carcasses at greater distances from turbines also increased exponentially, highlighting the diminishing returns of searching beyond 60 m from turbines.

The three years of study at Shiloh II provide additional data that improve understanding of bird and bat mortality in the MHWRA. When the eight years of data collected by Curry & Kerlinger at High Winds, Shiloh I, and Shiloh II were taken together, the average of yearly averages placed bird mortality at around 4.2 birds/MW/year, of which ~10% on average occurred among raptors, ~10% among waterbirds, and ~80% among landbirds. This mortality was divided among dozens of species, and the species that bore most of the mortality burden were abundant (e.g., blackbirds).

The fatalities of two California-threatened Black Rails in 2009 at Shiloh II should be considered in light of possible population-level impacts to this species. However, the origin of these birds is not known, so we do not know whether they were from the extensive San Francisco Bay estuary (including Suisun Marsh), the Sierra Nevada Foothills, or elsewhere. Mortality at Shiloh II was the likely the result of a dispersal or migration, the frequency of which is unknown, making it difficult to gauge the effect of turbine strikes in the MHWRA on its population. The analysis of Arnold and Zink (2011) suggests that turbine and communication tower strikes of small numbers of individuals are unlikely to produce a discernible population effect even in a bird as scarce as the California Black Rail. For these reasons, the impact is not likely to be significant.

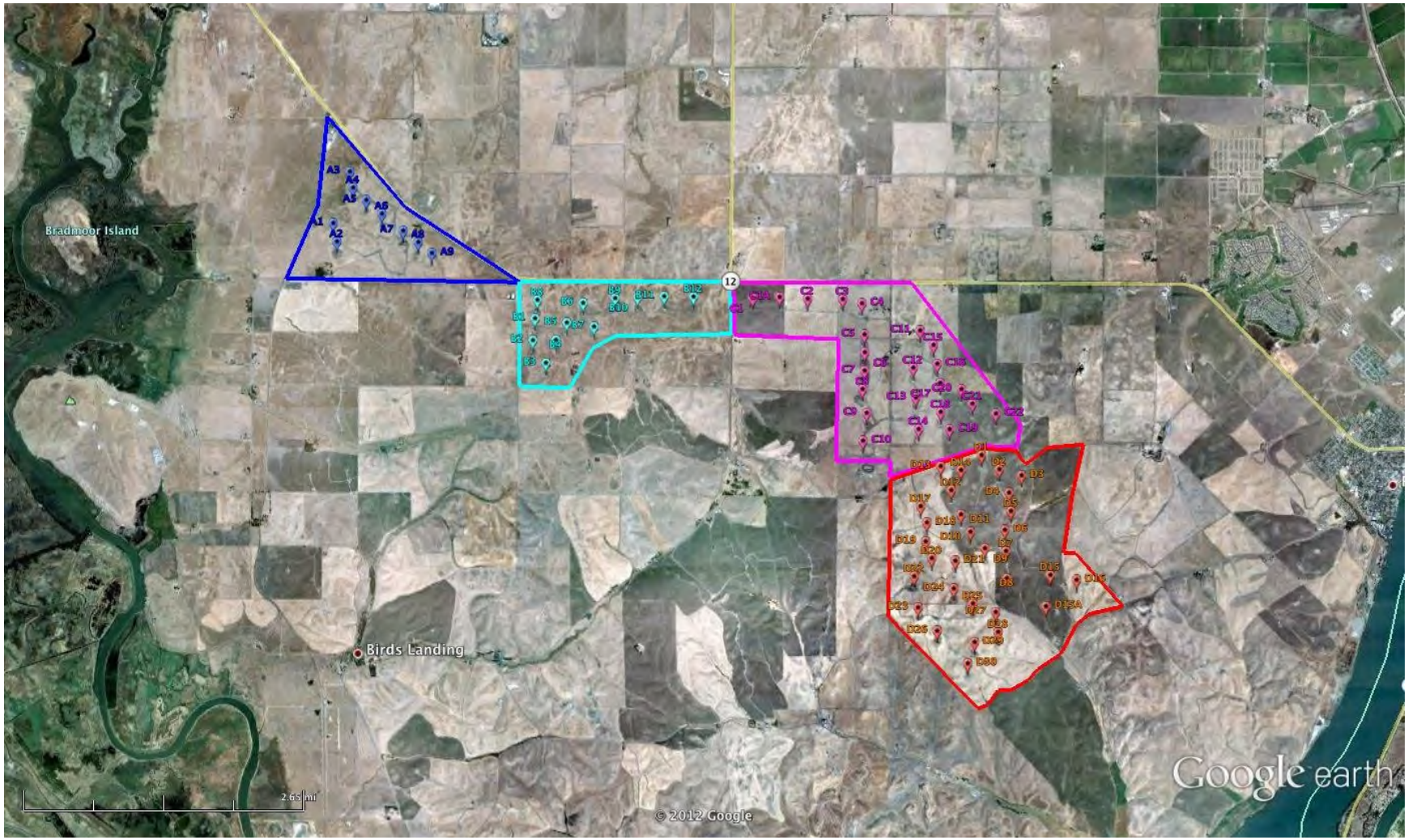
Bat mortality averaged around 3.4 bats/MW/year, but in two of the three studies (High Winds and Shiloh II), bat mortality was found to exceed bird mortality by a ratio of 1.3-1.4 bats for every bird. Unlike bird mortality, which was distributed among dozens of species, bat mortality at Shiloh II was divided among only three species, one of which (Western Red Bat) was a California Special Concern species. The cave-dwelling Mexican Free-tailed Bat could conceivably graduate to the special-status list if White-Nose Syndrome begins to affect its continental population. Silver-haired Bat was not recorded at Shiloh II, but small numbers had been recorded at High Winds and Shiloh I.

Table of Contents

Tables

Figure 1. Location of the Shiloh II Wind Power Project. Colors define turbine areas A through D.

Figure 2. Wind turbine locations within the footprint of the Shiloh II Wind Power Project.



Introduction

This report details the results of a three-year (2009-2012) study of post-construction fatalities and avian use (abundance and behavior) at the Shiloh II Wind Project, LLC (hereafter, Shiloh II). The Shiloh II project is located in the Montezuma Hills Wind Resource Area (MHWRA) in Solano County, California (Fig. 1). Shiloh II is owned and operated by EDF Renewable Energy, Inc. (f.k.a. enXco).

Operating wind farms in the MHWRA have been well studied, including pre-construction avian monitoring studies and risk assessments at Shiloh II (Kerlinger et al. 2006a), High Winds (Kerlinger et al. 2001), Shiloh I (Kerlinger et al. 2005), and Shiloh III (Kerlinger et al. 2009a). Post-construction avian and bat fatality monitoring studies, as well as post-construction avian abundance and use studies, have been conducted over two years at High Winds (Kerlinger et al. 2006b) and over three years at Shiloh I (Kerlinger et al. 2009b). Such studies in the MHWRA actually date back to the late 1980s (Orloff and Flannery 1992, Howell et al. 1988, Jones and Stokes Associates 1987).

The present study at Shiloh II provides an additional three years of fatality monitoring and use data, making the MHWRA one of the most thoroughly studied wind resource areas in the United States. In this report, we examined the species composition of fatalities, estimated the overall numbers of bird and bat fatalities, examined the incidence of rare species, determined the distribution of carcass distances from turbines, and abundance and behavior of birds observed during the study period. We also examined whether individual turbines accounted for disproportionate numbers of fatalities, whether taller turbines accounted for greater numbers of fatalities, and whether there were areas within Shiloh II in which fatalities were statistically greater. Finally, we compare the fatalities found at Shiloh II with results of fatality studies in other parts of the MHWRA.

Shiloh II dimensions and habitats

When it was constructed, Shiloh II increased generating capacity in the MHWRA by 150 MW, to a total of 824 MW (Solano County Department of Resource Management 2012). With the subsequent addition of Shiloh III and IV, generating capacity in the MHWRA now exceeds 1,000 MW.

Operating since 2008, Shiloh II has 75 wind turbines, each with a nameplate capacity of 2.0 MW. Rotor diameters were fixed at 94 m, but 33 turbines had hub heights of 68.5 m, and 42 had hub heights of 78 m. Thus, the rotor-swept zone (RSZ) of the shorter turbines was located at 21.5 to 115.5 m above ground level (agl), while the RSZ of the taller turbines was located at 31 to 125 m agl. Thirty-four (45%) of the 75 turbines has aviation obstruction lighting.

Turbines were distributed in four areas (A-D; Fig. 2), with 9 turbines in area A, 12 in B, 23 in C, and 31 in D. All 21 turbines in areas A and B had hub heights of 68.5 m, while nine in C and three in D had that hub height (Appendix A). All other 42 turbines in areas C and D had hub heights of 78 m.

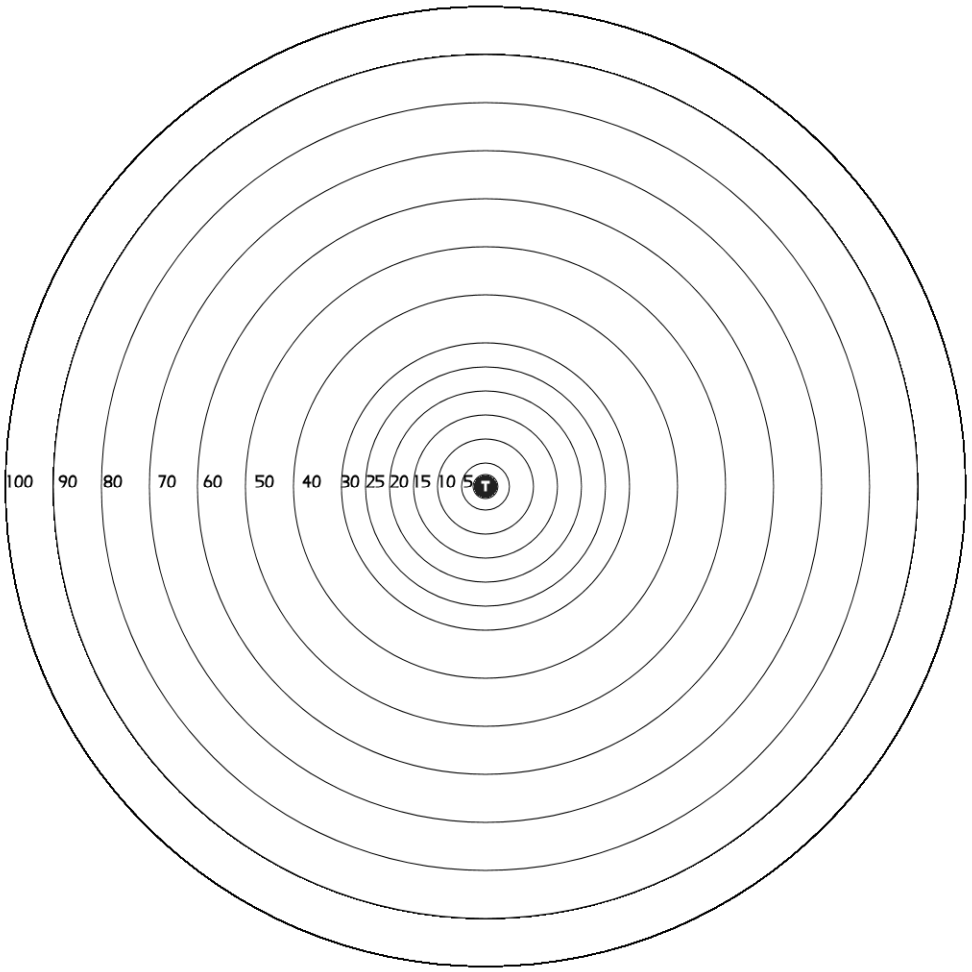
Shiloh II is located on rolling hills that reach a maximum elevation of about 70 m above mean sea level in areas C and D. Land use is entirely agricultural. Fields are left fallow and then are grazed by cattle or sheep once crops such as wheat, barley, and hay have been harvested. Other habitats within the project's footprint are minimal by comparison, including eucalyptus groves, patches of native oaks and junipers, and small cattail wetlands. Farms, some abandoned, are found throughout the site. Suisun Marsh, an extensive wetland complex, is located as close as about 2 km west of turbines in area A, and the Sacramento River Deep Water Ship Channel is located as close as about 4.5 km southeast of turbines in area D (Fig. 1).

Methods

Field methods for fatality monitoring study

Standardized carcass searches were conducted weekly at a different subset of 25 turbines each year so that, over a three-year period, all 75 turbines were searched. Turbines were assigned to different years based on their location in the wind farm, in an effort to search the same numbers of turbine in each area (A-D) in each year. As noted in the Results section, some turbines could not be searched when fields around them were treated with solid waste from sewage treatment plants (known as bio-solids).

Figure 3. Concentric search transects (distance from turbine base in m)



Trained observers were enlisted to search turbines, which they did in groups of three to five searchers by walking concentric circular transects around the base of each wind turbine. Aaron Hasch directed fieldwork with the assistance of Zach Smith. Both were qualified field biologists, expert in identification of bats and birds. They trained a number of additional searchers, including George Henry and Chris Mueller, who searched regularly, and Phil Jenkins and Brian Pirl, who were on call.

The circular transects that searchers walked were 10 m apart from 100 m to 30 m from turbine bases and 5 m apart between 30 m and 5 m from turbine bases (Fig. 3). Searchers used range finders to estimate distances from turbines and recheck them periodically.

When searchers arrived at a turbine, they searched from the outer transects inward. First, they positioned themselves in a line in adjacent transects and walked slowly as they scanned 5 m on each side of their transects for bat and bird carcasses. Thus, search areas extended to 105 m from the turbines. Searchers in outer transects walked somewhat faster than searchers walking transects closer to the turbines, but their pace was slow, allowing a careful search. When those transects were completed, the group of searchers moved to the next inward set of transects. When they reached transects within 30 m of turbines, the search area on each side of transects was reduced to 2.5 m since those transects were only 5 m apart. Despite the fact that this changed our sampling protocol used at High Winds and Shiloh I, which called for searching transects 15 m apart within 30 m of turbines, the change was done at the request of the Technical Advisory Committee.

The entire search area out to 105 m from a turbine included 3.5 ha. Together, the 13 concentric transects covered 3.7 km.

When a carcass or injured bat or bird was found, a standardized data-collection protocol was followed. Each carcass was assigned a date and a unique identification number, and its location was recorded two ways: (1) in UTM coordinates using a handheld geographical positioning system (GPS) device, and (2) by distance and bearing from the tower using a rangefinder and compass. The carcass was also photographed as it was found.

Carcasses were then identified to the species level, and age and sex were determined if possible. In all but a very few cases, carcasses were identified to species. The next step was to determine the nature and extent of injuries, and record whether scavenging or insect infestation had occurred and the degree to which carcasses were damaged or consumed. The time elapsed since death was also estimated. In the case of dismemberment, observers searched the vicinity for all body parts. Loose feathers were considered fatalities only if enough feathers were found to represent a dead bird. All loose feathers were collected to avoid counting them again in future searches.

Vegetation cover and its height where carcasses were found were also recorded, as were cover type and height generally within the 105-m search area surrounding a turbine. In the case of raptors, prey species that were present were noted.

Finally, carcasses were placed in plastic bags labeled with the date, species identification, tower number, and identification number. They were then deposited in a freezer on site for storage in accordance with U.S. Fish and Wildlife Service (FWS) requirements. When carcasses were found outside of standardized searches, such as during clean sweep surveys (see below), during other fieldwork, at other turbines, or when moving between sites, they were processed as above but classified as incidental finds, i.e., carcasses found outside of searches. Data from "incidental" carcasses have been included in this report, but they were not used for estimating

total numbers of fatalities because they were not found during scheduled sampling or in many cases within designated search areas.

When an injured animal was found, searchers recorded the same data, categorizing the find as an injured animal. Searchers then captured or restrained the animal in a manner that avoided either further injury to the animal or to searchers. Once the animal was secured, it was transported to a wildlife rehabilitator or veterinarian. The hospital accession number and the final disposition of the animal were recorded on the report form.

Clean sweep surveys were conducted at the beginning of each project year (in late April/early May) at each turbine to be surveyed. Their purpose was to increase the likelihood that all carcasses found during subsequent searches occurred during the study period and not before.

The number of carcasses found beneath towers did not reflect all of the bats and birds that collided with them, because searchers did not find all carcasses and scavengers removed some of them before they could be found. Thus, trials were conducted to estimate searcher efficiency (Se) and scavenger removal (Sr) rates.

A trial consisted of placing a carcass at a predetermined distance and bearing from a specific turbine early in the morning before a scheduled search. A team member other than the searchers determined the placement location using a random number table, and all searchers were tested. Trial carcasses were marked with black filament tied to a leg so that the marking did not make the carcass more visible, yet it could be determined upon examination that the find was a trial carcass and not a fatality. All trial carcasses were left in the field for up to 14 days to determine the Sr rate. Trial carcasses were dispersed throughout the wind farm in small numbers so as not to encourage scavenging.

Each trial carcass was used to measure the Se and Sr rates. The first morning's search was the Se trial, graded on whether searchers found the carcass or not. At the end of fieldwork that day, searchers reported results to the field leader. The field leader then checked each carcass that was not found to determine whether it had been missed or whether a scavenger had removed it before the search commenced. If he could not find the carcass, then the trial was thrown out with respect to determining the Se rate, but it was used to calibrate the Sr rate.

Each carcass was then checked daily for up to 14 days to determine if and when it disappeared or could no longer be found. On day 14, all remains of the trial carcass were removed.

Because bats were different in texture, shape, and coloration than small birds, and because large birds were more easily found than smaller birds, trials were conducted with carcasses of bats and different sized birds to determine Se and Sr rates for those categories. Following methods in Kerlinger et al. 2012, size classes for birds were large (e.g., Turkey Vulture, Red-tailed Hawk, and California Gull), medium (e.g., American Kestrel, Mourning Dove, and Western Meadowlark), and small (e.g., Horned Lark, European Starling, and Red-winged Blackbird). In other words, large carcasses exceeded 50 cm in length, small carcasses were less than 25 cm in length, and medium carcasses were in between. There was only one size class for bats: small.

Analysis of carcass distances from turbines

In an effort to quantitatively describe the spatial patterns of the carcass "fall zone" relative to the base of turbines, we divided the carcasses into five categories for statistical analysis: bats, all birds, small birds, medium birds, and large birds. Carcass frequency data were pooled into 5-m intervals from the turbine out to 105 m. These frequencies were subjected to curve fitting, using the R statistical package (R Development Core Team 2010) for each of the above categories, including determination of r-squared values and 95% confidence intervals for each curve. The purpose of conducting these analyses was to examine whether the search area was large enough to make robust estimates of fatalities. Because this is one of the only wind energy facilities where the carcass search zone has extended to 105 m, and because we included data from three years of searches (3,894 individual turbine searches), our study may be the most comprehensive of its sort to date.

Statistical methods for estimating overall fatalities of birds and bats

Estimates for the total number of tower-related fatalities were based on the searcher efficiency (Se) rate, scavenger removal (Sr) rate, and the observed number of carcasses found during standardized searches. They were calculated with an estimator published by Huso (2011). The average Se, Sr, adjusted fatalities, and corresponding standard error and 95% CI were derived using bootstrapping in R for birds of three size classes (large, medium, and small), as well as for birds of all size classes pooled and for bats (Canty and Ripley 2010, Davidson and Hinkley 1997, R Development Core Team 2010). Five thousand bootstrap iterations were used for each statistic.

The Se rate, expressed as *p*, was the average probability that a searcher would find a carcass during a given search (ratio of carcasses found to the number placed). Sr, the rate of carcass removal by scavengers before they could be detected, was calculated using the mean carcass removal time $\bar{t}$, that is, the average length of time (in days) that a carcass was expected to remain detectable in the search area. $\bar{t}$ was calculated from a maximum likelihood estimator assuming carcass removal times followed an exponential distribution with right-censoring of data (Young et al. 2009). In this study, carcasses were collected once they had been in the field for 14 consecutive days; thus, data were censored at 14 days. The maximum likelihood estimator was

$$\bar{t} = \frac{\sum_{i=1}^{S} t_i}{S - S_c}$$

where S was the number of carcasses placed in Sr trials and S_c was the number of carcasses censored.

The observed number of fatalities, $\bar{c}$, found per turbine per year was

$$\bar{c} = \frac{\sum_{j=1}^{n} c_j}{n \cdot \left(\frac{\mu}{12}\right)}$$

where c_j was the number of fatalities found at the *jth* turbine during weekly searches for the duration of the study period, *n* is the number of turbines, and μ is the length of the study period in months.

The final fatality estimate, $\bar{m}$, was found by dividing the observed number of fatalities, $\bar{c}$, by $\hat{r}$, *p*, and $\hat{v}$; these were factors that accounted for the probability of carcass persistence, probability of detection given persistence (i.e., *p*, as above), and the effective search interval, respectively (Huso, 2011). Thus,

$$\bar{m} = \frac{\sum_{j=1}^{n} c_j}{\hat{r} \cdot p \cdot \hat{v}}$$

where

$$\hat{r} = \frac{\bar{t}\left(1 - exp(-min(\tilde{I}, I)/\bar{t})\right)}{min(\tilde{I}, I)},$$

$$\hat{v} = \min\left(1, (\tilde{I}/I)\right),$$

$$\tilde{I} = -\log(0.01) \cdot \bar{t},$$

and I =7 since towers were searched weekly. $\bar{m}$, standard error, and the 95% CI were calculated by bootstrapping $\bar{c}$ 5000 times and applying the persistence, detection, and effective interval adjustment factors. In this report means are reported with standard errors (mean ± SE).

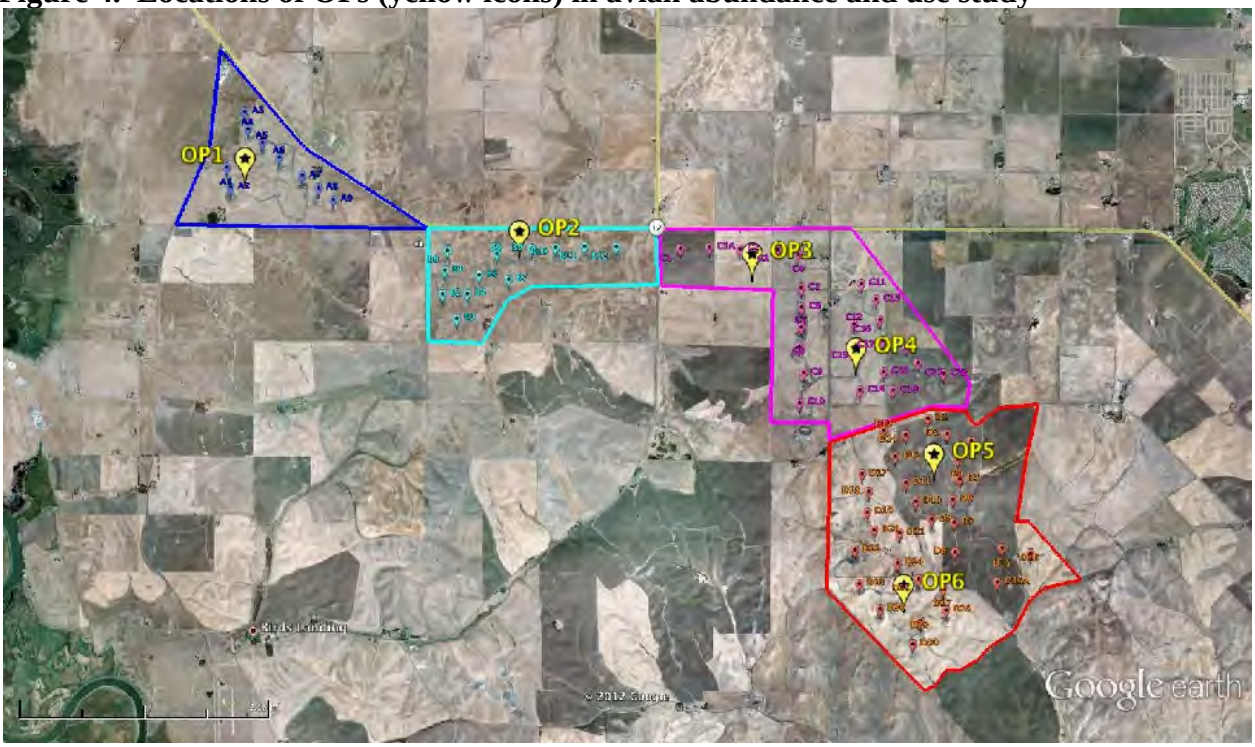
In previous reports that Kerlinger et al. (2006b, 2009b) have issued for post-construction studies in the MHWRA, a different estimator, one developed by Jain, was used. For details on that estimator, see those reports. Given that the Huso (2011) estimator is now most widely used in studies of this nature, we feature it here. Nonetheless, at the beginning of the Discussion, we compare estimates using both estimators. This comparison will show that there was no statistical difference in mean fatality rates, but with narrower 95% confidence intervals, the Huso estimate appeared to be more precise.

Means are reported with Standard Errors (mean ± SE), except when data were bootstrapped, when they are reported with 95% confidence intervals. This is because the bootstrap confidence interval is not centered on the mean, but takes into account some of the skew of the empirical distribution generated by the bootstrap procedure.

Avian abundance and behavior study

This study examined how birds were distributed and used the airspace at Shiloh II while turbines were operating. It also allowed comparison with pre-construction data to examine if any differences in abundance and use could be detected.

Figure 4. Locations of OPs (yellow icons) in avian abundance and use study



Six observation points (OPs) were selected to survey the Shiloh II site during the post-construction period (Fig. 4). They were located on hilltops and allowed good visibility out to 1.6 km. Their locations and landscape features were described as follows:

- OP 1: Located between turbines A2 and A5 on agricultural land. View included groves of eucalyptus trees, fence lines and two ponds (during winter months).
- OP 2: Located between turbines B6 and B9 in grazed pasture. View included fence lines and a grove of eucalyptus trees.
- OP 3: Located approximately ¼ mile south of turbine C2 in agricultural land. View included fence lines and two groves of eucalyptus trees.
- OP 4: Located near turbine C17 in agricultural land. View included fence lines and a grove of eucalyptus trees.
- OP 5: Located between turbines D11 and D5 in agricultural land. View included fence lines, transmission lines, and a small grove of eucalyptus and pepperwood trees.
- OP 6: Located between turbines D25 and D26 in agricultural land. View included fence lines and eucalyptus trees.

Observations were conducted twice weekly during August-November and March-June and once weekly during July and December-February. Thus, there were 87 rounds of observations each year for a total of 261 rounds during the three-year study.

On a normal day, observations began at about 8:00 and ended at about 15:00, a time span chosen because it corresponded to the hours when raptors were most active. Thirty minutes of observation were conducted at each point, and an equal amount of time was allotted for the observer to move between points. Thus, on a normal observation day, three hours of observations were conducted. If visibility decreased to under 1.6 km because of precipitation, then the round of observations was completed on the next day after visibility had improved. The sampling order of OPs was also rotated so that each OP was sampled at different hours of the day.

An observation period began with recording weather conditions, such as temperature, wind velocity and direction, percent cloud cover, precipitation if any, and distance of visibility. Then, the observer scanned the observation area with naked eye and binoculars. When one or more birds were seen, he recorded the following information:

- Species
- Number of individuals
- Start and stop time when bird(s) were observed
- Age of bird(s) if it could be determined (e.g., adult, subadult, and immature)
- Flight height relative to the rotor swept zone (RSZ), namely, low (below the RSZ, 0-30 m in altitude above the ground), medium (at an altitude equivalent to the RSZ, 30-120 m), and high (above the RSZ, >120 m). Nearby wind turbines helped to gauge flight height.
- Direction of flight
- Flight behavior (e.g., soaring, hunting, etc.)

Raptor nesting study

Searches were conducted each year during the raptor-nesting season to locate raptor nests. Trees, groves, and abandoned buildings were checked, and a special effort was made to check the status of nests that had been found previously, including during pre-construction surveys. Care was taken not to disturb nesting raptors, so most observations were made from a distance. Particular attention was given to behaviors that indicated nesting, such as birds soaring together in pairs, territorial displays, birds with nesting material, copulations, birds carrying food, etc. When those behaviors were noted, nearby trees and groves were examined more closely.

2009 surveys were conducted in April-June, but in 2010 and 2011, they were conducted during February-May.

Throughout this report, special-status species are highlighted or indicated when they appear in the text or tables. In order of priority, these are California threatened and endangered (T&E) species (CDFG 2009) and California Bird Species of Special Concern (SSC, Shuford and Gardali 2008, CDFG 2011). Bats and birds otherwise on the list of California Special Animals (CDFG 2011) were not highlighted because Solano County's COA did not require it. An exception,

however, were species designated as fully protected, such as Golden Eagle. It should be noted that no federally listed T&E species was observed on this site.

Results

Fatality monitoring study

Observed fatalities

A total of 3,894 turbine searches were conducted during the three-year study, plus 76 clean sweep searches (Appendices A and B). A total of 603 field days (Appendix B) and 4,409 field hours were invested. The average turbine search involving 3-5 searchers took 66.6 minutes, equivalent to 200 minutes or more of sampling per turbine search (66.6 minutes times 3-5 searchers).

During the three years, a total of 301 carcasses were found during standardized searches (Appendix C) and 32 in clean-sweep searches and as incidental finds (Appendix D). In standardized searches, 120 of the carcasses (40%) were of bats (Table 1) and 181 (60%) were of birds (Table 2).

Of the three bat species recorded, carcasses of Mexican Free-tailed Bat and Hoary Bat were most numerous, accounting for up 95% of bat fatalities. Thus, carcasses of Western Red Bat were relatively scarce (Table 1). Bat fatalities were evenly distributed between years (Table 1), but they were also strongly seasonal, occurring mostly during fall, with the observed fatality rate exceeding 12 bat carcasses in 100 searches in September (Fig. 5). We suggest this pattern was migration-related (see Kunz et al. 2007), but fatalities during the spring season were less than those during the late summer-fall season.

Table 1. Bats carcasses recorded during standardized searches by year

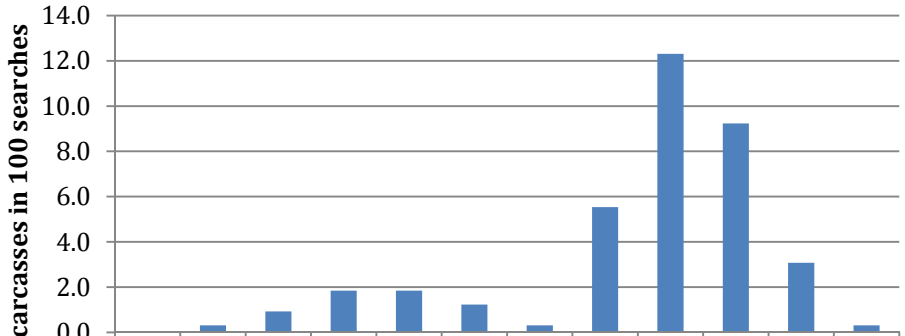
Species	Year 1	Year 2	Year 3	Total	Rate per 100 searches
Mexican Free-tailed Bat	21	24	19	64	1.64
Hoary Bat	8	19	23	50	1.28
Western Red Bat (CA Special Concern)	3	3		6	0.15
3 species	32	46	42	120	3.08

The 181 bird carcasses recorded during standardized searches were distributed among 45 identified species (Table 2), of which 105 were landbirds (58%), 52 were raptors (29%), and 24 were waterbirds (13%). Nearly 50% of carcasses were of five species: Red-tailed Hawk (25 carcasses), Western Meadowlark (22), American Kestrel (15), Red-winged Blackbird (15) and Horned Lark (12). More than one-half of species recorded were represented by one or two carcasses (Table 2).

Bird fatalities increased from year to year (Table 2), but the increase was mostly attributable to raptor fatalities, of which there were four in year-1, 15 in year-2, and 33 in year-3 (Table 2). As

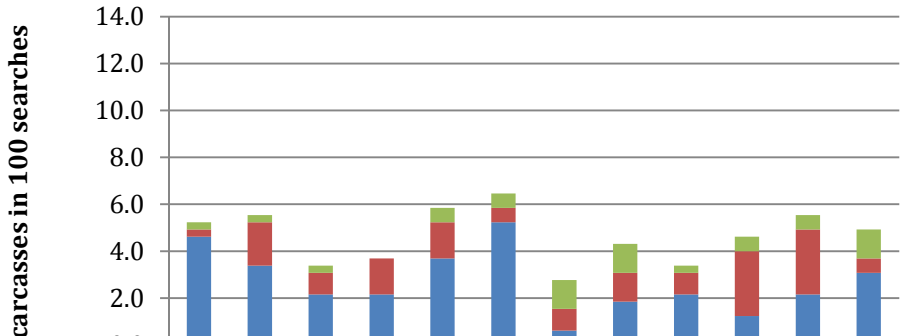
will be demonstrated below, this increase appeared to be correlated with an increase in raptor abundance within the Shiloh II project area.

Figure 5. Rate of observed bat fatality by month



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bat	0.0	0.3	0.9	1.8	1.8	1.2	0.3	5.5	12.3	9.2	3.1	0.3

Figure 6. Rate of observed bird fatalities by month



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Waterbird	0.3	0.3	0.3	0.0	0.6	0.6	1.2	1.2	0.3	0.6	0.6	1.2
Raptor	0.3	1.8	0.9	1.5	1.5	0.6	0.9	1.2	0.9	2.8	2.8	0.6
Landbird	4.6	3.4	2.2	2.2	3.7	5.2	0.6	1.8	2.2	1.2	2.2	3.1

Table 2. Birds recorded in standardized searches by class and year

Species	Class	Year 1	Year 2	Year 3	Total	Rate per 100 searches
Western Meadowlark	Landbird	8	8	6	22	0.56
Red-winged Blackbird	Landbird	5	7	3	15	0.39
Horned Lark	Landbird	3	5	4	12	0.31
Mourning Dove	Landbird	3	2	3	8	0.21
Tree Swallow	Landbird	1	3	2	6	0.15
Cliff Swallow	Landbird		3	2	5	0.13
Brewer's Blackbird	Landbird	2	2		4	0.10
European Starling	Landbird	2		2	4	0.10
Wilson's Warbler	Landbird	1	1	2	4	0.10
American Pipit	Landbird			3	3	0.08
Black-throated Gray Warbler	Landbird		1	1	2	0.05
Ring-necked Pheasant	Landbird		1	1	2	0.05
Savannah Sparrow	Landbird		2		2	0.05
Western Tanager	Landbird	1	1		2	0.05
American Goldfinch	Landbird		1		1	0.03
Blackbird sp.	Landbird	1			1	0.03
Bullock's Oriole	Landbird		1		1	0.03
Common Raven	Landbird			1	1	0.03
House Finch	Landbird		1		1	0.03
Loggerhead Shrike (CA Special Concern)	Landbird			1	1	0.03
Orange-crowned Warbler	Landbird		1		1	0.03
Rock Pigeon	Landbird	1			1	0.03
Townsend's Warbler	Landbird		1		1	0.03
Varied Thrush	Landbird	1			1	0.03
Vaux's Swift (CA Special Concern)	Landbird			1	1	0.03
Western Flycatcher	Landbird	1			1	0.03
Yellow Warbler (CA Special Concern)	Landbird	1			1	0.03
Yellow-rumped Warbler	Landbird		1		1	0.03
27 species		31	42	32	105	2.70
Red-tailed Hawk	Raptor	3	6	16	25	0.64
American Kestrel	Raptor	1	5	9	15	0.39
Barn Owl	Raptor		1	4	5	0.13
Turkey Vulture	Raptor		2	2	4	0.10
Northern Harrier (CA Special Concern)	Raptor		1	1	2	0.05
Ferruginous Hawk	Raptor			1	1	0.03
6 species		4	15	33	52	1.34
American Coot	Waterbird		1	3	4	0.10
Mallard	Waterbird	3	1		4	0.10
Sora	Waterbird	1	1	1	3	0.08
California Black Rail (CA threatened)	Waterbird	2			2	0.05
Virginia Rail	Waterbird		1	1	2	0.05
Canada Goose	Waterbird			1	1	0.03
Cinnamon Teal	Waterbird		1		1	0.03
Dunlin	Waterbird	1			1	0.03
Eared Grebe	Waterbird			1	1	0.03
Greater White-fronted Goose	Waterbird		1		1	0.03

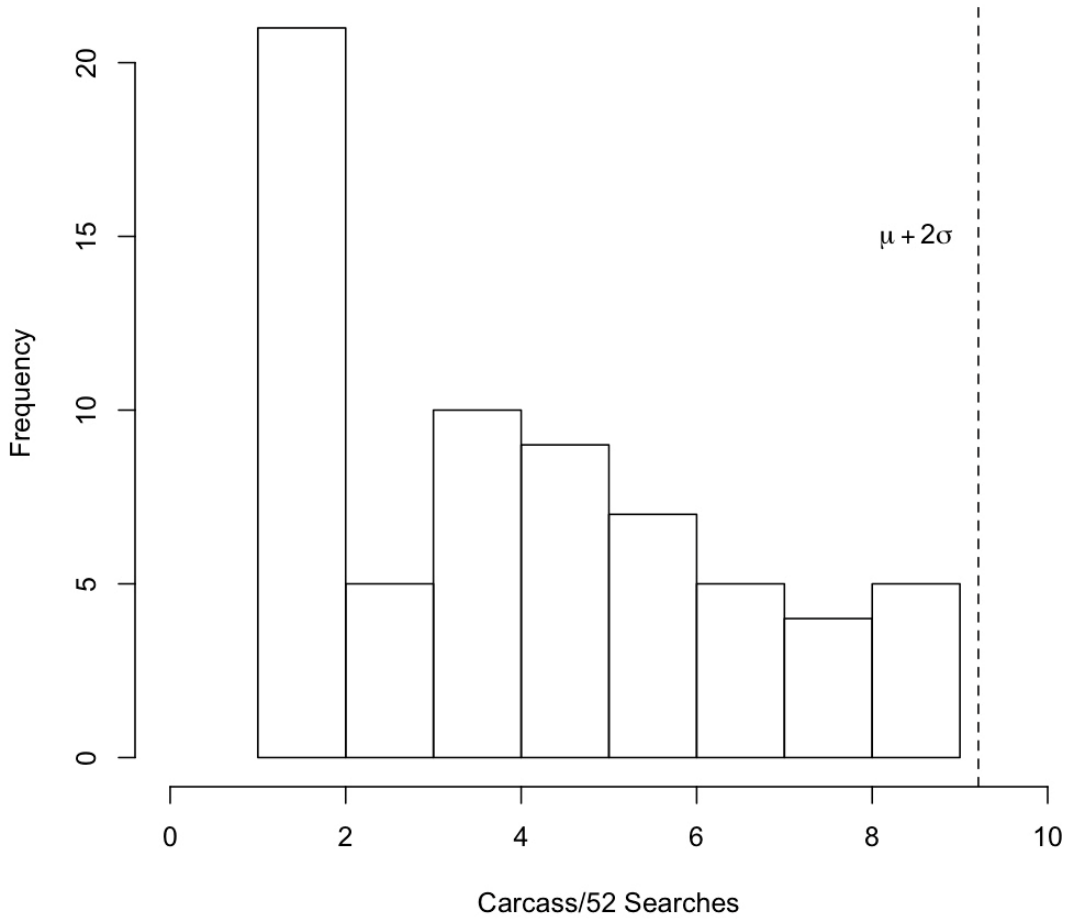
Grebe sp.	Waterbird	1			1	0.03
Long-billed Curlew	Waterbird	1			1	0.03
Waterbird sp.	Waterbird			1	1	0.03
Western Grebe	Waterbird		1		1	0.03
12 species		9	7	8	24	0.62
45 identified species		44	64	73	181	4.65

The rate of bird fatalities appeared to have seasonal trends for some types of birds (Fig. 6). The rate of observed landbird fatalities seems to have peaked in January (winter season) and June (breeding season), exceeding four landbird carcasses in 100 searches. However, this pattern is not very distinct and may not differ from random. It is also possible that there are patterns for some species, but these patterns are masked by other fatalities of landbirds.

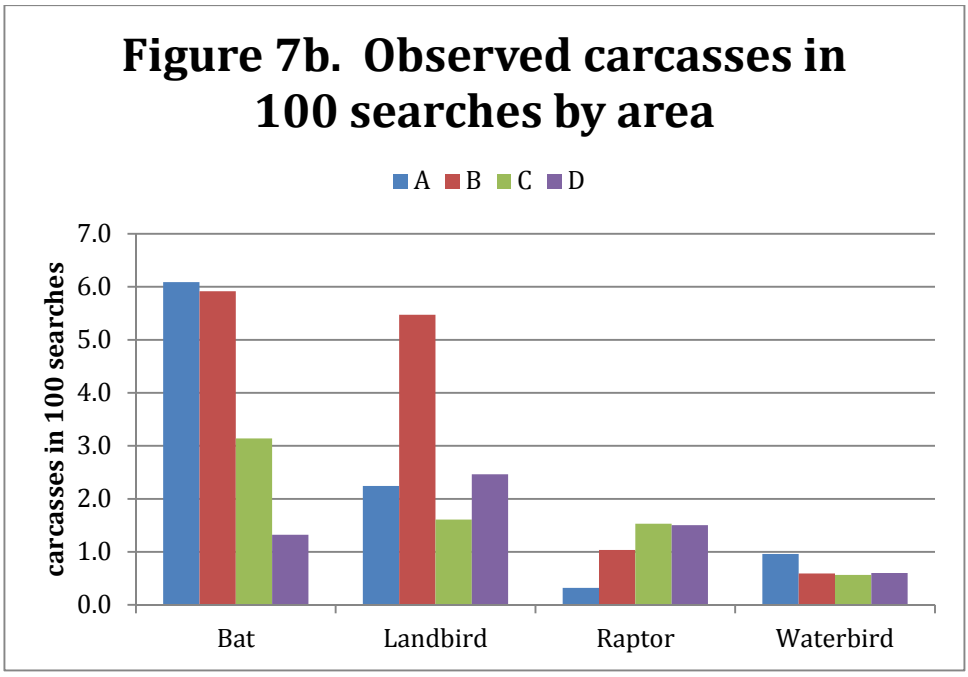
There did not appear to be a seasonal pattern of fatalities for waterbirds. The rate of observed raptor fatalities peaked in October-November, seemingly corresponding to fall migration and, or post-breeding dispersal. The rate for these two months exceeded 2.5 raptor carcasses in 100 searches. In eight months, observed bird fatalities exceeded four carcasses in 100 searches (Fig. 6). For bats, that rate was exceeded in three months (Fig. 5). Nonetheless, the greatest observed monthly rate for bats was twice that for birds.

When the rate of fatalities at individual turbines was examined for outliers, none was found. Statistical theory tells us that, for most distributions, approximately 95% of the data lie within about two standard deviations of the mean ($\mu + 2\sigma$). In this case (Fig. 7a), all of our observations were within two standard deviations of the mean. Given that no data exceeded $\mu + 2\sigma$ (dashed vertical line at right of graph), there was no suggestion of an outlying observation at a significance level of approximately 0.05.

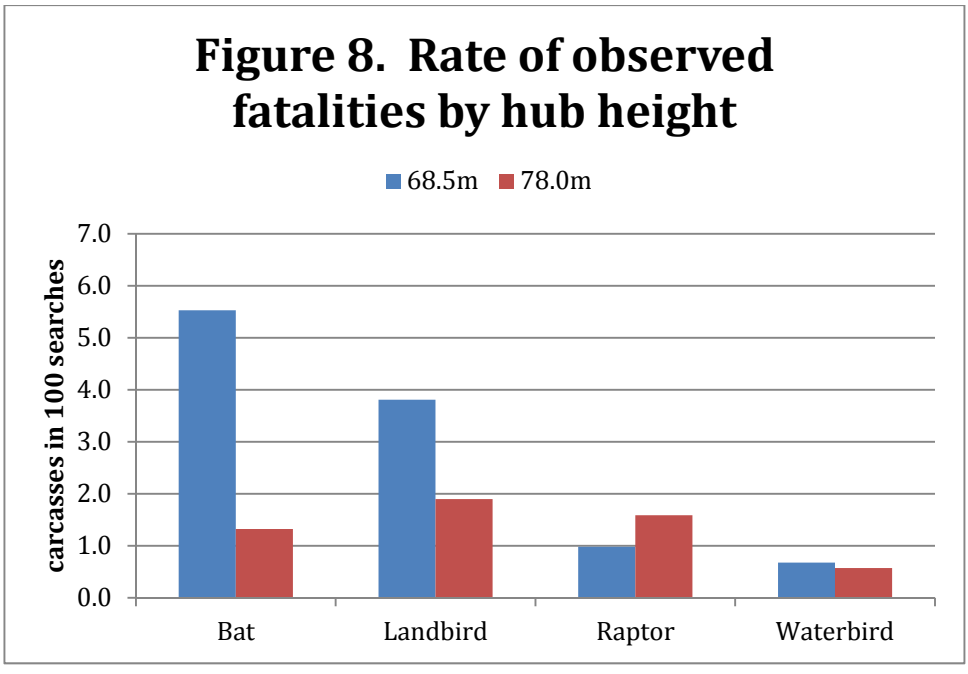
Figure 7a. Frequency distribution of carcass finds at turbines.



In other words, there was no evidence that any particular turbine killed significantly more bats or birds than others. Nonetheless, when the number of bat and bird carcasses found in each area of the wind farm was corrected for effort (i.e., the number of searches conducted in each area), it was found that bat fatalities were greatest in areas A and B and decreased eastward, whereas landbird fatalities were more than twice as great in area B than in other areas (Fig. 7b). Raptor fatalities appeared to increase from west to east, but note that no A turbines were searched in year 3 (Appendix A), when raptor fatalities were greatest (see above). Thus, raptor fatalities in area A were underrepresented. Waterbird fatalities were somewhat greater in area A, where two ponds that attracted waterbirds were visible, but the difference was minimal.



It is noteworthy that bats and landbirds (more daytime migrants or residents) appeared to collide with turbines with 68.5-m hub heights at much greater rates than with turbines with 78.0-m hub heights (Fig. 8). For bats, the fatality rate was more than four times greater at short turbines, and for landbirds, it was about twice as great. Raptors, on the other hand, had a fatality rate about 40% less at short turbines, while for waterbirds it was about 20% greater. When observed and expected frequencies were compared in a Chi-square test, differences were significant for bats ($p < 0.0001$) and landbirds ($p = 0.0003$) and not significant for raptors ($p = 0.1089$) and waterbirds ($p = 0.6788$).

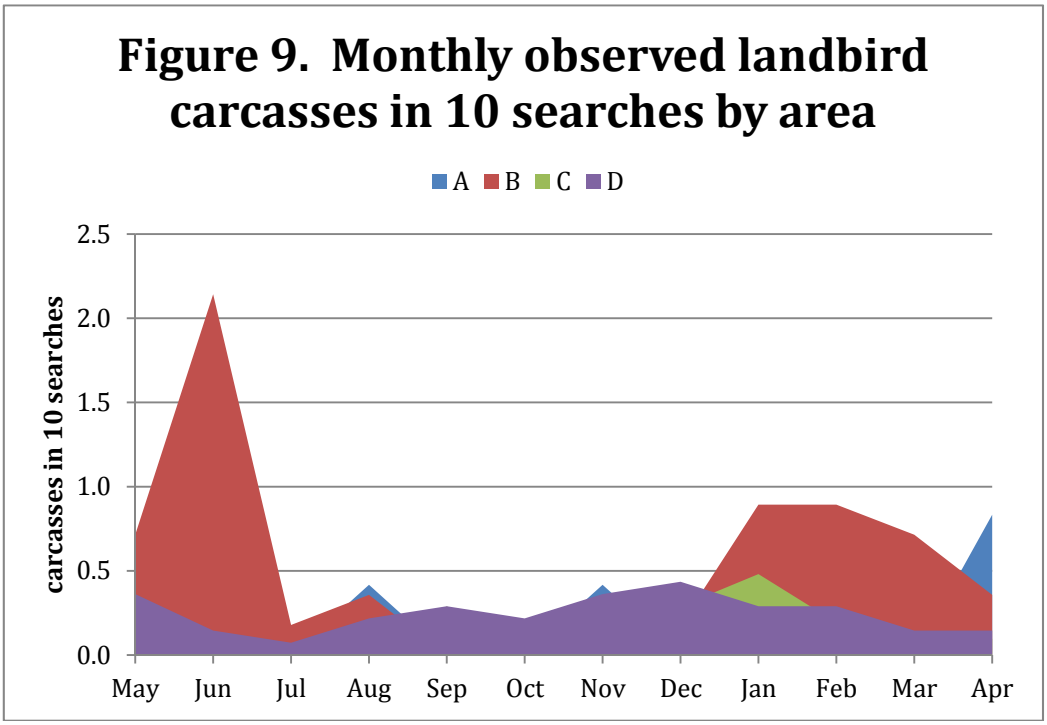


Considering that all turbines in the A and B areas had hub heights of 68.5 m (Appendix A), turbine location may have had more to do with the fatality rate than turbine height. But, when expected and observed fatalities at turbines in the C and D areas were examined in a Chi-square test, mortality was again significantly greater at shorter turbines for bats. 39% of searches in the C area and 9% of searches in the D area were at shorter turbines, yet 59% ($p = 0.0104$) and 36% ($p < 0.0001$) of bat fatalities in those areas were recorded in those searches. For landbirds, observed percentages were 40% ($p = 0.9269$) and 24% ($p = 0.0006$) respectively. Thus, at C turbines, a "short-turbine effect" was not apparent with respect to landbird fatalities, but at D turbines it was, significantly so. Nonetheless, landbird fatalities at D turbines were distributed among a wide range of species, strongly suggesting that the effect was not species-specific or habitat-specific.

These findings point to differences in the altitudes swept by rotors as the causative factor. At tall turbines, airspace was clear of spinning rotors up to an altitude of 31 m, but at short turbines, bats and birds would have encountered spinning rotors beginning at an altitude of 21.5 m. Thus, if foraging or migratory bats, or landbirds moving across Shiloh II, were more concentrated at altitudes below 31 m than above, then chance of collision would be greater at shorter turbines. We examined the flight-height data recorded for landbirds, raptors, and waterbirds to see if it supports this hypothesis. However, we have no flight-height data for bats.

That landbird carcasses were found at greater rates in area B is puzzling. When we examined the data more closely, we found much greater rates of carcass finds in June (2.1 carcasses in 10 searches) and in January-March (0.7-0.9 carcasses in 10 searches) relative to other months and areas (Fig. 9). June mortality was concentrated among Cliff Swallows (5 carcasses) and Horned Larks (4 carcasses), which made up 75% of carcasses found in that month. Given that Cliff Swallows feed on the wing and Horned Larks perform flight displays, their behaviors may explain why they were more susceptible to collisions than other species.

The greater rates in winter months are not easily explained, given that mortality was spread among many species. Nonetheless, Red-winged Blackbird and Western Meadowlark made up half the carcasses. They typically forage in flocks and fly at relatively low altitudes between foraging locations, suggesting that greater fatality rates at shorter turbines may be explained by the prevalence of these species both as foraging species within the project area. The relative scarcity of night migrating songbirds among the fatalities strongly suggests that the shorter turbines killed more birds because there are so few night migrants flying at the height of either the taller or shorter turbines.



Concerns have been raised that aviation obstruction lighting, which flashes visibly at night, may attract night-migrating songbirds or insects on which bats feed. Such attraction would increase fatality rates.

Aviation obstruction lighting was installed on 34 (45%) of 75 turbines, at which 1,803 (46%) of 3,894 searches were conducted. In those searches, 7 (58%) of 12 night-migrant fatalities were recorded ($p = 0.3848$), as well as 70 (58%) of 120 bat fatalities ($p = 0.0084$). That the difference between observed and expected values for birds was not statistically significant supports the conclusion of Kerlinger et al. (2010), who reviewed fatality monitoring studies at 30 wind farms across North American and found that night-migrating songbirds were not attracted to flashing lights on wind turbines. The statistically significant difference for bats, however, appears to be contrary to the conclusion of Kunz et al. (2007), who in a review found that preliminary evidence suggested that bats were not attracted to the lighting attached to wind turbines.

When bat fatalities with respect to lighting at short and tall turbines were examined in a Chi-square test, it was found that the difference in observed and expected fatalities at tall turbines was statistically significant ($p = 0.0317$), while at short turbines, where most bat fatalities occurred, it was not ($p = 0.9488$). These conflicting results suggest that something other than lighting was responsible for the difference in bat fatalities at lit and unlit tall turbines.

Carcass distance from turbines

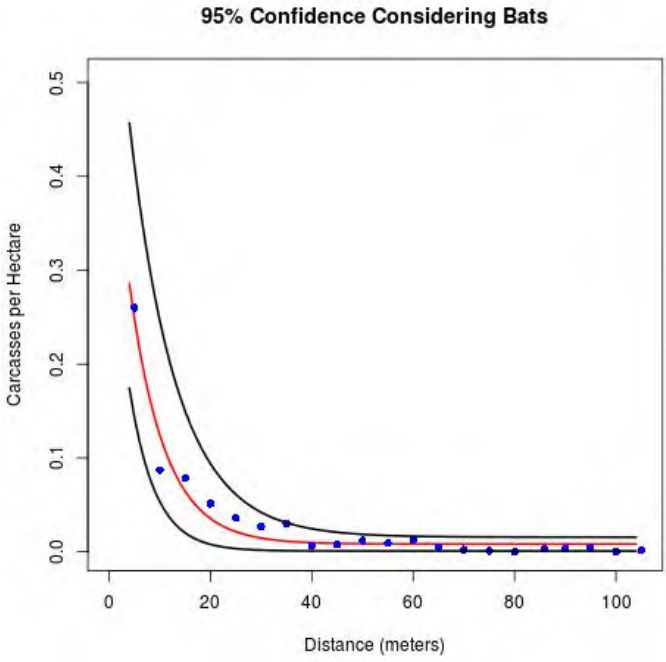
Bat carcasses were found, on average, much closer to turbines than were bird carcasses (Table 3). The mean distance for bat carcasses was about 14 m closer to turbines than was the case for all birds. Approximately 75% of bat carcasses were detected by the 55-m interval, but for birds, depending on the group, 75% or more of carcasses were found by the 70-m to 80-m intervals. The mean distance at which small-bird and large-bird carcasses were found was not statistically different ($p = 0.5268$), but it was between small birds and medium birds ($p = 0.0014$) and large birds and medium birds ($p = 0.0302$).

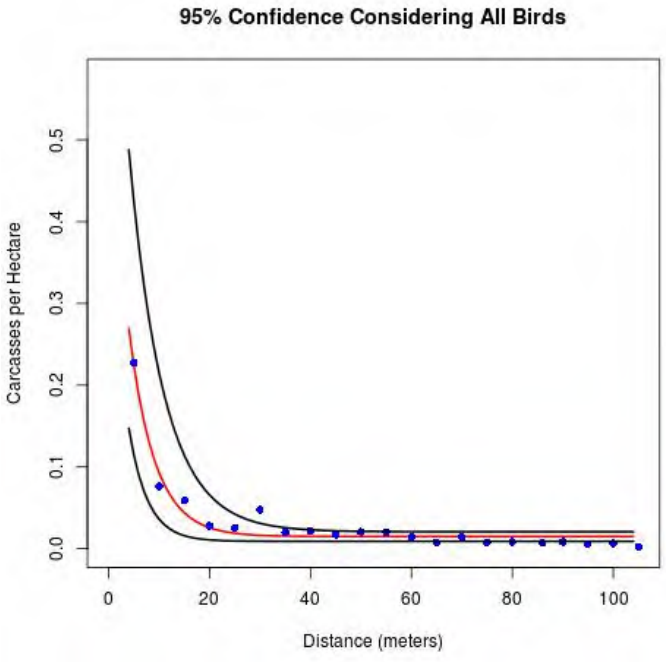
Table 3. Summary of distance statistics for bats and various-sized birds

Class	Sample Size	Mean ± SE	Distance interval at which 75% of carcasses were found	Formula that described the negative exponential distribution	R^2
Bats	120	37.6 ± 2.4	55-m (76%)		0.92750
All birds	181	51.4 ± 2.1	75-m (77%)		0.90296
Small birds	77	45.5 ± 3.3	65-m (77%)	$y = A + (R - A) \exp(-xe^{L})$	0.93152
Medium birds	62	60.5 ± 3.2	80-m (79%)		0.00661
Large birds	43	48.9 ± 4.3	70-m (77%)		0.51791

The density distribution of bat and bird carcass by distance conformed to a negative exponential distribution (Figure 10), which is also called a negative asymptotic regression. In other words, the density of carcasses for birds and bats declined dramatically from turbines out to distances of ~40-60 m depending on the bird category. Excellent fits to a negative exponential distribution were found for bats and small birds, and to a lesser degree for medium and large birds. When all birds were pooled, the negative exponential was an excellent fit and 95% confidence intervals were narrow. When examining the coefficients of determination (R^2 - the amount of variance accounted for), it was obvious that there was a strong relation between distance from turbines and density of carcasses fitting a negative exponential distribution.

Figure 10. Density distribution of bat and bird carcasses by distance from turbines





Fatalities of special-status species

With respect to endangered, threatened, special-concern, and other special-status species, the following were found dead during the three years of study:

- **California Black Rail**, listed as threatened in California (CDFG 2009, CDFG 2011), was recorded twice, on 7/30/09 and 8/21/09, at turbines D17 and A3 respectively. Given the dates, they may have been migrants, although the species may nest in the nearby Suisun Marsh or small wetlands nearby.
- **Northern Harrier**, listed as California Special Concern, Priority 3 (Shuford and Gardali 2008, CDFG 2011), was recorded twice, on 2/13/11 and 5/21/11. This raptor was known to nest locally (see Raptor Nesting Study).
- **Vaux's Swift,** listed as Special Concern, Priority 2 (Shuford and Gardali 2008, CDFG 2011), recorded once on 1/24/12. Given the date, it is uncertain whether the bird was a California breeder.
- **Loggerhead Shrike,** listed as Special Concern, Priority 2 (Shuford and Gardali 2008, CDFG 2011), was recorded once. The 6/6/11 date indicated that it was probably a resident breeder.
- **Yellow Warbler,** listed as a California Special Concern, Priority 2 (Shuford and Gardali 2008, CDFG 2011), was recorded once, on 5/20/09. Whether or not the bird belonged to the subspecies *brewsteri*, which is special-concern in California, or the transient *rubiginosa*, which is not listed, is uncertain.
- **Western Red Bat,** listed as California Special Concern (CDFG 2011), was recorded six times: once in August, twice in September, and three times in November.

Adjusted fatalities

During the three-year study, 193 carcasses were distributed within the study area for searcher efficiency (Se) and scavenger removal (Sr) trials. Of those carcasses, scavengers removed three before searchers could search for them. We know this because, immediately after tests, the field leader checked all trial carcasses missed by searchers. If he did not find a missed carcass that he had placed in the morning, it meant that a scavenger had removed it during that day (see Methods). Those were excluded as Se trials.

Table 4. Searcher efficiency (Se) and scavenger removal (Sr) rates by taxa and size (mean and 95% CI)

Category	# Se trials	mean efficiency	# Sr trials	mean persistence (days)
Bats (all small)	71	0.41 (0.30, 0.52)	72	6.1 (5.0, 7.3)
Small birds	57	0.58 (0.46, 0.70)	57	6.6 (5.4, 7.8)
Medium birds	27	0.85 (0.70, 0.96)	29	8.9 (6.8, 10.9)
Large birds	35	0.97 (0.91, 1.00)	35	13.0 (12.1, 13.7)
	190		193	

Se rates ranged from about 40% for bats to nearly 100% for large birds (Table 4). Scavengers removed bats and small bird carcasses at between 6 and 7 days, on average, but large bird

carcasses were more persistent, averaging 13 days in tests that were terminated at 14 days (see Methods). Thus, these larger carcasses undoubtedly persisted for more than two weeks making fatality estimates provided below somewhat conservative.

Table 5. Adjusted mortality by year (mean and 95% CI)

Group	N	Year 1 per MW per year	N	Year 2 per MW per year	N	Year 3 per MW per year	N	All years per MW per year
Bats	32	2.6 (1.9, 4.0)	46	3.8 (2.8, 5.8)	42	3.4 (2.5, 5.3)	120	3.3 (2.4, 5.0)
Small birds	22	1.2 (0.9, 1.7)	32	1.8 (1.4, 2.5)	23	1.3 (1.0, 1.8)	77	1.4 (1.1, 2.0)
Medium birds	16	0.5 (0.4, 0.7)	19	0.6 (0.5, 0.9)	27	0.9 (0.8, 1.2)	62	0.7 (0.6, 0.9)
Large birds	6	0.2 (0.2, 0.2)	13	0.3 (0.3, 0.4)	23	0.6 (0.6, 0.7)	42	0.4 (0.4, 0.4)
All birds	44	1.9 (1.6, 2.6)	64	2.8 (2.2, 3.7)	73	2.8 (2.3, 3.7)	181	2.5 (2.0, 3.3)

Se/Sr data from all years were pooled to calculate adjusted mortality at Shiloh II (Table 5). Bat mortality averaged 3.3 bats/MW/year, while bird mortality was about 25% less, averaging 2.5 birds/MW/year. Adjusted bird mortality was distributed as follows: small birds, 57%; medium birds, 28%; and large birds, 15%.

Table 6. Mean adjusted mortality (mean and 95% CI)

Group	per MW	per turbine	All turbines
Bats	3.3 (2.4, 5.0)	6.6 (4.8, 10.0)	492 (359, 752)
Small birds	1.4 (1.1, 2.0)	2.9 (2.2, 4.0)	216 (166, 300)
Medium birds	0.7 (0.6, 0.9)	1.4 (1.2, 1.9)	105 (87, 141)
Large birds	0.4 (0.4, 0.4)	0.8 (0.7, 0.8)	56 (54, 60)
All birds	2.5 (2.0, 3.4)	5.0 (4.1, 6.7)	377 (307, 502)

When all 75 turbines at Shiloh II were considered, bat mortality averaged nearly 500 bats per year, while bird mortality averaged slightly more than 375 birds per year (Table 6).

When raptor mortality was considered separately, it was found to range from one raptor at every five turbines in year 1 to nearly two raptors at each turbine in year 3 (Table 7). The three-year average was about one raptor per turbine per year. Annual estimates of raptor losses at Shiloh II were about 17 in year 1 to nearly 150 in year 3, averaging about 75 per year. The increase in raptor fatalities was correlated with an increase in raptor abundance (see below).

Table 7. Annual raptor mortality (mean and 95% CI)

Group	N	per MW	per turbine	All turbines
Year 1	4	0.11 (0.10, 0.13)	0.23 (0.21, 0.26)	17.1 (15.7, 19.8)
Year 2	15	0.44 (0.40, 0.53)	0.89 (0.80, 1.07)	66.5 (59.8, 79.8)
Year 3	33	0.97 (0.88, 1.17)	1.95 (1.75, 2.34)	146.1 (131.4, 175.1)
All years	52	0.51 (0.46, 0.61)	1.02 (0.92, 1.22)	76.6 (69.0, 91.6)

Figure 11. Percent difference of Se and Sr rates in medium/tall vegetation relative to short vegetation

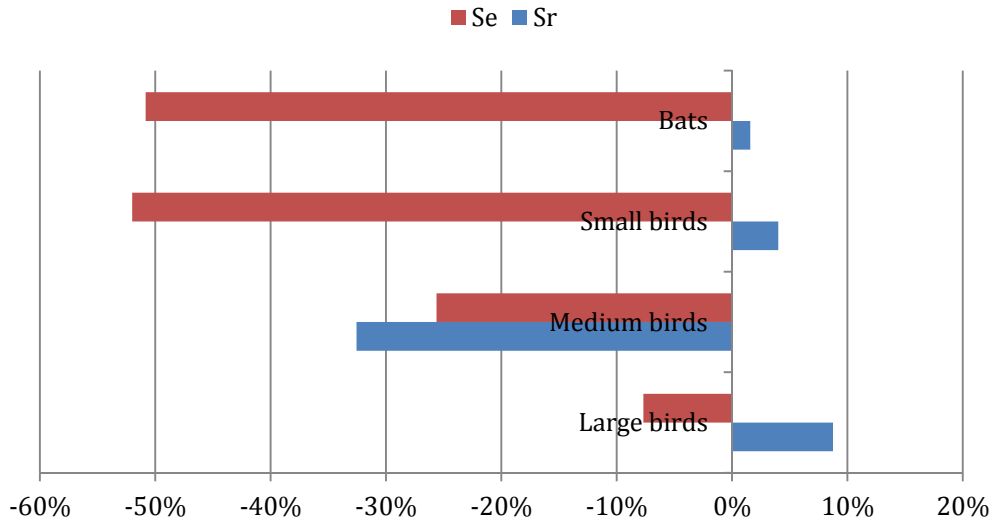
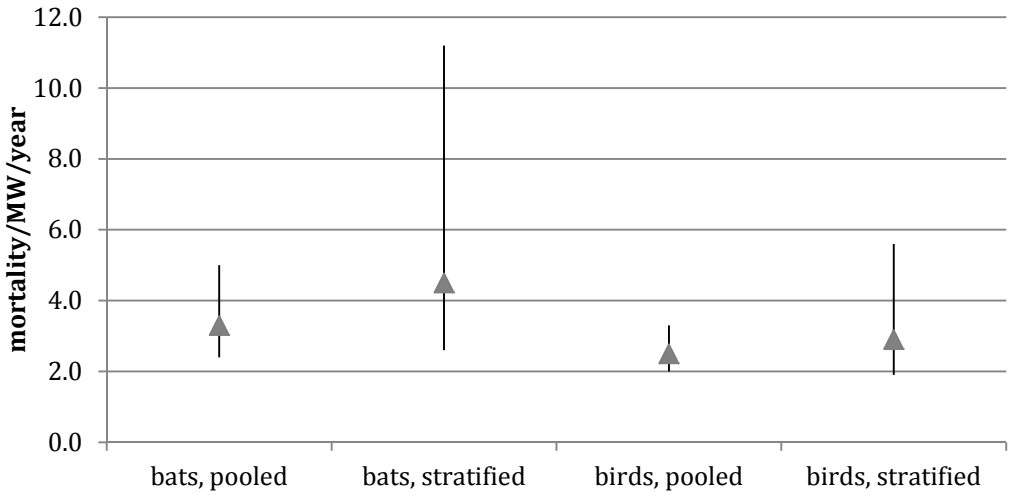


Figure 12. Comparison of adjusted mortality with data pooled or stratified by vegetation height



Vegetation height had a pronounced negative effect on Se rates, particularly for bats and small birds, but little consistent effect on Sr rates (Fig. 11). Taking bats as an example, searchers found 53% of test carcasses placed in short vegetation, but only 26% of those placed in medium/tall vegetation, a decrease of about 50% in the Se rate. Scavengers, on the other hand, were equally as good at finding test bat carcasses placed in short vegetation as finding those

placed in medium/tall vegetation (Sr rates of 6.1 and 6.2 days respectively). The Se rate for medium-sized birds decreased by about 25% in medium/tall vegetation, but for large birds, it only decreased by less than 10%. In other words, vegetation height had relatively little effect on finding large birds, such as Red-tailed Hawks.

It seems odd that scavengers might have found fewer medium-sized birds in taller vegetation, but not bats and small birds. Due to small sample size, we used the Wilcoxon Rank-Sum test, a nonparametric procedure, to test for differences in median scavenging rates involving medium birds. The test failed to reject the null hypothesis ($W = 48.5$, $p = 0.3507$). Thus, we conclude that there was no significant difference in scavenger efficiency for medium birds found in tall/medium vegetation versus medium birds found in short vegetation. The same was true for bats and small birds. In other words, under closer scrutiny, vegetation height does not appear to have a significant effect on scavenging for any size class. (This may be because fatalities are rare enough at wind turbines that scavengers have not been attracted to the site with expectation of finding food, thereby randomizing the results of scavenging studies conducted in vegetation of different heights and size classes.)

Estimated mortality reported above (Table 6) was calculated by pooling vegetation-height data, which effectively averaged out the variation due to vegetation height. When estimated mortality was calculated by stratifying vegetation-height data (i.e., when carcasses found in short vegetation were calculated separately from those found in medium/tall vegetation), estimated mortality calculated 35% greater for bats (4.5 bats/MW/year) and 16% greater for birds (2.9 birds/MW/year), but confidence intervals were much broader (Fig. 12). The overlap in confidence intervals suggests that the averages were not significantly different. However, the width of the intervals tells us something about the estimates. In the stratified estimates, the wider intervals appear to have resulted from smaller sample sizes, as each size class was divided into two (carcasses found in short vegetation and those found in medium/tall vegetation), which increased the experiment-wide error and widened the confidence intervals.

As will be seen below, in the comparison of MHWRA sites studied by Curry & Kerlinger (Table 11), we chose to use the pooled estimates because they were more precise. Had the stratified estimates been lower, we still would have featured the pooled estimates because of their greater precision.

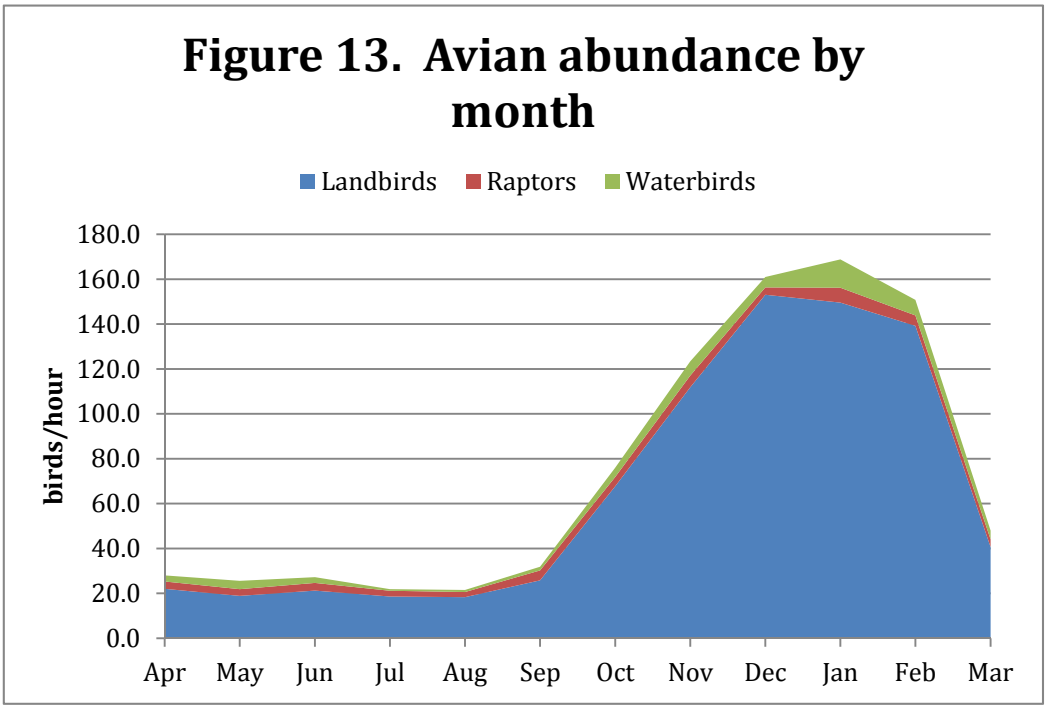
The vegetation height analysis underlines the need to maintain search sites at the highest possible searcher efficiency (e.g., by mowing) to limit a complicating factor that affects the precision of estimates.

Avian abundance and behavior study

Abundance and flight behavior of raptors, landbirds, and waterbirds were measured at six observation points (OPs) distributed throughout the Shiloh II area (Fig. 4). Over the three-year period, observations totaled 786 hours (131 hours/OP), with 249 hours (41.5 hours/OP) conducted in year 1, 276 hours (46.0 hours/OP) in year 2, and 261 hours (43.5 hours/OP) in year 3.

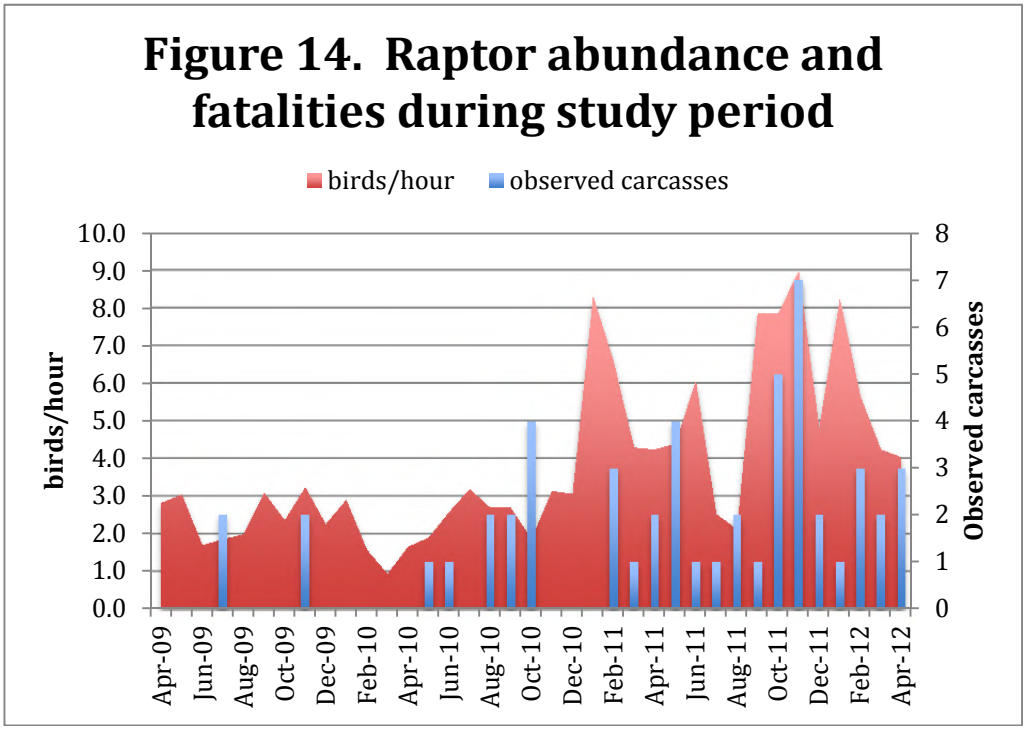
Observers identified 64 species during the three-year study. Annual abundance averaged 62.8 birds/hour (Table 8), but mixed blackbird flocks (i.e., flocks composed of more than one species of blackbird) made up 42% of the abundance. When mixed blackbird flocks were combined with the seven species recorded at >1 bird/hour, they accounted for 78% of the avian abundance at Shiloh II. Red-winged Blackbird (7.3 birds/hour not including those in mixed blackbird flocks) was the most abundant landbird, Red-tailed Hawk (1.4 birds/hour) the most abundant raptor, and Killdeer (0.8 birds/hour) the most abundant waterbird. More than half of species were recorded at <0.1 birds/hour and were relatively scarce.

Landbirds were the most abundant class of birds, making up 88% of all individuals recorded, with raptors and waterbirds each making up 6% of individuals recorded. Fluctuations in landbird numbers, particularly those of blackbirds, were mostly responsible for annual differences in yearly abundances as great as 20-30 birds/hour (Table 8).



When monthly abundance was plotted by avian class (Fig. 13), abundance increased dramatically in October-February, mainly as a result of landbird abundance. Waterbirds and raptors were most abundant in December-February. Clearly, winter was the season when avian abundance peaked at Shiloh II.

During the first half of the three-year study, monthly raptor abundance did not much exceed 3.0 birds/hour, but after December 2010, it generally exceeded 3.0 birds/hour and peaked above 8.0 birds/hour in January 2011, November 2011, and January 2012 (Fig. 14). Raptor fatalities were observed irregularly before February 2011, but after that month, they were observed monthly. When the relationship between raptor abundance and observed carcasses was examined (Fig. 14), there was a significant positive correlation (Spearman's $\varrho = 0.4235$, $p < 0.005$), although the relationship was not strong.



The correlation between abundance and observed fatalities was weaker for Red-tailed Hawk (Spearman's $\varrho = 0.3047$, $p = 0.068$) than for all raptors. Note that, though there was a significant correlation for the all-raptors relation, the coefficient of determination (r^2) was only 0.18 (18% of the variance accounted for). Thus, the relation is weak and, therefore, difficult to interpret.

The cause of the increased abundance is not known, but may be related to prey availability. Relatively large prey species were noted when observed during carcass searches, three of which were mammals (jackrabbit, cottontail, and ground squirrel) and three of which were reptiles (alligator lizard, gopher snake, and western racer). Fifty-six observations of these six species were recorded over the three years, with 11 in year 1, 25 in year 2, and 20 in year 3. Jackrabbit was most commonly observed (25 observations), followed by ground squirrel (10 observations) and gopher snake (9 observations). In addition, observers noticed many more voles in year 3 as compared with years 1 and 2.

We did not analyze these data further, nor did we attempt to correlate them with raptor abundance. Such an analysis would likely have required doing similar surveys in a broader area in an effort to develop a regression model. Nonetheless, predator abundance is known to respond directly to prey abundance (Odom 1971). Thus, increases in raptor abundances were

likely prey related at some geospatial scale. Without wider geographic surveys of raptors and prey, we are unable to examine this issue.

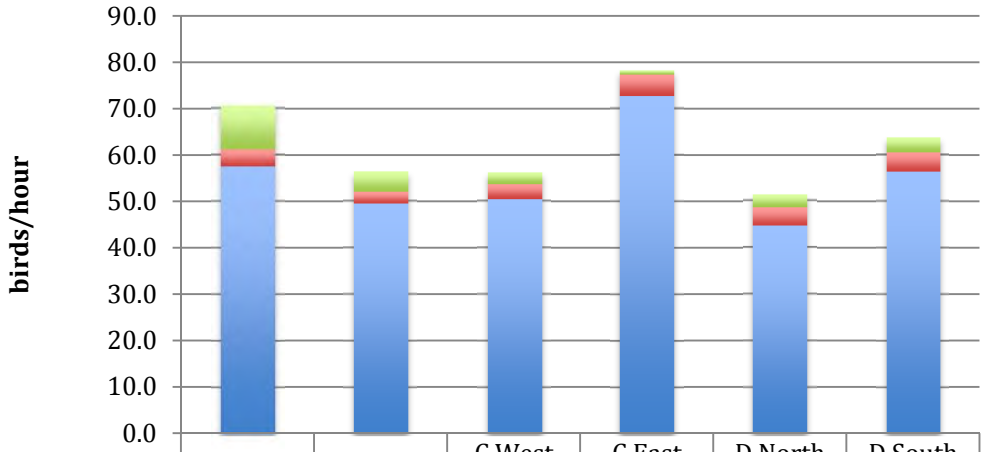
Table 8. Avian abundance (birds/hour) at Shiloh II, all OPs and all years pooled

Species	Class	Y1	Y2	Y3	Overall abundance
Mixed blackbirds	Landbird	20.72	44.35	13.03	26.46
Red-winged Blackbird	Landbird	6.96	9.37	5.29	7.25
Western Meadowlark	Landbird	1.52	4.08	5.52	3.75
European Starling	Landbird	1.57	2.52	5.73	3.28
Brewer's Blackbird	Landbird	0.69	5.25	2.07	2.75
Horned Lark	Landbird	1.69	2.68	2.79	2.40
Cliff Swallow	Landbird	0.96	2.13	1.98	1.71
Red-tailed Hawk	Raptor	0.53	1.25	2.45	1.42
Rock Pigeon	Landbird	0.88	0.75	1.24	0.95
Turkey Vulture	Raptor	0.74	0.72	1.25	0.90
American Goldfinch	Landbird	0.36	1.47	0.71	0.87
Common Raven	Landbird	0.31	1.06	0.99	0.80
Killdeer	Waterbird	0.26	0.60	1.43	0.77
Barn Swallow	Landbird	1.51	0.72	0.11	0.77
Tree Swallow	Landbird	0.49	1.20	0.57	0.76
American Pipit	Landbird	0.22	0.60	1.25	0.70
Long-billed Curlew	Waterbird	0.76	0.26	1.01	0.67
Savannah Sparrow	Landbird	0.43	0.82	0.74	0.67
Canada Goose	Waterbird	0.27	0.77	0.88	0.65
Mallard	Waterbird	0.28	0.86	0.57	0.58
American Kestrel	Raptor	0.39	0.53	0.79	0.57
Mourning Dove	Landbird	0.71	0.58	0.43	0.57
House Finch	Landbird	0.10	1.30	0.23	0.57
Northern Harrier (CA Special Concern)	Raptor	0.30	0.63	0.67	0.54
American White Pelican (CA Special Concern)	Waterbird	0.18	0.17	1.16	0.51
Loggerhead Shrike (CA Special Concern)	Landbird	0.24	0.21	0.46	0.30
Unidentified gulls	Waterbird		0.25	0.61	0.29
Yellow-rumped Warbler	Landbird	0.18	0.12	0.11	0.14
Snow Goose	Waterbird	0.40			0.13
Swainson's Hawk (CA Threatened)	Raptor	0.13	0.09	0.16	0.12
Say's Phoebe	Landbird	0.06	0.17	0.04	0.09
Unidentified birds			0.25		0.09
White-crowned Sparrow	Landbird	0.09	0.04	0.12	0.08
California Gull	Waterbird		0.12	0.10	0.08
Dark-eyed Junco	Landbird	0.03	0.14	0.04	0.07
Golden Eagle (CA Fully Protected)	Raptor	0.07	0.04	0.09	0.07
Unidentified ducks	Waterbird	0.20			0.06
House Sparrow	Landbird			0.12	0.04
American Crow	Landbird	0.06	0.02	0.04	0.04
Great Egret	Waterbird	0.01	0.01	0.07	0.03
Ferruginous Hawk	Raptor	0.03	0.01	0.04	0.03
Prairie Falcon	Raptor	0.02	0.01	0.05	0.03
White-tailed Kite (CA Fully Protected)	Raptor	0.03	0.02	0.03	0.03
Western Kingbird	Landbird	0.03	0.01	0.03	0.02
Burrowing Owl (CA Special Concern)	Raptor	0.00	0.00	0.04	0.02

Great Horned Owl	Raptor	0.01	0.02	0.02	0.02
Unidentified goldfinches	Landbird		0.04		0.02
Northern Flicker	Landbird	0.04	0.01		0.02
Northern Mockingbird	Landbird	0.03	0.00	0.01	0.02
Ring-necked Pheasant	Landbird	0.00	0.03	0.01	0.02
Mountain Bluebird	Landbird	0.04			0.01
Black Phoebe	Landbird	0.01	0.01	0.02	0.01
Dunlin	Waterbird		0.03		0.01
Varied Thrush	Landbird	0.01	0.01	0.02	0.01
Rough-legged Hawk	Raptor	0.02		0.00	0.01
American Robin	Landbird	0.00	0.01	0.01	0.01
Cinnamon Teal	Waterbird		0.01	0.01	0.01
Yellow-billed Magpie	Landbird	0.01		0.01	0.01
Western Tanager	Landbird	0.00	0.01	0.00	0.01
Greater Yellowlegs	Waterbird		0.01	0.00	0.00
Western Scrub Jay	Landbird	0.00		0.01	0.00
American Avocet	Waterbird			0.01	0.00
Lincoln Sparrow	Landbird		0.01		0.00
Swainson's Thrush	Landbird	0.00	0.00		0.00
Barn Owl	Raptor			0.00	0.00
Black Swift (CA Special Concern)	Landbird	0.00			0.00
Great Blue Heron	Waterbird			0.00	0.00
Merlin	Raptor	0.00			0.00
64 identified species		44.64	86.39	55.18	62.80

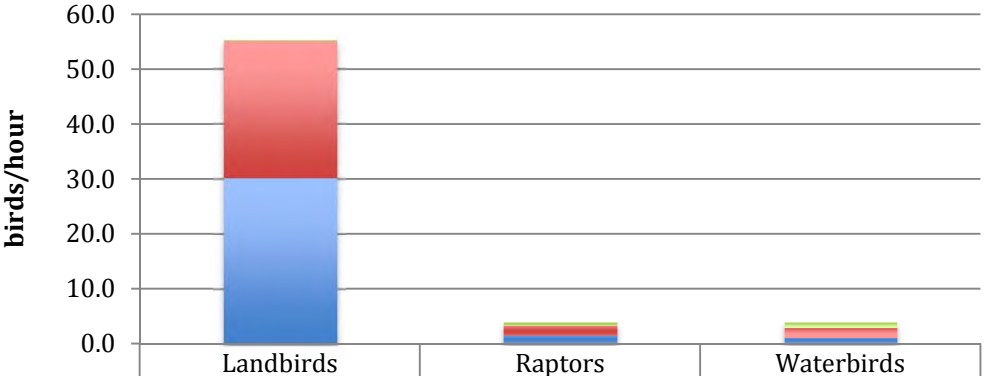
OP locations sampled avian abundance across Shiloh II from northwest to southeast (Fig. 4). When abundance was plotted by area and OP (Fig. 15), landbird abundance was more than 30% greater than average in area C (OP-4), and waterbird abundance was nearly 150% greater than average in area A (OP-1), which was closest to Suisun Marsh and where there were two ponds that attracted waterbirds.

Figure 15. Avian abundance by area



	A (OP1)	B (OP2)	C West (OP3)	C East (OP4)	D North (OP5)	D South (OP6)
Waterbirds	9.4	4.3	2.5	0.8	2.6	3.1
Raptors	3.6	2.5	3.3	4.7	4.1	4.3
Landbirds	57.7	49.6	50.5	72.8	44.6	56.4

Figure 16. Flight height by avian class



	Landbirds	Raptors	Waterbirds
High	0.1	0.6	1.0
Medium	25.0	1.6	1.7
Low	30.1	1.5	1.1

Many more landbirds were observed flying over Shiloh II than raptors or waterbirds (Fig. 16). Overall, landbirds were recorded in flight at a rate of 55.2 birds/hour, compared with 3.7 birds/hour for raptors, and 3.8 birds/hour for waterbirds. Nonetheless, the proportion of each flying at altitudes equivalent to the rotor-swept zone (RSZ) was about 45%.

The flight-height data may explain why more landbird carcasses were found under short turbines than under tall turbines (Fig. 8). Proportionally more landbirds (55%) used the low height zone than raptors (39%) or waterbirds (29%). Thus, the RSZ closer to the ground at short turbines would likely have affected more landbirds, particularly where short and tall turbines were mixed together (i.e., area D).

Eight special-status species were recorded in the abundance and use study. One was listed as threatened in California (CDFG 2009): Swainson's Hawk. Five were California Special Concern (Shuford and Gardali 2008, CDFG 2011): American White Pelican, Northern Harrier, Burrowing Owl, Black Swift, and Loggerhead Shrike. Two were listed as Fully Protected in California (CDFG 2011): Golden Eagle and White-tailed Kite.

Table 9. Monthly abundance (birds/hour) of special-status species at Shiloh II

Month	AWPE	BLSW	BUOW	GOEA	LOSH	NOHA	SWHA	WTKI
Apr				0.05	0.32	0.68	0.28	0.02
May	0.54			0.05	0.27	0.49	0.13	0.01
Jun	1.61			0.03	0.39	0.67	0.20	
Jul	0.40			0.02	0.31	0.40	0.24	
Aug				0.08	0.27	0.32	0.17	
Sep				0.06	0.33	0.36	0.28	0.01
Oct				0.08	0.23	0.42	0.03	0.04
Nov			0.01	0.05	0.14	0.37		0.05
Dec	1.00		0.02	0.12	0.17	0.40		0.02
Jan	1.90		0.15	0.15	0.49	0.92		0.10
Feb	0.78		0.06	0.14	0.44	0.75		0.06
Mar	1.00	0.01	0.03	0.04	0.38	0.90	0.01	0.03
	0.51	0.00	0.02	0.07	0.30	0.54	0.12	0.03

When monthly abundance of special-status species was considered (Table 9), all special-status species were found to be uncommon (occurring at <1 bird/hour) or scarce (occurring at <0.1 birds/hour). Swainson's Hawk (SWHA) was uncommon during April-September. As will be seen below, it nested at the site. Burrowing Owl (BUOW), on the other hand, was scarce during winter months, but its abundance was greatest in January. Loggerhead Shrike (LOSH) was an uncommon year-round resident, as was Northern Harrier (NOHA). American White Pelican (AWPE) was fairly common in May-July and December-March, when it was observed soaring generally at altitudes generally above the rotor-swept zone. Black Swift (BLSW) was scarce, with one individuals recorded in March 2010. Golden Eagle (GOEA) was generally scarce throughout the year, but its abundance was greatest in December-February. White-tailed Kite (WTKI) was scarce during September-May, with greatest abundance in January. While it was not recorded during June-August, it could breed at the site (see Small 1994).

Of these species, Loggerhead Shrike (one carcass) and Northern Harrier (two carcasses) were recorded among fatalities (Table 2).

Table 10. Results of raptor nesting study

					Breeding season		
Nest ID	**Date discovered**	**UTM Zone 10**	**Lat/Long**	**Substrate**	**2009**	**2010**	**2011**
AMKE-1	4/26/09	606572, 4223560	38.15363, -121.78364	Grove	Yes	Yes	Yes
AMKE-2	4/26/09	602131, 4225481	38.17146, -121.83404	Grove	Yes	No	No
AMKE-3	5/1/09	598364, 4226964	38.18523, -121.87683	Grove	Yes	Yes	Yes
AMKE-4	5/16/09	604658, 4225942	38.17532, -121.80513	Grove	Yes	Yes	Yes
AMKE-5	5/1/10	602131, 4225481	38.17146, -121.83404	Grove	No	Yes	Yes
AMKE-6	5/1/10	601276, 4226810	38.18353, -121.84361	Grove	No	Yes	No
					4	5	4
BAOW-1	5/1/11	601197, 4225557	38.17225, -121.84469	Grove	No	No	Yes
					0	0	1
GHOW-1	4/15/08	607882, 4222425	38.14325, -121.76886	Grove	Yes	Yes	No
GHOW-2	4/23/09	598346, 4226910	38.18475, -121.87705	Grove	Yes	Yes	Yes
GHOW-3	4/23/09	598114, 4227726	38.19213, -121.87958	Eucalyptus Tree	Yes	Yes	Yes
GHOW-4	4/23/09	607334, 4226144	38.17683, -121.77455	Grove	Yes	Yes	No
GHOW-5	4/25/09	597012, 4229383	38.20718, -121.89194	Grove	Yes	Yes	Yes
GHOW-6	5/1/09	599325, 4228195	38.19622, -121.86569	Grove	Yes	Yes	Yes
GHOW-7	4/29/10	609257, 4224830	38.16475, -121.75281	Transmission Line	No	Yes	Yes
					6	7	5
NOHA-1	5/26/09	601277, 4225707	38.17359, -121.84376	Ground	Yes	Yes	Yes
NOHA-2	5/23/11	607648, 4225012	38.16658, -121.77114	Ground	No	No	Yes
					1	1	2
RTHA-1	4/26/08	598239, 4226963	38.18524, -121.87826	Grove	Yes	Yes	Yes
RTHA-2	5/8/08	607202, 4224315	38.16036, -121.77634	Grove	Yes	Yes	No
RTHA-3	5/16/09	599715, 4227640	38.19118, -121.86131	Grove	Yes	Yes	Yes
RTHA-4	5/16/09	607895, 4222401	38.14303, -121.76872	Grove	Yes	No	No
RTHA-5	5/18/09	597259, 4226514	38.18130, -121.88951	Grove	Yes	Yes	Yes
RTHA-6	5/22/09	607269, 4226109	38.17652, -121.77530	Grove	Yes	No	Yes
RTHA-7	5/22/09	597043, 4228127	38.19586, -121.89177	Grove	Yes	Yes	Yes
					7	5	5
SWHA-1	5/1/08	606750, 4226452	38.17967, -121.78117	Grove	No	Yes	Yes
					0	1	1
				Total:	**18**	**19**	**18**

Raptor nesting study

Surveys during three nesting seasons located 24 raptor nests of six species within the Shiloh II footprint. Active nests fluctuated between 18 and 19 in a given nesting season (Table 10). American Kestrel (AMKE), Great Horned Owl (GHOW), and Red-tailed Hawk (RTHA) were the species with the most nests, with 4-7 nests of each found during a nesting season. Barn Owl (BAOW), Northern Harrier (NOHA), and the California-threatened Swainson's Hawk (SWHA) were less common, with 0-2 nests of each found during a nesting season.

Given that Shiloh II had an area of about 2,500 ha (6,100 acres; Solano County Department of Resource Management 2012), maximum nesting densities were 3.6 km^2/nest for Red-tailed Hawk and Great Horned Owl, 5.0 km^2/nest for American Kestrel, 12.5 km^2/nest ha for Northern Harrier, and 25.0 km^2/nest for Barn Owl.

Discussion

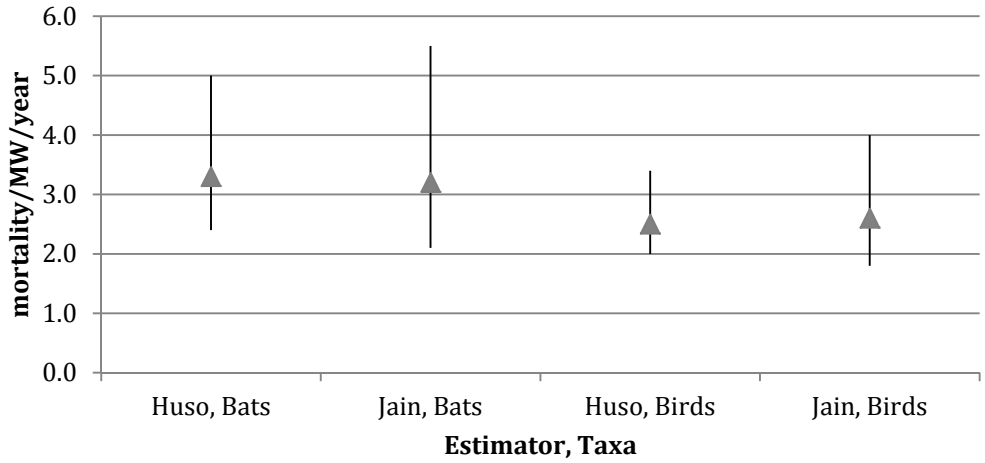
Comparison of estimators

The mortality estimates presented in this report were calculated using the Huso (2011) estimator (see Methods), which is now the most widely used for estimating mortality at wind turbines. The Huso estimator has also been peer reviewed and published in the peer-reviewed literature. In previous reports on avian and bat mortality in the MHWRA (Kerlinger et al. 2006b, 2009b), estimates were generated with the Jain estimator.

When the output from both estimators was compared using the Shiloh II data (Fig. 17), the means were not significantly different, but the Huso estimates appeared to be more precise, given the narrower confidence intervals.

We present this comparison to demonstrate that improvements in estimating mortality have not appreciably changed results. Certainly, there are no statistically significant differences between the fatality rates reported using the Jain vs. Huso methodologies. In the sections that follow, we compare Shiloh II estimates derived with the Huso (2011) estimator with published estimates from High Winds and Shiloh I, where the Jain estimator was used.

Figure 17. Comparison of estimators (mean and 95% confidence)



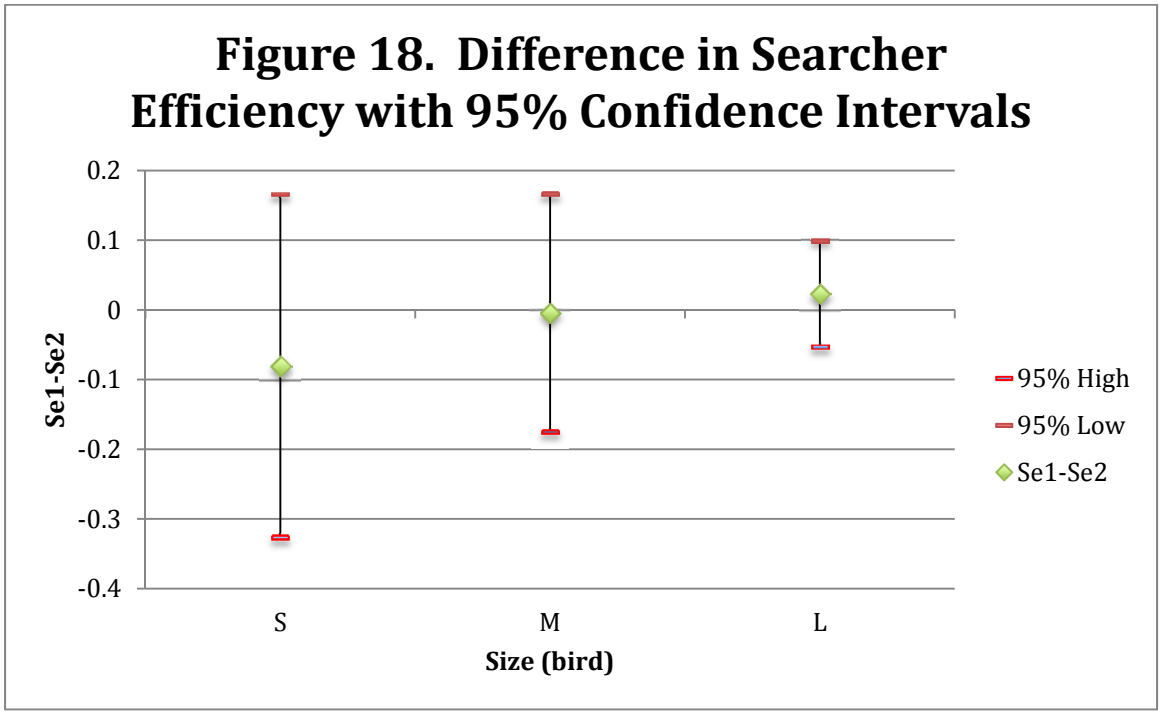
Comparison of mortality at MHWRA wind farms

Curry & Kerlinger has now conducted eight years of mortality monitoring in the MHWRA: two years at High Winds (Kerlinger et al. 2006b), three years at Shiloh I (Kerlinger et al. 2009b), and three years at Shiloh II (present study). These studies differed slightly with respect to turbine characteristics and search methodologies (Table 11). For example, 1.8-MW turbines at High Winds were searched at 15-day intervals and out to a distance of 75 m, whereas 1.5-MW turbines

at Shiloh I and 2.0-MW turbines at Shiloh II were searched on 7-day intervals out to a distance of 105 m.

In addition, search intensity within 30 m of turbines was greater during the third year at Shiloh I (third year) and all three years at Shiloh II than during the four previous years of searches at High Winds and Shiloh I. At High Winds and during the first two years at Shiloh I, transects were 15 m apart within 30 m of turbines and searched out to 7.5 m on each side, but in year 3 at Shiloh I and all years at Shiloh II, transects within 30 m of turbines were 5 m apart and searched out to 2.5 m on each side. Beyond 30 m from turbines, the search effort was the same throughout (transects 10 m apart searched out to 5 m on each side), except that the High Winds transects only went to 70 m from turbines. The Technical Advisory Committee (TAC) recommended this change in search methodology, thus complicating analysis, interpretation, and comparison of the data. Our analyses assume no difference between the search methodologies, in part because we observed no obvious difference between the 5 and 15 m wide transects.

In this regard, we pooled Se data for birds from the two years of High Winds and the first two years of Shiloh I (Se1) and from the final year of Shiloh I and the three years at Shiloh II (Se2), calculated searcher efficiency (Se) for birds of each size class for each group, and compared them by plotting the difference (Se1-Se2) with 95% confidence intervals (Fig. 18). These data were easily at hand because we had analyzed them for a peer-reviewed publication that had recently appeared in The Condor (Kerlinger et al. 2012). Since all three of the 95% CIs covered zero, we conclude that the difference in Se between these two groups was not significantly different from zero, at significance level 0.05. Thus, the change in transect searching protocol did not seem to have an effect on searcher efficiency, at least at those projects. We see no reason that the Se data for bats would yield a different result.



In addition, there were other factors that affected mortality estimates. Avian abundance differed from year to year (e.g., Table 8), as did geographic location (e.g., Shiloh I was closer to Suisun Marsh than High Winds or Shiloh II). The results of searcher efficiency (Se) and scavenger removal (Sr) trials also varied to some degree (Table 11).

Estimated bird mortality at Shiloh II averaged 2.5 birds/MW/year, which was 79% greater than the 1.4 birds/MW/year average for High Winds and 68% less than the 7.8 birds/MW/year average for Shiloh I (Table 11). However, this variability is not great when the absolute numbers of birds killed per species per year is examined. Note that the year 1 and year 2 estimates for Shiloh I were much greater than other yearly estimates. This was attributed to the effect of smaller numbers of Se and Sr trials, particularly in year 1, that indicated low searcher efficiency (Kerlinger et al. 2009b). As a result, the average Se rate for small birds and bats during three years at Shiloh I was 0.35, which were 30%-40% lower than those recorded at High Winds and Shiloh II.

When reported results were further examined, it was found that landbird mortality had the greatest effect on the Shiloh I bird mortality estimate in years 1 and 2, but most of the mortality was among common species, such as blackbirds, in proportions similar to those recorded at Shiloh II (see below). At Shiloh I, observed landbird carcasses were 4.0 per 100 searches in year 1, 3.2 per 100 searches in year 2, and 2.0 per 100 searches in year 3 (derived from data reported in Kerlinger et al. 2009b). At Shiloh II, the rate was 2.4-3.2 per 100 searches. Given that most landbird carcasses were small and relatively difficult to find, the combination of more carcasses and lower searcher efficiency rates in years 1 and 2, perhaps combined to increase annual mortality estimates. Nonetheless, mortality was mostly among common species and the absolute numbers of fatalities were not great enough to cause population impacts.

Table 11. Comparison of results of MHWRA studies

Turbine characteristics	High Winds[1]	Shiloh I[2]	Shiloh II[3]
Turbine capacity	1.8 MW	1.5 MW	2.0 MW
Turbine height	100 m	104 m	116-125 m
Search interval	15 days	7 days	7 days
Search radius	75 m	105 m	105 m
Average searcher efficiency			
Small birds	0.50	0.35	0.58
Medium birds	1.00	0.69	0.85
Large birds	1.00	1.00	0.97
Bats	0.50	0.35	0.41
Average scavenger removal			
Small birds	0.60	0.40	6.6 days (0.47)
Medium birds	0.70	0.62	8.9 days (0.64)
Large birds	0.43	0.91	13.0 days (0.93)
Bats	0.38	0.43	6.1 days (0.44)
Estimated birds/MW/year			
Year 1	1.6	12.0	1.9
Year 2	1.1	8.6	2.8
Year 3		2.8	2.8
Average	1.4	7.8	2.5
Estimated bats/MW/year			
Year 1	2.5	5.2	2.6
Year 2	1.5	5.8	3.8
Year 3		2.1	3.4
Average	2.0	4.4	3.3

[1] See Kerlinger et al. 2006b; estimates derived using Jain estimator.
[2] See Kerlinger et al. 2009b; estimates derived using Jain estimator. Note that when the three years of Shiloh I data were pooled, bird mortality was 7.0 birds/MW/year and bat mortality was 3.9 bats/MW/year (Kerlinger et al. 2009b).
[3] This report; estimates derived using Huso (2011) estimator.

In comparison, raptor fatality estimates were similar among studies, averaging 0.51 raptors/MW/year at Shiloh II (Table 7), 0.44 raptors/MW/year at Shiloh I (Kerlinger et al. 2009b), and 0.41 raptors/MW year at High Winds (Kerlinger et al. 2009b). That raptor fatality estimates between wind farms were similar indicates that the estimates are likely representative of the actual numbers killed and demonstrates that our research has yielded consistent results. Note, however, that these estimates are averages. At Shiloh II, for example, raptor mortality ranged from 0.11 raptors/MW/year in year 1 to 0.97 raptors/MW/year in year 3 (Table 7), which correlated with raptor abundance (Fig. 14).

Estimated bat mortality at Shiloh II averaged 3.3 bats/MW/year. This was 63% greater than the 2.0 bats/MW/year average at High Winds and 16% less that the 3.9 bats/MW/year average at Shiloh I (Table 10). Again, the averages in years 1 and 2 at Shiloh I were greater, but this was

likely the result of lower searcher efficiency rates. Note also that these differences amount to small absolute differences in the numbers of bats impacted.

It is noteworthy that bat mortality averaged greater than bird mortality in all years at High Winds and Shiloh II (1.3-1.4 bats for every bird), but the opposite was true at Shiloh I (0.6 bat for every bird), where the greatest estimated bat mortality was recorded (Table 10). This is explained by the greater than average landbird mortality estimated at Shiloh I, contributed by large numbers of blackbird flocks and other flocking birds that used the farm fields during winter. Also, Shiloh I's location was closer to the Suisun Marsh complex, where blackbird flocks tended to roost.

When the eight years of estimates (Table 11) were averaged, bird mortality was calculated at 4.2 birds/MW/year and bat mortality at 3.4 bats/MW/year. Nonetheless, at two of the three sites, bat mortality was found to exceed bird mortality.

It should be noted that two other MHWRA wind farms have also been studied, but not by Curry & Kerlinger. Solano Wind and Montezuma I were both studied for one year, and bird mortality was reported in a memorandum of 30 May 2012 from Point Impact Analysis to Solano County. The adjusted fatality rate for birds was 0.34 birds/MW/year at Solano Wind and 5.19 birds/MW/year at Montezuma I. When these were included, mean adjusted bird mortality in the MHWRA was 3.9 ± 1.2 birds/MW/year, slightly less than the mean reported above.

Johnson and Erickson (2011) recently reviewed 25 year-long mortality studies conducted at 23 wind-energy facilities representing 6,700 MW of installed capacity in the Columbia Plateau Ecoregion (CPE), which straddles eastern Oregon and Washington. Raptor mortality averaged 0.08 birds/MW/year, birds other than raptors averaged 2.28 birds/MW/year, and bats averaged 1.14 bats/MW/year. When compared with MHWRA studies (Tables 7 and 11), these rates were lower for raptors and bats and about the same for birds other than raptors. The authors concluded that their analysis suggested that no significant population-level effects were likely associated with wind-energy development in the CPE.

Despite the differences in mortality rates, if a similar analysis were done for the MHWRA, it would likely yield the same result: no significant population-level effects are likely associated with wind-energy development. The sections that follow explain why.

Biological significance of mortality

The mortality estimates resulting from three years of study at Shiloh II (Tables 6 and 7) indicated that about 500 bats and about 375 birds, including about 75 raptors, were killed on average by the Shiloh II turbines each year. The 95% confidence interval for the bat estimate ranged from about 360 to 750 bats per year, and overalapped with those for birds, which ranged from about 300 to about 500 (Table 6). The raptor range was from 69 to 91, but in years of high raptor abundance (e.g., year 3) mortality ranged between 130 and 175 raptors killed, while in low abundance years (e.g., year 1), mortality ranged between 16 and 20 raptors killed (Table 7).

Is the average annual loss of 350-750 bats and 300-500 birds at Shiloh II likely to cause a population decrease in any species or potentially decrease the conservation prospects of any special-status species? We examine this question below.

Birds in general

Bird mortality is distributed among dozens of species, and the species that are killed most are relatively abundant both continentally and in California.

Taking Red-winged Blackbird as an example, it had the highest mortality of any bird at Shiloh II, with likely far less than 100 birds are killed per year. These fatalities occurred throughout the year, strongly suggesting that fatalities were not limited to a resident population, but also occurred among migrants and winter visitors from elsewhere. The continental population of Red-winged Blackbird is estimated to be 190 million birds, of which 11 million (6%) are estimated to breed in California (Blancher et al. 2007). It is so abundant and considered such an agricultural pest that the Migratory Bird Treaty Act (MBTA) was amended in 1918 to allow farmers to kill Red-winged Blackbirds that threatened crops (Yasukawa and Searcy 1995). Despite this take, Red-winged Blackbird continues to be abundant, and it is unlikely that additional mortality at Shiloh II will impact even in its local abundance.

Other species with estimated fatalities likely exceeding dozens of individuals/year were Western Meadowlark (continental population of 30 million with 3% breeding in California; Blancher et al. 2007), Horned Lark (81 million, 3%), Red-tailed Hawk (2 million, 8%), and American Kestrel (4.3 million, 6%). These birds are similar to Red-winged Blackbird in that they are relatively abundant both continentally and in California and that fatalities were not limited to a resident population. Instead, birds killed were likely also migrants and winter visitors from a wide geographic area.

With respect to Red-tailed Hawk and American Kestrel, nesting within the Shiloh II project may be considered an index of the local population. However, pre-construction abundance was measured differently than post-construction, and we do not have a long enough study period of pre or post-construction data to establish clear trends. Nonetheless, kestrel nests fluctuated between four and five between 2009 and 2011, while Red-tailed Hawk nests decreased from seven to five (Table 10). It may be that increased raptor mortality in years 2 and 3 (Tables 2 and 7) depressed the local breeding population, but even unimpacted raptor populations also vary from year to year, as abundance data demonstrated (Table 8). Moreover, a study of Golden Eagle nesting in the Altamont Pass Wind Resource Area (APWRA) showed that, despite considerable mortality, a sample of 58 territories occupied by eagle pairs in 2000 were also occupied in 2005, most likely because of immigration from outside populations (Hunt and Hunt 2006). This demonstrates considerable resilience among local raptor populations.

Based on best available estimates, Erickson et al. (2005) estimated that annual bird mortality from human-caused sources (including building collisions, electrocutions, cat predation, pesticide poisoning, etc.) easily approached one billion birds in the U.S. alone, of which <0.01% was attributable to collisions with wind turbines. They also figured that human-caused mortality took approximately 5% to 10% of the U.S. landbird population each year. Of importance for

these statistics is the fact that federally funded and permitted projects, such as communication towers (both publicly and privately owned) and highways, are subject to the NEPA process prior to construction. What this means is that the millions of fatalities at these federally funded or permitted facilities have been subjected to review by federal and other wildlife agencies, which have not found those impacts to be biologically significant.

It is also noteworthy that the best wildlife management practices routinely allow harvests at or above these levels for waterfowl and gamebird populations, including some species of conservation concern. Using a common species as an example, in 2007, about 1.1 million hunters harvested 20.5 million Mourning Doves (Richkus et al. 2008). This accounts for 19% of the total population of about 110 million individuals (Blancher et al. 2007) and additive to the other human-caused mortality of Mourning Doves. Fewer than 20-25 Mourning Doves were expected to collide with Shiloh II turbines annually.

Recently, Arnold and Zink (2011) assessed the relative vulnerability of landbird populations in eastern North America to collisions with buildings and towers. Analyzing 243,103 collision records of 188 species, they found no correlation between relative collision mortality among species, which varied over four orders of magnitude, and long-term population trends. They concluded that, although million of birds are killed annually by collisions with manmade structures in North America, this source of mortality has no discernible effect on populations. Thus, the relatively small numbers of birds that collide with wind turbines, as compared to those killed by other structures, is unlikely to have a biologically significant impact on the species involved.

Population rankings of special-status birds

Special-status species require special consideration, because their populations are relatively small or decreasing markedly. Eight special-status birds were recorded in the abundance and use study (Table 9), of which two were recorded in the mortality study (Table 2). Their global (G) and state (S) populations were rated as follows (CDFG 2011):

- G/S5: Secure; common and widespread
- G/S4: Apparently secure; uncommon but not rare
- G/S3: Vulnerable; at moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors
- G/S2: Imperiled: at high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors
- G/S1: Critically imperiled: at very high risk of extinction due to extreme rarity (often five or fewer populations), very steep declines, or other factors

In general, special-status birds were relatively secure globally (G4 or above). At a state level, however, the threatened California Black Rail (not recorded in the abundance and use study, but recorded in the mortality study) was ranked S1 (critically imperilled), and the threatened Swainson's Hawk and special-concern Burrowing Owl were ranked S2 (imperiled). Six other species were ranked S3 (vulnerable; Table 12).

Table 12. Abundance and observed carcasses of special-status species recorded at Shiloh II

Special-status species	Status	Global population[1]	California population[1]	Average abundance, Shiloh II (birds/hour)[2]	Greatest monthly abundance (birds/hour)[2]	Observed carcasses, Shiloh II[3]	Observed carcasses at High Winds and Shiloh I (N)[4]
Black Rail	CA Threatened	G4	S1			2	No
Swainson's Hawk	CA Threatened	G5	S2	0.12	0.28	0	No
American White Pelican	CA Special Concern	G3	S1	0.51	1.90	0	No
Northern Harrier	CA Special Concern	G5	S3	0.54	0.92	2	Yes (2)
Burrowing Owl	CA Special Concern	G4	S2	0.02	0.15	0	No
Black Swift	CA Special Concern	G4	S2	<0.01	0.01	0	No
Loggerhead Shrike	CA Special Concern	G4	S4	0.30	0.49	1	No
Golden Eagle	CA Fully Protected	G5	S3	0.07	0.15	0	Yes (2)
White-tailed Kite	CA Fully Protected	G5	S3	0.03	0.10	0	Yes (3)
Western Red Bat	CA Special Concern	G5	S3?			6	Yes (5)

[1] From CDFG 2011
[2] See Table 9
[3] See Tables 1 and 2
[4] From Kerlinger et al. 2006b, 2009b

California Black Rail

That carcasses of two California Black Rails were found in year 1 of the study (July-August 2009) is noteworthy. One was recovered at turbine A3, close to Suisun Marsh, but the other was found at turbine D17, on the opposite side of Shiloh II. To our knowledge, these were first fatality records of this species for the MHWRA. The species is poorly known, but much of what is known about its migration has been gleaned from carcass recoveries at communication towers in the eastern U.S. (Eddleman et al. 1994). Adult California Black Rails are thought to be sedentary, but juveniles may disperse erratically (numerous citations in Eddleman et al. 1994). One of the birds recovered at Shiloh II was considered an adult, however.

Evens et al. (1991) found that the bulk of the Black Rail population in California (>80%) was confined to the northern reaches of the San Francisco Bay estuary, especially the tidal marshland of San Pablo Bay and associated rivers (~35 km distant from Shiloh II), but the species has recently been found nesting in the foothills of the Sierra Nevada[1]. Elsewhere regionally, distribution was patchy and subpopulations were small and isolated, including in Suisun Bay and the Carquinez Strait and in the Sacramento-San Joaquin River Delta (both <10 km distant from Shiloh II). A 1986 estimate of the population in San Pablo Bay was 6,111 individuals (range 3,204–8,905) (Evens et al. 1986, reported in Eddleman et al. 1994). The Black Rail's population decline and threatened status in California was the result of extensive draining and filling of marshes (Eddleman et al. 1994), as well as grazing and trampling of wet meadows and loss of water in marshes because of irrigation.

It is perhaps noteworthy that rails and allies were the group best represented among waterbird fatalities in searches. Observed carcasses at Shiloh II included four American Coots, three Soras, and two Virginia Rails, in addition to the two Black Rails, making up 11 of 24 waterbird carcasses (46%). At High Winds, rails and allies made up 9 of 10 waterbird carcasses (90%), and at Shiloh I, they made up 14 of 24 waterbird carcasses (58%). The high representation of rails and allies among waterbirds probably owes to the MHWRA's proximity to Suisun Marsh, Sacramento River, and other marshland complexes in and near San Francisco Bay.

The analysis of Arnold and Zink (2011) suggests that turbine and communication tower strikes of small numbers of individuals are unlikely to produce a discernible population effect even in a bird as scarce as the California Black Rail.

Other special-status birds

Nine special-status birds were recorded in the avian abundance and use study (Tables 9 and 12). Among them, there was a fairly strong correlation between greatest monthly and average monthly abundance and mortality (R^2 = 0.77235 and 0.78478 respectively). In other words, relatively abundant species such as Northern Harrier and Loggerhead Shrike were likelier to be killed by turbine strikes than relatively scarce species such as Burrowing Owl and Golden Eagle. An exception, however, was the relatively scarce Ferruginous Hawk.

[1] See https://www.cnr.berkeley.edu/beislab/rail/html/index.html.

Data indicated small annual losses of Northern Harrier, Ferruginous Hawk, and Loggerhead Shrike at Shiloh II. Based on measured abundance and the monthly distribution of observed carcasses, fatalities were drawn from both resident and wintering/migratory populations of the harrier, which has a continental population estimated at 400,000 birds and a California breeding population estimated at 19,000 birds (Blancher et al. 2007). Ferruginous Hawk fatalities in the MHWRA (including High Winds and Shiloh I) occurred in migration/winter, indicating that these birds were likely drawn from the continental population of 20,000 birds, not the California breeding population of 50 birds (Blancher et al. 2007). The lone Loggerhead Shrike carcass was found in early June, indicating that it was drawn from the California breeding population of 230,000 (Blancher et al. 2007), but given that it was present year-round with greatest abundance during winter months, potential for fatalities drawn from the 3.7 million continental population exists.

Other special-status species recorded in the abundance study were not recorded among fatalities, but they may occur, especially those species that numbered among fatalities at High Winds and Shiloh I. In that regard, Golden Eagle and Merlin were indicated.

Golden Eagle, a fully protected species in California, deserves special consideration given protection afforded under the Federal Bald and Golden Eagle Protection Act (BGEPA). Its continental population is estimated at 80,000 birds, of which 2,000 (2.5%) are estimated to breed in California (Blancher et al. 2007). Single Golden Eagle carcasses were recorded in searches both at High Winds and Shiloh I, plus two were recorded outside of searches at Shiloh I (Kerlinger et al. 2006b, 2009b). These data indicate the possibility of Golden Eagle fatalities at Shiloh II, but it is difficult to estimate the likely periodicity without modeling. In any event, this rate of loss appears unlikely to cause a discernible population effect, given the above-mentioned finding of Hunt and Hunt (2006) in the APWRA.

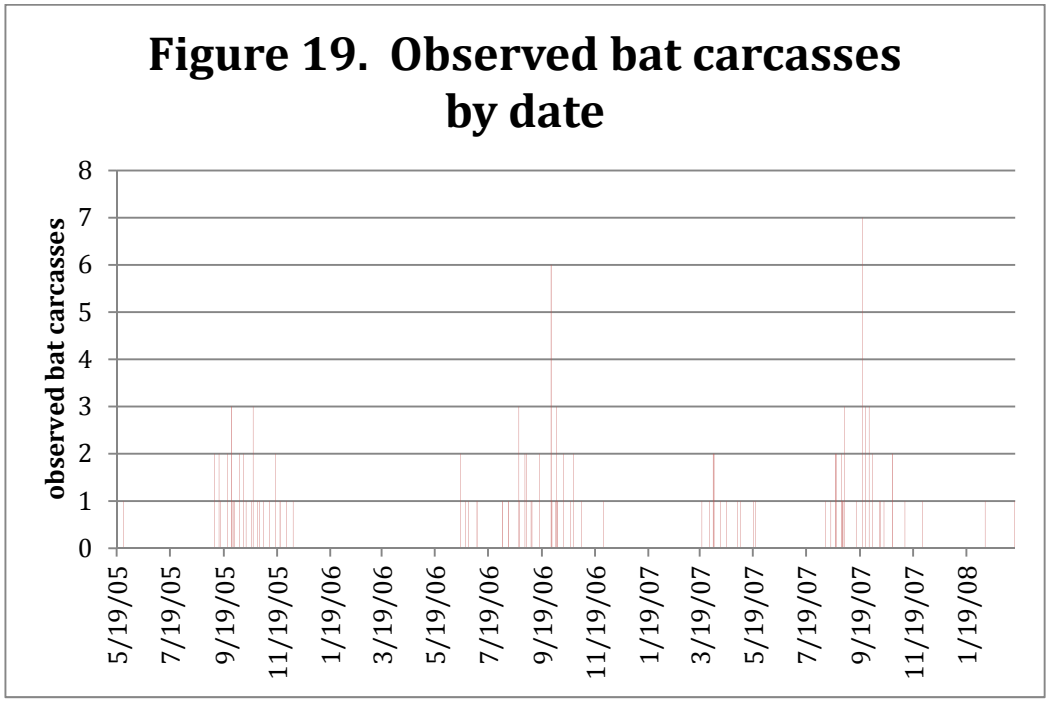
The California-threatened Swainson's Hawk also deserves special consideration, given its protected status and that it has bred within the Shiloh II footprint. That it was not recorded among fatalities at High Winds, Shiloh I, and Shiloh II would indicate less frequent mortality than Golden Eagle. Its California breeding population is estimated at 4,000 birds (Blancher et al. 2007). Given that it appears less susceptible to collision and has a larger California population, discernible population effects from collisions with Shiloh II turbines appear unlikely.

Bats

Given that bat mortality at Shiloh II was distributed among three species whereas bird mortality was distributed among dozens of species, bat mortality was found to be an order of magnitude greater at the species level than for any bird species. This may cause concern because bats are long-lived animals with small broods, demographic characteristics that make them less able to withstand additive mortality than, for example, night-migrating songbirds, which are short-lived and have large broods. Moreover, there is uncertainty regarding population numbers and trends (note CDFG's question marks under California population in Table 12).

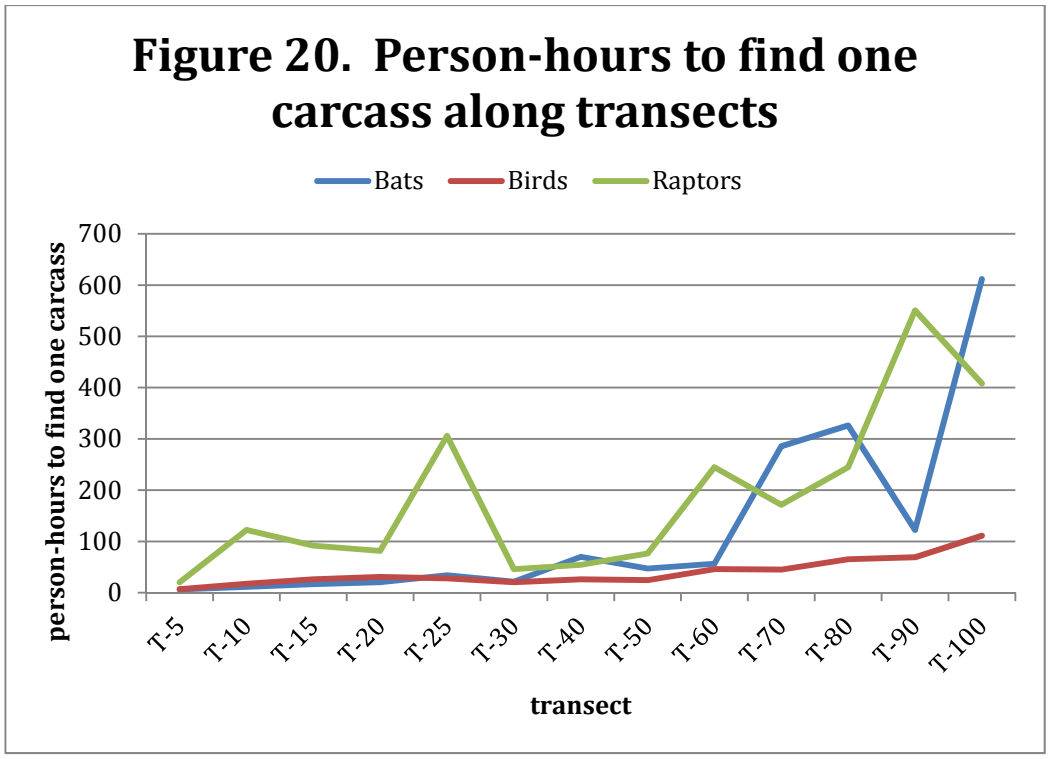
Based on the distribution of bat carcass finds by month (Fig. 5), it appeared that bats were both residents for at least a portion of the year and migrants at Shiloh II, with greatest numbers being

killed during late summer and in fall migration (or swarming). There is also a suggestion of passage in spring. Nonetheless, when carcass finds in each month of the study were examined (Fig. 19), a spring fatality "pulse" appeared not to occur every year, as no carcasses were recovered in spring 2010, and few in spring 2009. Fall fatalities were, however, more predictable, clustered mainly in September-October and suggesting migration or swarming at the project site.



Given that a majority of the bats being killed at Shiloh II were migratory, they were drawn from what must have been a large population, as roughly the same number per MW were killed for at least 8 years in the MHWRA (Table 10). Range maps available at the website of Bat Conservation International (www.batcon.org), however, show that none of the three species recorded at Shiloh II range far to the north along the Pacific coast. It is conceivable, therefore, that bats from many regions stage in the San Francisco Bay area, where insects are likely to be abundant.

When the eight years studied in the MHWRA (Table 10) were averaged, bat mortality was 3.4 bats/MW/year, which was 3% greater than the 3.3 bats/MW/year average at Shiloh II with most of the mortality among Mexican Free-tailed Bat and Hoary Bat and a smaller percentage among Western Red Bat (California Special Concern) and Silver-haired Bat.



Effort to find carcasses

At total of 4,301 field hours were invested to conduct 3,894 turbine searches at Shiloh II. Thus, it took 3-5 searchers 66.6 minutes on average to walk 3.7 km of transects in one turbine search (Fig, 3). Considering that searchers were not searching as they moved between transects and that most of the time three searchers worked together, we estimate that transects were covered at an approximate rate of 2 km/hour (~1 m every two seconds). We use this metric to estimate the time it took searchers to find carcasses along the various transects, which ranged from 31.4 m in length at 5 m from turbines to 628.3 m in length at 100 m from turbines.

Table 13. Effort to find carcasses

Tran-sect	Circumference (km)	Hours to walk transect at 2 km/hour	Hours to walk 3,894 transects	Bat carcasses found	Bird carcasses found	Raptor carcasses found	Hours to find one bat carcass	Hours to find one bird carcass	Hours to find one raptor carcass
5	0.03	0.02	61	10	9	3	6	7	20
10	0.06	0.03	122	11	7	1	11	17	122
15	0.09	0.05	184	11	7	2	17	26	92
20	0.13	0.06	245	12	8	3	20	31	82
25	0.16	0.08	306	9	11	1	34	28	306
30	0.19	0.09	367	17	18	8	22	20	46
40	0.25	0.13	489	7	19	9	70	26	54
50	0.31	0.16	612	13	25	8	47	24	76
60	0.38	0.19	734	13	16	3	56	46	245
70	0.44	0.22	856	3	19	5	285	45	171
80	0.50	0.25	979	3	15	4	326	65	245
90	0.57	0.28	1101	9	16	2	122	69	551
100	0.63	0.31	1223	2	11	3	612	111	408
	3.74	1.87	7279	120	181	52	61	40	140

On average, it took searchers 61 person-hours of effort to find one bat carcass and 40 person-hours of effort to find one bird carcass (Table 13). Among raptors, a subcategory of birds, it took 140 person-hours of effort to find one carcass (Table 13). But when average person-hours per transect was examined (Table 13, Fig. 20), the effort to find one bat or bird carcass remained below 25 person-hours out to the 30-m transect, after which the effort to find a bat carcasses diverged upward, exceeding 100 hours after the 60-m transect. The effort to find a raptor carcass first exceeded 100 hours after the 5-m transect and remained above 100 hours after the 50-m transect.

This relationship is the inverse of the fall distance/carcass density relationship presented above (Fig. 10). Together, they highlight the diminishing returns of searching farther from turbines. They also suggest that concern is unwarranted that significant bird and bat mortality goes unrecorded at wind turbines because it occurs beyond searched areas. Our data show that, while some carcasses are missed beyond 65 or 105 m, the number is minimal and this bias can be adjusted.

To look at it another way, 86% of bat carcasses, 66% of all bird carcasses, and 73% of raptor carcasses at Shiloh II were found within about 65m of the turbines. 3,120 person-hours (43% of total person-hours) were invested to search out to the 60-m transect, and searching out to the 100-m transect required another 4,159 person-hours (57% of total person-hours). Thus, the average effort to find carcasses out to the 60-m transect was 30 person-hours for bats, 24 person-hours for birds, and 82 person-hours for raptors, but the average effort to find carcasses beyond the 60-m transect increased dramatically to 245 person-hours for bats (>700%), 68 person-hours for birds (~180%), and 297 person-hours for raptors (>250%).

Conclusions

The three years of study at Shiloh II provide additional data that improve understanding of bird and bat mortality in the MHWRA. When the eight years of data from High Winds, Shiloh I, and Shiloh II were taken together, the average of yearly averages placed bird mortality at around 4.2 birds/MW/year, of which ~10% on average occurred among raptors, ~10% among waterbirds, and ~80% among landbirds. This mortality was divided among dozens of species, and the species that bore most of the mortality burden were abundant (e.g., blackbirds).

The fatalities of two California-threatened Black Rails in 2009 at Shiloh II should be considered in light of possible population-level impacts to this species. However, the origin of these birds is not known, i.e., whether they were from the California population of this poorly known species, which includes extensive San Francisco Bay estuary (including Suisun Marsh), the Sierra Nevada Foothills, or elsewhere. Mortality at Shiloh II was the likely result of a dispersal event or migration, the frequency of which is unknown, making it difficult to gauge the effect of turbine strikes in the MHWRA on its population. However, the analysis of Arnold and Zink (2011) suggests that turbine and communication tower strikes of small numbers of individuals are unlikely to produce a discernible population effect.

Bat mortality averaged around 3.4 bats/MW/year, but in two of the three studies (High Winds and Shiloh II), bat mortality was found to exceed bird mortality by a ratio of 1.3-1.4 bats for

every bird. Unlike bird mortality, which was distributed among dozens of species, bat mortality at Shiloh II was divided among only three species, one of which (Western Red Bat) was a California Special Concern species. The cave-dwelling Mexican Free-tailed Bat could conceivably graduate to the special-status list if White-Nose Syndrome begins to affect its continental population. Silver-haired Bat was not recorded at Shiloh II, but small numbers had been recorded at High Winds and Shiloh I.

Literature cited

Arnett, E. B., M. M. P. Huso, M. R. Schirmacher, and J. P. Hayes. 2010. Altering turbine speed reduces bat mortality at wind-energy facilities. *Front Ecol Environ* 2010; doi: 10.1890/100103.

Arnold, T.W., and R.M. Zink. 2011. Collision mortality has no discernible effect on population trends of North American birds. PLoS ONE 6(9): e24708.

Blancher, P. J., K. V. Rosenberg, A. O. Panjabi, B. Altman, J. Bart, C. J. Beardmore, G. S. Butcher, D. Demarest, R. Dettmers, E. H. Dunn, W. Easton, W. C. Hunter, E. E. Iñigo-Elias, D. N. Pashley, C. J. Ralph, T. D. Rich, C. M. Rustay, J. M. Ruth, and T. C. Will. 2007. Guide to the Partners in Flight Population Estimates Database. Version: North American Landbird Conservation Plan 2004. Partners in Flight Technical Series No 5. http://www.partnersinflight.org/

Canty, A. and B. Ripley. 2010. boot: Bootstrap R (S-Plus) Functions. R package version 1.2-43.

California Department of Fish and Game (CDFG). 2007. California Wildlife: Conservatiom Challenges, California's Wildlife Action Plan. Sacramento, California. 624 pp.

California Department of Fish and Game (CDFG). 2009. State & Federally Endangered & Threatened Species of California. Sacramento, California. 12 pp.

California Department of Fish and Game (CDFG). 2011. Special Animals (898 taxa). Sacramento, California. 60 pp.

Davison, A. C. & Hinkley, D. V. 1997. Bootstrap Methods and Their Applications. Cambridge University Press, Cambridge.

Eddleman, W. R., R. E. Flores and M. Legare. 1994. Black Rail (Laterallus jamaicensis), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/123 doi:10.2173/bna.123

Evens, J., G. W. Page, L. Stenzel, and N. Warnock. 1986. Distribution, abundance, and habitat of California Black Rails in tidal marshes of Marin and Sonoma counties, California. Unpubl. Rept., PRBO Contrib. no. 336. Point Reyes Bird Observatory, Point Reyes Station, CA.

Evens, J. G., G. W. Page, S. A. Laymon, and R. W. Stallcup. 1991. Distribution, relative abundance, and status of the California Black Rail in western North America. Condor 93:952-966.

Howell, J.A., and J.E. DiDonato. 1988. Raptor nesting survey related to wind turbine siting, Montezuma Hills, Solano County, California, Spring, 1988. Prepared for Solano County Dept. of Environ. Mgt., Fairfield, CA.

Hunt G., and T. Hunt. 2006. The trend of golden eagle territory occupancy in the vicinity of the Altamont Pass Wind Resource Area: 205 survey. Pier Final Project Report, CEC-500-2006-056. 17pp.

Huso, M. M. P. 2011. An estimator of wildlife fatality from observed carcasses. Environmetrics 22: 318–329.

Johnson, G.D., and W.P. Erickson. 2011. Avian, bat and habitat cumulative impacts associated with wind energy development in the Columbia Plateau Ecoregion of eastern Washington and Oregon. Prepared by Western EcoSystems Technology, Inc., for the Klickitat County Planning Department, Goldendale, WA.

Jones and Stokes Associates. 1987. Bird abundance and movements in the Potrero Hills Wind Turbine Site, Solano County, California. Prepared for Solano County Dept. of Environ. Mgt., Fairfield, CA.

Kerlinger, P., R. Curry, and L. Culp. 2001. Avian Monitoring Study and Risk Assessment for the High Winds Wind Power Project, Solano County, California. Prepared for FPL Energy.

Kerlinger, P., R. Curry, and A. Hasch. 2005. Avian Monitoring Study and Risk Assessment for the Shiloh Wind Power Project, Solano County, California. Prepared for enXco.

Kerlinger, P., R. Curry, C. Wilkerson, L. Culp, A. Hasch, and A. Jain. 2006a. Avian Monitoring Study and Risk Assessment for the Shiloh Wind Power Project, Solano County, California. Prepared for enXco.

Kerlinger, P., R. Curry, L. Culp, A. Jain, C. Wilkerson, B. Fischer, and A. Hasch. 2006b. Post-Construction Avian and Bat Fatality Monitoring Study for the High Winds Wind Power Project, Solano County, California: Two Year Report. Prepared for High Winds, LLC, and FPL Energy.

Kerlinger, P., R. Curry, C. Wilkerson, L. Culp, A. Hasch, and A. Jain. 2009a. Avian Monitoring Study and Risk Assessment for the Shiloh III Wind Power Project, Solano County, California. Prepared for enXco.

Kerlinger, P., R. Curry, L. Culp, A. Hasch, and A. Jain. 2009b. Post-Construction Avian Monitoring Study for the Shiloh I Wind Energy Project, Solano County, California: Final Report. Prepared for Iberdrola Renewables.

Kerlinger, P., J. Gehring, W.P. Erickson, R. Curry, A. Jain, and J. Guarnaccia. 2010. Night migrant fatalities and obstruction lighting at wind turbines in North America. Wilson Journal 122(4):744-754.

Kerlinger, P., J. Guarnaccia, A. Hasch, R.C.E. Culver, R.C. Curry, L. Tran, M.J. Stewart, and D. Riser-Espinoza. 2012. Avian collision mortality at 50- and 60-m guyed towers in central California. The Condor 114(3):462-469.

Kunz T. H., E. B. Arnett, W. P. Erickson, *et al*. 2007. Ecological impacts of wind energy development on bats: questions, hypotheses, and research needs. *Front Ecol Environ* **5**: 315–24

Odum, E.P. 1971. Fundamentals of Ecology. W.B. Saunders Company, Philadelphia, PA.

Orloff, S., and A. Flannery. 1992. Wind Turbine Effects on Avian Activity, Habitat Use, and Mortality in Altamont Pass and Solano County Wind Resource Areas. Work performed by BioSystems Analysis, Inc., Tiburon, CA. Sacramento, CA: California Energy Commission.

Preston, C. R. and R. D. Beane. 2009. Red-tailed Hawk (Buteo jamaicensis), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/052 doi:10.2173/bna.52

R Development Core Team. 2010. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Richkus, K.D., K.A. Wilkins, R.V. Raftovich, S.S. Williams, and H.L. Spriggs. 2008. Migratory bird hunting and harvest during the 2006 and 2007 hunting seasons: preliminary estimates. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Branch of Harvest Surveys, Laurel, Maryland. 65pp.

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2011. *The North American Breeding Bird Survey, Results and Analysis 1966 - 2010. Version 12.07.2011 USGS Patuxent Wildlife Research Center, Laurel, MD.*

Shuford, W.D., and T. Gardali, editors. 2008. California Bird Species of Special Concern: A ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento, California.

Small, A. 1994. California Birds: Their Status and Distribution. Ibis Publishing Company, Vista, CA.

Solano County Department of Resource Management. 2012. Commercial Wind Energy Facilities, Montezuma Hills Area. Fairfield, CA. 3 pp.

Yasukawa, Ken and William A. Searcy. 1995. Red-winged Blackbird (Agelaius phoeniceus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/184 doi:10.2173/bna.184

Young, D. P., Jr., W. P. Erickson, K. Bay, S. Nomani, and W. Tidhar. 2009. Mount Storm Wind Energy Facility, Phase 1 Post-Construction Avian and Bat Monitoring, July-October 2008. Prepared for NedPower Mount Storm, LLC. Prepared by Western EcoSystems Technology, Inc., Cheyenne, Wyoming. 54pp.

Appendix A. Turbine characteristics, years studied, and searches conducted

Turbine	Hub height (m)	Lighting	Year(s) studied	# searches	Notes (referring to asterisk)
A1	68.5	No	1	52	
A3	68.5	Yes	1	52	
A8	68.5	No	1	52	
B3	68.5	Yes	1	52	
B7	68.5	Yes	1	52	
B8	68.5	Yes	1, 3*	104	Repeated in year 3 to replace A turbine affected by bio-solid application
B10	68.5	Yes	1	52	
C1	68.5	Yes	1*	7	Not searched after 6/15/09, when bio-solids applied
C2	68.5	Yes	1*, 2*	81	Replaced C1 on 8/13/09; replaced C12 on 7/9/10
C3	68.5	No	1	52	
C6	68.5	Yes	1, 2*	94	Replaced C4 on 7/7/10
C9	78	No	1	52	
C13	78	No	1	52	
C15	78	No	1	52	
C18	78	No	1	52	
C21	78	No	1	52	
D4	78	No	1	52	
D8	78	No	1, 3	104	
D11	78	No	1	52	
D13	78	Yes	1	52	
D16	68.5	Yes	1	52	
D17	78	Yes	1	52	
D20	78	No	1	52	
D24	78	No	1	52	
D26	78	Yes	1	52	
D28	78	Yes	1	52	
A4	68.5	No	2	52	
A6	68.5	Yes	2	52	
A9	68.5	Yes	2	52	
B1	68.5	No	2	52	
B4	68.5	No	2	52	
B6	68.5	Yes	2	52	
B11	68.5	No	2	52	
C1a	68.5	No	2	52	

Appendix A, continued. Turbine characteristics, years studied, and searches conducted

Turbine	Hub height (m)	Lighting	Year(s) studied	# searches	Notes (referring to asterisk)
C4	78	Yes	2*, 3	62	Not searched after 7/7/10, when bio-solids applied
C7	68.5	No	2	52	
C8	68.5	Yes	2*	42	Replaced C16 on 7/9/10
C10	68.5	Yes	2	52	
C12	78	No	2*, 3	62	Not searched after 7/9/10, when bio-solids applied
C16	78	Yes	2*, 3	62	Not searched after 7/9/10, when bio-solids applied
C19	78	No	2	52	
C20	78	Yes	2	52	
D2	78	No	2	52	
D5	78	Yes	2	52	
D7	78	Yes	2	52	
D10	78	No	2	52	
D14	78	No	2	52	
D15a	78	Yes	2	52	
D18	78	No	2	52	
D22	68.5	Yes	2	52	
D25	78	No	2	52	
D29	78	No	2	52	
B2	68.5	Yes	3	52	
B5	68.5	No	3	52	
B9	68.5	No	3	52	
B12	68.5	Yes	3	52	
C5	68.5	No	3	52	
C11	78	Yes	3	52	
C14	78	No	3	52	
C17	78	No	3	52	
C23	78	Yes	3	52	
D1	78	No	3	52	
D3	78	Yes	3	52	
D6	78	No	3	52	
D9	78	No	3	52	
D12	78	No	3	52	
D15	68.5	No	3	52	

Appendix A, continued. Turbine characteristics, years studied, and searches conducted

Turbine	Hub height (m)	Lighting	Year(s) studied	# searches	Notes (referring to asterisk)
D19	78	Yes	3	52	
D21	78	No	3	52	
D23	78	Yes	3	52	
D27	78	No	3	52	
D30	78	Yes	3	52	
A2	68.5	Yes	*	0	Not surveyed because of bio-solid application
A5	68.5	No	*	0	Not surveyed because of bio-solid application
A7	68.5	No	*	0	Not surveyed because of bio-solid application
				3894	

Appendix B, Table 1. Search rounds in year 1

Project year	Calendar year	Dates	Search days	Search type	Round #	# scheduled turbine searches	# other turbine searches
1	2009	21-23 Apr	3	Clean sweep			25
1	2009	27 April-1 May	5	Scheduled	1	25	
1	2009	4-8 May	5	Scheduled	2	25	
1	2009	11-15 May	5	Scheduled	3	25	
1	2009	18-20 May	3	Scheduled	4	25	
1	2009	26-30 May	4	Scheduled	5	25	
1	2009	1-6 Jun	5	Scheduled	6	25	
1	2009	9-11 Jun	3	Scheduled	7	25	
1	2009	15-18 Jun	4	Scheduled	8	24	
1	2009	22-24 Jun	3	Scheduled	9	24	
1	2009	30 Jun-1 Jul	3	Scheduled	10	24	
1	2009	6-8 Jul	3	Scheduled	11	24	
1	2009	13-16 Jul	3	Scheduled	12	24	
1	2009	20-22-Jul	3	Scheduled	13	24	
1	2009	27-30 Jul	4	Scheduled	14	24	
1	2009	3-7 Aug	3	Scheduled	15	24	
1	2009	7-Aug	1	Clean sweep			1
1	2009	11-14 Aug	3	Scheduled	16	24	
1	2009	18-21 Aug	3	Scheduled	17	25	
1	2009	26-28 Aug	3	Scheduled	18	25	
1	2009	31 Aug-4 Sep	5	Scheduled	19	25	
1	2009	7-12 Sep	3	Scheduled	20	25	
1	2009	14-18 Sep	3	Scheduled	21	25	
1	2009	23-25 Sep	4	Scheduled	22	25	
1	2009	28 Sep-2 Oct	3	Scheduled	23	25	
1	2009	5-9 Oct	4	Scheduled	24	25	
1	2009	12-17 Oct	3	Scheduled	25	25	
1	2009	19-23 Oct	3	Scheduled	26	25	
1	2009	26-30 Oct	3	Scheduled	27	25	
1	2009	3-6 Nov	4	Scheduled	28	25	
1	2009	11-14 Nov	4	Scheduled	29	25	
1	2009	16-19 Nov	3	Scheduled	30	25	
1	2009	23-27 Nov	3	Scheduled	31	25	
1	2009	30 Nov-4 Dec	3	Scheduled	32	25	
1	2009	7-10 Dec	4	Scheduled	33	25	
1	2009	14-19 Dec	4	Scheduled	34	25	
1	2009	21-24 Dec	4	Scheduled	35	25	
1	2009	28-30 Dec	3	Scheduled	36	25	
1	2010	4-8 Jan	4	Scheduled	37	25	
1	2010	11-15 Jan	4	Scheduled	38	25	
1	2010	19-23 Jan	5	Scheduled	39	25	
1	2010	26-29 Jan	3	Scheduled	40	25	
1	2010	2-5 Feb	4	Scheduled	41	25	
1	2010	9-12 Feb	4	Scheduled	42	25	
1	2010	16-19 Feb	3	Scheduled	43	25	
1	2010	22-25 Feb	4	Scheduled	44	25	
1	2010	1-6 Mar	4	Scheduled	45	25	

Appendix B, Table 1, continued. Search rounds in year 1

Project year	Calendar year	Dates	Search days	Search type	Round #	# scheduled turbine searches	# other turbine searches
1	2010	8-13 Mar	5	Scheduled	46	25	
1	2010	15-19 Mar	4	Scheduled	47	25	
1	2010	22-25 Mar	4	Scheduled	48	25	
1	2010	29 Mar-1 Apr	4	Scheduled	49	25	
1	2010	6-8 Apr	3	Scheduled	50	25	
1	2010	14-16 Apr	3	Scheduled	51	25	
1	2010	19-24 Apr	5	Scheduled	52	25	
			195			1291	26

Appendix B, Table 2. Carcasses found in searches in year 1

Project year	Date	ID	Species	Class	Size	Turbine	Hub	Lighting	Veg. height	Dist
Y1	5/20/09	SH2-003-09	Mexican free-tailed Bat	Bat	Bat	A8	68.5	No	short	
Y1	5/27/09	SH2-005-09	Hoary Bat	Bat	Bat	B8	68.5	Yes	short	
Y1	9/9/09	SH2-021-09	Hoary Bat	Bat	Bat	D16	68.5	Yes	short	
Y1	9/9/09	SH2-022-09	Western Red Bat	Bat	Bat	B3	68.5	Yes	short	
Y1	9/14/09	SH2-023-09	Mexican free-tailed Bat	Bat	Bat	D13	78	Yes	short	
Y1	9/14/09	SH2-024-09	Mexican free-tailed Bat	Bat	Bat	A1	68.5	No	short	
Y1	9/16/09	SH2-024-09	Mexican free-tailed Bat	Bat	Bat	A8	68.5	No	short	
Y1	9/24/09	SH2-026-09	Hoary Bat	Bat	Bat	B7	68.5	Yes	short	
Y1	9/24/09	SH2-027-09	Mexican free-tailed Bat	Bat	Bat	B7	68.5	Yes	short	
Y1	9/28/09	SH2-031-09	Mexican free-tailed Bat	Bat	Bat	D16	68.5	Yes	medium	
Y1	9/28/09	SH2-032-09	Mexican free-tailed Bat	Bat	Bat	A1	68.5	No	short	
Y1	9/28/09	SH2-033-09	Mexican free-tailed Bat	Bat	Bat	A8	68.5	No	short	
Y1	9/30/09	SH2-030-09	Mexican free-tailed Bat	Bat	Bat	D16	68.5	Yes	medium	
Y1	10/2/09	SH2-035-09	Mexican free-tailed Bat	Bat	Bat	D13	78	Yes	short	
Y1	10/7/09	SH2-35B-09	Mexican free-tailed Bat	Bat	Bat	B3	68.5	Yes	short	
Y1	10/7/09	SH2-35C-09	Mexican free-tailed Bat	Bat	Bat	B8	68.5	Yes	short	
Y1	10/12/09	SH2-036-09	Mexican free-tailed Bat	Bat	Bat	A3	68.5	Yes	short	
Y1	10/12/09	SH2-037-09	Mexican free-tailed Bat	Bat	Bat	A8	68.5	No	short	
Y1	10/15/09	SH2-038-09	Mexican free-tailed Bat	Bat	Bat	C13	78	No	short	
Y1	10/21/09	SH2-040-09	Mexican free-tailed Bat	Bat	Bat	D17	78	Yes	medium	
Y1	10/23/09	SH2-041-09	Hoary Bat	Bat	Bat	D16	68.5	Yes	medium	
Y1	10/23/09	SH2-043-09	Mexican free-tailed Bat	Bat	Bat	A1	68.5	No	short	
Y1	10/23/09	SH2-044-09	Hoary Bat	Bat	Bat	A8	68.5	No	short	
Y1	10/28/09	SH2-045-09	Mexican free-tailed Bat	Bat	Bat	D16	68.5	Yes	medium	
Y1	10/30/09	SH2-047-09	Hoary Bat	Bat	Bat	B7	68.5	Yes	short	
Y1	11/4/09	SH2-048-09	Hoary Bat	Bat	Bat	D13	78	Yes	short	
Y1	11/11/09	SH2-049-09	Mexican free-tailed Bat	Bat	Bat	A3	68.5	Yes	medium	
Y1	11/18/09	SH2-052-09	Mexican free-tailed Bat	Bat	Bat	B3	68.5	Yes	short	
Y1	11/18/09	SH2-053-09	Western Red Bat	Bat	Bat	B8	68.5	Yes	short	
Y1	11/23/09	SH2-055-09	Mexican free-tailed Bat	Bat	Bat	A3	68.5	Yes	medium	
Y1	11/30/09	SH2-056-09	Western Red Bat	Bat	Bat	B7	68.5	Yes	short	
Y1	12/8/09	SH2-060-09	Hoary Bat	Bat	Bat	B3	68.5	Yes	short	
Y1	5/11/09	SH2-001-09	Red-winged Blackbird	Landbird	S	C18	78	No	short	
Y1	5/19/09	SH2-002-09	Blackbird sp.	Landbird	S	D26	78	Yes	tall	
Y1	5/20/09	SH2-004-09	Wilson's Warbler	Landbird	S	B8	68.5	Yes	short	

Appendix B, Table 2, continued. Carcasses found in searches in year 1

Project year	Date	ID	Species	Class	Size	Turbine	Hub	Lighting	Veg. height	Dist
Y1	5/27/09	SH2-004-09	Yellow Warbler	Landbird	S	D16	68.5	Yes	short	
Y1	6/10/09	SH2-005-09	Western Meadowlark	Landbird	M	B10	68.5	Yes	short	
Y1	7/8/09	SH2-008-09	Horned Lark	Landbird	S	B10	68.5	Yes	short	
Y1	7/27/09	SH2-013-09	Mourning Dove	Landbird	M	D16	68.5	Yes	medium	
Y1	9/25/09	SH2-025-09	Western Meadowlark	Landbird	M	D24	78	No	short	
Y1	9/25/09	SH2-028-09	Western Flycatcher	Landbird	S	C13	78	No	short	
Y1	9/25/09	SH2-029-09	Western Tanager	Landbird	S	D17	78	Yes	short	
Y1	11/16/09	SH2-050-09	Brewer's Blackbird	Landbird	S	D13	78	Yes	short	
Y1	12/2/09	SH2-057-09	Varied Thrush	Landbird	M	C21	78	No	short	
Y1	12/4/09	SH2-058-09	Horned Lark	Landbird	S	D11	78	No	short	
Y1	12/4/09	SH2-059-09	Western Meadowlark	Landbird	M	D13	78	Yes	tall	
Y1	12/18/09	SH2-063-09	Western Meadowlark	Landbird	M	D16	68.5	Yes	medium	
Y1	12/28/09	SH2-064-09	Red-winged Blackbird	Landbird	S	D17	78	Yes	medium	
Y1	1/8/10	SH2-065-10	Western Meadowlark	Landbird	M	B10	68.5	Yes	short	
Y1	1/22/10	SH2-066-10	European Starling	Landbird	S	B8	68.5	Yes	short	
Y1	1/28/10	SH2-067-10	Western Meadowlark	Landbird	M	B3	68.5	Yes	short	
Y1	1/28/10	SH2-068-10	Western Meadowlark	Landbird	M	B3	68.5	Yes	short	
Y1	1/29/10	SH2-070-10	Red-winged Blackbird	Landbird	S	C18	78	No	short	
Y1	1/29/10	SH2-069-10	Rock Pigeon	Landbird	M	C21	78	No	short	
Y1	2/1/10	SH2-071-10	Mourning Dove	Landbird	M	D17	78	Yes	short	
Y1	2/16/10	SH2-072-10	Red-winged Blackbird	Landbird	S	B10	68.5	Yes	short	
Y1	2/25/10	SH2-074-10	Mourning Dove	Landbird	M	B3	68.5	Yes	short	
Y1	3/10/10	SH2-075-10	Horned Lark	Landbird	S	B8	68.5	Yes	short	
Y1	3/10/10	SH2-076-10	Western Meadowlark	Landbird	M	B8	68.5	Yes	short	
Y1	4/6/10	SH2-077-10	European Starling	Landbird	S	B8	68.5	Yes	short	
Y1	4/6/10	SH2-078-10	Tree Swallow	Landbird	S	A1	68.5	No	medium	
Y1	4/8/10	SH2-080-10	Brewer's Blackbird	Landbird	S	D28	78	Yes	tall	
Y1	4/8/10	SH2-079-10	Red-winged Blackbird	Landbird	S	D28	78	Yes	tall	
Y1	7/21/09	SH2-009-09	Red-tailed Hawk	Raptor	L	B3	68.5	Yes	short	
Y1	7/30/09	SH2-015-09	American Kestrel	Raptor	M	C3	68.5	No	medium	
Y1	11/18/09	SH2-051-09	Red-tailed Hawk	Raptor	L	A8	68.5	No	medium	
Y1	11/23/09	SH2-054-09	Red-tailed Hawk	Raptor	L	D16	68.5	Yes	short	
Y1	6/2/09	SH2-005-09	Grebe sp.	Waterbird	M	B7	68.5	Yes	short	
Y1	6/24/09	SH2-006-09	Mallard	Waterbird	L	D4	78	No	short	
Y1	7/2/09	SH2-007-09	Mallard	Waterbird	L	D20	78	No	medium	

Appendix B, Table 2, continued. Carcasses found in searches in year 1

Project year	Date	ID	Species	Class	Size	Turbine	Hub	Lighting	Veg. height	Dist
Y1	7/29/09	SH2-014-09	Dunlin	Waterbird	S	B8	68.5	Yes	short	
Y1	7/30/09	SH2-016-09	California Black Rail	Waterbird	S	D17	78	Yes	medium	
Y1	8/21/09	SH2-017-09	California Black Rail	Waterbird	S	A3	68.5	Yes	medium	
Y1	9/2/09	SH2-019-09	Mallard	Waterbird	L	D28	78	Yes	short	
Y1	10/28/09	SH2-046-09	Sora	Waterbird	S	D24	78	No	short	
Y1	12/8/09	SH2-061-09	Long-billed Curlew	Waterbird	M	D11	78	No	short	

Appendix B, Table 3. Carcasses found outside of searches in year 1

Project year	Date	ID	Species	Class	Turbine	Dist_(m)	Notes
Y1	4/22/09		Horned Lark	Landbird	D28	30	Clean sweep survey
Y1	4/22/09		Warbling Vireo	Landbird	C15	39	Clean sweep survey
Y1	4/22/09		Hoary Bat	Bat	C18	11	Clean sweep survey
Y1	4/23/09		Hoary Bat	Bat	D20	21	Clean sweep survey
Y1	7/14/09		Mallard	Waterbird	A2	10	Incidental
Y1	10/2/09	SH2-034-09	Mexican Free-tailed bat	Bat	D19	42	Incidental
Y1	12/9/09	SH2-062-09	American Kestrel	Raptor	B11		Incidental
Y1	2/23/10	SH2-073-10	Western Meadowlark	Landbird	D13	106	Incidental

Appendix C, Table 1. Search rounds in year 2

Project year	Calendar year	Dates	Search days	Search type	Round #	# scheduled turbine searches	# other turbine searches
2	2010	27-30 Apr	4	Clean sweep			25
2	2010	4-6 May	3	Scheduled	1	25	
2	2010	11-13 May	3	Scheduled	2	25	
2	2010	18-22 May	4	Scheduled	3	25	
2	2010	24-29 May	4	Scheduled	4	25	
2	2010	31 May-5 Jun	5	Scheduled	5	25	
2	2010	7-11 Jun	5	Scheduled	6	25	
2	2010	16-19 Jun	4	Scheduled	7	25	
2	2010	22-25 Jun	4	Scheduled	8	25	
2	2010	28 Jun-2 Jul	4	Scheduled	9	25	
2	2010	5-9 Jul	5	Scheduled	10	25	
2	2010	12-14 Jul	3	Scheduled	11	25	
2	2010	21-23 Jul	3	Scheduled	12	25	
2	2010	26-29 Jul	4	Scheduled	13	25	
2	2010	4-6 Aug	3	Scheduled	14	25	
2	2010	10-13 Aug	4	Scheduled	15	25	
2	2010	18-20 Aug	3	Scheduled	16	25	
2	2010	24-26 Aug	3	Scheduled	17	25	
2	2010	30 Aug-2 Sep	4	Scheduled	18	25	
2	2010	6-9 Sep	4	Scheduled	19	25	
2	2010	12-17 Sep	4	Scheduled	20	25	
2	2010	21-24 Sep	4	Scheduled	21	25	
2	2010	27-30 Sep	4	Scheduled	22	25	
2	2010	4-7 Oct	4	Scheduled	23	25	
2	2010	12-15 Oct	3	Scheduled	24	25	
2	2010	19-22 Oct	4	Scheduled	25	25	
2	2010	26-28 Oct	3	Scheduled	26	25	
2	2010	1-4 Nov	3	Scheduled	27	25	
2	2010	8-11 Nov	4	Scheduled	28	25	
2	2010	16-18 Nov	3	Scheduled	29	25	
2	2010	22-26 Nov	4	Scheduled	30	25	
2	2010	29 Nov-3 Dec	4	Scheduled	31	25	
2	2010	6-10 Dec	4	Scheduled	32	25	
2	2010	13-18 Dec	4	Scheduled	33	25	
2	2010	20-23 Dec	4	Scheduled	34	25	
2	2010	27-31 Dec	4	Scheduled	35	25	
2	2011	4-7 Jan	4	Scheduled	36	25	
2	2011	10-13 Jan	4	Scheduled	37	25	
2	2011	19-21 Jan	3	Scheduled	38	25	
2	2011	26-29 Jan	4	Scheduled	39	25	
2	2011	31 Jan-4 Feb	4	Scheduled	40	25	
2	2011	8-10 Feb	3	Scheduled	41	25	
2	2011	14-18 Feb	4	Scheduled	42	25	
2	2011	22-24 Feb	3	Scheduled	43	25	
2	2011	28 Feb-4 Mar	4	Scheduled	44	25	
2	2011	5-9 Mar	4	Scheduled	45	25	
2	2011	15-18 Mar	4	Scheduled	46	25	
2	2011	21-25 Mar	3	Scheduled	47	25	

Appendix C, Table 1, continued. Search rounds in year 2

Project year	Calendar year	Dates	Search days	Search type	Round #	# scheduled turbine searches	# other turbine searches
2	2011	28-31 Mar	4	Scheduled	48	25	
2	2011	4-7 Apr	4	Scheduled	49	25	
2	2011	11-14 Apr	4	Scheduled	50	25	
2	2011	19-22 Apr	4	Scheduled	51	25	
2	2011	26-29 Apr	4	Scheduled	52	25	
			200			1300	25

Appendix C, Table 2. Carcasses found in searches in year 2

Project year	Date	ID	Species	Class	Size	Turbine	Hub	Lighting	Veg. height	Distance (m)
Y2	6/18/10	SH2Y2-025-10	Mexican free-tailed Bat	Bat	Bat	C12	78	No	medium	53
Y2	6/18/10	SH2Y2-026-10	Hoary Bat	Bat	Bat	C16	78	Yes	medium	64
Y2	6/24/10	SH2Y2-028-10	Hoary Bat	Bat	Bat	C10	68.5	Yes	medium	46
Y2	6/27/10	SH2Y2-027-10	Mexican free-tailed Bat	Bat	Bat	A4	68.5	No	medium	13
Y2	7/7/10	SH2Y2-030-10	Hoary Bat	Bat	Bat	C1A	68.5	No	medium	2
Y2	8/5/10	SH2Y2-031B-10	Mexican free-tailed Bat	Bat	Bat	A4	68.5	No	medium	10
Y2	8/12/10	SH2Y2-032-10	Hoary Bat	Bat	Bat	C1A	68.5	No	medium	57
Y2	8/24/10	SH2Y2-036-10	Mexican free-tailed Bat	Bat	Bat	A6	68.5	Yes	medium	60
Y2	8/24/10	SH2Y2-037-10	Mexican free-tailed Bat	Bat	Bat	A6	68.5	Yes	medium	7
Y2	8/24/10	SH2Y2-038-10	Hoary Bat	Bat	Bat	B1	68.5	No	short	10
Y2	8/25/10	SH2Y2-039-10	Western Red Bat	Bat	Bat	C10	68.5	Yes	short	59
Y2	8/31/10	SH2Y2-042-10	Hoary Bat	Bat	Bat	C10	68.5	Yes	short	32
Y2	8/31/10	SH2Y2-044-10	Hoary Bat	Bat	Bat	C10	68.5	Yes	medium	100
Y2	9/2/10	SH2Y2-046-10	Hoary Bat	Bat	Bat	D22	68.5	Yes	short	12
Y2	9/2/10	SH2Y2-047-10	Hoary Bat	Bat	Bat	D22	68.5	Yes	short	50
Y2	9/7/10	SH2Y2-052-10	Mexican free-tailed Bat	Bat	Bat	C19	78	No	medium	18
Y2	9/8/10	SH2Y2-053-10	Mexican free-tailed Bat	Bat	Bat	A6	68.5	Yes	medium	41
Y2	9/17/10	SH2Y2-055-10	Hoary Bat	Bat	Bat	C6	68.5	Yes	short	16
Y2	9/17/10	SH2Y2-056-10	Mexican free-tailed Bat	Bat	Bat	C6	68.5	Yes	short	57
Y2	9/30/10	SH2Y2-058-10	Hoary Bat	Bat	Bat	B11	68.5	No	short	33
Y2	9/30/10	SH2Y2-060-10	Western Red Bat	Bat	Bat	B1	68.5	No	short	36
Y2	9/30/10	SH2Y2-061-10	Hoary Bat	Bat	Bat	B1	68.5	No	short	86
Y2	9/30/10	SH2Y2-062-10	Mexican free-tailed Bat	Bat	Bat	B1	68.5	No	short	82
Y2	9/30/10	SH2Y2-063-10	Mexican free-tailed Bat	Bat	Bat	A6	68.5	Yes	medium	2
Y2	9/30/10	SH2Y2-064-10	Mexican free-tailed Bat	Bat	Bat	A6	68.5	Yes	medium	19
Y2	10/1/10	SH2Y2-065-10	Hoary Bat	Bat	Bat	C7	68.5	No	short	19
Y2	10/5/10	SH2Y2-069-10	Mexican free-tailed Bat	Bat	Bat	B1	68.5	No	short	30
Y2	10/6/10	SH2Y2-069B-10	Hoary Bat	Bat	Bat	C7	68.5	No	short	51
Y2	10/6/10	SH2Y2-070-10	Mexican free-tailed Bat	Bat	Bat	C6	68.5	Yes	short	82
Y2	10/6/10	SH2Y2-071-10	Mexican free-tailed Bat	Bat	Bat	C6	68.5	Yes	short	28
Y2	10/7/10	SH2Y2-072-10	Mexican free-tailed Bat	Bat	Bat	C20	78	Yes	medium	4
Y2	10/14/10	SH2Y2-073-10	Hoary Bat	Bat	Bat	B6	68.5	Yes	short	25
Y2	10/14/10	SH2Y2-075B-10	Mexican free-tailed Bat	Bat	Bat	C10	68.5	Yes	short	58
Y2	10/22/10	SH2Y2-082-10	Mexican free-tailed Bat	Bat	Bat	A4	68.5	No	medium	49

Appendix C, Table 2, continued. Carcasses found in searches in year 2

Project year	Date	ID	Species	Class	Size	Turbine	Hub	Lighting	Veg. height	Distance (m)
Y2	10/26/10	SH2Y2-083-10	Mexican free-tailed Bat	Bat	Bat	C6	68.5	Yes	short	57
Y2	10/26/10	SH2Y2-084-10	Mexican free-tailed Bat	Bat	Bat	C6	68.5	Yes	short	27
Y2	11/4/10	SH2Y2-092-10	Mexican free-tailed Bat	Bat	Bat	B11	68.5	No	short	52
Y2	11/29/10	SH2Y2-093-10	Western Red Bat	Bat	Bat	D29	78	No	short	12
Y2	3/22/11	SH2Y2-111-11	Hoary Bat	Bat	Bat	C1A	68.5	No	short	84
Y2	3/31/11	SH2Y2-112-11	Mexican free-tailed Bat	Bat	Bat	D5	78	Yes	medium	3
Y2	4/4/11	SH2Y2-114-11	Hoary Bat	Bat	Bat	B6	68.5	Yes	short	16
Y2	4/4/11	SH2Y2-115-11	Mexican free-tailed Bat	Bat	Bat	B11	68.5	No	short	88
Y2	4/5/11	SH2Y2-117-11	Mexican free-tailed Bat	Bat	Bat	C1A	68.5	No	short	1
Y2	4/5/11	SH2Y2-118-11	Hoary Bat	Bat	Bat	C10	68.5	Yes	short	34
Y2	4/12/11	SH2Y2-120-11	Mexican free-tailed Bat	Bat	Bat	C7	68.5	No	medium	10
Y2	4/19/11	SH2Y2-121A-11	Hoary Bat	Bat	Bat	C2	68.5	Yes	medium	11
Y2	5/4/10	SH2Y2-002-10	Mourning Dove	Landbird	M	C1A	68.5	No	tall	27
Y2	5/4/10	SH2Y2-001-10	Western Meadowlark	Landbird	M	B1	68.5	No	short	67
Y2	5/21/10	SH2Y2-008-10	Wilson's Warbler	Landbird	S	B6	68.5	Yes	short	15
Y2	5/24/10	SH2Y2-009-10	Western Meadowlark	Landbird	M	C16	78	Yes	short	99
Y2	6/1/10	SH2Y2-012-10	Townsend's Warbler	Landbird	S	D22	68.5	Yes	medium	45
Y2	6/2/10	SH2Y2-013-10	Black-throated Gray Warbler	Landbird	S	B6	68.5	Yes	short	65
Y2	6/2/10	SH2Y2-014-10	Horned Lark	Landbird	S	B6	68.5	Yes	short	50
Y2	6/2/10	SH2Y2-015-10	Horned Lark	Landbird	S	B6	68.5	Yes	short	52
Y2	6/8/10	SH2Y2-017-10	Horned Lark	Landbird	S	D25	78	No	medium	86
Y2	6/8/10	SH2Y2-018-10	Red-winged Blackbird	Landbird	S	A4	68.5	No	medium	71
Y2	6/9/10	SH2Y2-020-10	Cliff Swallow	Landbird	S	B11	68.5	No	short	10
Y2	6/9/10	SH2Y2-021-10	Cliff Swallow	Landbird	S	B11	68.5	No	short	29
Y2	6/9/10	SH2Y2-022-10	Horned Lark	Landbird	S	B11	68.5	No	short	8
Y2	6/9/10	SH2Y2-019-10	Western Tanager	Landbird	S	B11	68.5	No	short	83
Y2	6/17/10	SH2Y2-023-10	Brewer's Blackbird	Landbird	S	A4	68.5	No	medium	25
Y2	6/17/10	SH2Y2-024-10	Cliff Swallow	Landbird	S	B11	68.5	No	short	47
Y2	6/28/10	SH2Y2-029-10	Horned Lark	Landbird	S	B1	68.5	No	short	10
Y2	8/18/10	SH2Y2-033-10	Bullock's Oriole	Landbird	S	A4	68.5	No	medium	105
Y2	8/30/10	SH2Y2-041-10	Western Meadowlark	Landbird	M	B11	68.5	No	short	86
Y2	9/2/10	SH2Y2-048-10	Orange-crowned Warbler	Landbird	S	D22	68.5	Yes	short	36
Y2	9/2/10	SH2Y2-045-10	Tree Swallow	Landbird	S	D2	78	No	medium	63

Appendix C, Table 2, continued. Carcasses found in searches in year 2

Project year	Date	ID	Species	Class	Size	Turbine	Hub	Lighting	Veg. height	Distance (m)
Y2	9/6/10	SH2Y2-050-10	Red-winged Blackbird	Landbird	S	C6	68.5	Yes	short	31
Y2	10/1/10	SH2Y2-066-10	Western Meadowlark	Landbird	M	C8	68.5	Yes	short	71
Y2	10/22/10	SH2Y2-079-10	Ring-necked Pheasant	Landbird	L	D25	78	No	short	82
Y2	10/22/10	SH2Y2-077-10	Western Meadowlark	Landbird	M	D22	68.5	Yes	short	77
Y2	11/4/10	SH2Y2-087-10	Brewer's Blackbird	Landbird	S	D29	78	No	short	22
Y2	11/4/10	SH2Y2-090-10	American Goldfinch	Landbird	S	A9	68.5	Yes	short	27
Y2	11/4/10	SH2Y2-088-10	Red-winged Blackbird	Landbird	S	D29	78	No	short	30
Y2	11/4/10	SH2Y2-089-10	Red-winged Blackbird	Landbird	S	D29	78	No	short	60
Y2	11/4/10	SH2Y2-091-10	Tree Swallow	Landbird	S	B1	68.5	No	short	42
Y2	12/2/10	SH2Y2-094-10	Yellow-rumped Warbler	Landbird	S	C7	68.5	No	short	50
Y2	12/6/10	SH2Y2-094B-10	Red-winged Blackbird	Landbird	S	D25	78	No	short	53
Y2	1/6/11	SH2Y2-098-11	Savannah Sparrow	Landbird	S	D22	68.5	Yes	short	95
Y2	1/12/11	SH2Y2-101-11	Western Meadowlark	Landbird	M	A6	68.5	Yes	medium	66
Y2	1/19/11	SH2Y2-102-11	Red-winged Blackbird	Landbird	S	D2	78	No	short	50
Y2	2/1/11	SH2Y2-104-11	Red-winged Blackbird	Landbird	S	B1	68.5	No	short	30
Y2	2/10/11	SH2Y2-106-11	House Finch	Landbird	S	D25	78	No	short	37
Y2	3/16/11	SH2Y2-109-11	Western Meadowlark	Landbird	M	D22	68.5	Yes	short	54
Y2	3/21/11	SH2Y2-110-11	Savannah Sparrow	Landbird	S	D10	78	No	short	5
Y2	4/4/11	SH2Y2-116-11	Western Meadowlark	Landbird	M	B6	68.5	Yes	short	69
Y2	4/12/11	SH2Y2-119-11	Tree Swallow	Landbird	S	C6	68.5	Yes	short	25
Y2	4/14/11	SH2Y2-121-11	Mourning Dove	Landbird	M	A4	68.5	No	short	65
Y2	6/3/10	SH2Y2-016-10	American Kestrel	Raptor	M	C10	68.5	Yes	medium	28
Y2	8/18/10	SH2Y2-035-10	Red-tailed Hawk	Raptor	L	B4	68.5	No	short	94
Y2	8/26/10	SH2Y2-040-10	American Kestrel	Raptor	M	D15A	78	Yes	medium	67
Y2	9/23/10	SH2Y2-057-10	American Kestrel	Raptor	M	B4	68.5	No	short	6
Y2	9/30/10	SH2Y2-059-10	American Kestrel	Raptor	M	B4	68.5	No	short	54
Y2	10/14/10	SH2Y2-075-10	American Kestrel	Raptor	M	C8	68.5	Yes	short	90
Y2	10/15/10	SH2Y2-076-10	Red-tailed Hawk	Raptor	L	D10	78	No	medium	6
Y2	10/22/10	SH2Y2-080-10	Turkey Vulture	Raptor	L	D25	78	No	short	58
Y2	10/22/10	SH2Y2-081-10	Turkey Vulture	Raptor	L	D25	78	No	short	39
Y2	2/10/11	SH2Y2-103-11	Barn Owl	Raptor	M	D25	78	No	short	34
Y2	2/10/11	SH2Y2-105-11	Red-tailed Hawk	Raptor	L	D15A	78	Yes	short	50
Y2	2/15/11	SH2Y2-107-11	Northern Harrier	Raptor	L	C8	68.5	Yes	short	39
Y2	3/3/11	SH2Y2-108-11	Red-tailed Hawk	Raptor	L	B4	68.5	No	short	47

Appendix C, Table 2, continued. Carcasses found in searches in year 2

Project year	Date	ID	Species	Class	Size	Turbine	Hub	Lighting	Veg. height	Distance (m)
Y2	4/4/11	SH2Y2-113-11	Red-tailed Hawk	Raptor	L	B4	68.5	No	short	35
Y2	4/10/11	SH2Y2-118A-11	Red-tailed Hawk	Raptor	L	C16	78	Yes	tall	20
Y2	5/26/10	SH2Y2-011-10	Mallard	Waterbird	L	C7	68.5	No	short	23
Y2	7/22/10	SH2Y2-031A-10	Western Grebe	Waterbird	L	C2	68.5	Yes	medium	100
Y2	8/18/10	SH2Y2-034-10	Cinnamon Teal	Waterbird	M	A4	68.5	No	medium	51
Y2	8/31/10	SH2Y2-043-10	Virginia Rail	Waterbird	M	C19	78	No	medium	99
Y2	12/6/10	SH2Y2-095-10	American Coot	Waterbird	M	A9	68.5	Yes	medium	35
Y2	12/15/10	SH2Y2-096-10	Sora	Waterbird	S	C2	68.5	Yes	short	30
Y2	1/10/11	SH2Y2-100-11	Greater White-fronted Goose	Waterbird	L	D2	78	No	short	98

Appendix C, Table 3. Carcasses found outside of searches in year 2

Project year	Date	ID	Species	Class	Turbine	Dist_(m)	Notes
Y2	5/4/10	SH2Y2-005A-10	Savannah Sparrow	Landbird			Incidental
Y2	5/4/10	SH2Y2-006A-10	Savannah Sparrow	Landbird			Incidental
Y2	5/4/10	SH2Y2-005B-10	Warbling Vireo	Landbird	D10		Incidental
Y2	5/11/10	SH2Y2-006B-10	Swainson's Thrush	Landbird	B11	65	Incidental
Y2	5/11/10	SH2Y2-007-10	Swainson's Thrush	Landbird	C7	62	Incidental
Y2	5/26/10	SH2Y2-010-10	Horned Lark	Landbird	B1	50	Incidental
Y2	9/27/10	SH2Y2-067-10	Turkey Vulture	Raptor	B3	20	Incidental
Y2	9/27/10	SH2Y2-068-10	Turkey Vulture	Raptor	B3	40	Incidental
Y2	10/14/10	SH2Y2-074-10	Mexican Free-tailed bat	Bat	B5	58	Incidental
Y2	10/19/10	SH2Y2-AB1-10	Barn Owl	Raptor	C17	41	Incidental
Y2	12/30/10	SH2Y2-097-10	American Kestrel	Raptor	C11	3	Incidental
Y2	2/7/11	SH2Y2-099-11	American Kestrel	Raptor	C23	0	Incidental
Y2	4/10/11	SH2Y2-118B-11	Red-tailed Hawk	Raptor	A2	34	Incidental

Appendix D, Table 1. Search rounds in year 3

Project year	Calendar year	Dates	Search days	Search type	Round #	# scheduled turbine searches	# other turbine searches
3	2011	2-6 May	5	Clean sweep			25
3	2011	2-6 May	5	Scheduled	1	25	
3	2011	11-15 May	5	Scheduled	2	25	
3	2011	16-20 May	4	Scheduled	3	25	
3	2011	23-26 May	4	Scheduled	4	25	
3	2011	31 May-3 Jun	4	Scheduled	5	25	
3	2011	6-10 Jun	5	Scheduled	6	25	
3	2011	13-15 Jun	3	Scheduled	7	25	
3	2011	20-24 Jun	4	Scheduled	8	25	
3	2011	27-29 Jun	3	Scheduled	9	25	
3	2011	5-8 Jul	4	Scheduled	10	25	
3	2011	11-14 Jul	4	Scheduled	11	25	
3	2011	18-21 Jul	4	Scheduled	12	25	
3	2011	25-28 Jul	4	Scheduled	13	25	
3	2011	1-3 Aug	3	Scheduled	14	25	
3	2011	8-11 Aug	4	Scheduled	15	25	
3	2011	15-18 Aug	4	Scheduled	16	25	
3	2011	22-26 Aug	4	Scheduled	17	25	
3	2011	29 Aug-2 Sep	4	Scheduled	18	25	
3	2011	5-9 Sep	4	Scheduled	19	25	
3	2011	13-16 Sep	4	Scheduled	20	25	
3	2011	19-22 Sep	4	Scheduled	21	25	
3	2011	26-30 Sep	4	Scheduled	22	25	
3	2011	3-6 Oct	4	Scheduled	23	25	
3	2011	11-14 Oct	4	Scheduled	24	25	
3	2011	17-21 Oct	4	Scheduled	25	25	
3	2011	24-29 Oct	4	Scheduled	26	25	
3	2011	1-4 Nov	4	Scheduled	27	25	
3	2011	7-10 Nov	4	Scheduled	28	25	
3	2011	14-17 Nov	4	Scheduled	29	25	
3	2011	21-23 Nov	3	Scheduled	30	25	
3	2011	25-30 Nov	4	Scheduled	31	25	
3	2011	5-7 Dec	3	Scheduled	32	25	
3	2011	12-15 Dec	4	Scheduled	33	25	
3	2011	19-21 Dec	3	Scheduled	34	25	
3	2011	27-30 Dec	4	Scheduled	35	25	
3	2012	2-5 Jan	4	Scheduled	36	25	
3	2012	9-12 Jan	4	Scheduled	37	25	
3	2012	16-19 Jan	4	Scheduled	38	25	
3	2012	23-27 Jan	4	Scheduled	39	25	
3	2012	30 Jan-2 Feb	4	Scheduled	40	25	
3	2012	5-8 Feb	3	Scheduled	41	25	
3	2012	13-17 Feb	4	Scheduled	42	25	
3	2012	20-22 Feb	3	Scheduled	43	25	
3	2012	27-29 Feb	3	Scheduled	44	25	
3	2012	5-9 Mar	4	Scheduled	45	25	
3	2012	12-16 Mar	4	Scheduled	46	25	
3	2012	19-22 Mar	4	Scheduled	47	25	

Appendix D, Table 1, continued. Search rounds in year 3

Project year	Calendar year	Dates	Search days	Search type	Round #	# scheduled turbine searches	# other turbine searches
3	2012	26-30 Mar	4	Scheduled	48	25	
3	2012	2-5 Apr	4	Scheduled	49	25	
3	2012	9-13 Apr	5	Scheduled	50	25	
3	2012	16-20 Apr	4	Scheduled	51	25	
3	2012	23-26 Apr	4	Scheduled	52	25	
			208			1300	25

Appendix D, Table 2. Carcasses found in searches in year 3

Project year	Date	ID	Species	Class	Size	Turbine	Hub	Lighting	Veg. height	Distance (m)
Y3	5/2/11	SH2Y3-001-11	Hoary Bat	Bat	Bat	B9	68.5	No	short	21
Y3	5/5/11	SH2Y3-004-11	Mexican free-tailed Bat	Bat	Bat	D30	78	Yes	short	21
Y3	5/20/11	SH2Y3-011-11	Hoary Bat	Bat	Bat	B9	68.5	No	short	20
Y3	5/23/11	SH2Y3-012-11	Hoary Bat	Bat	Bat	C17	78	No	medium	94
Y3	8/11/11	SH2Y3-025-11	Hoary Bat	Bat	Bat	C23	78	Yes	short	8
Y3	8/17/11	SH2Y3-031-11	Hoary Bat	Bat	Bat	C23	78	Yes	short	25
Y3	8/22/11	SH2Y3-032-11	Hoary Bat	Bat	Bat	B2	68.5	Yes	short	50
Y3	8/22/11	SH2Y3-033-11	Hoary Bat	Bat	Bat	B2	68.5	Yes	short	30
Y3	8/23/11	SH2Y3-035-11	Hoary Bat	Bat	Bat	C5	68.5	No	short	49
Y3	8/23/11	SH2Y3-036-11	Hoary Bat	Bat	Bat	C11	78	Yes	short	50
Y3	8/29/11	SH2Y3-038-11	Hoary Bat	Bat	Bat	B9	68.5	No	short	57
Y3	8/29/11	SH2Y3-039-11	Hoary Bat	Bat	Bat	B9	68.5	No	short	39
Y3	8/30/11	SH2Y3-040-11	Hoary Bat	Bat	Bat	C5	68.5	No	short	6
Y3	8/31/11	SH2Y3-041-11	Hoary Bat	Bat	Bat	D3	78	Yes	short	32
Y3	9/2/11	SH2Y3-042-11	Hoary Bat	Bat	Bat	B2	68.5	Yes	short	15
Y3	9/2/11	SH2Y3-043-11	Hoary Bat	Bat	Bat	B2	68.5	Yes	short	29
Y3	9/2/11	SH2Y3-044-11	Hoary Bat	Bat	Bat	B2	68.5	Yes	short	46
Y3	9/15/11	SH2Y3-046-11	Mexican free-tailed Bat	Bat	Bat	D15	68.5	No	short	41
Y3	9/22/11	SH2Y3-048-11	Hoary Bat	Bat	Bat	B8	68.5	Yes	short	86
Y3	9/22/11	SH2Y3-049-11	Hoary Bat	Bat	Bat	B8	68.5	Yes	short	67
Y3	9/22/11	SH2Y3-050-11	Mexican free-tailed Bat	Bat	Bat	B8	68.5	Yes	short	61
Y3	9/22/11	SH2Y3-051-11	Hoary Bat	Bat	Bat	B8	68.5	Yes	short	61
Y3	9/22/11	SH2Y3-052-11	Mexican free-tailed Bat	Bat	Bat	C5	68.5	No	short	92
Y3	9/22/11	SH2Y3-053-11	Hoary Bat	Bat	Bat	C11	78	Yes	short	22
Y3	9/22/11	SH2Y3-054-11	Mexican free-tailed Bat	Bat	Bat	C11	78	Yes	short	25
Y3	9/26/11	SH2Y3-055-11	Mexican free-tailed Bat	Bat	Bat	D12	78	No	short	91
Y3	9/26/11	SH2Y3-056-11	Hoary Bat	Bat	Bat	D12	78	No	short	35
Y3	9/26/11	SH2Y3-057-11	Mexican free-tailed Bat	Bat	Bat	D9	78	No	short	31
Y3	9/30/11	SH2Y3-058-11	Mexican free-tailed Bat	Bat	Bat	C12	78	No	short	2
Y3	9/30/11	SH2Y3-059-11	Mexican free-tailed Bat	Bat	Bat	C12	78	No	short	1
Y3	9/30/11	SH2Y3-061-11	Mexican free-tailed Bat	Bat	Bat	C16	78	Yes	short	15
Y3	10/4/11	SH2Y3-067-11	Hoary Bat	Bat	Bat	B9	68.5	No	short	94
Y3	10/4/11	SH2Y3-068-11	Mexican free-tailed Bat	Bat	Bat	B12	68.5	Yes	short	12
Y3	10/12/11	SH2Y3-069-11	Mexican free-tailed Bat	Bat	Bat	B5	68.5	No	short	26

Appendix D, Table 2, continued. Carcasses found in searches in year 3

Project year	Date	ID	Species	Class	Size	Turbine	Hub	Lighting	Veg. height	Distance (m)
Y3	10/13/11	SH2Y3-071-11	Mexican free-tailed Bat	Bat	Bat	C23	78	Yes	short	35
Y3	10/17/11	SH2Y3-072-11	Mexican free-tailed Bat	Bat	Bat	B5	68.5	No	short	32
Y3	10/27/11	SH2Y3-075-11	Hoary Bat	Bat	Bat	D12	78	No	short	94
Y3	10/27/11	SH2Y3-076-11	Mexican free-tailed Bat	Bat	Bat	D8	78	No	short	57
Y3	11/10/11	SH2Y3-081-11	Mexican free-tailed Bat	Bat	Bat	B12	68.5	Yes	short	27
Y3	11/30/11	SH2Y3-089-11	Mexican free-tailed Bat	Bat	Bat	C23	78	Yes	short	12
Y3	2/10/12	SH2Y3-110-12	Mexican free-tailed Bat	Bat	Bat	D21	78	No	short	20
Y3	3/15/12	SH2Y3-121-12	Mexican free-tailed Bat	Bat	Bat	B12	68.5	Yes	short	54
Y3	5/5/11	SH2Y3-005-11	Wilson's Warbler	Landbird	S	D27	78	No	short	90
Y3	5/19/11	SH2Y3-010-11	Horned Lark	Landbird	S	B2	68.5	Yes	short	10
Y3	5/31/11	SH2Y3-014-11	Red-winged Blackbird	Landbird	S	D12	78	No	tall	3
Y3	5/31/11	SH2Y3-015-11	Red-winged Blackbird	Landbird	S	D30	78	Yes	tall	95
Y3	6/8/11	SH2Y3-016-11	Cliff Swallow	Landbird	S	B9	68.5	No	short	42
Y3	6/9/11	SH2Y2-017-11	Loggerhead Shrike	Landbird	S	C11	78	Yes	short	75
Y3	6/20/11	SH2Y3-020-11	Cliff Swallow	Landbird	S	B2	68.5	Yes	short	37
Y3	8/2/11	SH2Y3-024-11	Horned Lark	Landbird	S	B9	68.5	No	short	13
Y3	8/15/11	SH2Y3-027-11	Tree Swallow	Landbird	S	D15	68.5	No	short	12
Y3	8/15/11	SH2Y3-030-11	Tree Swallow	Landbird	S	D27	78	No	short	53
Y3	8/24/11	SH2Y3-037-11	Common Raven	Landbird	L	D19	78	Yes	short	100
Y3	9/6/11	SH2Y3-046-11	Wilson's Warbler	Landbird	S	C17	78	No	short	70
Y3	10/3/11	SH2Y3-063-11	Black-throated Gray Warbler	Landbird	S	D8	78	No	short	27
Y3	11/3/11	SH2Y3-078-11	European Starling	Landbird	S	D3	78	Yes	short	83
Y3	12/12/11	SH2Y3-092-11	Western Meadowlark	Landbird	M	B8	68.5	Yes	short	59
Y3	12/15/11	SH2Y3-094-11	Mourning Dove	Landbird	M	D8	78	No	short	97
Y3	12/27/11	SH2Y3-095-11	European Starling	Landbird	S	C5	68.5	No	short	19
Y3	1/2/12	SH2Y3-097-12	Horned Lark	Landbird	S	C5	68.5	No	short	18
Y3	1/2/12	SH2Y3-098-12	Western Meadowlark	Landbird	M	C11	78	Yes	short	15
Y3	1/3/12	SH2Y3-099-12	American Pipit	Landbird	S	C14	78	No		15
Y3	1/5/12	SH2Y3-100-12	Ring-necked Pheasant	Landbird	L	D27	78	No	short	75
Y3	1/17/12	SH2Y3-102-12	American Pipit	Landbird	S	D15	68.5	No	short	82
Y3	1/24/12	SH2Y3-105-12	Vaux's Swift	Landbird	S	B2	68.5	Yes	short	58
Y3	2/1/12	SH2Y3-106-12	Western Meadowlark	Landbird	M	C5	68.5	No	short	92
Y3	2/1/12	SH2Y3-107-12	Western Meadowlark	Landbird	M	C12	78	No	short	89
Y3	2/20/12	SH2Y3-111-12	American Pipit	Landbird	S	B9	68.5	No	short	33

Appendix D, Table 2, continued. Carcasses found in searches in year 3

Project year	Date	ID	Species	Class	Size	Turbine	Hub	Lighting	Veg. height	Distance (m)
Y3	2/21/12	SH2Y3-112-12	Western Meadowlark	Landbird	M	D12	78	No	short	60
Y3	2/21/12	SH2Y3-113-12	Western Meadowlark	Landbird	M	D1	78	No	short	83
Y3	2/29/12	SH2Y3-117-12	Horned Lark	Landbird	S	B5	68.5	No	short	48
Y3	3/15/12	SH2Y3-120-12	Red-winged Blackbird	Landbird	S	B5	68.5	No	short	57
Y3	3/21/12	SH2Y3-122-12	Mourning Dove	Landbird	M	C4	78	Yes	short	36
Y3	3/28/12	SH2Y3-124-12	Mourning Dove	Landbird	M	B12	68.5	Yes	short	30
Y3	5/3/11	SH2Y2-003-11	Red-tailed Hawk	Raptor	L	C17	78	No	medium	78
Y3	5/5/11	SH2Y3-006-11	Red-tailed Hawk	Raptor	L	D27	78	No	short	70
Y3	5/12/11	SH2Y3-008-11	Barn Owl	Raptor	M	C14	78	No	medium	55
Y3	5/17/11	SH2Y3-009-11	Turkey Vulture	Raptor	L	D9	78	No	tall	33
Y3	5/24/11	SH2Y3-013-11	Northern Harrier	Raptor	L	D30	78	Yes	tall	2
Y3	6/23/11	SH2Y3-018-11	Turkey Vulture	Raptor	L	D21	78	No	medium	36
Y3	7/26/11	SH2Y3-023-11	Red-tailed Hawk	Raptor	L	D6	78	No	short	41
Y3	8/11/11	SH2Y3-026-11	American Kestrel	Raptor	M	C14	78	No	short	80
Y3	8/23/11	SH2Y3-034-11	American Kestrel	Raptor	M	C5	68.5	No	short	81
Y3	9/30/11	SH2Y3-060-11	American Kestrel	Raptor	M	C12	78	No	short	15
Y3	10/3/11	SH2Y3-062-11	Red-tailed Hawk	Raptor	L	D1	78	No	short	42
Y3	10/3/11	SH2Y3-064-11	American Kestrel	Raptor	M	D9	78	No	short	42
Y3	10/13/11	SH2Y3-070-11	Red-tailed Hawk	Raptor	L	C11	78	Yes	short	53
Y3	10/18/11	SH2Y3-073-11	Ferruginous Hawk	Raptor	L	C12	78	No	short	48
Y3	10/26/11	SH2Y3-074-11	Red-tailed Hawk	Raptor	L	C17	78	No	short	85
Y3	11/3/11	SH2Y3-077-11	Red-tailed Hawk	Raptor	L	D1	78	No	short	104
Y3	11/3/11	SH2Y3-079-11	Red-tailed Hawk	Raptor	L	D15	68.5	No	short	1
Y3	11/4/11	SH2Y3-080-11	American Kestrel	Raptor	M	D23	78	Yes	short	20
Y3	11/10/11	SH2Y3-083-11	American Kestrel	Raptor	M	C4	78	Yes	short	59
Y3	11/14/11	SH2Y3-085-11	Red-tailed Hawk	Raptor	L	C14	78	No	short	66
Y3	11/15/11	SH2Y3-086-11	Red-tailed Hawk	Raptor	L	D12	78	No	short	31
Y3	11/17/11	SH2Y3-087-11	Red-tailed Hawk	Raptor	L	C12	78	No	short	32
Y3	12/7/11	SH2Y3-093-11	Red-tailed Hawk	Raptor	L	C23	78	Yes	short	38
Y3	12/28/11	SH2Y3-096-11	Barn Owl	Raptor	M	D12	78	No	short	100
Y3	1/17/12	SH2Y3-103-12	Barn Owl	Raptor	M	D30	78	Yes	short	54
Y3	2/5/12	SH2Y3-108-12	Barn Owl	Raptor	M	D23	78	Yes	short	101
Y3	2/7/12	SH2Y3-109-12	American Kestrel	Raptor	M	B9	68.5	No	short	42
Y3	2/28/12	SH2Y3-115-12	American Kestrel	Raptor	M	D19	78	Yes	short	30

Appendix D, Table 2, continued. Carcasses found in searches in year 3

Project year	Date	ID	Species	Class	Size	Turbine	Hub	Lighting	Veg. height	Distance (m)
Y3	3/13/12	SH2Y3-118-12	Red-tailed Hawk	Raptor	L	D27	78	No	medium	15
Y3	3/26/12	SH2Y3-123-12	American Kestrel	Raptor	M	D15	68.5	No	medium	27
Y3	4/10/12	SH2Y3-126-12	Red-tailed Hawk	Raptor	L	C4	78	Yes	tall	30
Y3	4/10/12	SH2Y3-127-12	Red-tailed Hawk	Raptor	L	C14	78	No	tall	19
Y3	4/14/12	SH2Y3-128-12	Red-tailed Hawk	Raptor	L	D9	78	No	medium	43
Y3	5/3/11	SH2Y3-002-11	Canada Goose	Waterbird	L	C14	78	No	tall	5
Y3	8/15/11	SH2Y3-029-11	Sora	Waterbird	S	D23	78	Yes	short	50
Y3	10/3/11	SH2Y3-065-11	Virginia Rail	Waterbird	M	D15	68.5	No	short	67
Y3	11/10/11	SH2Y3-082-11	Eared Grebe	Waterbird	M	B8	68.5	Yes	short	52
Y3	11/30/11	SH2Y3-088-11	American Coot	Waterbird	M	C23	78	Yes	short	21
Y3	12/7/11	SH2Y3-091-11	Waterbird sp.	Waterbird	S	C17	78	No	short	27
Y3	2/28/12	SH2Y3-116-12	American Coot	Waterbird	M	D12	78	No	short	69
Y3	3/13/12	SH2Y3-119-12	American Coot	Waterbird	M	B2	68.5	Yes	short	71

Appendix D, Table 3. Carcasses found outside of searches in year 3

Project year	Date	ID	Species	Class	Turbine	Dist_(m)	Notes
Y3	5/11/11	SH2Y3-007-11	Hermit Warbler	Landbird	B1	45	Incidental
Y3	5/31/11	SH2Y3-016-11	Turkey Vulture	Raptor	D15A	30	Incidental
Y3	6/8/11	SH2Y3-018a-11	Red-tailed Hawk	Raptor	C4	50	Incidental
Y3	6/23/11	SH2Y3-022A-11	Red-tailed Hawk	Raptor	A7	23	Incidental
Y3	6/24/11	SH2Y3-022B-11	Red-tailed Hawk	Raptor	D10		Incidental
Y3	8/15/11	SH2Y3-028-11	Turkey Vulture	Raptor	D15A	29	Incidental
Y3	9/5/11	SH2Y3-045-11	Western Meadowlark	Landbird	C12	80	Incidental
Y3	9/20/11	SH2Y3-047-11	Turkey Vulture	Raptor	D10	45	Incidental
Y3	1/11/12	SH2Y3-101-12	Western Meadowlark	Landbird	D30	25	Incidental
Y3	1/24/12	SH2Y3-104-12	Rock Pigeon	Landbird	D15A	250	Incidental
Y3	2/21/12	SH2Y3-114-12	Red-tailed Hawk	Raptor	A4	1	Incidental

Appendix E. Searcher efficiency (Se) and scavenger removal (Sr) trials

Date	Turbine	Species	Class	Size	Veg Height	Se (1/0)	Sr (days)
Sep-09	A1	Mexican Free-tailed Bat	Bat	Bat	medium	0	10
Sep-09	A8	Mexican Free-tailed Bat	Bat	Bat	medium	0	5
Sep-09	B7	Mexican Free-tailed Bat	Bat	Bat	short	0	5
Sep-09	B8	Mexican Free-tailed Bat	Bat	Bat	short	1	14
Sep-09	A3	Red-winged Blackbird	Landbird	S	medium	0	6
Sep-09	B3	Red-winged Blackbird	Landbird	S	short	1	3
Sep-09	A8	Turkey Vulture	Raptor	L	medium	1	14
Sep-09	A3	American Coot	Waterbird	M	medium	0	0
Jan-10	C15	Hoary Bat	Bat	Bat	short	1	4
Jan-10	C18	Mexican Free-tailed Bat	Bat	Bat	medium	0	1
Jan-10	C18	Hoary Bat	Bat	Bat	medium	0	1
Jan-10	C21	Mexican Free-tailed Bat	Bat	Bat	short	1	14
Jan-10	D20	Hoary Bat	Bat	Bat	short	1	5
Jan-10	C15	Rock Pigeon	Landbird	M	short	1	12
Jan-10	C15	Varied Thrush	Landbird	M	short	1	2
Jan-10	D11	European Starling	Landbird	S	short	1	14
Jan-10	D17	Brewer's Blackbird	Landbird	S	tall	0	6
Jan-10	C18	Red-tailed Hawk	Raptor	L	medium	1	14
Jan-10	D13	American Kestrel	Raptor	M	medium	1	1
Mar-10	B10	Mexican Free-tailed Bat	Bat	Bat	short	1	6
Mar-10	C13	Western Red Bat	Bat	Bat	tall	0	0
Mar-10	C15	Mexican Free-tailed Bat	Bat	Bat	tall	0	0
Mar-10	C3	Mexican Free-tailed Bat	Bat	Bat	tall	0	5
Mar-10	C6	Mexican Free-tailed Bat	Bat	Bat	short	0	8
Mar-10	C13	Winter Wren	Landbird	S	tall	1	3
Mar-10	C2	Red-winged Blackbird	Landbird	S	tall	0	8
Mar-10	C6	Savannah Sparrow	Landbird	S	short	1	14
Mar-10	C6	Northern Harrier	Raptor	L	short	1	14
Mar-10	C9	American Kestrel	Raptor	M	short	1	7
Mar-10	C3	Snow Goose	Waterbird	L	tall	1	14
Apr-10	D16	Mexican Free-tailed Bat	Bat	Bat	tall	0	5
Apr-10	D24	Mexican Free-tailed Bat	Bat	Bat	tall	0	14
Apr-10	D4	Mexican Free-tailed Bat	Bat	Bat	tall	0	3
Apr-10	D24	American Kestrel	Raptor	M	tall	1	14
Apr-10	D8	Red-tailed Hawk	Raptor	L	tall	0	14
Apr-10	D16	Black Rail	Waterbird	S	tall	1	4
Apr-10	D8	Black Rail	Waterbird	S	tall	1	14
Aug-10	A9	Hoary Bat	Bat	Bat	medium	1	3
Aug-10	B1	Western Red Bat	Bat	Bat	short	0	14
Aug-10	B6	Mexican Free-tailed Bat	Bat	Bat	short	X	0
Aug-10	C1A	Hoary Bat	Bat	Bat	medium	1	7
Aug-10	C2	Mexican Free-tailed Bat	Bat	Bat	medium	1	14
Aug-10	B11	Horned Lark	Landbird	S	short	0	7
Aug-10	B4	Horned Lark	Landbird	S	short	0	4
Aug-10	C1A	Cliff Swallow	Landbird	S	medium	1	2
Aug-10	C2	Horned Lark	Landbird	S	medium	0	4
Aug-10	B1	American Kestrel	Raptor	M	short	1	9
Aug-10	B4	Great Horned Owl	Raptor	L	short	1	14
Nov-10	A4	Hoary Bat	Bat	Bat	medium	0	0

Appendix E, continued. Searcher efficiency (Se) and scavenger removal (Sr) trials

Date	Turbine	Species	Class	Size	Veg Height	Se (1/0)	Sr (days)
Nov-10	A4	Hoary Bat	Bat	Bat	medium	1	14
Nov-10	A9	Mexican Free-tailed Bat	Bat	Bat	medium	0	14
Nov-10	A9	Mexican Free-tailed Bat	Bat	Bat	medium	0	14
Nov-10	B6	Western Red Bat	Bat	Bat	short	0	8
Nov-10	D22	Hoary Bat	Bat	Bat	short	1	6
Nov-10	A6	European Starling	Landbird	S	medium	0	11
Nov-10	A6	European Starling	Landbird	S	medium	0	14
Nov-10	B1	Mourning Dove	Landbird	M	short	X	0
Nov-10	B4	European Starling	Landbird	S	short	1	4
Nov-10	B4	European Starling	Landbird	S	short	1	6
Nov-10	D25	European Starling	Landbird	S	short	1	6
Nov-10	D25	European Starling	Landbird	S	short	1	11
Nov-10	D29	European Starling	Landbird	S	short	1	11
Nov-10	D29	European Starling	Landbird	S	short	0	14
Nov-10	A4	Red-tailed Hawk	Raptor	L	medium	1	14
Nov-10	B11	Red-tailed Hawk	Raptor	L	short	1	14
Nov-10	B4	American Kestrel	Raptor	M	short	1	14
Nov-10	D22	Turkey Vulture	Raptor	L	short	1	14
Nov-10	D29	Turkey Vulture	Raptor	L	short	1	14
Feb-11	C20	Mexican Free-tailed Bat	Bat	Bat	medium	0	0
Feb-11	D10	Mexican Free-tailed Bat	Bat	Bat	medium	1	10
Feb-11	D15A	Mexican Free-tailed Bat	Bat	Bat	medium	0	4
Feb-11	D15A	Mexican Free-tailed Bat	Bat	Bat	medium	0	7
Feb-11	D18	Hoary Bat	Bat	Bat	short	0	6
Feb-11	D18	Hoary Bat	Bat	Bat	short	1	0
Feb-11	D2	Hoary Bat	Bat	Bat	medium	0	0
Feb-11	D5	Mexican Free-tailed Bat	Bat	Bat	medium	1	10
Feb-11	D7	Hoary Bat	Bat	Bat	medium	0	14
Feb-11	C20	Red-winged Blackbird	Landbird	S	medium	0	10
Feb-11	C20	European Starling	Landbird	S	medium	0	9
Feb-11	D10	Tree Swallow	Landbird	S	medium	0	14
Feb-11	D14	European Starling	Landbird	S	medium	1	2
Feb-11	D14	American Goldfinch	Landbird	S	medium	0	6
Feb-11	D14	European Starling	Landbird	S	medium	0	9
Feb-11	D18	Western Meadowlark	Landbird	M	short	1	0
Feb-11	D5	Brewer's Blackbird	Landbird	S	medium	1	2
Feb-11	D7	House Finch	Landbird	S	medium	1	7
Feb-11	C19	American Kestrel	Raptor	M	medium	X	0
Feb-11	D18	Barn Owl	Raptor	L	short	1	14
Feb-11	D2	American Kestrel	Raptor	M	medium	0	8
Feb-11	C19	California Gull	Waterbird	L	medium	1	14
Feb-11	C19	California Gull	Waterbird	L	medium	1	14
Feb-11	D15A	California Gull	Waterbird	L	medium	1	14
Feb-11	D2	California Gull	Waterbird	L	medium	1	14
Feb-11	D5	Dunlin	Waterbird	S	medium	0	1
Apr-11	B11	Mexican Free-tailed Bat	Bat	Bat	short	1	4
Apr-11	B11	Hoary Bat	Bat	Bat	short	1	10
Apr-11	C1A	Mexican Free-tailed Bat	Bat	Bat	tall	0	0
Apr-11	C2	Hoary Bat	Bat	Bat	tall	1	7

Appendix E, continued. Searcher efficiency (Se) and scavenger removal (Sr) trials

Date	Turbine	Species	Class	Size	Veg Height	Se (1/0)	Sr (days)
Apr-11	C20	Mexican Free-tailed Bat	Bat	Bat	tall	0	1
Apr-11	C7	Hoary Bat	Bat	Bat	short	1	10
Apr-11	B11	European Starling	Landbird	S	short	0	14
Apr-11	C10	European Starling	Landbird	S	tall	1	9
Apr-11	C10	American Crow	Landbird	M	tall	1	14
Apr-11	C10	European Starling	Landbird	S	tall	0	3
Apr-11	C1A	American Crow	Landbird	M	tall	1	5
Apr-11	C20	European Starling	Landbird	S	tall	0	0
Apr-11	C6	European Starling	Landbird	S	short	1	4
Apr-11	C7	European Starling	Landbird	S	short	1	14
Apr-11	C8	European Starling	Landbird	S	medium	1	14
Apr-11	C8	Western Meadowlark	Landbird	M	medium	1	3
Apr-11	C1A	Red-tailed Hawk	Raptor	L	tall	1	14
Apr-11	C2	Western Gull	Waterbird	L	tall	1	14
Apr-11	C2	Western Gull	Waterbird	L	tall	1	14
Apr-11	C6	Western Gull	Waterbird	L	short	1	14
Sep-11	B12	Hoary Bat	Bat	Bat	short	1	9
Sep-11	B5	Mexican Free-tailed Bat	Bat	Bat	short	1	3
Sep-11	B8	Western Red Bat	Bat	Bat	short	1	9
Sep-11	C11	Mexican Free-tailed Bat	Bat	Bat	short	1	0
Sep-11	C12	Mexican Free-tailed Bat	Bat	Bat	short	1	14
Sep-11	C12	Mexican Free-tailed Bat	Bat	Bat	short	1	7
Sep-11	C4	Mexican Free-tailed Bat	Bat	Bat	short	0	11
Sep-11	B5	Mourning Dove	Landbird	M	short	1	1
Sep-11	B8	Cliff Swallow	Landbird	S	short	0	4
Sep-11	B9	Wilson's Warbler	Landbird	S	short	1	0
Sep-11	C11	Hammond's Flycatcher	Landbird	S	short	1	4
Sep-11	C16	House Finch	Landbird	S	short	1	1
Sep-11	C16	Tree Swallow	Landbird	S	short	1	9
Sep-11	C4	Savannah Sparrow	Landbird	S	short	1	9
Sep-11	C5	Oranged-crowned Warbler	Landbird	S	short	0	4
Sep-11	C5	Cliff Swallow	Landbird	S	short	1	8
Sep-11	B12	Red-tailed Hawk	Raptor	L	short	1	13
Sep-11	B8	Barn Owl	Raptor	L	short	1	14
Sep-11	B9	Turkey Vulture	Raptor	L	short	1	14
Sep-11	B9	Turkey Vulture	Raptor	L	short	1	14
Sep-11	C11	Red-tailed Hawk	Raptor	L	short	1	13
Sep-11	C16	Red-tailed Hawk	Raptor	L	short	1	14
Dec-11	C16	Hoary Bat	Bat	Bat	short	0	2
Dec-11	C17	Mexican Free-tailed Bat	Bat	Bat	short	0	8
Dec-11	D1	Mexican Free-tailed Bat	Bat	Bat	short	0	0
Dec-11	D12	Mexican Free-tailed Bat	Bat	Bat	short	1	1
Dec-11	D19	Hoary Bat	Bat	Bat	short	0	8
Dec-11	D21	Mexican Free-tailed Bat	Bat	Bat	short	0	2
Dec-11	D21	Hoary Bat	Bat	Bat	short	0	6
Dec-11	D3	Mexican Free-tailed Bat	Bat	Bat	short	0	5
Dec-11	C14	European Starling	Landbird	S	short	1	3
Dec-11	C14	American Crow	Landbird	M	short	1	11
Dec-11	C16	American Crow	Landbird	M	short	0	14

Appendix E, continued. Searcher efficiency (Se) and scavenger removal (Sr) trials

Date	Turbine	Species	Class	Size	Veg Height	Se (1/0)	Sr (days)
Dec-11	C17	American Crow	Landbird	M	short	1	14
Dec-11	C17	Swainson's Thrush	Landbird	S	short	1	1
Dec-11	D1	Red-winged Blackbird	Landbird	S	short	1	4
Dec-11	D1	American Crow	Landbird	M	short	1	14
Dec-11	D19	American Crow	Landbird	M	short	1	14
Dec-11	D21	American Crow	Landbird	M	short	1	14
Dec-11	D3	American Crow	Landbird	M	short	1	14
Dec-11	D3	Red-winged Blackbird	Landbird	S	short	1	0
Dec-11	C14	Red-tailed Hawk	Raptor	L	short	1	3
Dec-11	C16	Red-tailed Hawk	Raptor	L	short	1	14
Dec-11	C17	Red-tailed Hawk	Raptor	L	short	1	13
Dec-11	C23	Red-tailed Hawk	Raptor	L	short	1	9
Dec-11	D12	Red-tailed Hawk	Raptor	L	short	1	8
Dec-11	D19	Red-tailed Hawk	Raptor	L	short	1	14
Jan-12	B2	Hoary Bat	Bat	Bat	short	1	9
Jan-12	B8	Mexican Free-tailed Bat	Bat	Bat	short	1	14
Jan-12	B8	Mexican Free-tailed Bat	Bat	Bat	short	1	0
Jan-12	B9	Mexican Free-tailed Bat	Bat	Bat	short	0	2
Jan-12	B9	Hoary Bat	Bat	Bat	short	0	0
Jan-12	D23	Mexican Free-tailed Bat	Bat	Bat	short	0	0
Jan-12	D27	Mexican Free-tailed Bat	Bat	Bat	short	0	7
Jan-12	D30	Hoary Bat	Bat	Bat	short	1	0
Jan-12	B2	American Crow	Landbird	M	short	1	14
Jan-12	B5	Tree Swallow	Landbird	S	short	0	1
Jan-12	B8	American Crow	Landbird	M	short	1	14
Jan-12	D15	Red-winged Blackbird	Landbird	S	short	1	14
Jan-12	D23	American Crow	Landbird	M	short	1	14
Jan-12	D27	Swainson's Thrush	Landbird	S	short	1	1
Jan-12	D30	Red-winged Blackbird	Landbird	S	short	0	5
Jan-12	B9	Red-tailed Hawk	Raptor	L	short	1	8
Jan-12	D30	Barn Owl	Raptor	L	short	1	14
Apr-12	C11	Hoary Bat	Bat	Bat	medium	0	8
Apr-12	C14	Hoary Bat	Bat	Bat	medium	0	14
Apr-12	C16	Hoary Bat	Bat	Bat	medium	0	3
Apr-12	C23	Hoary Bat	Bat	Bat	tall	1	4
Apr-12	D19	Hoary Bat	Bat	Bat	short	0	6
Apr-12	D21	Mexican Free-tailed Bat	Bat	Bat	short	0	13
Apr-12	C11	Mourning Dove	Landbird	M	medium	1	2
Apr-12	C14	Horned Lark	Landbird	S	medium	0	0
Apr-12	C23	Cliff Swallow	Landbird	S	tall	0	11
Apr-12	C23	American Crow	Landbird	M	tall	1	14
Apr-12	D19	Horned Lark	Landbird	S	short	1	14
Apr-12	D21	Hermit Warbler	Landbird	S	short	1	0
Apr-12	C14	Red-tailed Hawk	Raptor	L	medium	1	10
Apr-12	D21	Red-tailed Hawk	Raptor	L	short	1	14
Apr-12	C16	American Coot	Waterbird	M	medium	0	14