Post-Construction Studies for the North Sky River Wind Energy Facility Kern County, California

Final Report for the Third Year of Operation

January 2015 – January 2016

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EXECUTIVE SUMMARY

North Sky River Energy LLC (NSRE LLC), a subsidiary of NextEra Energy Resources (NextEra), owns and operates a wind energy facility in Kern County, California, referred to as the North Sky River Wind Energy Facility (NSR). Western EcoSystems Technology, Inc. (WEST) was contracted by NSRE LLC to develop and implement study protocols for post-construction monitoring at NSR for the purpose of estimating the impacts of the wind energy facility on birds and bats. Consistent with mitigation measures under the North Sky River Wind Energy Project and Jawbone Wind Energy Project Environmental Impact Report (EIR), WEST conducted fatality monitoring (Mitigation Measure [MM] 4.4-17) and breeding raptor monitoring (MM 4.4-16) at NSR during the third year of operation from January 2015 to January 2016.

As stated in MM 4.4-17 of the EIR, the ultimate goal of the fatality monitoring study was to demonstrate that the level of incidental mortality does not result in an unanticipated long-term decline in populations of avian or bat species in the vicinity of NSR. To this end, WEST designed and implemented a study to determine the level of bird and bat mortality attributable to collisions with wind turbines at the facility on an annual basis. The monitoring study consisted of four components: 1) standardized carcass surveys of selected turbines; 2) searcher efficiency trials to estimate the percentage of carcasses found by searchers; 3) carcass removal trials to estimate the length of time that a carcass remained in the field for possible detection; and 4) adjusted fatality estimates for birds and bats, calculated using the results from searcher efficiency trials and carcass removal trials to estimate the approximate level of bird and bat mortality within NSR.

A sample of 30 turbines (30% of 100 total turbines), was searched every two weeks from January 19, 2015 to January 12, 2016, for a total of 733 searches at year-round study turbines. Additionally, due to concerns over potential impacts to nocturnal migrants at turbines in the northeast portion of NSR, intensive searches (twice per week) were conducted at seven additional turbines in the northeastern portion of the facility during spring migration, for a total of 140 turbine searches. Twenty-one bird fatalities, representing nine identifiable species, were found during carcass surveys or incidentally during the study period. The bird species most commonly found as fatalities were red-tailed hawk (five fatalities), and American kestrel (three fatalities). Six of the 21 bird fatalities documented during the study were found during the intensive spring searches, including two of the red-tailed hawk fatalities. Bird fatalities documented at the year-round search plots were found during all seasons, but were more frequently encountered in the fall. No state or federally listed bird species were found during the study.

A total of 11 bats, representing two identifiable species, were found during carcass surveys or incidentally during the study period. The bat species found as fatalities were Mexican free-tailed bat (eight fatalities) and hoary bat (three fatalities). Three of the 11 bat fatalities documented during the study were found during the intensive spring searches (one Mexican free-tailed bat and two hoary bats). No state or federally listed bat species were found during the study,

although the hoary bat appears on the California Department of Fish and Wildlife's (CDFW) Special Animals List and is protected under the California Environmental Quality Act. All bat fatalities occurred between mid-March and late September.

A total of 108 bird carcasses were placed for searcher efficiency trials in Year 3: 32 large birds and 76 small birds. Due to the unavailability of bat carcasses, dark colored mice were used as surrogates for bats, with 23 mice placed as surrogates for bats. Searcher efficiency trial data were compared across seasons and years. Because there were no statistical differences among seasons or years, data from all seasons and years were combined to produce a single searcher efficiency estimate for each carcass size class. Overall searcher efficiency rates were 96.2% for large birds, 82.0% for small birds, and 81.7% for bats. A total of 150 carcasses were placed during carcass removal trials. By day 10, approximately 28% of the large birds remained, while approximately 12% of small birds and 12% of bats remained. Mean carcass removal times were 1.60 days in spring, summer, and fall, and 3.69 days in winter for small birds; 1.97 days in spring, summer, and fall, and 3.75 days in winter for bats; and 23.28 days across all seasons for large birds.

Fatality estimates were adjusted based on the corrections for carcass removal and observer detection bias. The probability that a carcass would remain in the search plot and be found by a searcher varied by season: 0.09 for small birds and bats during summer, fall, and spring, and 0.20 in winter. For bats this probability was 0.11 during spring, summer, and fall. No bats were found during winter. For large birds, the probability was higher and consistent throughout the year at 0.73. During the intensive, twice weekly spring searches, the average probability that a carcass would remain in the search plot and be found by a searcher was 0.35, 0.40, and 0.93 for small birds, bats, and large birds, respectively.

Based on the 1.6-megawatt (MW) capacity of the turbines at NSR, the estimated fatality rate for all birds was 0.72 birds/MW/year, with an estimated fatality rate of 0.17 diurnal raptors/MW/year. The estimated fatality rate for bats was 1.51 bats/MW/year. At the turbines searched twice weekly during the spring, the estimated fatality rates for all birds and diurnal raptors were 1.06 and 0.19 birds/MW/study period, respectively. The estimated fatality rate for bats was 0.44 bats/MW/study period during the intensive spring migration searches. It should be noted that fatality rates for the intensive spring searches are not considered representative of the project as a whole and should not be extrapolated to all of NSR.

As stated in MM 4.4-16 of the EIR, the purpose of the breeding monitoring is to demonstrate that sensitive resident raptors are compatible with the operation of wind turbines and that the level of mortality does not result in long-term declines in sensitive raptor species in the region. Consistent with this mitigation measure, WEST conducted raptor nest surveys to determine the presence or absence of raptor nests, particularly mid-sized to large raptor nests, within areas of suitable habitat (e.g., oak and Joshua tree woodlands, utility poles, and transmission towers) and gathered reproductive success data where possible, within the NSR project area. Four surveys of the project area were conducted, with one each in March, April, May, and June. Active raptor nests documented during the survey included two great horned owl nests, two

red-tailed hawk nests, and four common raven (Corvus corax) nests. The great-horned owl and red-tailed hawk nests successfully fledged young. Two of the common raven nests fledged young, while success of the remaining two raven nests was undetermined. Nest monitoring results over the three years of post-construction studies indicate that raptors continue to successfully nest within NSR and that construction and operation of NSR has not substantially altered local raptor nesting activities or nest success.

During this third year of monitoring at NSR, the all bird and bat fatality rates were generally low compared to other wind energy facilities in western North America, and consistent with other facilities in the Tehachapi Wind Resource Area (TWRA). Diurnal raptor fatality rates were slightly above average for the area during this third year of monitoring, but the average fatality rate for diurnal raptors at NSR over the three years of monitoring is consistent with other raptor fatality rates reported for nearby projects (e.g., Alta Wind, Alta VIII, Mustang Hills) and lower than most other projects in California. Additional monitoring is being conducted at NSR during the fourth year of operation (January 2016 – January 2017), which will provide additional insight into the annual variation among estimated fatality rates at the project. Upon completion of the fourth year of study at NSR, a more complete picture of the potential impact and annual variability of the project on bird and bat species will be available, providing a sound basis for assessing NSR's potential long term impacts on birds and bats and its level of impact relative to other wind energy facilities in the region.

STUDY PARTICIPANTS

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REPORT REFERENCE

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INTRODUCTION

North Sky River Energy LLC (NSRE LLC), a subsidiary of NextEra Energy Resources (NextEra), has constructed a wind energy facility in Kern County, California, referred to as the North Sky River Wind Energy Facility (NSR). As described in Mitigation Measures (MM) 4.4-17 and 4.4-16 of the *North Sky River Wind Energy Project and Jawbone Wind Energy Project Draft Environmental Impact Report* (EIR; Kern County Planning Department 2011), NSRE LLC committed to conducting post-construction avian and bat mortality monitoring at the NSR during the first, second, third, and fourth years of operation and raptor breeding monitoring during the first, second, and third years of operation. Following construction of NSR in the fall of 2012, Western EcoSystems Technology, Inc. (WEST), was contracted by NSRE LLC to develop and implement a standardized protocol for post-construction monitoring at NSR for the purpose of estimating the impacts of facility operation on birds and bats. The monitoring protocols were similar to those used at other wind energy facilities throughout California and the US, and consistent with industry standards and agency recommendations. Data collection and analysis followed the recommendations presented in the US Fish and Wildlife Service (USFWS) final *Land-Based Wind Energy Guidelines* (WEG; USFWS 2012), the *California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development* (California Wind Energy Guidelines; California Energy Commission [CEC] and California Department of Fish and Game [CDFG] 2007), and was further based on WEST's experience studying wildlife at wind energy projects throughout the US. This report presents the results of avian and bat fatality monitoring and raptor breeding monitoring conducted at NSR during the third year of operation, from January 2015 to January 2016. Results from the first and second years of monitoring can be found in Levenstein et al. (2014) and Levenstein and Riser-Espinoza (2015).

As stated in MM 4.4-17 of the EIR, the ultimate goal of the fatality monitoring study was to demonstrate that the level of incidental mortality will not result in an unanticipated long-term decline in populations of avian or bat species in the vicinity of NSR. To this end, WEST conducted a fatality study to determine the level of bird and bat mortality attributable to collisions with wind turbines at NSR on an annual basis. If, after four years of post-construction mortality monitoring, the Kern County Planning Department, in consultation with the California Department of Fish and Wildlife (CDFW [formerly CDFG]) and the USFWS, determines that NSR is causing unanticipated significant adverse impacts to populations of avian or bat species, NSRE LLC is required to provide supplemental mitigation as described in MM 4.4-20 (Kern County Planning Department 2011). Consistent with MM 4.4-15 of the EIR, surveys for nesting raptors were also conducted throughout the NSR during the 2015 breeding season.

Post-construction monitoring at NSR was conducted from January 19, 2015 through January 12, 2016. In addition to site-specific data, this report presents existing information and results of post-construction studies conducted at other wind energy facilities in the region and, where possible, comparisons with local studies were made.

STUDY AREA

NSR is located approximately nine miles (14 kilometers [km]) west of the Bureau of Land Management (BLM) Jawbone Off-Highway Vehicle Station, Highway 14 at Jawbone Canyon Road, Cantil, in Kern County, California (Figure 1). NSR consists of 100 GE 1.6-megawatt (MW) turbines located on approximately 12,904 acres (5,222 hectares [ha]) of private and BLM-managed land. The turbine towers are approximately 80 meters (m; 262 feet [ft]) tall and the rotor blades are approximately 100 to 113 m (328 to 371 ft) in diameter, for a maximum height of approximately 130 to 136.5 m (427 to 448 ft) from turbine base to the fully extended blade tip.

NSR is located near the intersection of two ecological subsections: the High Desert Plains and Hills Subsection of the Mojave Desert to the south and east, and the Eastern Slopes Subsection of the Sierra Nevada to the north and west (US Department of Agriculture [USDA] Forest Service 1997). Topography within NSR is characterized by gently rolling hills to relatively steep, low mountains. Elevations range from approximately 3,120 ft (950 m) in the southeastern portion of the project area to just over 5,580 ft (1,700 m) in the southwest. The dominant vegetation community is Mojavean juniper (*Juniperus* spp.) woodland and scrub characterized by widely spaced California junipers (*J. californica*) interspersed with smaller woody shrubs, forbs, and grasses. Desert scrub vegetation with small areas of Joshua tree (*Yucca brevifolia*) woodland are present within the lower elevations of the study area, while juniper-pinyon pine (*Pinus monophylla*) and oak (*Quercus* spp.) woodlands are found at the higher elevations.

Several natural springs occur throughout the project area, as well as a number of small intermittent drainages, which contain riparian vegetation such as willow (*Salix* spp.) and tamarisk (*Tamarix* spp.). The largest of these drainages is Cottonwood Creek, which runs through the center of the project area from the northwest to the southeast and contains areas of more substantial riparian woodlands with an overstory dominated by Fremont cottonwood (*Populus fremontii*).

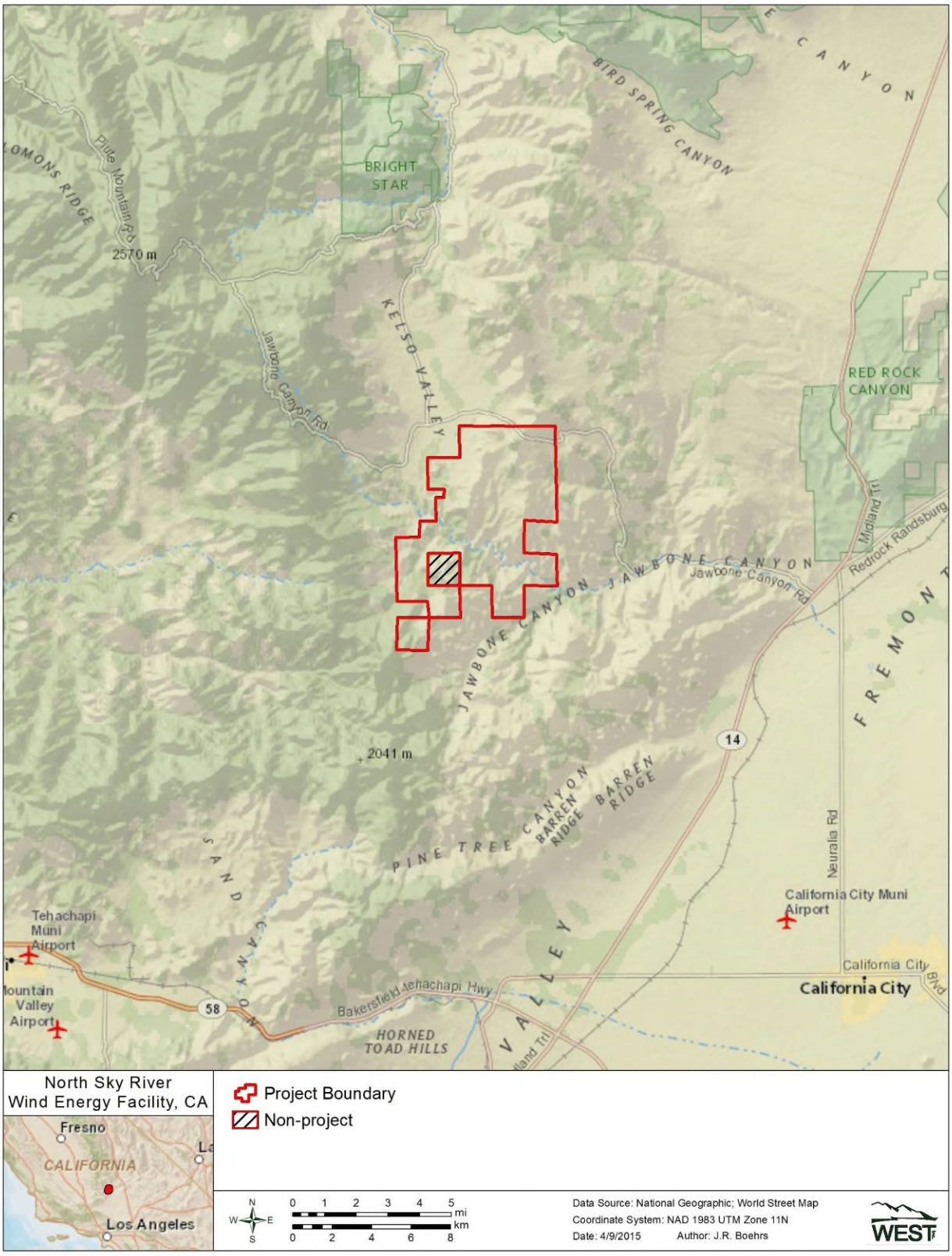

Figure 1. Location of the North Sky River Wind Energy Facility.

METHODS

Avian and Bat Fatality Monitoring

The primary objective of the fatality monitoring study was to estimate the level of bird and bat mortality attributable to collisions with wind turbines at the facility on an annual basis. The methods for the fatality study consisted of four primary components: 1) standardized carcass surveys of selected turbines; 2) searcher efficiency trials to estimate the percentage of carcasses found by searchers; 3) carcass removal trials to estimate the length of time that a carcass remained in the field for possible detection; and 4) calculation of adjusted mortality estimates for bird and bat species using the results from searcher efficiency trials and carcass removal trials.

There were three scenarios under which casualties were found within the facility: 1) during the standardized carcass searches for the study; 2) while study personnel were on site, but not conducting a standardized search (i.e., an incidental find); and 3) by facility personnel or others on site for other purposes (also considered incidental). Casualties found by study personnel, regardless of timing (i.e., during a standardized survey or incidentally), were recorded by the methods described below. All casualties found within a search plot during the study period, even if outside of the standard survey period, were included in the dataset under the conservative assumption that these casualties would have been found during standardized surveys.

The total number of bird and bat carcasses at the facility was estimated by adjusting for search frequency, removal bias (length of persistence in the field) and searcher efficiency bias (percent found). For carcasses where the cause of death was not apparent, the assumption that the casualty was the result of collision with a wind turbine was made for the analysis. This approach likely led to an overestimate of the true number of facility-related casualties, but most wind energy facilities have used this conservative approach because of the relative high cost associated with obtaining accurate estimates of natural or reference mortality (see Johnson et al. 2000).

Study Components and Field Methodology

Standardized Carcass Searches

The objective of the standardized carcass searches was to systematically search the ground beneath turbines for avian and bat casualties attributable to collision with project facilities. Prior to the initiation of the 4-year fatality monitoring study, in accordance with the California Wind Energy Guidelines and the USFWS WEG (CDFG and CEC 2007, USFWS 2012), a sample of 30 turbines (30% of NSR's 100 turbines) was selected for conducting the carcass searches. The turbine sample was chosen by dividing the NSR project map into square grid cells approximately 1.25 miles by 1.25 miles (2.01 km by 2.01 km). Cells were numbered from left to right, top to bottom. Turbines were then listed from top to bottom and left to right by grid cell. A systematic sample was taken with a random starting value of 53; therefore, Turbine 1 in the selection process was the 53rd turbine in the list. Starting with the 53rd turbine on the list,

turbines were selected by taking the third turbine counting forward, then the third turbine counting forward, then the fourth turbine counting forward. This process yielded a list of 30 turbines to be searched during the fatality monitoring study (Figure 2). Turbine selections were viewed on a map to verify adequate spatial distribution and coverage (Figure 2). The same turbine sample was used for the first three years of the study and is also being used for the fourth year of the study, which is currently ongoing.

Searches at each sampled turbine were conducted within 160-m (197-ft) diameter circular plots centered on the turbine (Figure 3). Each plot was searched along parallel transects spaced six to 10 m (20 to 33 ft) apart (depending on detection ability), with the orientation of the transects based on the orientation of the topography surrounding the turbines.

For all casualties found, data recorded included: species, sex and age when possible, date and time encountered, Global Positioning System (GPS) location, condition of carcass, and any comments that indicated possible cause of death. All casualties were photographed as found, including detailed close-up photos of the carcass or feathers for identification purposes, as well as photos showing location of the carcass or feathers in relation to the closest wind turbine or other project facilities, such as overhead power lines. The condition of each carcass found was recorded using the following categories:

- Intact - a carcass that was completely intact, was not badly decomposed, and showed no sign of being fed upon by a predator or scavenger.
- Scavenged - an entire carcass, which showed signs of being fed upon by a predator or scavenger, or a portion(s) of a carcass in one location (e.g., wings, skeletal remains, portion of a carcass, etc.), or a carcass that was heavily infested by insects.
- Feather Spot - 10 or more feathers or two or more primaries at one location, indicating a bird casualty had likely been there.

In addition to carcasses, any injured bird or bat observed in the search plots was recorded and treated as a fatality. Casualties found outside the formal search area by study personnel were documented following the above protocol as closely as possible. Casualties observed in non-search areas (e.g., near a turbine not included in the search plots), or observed within search areas but outside of the standard search period, were coded as incidental discoveries and were documented in a similar fashion as those found during standard searches; however, only casualties found within standard search plots were used in the estimation of fatality rates. Casualties found by maintenance personnel and other personnel not conducting the formal searches were similarly documented and included in the overall dataset.

Standardized carcass surveys were conducted every two weeks during the fall (August 16 – November 6), winter (November 7 to March 17), spring (March 18 to May 12), and summer (May 13 to August 15) at each of the 30 sampled turbines.

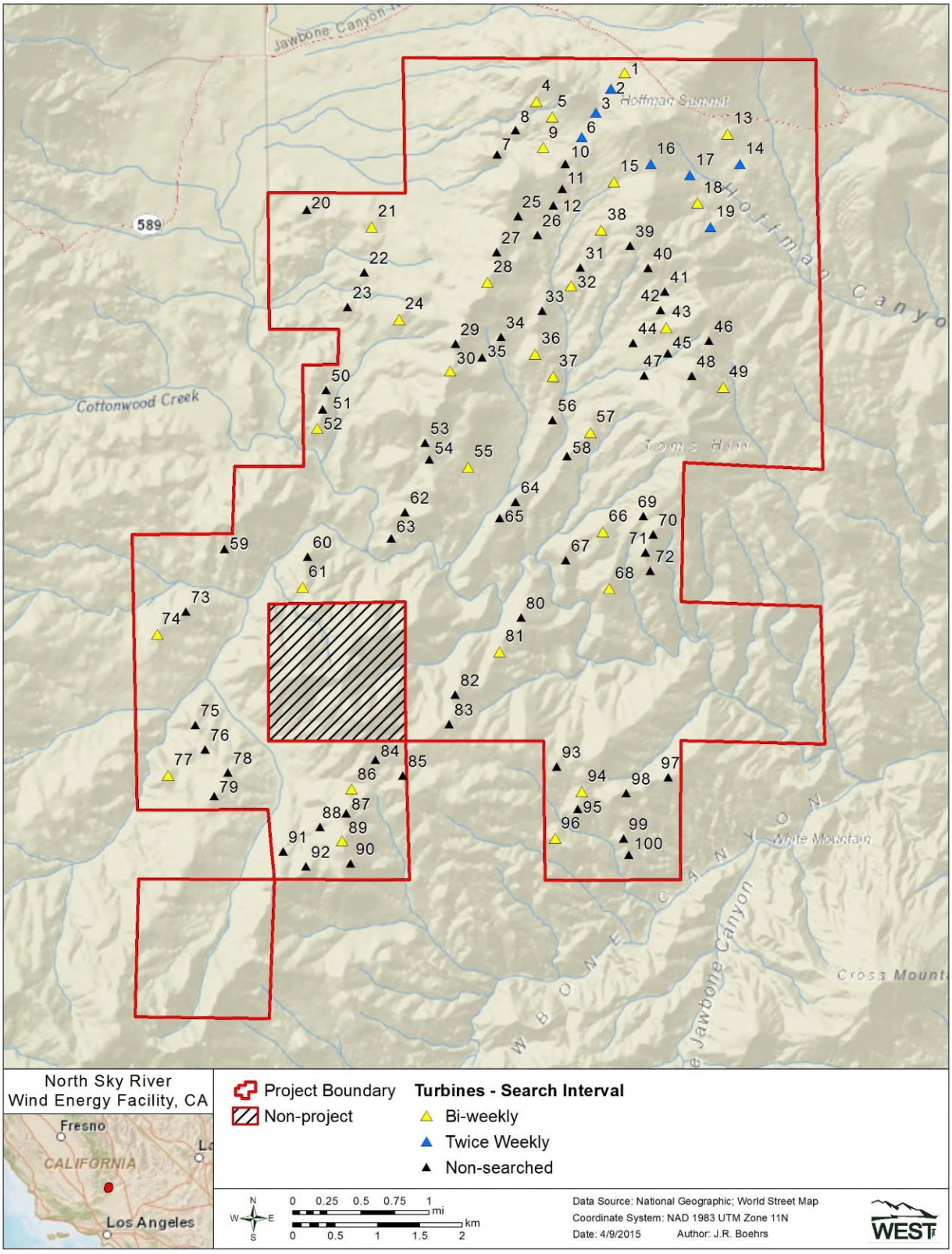

Figure 2. Turbine layout at the North Sky River Wind Energy Facility showing turbines selected for fatality monitoring.

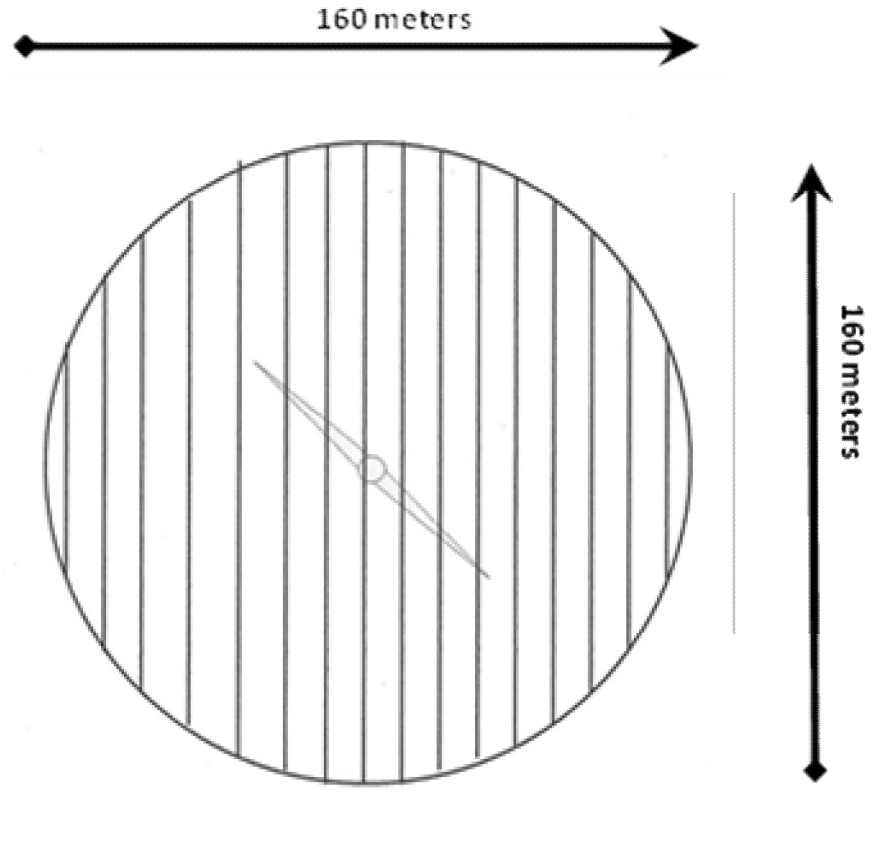

Figure 3. Schematic of turbine search plot and transects.

Intensive Spring Migration Carcass Searches

During pre-construction bird use surveys conducted at NSR during the spring migration period (April and May) of 2010 and 2011, relatively high numbers of migrating songbirds (and some migrating shorebirds) were observed passing over the northeastern portion of the project area. To investigate the potential for collision of nocturnal migrants with turbines in this portion of the NSR, the monitoring study protocol implemented included an intensive carcass search effort conducted each spring at seven turbines located in the northeast corner of NSR (Figure 2). In 2015, the seven turbines were searched twice weekly for approximately nine weeks (March 31 – June 4). Plot size and methodology for the intensive spring migration carcass searches was identical to that described above for the standardized (year-round) carcass searches.

Searcher Efficiency Trials

The objective of the searcher efficiency trials was to estimate the percentage of casualties found by searchers. Searcher efficiency trials were conducted in the same areas as carcass surveys and searcher efficiency was estimated by the size of carcass (large or small bird) and season. Estimates of searcher efficiency were used to adjust the total number of carcasses found for those missed by searchers, correcting for detection bias.

Searcher efficiency trials were conducted throughout the year to encompass variable field conditions that may affect surveyor carcass detection. Carcasses used for trials consisted of non-native or commercially-available species. Large birds were represented by mallards (*Anas platyrhynchos*) and rock pigeons (*Columba livia*), while small birds included house sparrows (*Passer domesticus*) and Coturnix quail (*Coturnix* spp.). Due to the unavailability of bat carcasses, dark-colored domestic mice (*Mus musculus*) were used as surrogates for bats. Large and small bird carcasses were used in each trial, while bats/bat surrogates were only used in summer and fall trials.

All searcher efficiency trial carcasses were placed at random locations within the search area prior to that day's scheduled carcass survey. Personnel conducting carcass surveys did not know when searcher efficiency trials were being conducted or the location of the trial carcasses. Each trial carcass was discreetly marked with electrical tape so that it could be identified as a study carcass after it was found. The number and location of the searcher efficiency carcasses found during the carcass survey were recorded. The number of carcasses available for detection during each trial was determined immediately after the trial by the person responsible for distributing the carcasses.

Carcass Removal Trials

The objective of carcass removal trials was to estimate the average length of time a carcass remained in the study area and was potentially detectable. Carcass removal included removal by predation or scavenging, or removal by other less likely means, such as burial by wind-blown sand. Estimates of carcass removal were used to adjust the total number of carcasses found for those removed from the study area, correcting for removal bias.

Trials were spread throughout the year to incorporate possible effects of varying site conditions (e.g., weather, vegetation, scavenger densities). All trial carcasses were handled with disposable gloves to minimize human scent on the carcasses. Trial carcasses were of similar composition to those used for searcher efficiency trials.

Turbines, including searched and non-searched turbines, were randomly selected for inclusion in the removal trials. Trial carcasses were randomly placed at selected turbines within a plot of similar size to the actual search plots. Personnel conducting carcass searches monitored the trial carcasses over a 40-day period, checking the carcasses every day for the first four days of the trial, and then again on days seven, 10, 14, 18, 24, 30, and 40. This schedule varied somewhat depending on weather and coordination with the other survey work. Removal trial carcasses were discreetly marked (e.g., with dark electrical tape around one or both legs) for recognition by searchers and other personnel, and left at the location until the end of the trial. At the end of the 40-day period, any remaining evidence of the carcass was removed.

Statistical Analysis

Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) measures were implemented at all stages of the study, including in the field, during data entry and analysis, and report writing. Following field

surveys, observers were responsible for inspecting data forms for completeness, accuracy, and legibility. A sample of records from an electronic database was compared to the raw data forms and any errors detected were corrected. Irregular codes or data suspected as questionable were discussed with the observer and/or project manager. Errors, omissions, or problems identified in later stages of analysis were traced back to the raw data forms, and appropriate changes in all steps were made.

Data Compilation and Storage

A Microsoft® ACCESS database was developed to store, organize, and retrieve survey data. Data were keyed into the electronic database using a pre-defined format to facilitate subsequent QA/QC and data analysis. All data forms, field notebooks, and electronic data files were retained for reference.

Fatality Surveys

Estimates of facility-related fatalities are based on:

(1) Observed number of carcasses found during standardized searches during the monitoring year for which the cause of death is either unknown or is probably facility-related;

(2) Non-removal rates, expressed as the estimated average probability a trial carcass was expected to remain in the study area and be available for detection by the searchers; and

(3) Searcher efficiency, expressed as the proportion of trial carcasses found by searchers.

Overall fatality estimates were calculated for six categories: 1) small birds, 2) large birds, 3) diurnal raptors, 4) all birds, and 5) bats.

Definition of Variables

The following variables are used in the equations below:

c_i the number of carcasses detected at plot *i* for the study period of interest (e.g., one monitoring year), for which the cause of death was either unknown or was attributed to the facility

n the number of search plots

k the number of turbines searched (including the turbines centered within each search plot)

$\bar{c}$ the average number of carcasses observed per turbine per monitoring year

s the number of carcasses used in removal trials

s_c the number of carcasses in removal trials that remained in the study area after 40 days

- t_j the time (in days) carcass *j* remained in the study area before it was removed, as determined by the removal trials
- $\bar{t}$ the average time (in days) a carcass remained in the study area before it was removed, as determined by the removal trials
- *p* the estimated proportion of detectable carcasses found by searchers, as determined by the searcher efficiency trials
- *I* the average interval between standardized carcass searches, in days
- A proportion of the search area of a turbine actually searched
- $\hat{\pi}$ the estimated probability that a carcass was both available to be found during a search and was found, as determined by the removal trials and the searcher efficiency trials
- *m* the estimated annual average number of fatalities per turbine per year, adjusted for removal and searcher efficiency bias

Observed Number of Carcasses

The estimated average number of carcasses ($\bar{c}$) observed per turbine per monitoring year was:

$$\bar{c} = \frac{\sum_{i=1}^{n} c_i}{k \cdot A} \quad (1)$$

Estimation of Carcass Non-Removal Rates

Estimates of carcass non-removal rates were used to adjust carcass counts for removal bias. Carcass removal times from Year 3 were compared to data from Years 1 and 2 and across seasons, with data pooled for seasons and/or years where no statistical differences were detected. Mean carcass removal time ($\bar{t}$) was the average length of time a carcass remained in the study area before it is removed:

$$\bar{t} = \frac{\sum_{j=1}^{s} t_j}{s - s_c} \quad (2)$$

Estimation of Searcher Efficiency Rates

Searcher efficiency rates are expressed as *p,* the proportion of trial carcasses that were detected by searchers in the searcher efficiency trials. These rates were estimated by carcass size and season. Searcher efficiency rates in Year 3 were compared to data from Years 1 and 2 and across seasons, with data pooled for seasons and/or years where no statistical differences were detected.

Estimation of Facility-Related Fatality Rates

The estimated per turbine annual fatality rate (*m*) was calculated by:

$$m = \frac{\bar{c}}{\hat{\pi}} \quad (3)$$

where $\hat{\pi}$ included adjustments for both carcass removal (from scavenging and other means) and searcher efficiency bias. Carcass removal data were compared to prior years, across seasons, and by plot type. If not statistically different across, years, seasons, or plot types, data for carcass removal and searcher efficiency bias were pooled to estimate $\hat{\pi}$.

$\hat{\pi}$ was calculated as follows:

$$\hat{\pi} = \frac{\bar{t} \cdot p}{I} \cdot \left[\frac{\exp\left(I/\bar{t}\right) - 1}{\exp\left(I/\bar{t}\right) - 1 + p} \right]$$

This formula has been independently verified by Shoenfeld (2004). The 90% confidence intervals for reported estimates were calculated using bootstrapping (Manly 1997). Bootstrapping is a computer simulation technique that is useful for calculating point estimates, variances, and confidence intervals for complicated test statistics. For each bootstrap sample, $\bar{c}$, $\bar{t}$, p, $\hat{\pi}$, and *m* were calculated. A total of 1,000 bootstrap samples were used. The lower 5th and upper 95th percentiles of the 1,000 bootstrap estimates are estimates of the lower limit and upper limit of 90% confidence intervals.

Raptor Breeding Monitoring

The primary objective of the raptor breeding monitoring was to determine the presence or absence of raptor nests, particularly mid-sized to large raptor nests, and associated reproductive success information where possible within areas of suitable habitat in the NSR project area. Following guidance of MM 4.4-16 of the EIR (Kern County Planning Department 2011), ground-based raptor nest surveys were conducted within the project boundary during the spring 2014 breeding season. The surveys consisted of driving and/or walking throughout the study area searching for raptor nest structures within areas of suitable nesting habitat (e.g., pine and oak woodland, Joshua tree woodland, utility poles, and transmission towers). Surveys were completed monthly during the spring nesting season (March – June).

Global Positioning System coordinates were recorded for all nests of raptors or other large bird species (e.g., ravens) identified during the survey and mapped on a geographic information system (GIS) ArcGIS project utilizing US Geological Survey (USGS) topographic maps (1:24000 scale) as the base. Additionally, information was collected on species, habitat, nest substrate,

nest condition, and status. The locations of all inactive nests were also recorded as they may become active during subsequent years.

RESULTS

Avian and Bat Fatality Monitoring

Thirty search plots, representing 30% of all turbines at NSR, were searched every two weeks during the year-round standardized carcass searches, for a total of 733 plot searches. Searches were conducted at the seven additional intensive search turbines twice per week during spring migration, for a total of 140 additional plot searches. Over the course of the fatality monitoring study, 21 birds and 11 bats were found during scheduled carcass surveys (Table 1), while none were found incidentally. The number, species, location, other characteristics of the bird and bat fatalities, and the fatality estimates adjusted for searcher efficiency and carcass removal biases are discussed below, with a full listing of casualties presented in Appendix A.

Table 1. Total number of bird and bat casualties and the composition of casualties discovered at the North Sky River Wind Energy Facility from January 19, 2015 – January 12, 2016. No fatalities were found incidentally outside of search plots.

	Fatalities Found During Year-Round Scheduled Searches		Fatalities Found During Intensive Spring Searches		Total	
Species	**Total**	**% Comp.**	**Total**	**% Comp.**	**Total**	**% Comp.**
unidentified bird (small)	4	26.7	1	16.7	5	23.8
red-tailed hawk	3	20.0	2	33.3	5	23.8
American kestrel	3	20.0	0	0	3	14.3
chukar	1	6.7	0	0	1	4.8
mourning dove	1	6.7	0	0	1	4.8
northern flicker	1	6.7	0	0	1	4.8
rock pigeon	1	6.7	0	0	1	4.8
western scrub-jay	1	6.7	0	0	1	4.8
lark sparrow	0	0	1	16.7	1	4.8
loggerhead shrike	0	0	1	16.7	1	4.8
unidentified large bird	0	0	1	16.7	1	4.8
Overall Birds	**15**	**100**	**6**	**100**	**21**	**100**
Bats						
Mexican free-tailed bat	7	87.5	1	33.3	8	72.7
hoary bat	1	12.5	2	66.7	3	27.3
Overall Bats	**8**	**100**	**3**	**100**	**11**	**100**

*Fatalities found incidentally on turbine search plots were included in analyses.

Bird Fatalities

Twenty-one birds comprising seven identifiable species were found during scheduled searches (Table 1, Figure 4). The bird species most commonly found as casualties during the study were red-tailed hawk (*Buteo jamaicensis*; five carcasses) and American kestrel (*Falco sparverius*; three carcasses). All other identifiable bird species found during the study were represented by individual carcasses/feather spots (Table 1). Six of the 21 bird casualties documented during

the study were found at the seven turbines in the northeast portion of NSR that were intensively searched during the peak spring migration period, including two of the five red-tailed hawk casualties (Appendix A). No state or federally listed bird species were found during the study.

In general, casualties were more commonly found at turbines located in the northern half of NSR, including all raptor casualties (Figure 4). The greatest number of bird fatalities found at any one of the year-round search turbines was three, at Turbine 38 (Figures 4 and 5). The greatest number of bird fatalities found at any one of the seven turbines searched intensively during the spring migration period was two, at each of Turbines 2, 3, and 14 (Figure 6). No bird fatalities were found at the other four intensive spring search plots. Bird fatalities found during both year-round searches and spring intensive searches were well distributed throughout search plots (Tables 2 and 3, Figure7). At the 30 year-round search turbines, bird fatalities were more frequently discovered from late summer through early winter, with a slight peak in the fall (Figure 8). Few bird fatalities were found at the year-round search turbines from late winter through the spring (Figure 8). At the seven intensive spring search turbines, the greatest number of fatalities found per turbine search was in early June; however there were no major temporal concentrations during the spring migration period (Figure 9).

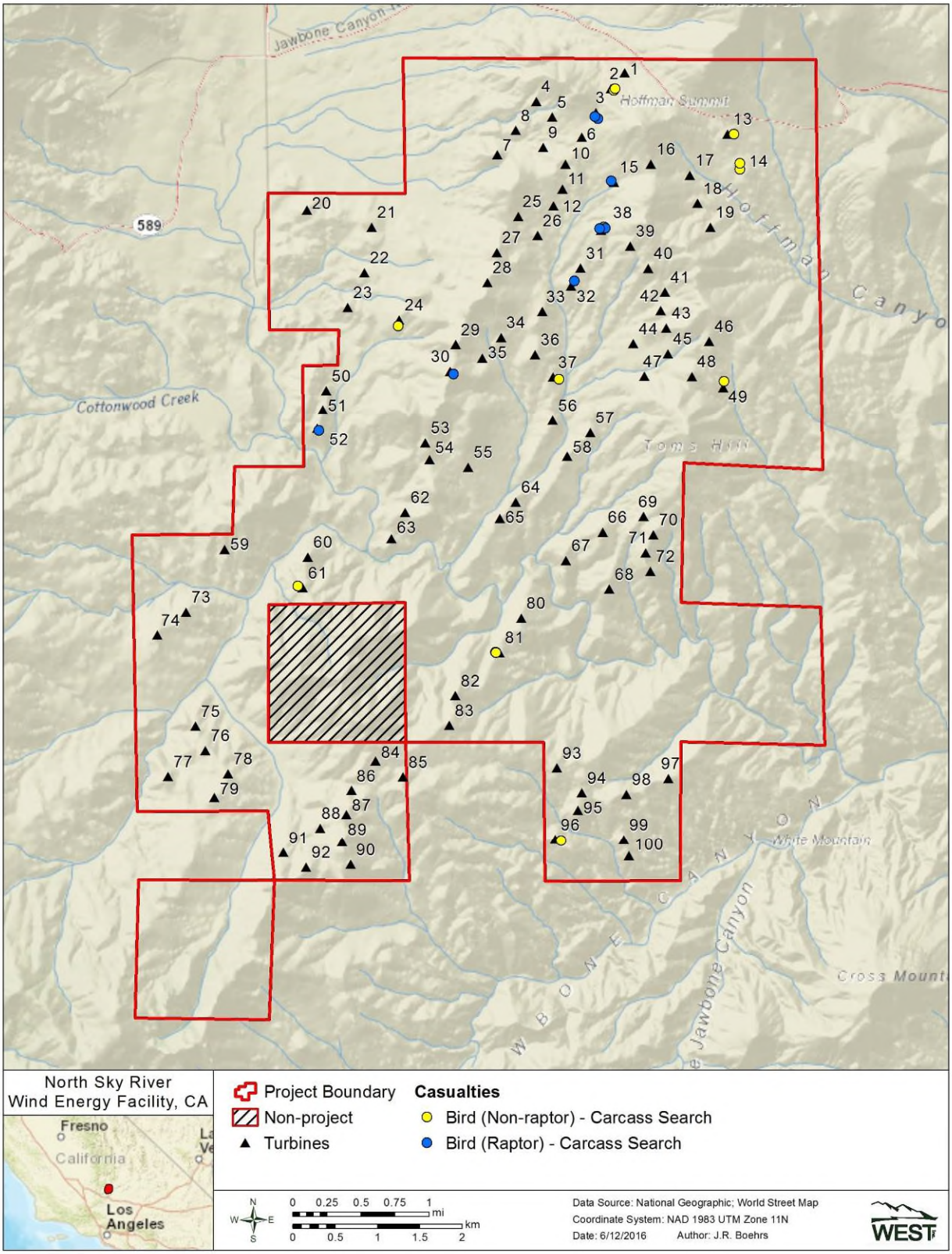

Figure 4. Location of all bird casualties found at the North Sky River Wind Energy Facility during the third year of fatality monitoring from January 19, 2015 – January 12, 2016.

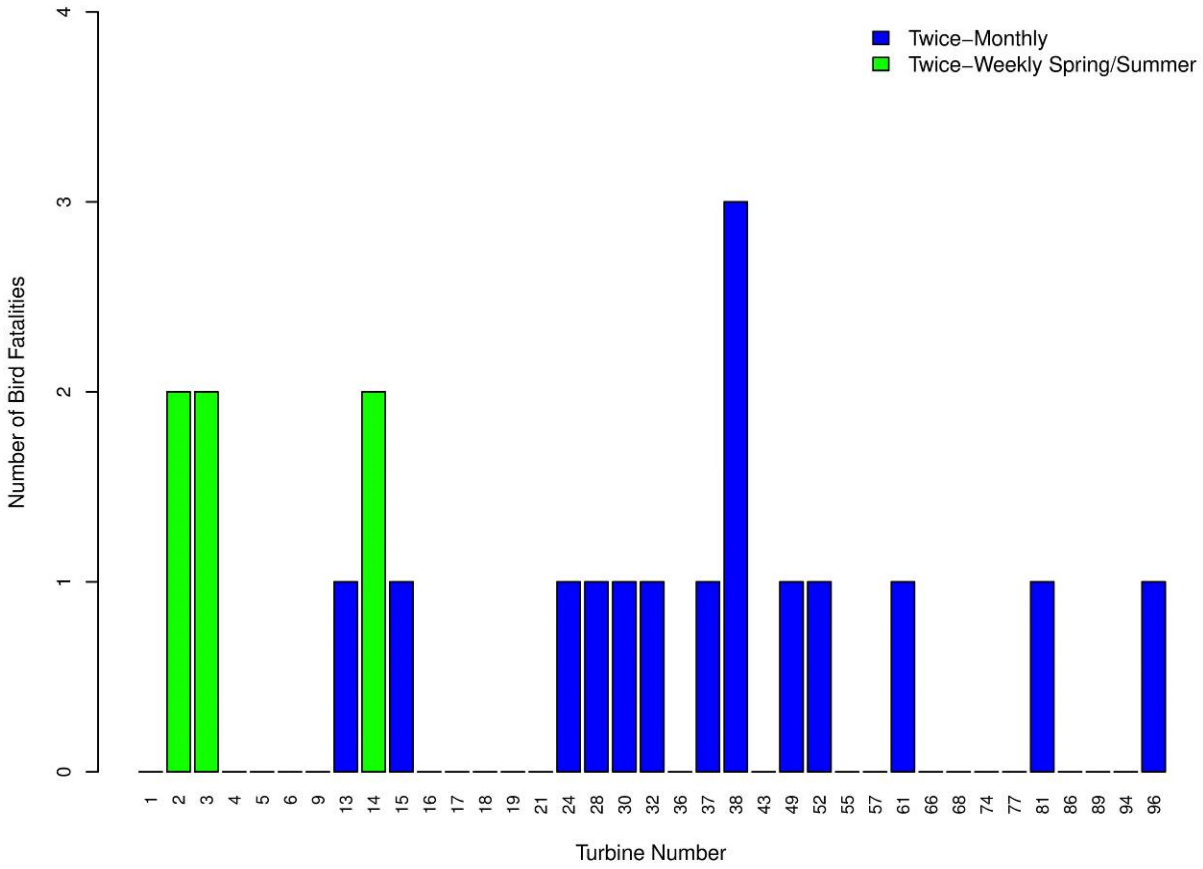

Figure 5. Number of bird fatalities found, by turbine, during scheduled searches or incidentally on search plots at the North Sky River Wind Energy Facility from searches conducted every two weeks at 30 turbines from January 19, 2015 – January 12, 2016 (shown by the blue bars), and at seven turbines searched twice per week during the spring migration period (March 31 - June 4, 2015; shown by the green bars).

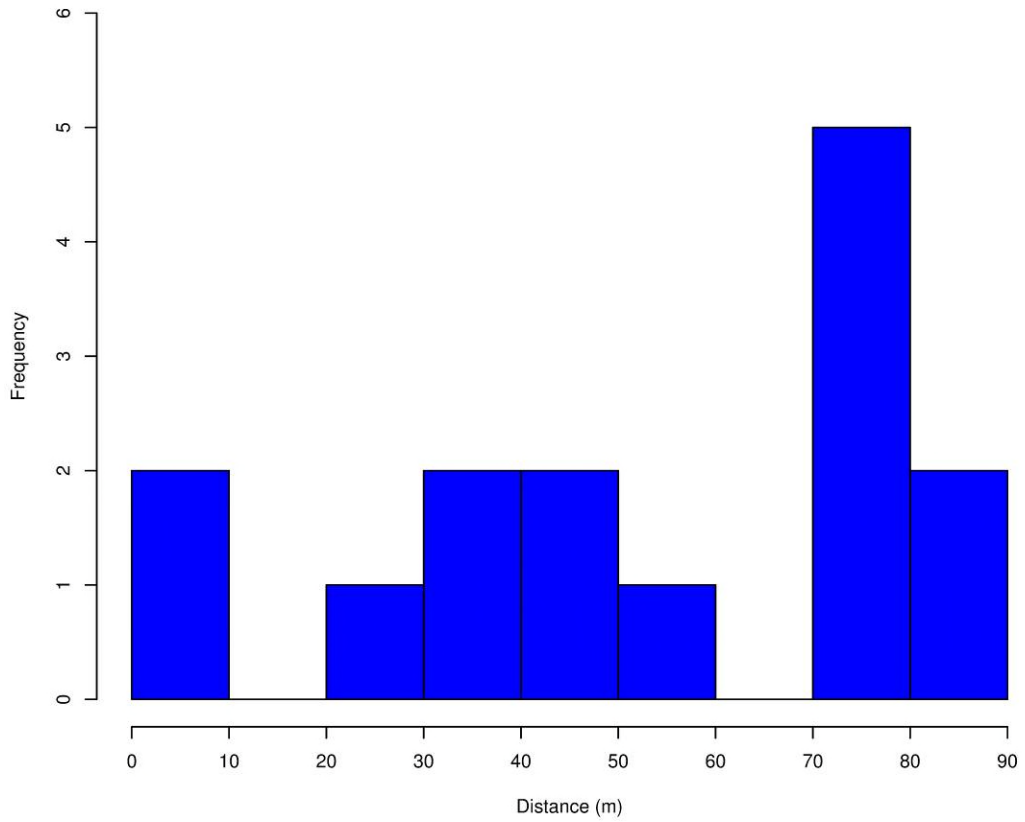

Figure 6. Distance from the turbine for bird fatalities found during scheduled searches at the North Sky River Wind Energy Facility from searches conducted every two weeks at 30 turbines from January 19, 2015 – January 12, 2016.

Table 2. Distribution of distances from turbines of bird and bat casualties found during scheduled searches or incidentally on search plots at the North Sky River Wind Energy Facility from searches conducted every two weeks at 30 turbines from January 19, 2015 – January 12, 2016.

Distance to Turbine (m)	% Bird Casualties	% Bat Casualties
0 to 10	13.3	25.0
10 to 20	0	50.0
20 to 30	6.7	0
30 to 40	13.3	12.5
40 to 50	13.3	0
50 to 60	6.7	0
60 to 70	0	12.5
70 to 80	33.3	0
80 to 90	13.3	0
> 90	0	0

Table 3. Distribution of distances from turbines of bird and bat casualties found during scheduled searches or incidentally on search plots at the North Sky River Wind Energy Facility from the seven turbines searched twice per week during the spring migration period (March 31 - June 4, 2015).

Distance to Turbine (m)	% Bird Casualties	% Bat Casualties
0 to 10	0	0
10 to 20	16.7	0
20 to 30	0	0
30 to 40	0	0
40 to 50	16.7	0
50 to 60	33.3	50.0
60 to 70	16.7	50.0
70 to 80	16.7	0
> 80	0	0

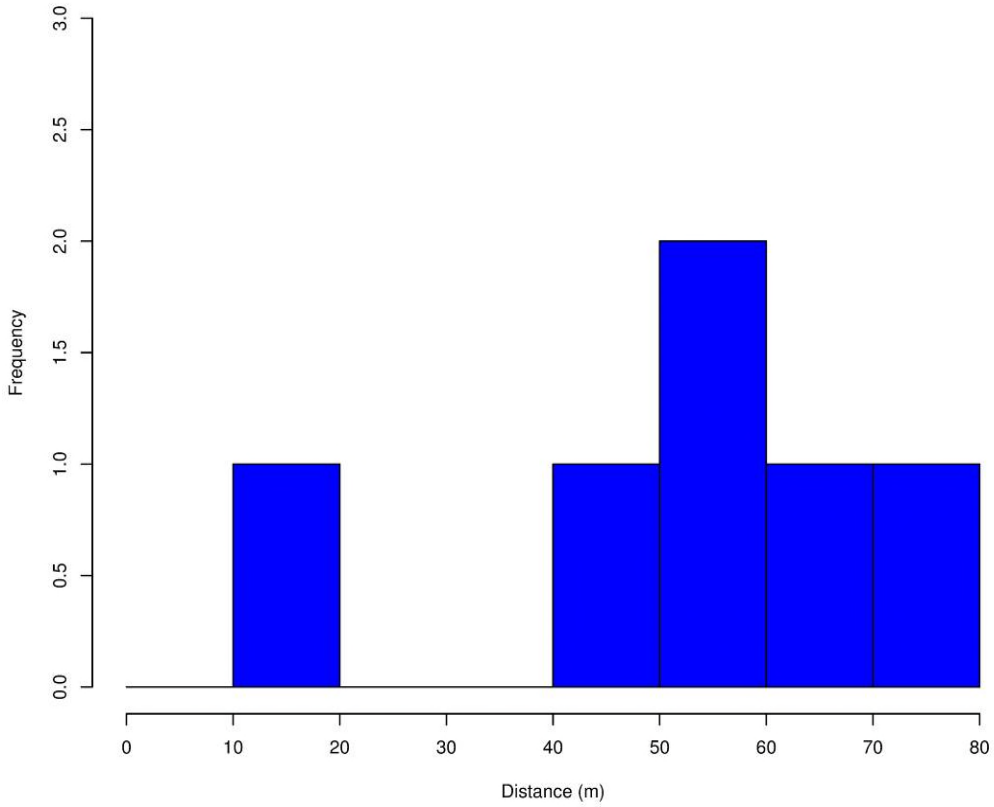

Figure 7. Distance from the turbine for bird fatalities found during scheduled searches at the North Sky River Wind Energy Facility from the seven turbines searched twice per week during the spring migration period (March 31 - June 4, 2015).

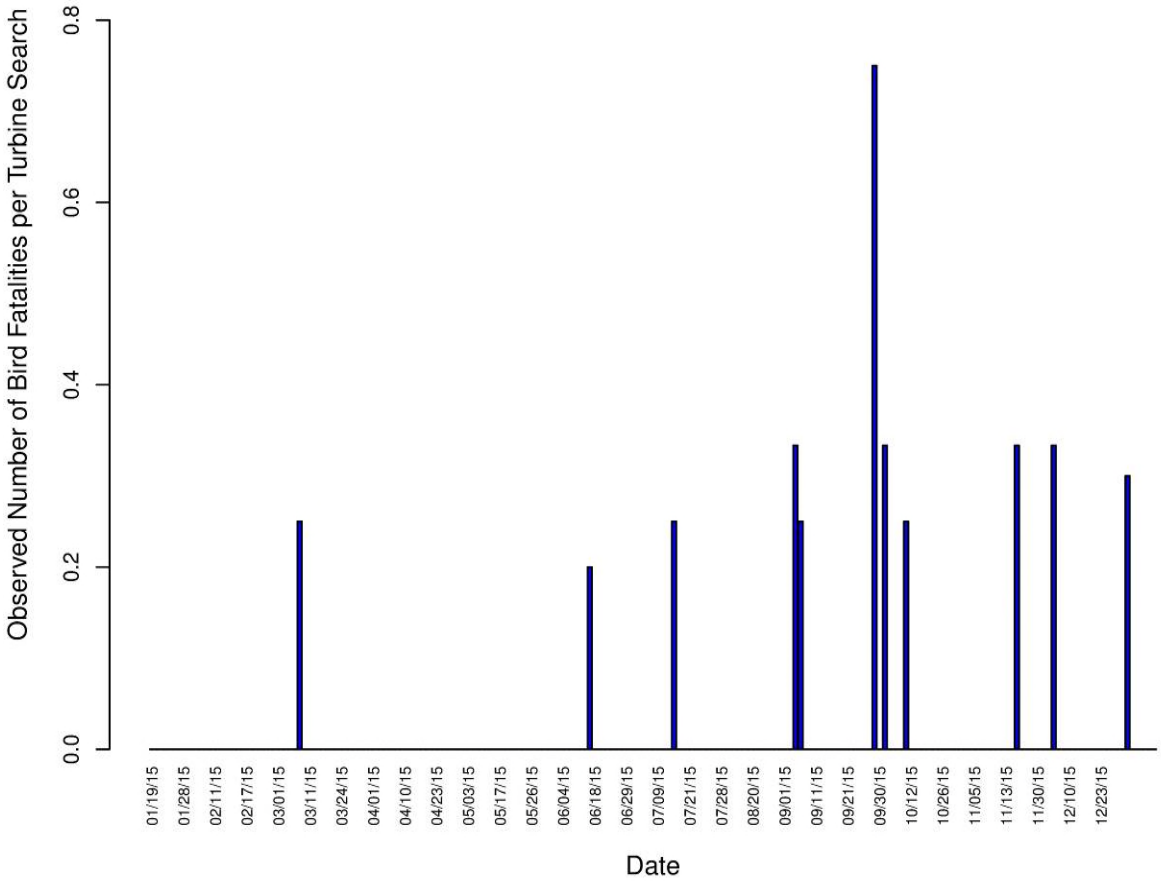

Figure 8. Timing of bird fatalities found during scheduled searches conducted every two weeks at 30 turbines in the North Sky River Wind Energy Facility from January 19, 2015 – January 12, 2016.

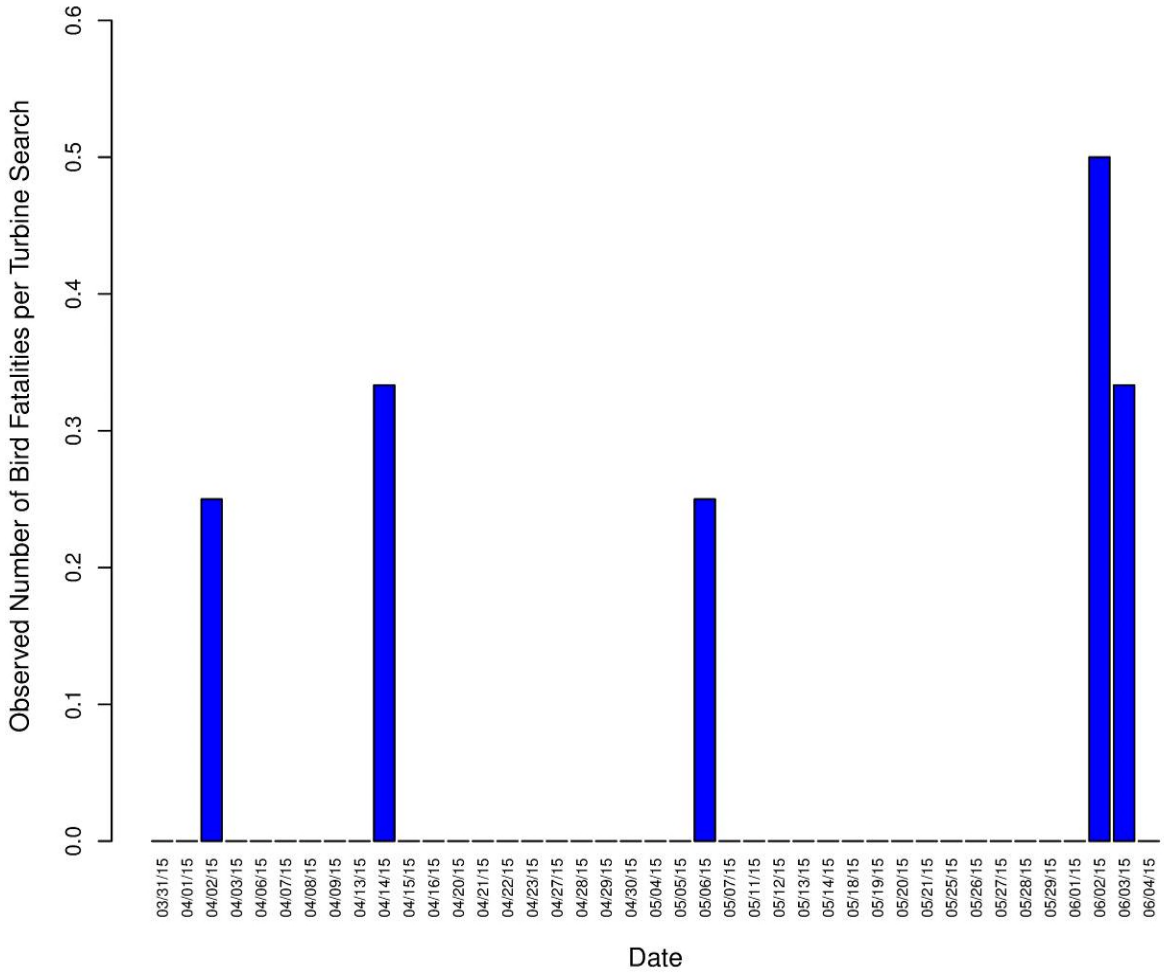

Figure 9. Timing of bird fatalities found during scheduled searches at the North Sky River Wind Energy Facility from the seven turbines searched twice per week during the spring migration period (March 31 - June 4, 2015).

Bat Fatalities

Eleven bats comprising two species were found during scheduled searches (Table 1, Figure 10). The two bat species found as fatalities during the study period were Mexican free-tailed bat (*Tadarida brasiliensis*; eight carcasses) and hoary bat (*Lasiurus cinereus;* three carcasses). Neither species is state or federally listed (CDFW 2016b), although the hoary bat appears on the California Department of Fish and Wildlife's (CDFW) Special Animals List (California Department of Fish and Wildlife [CDFW 2016a) and is protected under the California Environmental Quality Act (CEQA 1970). All bat fatalities occurred between mid-March and late September. Bat fatalities were more commonly encountered in the northern portion of the NSR project area (Figure 10). Eight bat fatalities were found at the year-round search turbines, while three were found at the seven intensive spring search turbines (Figure 11; Appendix A). Of the bat fatalities found at year-round search turbines, 75% were found within 20 m (66 ft) of search turbines (Table 2, Figure 12). One of the three bats found at the intensive spring plots was found during the clearing search and was therefore excluded from the analysis and associated

figures below. It was found 35 m (115 ft) from Turbine 3 (Appendix A). The remaining two bat fatalities found during intensive spring searches were found between 50 and 70 m (164 and 230 ft) from search turbines (Table 2). Bat fatalities were documented only in during the spring and fall seasons (Figures 13 and 14).

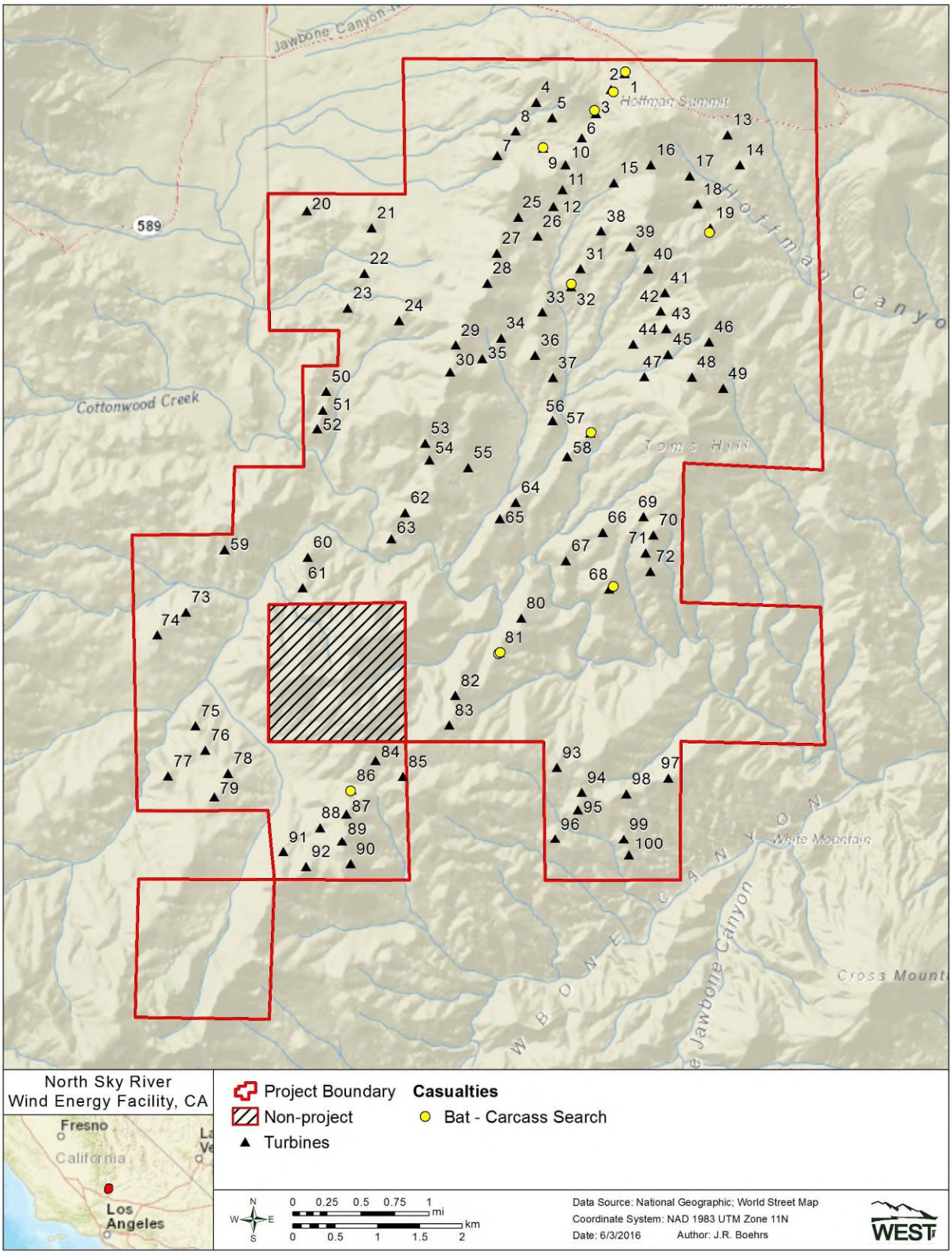

Figure 10. Location of all bat casualties found at the North Sky River Wind Energy Facility during the third year of fatality monitoring from January 19, 2015 – January 12, 2016.

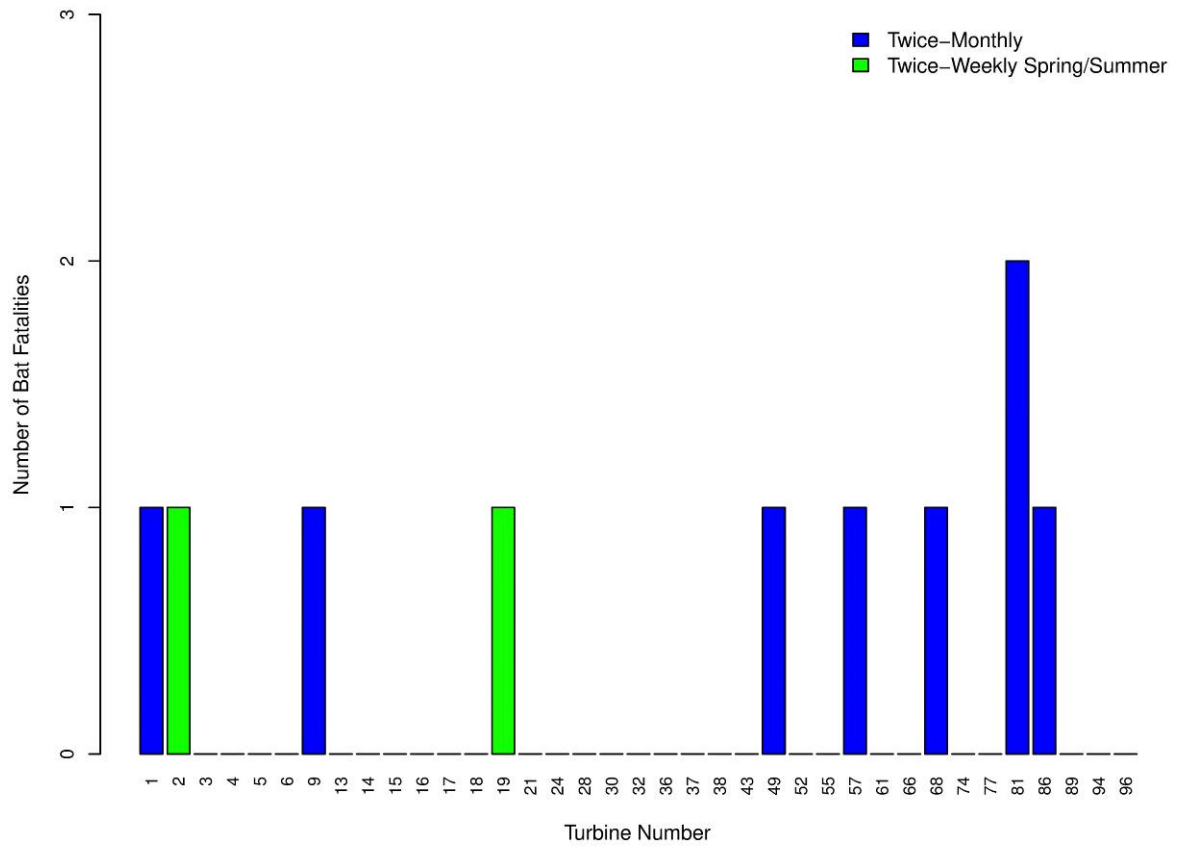

Figure 11. Number of bat fatalities found, by turbine, during scheduled searches or incidentally on search plots at the North Sky River Wind Energy Facility from searches conducted every two weeks at 30 turbines from January 19, 2015 – January 12, 2016 (shown by the blue bars), and at seven turbines searched twice per week during the spring migration period (March 31 - June 4, 2015; shown by the green bars).

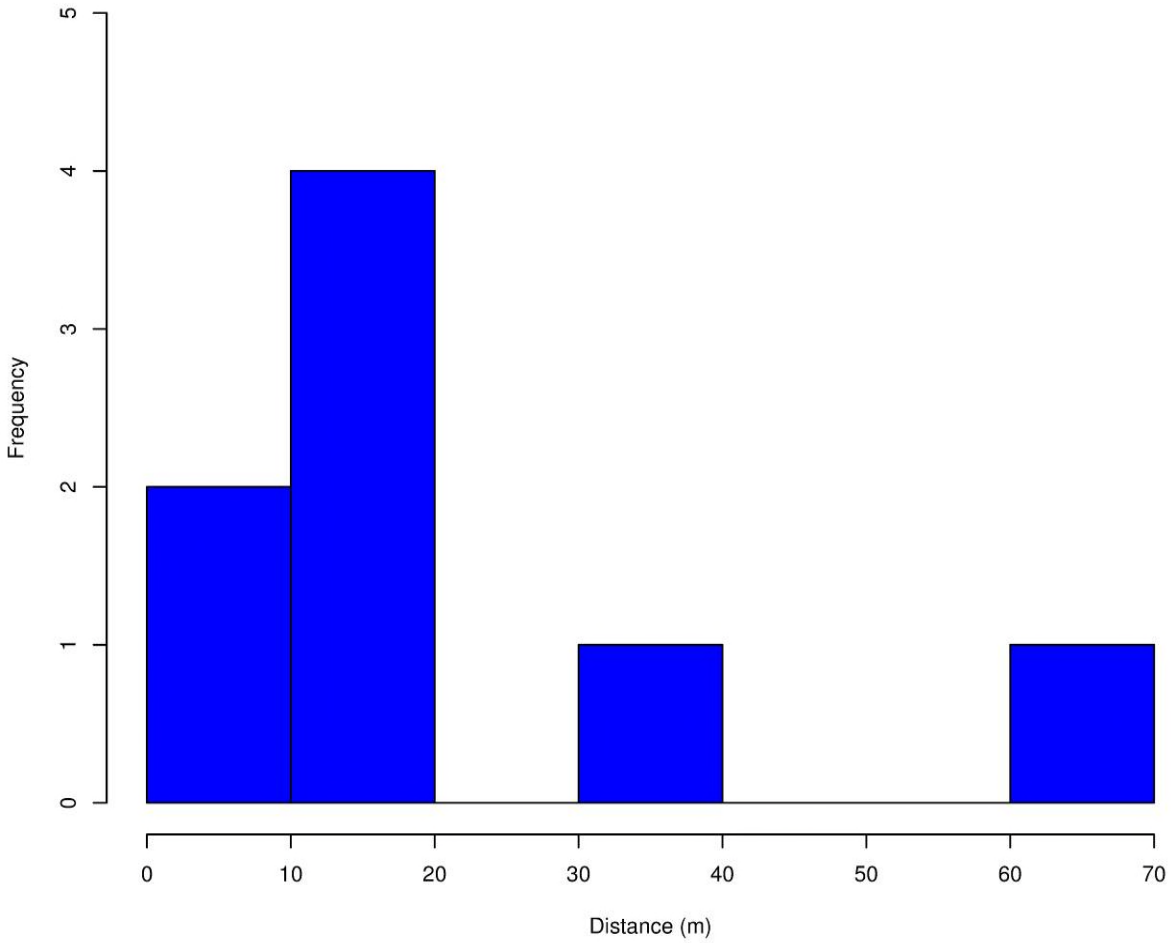

Figure 12. Distance from the turbine for bat fatalities found during scheduled searches or incidentally on search plots at the North Sky River Wind Energy Facility from searches conducted every two weeks at 30 turbines from January 19, 2015 – January 12, 2016.

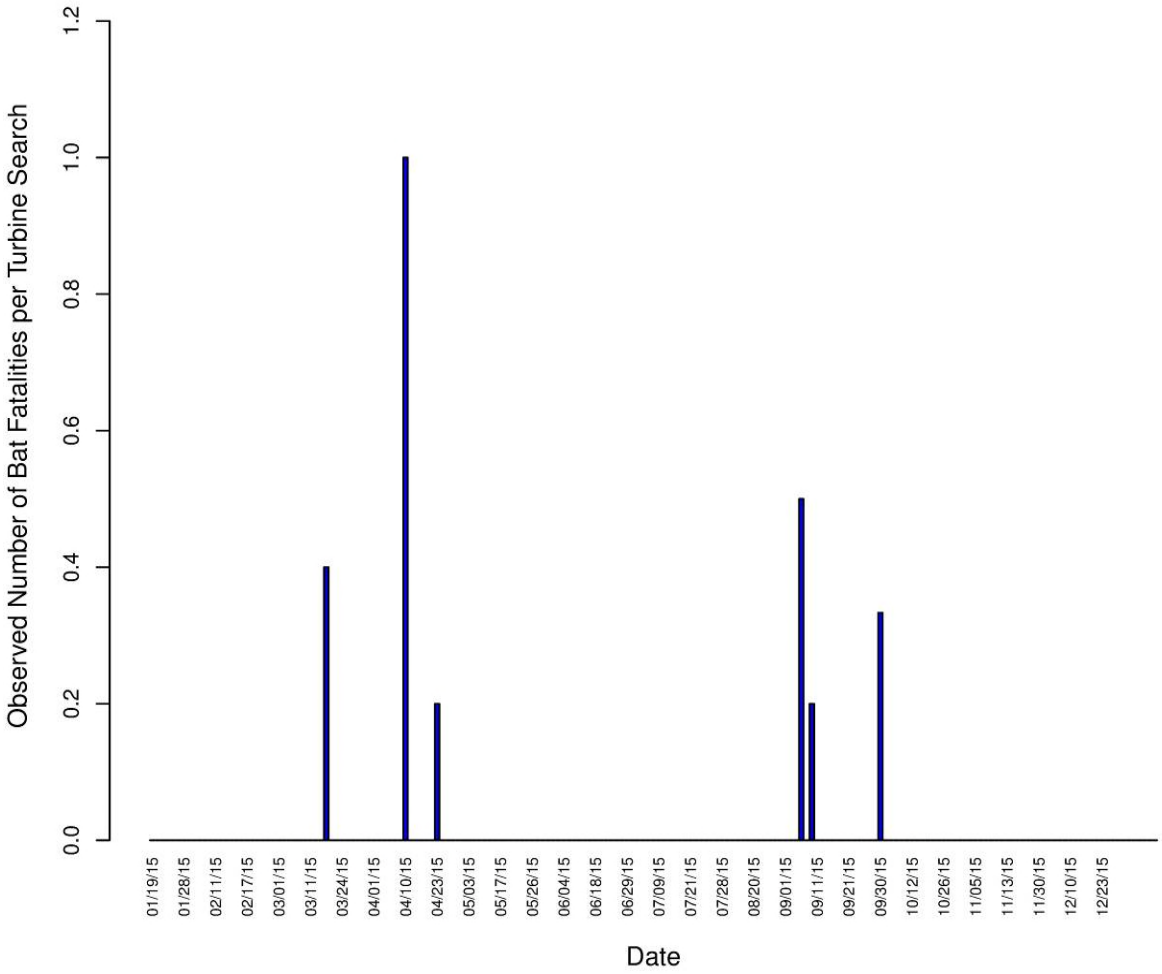

Figure 13. Timing of bat fatalities found during scheduled searches on search plots at the North Sky River Wind Energy Facility from searches conducted every two weeks at 30 turbines from January 19, 2015 – January 12, 2016.

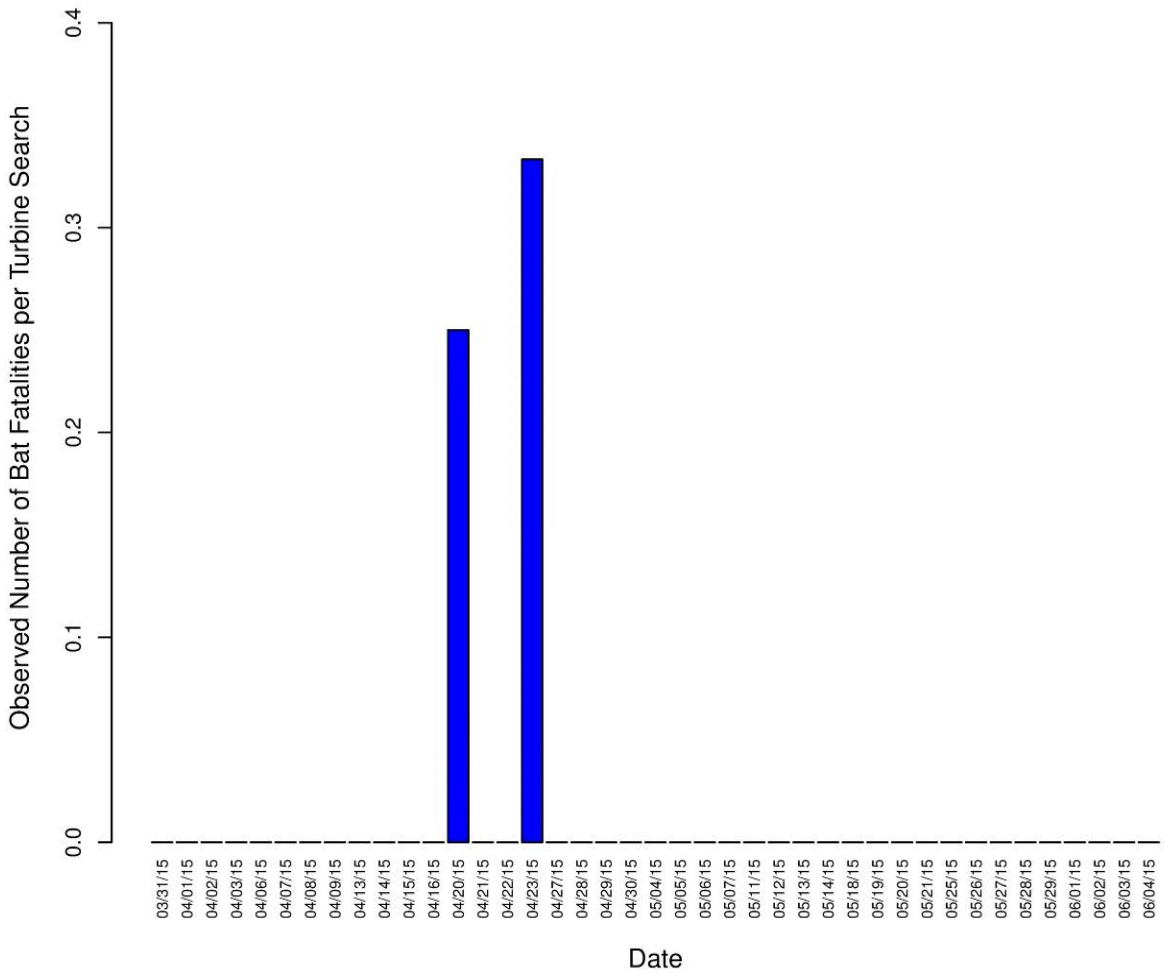

Figure 14. Timing of bat fatalities found during scheduled searches or incidentally on search plots at the North Sky River Wind Energy Facility from the seven turbines searched twice per week during the spring migration period (March 31 - June 4, 2015).

Searcher Efficiency Trials

A total of 131 carcasses (32 large birds, 76 small birds, and 23 mice [bat surrogates]) were used in searcher efficiency trials conducted on seven different dates during the Year 3 study. Searcher efficiency in Year 3 was compared across seasons and to prior years and no statistically significant differences were detected; therefore searcher efficiency data were pooled for all seasons and years to produce a single searcher efficiency estimate for each carcass size class (i.e., large bird, small bird, bat; Table 4). The overall searcher efficiency rate was 96.2% for large birds, 82.0% for small birds, and 81.7% for bats (Table 4).

Table 4. Results of trials used to estimate searcher efficiency at the North Sky River Wind Energy Facility as a function of season and carcass size. Data from Year 3 trials were pooled with data from Years 1 and 2. Mice were included in trials as surrogates for bats.

Size	Date	# Placed	# Available	# Found	% Found
Small Birds	2/19/2013	7	4	1	25.0
	5/7/2013	4	3	3	100
	6/27/2013	6	6	6	100
	8/14/2013	7	7	5	71.4
	10/1/2013	8	8	7	87.5
	11/14/2013	10	10	8	80.0
	1/10/2014	10	8	7	87.5
	2/21/2014	9	9	7	77.8
	5/9/2014	2	2	2	100
	6/10/2014	5	5	4	80.0
	8/9/2014	5	5	4	80.0
	10/30/2014	5	5	4	80.0
	1/20/2015	15	12	10	83.3
	2/6/2015	15	11	10	90.9
	4/28/2015	11	4	4	100
	6/2/2015	9	8	7	87.5
	8/25/2015	12	12	8	66.7
	8/26/2015	7	7	7	100
	11/19/2015	7	7	5	71.4
Small Bird Total		**154**	**133**	**109**	**82.0**
Large Birds	2/19/2013	6	5	5	100
	5/7/2013	7	6	5	83.3
	6/27/2013	8	8	8	100
	8/14/2013	7	7	7	100
	10/1/2013	9	9	9	100
	11/14/2013	9	9	9	100
	1/10/2014	7	7	7	100
	2/21/2014	6	5	4	80.0
	5/9/2014	6	6	6	100
	6/10/2014	5	5	5	100
	8/9/2014	2	2	2	100
	10/30/2014	5	5	5	100
	1/20/2015	6	6	5	83.3
	2/6/2015	5	5	4	80.0
	4/28/2015	4	4	4	100
	6/2/2015	6	6	6	100
	8/25/2015	4	4	4	100
	8/26/2015	2	2	2	100
	11/19/2015	5	5	5	100
Large Bird Total		**109**	**106**	**102**	**96.2**

Table 4. Results of trials used to estimate searcher efficiency at the North Sky River Wind Energy Facility as a function of season and carcass size. Data from Year 3 trials were pooled with data from Years 1 and 2. Mice were included in trials as surrogates for bats.

Size	Date	# Placed	# Available	# Found	% Found
	2/19/2013	10	10	7	70.0
	5/7/2013	4	2	1	50.0
	6/27/2013	6	6	4	66.7
	8/14/2013	8	8	8	100
	10/1/2013	8	8	7	87.5
	11/14/2013	8	8	7	87.5
	1/10/2014	7	5	5	100
Bats	2/21/2014	10	10	10	100
	5/9/2014	16	11	9	81.8
	6/10/2014	11	11	7	63.6
	8/9/2014	8	8	6	75.0
	10/30/2014	10	10	7	70.0
	8/25/2015	4	4	4	100
	8/26/2015	11	11	9	81.8
	11/19/2015	8	8	7	87.5
Bat Total		**129**	**120**	**98**	**81.7**

Carcass Removal Trials

A total of 150 carcasses (41 large birds, 96 small birds, and 13 bats) were used in carcass removal trials during the Year 3 study. Seven removal trials were conducted during the Year 3 study, with approximately 15 to 25 carcasses used in each trial. Carcass removal rates in Year 3 were compared across seasons and to prior years and no statistically significant differences were detected; therefore, trial data were pooled across seasons and years for each size class. By day 10, approximately 28% of large birds remained in the search area, while approximately 12% of small birds and bat carcasses remained. By day 30, approximately 20% of large bird carcasses remained and10% of small bird and bat carcasses persisted within the study area (Figure 15). Mean carcass removal times were 1.60 days in spring, summer, and fall, and 3.69 days in winter for small birds, and 1.97 days in spring, summer, and fall, and 3.75 days in winter for bats. The mean carcass removal time for large birds was 23.28 days and did not differ across seasons (Appendix B).

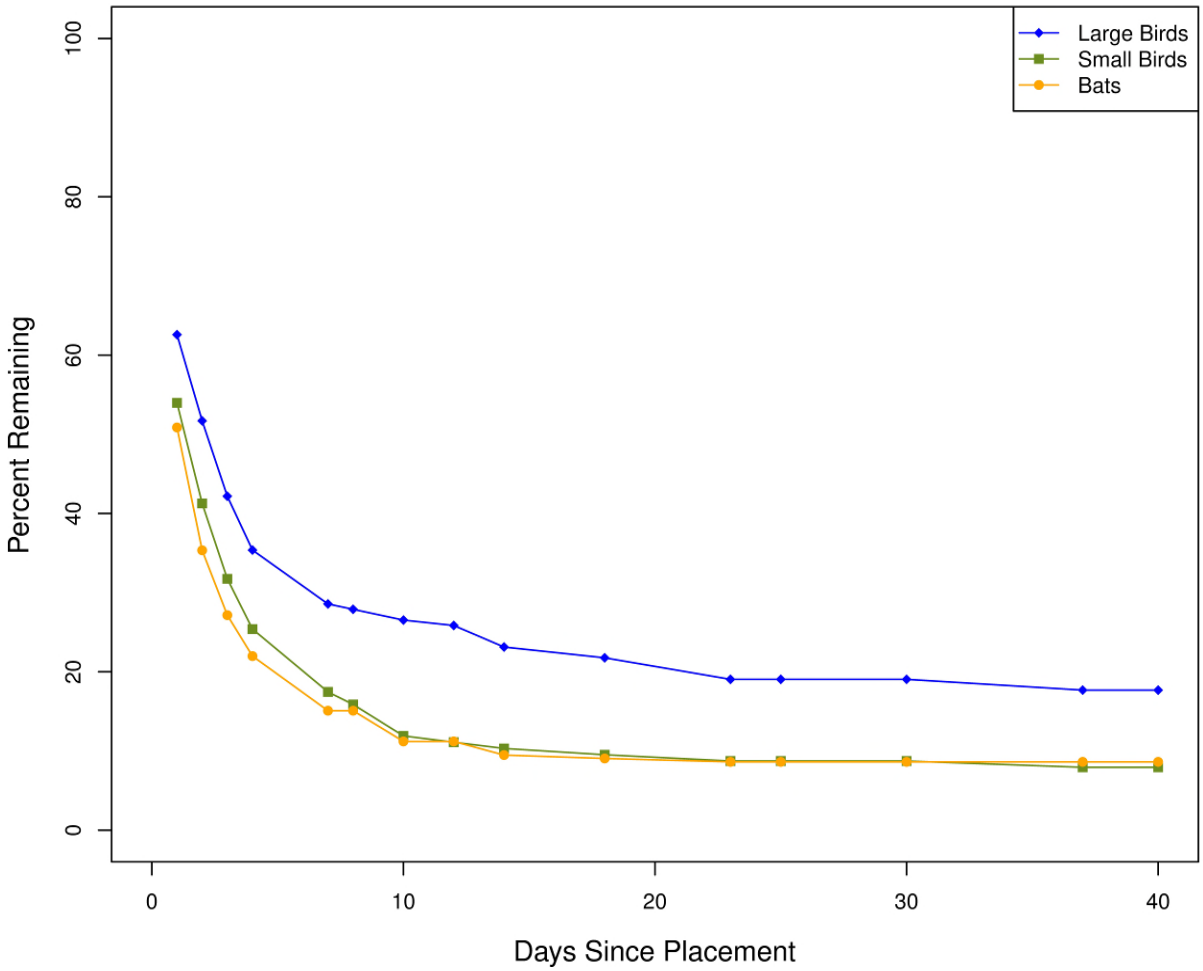

Figure 15. Carcass removal rates at the North Sky River Wind Energy Facility.

Adjusted Fatality Estimates

Overall project-wide fatality estimates and 90% confidence intervals were calculated on a per turbine and per MW basis for each bird/bat category based on the carcass searches conducted every two weeks at 30 turbines throughout the monitoring year (Table 5), as well as a seasonal fatality estimate based on the intensive searches conducted at seven turbines during spring migration (Table 6). All fatality estimates were adjusted based on the corrections for carcass removal and searcher efficiency (Appendix B). Because 100% of each search plot was surveyed, no search area correction factor was applied. At the 30 turbines searched throughout the year, the probability that a small bird would remain in the search plot and be found by a searcher was 0.09 in spring, summer, and fall, and 0.20 in winter. The probability that a bat carcass would remain in the search plot and be found by a searcher was 0.11 during spring, summer, and fall. No bats were found during winter. For large birds, the probability was considerably higher and remained the same throughout the year at 0.73 (Appendix B1). At the seven turbines searched intensively in the spring, the average probability a carcass would remain in the search plot and be found by a searcher was 0.93 for large birds, 0.35 for small birds, and 0.40 for bats (Appendix B2). It must be noted that project-wide fatality rates were

based on the sample of 30 turbines searched year-round because they were sampled based on a randomized selection process with the specific purpose of estimating the average per turbine fatality rate across the entire NSR project area. Per turbine fatality rates at the seven intensively searched turbines only represent the fatality rate of those seven turbines during the specified study period and cannot be extrapolated to the project as a whole.

Table 5. Adjusted annual bird and bat fatality estimates for the North Sky River Wind Energy Facility from searches conducted every two weeks at 30 turbines from January 19, 2015 – January 12, 2016. For more details concerning correction factors and confidence intervals for both bird and bat fatality estimates, refer to Appendix B1.

	Adjusted Overall Fatality Estimate and 90% Confidence Intervals	
	Mean	**CI**
	# fatalities/turbine/year	
small birds	0.70	0.13 – 1.54
large birds	0.46	0.19 – 0.74
diurnal raptors	0.27	0.10 – 0.50
all birds	1.16	0.48 – 2.04
bats	2.42	1.12 – 4.33
	# fatalities/MW/year	
small birds	0.44	0.08 – 0.96
large birds	0.29	0.12 – 0.46
diurnal raptors	0.17	0.06 – 0.31
all birds	0.72	0.30 – 1.27
bats	1.51	0.70 – 2.71

Table 6. Adjusted seasonal bird and bat fatality estimates for the seven turbines searched twice per week during the spring migration period (March 31 - June 4, 2015) at the North Sky River Wind Energy Facility. For more details concerning correction factors and confidence intervals for both bird and bat fatality estimates, refer to Appendix B2.

	Adjusted Overall Fatality Estimate and 90% Confidence Intervals	
	Mean	**CI**
	# fatalities/turbine/study period	
small birds	1.23	--
large birds	0.46	--
diurnal raptors	0.31	--
all birds	1.69	--
bats	0.71	--
	# fatalities/MW/study period	
small birds	0.77	--
large birds	0.29	--
diurnal raptors	0.19	--
all birds	1.06	--
bats	0.44	--

Small Birds

The estimated fatality rate for small birds, based on the 30 year-round search turbines, was 0.37 birds per turbine for the combined spring/summer/fall period and 0.33 during the winter (Appendix B1). Combining all seasons, the overall estimated small bird fatality rate was 0.70 birds/turbine/year (Table 5: Appendix B1). The small bird fatality rate at the seven turbines

searched during spring migration was 1.23 birds/turbine/study period (Table 6: Appendix B2). A detailed breakdown of small bird fatality rates and the associated correction factors is presented in Appendix B.

Large Birds

The estimated fatality rate for large birds, based on the 30 year-round search turbines, was 0.46 birds/turbine/year (Table 5; Appendix B1). The large bird fatality rate at the seven turbines searched during spring migration was 0.46 birds/turbine/study period (Table 6; Appendix B2). A detailed breakdown of large bird fatality rates and the associated correction factors is presented in Appendix B.

Diurnal Raptors

The estimated fatality rate for diurnal raptors, based on the 30 year-round search turbines, was 0.27 diurnal raptors/turbine/year (Table 5; Appendix B1). The diurnal raptor fatality rate at the seven turbines searched intensively during spring migration was 0.31 diurnal raptors/turbine/study period (Table 6; Appendix B2). A detailed breakdown of diurnal raptor fatality rates and the associated correction factors is presented in Appendix B.

All Birds

The overall estimated fatality rate for all birds was 1.16 birds/turbine/year (Table 5; Appendix B1). The estimated annual fatality rate for all bird species at turbines searched intensely in spring was 1.69 birds/turbine/study period (Table 6; Appendix B2).

Bats

The estimated fatality rate for bats was 2.42 bats per turbine for the combined spring/summer/fall period and zero in winter (Appendix B1). Combining all seasons, the estimated annual bat fatality rate was 2.42 bats/turbine/year (Table 5; Appendix B1). The bat fatality rate at the seven turbines searched intensively during spring migration was 0.71 bats/turbine/study period (Table 6; Appendix B2). A detailed breakdown of bat fatality rates and the associated correction factors is presented in Appendix B.

Overall Fatality Estimates

Using the data collected during standardized searches conducted year-round at 30 of the 100 turbines at NSR, overall annual fatality rates were calculated for NSR on a per MW basis based on the 1.6-MW capacity the turbines. The estimated per MW fatality rates were 0.44 small birds/MW/year, 0.29 large birds/MW/year, 0.17 diurnal raptors/MW/year, and 1.51 bats/MW/year. The estimated fatality rate for all birds (both size classes combined) was 0.72 birds/MW/year (Table 5).

Raptor Breeding Monitoring

Raptor nest surveys were conducted throughout the NSR project area in March, April, May, and June 2015. A total of eight active nests were located during surveys including two great horned owl (*Bubo virginianus*) nests, two red-tailed hawk nests, and four

common raven (*Corvus corax*) nests (Figure 16). A total of 21 inactive raptor/raven nests were also observed within the NSR project area during surveys. The great-horned owl nests and the red-tailed hawk nests successfully fledged young. Two of the common raven nests fledged young and the success of the remaining two raven nests was undetermined.

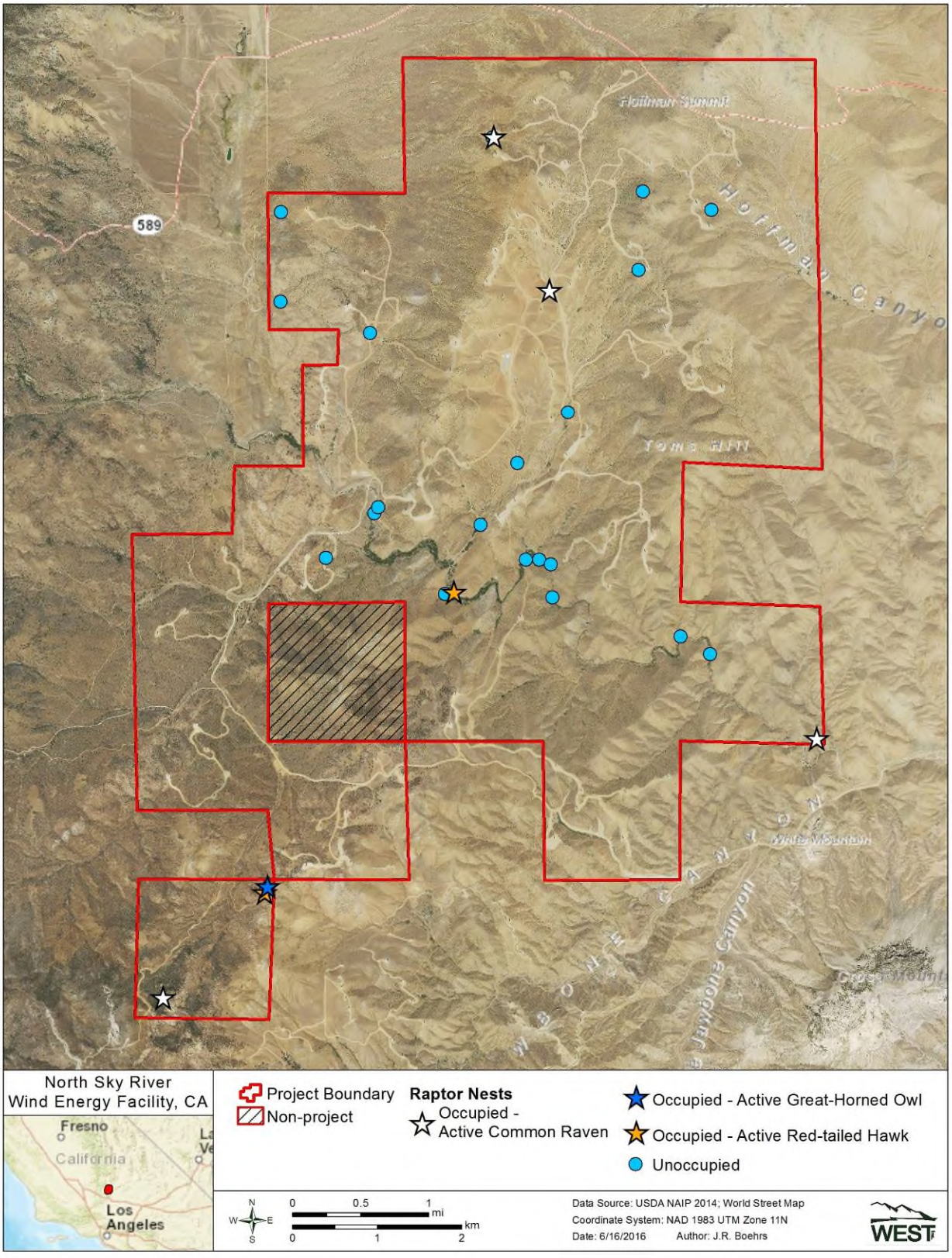

Figure 16. Raptor nests identified at the North Sky River Project in 2015.

DISCUSSION AND IMPACT ASSESSMENT

The approach used for calculating adjusted fatality estimates is consistent with the approach outlined by Shoenfeld (2004) and Erickson (2006), and accounted for search interval, searcher efficiency rates, and carcass removal rates. This approach is consistent with the analytical methods used in Year 1 and Year 2 monitoring at NSR, therefore it allows for year to year comparisons useful in assessing annual variation in fatality rates.

There are numerous factors that could contribute to both positive and negative biases in estimating fatality rates (Erickson 2006). The overall design of this study incorporated several assumptions or factors that could affect the results of the fatality estimates. First, all bird casualties found within the standardized search plots during the study were included in the analysis. Second, it was assumed that all carcasses found during the study were a result of collision with wind turbines, while the true cause of death is unknown for most of the fatalities. It is possible that some of the bird fatalities were caused by predators, and some of the casualties included in the data pool were potentially due to natural causes (i.e., background mortality). However, it is less likely that any bat fatalities were due to factors unrelated to interaction with wind turbines.

There are some other potential negative biases. For example, no adjustments were made for fatalities possibly occurring outside of the circular plot boundaries. Plot boundaries were established at a distance of 80 m from the turbines based on results of other studies (Higgins et al. 1996; Erickson et al. 2004; Johnson et al. 2002b, 2003b, 2004; Kerlinger et al. 2007; Young et al. 2003c, 2005) which indicate that a distance equal to the approximate height of the turbine appeared to capture a very large percentage of fatalities. The plot size exceeded that recommended in the California Wind Energy Guidelines (CEC and CDFG 2007), which is a minimum plot width equal to the maximum rotor tip height, which would have been a plot diameter of approximately 65 m for the turbines at NSR. Based on the distribution of fatalities as a function of distance from turbines (Figures 6, 7, and 12), a small percentage of bird and bat fatalities possibly fell outside the search plots and may have been missed. This factor would lead to an underestimate of fatality rates.

Other potential biases are associated with the experimental carcasses used in searcher efficiency and carcass removal trials and whether or not they were representative of actual carcasses. This may occur if the types of birds used are larger or smaller than the carcasses of fatalities, more or less cryptic in color than the actual fatalities. It is generally not practical or feasible to obtain many of the native bird and bat species in fresh condition for these trials. A variety of bird species (e.g., rock pigeon, mallard, Coturnix quail, and house sparrows) were used to represent the range of bird fatalities expected. It is believed that this range captures the range of sizes and other characteristics of actual fatalities and should be a reasonable representation of scavenging rates of the birds as a group. Additionally, small birds (house sparrows and juvenile Coturnix quail) were used to estimate searcher efficiency and carcass removal rates for bats during Years 1 and 2. During Year 3, a limited number of bats were used

in carcass removal trials, while dark colored mice which were used as surrogates for bats in searcher efficiency trials. Trial data were compared across seasons and years, and pooled when trial results were not statically different, bolstering sample sizes and overall data quality.

Concern has also been raised regarding how the number of carcasses placed in the field for carcass removal trials on a given day could lead to biased estimates of scavenging rates (e.g., Smallwood 2007, Smallwood et al. 2010). Hypothetically, this would lead to underestimating true scavenging rates if the scavenger densities were low enough such that scavenging rates for trial carcasses were lower than for actual fatalities. The logic is that if the trials were based on too many carcasses on a given day, scavengers were unable to access all trial carcasses, whereas they could access all wind turbine collisions. If this was the case, and the trial carcass density was much greater than actual turbine fatality density, the trials would underestimate scavenging rates.

There are inherent biases that exist under certain conditions in the models used to estimate fatalities; the Shoenfeld estimator included (Huso 2011). In particular, when carcass counts are low (e.g., less than five carcasses), regardless of turbine sample size, estimates and confidence intervals can be unstable and must be interpreted with caution (Korner-Nievergelt et al. 2011). Since all size class and season factor combinations resulted in less than five carcasses, adjusted fatality estimates by size and season should be interpreted with caution (Appendix B1). Overall estimates by size class were based on more than five carcasses (with the exception of large birds, with four carcasses); thus, overall estimates should be less affected by effects from low carcass counts.

Bird Fatalities

Overall bird fatality estimates at wind energy facilities across North America have ranged from 0.08 to 17.44 birds/MW/year (Appendix C1; Figure 17). In California, bird fatality rates have ranged from 0.55 to 17.44 birds/MW/year (Appendix C1). Within the Tehachapi Wind Resource Area (TWRA), mortality data are currently available from only two modern facilities: the Pine Tree Wind Farm (Pine Tree), located immediately to the south of NSR, and Alta Wind (consisting of Phases I-IV), located approximately 20 miles (32 km) to the southwest of NSR. During an 18-month study at Pine Tree in 2009-2011, the estimated avian fatality rate was 17.44 birds/MW/year (BioResource Consultants [BRC] 2012). Though, if approximately 131 of 167 fatalities were attributed to predation, as was the case in the Pine Tree report (BRC 2012), the fatality rate would become 3.76 birds/MW/year. While some fatalities were undoubtedly due to predation events, it can be very difficult to determine which fatalities those were, and the more conservative assumption is typically made in reporting that fatalities are due to the presence of the wind farm, whether the deaths were due to collision with turbines or not. During the initial year of monitoring at Alta Wind in 2011-2012, Phase I (Alta I) had an estimated fatality rate of 7.07 birds/MW/year, while the adjacent Phases (Alta II-V) had an estimated fatality rate of 1.66 birds/MW/year (Chatfield et al. 2012). The estimated annual bird fatality rate at NSR (0.72 birds/MW/year; Table 5) was low compared to other wind energy facilities in western North America (Appendix C1), as well other facilities within the TWRA, and it is lower than the fatality rate estimated during the first and second years of study at NSR (2.05 and 1.23 birds/MW/year,

respectively [Figure 17, Appendix C1]). During the Year 3 study at NSR, 13 (62%) of the 21 bird fatalities found during the study were large birds. Of these, eight were diurnal raptors (five red-tailed hawks and three American kestrels). Small birds accounted for only 38% of all bird fatalities found during the study (Appendix A). This was similar to the results of Year 1 study results at NSR, as well as the results reported for Pine Tree (BRC 2012) and Alta Wind (Chatfield et al. 2012), but contrary to the Year 2 results at NSR, when small birds accounted for 57% of the documented bird fatalities (Levenstein and Riser-Espinoza 2015).

In general, fatalities were more commonly found at turbines located in the northern half of NSR; however, no specific areas of concentrated mortality were observed during the study. At the seven turbines in the northeast corner of NSR that were searched intensively during spring due to concerns regarding impacts to nocturnally migrating passerines, six bird fatalities were found: two red-tailed hawks, the remains of an unidentified large bird, one loggerhead shrike (*Lanius ludovicianus*), one lark sparrow (*Chondestes grammacus*), and the remains of one unidentified small bird. The fatality rate calculated for these seven turbines was 1.06 birds/MW/study period (Table 6). While bird fatalities were documented in all seasons during the year-round study of 30 turbines, they were more frequently found in the fall (see Figure 8).

Diurnal raptor fatality estimates at wind energy facilities throughout North America have ranged from zero to 1.06 raptors/MW/year, with the highest fatality estimates being reported in California (Figure 18, Appendix C2). At the nearby Alta Wind facility in the TWRA during 2011 – 2012 studies, Alta I had a diurnal raptor fatality estimate of 0.27 raptors/MW/year and Alta II-V had an estimate of 0.05 raptors/MW/year during a 2011 – 2012 study (Chatfield et al. 2012), while during 2013 – 2014 studies, Alta I-V had an estimate of 0.08 raptors/MW/year (Chatfield et al. 2014) and Alta VIII had an estimate of 0.02 raptors/MW/year (Chatfield and Bay 2014). While a raptor fatality estimate was not calculated for Pine Tree, out of a total of 171 bird fatalities documented during the 17-month study, only four were diurnal raptors (one American kestrel and three golden eagles [*Aquila chrysaetos*]; BRC 2012). The overall raptor fatality rate at NSR (0.17 raptors/MW/year; Table 5) was higher than the estimated fatality rate during the first (2013 – 2014; 0.05 raptors/MW/year; Levenstein et al. 2014) and second years of monitoring (2014 – 2015; 0.07 raptors/MW/year; Levenstein and Riser-Espinoza 2015), but still lower than that reported for 15 other studies at wind energy facilities in California and the Pacific Northwest region (Figure 18). Overall, raptor fatality rates at NSR for the three years of monitoring have been average to low compared to other facilities in California and the Pacific Northwest (Figure 18).

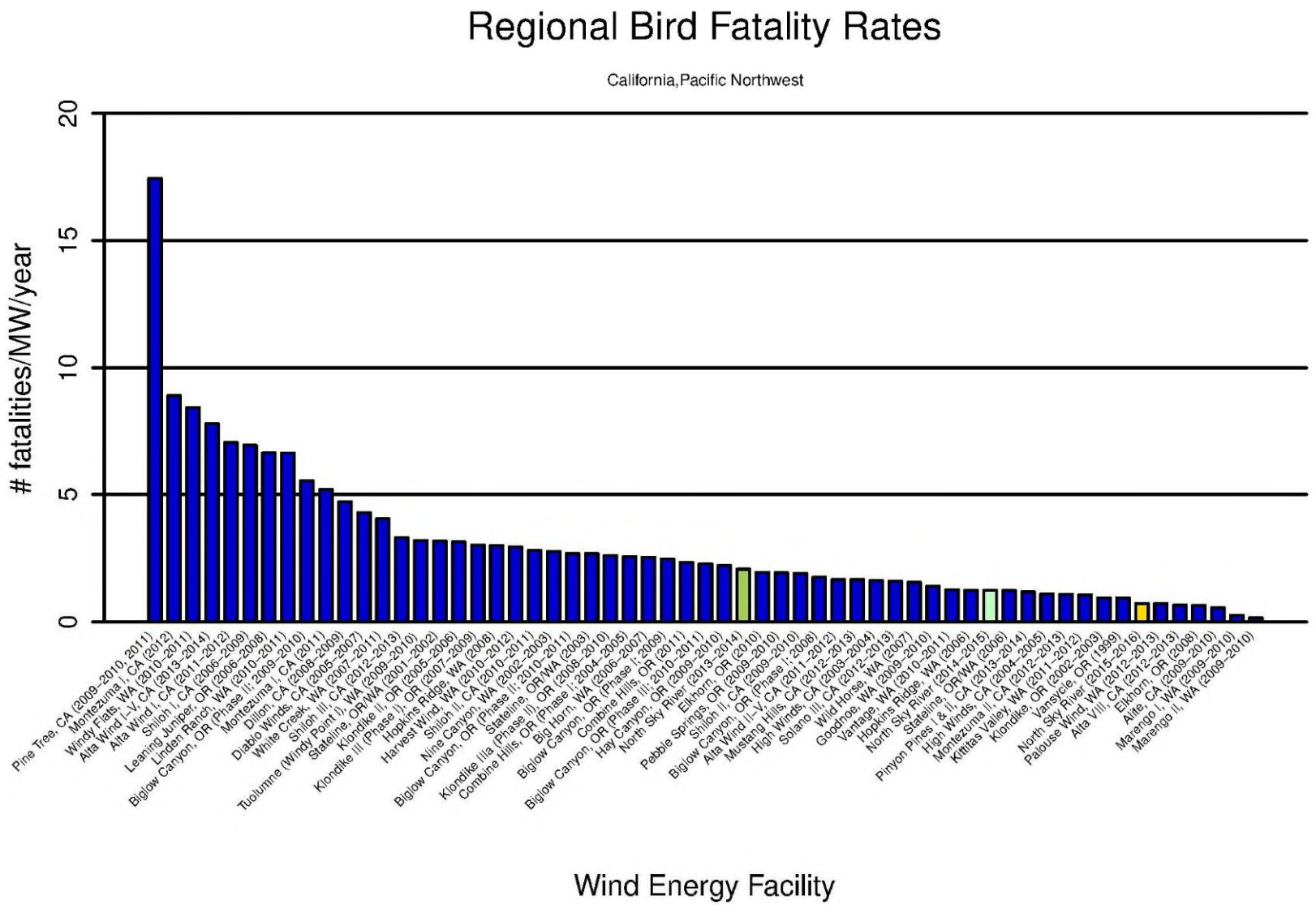

Figure 17. Fatality rates for all birds (number of birds per MW per year) at the North Sky River Wind Energy Facility compared with rates at publicly-available studies at wind energy facilities in California and the Pacific Northwest. Results for the first year of fatality monitoring (2013-2014) are indicated in green, results for the second year of fatality monitoring (2014-2015) are indicated in teal, and results for the third year (2015-2016) are indicated in yellow.

Figure 17 (*continued*). Fatality rates for all birds (number of birds per MW per year) at the North Sky River Wind Energy Facility compared with rates at publicly-available studies at wind energy facilities in California and the Pacific Northwest.

Data from the following sources:

Wind Energy Facility	Reference	Wind Energy Facility	Reference	Wind Energy Facility	Reference
North Sky River, CA (15)	This study.				
North Sky River, CA (14)	Levenstein and Riser-Espinoza 2015				
North Sky River, CA (13)	Levenstein et al. 2014				
Pine Tree, CA (09-10, 11)	BioResource Consultants 2012	Harvest Wind, WA (10-12)	Downes and Gritski 2012a	Solano III, CA (12-13)	AECOM 2013
Montezuma I, CA (12)	ICF International 2013	Shiloh II, CA (10-11)	Kerlinger et al. 2013a	Wild Horse, WA (07)	Erickson et al. 2008
Windy Flats, WA (10-11)	Enz et al. 2011	Nine Canyon, WA (02-03)	Erickson et al. 2003a	Goodnoe, WA (09-10)	URS Corporation 2010a
Alta Wind I-V, CA (13-14)	Chatfield et al. 2014	Biglow Canyon, OR (Phase II; 10-11)	Enk et al. 2012b	Vantage, WA (10-11)	Ventus Environmental Solutions 2012
Alta Wind I, CA (11-12)	Chatfield et al. 2012	Stateline, OR/WA (03)	Erickson et al. 2004	Hopkins Ridge, WA (06)	Young et al. 2007
Shiloh I, CA (06-09)	Kerlinger et al. 2009	Klondike IIIa (Phase II), OR (08-10)	Gritski et al. 2011	Stateline, OR/WA (06)	Erickson et al. 2007
Leaning Juniper, OR (06-08)	Gritski et al. 2008	Combine Hills, OR (Phase I; 04-05)	Young et al. 2006	Pinyon Pines I & II, CA (13-14)	Chatfield and Russo 2014
Linden Ranch, WA (10-11)	Enz and Bay 2011	Big Horn, WA (06-07)	Kronner et al. 2008	High Winds, CA (04-05)	Kerlinger et al. 2006
Biglow Canyon, OR (Phase II; 09-10)	Enk et al. 2011a	Biglow Canyon, OR (Phase I; 09)	Enk et al. 2010	Montezuma II, CA (12-13)	Harvey & Associates 2013
Montezuma I, CA (11)	ICF International 2012	Combine Hills, OR (11)	Enz et al. 2012	Kittitas Valley, WA (11-12)	Stantec Consulting Services 2012
Dillon, CA (08-09)	Chatfield et al. 2009	Biglow Canyon, OR (Phase III; 10-11)	Enk et al. 2012a	Klondike, OR (02-03)	Johnson et al. 2003b
Diablo Winds, CA (05-07)	WEST 2006, 2008	Hay Canyon, OR (09-10)	Gritski and Kronner 2010a	Vansycle, OR (99)	Erickson et al. 2000a
White Creek, WA (07-11)	Downes and Gritski 2012b	Elkhorn, OR (10)	Enk et al. 2011b	Palouse Wind, WA (12-13)	Stantec 2013a
Shiloh III, CA (12-13)	Kerlinger et al. 2013b	Pebble Springs, OR (09-10)	Gritski and Kronner 2010b	Alta VIII, CA (12-13)	Chatfield and Bay 2014
Tuolumne (Windy Point I), WA (09-10)	Enz and Bay 2010	Shiloh II, CA (09-10)	Kerlinger et al. 2010, 2013a	Elkhorn, OR (08)	Jeffrey et al. 2009b
Stateline, OR/WA (01-02)	Erickson et al. 2004	Biglow Canyon, OR (Phase I; 08)	Jeffrey et al. 2009a	Alite, CA (09-10)	Chatfield et al. 2010
Klondike II, OR (05-06)	NWC and WEST 2007	Alta Wind II-V, CA (11-12)	Chatfield et al. 2012	Marengo I, WA (09-10)	URS Corporation 2010b
Klondike III (Phase I), OR (07-09)	Gritski et al. 2010	Mustang Hills, CA (12-13)	Chatfield and Bay 2014	Marengo II, WA (09-10)	URS Corporation 2010c
Hopkins Ridge, WA (08)	Young et al. 2009c	High Winds, CA (03-04)	Kerlinger et al. 2006		

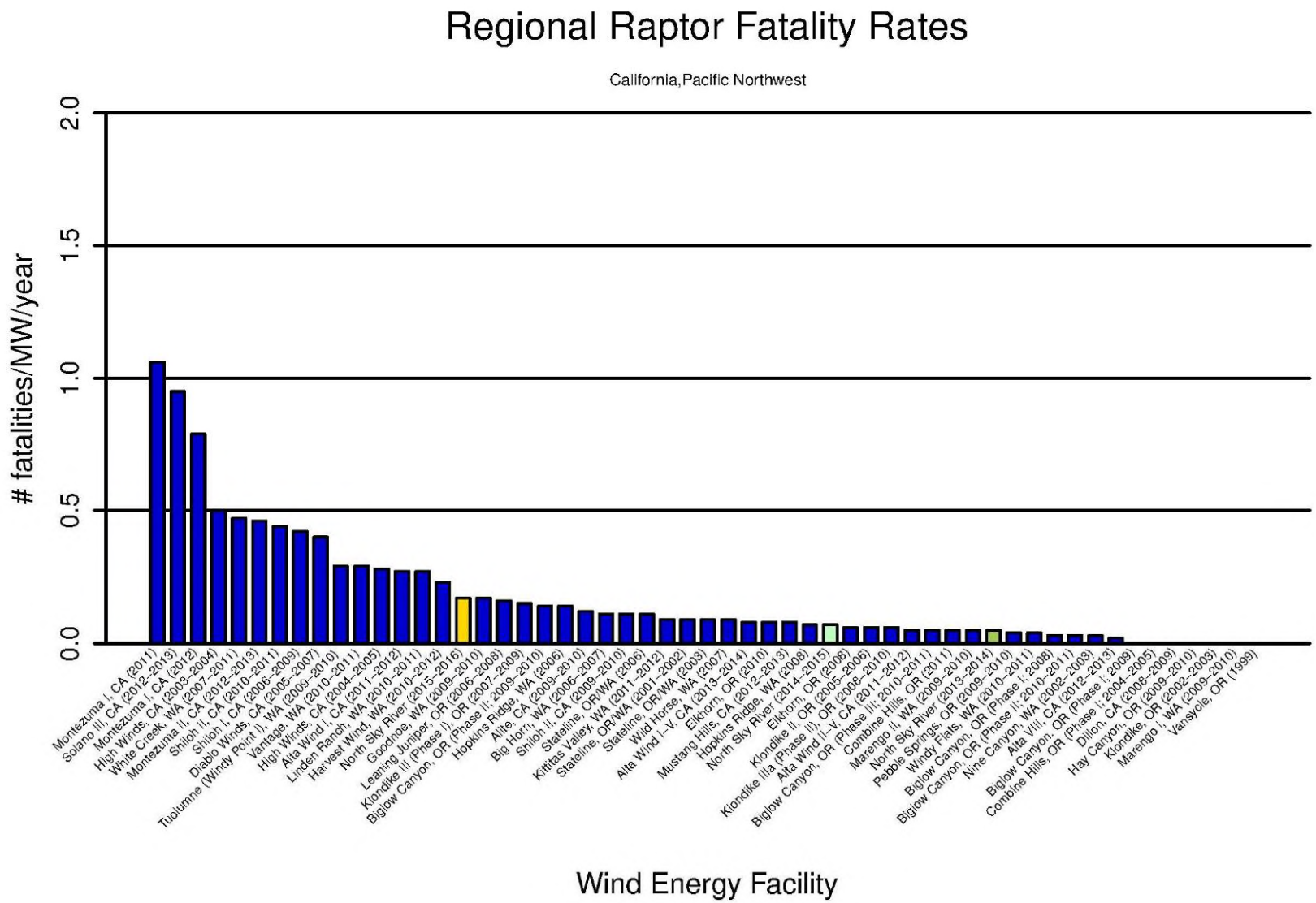

Figure 18. Fatality rates for raptors (number of raptors per MW per year) at the North Sky River Wind Energy Facility compared with rates at publicly-available studies at wind energy facilities in California and the Pacific Northwest. Results for the first year of fatality monitoring (2013-2014) are indicated in green, results for the second year of fatality monitoring (2014-2015) are indicated in teal, and results for the third year (2015-2016) are indicated in yellow.

Figure 18 (*continued*). Fatality rates for raptors (number of raptors per MW per year) at the North Sky River Wind Energy Facility compared with rates at publicly-available studies at wind energy facilities in California and the Pacific Northwest.

Data from the following sources:

Wind Energy Facility	Reference	Wind Energy Facility	Reference	Wind Energy Facility	Reference
North Sky River, CA (15)	This study				
North Sky River, CA (14)	Levenstein and Riser-Espinoza 2015				
North Sky River, CA (13)	Levenstein et al. 2014				
Montezuma I, CA (11)	ICF International 2012	Biglow Canyon, OR (Phase II; 09-10)	Enk et al. 2011a	Biglow Canyon, OR (Phase III; 10-11)	Enk et al. 2012a
Solano III, CA (12-13)	AECOM 2013	Hopkins Ridge, WA (06)	Young et al. 2007	Combine Hills, OR (11)	Enz et al. 2012
Montezuma I, CA (12)	ICF International 2013	Alite, CA (09-10)	Chatfield et al. 2010	Marengo II, WA (09-10)	URS Corporation 2010c
High Winds, CA (03-04)	Kerlinger et al. 2006	Big Horn, WA (06-07)	Kronner et al. 2008	Pebble Springs, OR (09-10)	Gritski and Kronner 2010b
White Creek, WA (07-11)	Downes and Gritski 2012b	Shiloh II, CA (09-10)	Kerlinger et al. 2010, 2013a	Windy Flats, WA (10-11)	Enz et al. 2011
Montezuma II, CA (12-13)	Harvey & Associates 2013	Stateline, OR/WA (06)	Erickson et al. 2007	Biglow Canyon, OR (Phase I; 08)	Jeffrey et al. 2009a
Shiloh II, CA (10-11)	Kerlinger et al. 2013a	Kittitas Valley, WA (11-12)	Stantec Consulting Services 2012	Biglow Canyon, OR (Phase II; 10-11)	Enk et al. 2012b
Shiloh I, CA (06-09)	Kerlinger et al. 2009	Stateline, OR/WA (01-02)	Erickson et al. 2004	Nine Canyon, WA (02-03)	Erickson et al. 2003a
Diablo Winds, CA (05-07)	WEST 2006, 2008	Stateline, OR/WA (03)	Erickson et al. 2004	Alta VIII, CA (12-13)	Chatfield and Bay 2014
Tuolumne (Windy Point I), WA (09-10)	Enz and Bay 2010	Wild Horse, WA (07)	Erickson et al. 2008	Biglow Canyon, OR (Phase I; 09)	Enk et al. 2010
Vantage, WA (10-11)	Ventus Environmental Solutions 2012	Alta Wind I-V, CA (13-14)	Chatfield et al. 2014	Combine Hills, OR (Phase I; 04-05)	Young et al. 2006
High Winds, CA (04-05)	Kerlinger et al. 2006	Elkhorn, OR (10)	Enk et al. 2011b	Dillon, CA (08-09)	Chatfield et al. 2009
Alta Wind I, CA (11-12)	Chatfield et al. 2012	Mustang Hills, CA (12-13)	Chatfield and Bay 2014	Hay Canyon, OR (09-10)	Gritski and Kronner 2010a
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Harvest Wind, WA (10-12)	Downes and Gritski 2012a	Elkhorn, OR (08)	Jeffrey et al. 2009b	Marengo I, WA (09-10)	URS Corporation 2010b
Goodnoe, WA (09-10)	URS Corporation 2010a	Klondike II, OR (05-06)	NWC and WEST 2007	Vansycle, OR (99)	Erickson et al. 2000a
Leaning Juniper, OR (06-08)	Gritski et al. 2008	Klondike IIIa (Phase II), OR (08-10)	Gritski et al. 2011		
Klondike III (Phase I), OR (07-09)	Gritski et al. 2010	Alta Wind II-V, CA (11-12)	Chatfield et al. 2012		

Bat Fatalities

A total of 11 bats, representing two identifiable species, were documented during the study. In California, bat fatality rates have ranged from zero to 3.92 bats/MW/year (Figure 19; Appendix C3). The estimated bat fatality rate at NSR during this third year of study (1.51 bats/MW/year; Table 5) was intermediate when compared to the prior to years of study at NSR (Figure 19) and would be considered moderate to slightly above average compared to other projects in California (Appendix C3). However, bat fatalities in California are generally low compared to other sites within western North America, which have ranged from zero to 11.42 bats/MW/year (Appendix C3).

While still relatively low, the bat fatality rate calculated at NSR is somewhat higher than that documented at several other facilities in the TWRA. At the adjacent Pine Tree facility, only four bats were found during the 17-month study (BRC 2012). Due to the small sample size, no bat fatality rates were calculated for Pine Tree. However, other nearby projects within the Tehachapi area (e.g., Alta Wind, Alta VIII, Pinyon Pines, and Mustang Hills) have reported bat fatality rates from zero to 1.28 bats/MW/year, which are all lower than the rates estimated for the first three years of monitoring at NSR (Appendix C3). During pre-construction acoustic monitoring conducted at NSR, bat activity rates were found to be moderate compared to the very low rates of bat activity recorded at other wind energy projects in the Tehachapi region (Chatfield et al. 2011). This suggested that more moderate levels of bat mortality might be expected to occur at NSR, which is consistent with the mortality rates documented during the three years of study to date.

Three species of migratory tree bat (hoary bat, silver-haired bat [*Lasionycteris noctivagans*], and eastern red bat [*Lasiurus cinereus*]) have accounted for a large majority of documented bat mortality at wind energy facilities across North America (Arnett et al. 2008, Gruver et al. 2011). However, several post-construction studies at facilities in the western US have reported that Mexican free-tailed bats as accounting for a majority of identified bat fatalities (Arnett et al. 2008). The species composition of bat fatalities at NSR was consistent with these findings, in that Mexican free-tailed bat and hoary bat were the only species found during the third year of fatality monitoring at NSR.

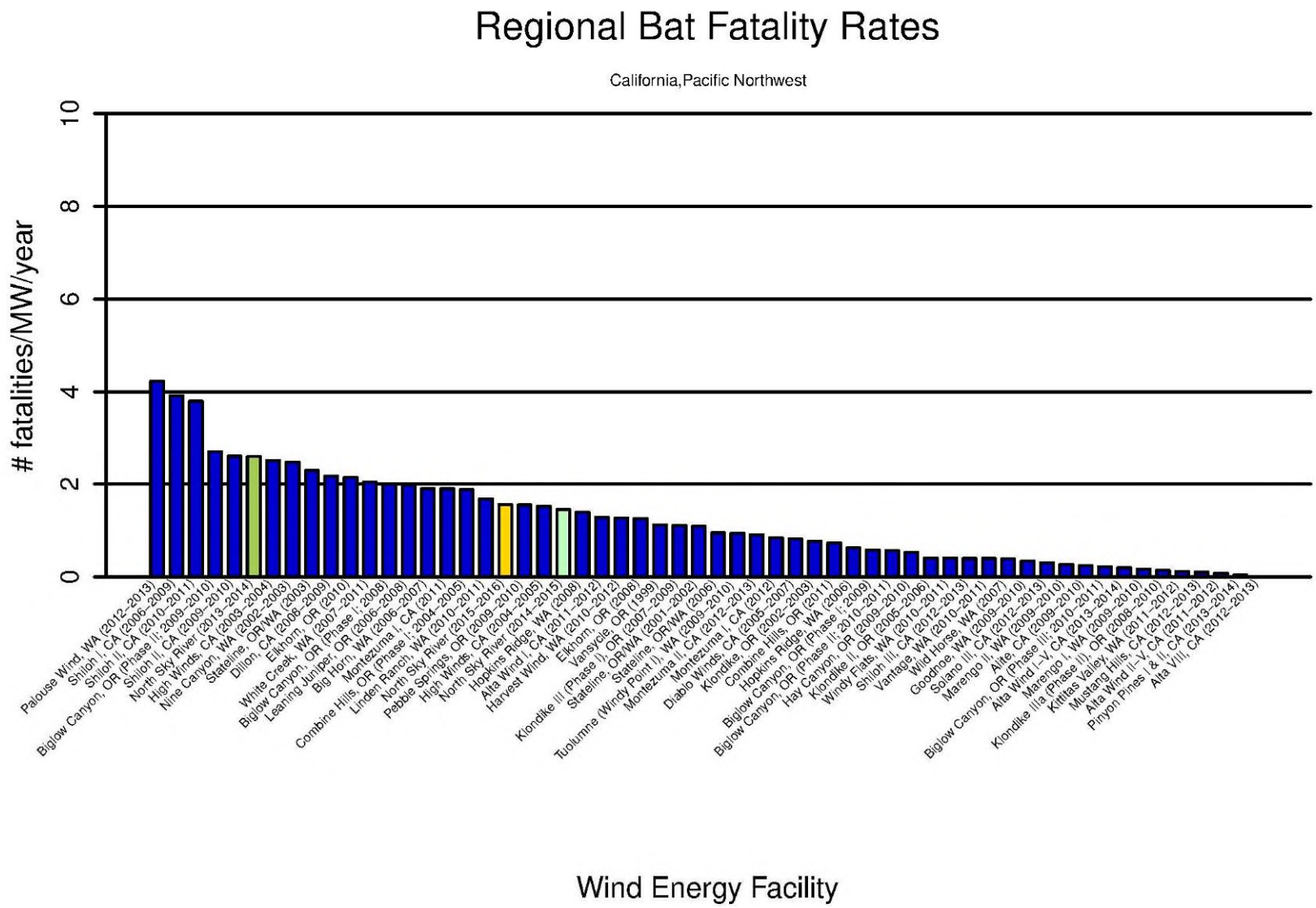

Figure 19. Fatality rates for bats (number of bats per MW per year) at the North Sky River Wind Energy Facility compared with rates at publicly-available studies at wind energy facilities in California and the Pacific Northwest. Results for the first year of fatality monitoring (2013) are indicated in green, results for the second year of fatality monitoring (2014) are indicated in teal, and results for the third year (2015) are indicated in yellow.

Figure 19 (*continued*). Fatality rates for bats (number of bats per MW per year) at the North Sky River Wind Energy Facility compared with rates at publicly-available studies at wind energy facilities in California and the Pacific Northwest.

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North Sky River, CA (13)	Levenstein et al. 2014				
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Shiloh I, CA (06-09)	Kerlinger et al. 2009	Alta Wind I, CA (11-12)	Chatfield et al. 2012	Shiloh III, CA (12-13)	Kerlinger et al. 2013b
Shiloh II, CA (10-11)	Kerlinger et al. 2013a	Harvest Wind, WA (10-12)	Downes and Gritski 2012a	Vantage, WA (10-11)	Ventus Environmental Solutions 2012
Biglow Canyon, OR (Phase II; 09-10)	Enk et al. 2011a	Elkhorn, OR (08)	Jeffrey et al. 2009b	Wild Horse, WA (07)	Erickson et al. 2008
Shiloh II, CA (09-10)	Kerlinger et al. 2010, 2013a	Vansycle, OR (99)	Erickson et al. 2000a	Goodnoe, WA (09-10)	URS Corporation 2010a
High Winds, CA (03-04)	Kerlinger et al. 2006	Klondike III (Phase I), OR (07-09)	Gritski et al. 2010	Solano III, CA (12-13)	AECOM 2013
Nine Canyon, WA (02-03)	Erickson et al. 2003a	Stateline, OR/WA (01-02)	Erickson et al. 2004	Marengo II, WA (09-10)	URS Corporation 2010c
Stateline, OR/WA (03)	Erickson et al. 2004	Stateline, OR/WA (06)	Erickson et al. 2007	Alite, CA (09-10)	Chatfield et al. 2010
Dillon, CA (08-09)	Chatfield et al. 2009	Tuolumne (Windy Point I), WA (09-10)	Enz and Bay 2010	Biglow Canyon, OR (Phase III; 10-11)	Enk et al. 2012a
Elkhorn, OR (10)	Enk et al. 2011b	Montezuma II, CA (12-13)	Harvey & Associates 2013	Alta Wind I-V, CA (13-14)	Chatfield et al. 2014
White Creek, WA (07-11)	Downes and Gritski 2012b	Montezuma I, CA (12)	ICF International 2013	Marengo I, WA (09-10)	URS Corporation 2010b
Biglow Canyon, OR (Phase I; 08)	Jeffrey et al. 2009a	Diablo Winds, CA (05-07)	WEST 2006, 2008	Klondike IIIa (Phase II), OR (08-10)	Gritski et al. 2011
Leaning Juniper, OR (06-08)	Gritski et al. 2008	Klondike, OR (02-03)	Johnson et al. 2003b	Kittitas Valley, WA (11-12)	Stantec Consulting Services 2012
Big Horn, WA (06-07)	Kronner et al. 2008	Combine Hills, OR (11)	Enz et al. 2012	Mustang Hills, CA (12-13)	Chatfield and Bay 2014
Montezuma I, CA (11)	ICF International 2012	Hopkins Ridge, WA (06)	Young et al. 2007	Alta Wind II-V, CA (11-12)	Chatfield et al. 2012
Combine Hills, OR (Phase I; 04-05)	Young et al. 2006	Biglow Canyon, OR (Phase I; 09)	Enk et al. 2010	Pinyon Pines I & II, CA (13-14)	Chatfield and Russo 2014
Linden Ranch, WA (10-11)	Enz and Bay 2011	Biglow Canyon, OR (Phase II; 10-11)	Enk et al. 2012b	Alta VIII, CA (12-13)	Chatfield and Bay 2014
Pebble Springs, OR (09-10)	Gritski and Kronner 2010b	Hay Canyon, OR (09-10)	Gritski and Kronner 2010a		
High Winds, CA (04-05)	Kerlinger et al. 2006	Klondike II, OR (05-06)	NWC and WEST 2007		

Raptor Breeding Monitoring

Raptor nest surveys conducted in 2015 resulted in eight active nests, representing three species (great horned owl, red-tailed hawk, and common raven). This compares to seven active nests found during Year 2 nest surveys (Levenstein and Riser-Espinoza 2015) and six active nests found in Year 1 surveys (Levenstein et al. 2014). Six of the eight active nests in Year 3 fledged young, while the success of the other two was unconfirmed. The number of raptor and raven nests recorded in the NSR project areas over the three years of monitoring has been consistent with the number o nests observed prior to construction, with a slight increase in the number of active nests from Year 1 (six active) through Year 3 (eight active). Given the consistency in nesting activity over time and the continued success of nests within the NSR project area, it appears that NSR has not significantly altered raptor nesting within its boundaries.

CONCLUSIONS AND RECOMMENDATIONS

Results of the third year of fatality monitoring at NSR further contribute to our understanding of the effects of wind energy on birds and bats. During this third year of monitoring at NSR, the all bird and bat fatality rates were generally low compared to other wind energy facilities in western North America, and consistent with other facilities in the TWRA region. Diurnal raptor fatality rates were slightly above average during this third year of monitoring (0.17 raptor fatalities/MW/year), but still lower than that observed at 15 studies at 10 other wind energy facilities in California and the Pacific Northwest. Additionally, the 3-year average fatality rate for diurnal raptors at NSR (0.097 fatalities/MW/year) is consistent with other raptor fatality rates reported for nearby projects (e.g., Alta Wind, Alta VIII, Mustang Hills) and lower than most other projects in California (Appendix C2). Additional monitoring is being conducted at NSR during the fourth year of operation (January 2016 – January 2017), which will provide additional insight into the annual variation among estimated fatality rates at the project. The results of the surveys conducted to date (Years 1-3) do not suggest the need for deviation from the established protocol during the fourth year of mortality surveys. Upon completion of the final year of study at NSR, a more complete picture of the potential impact and annual variability of the project on bird and bat species will be available, providing a sound basis for assessing NSR's potential long term impacts on species and its impact relative to other wind energy facilities in the region.

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Appendix A. Complete Listing of Fatalities During the Third Year of Avian and Bat Fatality Monitoring at the North Sky River Wind Energy Facility, January 14, 2014 –January 16, 2015

Appendix A. Complete listing of fatalities for the North Sky River Wind Energy Facility, January 19, 2015 – January 12, 2016

Date	Common Name	Location	Distance from Turbine (m)	Type of Find	Search Type	Condition
3/7/2015	western scrub-jay	T13	78	casualty search	every 2 weeks all year	feather spot
3/18/2015	Mexican free-tailed bat	T1	13	casualty search	every 2 weeks all year	injured
3/18/2015	Mexican free-tailed bat	T9	2	casualty search	every 2 weeks all year	intact
4/10/2015	Mexican free-tailed bat	T81	20	casualty search	every 2 weeks all year	intact
4/23/2015	hoary bat	T86	33	casualty search	every 2 weeks all year	scavenged
6/17/2015	red-tailed hawk	T52	32	casualty search	every 2 weeks all year	dismembered
7/15/2015	mourning dove	T61	1	casualty search	every 2 weeks all year	intact
9/3/2015	rock pigeon	T24	75	casualty search	every 2 weeks all year	feather spot
9/8/2015	Mexican free-tailed bat	T57	9	casualty search	every 2 weeks all year	intact
9/8/2015	Mexican free-tailed bat	T68	63	casualty search	every 2 weeks all year	intact
9/8/2015	unidentified small bird	T37	89	casualty search	every 2 weeks all year	feather spot
9/10/2015	Mexican free-tailed bat	T81	14	casualty search	every 2 weeks all year	scavenged
9/29/2015	American kestrel	T15	28	casualty search	every 2 weeks all year	feather spot
9/29/2015	chukar	T38	49	casualty search	every 2 weeks all year	feather spot
9/29/2015	American kestrel	T32	75	casualty search	every 2 weeks all year	feather spot
9/30/2015	Mexican free-tailed bat	T49	20	casualty search	every 2 weeks all year	intact
10/1/2015	American kestrel	T30	53	casualty search	every 2 weeks all year	feather spot
10/9/2015	unidentified bird (small)	T96	73	casualty search	every 2 weeks all year	feather spot
11/19/2015	northern flicker	T81	45	casualty search	every 2 weeks all year	feather spot
12/3/2015	unidentified small bird	T28	80	casualty search	every 2 weeks all year	feather spot
1/3/2016	unidentified small bird	T49	83	casualty search	every 2 weeks all year	feather spot
1/3/2016	red-tailed hawk	T38	0	casualty search	every 2 weeks all year	feather spot
1/3/2016	red-tailed hawk	T38	31	casualty search	every 2 weeks all year	feather spot
3/31/2015	Mexican free-tailed bat	T3	35	casualty search	twice weekly – spring	intact
4/2/2015	red-tailed hawk	T3	75	casualty search	twice weekly – spring	scavenged
4/14/2015	unidentified large bird	T14	70	casualty search	twice weekly – spring	feather spot
4/20/2015	hoary bat	T2	53	casualty search	twice weekly – spring	intact
4/23/2015	hoary bat	T19	63	casualty search	twice weekly – spring	scavenged
5/6/2015	unidentified small bird	T2	51	casualty search	twice weekly – spring	dismembered
6/2/2015	red-tailed hawk	T3	47	casualty search	twice weekly – spring	feather spot
6/2/2015	loggerhead shrike	T2	55	casualty search	twice weekly – spring	feather spot
6/3/2015	lark sparrow	T14	12	casualty search	twice weekly - spring	scavenged

Appendix B. Complete Bird and Bat Fatality Table for the North Sky River Wind Energy Facility for Carcass Searches Conducted from January 19, 2015 – January 12, 2016

Appendix B1. Correction factors and bird and bat fatality rates by season/study period from data collected at 30 turbines searched every two weeks within the North Sky River Wind Energy Facility from January 19, 2015 – January 12, 2016.

	Spring		Summer		Fall		Winter	
Parameter	**Mean**	**CI**	**Mean**	**CI**	**Mean**	**CI**	**Mean**	**CI**
Observer Detection								
p (small birds)	0.82	0.76 – 0.88	0.82	0.76 – 0.88	0.82	0.76 – 0.88	0.82	0.76 – 0.88
p (large birds)	0.96	0.93 – 0.99	0.96	0.93 – 0.99	0.96	0.93 – 0.99	0.96	0.93 – 0.99
p (bats)[1]	0.82	0.76 – 0.88	0.82	0.76 – 0.88	0.82	0.76 – 0.88	0.82	0.76 – 0.88
Mean Carcass Removal Time (Days)								
$\bar{t}$ *(small birds)*	1.60	1.30 – 1.90	1.60	1.30 – 1.90	1.60	1.30 – 1.90	3.69	2.59 – 4.91
$\bar{t}$ *(large birds)*	23.28	18.32 – 28.88	23.28	18.32 – 28.88	23.28	18.32 – 28.88	23.28	18.32 – 28.88
$\bar{t}$ *(bats)*[2]	1.97	1.30 – 1.90	1.97	1.30 – 1.90	1.97	1.30 – 1.90	3.75	2.59 – 5.31
Observed Fatality Rates (Fatalities/Turbine/Season)								
Small birds	0.03	0 – 0.10	0.03	0 – 0.10	0.03	0 – 0.10	0.07	0 – 0.13
Large birds	0.33	0.13 – 0.53	0.33	0.13 – 0.53	0.33	0.13 – 0.53	0.33	0.13 – 0.53
Raptors	0.20	0.07 – 0.37	0.20	0.07 – 0.37	0.20	0.07 – 0.37	0.20	0.07 – 0.37
Bats	0.27	0.13 – 0.43	0.27	0.13 – 0.43	0.27	0.13 – 0.43	0	--
Average Probability of Carcass Availability and Detected								
Small birds	0.09	0.07 – 0.11	0.09	0.07 – 0.11	0.09	0.07 – 0.11	0.20	0.14 – 0.26
Large birds	0.73	0.67 – 0.77	0.73	0.67 – 0.77	0.73	0.67 – 0.77	0.73	0.67 – 0.77
Bats	0.11	0.08 – 0.14	0.11	0.08 – 0.14	0.11	0.08 – 0.14	0	--
Adjusted Fatality Estimates (Fatalities/Turbine/study period)								
	Spring/Summer/Fall						**Winter**	
Small birds	0.37				0 – 1.11		0.33	0 – 0.77
Bats	2.42				1.12 – 4.33		--	--
	Spring/Summer/Fall/Winter							
Large birds	0.46					0.19 – 0.74		
Raptors	0.27					0.10 – 0.50		

[1]During searcher efficiency trials, small brown birds were used as a surrogate for bats.
[2]During carcass removal trials, small brown birds were used as a surrogate for bats.

Appendix B2. Correction factors and bird and bat fatality rates from data collected at seven turbines searched intensively within the North Sky River Wind Energy Facility from March 31 – June 4, 2016.

	Spring (7 Turbines Searched)	
Parameter	**Mean**	**CI**
Search Area Adjustment		
A (small birds)	1.00	--
A (large birds)	1.00	--
A (bats)	1.00	--
Observer Detection Rate		
p (small birds)	0.82	0.76 – 0.88
p (large birds)	0.96	0.93 – 0.99
p (bats)[1]	0.82	0.76 – 0.88
Mean Carcass Removal Time (Days)		
$\bar{t}$ (small birds)	1.60	1.30 – 1.90
$\bar{t}$ (large birds)	23.28	18.32 – 28.88
$\bar{t}$ (bats)[2]	1.97	1.30 – 1.90
Observed Fatality Rates (Fatalities/Turbine/Study Period)		
small birds	0.43	--
large birds	0.43	--
raptors	0.29	--
bats	0.29	--
Average Probability of Carcass Availability and Detected		
small birds	0.35	--
large birds	0.93	--
bats	0.40	--
Observed Adjusted Fatality Rates (Fatalities/Turbine/Study Period)		
	Mean	**CI**
small birds	1.23	--
large birds	0.46	--
raptors	0.31	--
bats	0.71	--

[1] During searcher efficiency trials, mice were used as a surrogate for bats.
[2] During carcass removal trials, mice birds were used as a surrogate for bats.

Appendix C. North American Fatality Summary Tables

Appendix C1. Wind energy facilities in North America with fatality data for all bird species, by geographic region. Fatality estimate presented as number of bird fatalities per megawatt (MW) per year.

Wind Energy Facility	Fatality Estimate	No. of Turbines	Total MW
North Sky River, CA (2015)	**0.72**	**100**	**160**
North Sky River, CA (2014)	**1.23**	**100**	**160**
North Sky River, CA (2013)	**2.05**	**100**	**160**
California			
Pine Tree, CA (2009-2010, 2011)	17.44	90	135
Montezuma I, CA (2012)	8.91	16	36.8
Alta Wind I-V, CA (2013-2014)	7.8	290	720 (150 GE, 570 vestas)
Alta Wind I, CA (2011-2012)	7.07	100	150
Shiloh I, CA (2006-2009)	6.96	100	150
Montezuma I, CA (2011)	5.19	16	36.8
Dillon, CA (2008-2009)	4.71	45	45
Diablo Winds, CA (2005-2007)	4.29	31	20.46
Shiloh III, CA (2012-2013)	3.3	50	102.5
Shiloh II, CA (2010-2011)	2.8	75	150
Shiloh II, CA (2009-2010)	1.9	75	150
Mustang Hills, CA (2012-2013)	1.66	50	150
Alta Wind II-V, CA (2011-2012)	1.66	190	570
High Winds, CA (2003-2004)	1.62	90	162
Solano III, CA (2012-2013)	1.6	55	128
Pinyon Pines I & II, CA (2013-2014)	1.18	100	NA
High Winds, CA (2004-2005)	1.1	90	162
Montezuma II, CA (2012-2013)	1.08	34	78.2
Alta VIII, CA (2012-2013)	0.66	50	150
Alite, CA (2009-2010)	0.55	8	24
Pacific Northwest			
Windy Flats, WA (2010-2011)	8.45	114	262.2
Leaning Juniper, OR (2006-2008)	6.66	67	100.5
Linden Ranch, WA (2010-2011)	6.65	25	50
Biglow Canyon, OR (Phase II; 2009-2010)	5.53	65	150
White Creek, WA (2007-2011)	4.05	89	204.7
Tuolumne (Windy Point I), WA (2009-2010)	3.2	62	136.6
Stateline, OR/WA (2001-2002)	3.17	454	299
Klondike II, OR (2005-2006)	3.14	50	75
Klondike III (Phase I), OR (2007-2009)	3.02	125	223.6
Hopkins Ridge, WA (2008)	2.99	87	156.6
Harvest Wind, WA (2010-2012)	2.94	43	98.9
Nine Canyon, WA (2002-2003)	2.76	37	48.1
Biglow Canyon, OR (Phase II; 2010-2011)	2.68	65	150
Stateline, OR/WA (2003)	2.68	454	299
Klondike IIIa (Phase II), OR (2008-2010)	2.61	51	76.5
Combine Hills, OR (Phase I; 2004-2005)	2.56	41	41
Big Horn, WA (2006-2007)	2.54	133	199.5
Biglow Canyon, OR (Phase I; 2009)	2.47	76	125.4
Combine Hills, OR (2011)	2.33	104	104
Biglow Canyon, OR (Phase III; 2010-2011)	2.28	76	174.8
Hay Canyon, OR (2009-2010)	2.21	48	100.8
Elkhorn, OR (2010)	1.95	61	101
Pebble Springs, OR (2009-2010)	1.93	47	98.7
Biglow Canyon, OR (Phase I; 2008)	1.76	76	125.4
Wild Horse, WA (2007)	1.55	127	229

Appendix C1. Wind energy facilities in North America with fatality data for all bird species, by geographic region. Fatality estimate presented as number of bird fatalities per megawatt (MW) per year.

Wind Energy Facility	Fatality Estimate	No. of Turbines	Total MW
Goodnoe, WA (2009-2010)	1.4	47	94
Vantage, WA (2010-2011)	1.27	60	90
Hopkins Ridge, WA (2006)	1.23	83	150
Stateline, OR/WA (2006)	1.23	454	299
Kittitas Valley, WA (2011-2012)	1.06	48	100.8
Klondike, OR (2002-2003)	0.95	16	24
Vansycle, OR (1999)	0.95	38	24.9
Palouse Wind, WA (2012-2013)	0.72	58	104.4
Elkhorn, OR (2008)	0.64	61	101
Marengo I, WA (2009-2010)	0.27	78	140.4
Marengo II, WA (2009-2010)	0.16	39	70.2
Rocky Mountains			
Foote Creek Rim, WY (Phase I; 1999)	3.4	69	41.4
Foote Creek Rim, WY (Phase I; 2000)	2.42	69	41.4
Foote Creek Rim, WY (Phase I; 2001-2002)	1.93	69	41.4
Summerview, Alb (2005-2006)	1.06	39	70.2
Milford I & II, UT (2011-2012)	0.73	107	160.5 (58.5 I, 102 II)
Milford I, UT (2010-2011)	0.56	58	145
Southwest			
Dry Lake I, AZ (2009-2010)	2.02	30	63
Dry Lake II, AZ (2011-2012)	1.57	31	65
Midwest			
Wessington Springs, SD (2009)	8.25	34	51
Blue Sky Green Field, WI (2008; 2009)	7.17	88	145
Cedar Ridge, WI (2009)	6.55	41	67.6
Buffalo Ridge, MN (Phase III; 1999)	5.93	138	103.5
Moraine II, MN (2009)	5.59	33	49.5
Barton I & II, IA (2010-2011)	5.5	80	160
Buffalo Ridge I, SD (2009-2010)	5.06	24	50.4
Buffalo Ridge, MN (Phase I; 1996)	4.14	73	25
Winnebago, IA (2009-2010)	3.88	10	20
Rugby, ND (2010-2011)	3.82	71	149
Cedar Ridge, WI (2010)	3.72	41	68
Elm Creek II, MN (2011-2012)	3.64	62	148.8
Buffalo Ridge, MN (Phase II; 1999)	3.57	143	107.25
Buffalo Ridge, MN (Phase I; 1998)	3.14	73	25
Ripley, Ont (2008)	3.09	38	76
Fowler I, IN (2009)	2.83	162	301
Buffalo Ridge, MN (Phase I; 1997)	2.51	73	25
Buffalo Ridge, MN (Phase II; 1998)	2.47	143	107.25
PrairieWinds SD1, SD (2012-2013)	2.01	108	162
Buffalo Ridge II, SD (2011-2012)	1.99	105	210
Kewaunee County, WI (1999-2001)	1.95	31	20.46
PrairieWinds SD1, SD (2013-2014)	1.66	108	162
NPPD Ainsworth, NE (2006)	1.63	36	20.5
PrairieWinds ND1 (Minot), ND (2011)	1.56	80	115.5
Elm Creek, MN (2009-2010)	1.55	67	100
PrairieWinds ND1 (Minot), ND (2010)	1.48	80	115.5
Buffalo Ridge, MN (Phase I; 1999)	1.43	73	25

Appendix C1. Wind energy facilities in North America with fatality data for all bird species, by geographic region. Fatality estimate presented as number of bird fatalities per megawatt (MW) per year.

Wind Energy Facility	Fatality Estimate	No. of Turbines	Total MW
PrairieWinds SD1, SD (2011-2012)	1.41	108	162
Wessington Springs, SD (2010)	0.89	34	51
Rail Splitter, IL (2012-2013)	0.84	67	100.5
Top of Iowa, IA (2004)	0.81	89	80
Top Crop I & II, IL (2012-2013)	0.6	200 (68 Phase I, 132 Phase II)	300 (102 Phase I, 198 Phase II)
Big Blue, MN (2013)	0.6	18	36
Grand Ridge I, IL (2009-2010)	0.48	66	99
Top of Iowa, IA (2003)	0.42	89	80
Big Blue, MN (2014)	0.37	18	36
Pioneer Prairie I, IA (Phase II; 2011-2012)	0.27	62	102.3
Southern Plains			
Buffalo Gap I, TX (2006)	1.32	67	134
Barton Chapel, TX (2009-2010)	1.15	60	120
Buffalo Gap II, TX (2007-2008)	0.15	155	233
Big Smile, OK (2012-2013)	0.09	66	132
Red Hills, OK (2012-2013)	0.08	82	123
Northeast			
Stetson Mountain I, ME (2013)	6.95	38	57
Criterion, MD (2011)	6.4	28	70
Mount Storm, WV (2011)	4.24	132	264
Pinnacle, WV (2012)	3.99	23	55.2
Mount Storm, WV (2009)	3.85	132	264
Record Hill, ME (2012)	3.7	22	50.6
Criterion, MD (2013)	3.49	28	70
Lempster, NH (2009)	3.38	12	24
Stetson Mountain II, ME (2012)	3.37	17	25.5
Rollins, ME (2012)	2.9	40	60
Casselman, PA (2009)	2.88	23	34.5
Mountaineer, WV (2003)	2.69	44	66
Stetson Mountain I, ME (2009)	2.68	38	57
Noble Ellenburg, NY (2009)	2.66	54	80
Lempster, NH (2010)	2.64	12	24
Mount Storm, WV (2010)	2.6	132	264
Maple Ridge, NY (2007)	2.34	195	321.75
Noble Bliss, NY (2009)	2.28	67	100
Criterion, MD (2012)	2.14	28	70
Maple Ridge, NY (2007-2008)	2.07	195	321.75
Record Hill, ME (2014)	1.84	22	50.6
Noble Altona, NY (2010)	1.84	65	97.5
High Sheldon, NY (2010)	1.76	75	112.5
Mars Hill, ME (2008)	1.76	28	42
Noble Wethersfield, NY (2010)	1.7	84	126
Mars Hill, ME (2007)	1.67	28	42
Noble Chateaugay, NY (2010)	1.66	71	106.5
Noble Clinton, NY (2008)	1.59	67	100
High Sheldon, NY (2011)	1.57	75	112.5
Casselman, PA (2008)	1.51	23	34.5
Beech Ridge, WV (2013)	1.48	67	100.5
Munnsville, NY (2008)	1.48	23	34.5
Stetson Mountain II, ME (2010)	1.42	17	25.5

Appendix C1. Wind energy facilities in North America with fatality data for all bird species, by geographic region. Fatality estimate presented as number of bird fatalities per megawatt (MW) per year.

Wind Energy Facility	Fatality Estimate	No. of Turbines	Total MW
Cohocton/Dutch Hill, NY (2009)	1.39	50	125
Cohocton/Dutch Hills, NY (2010)	1.32	50	125
Noble Bliss, NY (2008)	1.3	67	100
Beech Ridge, WV (2012)	1.19	67	100.5
Stetson Mountain I, ME (2011)	1.18	38	57
Noble Clinton, NY (2009)	1.11	67	100
Locust Ridge, PA (Phase II; 2009)	0.84	51	102
Noble Ellenburg, NY (2008)	0.83	54	80
Locust Ridge, PA (Phase II; 2010)	0.76	51	102
Southeast			
Buffalo Mountain, TN (2000-2003)	11.02	3	1.98
Buffalo Mountain, TN (2005)	1.1	18	28.98

Appendix C1 (*continued*). Wind energy facilities in North America with fatality data for all bird species.

Data from the following sources:

Wind Energy Facility	Estimate Reference	Wind Energy Facility	Estimate Reference
North Sky River, CA (15)	This study		
North Sky River, CA (14)	Levenstein and Riser-Espinoza 2015		
North Sky River, CA (13)	Levenstein et al. 2014		
Alite, CA (09-10)	Chatfield et al. 2010	Locust Ridge, PA (Phase II; 09)	Arnett et al. 2011
Alta Wind I, CA (11-12)	Chatfield et al. 2012	Locust Ridge, PA (Phase II; 10)	Arnett et al. 2011
Alta Wind I-V, CA (13-14)	Chatfield et al. 2014	Maple Ridge, NY (07)	Jain et al. 2009a
Alta Wind II-V, CA (11-12)	Chatfield et al. 2012	Maple Ridge, NY (07-08)	Jain et al. 2009d
Alta VIII, CA (12-13)	Chatfield and Bay 2014	Marengo I, WA (09-10)	URS Corporation 2010b
Barton I & II, IA (10-11)	Derby et al. 2011a	Marengo II, WA (09-10)	URS Corporation 2010c
Barton Chapel, TX (09-10)	WEST 2011	Mars Hill, ME (07)	Stantec 2008a
Beech Ridge, WV (12)	Tidhar et al. 2013b	Mars Hill, ME (08)	Stantec 2009a
Beech Ridge, WV (13)	Young et al. 2014b	Milford I & II, UT (11-12)	Stantec 2012b
Big Blue, MN (13)	Fagen Engineering 2014	Milford I, UT (10-11)	Stantec 2011b
Big Blue, MN (14)	Fagen Engineering 2015	Montezuma I, CA (11)	ICF International 2012
Big Horn, WA (06-07)	Kronner et al. 2008	Montezuma I, CA (12)	ICF International 2013
Big Smile, OK (12-13)	Derby et al. 2013b	Montezuma II, CA (12-13)	Harvey & Associates 2013
Biglow Canyon, OR (Phase I; 08)	Jeffrey et al. 2009a	Moraine II, MN (09)	Derby et al. 2010d
Biglow Canyon, OR (Phase I; 09)	Enk et al. 2010	Mount Storm, WV (09)	Young et al. 2009a, 2010b
Biglow Canyon, OR (Phase II; 09-10)	Enk et al. 2011a	Mount Storm, WV (10)	Young et al. 2010a, 2011b
Biglow Canyon, OR (Phase II; 10-11)	Enk et al. 2012b	Mount Storm, WV (11)	Young et al. 2011a, 2012b
Biglow Canyon, OR (Phase III; 10-11)	Enk et al. 2012a	Mountaineer, WV (03)	Kerns and Kerlinger 2004
Blue Sky Green Field, WI (08; 09)	Gruver et al. 2009	Munnsville, NY (08)	Stantec 2009b
Buffalo Gap I, TX (06)	Tierney 2007	Mustang Hills, CA (12-13)	Chatfield and Bay 2014
Buffalo Gap II, TX (07-08)	Tierney 2009	Nine Canyon, WA (02-03)	Erickson et al. 2003a
Buffalo Mountain, TN (00-03)	Nicholson et al. 2005	Noble Altona, NY (10)	Jain et al. 2011b
Buffalo Mountain, TN (05)	Fiedler et al. 2007	Noble Bliss, NY (08)	Jain et al. 2009e
Buffalo Ridge, MN (Phase I; 96)	Johnson et al. 2000	Noble Bliss, NY (09)	Jain et al. 2010a
Buffalo Ridge, MN (Phase I; 97)	Johnson et al. 2000	Noble Chateaugay, NY (10)	Jain et al. 2011c
Buffalo Ridge, MN (Phase I; 98)	Johnson et al. 2000	Noble Clinton, NY (08)	Jain et al. 2009c
Buffalo Ridge, MN (Phase I; 99)	Johnson et al. 2000	Noble Clinton, NY (09)	Jain et al. 2010b
Buffalo Ridge, MN (Phase II; 98)	Johnson et al. 2000	Noble Ellenburg, NY (08)	Jain et al. 2009b
Buffalo Ridge, MN (Phase II; 99)	Johnson et al. 2000	Noble Ellenburg, NY (09)	Jain et al. 2010c
Buffalo Ridge, MN (Phase III; 99)	Johnson et al. 2000	Noble Wethersfield, NY (10)	Jain et al. 2011a
Buffalo Ridge I, SD (09-10)	Derby et al. 2010b	NPPD Ainsworth, NE (06)	Derby et al. 2007
Buffalo Ridge II, SD (11-12)	Derby et al. 2012a	Palouse Wind, WA (12-13)	Stantec 2013a
Casselman, PA (08)	Arnett et al. 2009b	Pebble Springs, OR (09-10)	Gritski and Kronner 2010b
Casselman, PA (09)	Arnett et al. 2010	Pine Tree, CA (09-10, 11)	BioResource Consultants 2012
Cedar Ridge, WI (09)	BHE Environmental 2010	Pinnacle, WV (12)	Hein et al. 2013a
Cedar Ridge, WI (10)	BHE Environmental 2011	Pinyon Pines I & II, CA (13-14)	Chatfield and Russo 2014
Cohocton/Dutch Hill, NY (09)	Stantec 2010	Pioneer Prairie I, IA (Phase II; 11-12)	Chodachek et al. 2012
Cohocton/Dutch Hill, NY (10)	Stantec 2011a	PrairieWinds ND1 (Minot), ND (10)	Derby et al. 2011c
Combine Hills, OR (Ph. I; 04-05)	Young et al. 2006	PrairieWinds ND1 (Minot), ND (11)	Derby et al. 2012c
Combine Hills, OR (11)	Enz et al. 2012	PrairieWinds SD1 (Crow Lake), SD (11-12)	Derby et al. 2012d
Criterion, MD (11)	Young et al. 2012a	PrairieWinds SD1 (Crow Lake), SD (12-13)	Derby et al. 2013a
Criterion, MD (12)	Young et al. 2013	PrairieWinds SD1, SD (13-14)	Derby et al. 2014b
Criterion, MD (13)	Young et al. 2014a	Rail Splitter, IL (12-13)	Good et al. 2013b
Diablo Winds, CA (05-07)	WEST 2006, 2008	Record Hill, ME (12)	Stantec 2013b
Dillon, CA (08-09)	Chatfield et al. 2009	Record Hill, ME (14)	Stantec 2015
Dry Lake I, AZ (09-10)	Thompson et al. 2011	Red Hills, OK (12-13)	Derby et al. 2013c
Dry Lake II, AZ (11-12)	Thompson and Bay 2012	Ripley, Ont (08)	Jacques Whitford 2009
Elkhorn, OR (08)	Jeffrey et al. 2009b	Rollins, ME (12)	Stantec 2013c
Elkhorn, OR (10)	Enk et al. 2011b	Rugby, ND (10-11)	Derby et al. 2011b
Elm Creek, MN (09-10)	Derby et al. 2010c	Shiloh I, CA (06-09)	Kerlinger et al. 2009
Elm Creek II, MN (11-12)	Derby et al. 2012b	Shiloh II, CA (09-10)	Kerlinger et al. 2010
Foote Creek Rim, WY (Phase I; 99)	Young et al. 2003b	Shiloh II, CA (10-11)	Kerlinger et al. 2013a
Foote Creek Rim, WY (Phase I; 00)	Young et al. 2003b	Shiloh III, CA (12-13)	Kerlinger et al. 2013b
Foote Creek Rim, WY (Ph. I; 01-02)	Young et al. 2003b	Solano III, CA (12-13)	AECOM 2013
Fowler I, IN (09)	Johnson et al. 2010a	Stateline, OR/WA (01-02)	Erickson et al. 2004
Goodnoe, WA (09-10)	URS Corporation 2010a	Stateline, OR/WA (03)	Erickson et al. 2004
Grand Ridge, IL (09-10)	Derby et al. 2010g	Stateline, OR/WA (06)	Erickson et al. 2007
Harvest Wind, WA (10-12)	Downes and Gritski 2012a	Stetson Mountain I, ME (09)	Stantec 2009c
Hay Canyon, OR (09-10)	Gritski and Kronner 2010a	Stetson Mountain I, ME (11)	Normandeau Associates 2011
High Sheldon, NY (10)	Tidhar et al. 2012a	Stetson Mountain I, ME (13)	Stantec 2014
High Sheldon, NY (11)	Tidhar et al. 2012b	Stetson Mountain II, ME (10)	Normandeau Associates 2010
High Winds, CA (03-04)	Kerlinger et al. 2006	Stetson Mountain II, ME (12)	Stantec 2013e
High Winds, CA (04-05)	Kerlinger et al. 2006	Summerview, Alb (05-06)	Brown and Hamilton 2006b
Hopkins Ridge, WA (06)	Young et al. 2007	Top Crop I & II, IL (12-13)	Good et al. 2013a

Appendix C1 (*continued*). Wind energy facilities in North America with fatality data for all bird species.

Data from the following sources:

Wind Energy Facility	Estimate Reference	Wind Energy Facility	Estimate Reference
Hopkins Ridge, WA (08)	Young et al. 2009c	Top of Iowa, IA (03)	Jain 2005
Kewaunee County, WI (99-01)	Howe et al. 2002	Top of Iowa, IA (04)	Jain 2005
Kittitas Valley, WA (11-12)	Stantec 2012	Tuolumne (Windy Point I), WA (09-10)	Enz and Bay 2010
Klondike, OR (02-03)	Johnson et al. 2003a	Vansycle, OR (99)	Erickson et al. 2000b
Klondike II, OR (05-06)	NWC and WEST 2007	Vantage, WA (10-11)	Ventus 2012
Klondike III, OR (Phase I; 07-09)	Gritski et al. 2010	Wessington Springs, SD (09)	Derby et al. 2010f
Klondike IIIa, OR (Phase II; 08-10)	Gritski et al. 2011	Wessington Springs, SD (10)	Derby et al. 2011d
Leaning Juniper, OR (06-08)	Gritski et al. 2008	White Creek, WA (07-11)	Downes and Gritski 2012b
Lempster, NH (09)	Tidhar et al. 2010	Wild Horse, WA (07)	Erickson et al. 2008
Lempster, NH (10)	Tidhar et al. 2011	Windy Flats, WA (10-11)	Enz et al. 2011
Linden Ranch, WA (10-11)	Enz and Bay 2011	Winnebago, IA (09-10)	Derby et al. 2010e

Appendix C2. Wind energy facilities in North America with use and fatality data for raptors. Use estimate presented as number of raptors per plot per 20-minute survey. Raptor fatality estimate is number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Use Estimate	Raptor Fatality Estimate	No. of Turbines	Total MW
North Sky River, CA (2015)	**0.28**	**0.17**	**100**	**160**
North Sky River, CA (2014)	**0.28**	**0.07**	**100**	**160**
North Sky River, CA (2013)	**0.28**	**0.05**	**100**	**160**
	California			
Montezuma I, CA (2011)	NA	1.06	16	36.8
Solano III, CA (2012-2013)	NA	0.95	55	128
Montezuma I, CA (2012)	NA	0.79	16	36.8
High Winds, CA (2003-2004)	2.337	0.5	90	162
Montezuma II, CA (2012-2013)	NA	0.46	34	78.2
Shiloh II, CA (2010-2011)	NA	0.44	75	150
Shiloh I, CA (2006-2009)	NA	0.42	100	150
Diablo Winds, CA (2005-2007)	2.161	0.4	31	20.46
High Winds, CA (2004-2005)	2.337	0.28	90	162
Alta Wind I, CA (2011-2012)	0.19	0.27	100	150
Alite, CA (2009-2010)	NA	0.12	8	24
Shiloh II, CA (2009-2010)	NA	0.11	75	150
Mustang Hills, CA (2012-2013)	NA	0.08	50	150
Alta Wind I-V, CA (2013-2014)	NA	0.08	290	720 (150 GE, 570 vestas)
Alta Wind II-V, CA (2011-2012)	0.04	0.05	190	570
Alta VIII, CA (2012-2013)	NA	0.02	50	150
Dillon, CA (2008-2009)	NA	0	45	45
	Pacific Northwest			
White Creek, WA (2007-2011)	NA	0.47	89	204.7
Tuolumne (Windy Point I), WA (2009-2010)	0.77	0.29	62	136.6
Vantage, WA (2010-2011)	NA	0.29	60	90
Linden Ranch, WA (2010-2011)	NA	0.27	25	50
Harvest Wind, WA (2010-2012)	NA	0.23	43	98.9
Goodnoe, WA (2009-2010)	NA	0.17	47	94
Leaning Juniper, OR (2006-2008)	0.522	0.16	67	100.5
Klondike III (Phase I), OR (2007-2009)	NA	0.15	125	223.6
Hopkins Ridge, WA (2006)	0.698	0.14	83	150
Biglow Canyon, OR (Phase II; 2009-2010)	0.318	0.14	65	150
Big Horn, WA (2006-2007)	0.511	0.11	133	199.5
Stateline, OR/WA (2006)	0.478	0.11	454	299
Kittitas Valley, WA (2011-2012)	NA	0.09	48	100.8
Wild Horse, WA (2007)	0.291	0.09	127	229
Stateline, OR/WA (2001-2002)	0.478	0.09	454	299
Stateline, OR/WA (2003)	0.478	0.09	454	299
Elkhorn, OR (2010)	1.07	0.08	61	101
Hopkins Ridge, WA (2008)	0.698	0.07	87	156.6
Elkhorn, OR (2008)	1.07	0.06	61	101
Klondike II, OR (2005-2006)	0.504	0.06	50	75
Klondike IIIa (Phase II), OR (2008-2010)	NA	0.06	51	76.5
Combine Hills, OR (2011)	0.746	0.05	104	104
Biglow Canyon, OR (Phase III; 2010-2011)	0.318	0.05	76	174.8
Marengo II, WA (2009-2010)	NA	0.05	39	70.2

Appendix C2. Wind energy facilities in North America with use and fatality data for raptors. Use estimate presented as number of raptors per plot per 20-minute survey. Raptor fatality estimate is number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Use Estimate	Raptor Fatality Estimate	No. of Turbines	Total MW
Windy Flats, WA (2010-2011)	NA	0.04	114	262.2
Pebble Springs, OR (2009-2010)	NA	0.04	47	98.7
Biglow Canyon, OR (Phase I; 2008)	0.318	0.03	76	125.4
Biglow Canyon, OR (Phase II; 2010-2011)	0.318	0.03	65	150
Nine Canyon, WA (2002-2003)	0.35	0.03	37	48.1
Hay Canyon, OR (2009-2010)	NA	0	48	100.8
Biglow Canyon, OR (Phase I; 2009)	0.318	0	76	125.4
Marengo I, WA (2009-2010)	NA	0	78	140.4
Klondike, OR (2002-2003)	0.504	0	16	24
Vansycle, OR (1999)	0.66	0	38	24.9
Combine Hills, OR (Phase I; 2004-2005)	0.746	0	41	41
Rocky Mountains				
Summerview, Alb (2005-2006)	NA	0.11	39	70.2
Foote Creek Rim, WY (Phase I; 1999)	0.554	0.08	69	41.4
Foote Creek Rim, WY (Phase I; 2000)	0.554	0.05	69	41.4
Milford I & II, UT (2011-2012)	NA	0.04	107	160.5 (58.5 Phase I, 102 Phase II)
Foote Creek Rim, WY (Phase I; 2001-2002)	0.554	0	69	41.4
Southwest				
Dry Lake I, AZ (2009-2010)	0.13	0	30	63
Dry Lake II, AZ (2011-2012)	NA	0	31	65
Midwest				
Buffalo Ridge, MN (Phase I; 1999)	NA	0.47	73	25
Moraine II, MN (2009)	NA	0.37	33	49.5
Winnebago, IA (2009-2010)	NA	0.27	10	20
Buffalo Ridge I, SD (2009-2010)	NA	0.2	24	50.4
Cedar Ridge, WI (2009)	NA	0.18	41	67.6
PrairieWinds SD1, SD (2013-2014)	NA	0.17	108	162
Top of Iowa, IA (2004)	NA	0.17	89	80
Cedar Ridge, WI (2010)	NA	0.13	41	68
Ripley, Ont (2008)	NA	0.1	38	76
Wessington Springs, SD (2010)	0.232	0.07	34	51
Rugby, ND (2010-2011)	NA	0.06	71	149
NPPD Ainsworth, NE (2006)	NA	0.06	36	20.5
Wessington Springs, SD (2009)	0.232	0.06	34	51
PrairieWinds ND1 (Minot), ND (2011)	NA	0.05	80	115.5
PrairieWinds ND1 (Minot), ND (2010)	NA	0.05	80	115.5
PrairieWinds SD1, SD (2012-2013)	NA	0.03	108	162
Elm Creek, MN (2009-2010)	NA	0	67	100
Rail Splitter, IL (2012-2013)	NA	0	67	100.5
Pioneer Prairie I, IA (Phase II; 2011-2012)	NA	0	62	102.3
Buffalo Ridge, MN (Phase III; 1999)	NA	0	138	103.5
Buffalo Ridge, MN (Phase II; 1998)	NA	0	143	107.25
Buffalo Ridge, MN (Phase II; 1999)	NA	0	143	107.25
Blue Sky Green Field, WI (2008; 2009)	NA	0	88	145
Elm Creek II, MN (2011-2012)	NA	0	62	148.8
Barton I & II, IA (2010-2011)	NA	0	80	160

Appendix C2. Wind energy facilities in North America with use and fatality data for raptors. Use estimate presented as number of raptors per plot per 20-minute survey. Raptor fatality estimate is number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Use Estimate	Raptor Fatality Estimate	No. of Turbines	Total MW
PrairieWinds SD1, SD (2011-2012)	NA	0	108	162
Kewaunee County, WI (1999-2001)	NA	0	31	20.46
Buffalo Ridge II, SD (2011-2012)	NA	0	105	210
Buffalo Ridge, MN (Phase I; 1996)	NA	0	73	25
Buffalo Ridge, MN (Phase I; 1997)	NA	0	73	25
Buffalo Ridge, MN (Phase I; 1998)	NA	0	73	25
Fowler I, IN (2009)	NA	0	162	301
Big Blue, MN (2013)	NA	0	18	36
Big Blue, MN (2014)	NA	0	18	36
Top of Iowa, IA (2003)	NA	0	89	80
Grand Ridge I, IL (2009-2010)	0.195	0	66	99
Southern Plains				
Barton Chapel, TX (2009-2010)	NA	0.25	60	120
Buffalo Gap I, TX (2006)	NA	0.1	67	134
Red Hills, OK (2012-2013)	NA	0.04	82	123
Big Smile, OK (2012-2013)	NA	0	66	132
Buffalo Gap II, TX (2007-2008)	NA	0	155	233
Northeast				
Munnsville, NY (2008)	NA	0.59	23	34.5
Noble Ellenburg, NY (2009)	NA	0.25	54	80
Noble Clinton, NY (2009)	NA	0.16	67	100
Noble Wethersfield, NY (2010)	NA	0.13	84	126
Noble Bliss, NY (2009)	NA	0.12	67	100
Noble Ellenburg, NY (2008)	NA	0.11	54	80
Noble Bliss, NY (2008)	NA	0.1	67	100
Noble Clinton, NY (2008)	NA	0.1	67	100
Mount Storm, WV (2010)	NA	0.1	132	264
Noble Chateaugay, NY (2010)	NA	0.08	71	106.5
Cohocton/Dutch Hills, NY (2010)	NA	0.08	50	125
Mountaineer, WV (2003)	NA	0.07	44	66
High Sheldon, NY (2010)	NA	0.06	75	112.5
Mount Storm, WV (2011)	NA	0.03	132	264
Maple Ridge, NY (2007-2008)	NA	0.03	195	321.75
Criterion, MD (2011)	NA	0.02	28	70
Beech Ridge, WV (2012)	NA	0.01	67	100.5
Beech Ridge, WV (2013)	NA	0.01	67	100.5
Locust Ridge, PA (Phase II; 2009)	NA	0	51	102
Locust Ridge, PA (Phase II; 2010)	NA	0	51	102
High Sheldon, NY (2011)	NA	0	75	112.5
Cohocton/Dutch Hill, NY (2009)	NA	0	50	125
Lempster, NH (2009)	NA	0	12	24
Lempster, NH (2010)	NA	0	12	24
Stetson Mountain II, ME (2010)	NA	0	17	25.5
Stetson Mountain II, ME (2012)	NA	0	17	25.5
Mount Storm, WV (2009)	NA	0	132	264
Casselman, PA (2009)	NA	0	23	34.5
Casselman, PA (2008)	NA	0	23	34.5

Appendix C2. Wind energy facilities in North America with use and fatality data for raptors. Use estimate presented as number of raptors per plot per 20-minute survey. Raptor fatality estimate is number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Use Estimate	Raptor Fatality Estimate	No. of Turbines	Total MW
Mars Hill, ME (2007)	NA	0	28	42
Mars Hill, ME (2008)	NA	0	28	42
Pinnacle, WV (2012)	NA	0	23	55.2
Stetson Mountain I, ME (2011)	NA	0	38	57
Stetson Mountain I, ME (2009)	NA	0	38	57
Stetson Mountain I, ME (2013)	NA	0	38	57
Noble Altona, NY (2010)	NA	0	65	97.5
Southeast				
Buffalo Mountain, TN (2000-2003)	NA	0	3	1.98
Buffalo Mountain, TN (2005)	NA	0	18	28.98

Appendix C2 (*continued*). Wind energy facilities in North America with use and fatality data for raptors.

Data from the following sources:

Facility	Use Estimate	Fatality Estimate	Facility	Use Estimate	Fatality Estimate
North Sky River, CA (15)	Erickson et al. 2011	This study			
North Sky River, CA (14)	Erickson et al. 2011	Levenstein and Riser-Espinoza 2015			
North Sky River, CA (13)	Erickson et al. 2011	Levenstein et al. 2014			
Alite, CA (09-10)	Erickson and Chatfield 2009	Chatfield et al. 2010	Leaning Juniper, OR (06-08)	Kronner et al. 2005	Gritski et al. 2008
Alta Wind I, CA (11-12)		Chatfield et al. 2012	Lempster, NH (09)		Tidhar et al. 2010
Alta Wind I-V, CA (13-14)		Chatfield et al. 2014	Lempster, NH (10)		Tidhar et al. 2011
Alta Wind II-V, CA (11-12)	Erickson and Chatfield 2009	Chatfield et al. 2012	Linden Ranch, WA (10-11)		Enz and Bay 2011
Alta VIII, CA (12-13)		Chatfield and Bay 2014	Locust Ridge, PA (Phase II; 09)		Arnett et al. 2011
Barton I & II, IA (10-11)		Derby et al. 2011a	Locust Ridge, PA (Phase II; 10)		Arnett et al. 2011
Barton Chapel, TX (09-10)		WEST 2011	Maple Ridge, NY (07-08)		Jain et al. 2009d
Beech Ridge, WV (12)		Tidhar et al. 2013b	Marengo I, WA (09-10)		URS Corporation 2010b
Beech Ridge, WV (13)		Young et al. 2014b	Marengo II, WA (09-10)		URS Corporation 2010c
Big Blue, MN (13)		Fagen Engineering 2014	Mars Hill, ME (07)		Stantec 2008a
Big Blue, MN (14)		Fagen Engineering 2015	Mars Hill, ME (08)		Stantec 2009a
Big Horn, WA (06-07)	Johnson and Erickson 2004	Kronner et al. 2008	Milford I & II, UT (11-12)		Stantec 2012b
Big Smile, OK (12-13)		Derby et al. 2013b	Montezuma I, CA (11)		ICF International 2012
Biglow Canyon, OR (Phase I; 08)	WEST 2005b	Jeffrey et al. 2009a	Montezuma I, CA (12)		ICF International 2013
Biglow Canyon, OR (Phase I; 09)	WEST 2005b	Enk et al. 2010	Montezuma II, CA (12-13)		Harvey & Associates 2013
Biglow Canyon, OR (Phase II; 09-10)	WEST 2005b	Enk et al. 2011a	Moraine II, MN (09)		Derby et al. 2010d
Biglow Canyon, OR (Phase II; 10-11)	WEST 2005b	Enk et al. 2012b	Mount Storm, WV (09)		Young et al. 2009a, 2010b
Biglow Canyon, OR (Phase III; 10-11)	WEST 2005b	Enk et al. 2012a	Mount Storm, WV (10)		Young et al. 2010a, 2011b
Blue Sky Green Field, WI (08; 09)		Gruver et al. 2009	Mount Storm, WV (11)		Young et al. 2011a, 2012b
Buffalo Gap I, TX (06)		Tierney 2007	Mountaineer, WV (03)		Kerns and Kerlinger 2004
Buffalo Gap II, TX (07-08)		Tierney 2009	Munnsville, NY (08)		Stantec 2009b
Buffalo Mountain, TN (00-03)		Nicholson et al. 2005	Mustang Hills, CA (12-13)		Chatfield and Bay 2014
Buffalo Mountain, TN (05)		Fiedler et al. 2007	Nine Canyon, WA (02-03)	Erickson et al. 2001	Erickson et al. 2003a
Buffalo Ridge, MN (Phase I; 96)		Johnson et al. 2000	Noble Altona, NY (10)		Jain et al. 2011b
Buffalo Ridge, MN (Phase I; 97)		Johnson et al. 2000	Noble Bliss, NY (08)		Jain et al. 2009e
Buffalo Ridge, MN (Phase I; 98)		Johnson et al. 2000	Noble Bliss, NY (09)		Jain et al. 2010a
Buffalo Ridge, MN (Phase I; 99)		Johnson et al. 2000	Noble Chateaugay, NY (10)		Jain et al. 2011c
Buffalo Ridge, MN (Phase II; 98)		Johnson et al. 2000	Noble Clinton, NY (08)		Jain et al. 2009c
Buffalo Ridge, MN (Phase II; 99)		Johnson et al. 2000	Noble Clinton, NY (09)		Jain et al. 2010b
Buffalo Ridge, MN (Phase III; 99)		Johnson et al. 2000	Noble Ellenburg, NY (08)		Jain et al. 2009b
Buffalo Ridge I, SD (09-10)		Derby et al. 2010b	Noble Ellenburg, NY (09)		Jain et al. 2010c
Buffalo Ridge II, SD (11-12)		Derby et al. 2012a	Noble Wethersfield, NY (10)		Jain et al. 2011a
Casselman, PA (08)		Arnett et al. 2009b	NPPD Ainsworth, NE (06)		Derby et al. 2007
Casselman, PA (09)		Arnett et al. 2010	Pebble Springs, OR (09-10)		Gritski and Kronner 2010b
Cedar Ridge, WI (09)		BHE Environmental 2010	Pinnacle, WV (12)		Hein et al. 2013a
Cedar Ridge, WI (10)		BHE Environmental 2011	Pioneer Prairie I, IA (Phase II; 11-12)		Chodachek et al. 2012
Cohocton/Dutch Hill, NY (09)		Stantec 2010	PrairieWinds ND1 (Minot), ND (10)		Derby et al. 2011c
Cohocton/Dutch Hills, NY (10)		Stantec 2011a	PrairieWinds ND1 (Minot), ND (11)		Derby et al. 2012c
Combine Hills, OR (Phase I; 04-05)	Young et al. 2003c	Young et al. 2006	PrairieWinds SD1 (Crow Lake), SD (11-12)		Derby et al. 2012d

Appendix C2 (*continued*). Wind energy facilities in North America with use and fatality data for raptors.

Data from the following sources:

Facility	Use Estimate	Fatality Estimate	Facility	Use Estimate	Fatality Estimate
Combine Hills, OR (11)	Young et al. 2003c	Enz et al. 2012	PrairieWinds SD1 (Crow Lake), SD (12-13)		Derby et al. 2013a
Criterion, MD (11)		Young et al. 2012a	PrairieWinds SD1, SD (13-14)		Derby et al. 2014a
Diablo Winds, CA (05-07)	WEST 2006, 2008	WEST 2006, 2008	Rail Splitter, IL (12-13)		Good et al. 2013b
Dillon, CA (08-09)		Chatfield et al. 2009	Red Hills, OK (12-13)		Derby et al. 2013c
Dry Lake I, AZ (09-10)	Thompson et al. 2011	Thompson et al. 2011	Ripley, Ont (08)		Jacques Whitford 2009
Dry Lake II, AZ (11-12)		Thompson and Bay 2012	Rugby, ND (10-11)		Derby et al. 2011b
Elkhorn, OR (08)	WEST 2005a	Jeffrey et a. 2009b	Shiloh I, CA (06-09)		Kerlinger et al. 2009
Elkhorn, OR (10)	WEST 2005a	Enk et al. 2011b	Shiloh II, CA (09-10)		Kerlinger et al. 2010
Elm Creek, MN (09-10)		Derby et al. 2010c	Shiloh II, CA (10-11)		Kerlinger et al. 2013a
Elm Creek II, MN (11-12)		Derby et al. 2012b	Solano III, CA (12-13)		AECOM 2013
Foote Creek Rim, WY (Phase I; 99)	Gruver 2002	Young et al. 2003b	Stateline, OR/WA (01-02)	Erickson et al. 2003c	Erickson et al. 2004
Foote Creek Rim, WY (Phase I; 00)	Gruver 2002	Young et al. 2003b, 2003d	Stateline, OR/WA (03)	Erickson et al. 2003c	Erickson et al. 2004
Foote Creek Rim, WY (Phase I; 01-02)	Gruver 2002	Young et al. 2003b, 2003d	Stateline, OR/WA (06)	Erickson et al. 2003c	Erickson et al. 2007
Fowler I, IN (09)		Johnson et al. 2010a	Stetson Mountain I, ME (09)		Stantec 2009c
Goodnoe, WA (09-10)		URS Corporation 2010a	Stetson Mountain I, ME (11)		Normandeau Associates 2011
Grand Ridge I, IL (09-10)	Derby et al. 2009	Derby et al. 2010g	Stetson Mountain I, ME (13)		Stantec 2014
Harvest Wind, WA (10-12)		Downes and Gritski 2012a	Stetson Mountain II, ME (10)		Normandeau Associates 2010
Hay Canyon, OR (09-10)		Gritski and Kronner 2010a	Stetson Mountain II, ME (12)		Stantec 2013e
High Sheldon, NY (10)		Tidhar et al. 2012a	Summerview, Alb (05-06)		Brown and Hamilton 2006b
High Sheldon, NY (11)		Tidhar et al. 2012b	Top of Iowa, IA (03)		Jain 2005
High Winds, CA (03-04)	Kerlinger et al. 2005	Kerlinger et al. 2006	Top of Iowa, IA (04)		Jain 2005
High Winds, CA (04-05)	Kerlinger et al. 2005	Kerlinger et al. 2006	Tuolumne (Windy Point I), WA (09-10)	Johnson et al. 2006	Enz and Bay 2010
Hopkins Ridge, WA (06)	Young et al. 2003a	Young et al. 2007	Vansycle, OR (99)	WCIA and WEST 1997	Erickson et al. 2000b
Hopkins Ridge, WA (08)	Young et al. 2003a	Young et al. 2009c	Vantage, WA (10-11)		Ventus 2012
Kewaunee County, WI (99-01)		Howe et al. 2002	Wessington Springs, SD (09)	Derby et al. 2008	Derby et al. 2010f
Kittitas Valley, WA (11-12)		Stantec 2012	Wessington Springs, SD (10)	Derby et al. 2008	Derby et al. 2011d
Klondike, OR (02-03)	Johnson et al. 2002a	Johnson et al. 2003a	White Creek, WA (07-11)		Downes and Gritski 2012b
Klondike II, OR (05-06)	Johnson et al. 2002a	NWC and WEST 2007	Wild Horse, WA (07)	Erickson et al. 2003b	Erickson et al. 2008
Klondike III (Phase I), OR (07-09)		Gritski et al. 2010	Windy Flats, WA (10-11)		Enz et al. 2011
Klondike IIIa (Phase II), OR (08-10)		Gritski et al. 2011	Winnebago, IA (09-10)		Derby et al. 2010e

Appendix C3. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Bat activity presented as number of bat passes per detector-night. Fatality estimate given as number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
North Sky River, CA (2015)	**13.88**	**8/17/10 – 9/5/11**	**1.51**	**100**	**160**
North Sky River, CA (2014)	**13.88**	**8/17/10 – 9/5/11**	**1.45**	**100**	**160**
North Sky River, CA (2013)	**13.88**	**8/17/10 – 9/5/11**	**2.59**	**100**	**160**
		California			
Shiloh I, CA (2006-2009)	NA	NA	3.92	100	150
Shiloh II, CA (2010-2011)	NA	NA	3.8	75	150
Shiloh II, CA (2009-2010)	NA	NA	2.6	75	150
High Winds, CA (2003-2004)	NA	NA	2.51	90	162
Dillon, CA (2008-2009)	NA	NA	2.17	45	45
Montezuma I, CA (2011)	NA	NA	1.9	16	36.8
High Winds, CA (2004-2005)	NA	NA	1.52	90	162
Alta Wind I, CA (2011-2012)	4.42[A]	6/26/09 -10/31/09	1.28	100	150
Montezuma II, CA (2012-2013)	NA	NA	0.91	34	78.2
Montezuma I, CA (2012)	NA	NA	0.84	16	36.8
Diablo Winds, CA (2005-2007)	NA	NA	0.82	31	20.46
Shiloh III, CA (2012-2013)	NA	NA	0.4	50	102.5
Solano III, CA (2012-2013)	NA	NA	0.31	55	128
Alite, CA (2009-2010)	NA	NA	0.24	8	24
Alta Wind I-V, CA (2013-2014)	NA	NA	0.2	290	720 (150 GE, 570 vestas)
Mustang Hills, CA (2012-2013)	NA	NA	0.1	50	150
Alta Wind II-V, CA (2011-2012)	0.78	6/26/09 -10/31/09	0.08	190	570
Pinyon Pines I & II, CA (2013-2014)	NA	NA	0.04	100	NA
Alta VIII, CA (2012-2013)	NA	NA	0	50	150
		Pacific Northwest			
Palouse Wind, WA (2012-2013)	NA	NA	4.23	58	104.4
Biglow Canyon, OR (Phase II; 2009-2010)	NA	NA	2.71	65	150
Nine Canyon, WA (2002-2003)	NA	NA	2.47	37	48.1
Stateline, OR/WA (2003)	NA	NA	2.29	454	299
Elkhorn, OR (2010)	NA	NA	2.14	61	101
White Creek, WA (2007-2011)	NA	NA	2.04	89	204.7
Biglow Canyon, OR (Phase I; 2008)	NA	NA	1.99	76	125.4
Leaning Juniper, OR (2006-2008)	NA	NA	1.98	67	100.5
Big Horn, WA (2006-2007)	NA	NA	1.9	133	199.5
Combine Hills, OR (Phase I; 2004-2005)	NA	NA	1.88	41	41
Linden Ranch, WA (2010-2011)	NA	NA	1.68	25	50
Pebble Springs, OR (2009-2010)	NA	NA	1.55	47	98.7
Hopkins Ridge, WA (2008)	NA	NA	1.39	87	156.6
Harvest Wind, WA (2010-2012)	NA	NA	1.27	43	98.9
Elkhorn, OR (2008)	NA	NA	1.26	61	101
Vansycle, OR (1999)	NA	NA	1.12	38	24.9
Klondike III (Phase I), OR (2007-2009)	NA	NA	1.11	125	223.6
Stateline, OR/WA (2001-2002)	NA	NA	1.09	454	299
Stateline, OR/WA (2006)	NA	NA	0.95	454	299
Tuolumne (Windy Point I), WA (2009-2010)	NA	NA	0.94	62	136.6
Klondike, OR (2002-2003)	NA	NA	0.77	16	24

Appendix C3. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Bat activity presented as number of bat passes per detector-night. Fatality estimate given as number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Combine Hills, OR (2011)	NA	NA	0.73	104	104
Hopkins Ridge, WA (2006)	NA	NA	0.63	83	150
Biglow Canyon, OR (Phase I; 2009)	NA	NA	0.58	76	125.4
Biglow Canyon, OR (Phase II; 2010-2011)	NA	NA	0.57	65	150
Hay Canyon, OR (2009-2010)	NA	NA	0.53	48	100.8
Windy Flats, WA (2010-2011)	NA	NA	0.41	114	262.2
Klondike II, OR (2005-2006)	NA	NA	0.41	50	75
Vantage, WA (2010-2011)	NA	NA	0.4	60	90
Wild Horse, WA (2007)	NA	NA	0.39	127	229
Goodnoe, WA (2009-2010)	NA	NA	0.34	47	94
Marengo II, WA (2009-2010)	NA	NA	0.27	39	70.2
Biglow Canyon, OR (Phase III; 2010-2011)	NA	NA	0.22	76	174.8
Marengo I, WA (2009-2010)	NA	NA	0.17	78	140.4
Klondike IIIa (Phase II), OR (2008-2010)	NA	NA	0.14	51	76.5
Kittitas Valley, WA (2011-2012)	NA	NA	0.12	48	100.8
Rocky Mountains					
Summerview, Alb (2006; 2007)	7.65[B]	07/15/06-07-09/30/06-07	11.42	39	70.2
Summerview, Alb (2005-2006)	NA	NA	10.27	39	70.2
Judith Gap, MT (2006-2007)	NA	NA	8.93	90	135
Foote Creek Rim, WY (Phase I; 1999)	NA	NA	3.97	69	41.4
Judith Gap, MT (2009)	NA	NA	3.2	90	135
Milford I, UT (2010-2011)	NA	NA	2.05	58	145
Milford I & II, UT (2011-2012)	NA	NA	1.67	107	160.5 (58.5 I, 102 II)
Foote Creek Rim, WY (Phase I; 2001-2002)	2.2[B,C]	6/15/01-9/1/01	1.57	69	41.4
Foote Creek Rim, WY (Phase I; 2000)	2.2[B,C]	6/15/00-9/1/00	1.05	69	41.4
Southwest					
Dry Lake I, AZ (2009-2010)	8.8	4/29/10-11/10/10	3.43	30	63
Dry Lake II, AZ (2011-2012)	11.5	5/11/11-10/26/11	1.66	31	65
Midwest					
Cedar Ridge, WI (2009)	9.97[B,C,D,E]	7/16/07-9/30/07	30.61	41	67.6
Top Crop I & II, IL (2012-2013)	NA	NA	26.85	200 (68 Phase I, 132 Phase II)	300 (102 Phase I, 198 Phase II)
Blue Sky Green Field, WI (2008; 2009)	7.7[D]	7/24/07-10/29/07	24.57	88	145
Cedar Ridge, WI (2010)	9.97[B,C,D,E]	7/16/07-9/30/07	24.12	41	68
Rail Splitter, IL (2012-2013)	NA	NA	22.53	67	100.5
Fowler I, II, III, IN (2011)	NA	NA	20.19	355	600
Fowler I, II, III, IN (2010)	NA	NA	18.96	355	600
Forward Energy Center, WI (2008-2010)	6.97	8/5/08-11/08/08	18.17	86	129

Appendix C3. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Bat activity presented as number of bat passes per detector-night. Fatality estimate given as number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Harrow, Ont (2010)	NA	NA	11.13	24 (four 6-turbine facilities)	39.6
Top of Iowa, IA (2004)	35.7	5/26/04-9/24/04	10.27	89	80
Pioneer Prairie I, IA (Phase II; 2011-2012)	NA	NA	10.06	62	102.3
Fowler I, IN (2009)	NA	NA	8.09	162	301
Crystal Lake II, IA (2009)	NA	NA	7.42	80	200
Top of Iowa, IA (2003)	NA	NA	7.16	89	80
Kewaunee County, WI (1999-2001)	NA	NA	6.45	31	20.46
Ripley, Ont (2008)	NA	NA	4.67	38	76
Winnebago, IA (2009-2010)	NA	NA	4.54	10	20
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	2.2[B]	6/15/01-9/15/01	4.35	143	107.25
Pioneer Prairie II, IA (2013)	NA	NA	3.83	62	102.3
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	2.2[B]	6/15/01-9/15/01	3.71	138	103.5
Crescent Ridge, IL (2005-2006)	NA	NA	3.27	33	49.5
Fowler I, II, III, IN (2012)	NA	NA	2.96	355	600
Elm Creek II, MN (2011-2012)	NA	NA	2.81	62	148.8
Buffalo Ridge II, SD (2011-2012)	NA	NA	2.81	105	210
Buffalo Ridge, MN (Phase III; 1999)	NA	NA	2.72	138	103.5
Buffalo Ridge, MN (Phase II; 1999)	NA	NA	2.59	143	107.25
Moraine II, MN (2009)	NA	NA	2.42	33	49.5
Buffalo Ridge, MN (Phase II; 1998)	NA	NA	2.16	143	107.25
PrairieWinds ND1 (Minot), ND (2010)	NA	NA	2.13	80	115.5
Grand Ridge I, IL (2009-2010)	NA	NA	2.1	66	99
Big Blue, MN (2013)	NA	NA	2.04	18	36
Barton I & II, IA (2010-2011)	NA	NA	1.85	80	160
Fowler III, IN (2009)	NA	NA	1.84	60	99
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	1.9[B]	6/15/02-9/15/02	1.81	138	103.5
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	1.9[B]	6/15/02-9/15/02	1.64	143	107.25
Rugby, ND (2010-2011)	NA	NA	1.6	71	149
Elm Creek, MN (2009-2010)	NA	NA	1.49	67	100
Wessington Springs, SD (2009)	NA	NA	1.48	34	51
Big Blue, MN (2014)	NA	NA	1.43	18	36
PrairieWinds ND1 (Minot), ND (2011)	NA	NA	1.39	80	115.5
PrairieWinds SD1, SD (2011-2012)	NA	NA	1.23	108	162
NPPD Ainsworth, NE (2006)	NA	NA	1.16	36	20.5
PrairieWinds SD1, SD (2012-2013)	NA	NA	1.05	108	162
Buffalo Ridge, MN (Phase I; 1999)	NA	NA	0.74	73	25
PrairieWinds SD1, SD (2013-2014)	NA	NA	0.52	108	162
Wessington Springs, SD (2010)	NA	NA	0.41	34	51
Buffalo Ridge I, SD (2009-2010)	NA	NA	0.16	24	50.4

Appendix C3. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Bat activity presented as number of bat passes per detector-night. Fatality estimate given as number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Southern Plains					
Barton Chapel, TX (2009-2010)	NA	NA	3.06	60	120
Big Smile, OK (2012-2013)	NA	NA	2.9	66	132
Buffalo Gap II, TX (2007-2008)	NA	NA	0.14	155	233
Red Hills, OK (2012-2013)	NA	NA	0.11	82	123
Buffalo Gap I, TX (2006)	NA	NA	0.1	67	134
Northeast					
Pinnacle, WV (2012)	NA	NA	40.2	23	55.2
Mountaineer, WV (2003)	NA	NA	31.69	44	66
Mount Storm, WV (2009)	30.09	7/15/09-10/7/09	17.53	132	264
Noble Wethersfield, NY (2010)	NA	NA	16.3	84	126
Criterion, MD (2011)	NA	NA	15.61	28	70
Mount Storm, WV (2010)	36.67[F]	4/18/10-10/15/10	15.18	132	264
Locust Ridge, PA (Phase II; 2010)	NA	NA	14.38	51	102
Locust Ridge, PA (Phase II; 2009)	NA	NA	14.11	51	102
Casselman, PA (2008)	NA	NA	12.61	23	34.5
Maple Ridge, NY (2006)	NA	NA	11.21	120	198
Cohocton/Dutch Hills, NY (2010)	NA	NA	10.32	50	125
Wolfe Island, Ont (July-December 2010)	NA	NA	9.5	86	197.8
Cohocton/Dutch Hill, NY (2009)	NA	NA	8.62	50	125
Casselman, PA (2009)	NA	NA	8.6	23	34.5
Noble Bliss, NY (2008)	NA	NA	7.8	67	100
Criterion, MD (2012)	NA	NA	7.62	28	70
Mount Storm, WV (2011)	NA	NA	7.43	132	264
Maple Ridge, NY (2012)	NA	NA	7.3	195	321.75
Mount Storm, WV (Fall 2008)	35.2	7/20/08-10/12/08	6.62	82	164
Maple Ridge, NY (2007)	NA	NA	6.49	195	321.75
Wolfe Island, Ont (July-December 2009)	NA	NA	6.42	86	197.8
Criterion, MD (2013)	NA	NA	5.32	28	70
Maple Ridge, NY (2007-2008)	NA	NA	4.96	195	321.75
Noble Clinton, NY (2009)	1.9[E]	8/1/09-09/31/09	4.5	67	100
Casselman Curtailment, PA (2008)	NA	NA	4.4	23	35.4
Noble Altona, NY (2010)	NA	NA	4.34	65	97.5
Noble Ellenburg, NY (2009)	16.1[E]	8/16/09-09/15/09	3.91	54	80
Noble Bliss, NY (2009)	NA	NA	3.85	67	100
Lempster, NH (2010)	NA	NA	3.57	12	24
Noble Ellenburg, NY (2008)	NA	NA	3.46	54	80
Noble Clinton, NY (2008)	2.1[E]	8/8/08-09/31/08	3.14	67	100
Lempster, NH (2009)	NA	NA	3.11	12	24
Record Hill, ME (2012)	24.6	4/16/12-10/23/12	2.96	22	50.6
Mars Hill, ME (2007)	NA	NA	2.91	28	42
Wolfe Island, Ont (July-December 2011)	NA	NA	2.49	86	197.8
Noble Chateaugay, NY (2010)	NA	NA	2.44	71	106.5
High Sheldon, NY (2010)	NA	NA	2.33	75	112.5
Stetson Mountain II, ME (2012)	NA	NA	2.27	17	25.5
Beech Ridge, WV (2012)	NA	NA	2.03	67	100.5
Munnsville, NY (2008)	NA	NA	1.93	23	34.5

Appendix C3. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Bat activity presented as number of bat passes per detector-night. Fatality estimate given as number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
High Sheldon, NY (2011)	NA	NA	1.78	75	112.5
Stetson Mountain II, ME (2010)	NA	NA	1.65	17	25.5
Stetson Mountain I, ME (2009)	28.5; 0.3[G]	7/10/09-10/15/09	1.4	38	57
Beech Ridge, WV (2013)	NA	NA	0.58	67	100.5
Record Hill, ME (2014)	NA	NA	0.55	22	50.6
Mars Hill, ME (2008)	NA	NA	0.45	28	42
Stetson Mountain I, ME (2011)	NA	NA	0.28	38	57
Stetson Mountain I, ME (2013)	NA	NA	0.18	38	57
Rollins, ME (2012)	NA	NA	0.18	40	60
Kibby, ME (2011)	NA	NA	0.12	44	132
Southeast					
Buffalo Mountain, TN (2005)	NA	NA	39.7	18	28.98
Buffalo Mountain, TN (2000-2003)	23.7[C]	NA	31.54	3	1.98

A = Average of ground-based detectors at CPC Proper (Phase I) for late summer/fall period only
B = Activity rate was averaged across phases and/or years
C = Activity rate calculated by WEST from data presented in referenced report
D = Activity rate based on pre-construction monitoring; data for all other activity and fatality rates were collected concurrently
E = Activity rate based on data collected at various heights all other activity rates are from ground-based units only
F = Activity rate based on data collected from ground-based units excluding reference stations during the spring, summer, and fall seasons
G = The overall activity rate of 28.5 is from reference stations located along forest edges which may be attractive to bats; the activity rate of 0.3 is from one unit placed on a nacelle

Appendix C3 (*continued*). Wind energy facilities in North America with comparable activity and fatality data for bats.

Data from the following sources:

Facility	Activity Estimate	Fatality Estimate	Facility	Activity Estimate	Fatality Estimate
North Sky River, CA (15)	Chatfield et al. 2011	This study.			
North Sky River, CA (14)	Chatfield et al. 2011	Levenstein and Riser-Espinoza 2015			
North Sky River, CA (13)	Chatfield et al. 2011	Levenstein et al. 2014			
Alite, CA (09-10)		Chatfield et al. 2010	Lempster, NH (09)		Tidhar et al. 2010
Alta Wind I, CA (11-12)	Solick et al. 2010b	Chatfield et al. 2012	Lempster, NH (10)		Tidhar et al. 2011
Alta Wind I-V, CA (13-14)		Chatfield et al. 2014	Linden Ranch, WA (10-11)		Enz and Bay 2011
Alta Wind II-V, CA (11-12)	Solick et al. 2010b	Chatfield et al. 2012	Locust Ridge, PA (Phase II; 09)		Arnett et al. 2011
Alta VIII, CA (12-13)		Chatfield and Bay 2014	Locust Ridge, PA (Phase II; 10)		Arnett et al. 2011
Barton I & II, IA (10-11)		Derby et al. 2011a	Maple Ridge, NY (06)		Jain et al. 2007
Barton Chapel, TX (09-10)		WEST 2011	Maple Ridge, NY (07)		Jain et al. 2009a
Beech Ridge, WV (12)		Tidhar et al. 2013b	Maple Ridge, NY (07-08)		Jain et al. 2009d
Beech Ridge, WV (13)		Young et al. 2014b	Maple Ridge, NY (12)		Tidhar et al. 2013a
Big Blue, MN (13)		Fagen Engineering 2014	Marengo I, WA (09-10)		URS Corporation 2010b
Big Blue, MN (14)		Fagen Engineering 2015	Marengo II, WA (09-10)		URS Corporation 2010c
Big Horn, WA (06-07)		Kronner et al. 2008	Mars Hill, ME (07)		Stantec 2008a
Big Smile, OK (12-13)		Derby et al. 2013b	Mars Hill, ME (08)		Stantec 2009a
Biglow Canyon, OR (Phase I; 08)		Jeffrey et al. 2009a	Milford I, UT (10-11)		Stantec 2011b
Biglow Canyon, OR (Phase I; 09)		Enk et al. 2010	Milford I & II, UT (11-12)		Stantec 2012b
Biglow Canyon, OR (Phase II; 09-10)		Enk et al. 2011a	Montezuma I, CA (11)		ICF International 2012
Biglow Canyon, OR (Phase II; 10-11)		Enk et al. 2012b	Montezuma I, CA (12)		ICF International 2013
Biglow Canyon, OR (Phase III; 10-11)		Enk et al. 2012a	Montezuma II, CA (12-13)		Harvey & Associates 2013
Blue Sky Green Field, WI (08; 09)	Gruver 2008	Gruver et al. 2009	Moraine II, MN (09)		Derby et al. 2010d
Buffalo Gap I, TX (06)		Tierney 2007	Mount Storm, WV (Fall 08)	Young et al. 2009b	Young et al. 2009b
Buffalo Gap II, TX (07-08)		Tierney 2009	Mount Storm, WV (09)	Young et al. 2009a, 2010b	Young et al. 2009a, 2010b
Buffalo Mountain, TN (00-03)	Fiedler 2004	Nicholson et al. 2005	Mount Storm, WV (10)	Young et al. 2010a, 2011b	Young et al. 2010a, 2011b
Buffalo Mountain, TN (05)		Fiedler et al. 2007	Mount Storm, WV (11)		Young et al. 2011a, 2012b
Buffalo Ridge, MN (Phase I; 99)		Johnson et al. 2000	Mountaineer, WV (03)		Kerns and Kerlinger 2004
Buffalo Ridge, MN (Phase II; 98)		Johnson et al. 2000	Munnsville, NY (08)		Stantec 2009b
Buffalo Ridge, MN (Phase II; 99)		Johnson et al. 2000	Mustang Hills, CA (12-13)		Chatfield and Bay 2014
Buffalo Ridge, MN (Phase II; 01/Lake Benton I)	Johnson et al. 2004	Johnson et al. 2004	Nine Canyon, WA (02-03)		Erickson et al. 2003a
Buffalo Ridge, MN (Phase II; 02/Lake Benton I)	Johnson et al. 2004	Johnson et al. 2004	Noble Altona, NY (10)		Jain et al. 2011b
Buffalo Ridge, MN (Phase III; 99)		Johnson et al. 2000	Noble Bliss, NY (08)		Jain et al.2009e
Buffalo Ridge, MN (Phase III; 01/Lake Benton II)	Johnson et al. 2004	Johnson et al. 2004	Noble Bliss, NY (09)		Jain et al. 2010a
Buffalo Ridge, MN (Phase III; 02/Lake Benton II)	Johnson et al. 2004	Johnson et al. 2004	Noble Chateaugay, NY (10)		Jain et al. 2011c
Buffalo Ridge I, SD (09-10)		Derby et al. 2010b	Noble Clinton, NY (08)	Reynolds 2010a	Jain et al. 2009c
Buffalo Ridge II, SD (11-12)		Derby et al. 2012a	Noble Clinton, NY (09)	Reynolds 2010a	Jain et al. 2010b
Casselman, PA (08)		Arnett et al. 2009b	Noble Ellenburg, NY (08)		Jain et al. 2009b
Casselman, PA (09)		Arnett et al. 2010	Noble Ellenburg, NY (09)	Reynolds 2010b	Jain et al. 2010c
Casselman Curtailment, PA (08)		Arnett et al. 2009a	Noble Wethersfield, NY (10)		Jain et al. 2011a
Cedar Ridge, WI (09)	BHE Environmental 2008	BHE Environmental 2010	NPPD Ainsworth, NE (06)		Derby et al. 2007
Cedar Ridge, WI (10)	BHE Environmental 2008	BHE Environmental 2011	Palouse Wind, WA (12-13)		Stantec 2013a
Cohocton/Dutch Hill, NY (09)		Stantec 2010	Pebble Springs, OR (09-10)		Gritski and Kronner 2010b
Cohocton/Dutch Hills, NY (10)		Stantec 2011a	Pinnacle, WV (12)		Hein et al. 2013a
Combine Hills, OR (Phase I; 04-05)		Young et al. 2006	Pinyon Pines I&II, CA (13-14)		Chatfield and Russo 2014
Combine Hills, OR (11)		Enz et al. 2012	Pioneer Prairie I, IA (Phase II; 11-12)		Chodachek et al. 2012
Crescent Ridge, IL (05-06)		Kerlinger et al. 2007	Pioneer Prairie II, IA (13)		Chodachek et al. 2014
Criterion, MD (11)		Young et al. 2012a	PrairieWinds ND1 (Minot), ND (10)		Derby et al. 2011c

Appendix C3 (*continued*). Wind energy facilities in North America with comparable activity and fatality data for bats.

Data from the following sources:

Facility	Activity Estimate	Fatality Estimate	Facility	Activity Estimate	Fatality Estimate
Criterion, MD (12)		Young et al. 2013	PrairieWinds ND1 (Minot), ND (11)		Derby et al. 2012c
Criterion, MD (13)		Young et al. 2014a	PrairieWinds SD1 (Crow Lake), SD (11-12)		Derby et al. 2012d
Crystal Lake II, IA (09)		Derby et al. 2010a	PrairieWinds SD1 (Crow Lake), SD (12-13)		Derby et al. 2013a
Diablo Winds, CA (05-07)		WEST 2006, 2008	PrairieWinds SD1, SD (13-14)		Derby et al. 2014a
Dillon, CA (08-09)		Chatfield et al. 2009	Rail Splitter, IL (12-13)		Good et al. 2013b
Dry Lake I, AZ (09-10)	Thompson et al. 2011	Thompson et al. 2011	Record Hill, ME (12)	Stantec 2008b	Stantec 2013b
Dry Lake II, AZ (11-12)	Thompson and Bay 2012	Thompson and Bay 2012	Record Hill, ME (14)		Stantec 2015
Elkhorn, OR (08)		Jeffrey et a. 2009b	Red Hills, OK (12-13)		Derby et al. 2013c
Elkhorn, OR (10)		Enk et al. 2011b	Ripley, Ont (08)		Jacques Whitford 2009
Elm Creek, MN (09-10)		Derby et al. 2010c	Rollins, ME (12)		Stantec 2013c
Elm Creek II, MN (11-12)		Derby et al. 2012b	Rugby, ND (10-11)		Derby et al. 2011b
Foote Creek Rim, WY (Phase I; 99)		Young et al. 2003b	Shiloh I, CA (06-09)		Kerlinger et al. 2009
Foote Creek Rim, WY (Phase I; 00)	Gruver 2002	Young et al. 2003b, 2003d	Shiloh II, CA (09-10)		Kerlinger et al. 2010
Foote Creek Rim, WY (Phase I; 01-02)	Gruver 2002	Young et al. 2003b, 2003d	Shiloh II, CA (10-11)		Kerlinger et al. 2013a
Forward Energy Center, WI (08-10)	Watt and Drake 2011	Grodsky and Drake 2011	Shiloh III, CA (12-13)		Kerlinger et al. 2013b
Fowler I, IN (09)		Johnson et al. 2010a	Solano III, CA (12-13)		AECOM 2013
Fowler III, IN (09)		Johnson et al. 2010b	Stateline, OR/WA (01-02)		Erickson et al. 2004
Fowler I, II, III, IN (10)		Good et al. 2011	Stateline, OR/WA (03)		Erickson et al. 2004
Fowler I, II, III, IN (11)		Good et al. 2012	Stateline, OR/WA (06)		Erickson et al. 2007
Fowler I, II, III, IN (12)		Good et al. 2013c	Stetson Mountain I, ME (09)	Stantec 2009c	Stantec 2009c
Goodnoe, WA (09-10)		URS Corporation 2010a	Stetson Mountain I, ME (11)		Normandeau Associates 2011
Grand Ridge I, IL (09-10)		Derby et al. 2010g	Stetson Mountain I, ME (13)		Stantec 2014
Harrow, Ont (10)		NRSI 2011	Stetson Mountain II, ME (10)		Normandeau Associates 2010
Harvest Wind, WA (10-12)		Downes and Gritski 2012a	Stetson Mountain II, ME (12)		Stantec 2013e
Hay Canyon, OR (09-10)		Gritski and Kronner 2010a	Summerview, Alb (05-06)		Brown and Hamilton 2006b
High Sheldon, NY (10)		Tidhar et al. 2012a	Summerview, Alb (06; 07)	Baerwald 2008	Baerwald 2008
High Sheldon, NY (11)		Tidhar et al. 2012b	Top Crop I & II, IL (12-13)		Good et al. 2013a
High Winds, CA (03-04)		Kerlinger et al. 2006	Top of Iowa, IA (03)		Jain 2005
High Winds, CA (04-05)		Kerlinger et al. 2006	Top of Iowa, IA (04)	Jain 2005	Jain 2005
Hopkins Ridge, WA (06)		Young et al. 2007	Tuolumne (Windy Point I), WA (09-10)		Enz and Bay 2010
Hopkins Ridge, WA (08)		Young et al. 2009c	Vansycle, OR (99)		Erickson et al. 2000a
Judith Gap, MT (06-07)		TRC 2008	Vantage, WA (10-11)		Ventus 2012
Judith Gap, MT (09)		Poulton and Erickson 2010	Wessington Springs, SD (09)		Derby et al. 2010f
Kewaunee County, WI (99-01)		Howe et al. 2002	Wessington Springs, SD (10)		Derby et al. 2011d
Kibby, ME (11)		Stantec 2012a	White Creek, WA (07-11)		Downes and Gritski 2012b
Kittitas Valley, WA (11-12)		Stantec Consulting Services 2012	Wild Horse, WA (07)		Erickson et al. 2008
Klondike, OR (02-03)		Johnson et al. 2003b	Windy Flats, WA (10-11)		Enz et al. 2011
Klondike II, OR (05-06)		NWC and WEST 2007	Winnebago, IA (09-10)		Derby et al. 2010e
Klondike III (Phase I), OR (07-09)		Gritski et al. 2010	Wolfe Island, Ont (July-December 09)		Stantec Ltd. 2010b
Klondike IIIa (Phase II), OR (08-10)		Gritski et al. 2011	Wolfe Island, Ont (July-December 10)		Stantec Ltd. 2011b
Leaning Juniper, OR (06-08)		Gritski et al. 2008	Wolfe Island, Ont (July-December 11)		Stantec Ltd. 2012

Appendix C4. Fatality estimates for North American wind energy facilities.

Project	Bird Fatalities (birds/MW/ year)	Raptor Fatalities (raptors/MW/ year)	Bat Fatalities (bats/MW/ year)	Predominant Habitat Type	Citation
Alite, CA (2009-2010)	0.55	0.12	0.24	Shrub/scrub & grassland	Chatfield et al. 2010
Alta Wind I, CA (2011-2012)	7.07	0.27	1.28	Woodland, grassland, shrubland	Chatfield et al. 2012
Alta Wind I-V, CA (2013-2014)	7.8	0.08	0.2	NA	Chatfield et al. 2014
Alta Wind II-V, CA (2011-2012)	1.66	0.05	0.08	Desert scrub	Chatfield et al. 2012
Alta VIII, CA (2012-2013)	0.66	0.02	0	Grassland and riparian	Chatfield and Bay 2014
Barton I & II, IA (2010-2011)	5.5	0	1.85	Agriculture	Derby et al. 2011a
Barton Chapel, TX (2009-2010)	1.15	0.25	3.06	Agriculture/forest	WEST 2011
Beech Ridge, WV (2012)	1.19	0.01	2.03	Forest	Tidhar et al. 2013b
Beech Ridge, WV (2013)	1.48	0.01	0.58	Forest	Young et al. 2014b
Big Blue, MN (2013)	0.6	0	2.04	Agriculture	Fagen Engineering 2014
Big Blue, MN (2014)	0.37	0	1.43	Agriculture	Fagen Engineering 2015
Big Horn, WA (2006-2007)	2.54	0.11	1.9	Agriculture/grassland	Kronner et al. 2008
Big Smile, OK (2012-2013)	0.09	0	2.9	Grassland, agriculture	Derby et al. 2013b
Biglow Canyon, OR (Phase I; 2008)	1.76	0.03	1.99	Agriculture/grassland	Jeffrey et al. 2009a
Biglow Canyon, OR (Phase I; 2009)	2.47	0	0.58	Agriculture/grassland	Enk et al. 2010
Biglow Canyon, OR (Phase II; 2009-2010)	5.53	0.14	2.71	Agriculture	Enk et al. 2011a
Biglow Canyon, OR (Phase II; 2010-2011)	2.68	0.03	0.57	Grassland/shrub-steppe, agriculture	Enk et al. 2012b
Biglow Canyon, OR (Phase III; 2010-2011)	2.28	0.05	0.22	Grassland/shrub-steppe, agriculture	Enk et al. 2012a
Blue Sky Green Field, WI (2008; 2009)	7.17	0	24.57	Agriculture	Gruver et al. 2009
Buffalo Gap I, TX (2006)	1.32	0.1	0.1	Grassland	Tierney 2007
Buffalo Gap II, TX (2007-2008)	0.15	0	0.14	Forest	Tierney 2009
Buffalo Mountain, TN (2000-2003)	11.02	0	31.54	Forest	Nicholson et al. 2005
Buffalo Mountain, TN (2005)	1.1	0	39.7	Forest	Fiedler et al. 2007
Buffalo Ridge, MN (Phase I; 1996)	4.14	0	NA	Agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase I; 1997)	2.51	0	NA	Agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase I; 1998)	3.14	0	NA	Agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase I; 1999)	1.43	0.47	0.74	Agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1998)	2.47	0	2.16	Agriculture	Johnson et al. 2000

Appendix C4. Fatality estimates for North American wind energy facilities.

Project	Bird Fatalities (birds/MW/ year)	Raptor Fatalities (raptors/MW/ year)	Bat Fatalities (bats/MW/ year)	Predominant Habitat Type	Citation
Buffalo Ridge, MN (Phase II; 1999)	3.57	0	2.59	Agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	NA	NA	4.35	Agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	NA	NA	1.64	Agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase III; 1999)	5.93	0	2.72	Agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	NA	NA	3.71	Agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	NA	NA	1.81	Agriculture	Johnson et al. 2004
Buffalo Ridge I, SD (2009-2010)	5.06	0.2	0.16	Agriculture/grassland	Derby et al. 2010b
Buffalo Ridge II, SD (2011-2012)	1.99	0	2.81	Agriculture, grassland	Derby et al. 2012a
Casselman, PA (2008)	1.51	0	12.61	Forest	Arnett et al. 2009b
Casselman, PA (2009)	2.88	0	8.6	Forest, pasture, grassland	Arnett et al. 2010
Casselman Curtailment, PA (2008)	NA	NA	4.4	Forest	Arnett et al. 2009a
Cedar Ridge, WI (2009)	6.55	0.18	30.61	Agriculture	BHE Environmental 2010
Cedar Ridge, WI (2010)	3.72	0.13	24.12	Agriculture	BHE Environmental 2011
Cohocton/Dutch Hill, NY (2009)	1.39	0	8.62	Agriculture/forest	Stantec 2010
Cohocton/Dutch Hills, NY (2010)	1.32	0.08	10.32	Agriculture, forest	Stantec 2011a
Combine Hills, OR (Phase I; 2004-2005)	2.56	0	1.88	Agriculture/grassland	Young et al. 2006
Combine Hills, OR (2011)	2.33	0.05	0.73	Grassland/shrub-steppe, agriculture	Enz et al. 2012
Crescent Ridge, IL (2005-2006)	NA	NA	3.27	Agriculture	Kerlinger et al. 2007
Criterion, MD (2011)	6.4	0.02	15.61	Forest, agriculture	Young et al. 2012a
Criterion, MD (2012)	2.14	NA	7.62	Forest, agriculture	Young et al. 2013
Criterion, MD (2013)	3.49	NA	5.32	Forest, agriculture	Young et al. 2014a
Crystal Lake II, IA (2009)	NA	NA	7.42	Agriculture	Derby et al. 2010a
Diablo Winds, CA (2005-2007)	4.29	0.4	0.82	NA	WEST 2006, 2008
Dillon, CA (2008-2009)	4.71	0	2.17	Desert	Chatfield et al. 2009
Dry Lake I, AZ (2009-2010)	2.02	0	3.43	Desert grassland/forested	Thompson et al. 2011
Dry Lake II, AZ (2011-2012)	1.57	0	1.66	Desert grassland/forested	Thompson and Bay 2012

Appendix C4. Fatality estimates for North American wind energy facilities.

Project	Bird Fatalities (birds/MW/ year)	Raptor Fatalities (raptors/MW/ year)	Bat Fatalities (bats/MW/ year)	Predominant Habitat Type	Citation
Elkhorn, OR (2008)	0.64	0.06	1.26	Shrub/scrub & agriculture	Jeffrey et al. 2009b
Elkhorn, OR (2010)	1.95	0.08	2.14	Shrub/scrub & agriculture	Enk et al. 2011b
Elm Creek, MN (2009-2010)	1.55	0	1.49	Agriculture	Derby et al. 2010c
Elm Creek II, MN (2011-2012)	3.64	0	2.81	Agriculture, grassland	Derby et al. 2012b
Foote Creek Rim, WY (Phase I; 1999)	3.4	0.08	3.97	Grassland	Young et al. 2003b
Foote Creek Rim, WY (Phase I; 2000)	2.42	0.05	1.05	Grassland	Young et al. 2003b
Foote Creek Rim, WY (Phase I; 2001-2002)	1.93	0	1.57	Grassland	Young et al. 2003b
Forward Energy Center, WI (2008-2010)	NA	NA	18.17	Agriculture	Grodsky and Drake 2011
Fowler I, IN (2009)	2.83	0	8.09	Agriculture	Johnson et al. 2010a
Fowler I, II, III, IN (2010)	NA	NA	18.96	Agriculture	Good et al. 2011
Fowler I, II, III, IN (2011)	NA	NA	20.19	Agriculture	Good et al. 2012
Fowler I, II, III, IN (2012)	NA	NA	2.96	Agriculture	Good et al. 2013c
Fowler III, IN (2009)	NA	NA	1.84	Agriculture	Johnson et al. 2010b
Goodnoe, WA (2009-2010)	1.4	0.17	0.34	Grassland and shrub-steppe	URS Corporation 2010a
Grand Ridge I, IL (2009-2010)	0.48	0	2.1	Agriculture	Derby et al. 2010g
Harrow, Ont (2010)	NA	NA	11.13	Agriculture	Natural Resource Solutions Inc. (NRSI) 2011
Harvest Wind, WA (2010-2012)	2.94	0.23	1.27	Grassland/shrub-steppe	Downes and Gritski 2012a
Hay Canyon, OR (2009-2010)	2.21	0	0.53	Agriculture	Gritski and Kronner 2010a
High Sheldon, NY (2010)	1.76	0.06	2.33	Agriculture	Tidhar et al. 2012a
High Sheldon, NY (2011)	1.57	0	1.78	Agriculture	Tidhar et al. 2012b
High Winds, CA (2003-2004)	1.62	0.5	2.51	Agriculture/grassland	Kerlinger et al. 2006
High Winds, CA (2004-2005)	1.1	0.28	1.52	Agriculture/grassland	Kerlinger et al. 2006
Hopkins Ridge, WA (2006)	1.23	0.14	0.63	Agriculture/grassland	Young et al. 2007
Hopkins Ridge, WA (2008)	2.99	0.07	1.39	Agriculture/grassland	Young et al. 2009c
Judith Gap, MT (2006-2007)	NA	NA	8.93	Agriculture/grassland	TRC 2008
Judith Gap, MT (2009)	NA	NA	3.2	Agriculture/grassland	Poulton and Erickson 2010

Appendix C4. Fatality estimates for North American wind energy facilities.

Project	Bird Fatalities (birds/MW/ year)	Raptor Fatalities (raptors/MW/ year)	Bat Fatalities (bats/MW/ year)	Predominant Habitat Type	Citation
Kewaunee County, WI (1999-2001)	1.95	0	6.45	Agriculture	Howe et al. 2002
Kibby, ME (2011)	NA	NA	0.12	Forest; commercial forest	Stantec 2012a
Kittitas Valley, WA (2011-2012)	1.06	0.09	0.12	Sagebrush-steppe, grassland	Stantec Consulting Services 2012
Klondike, OR (2002-2003)	0.95	0	0.77	Agriculture/grassland	Johnson et al. 2003b
Klondike II, OR (2005-2006)	3.14	0.06	0.41	Agriculture/grassland	NWC and WEST 2007
Klondike III (Phase I), OR (2007-2009)	3.02	0.15	1.11	Agriculture/grassland	Gritski et al. 2010
Klondike IIIa (Phase II), OR (2008-2010)	2.61	0.06	0.14	Grassland/shrub-steppe and agriculture	Gritski et al. 2011
Leaning Juniper, OR (2006-2008)	6.66	0.16	1.98	Agriculture	Gritski et al. 2008
Lempster, NH (2009)	3.38	0	3.11	Grasslands/forest/rocky embankments	Tidhar et al. 2010
Lempster, NH (2010)	2.64	0	3.57	Grasslands/forest/rocky embankments	Tidhar et al. 2011
Linden Ranch, WA (2010-2011)	6.65	0.27	1.68	Grassland/shrub-steppe, agriculture	Enz and Bay 2011
Locust Ridge, PA (Phase II; 2009)	0.84	0	14.11	Grassland	Arnett et al. 2011
Locust Ridge, PA (Phase II; 2010)	0.76	0	14.38	Grassland	Arnett et al. 2011
Maple Ridge, NY (2006)	NA	NA	11.21	Agriculture/forested	Jain et al. 2007
Maple Ridge, NY (2007)	2.34	NA	6.49	Agriculture/forested	Jain et al. 2009a
Maple Ridge, NY (2007-2008)	2.07	0.03	4.96	Agriculture/forested	Jain et al. 2009d
Maple Ridge, NY (2012)	NA	NA	7.3	Agriculture/forested	Tidhar et al. 2013a
Marengo I, WA (2009-2010)	0.27	0	0.17	Agriculture	URS Corporation 2010b
Marengo II, WA (2009-2010)	0.16	0.05	0.27	Agriculture	URS Corporation 2010c
Mars Hill, ME (2007)	1.67	0	2.91	Forest	Stantec 2008a
Mars Hill, ME (2008)	1.76	0	0.45	Forest	Stantec 2009a
Milford I, UT (2010-2011)	0.56	NA	2.05	Desert shrub	Stantec 2011b
Milford I & II, UT (2011-2012)	0.73	0.04	1.67	Desert shrub	Stantec 2012b
Montezuma I, CA (2011)	5.19	1.06	1.9	Agriculture and grasslands	ICF International 2012
Montezuma I, CA (2012)	8.91	0.79	0.84	Agriculture and grasslands	ICF International 2013
Montezuma II, CA (2012-2013)	1.08	0.46	0.91	Agriculture	Harvey & Associates 2013
Moraine II, MN (2009)	5.59	0.37	2.42	Agriculture/grassland	Derby et al. 2010d
Mount Storm, WV (Fall 2008)	NA	NA	6.62	Forest	Young et al. 2009b

Appendix C4. Fatality estimates for North American wind energy facilities.

Project	Bird Fatalities (birds/MW/ year)	Raptor Fatalities (raptors/MW/ year)	Bat Fatalities (bats/MW/ year)	Predominant Habitat Type	Citation
Mount Storm, WV (2009)	3.85	0	17.53	Forest	Young et al. 2009a, 2010b
Mount Storm, WV (2010)	2.6	0.1	15.18	Forest	Young et al. 2010a, 2011b
Mount Storm, WV (2011)	4.24	0.03	7.43	Forest	Young et al. 2011a, 2012b
Mountaineer, WV (2003)	2.69	0.07	31.69	Forest	Kerns and Kerlinger 2004
Munnsville, NY (2008)	1.48	0.59	1.93	Agriculture/forest	Stantec 2009b
Mustang Hills, CA (2012-2013)	1.66	0.08	0.1	Grasslands and Riparian	Chatfield and Bay 2014
Nine Canyon, WA (2002-2003)	2.76	0.03	2.47	Agriculture/grassland	Erickson et al. 2003a
Noble Altona, NY (2010)	1.84	0	4.34	Forest	Jain et al. 2011b
Noble Bliss, NY (2008)	1.3	0.1	7.8	Agriculture/forest	Jain et al. 2009e
Noble Bliss, NY (2009)	2.28	0.12	3.85	Agriculture/forest	Jain et al. 2010a
Noble Chateaugay, NY (2010)	1.66	0.08	2.44	Agriculture	Jain et al. 2011c
Noble Clinton, NY (2008)	1.59	0.1	3.14	Agriculture/forest	Jain et al. 2009c
Noble Clinton, NY (2009)	1.11	0.16	4.5	Agriculture/forest	Jain et al. 2010b
Noble Ellenburg, NY (2008)	0.83	0.11	3.46	Agriculture/forest	Jain et al. 2009b
Noble Ellenburg, NY (2009)	2.66	0.25	3.91	Agriculture/forest	Jain et al. 2010c
Noble Wethersfield, NY (2010)	1.7	0.13	16.3	Agriculture	Jain et al. 2011a
North Sky River, CA (2013)	2.05	NA	2.59	Mojavean juniper woodland and scrub	
North Sky River, CA (2014)	1.23	0.28	1.45	Mojavean juniper woodland and scrub	
North Sky River (2015-2016)	0.72	0.17	1.51	Mojavean juniper woodland and scrub	This study
NPPD Ainsworth, NE (2006)	1.63	0.06	1.16	Agriculture/grassland	Derby et al. 2007
Palouse Wind, WA (2012-2013)	0.72	NA	4.23	Agriculture and grasslands	Stantec 2013a
Pebble Springs, OR (2009-2010)	1.93	0.04	1.55	Grassland	Gritski and Kronner 2010b
Pine Tree, CA (2009-2010, 2011)	17.44	NA	NA	Grassland	BioResource Consultants 2012
Pinnacle, WV (2012)	3.99	0	40.2	Forest	Hein et al. 2013a
Pinyon Pines I & II, CA (2013-2014)	1.18	NA	0.04	Na	Chatfield and Russo 2014
Pioneer Prairie I, IA (Phase II; 2011-2012)	0.27	0	10.06	Agriculture, grassland	Chodachek et al. 2012
Pioneer Prairie II, IA (2013)	NA	NA	3.83	Agriculture	Chodachek et al. 2014
PrairieWinds ND1 (Minot), ND (2010)	1.48	0.05	2.13	Agriculture	Derby et al. 2011c

Appendix C4. Fatality estimates for North American wind energy facilities.

Project	Bird Fatalities (birds/MW/ year)	Raptor Fatalities (raptors/MW/ year)	Bat Fatalities (bats/MW/ year)	Predominant Habitat Type	Citation
PrairieWinds ND1 (Minot), ND (2011)	1.56	0.05	1.39	Agriculture, grassland	Derby et al. 2012c
PrairieWinds SD1, SD (2011-2012)	1.41	0	1.23	Grassland	Derby et al. 2012d
PrairieWinds SD1, SD (2012-2013)	2.01	0.03	1.05	Grassland	Derby et al. 2013a
PrairieWinds SD1, SD (2013-2014)	1.66	0.17	0.52	Grassland	Derby et al. 2014a
Rail Splitter, IL (2012-2013)	0.84	0	22.53	Agriculture	Good et al. 2013b
Record Hill, ME (2012)	3.7	NA	2.96	Forest	Stantec 2013b
Record Hill, ME (2014)	1.84	NA	0.55	Forest	Stantec 2015
Red Hills, OK (2012-2013)	0.08	0.04	0.11	Grassland	Derby et al. 2013c
Ripley, Ont (2008)	3.09	0.1	4.67	Agriculture	Jacques Whitford 2009
Rollins, ME (2012)	2.9	NA	0.18	Forest	Stantec 2013c
Rugby, ND (2010-2011)	3.82	0.06	1.6	Agriculture	Derby et al. 2011b
Shiloh I, CA (2006-2009)	6.96	0.42	3.92	Agriculture/grassland	Kerlinger et al. 2009
Shiloh II, CA (2009-2010)	1.9	0.11	2.6	Agriculture	Kerlinger et al. 2010, 2013a
Shiloh II, CA (2010-2011)	2.8	0.44	3.8	Agriculture	Kerlinger et al. 2013a
Shiloh III, CA (2012-2013)	3.3	NA	0.4	NA	Kerlinger et al. 2013b
Solano III, CA (2012-2013)	1.6	0.95	0.31	NA	AECOM 2013
Stateline, OR/WA (2001-2002)	3.17	0.09	1.09	Agriculture/grassland	Erickson et al. 2004
Stateline, OR/WA (2003)	2.68	0.09	2.29	Agriculture/grassland	Erickson et al. 2004
Stateline, OR/WA (2006)	1.23	0.11	0.95	Agriculture/grassland	Erickson et al. 2007
Stetson Mountain I, ME (2009)	2.68	0	1.4	Forest	Stantec 2009c
Stetson Mountain I, ME (2011)	1.18	0	0.28	Forest	Normandeau Associates 2011
Stetson Mountain I, ME (2013)	6.95	0	0.18	Forest	Stantec 2014
Stetson Mountain II, ME (2010)	1.42	0	1.65	Forest	Normandeau Associates 2010
Stetson Mountain II, ME (2012)	3.37	0	2.27	Forest	Stantec 2013e
Summerview, Alb (2005-2006)	1.06	0.11	10.27	Agriculture	Brown and Hamilton 2006b
Summerview, Alb (2006; 2007)	NA	NA	11.42	Agriculture/grassland	Baerwald 2008
Top Crop I & II, IL (2012-2013)	0.6	NA	26.85	Agriculture	Good et al. 2013a
Top of Iowa, IA (2003)	0.42	0	7.16	Agriculture	Jain 2005
Top of Iowa, IA (2004)	0.81	0.17	10.27	Agriculture	Jain 2005

Appendix C4. Fatality estimates for North American wind energy facilities.

Project	Bird Fatalities (birds/MW/ year)	Raptor Fatalities (raptors/MW/ year)	Bat Fatalities (bats/MW/ year)	Predominant Habitat Type	Citation
Tuolumne (Windy Point I), WA (2009-2010)	3.2	0.29	0.94	Grassland/shrub-steppe, agriculture and forest	Enz and Bay 2010
Vansycle, OR (1999)	0.95	0	1.12	Agriculture/grassland	Erickson et al. 2000a
Vantage, WA (2010-2011)	1.27	0.29	0.4	Shrub-steppe, grassland	Ventus Environmental Solutions 2012
Wessington Springs, SD (2009)	8.25	0.06	1.48	Grassland	Derby et al. 2010f
Wessington Springs, SD (2010)	0.89	0.07	0.41	Grassland	Derby et al. 2011d
White Creek, WA (2007-2011)	4.05	0.47	2.04	Grassland/shrub-steppe, agriculture	Downes and Gritski 2012b
Wild Horse, WA (2007)	1.55	0.09	0.39	Grassland	Erickson et al. 2008
Windy Flats, WA (2010-2011)	8.45	0.04	0.41	Grassland/shrub-steppe, agriculture	Enz et al. 2011
Winnebago, IA (2009-2010)	3.88	0.27	4.54	Agriculture/grassland	Derby et al. 2010e
Wolfe Island, Ont (July-December 2009)	NA	NA	6.42	Grassland	Stantec Ltd. 2010b
Wolfe Island, Ont (July-December 2010)	NA	NA	9.5	Grassland	Stantec Ltd. 2011b
Wolfe Island, Ont (July-December 2011)	NA	NA	2.49	Grassland	Stantec Ltd. 2012

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
Alite, CA (2009-2010)	8	24	80	8	200 m x 200 m	1 year	Weekly (spring, fall), bi-monthly (summer, winter)
Alta Wind I, CA (2011-2012)	100	150	80	25	120-m radius circle	12.5 months	Every two weeks
Alta Wind I-V, CA (2013-2014)	290	720 (150 GE, 570 vestas)	80	55 (25 at Alta I, 30 at Alta II-V)	120 m radius circles	Na	Monthly or bi-weekly
Alta Wind II-V, CA (2011-2012)	190	570	80	41	120-m radius circle	14.5 months	Every two weeks
Alta VIII, CA (2012-2013)	50	150	90	12 plots (equivalent to 15 turbines)	240 x 240 m	1 year	Bi-weekly
Barton I & II, IA (2010-2011)	80	160	100	35 (9 turbines were dropped in June 2010 due to landowner issues) 26 turbines were searched for the remainder of the study	200 m x 200 m	1 year	Weekly (spring, fall; migratory turbines), monthly (summer, winter; non-migratory turbines)
Barton Chapel, TX (2009-2010)	60	120	78	30	200 m x 200 m	1 year	10 turbines weekly, 20 monthly
Beech Ridge, WV (2012)	67	100.5	80	67	40 m radius	7 months	Every two days
Beech Ridge, WV (2013)	67	100.5	80	67	40 m radius	7.5 months	Every two days

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
Big Blue, MN (2013)	18	36	78 or 90 (according to Gamesa website)	18	200-m diameter	Na	Weekly, monthly (Nov and Dec)
Big Blue, MN (2014)	18	36	78 or 90 (according to Gamesa website)	18	200-m diameter	Na	Weekly, monthly (Nov and Dec)
Big Horn, WA (2006-2007)	133	199.5	80	133	180 m x 180 m	1 year	Bi-monthly (spring, fall), monthly (winter, summer)
Big Smile, OK (2012-2013)	66	132	78	17 (plus one met tower)	100 x 100	1 year	Weekly (spring, summer, fall), monthly (winter)
Biglow Canyon, OR (Phase I; 2008)	76	125.4	80	50	110 m x 110 m	1 year	Bi-monthly (spring, fall), monthly (winter, summer)
Biglow Canyon, OR (Phase I; 2009)	76	125.4	80	50	110 m x 110 m	1 year	Bi-monthly (spring, fall), monthly (winter, summer)
Biglow Canyon, OR (Phase II; 2009-2010)	65	150	80	50	250 m x 250 m	1 year	Bi-monthly (spring, fall), monthly (winter, summer)
Biglow Canyon, OR (Phase II; 2010-2011)	65	150	80	50	252 m x 252 m	1 year	Bi-weekly(spring, fall), monthly (summer, winter)
Biglow Canyon, OR (Phase III; 2010-2011)	76	174.8	80	50	252 m x 252 m	1 year	Bi-weekly(spring, fall), monthly (summer, winter)
Blue Sky Green Field, WI (2008; 2009)	88	145	80	30	160 m x 160 m	Fall, spring	Daily(10 turbines), weekly (20 turbines)
Buena Vista, CA (2008-2009)	38	38	45-55	38	75-m radius	1 year	Monthly to bi-monthly starting in September 2008
Buffalo Gap I, TX (2006)	67	134	78	21	215 m x 215 m	10 months	Every 3 weeks
Buffalo Gap II, TX (2007-2008)	155	233	80	36	215 m x 215 m	14 months	Every 21 days

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
Buffalo Mountain, TN (2000-2003)	3	1.98	65	3	50-m radius	3 years	Bi-weekly, weekly, bi-monthly
Buffalo Mountain, TN (2005)	18	28.98	V47 = 65; V80 = 78	18	50-m radius	1 year	Bi-weekly, weekly, bi-monthly, and 2 to 5 day intervals
Buffalo Ridge, MN (1994-1995)	73	25	37	1994:10 plots (3 turbines/plot), 20 addition plots in Sept & Oct 1994, 1995: 30 turbines search every other week (Jan-Mar), 60 searched weekly (Apr, July, Aug) 73 searched weekly (May-June and Sept-Oct), 30 searched weekly (Nov-Dec)	100 x 100m	20 months	Varies. See number turbines searched or page 44 of report
Buffalo Ridge, MN (Phase I; 1996)	73	25	36	21	126 m x 126 m	1 year	Bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase I; 1997)	73	25	36	21	126 m x 126 m	1 year	Bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase I; 1998)	73	25	36	21	126 m x 126 m	1 year	Bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase I; 1999)	73	25	36	21	126 m x 126 m	1 year	Bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase II; 1998)	143	107.25	50	40	126 m x 126 m	1 year	Bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase II; 1999)	143	107.25	50	40	126 m x 126 m	1 year	Bi-monthly (spring, summer, and fall)

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	143	107.25	50	83	60 m x 60 m	Summer, fall	Bi-monthly
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	143	107.25	50	103	60 m x 60 m	Summer, fall	Bi-monthly
Buffalo Ridge, MN (Phase III; 1999)	138	103.5	50	30	126 m x 126 m	1 year	Bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	138	103.5	50	83	60 m x 60 m	Summer, fall	Bi-monthly
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	138	103.5	50	103	60 m x 60 m	Summer, fall	Bi-monthly
Buffalo Ridge I, SD (2009-2010)	24	50.4	79	24	200 m x 200 m	1 year	Weekly (migratory), monthly (non-migratory)
Buffalo Ridge II, SD (2011-2012)	105	210	78	65 (60 road and pad, 5 turbine plots)	100 x 100m	1 year	Weekly (spring, summer, fall), monthly (winter)
Casselman, PA (2008)	23	34.5	80	10	126 m x 120 m	7 months	Daily
Casselman, PA (2009)	23	34.5	80	10	126 m x 120 m	7.5 months	Daily searches
Casselman Curtailment, PA (2008)	23	35.4	80	12 experimental; 10 control	126 m x 120 m	2.5 months	Daily
Castle River, Alb (2001-2002)	60	39.6	50	60	50-m radius	2 years	Weekly, bi-weekly
Castle River, Alb (2001-2002)	60	39.6	50	60	50-m radius	2 years	Weekly, bi-weekly
Cedar Ridge, WI (2009)	41	67.6	80	20	160 m x 160 m	Spring, summer, fall	Daily, every 4 days; late fall searched every 3 days

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
Cedar Ridge, WI (2010)	41	68	80	20	160 m x 160 m	1 year	Five turbines were surveyed daily, 15 turbines surveyed every 4 days in rotating groups each day. All 20 surveyed every three days during late fall
Cohocton/Dutch Hill, NY (2009)	50	125	80	17	130 m x 130 m	Spring, summer, fall	Daily (5 turbines), weekly (12 turbines)
Cohocton/Dutch Hills, NY (2010)	50	125	80	17	120 m x 120 m	Spring, summer, fall	Daily, weekly
Combine Hills, OR (Phase I; 2004-2005)	41	41	53	41	90-m radius	1 year	Monthly
Combine Hills, OR (2011)	104	104	53	52 (plus 1 MET tower)	180 m x 180 m	1 year	Bi-weekly(spring, fall), monthly (summer, winter)
Condon, OR	84	NA	NA	NA	NA	NA	NA
Crescent Ridge, IL (2005-2006)	33	49.5	80	33	70-m radius	1 year	Weekly (fall, spring)
Criterion, MD (2011)	28	70	80	28	40-50m radius	7.3 months	Daily
Criterion, MD (2012)	28	70	80	14	40-50m radius	7.5 months	Weekly
Criterion, MD (2013)	28	70	80	14	40-50m radius	7.5 months	Weekly
Crystal Lake II, IA (2009)	80	200	80	16 turbines through week 6, and then 15 for duration of study	100 m x 100 m	Spring, summer, fall	3 times per week for 26 weeks
Diablo Winds, CA (2005-2007)	31	20.46	50 and 55	31	75 m x 75 m	2 years	Monthly
Dillon, CA (2008-2009)	45	45	69	15	200 m x 200 m	1 year	Weekly, bi-monthly in winter
Dry Lake I, AZ (2009-2010)	30	63	78	15	160 m x 160 m	1 year	Bi-monthly (spring, fall), monthly (winter, summer)
Dry Lake II, AZ (2011-2012)	31	65	78	31: 5 (full plot), 26 (road & pad)	160 m x 160 m	1 year	Twice weekly (spring, summer, fall), weekly (winter)
Elkhorn, OR (2008)	61	101	80	61	220 m x 220 m	1 year	Monthly

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
Elkhorn, OR (2010)	61	101	80	31	220 m x 220 m	1 year	Bi-monthly (spring, fall), monthly (winter, summer)
Elm Creek, MN (2009-2010)	67	100	80	29	200 m x 200 m	1 year	Weekly, monthly
Elm Creek II, MN (2011-2012)	62	148.8	80	30	200 x 200m (2 random migration search areas 100 x 100m)	1 year	20 searched every 28 days, 10 turbines every 7 days during migration)
Erie Shores, Ont (2006)	66	99	80	66	40-m radius	2 years	Weekly, bi-monthly, 2-3 times weekly (migration)
Foote Creek Rim, WY (Phase I; 1999)	69	41.4	40	69	126 m x 126 m	1 year	Monthly
Foote Creek Rim, WY (Phase I; 2000)	69	41.4	40	69	126 m x 126 m	1 year	Monthly
Foote Creek Rim, WY (Phase I; 2001-2002)	69	41.4	40	69	126 m x 126 m	1 year	Monthly
Forward Energy Center, WI (2008-2010)	86	129	80	29	160 m x 160 m	2 years	11 turbines daily, 9 every 3 days, 9 every 5 days
Fowler I, IN (2009)	162	301	78 (Vestas), 80 (Clipper)	25	160 m x 160 m	Spring, summer, fall	Weekly, bi-weekly
Fowler I, II, III, IN (2010)	355	600	Vestas = 80, Clipper = 80, GE = 80	36 turbines, 100 road and pads	80 m x 80 m for turbines ; 40-m radius for roads and pads	Spring, fall	Daily, weekly

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
Fowler I, II, III, IN (2011)	355	600	Vestas = 80, Clipper = 80, GE = 80	177 road and pads (spring), 9 turbines & 168 roads and pads (fall)	turbines (80 m circular plot), roads and pads (out to 80 m)	Spring, fall	Daily, weekly
Fowler I, II, III, IN (2012)	355	600	Vestas = 80, Clipper = 80, GE = 80	118 roads and pads	roads and pads (out to 80 m)	2.5 months	Weekly
Fowler III, IN (2009)	60	99	78	12	160 m x 160 m	10 weeks	Weekly, bi-weekly
Goodnoe, WA (2009-2010)	47	94	80	24	180 m x 180 m	1 year	14 days during migration periods, 28 days during non-migration periods
Grand Ridge I, IL (2009-2010)	66	99	80	30	160 m x 160 m	1 year	Weekly, monthly
Harrow, Ont (2010)	24 (four 6-turb facilities)	39.6	NA	12 in July, 24 Aug-Oct	50-m radius from turbine base	4 months	Twice-weekly
Harvest Wind, WA (2010-2012)	43	98.9	80	32	180 m x 180 m & 240 m x 240 m	2 years	Twice a week, weekly and monthly
Hay Canyon, OR (2009-2010)	48	100.8	79	20	180 m x 180 m	1 year	Bi-monthly (spring, fall), monthly (winter, summer)
Heritage Garden I, MI (2012-2014)	14	28	90	14	120x120 m except one plot that was 280x280 m	2 years	Weekly (spring, summer, and fall) and bi-weekly (winter)
High Sheldon, NY (2010)	75	112.5	80	25	115 m x 115 m	7 months	Daily (8 turbines), weekly (17 turbines)
High Sheldon, NY (2011)	75	112.5	80	25	115 m x 115 m	7 months	Daily (8 turbines), weekly (17 turbines)

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
High Winds, CA (2003-2004)	90	162	60	90	75-m radius	1 year	Bi-monthly
High Winds, CA (2004-2005)	90	162	60	90	75-m radius	1 year	Bi-monthly
Hopkins Ridge, WA (2006)	83	150	67	41	180 m x 180 m	1 year	Monthly, weekly (subset of 22 turbines spring and fall migration)
Hopkins Ridge, WA (2008)	87	156.6	67	41-43	180 m x 180 m	1 year	Bi-monthly (spring, fall), monthly (winter, summer)
Jersey Atlantic, NJ (2008)	5	7.5	80	5	130 m x 120 m	9 months	Weekly
Judith Gap, MT (2006-2007)	90	135	80	20	190 m x 190 m	7 months	Monthly
Judith Gap, MT (2009)	90	135	80	30	100 m x 100 m	5 months	Bi-monthly
Kewaunee County, WI (1999-2001)	31	20.46	65	31	60 m x 60 m	2 years	Bi-weekly (spring, summer), daily (spring, fall migration), weekly (fall, winter)
Kibby, ME (2011)	44	132	124	22 turbines	75-m diameter circular plots	22 weeks	Avg 5-day
Kittitas Valley, WA (2011-2012)	48	100.8	80	48	100 m x 102 m	1 year	Bi-weekly from Aug 15 - Oct 31 and March 16 - May 15; every 4 weeks from Nov 1 - March 15 and May 16 - Aug 14
Klondike, OR (2002-2003)	16	24	80	16	140 m x 140 m	1 year	Monthly
Klondike II, OR (2005-2006)	50	75	80	25	180 m x 180 m	1 year	Bi-monthly (spring, fall), monthly (summer, winter)
Klondike III (Phase I), OR (2007-2009)	125	223.6	GE = 80; Siemens= 80, Mitsubishi = 80	46	240 m x 240 m (1.5MW) 252 m x 252 m (2.3MW)	2 year	Bi-monthly (spring, fall migration), monthly (summer, winter)

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
Klondike IIIa (Phase II), OR (2008-2010)	51	76.5	GE = 80	34	240 m x 240 m	2 years	Bi-monthly (spring, fall), monthly (summer, winter)
Lakefield Wind, MN (2012)	137	205.5	80	26	100 m x 100 m	7.5 months	3 times per week
Leaning Juniper, OR (2006-2008)	67	100.5	80	17	240 m x 240 m	2 years	Bi-monthly (spring, fall), monthly (winter, summer)
Lempster, NH (2009)	12	24	78	4	120 m x 130 m	6 months	Daily
Lempster, NH (2010)	12	24	78	12	120 m x 130 m	6 months	Weekly
Linden Ranch, WA (2010-2011)	25	50	80	25	110 m x 110 m	1 year	Bi-weekly(spring, fall), monthly (summer, winter)
Locust Ridge, PA (Phase II; 2009)	51	102	80	15	120m x 126m	6.5 months	Daily
Locust Ridge, PA (Phase II; 2010)	51	102	80	15	120m x 126m	6.5 months	Daily
Madison, NY (2001-2002)	7	11.55	67	7	60-m radius	1 year	Weekly (spring, fall), monthly (summer)
Maple Ridge, NY (2006)	120	198	80	50	130 m x 120 m	5 months	Daily (10 turbines), every 3 days (10 turbines), weekly (30 turbines)
Maple Ridge, NY (2007)	195	321.75	80	64	130 m x 120 m	7 months	Weekly
Maple Ridge, NY (2007-2008)	195	321.75	80	64	130 m x 120 m	7 months	Weekly
Maple Ridge, NY (2012)	195	321.75	80	105 (5 turbines, 100 roads/pads)	100 m x 100 m	3 months	Weekly
Marengo I, WA (2009-2010)	78	140.4	67	39	180 m x 180 m	1 year	Bi-monthly (spring, fall), monthly (winter, summer)
Marengo II, WA (2009-2010)	39	70.2	67	20	180 m x 180 m	1 year	Bi-monthly (spring, fall), monthly (winter, summer)
Mars Hill, ME (2007)	28	42	80.5	28	76-m diameter, extended plot 238-m diameter	Spring, summer, fall	Daily (2 random turbines), weekly (all turbines): extended plot searched once per season

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
Mars Hill, ME (2008)	28	42	80.5	28	76-m diameter, extended plot 238-m diameter	Spring, summer, fall	Weekly: extended plot searched once per season
McBride, Alb (2004)	114	75	50	114	4 parallel transects 120-m wide	1 year	Weekly, bi-weekly
Melancthon, Ont (Phase I; 2007)	45	NA	NA	45	35m radius	5 months	Weekly, twice weekly
Meyersdale, PA (2004)	20	30	80	20	130 m x 120 m	6 weeks	Daily (half turbines), weekly (half turbines)
Milford I, UT (2010-2011)	58	145	80	24	120x120	NA	Weekly
Milford I & II, UT (2011-2012)	107	160.5 (58.5 I, 102 II)	80	43	120x120	NA	Every 10.5 days
Montezuma I, CA (2011)	16	36.8	80	16	105 m radius	1 year	Weekly and bi-Weekly
Montezuma I, CA (2012)	16	36.8	80	16	105 m radius	1 year	Weekly and bi-Weekly
Montezuma II, CA (2012-2013)	34	78.2	80	17	105 m radius	1 year	Weekly
Moraine II, MN (2009)	33	49.5	82.5	30	200 m x 200 m	1 year	Weekly (migratory), monthly (non-migratory)
Mount Storm, WV (Fall 2008)	82	164	78	27	varied	3 months	Weekly (18 turbines), daily (9 turbines)
Mount Storm, WV (2009)	132	264	78	44	varied	4.5 months	Weekly (28 turbines), daily (16 turbines)
Mount Storm, WV (2010)	132	264	78	24	20 to 60 m from turbine	6 months	Daily
Mount Storm, WV (2011)	132	264	78	24	varied	6 months	Daily
Mountaineer, WV (2003)	44	66	80	44	60-m radius	7 months	Weekly, monthly
Mountaineer, WV (2004)	44	66	80	44	130 m x 120 m	6 weeks	Daily, weekly

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
Munnsville, NY (2008)	23	34.5	69.5	12	120 m x 120 m	Spring, summer, fall	Weekly
Mustang Hills, CA (2012-2013)	50	150	90	13 plots (equivalent to 15 turbines)	240 x 240 m	1 year	Bi-weekly
Nine Canyon, WA (2002-2003)	37	48.1	60	37	90-m radius	1 year	Bi-monthly (spring, summer, fall), monthly (winter)
Nine Canyon II, WA (2004)	12	15.6	60	12	90 m x 90 m	3 months	Once every two weeks
Noble Altona, NY (2010)	65	97.5	80	22	120 m x 120 m	Spring, summer, fall	Daily, weekly
Noble Altona, NY (2011)	65	97.5	80	22	120m x 120m	2 months	Daily
Noble Bliss, NY (2008)	67	100	80	23	120 m x 120 m	Spring, summer, fall	Daily (8 turbines), 3-day (8 turbines), weekly (7 turbines)
Noble Bliss, NY (2009)	67	100	80	23	120 m x 120 m	Spring, summer, fall	Weekly, 8 turbines searched daily from July 1 to August 15
Noble Bliss/ Wethersfield, NY (2011)	151	226	80	48 (24 from each site:12 ag, 12 forest)	road & pad 70 m out from turbine	2 months	Daily
Noble Chateaugay, NY (2010)	71	106.5	80	24	120 m x 120 m	Spring, summer, fall	Weekly
Noble Clinton, NY (2008)	67	100	80	23	120 m x 120 m	Spring, summer, fall	Daily (8 turbines), 3-day (8 turbines), weekly (7 turbines)
Noble Clinton, NY (2009)	67	100	80	23	120 m x 120 m	Spring, summer, fall	Daily (8 turbines), weekly (15 turbines), all turbines weekly from July 1 to August 15
Noble Ellenburg, NY (2008)	54	80	80	18	120 m x 120 m	Spring, summer, fall	Daily (6 turbines), 3-day (6 turbines), weekly (6 turbines)
Noble Ellenburg, NY (2009)	54	80	80	18	120 m x 120 m	Spring, summer, fall	Daily (6 turbines), weekly (12 turbines), all turbines weekly from July 1 to August 15

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
Noble Wethersfield, NY (2010)	84	126	80	28	120 m x 120 m	Spring, summer, fall	Weekly
NPPD Ainsworth, NE (2006)	36	20.5	70	36	220 m x 220 m	Spring, summer, fall	Bi-monthly
Oklahoma Wind Energy Center, OK (2004; 2005)	68	102	70	68	20-m radius	3 months (2 years)	Bi-monthly
Pacific, CA (2012-2013)	70	140	78.5	20	126 m radius	Na	Twice weekly (fall), and biweekly
Palouse Wind, WA (2012-2013)	58	104.4	80, 90, or 105 M (according to the Vestas website)	19	120 m x 120 m	1 year	Monthly (winter) and weekly (spring-fall)
Pebble Springs, OR (2009-2010)	47	98.7	79	20	180 m x 180 m	1 year	Bi-monthly (spring, fall), monthly (winter, summer)
Pine Tree, CA (2009-2010, 2011)	90	135	65	40	100 m radius	1.5 year	Bi-weekly, weekly
Pinnacle, WV (2012)	23	55.2	80	11	126 m x 120m	9 months	Weekly
Pinnacle Operational Mitigation Study (2012)	23	55.2	80	12	126m x 120m	2.5 months	Daily
Pinyon Pines I & II, CA (2013-2014)	100	NA	90	25 plots (approx. 31 turbines)	240x240 m	NA	Bi-weekly
Pioneer Prairie I, IA (Phase II; 2011-2012)	62	102.3	80	62 (57 road/pad) 5 full search plots	80 x 80m	1 year	Weekly (spring and fall), every two weeks (summer), monthly (winter)
Pioneer Prairie II, IA (2013)	62	102.3	80	62	80x80 m (5 turbines), road and pad within 100 m of turbine (57 turbines)	NA	Weekly

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
Pioneer Trail, IL (2012-2013)	94	150.5	NA	50	80x80m	Fall, spring	Weekly
Prairie Rose, MN (2014)	119	200	80	10	100x100m	6 months	Weekly
PrairieWinds ND1 (Minot), ND (2010)	80	115.5	89	35	minimum of 100 m x 100 m	3 seasons	Bi-monthly
PrairieWinds ND1 (Minot), ND (2011)	80	115.5	80	35	minimum 100 x 100m	3 season	Twice monthly
PrairieWinds SD1, SD (2011-2012)	108	162	80	50	200 x 200m	1 year	Twice monthly (spring, summer, fall), monthly (winter)
PrairieWinds SD1, SD (2012-2013)	108	162	80	50	200 x 200m	1 year	Bi-weekly
PrairieWinds SD1, SD (2013-2014)	108	162	80	45	200 x 200m	1 year	Twice monthly (spring, summer, fall), monthly (winter)
Rail Splitter, IL (2012-2013)	67	100.5	80	34	60 m radius	1 year	Weekly (spring, summer, and fall) and bi-weekly (winter)
Record Hill, ME (2012)	22	50.6	80	22	126.5x126.5	5 months	Three times every two weeks
Record Hill, ME (2014)	22	50.6	80	10	varied due to steep terrain and heavily vegetated areas	4.5 months	Daily for 5 days a week
Red Canyon, TX (2006-2007)	56	84	70	28	200 m x 200 m in fall and winter; 160 m x 160 m in spring and summer	1 year	Every 14 days in fall and winter; 7 days in spring, 3 days in summer
Red Hills, OK (2012-2013)	82	123	80	20 (plus one met tower)	100 x 100	1 year	Weekly (spring, summer, fall), monthly (winter)
Ripley, Ont (2008)	38	76	64	38	80 m x 80 m	Spring, fall	Twice weekly for odd turbines; weekly for even turbines.
Ripley, Ont (2008-2009)	38	76	64	38	80 m x 80 m	6 weeks	Twice weekly for odd turbines; weekly for even turbines.

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
Rollins, ME (2012)	40	60	80	20	varied; turbine laydown area and gravel access roads out to 60m	6 months	Weekly
Roth Rock, MD (2011)	20	50	80	10	80m x 80m	3 months	Daily
Rugby, ND (2010-2011)	71	149	78	32	200 m x 200 m	1 year	Weekly (spring, fall; migratory turbines), monthly (non-migratory turbines)
San Gorgonio, CA (1997-1998; 1999-2000)	3000	n/a	24.4-42.7	NA	50-m radius	2 years	Quarterly
Searsburg, VT (1997)	11	7	65	11	20- to 55-m radius	Spring, fall	Weekly (fall migration)
Sheffield, VT (2012)	16	40	80	8	126m x 120m	3 months	Daily
Sheffield Operational Mitigation Study (2012)	16	40	80	16	126m x 120m	4 months	Daily
Shiloh I, CA (2006-2009)	100	150	65	100	105-m radius	3 years	Weekly
Shiloh II, CA (2009-2010)	75	150	80	25	100m radius	1 year	Weekly
Shiloh II, CA (2010-2011)	75	150	80	25	100 m radius	1 year	Weekly
Shiloh III, CA (2012-2013)	50	102.5	78.5	25	100 m radius	NA	Weekly
SMUD Solano, CA (2004-2005)	22	15	65	22	60-m radius	1 year	Bi-monthly
Solano III, CA (2012-2013)	55	128	80	19	100 m radius	NA	Bi-Weekly
Spruce Mountain, ME (2012)	10	20	78	10	100 m x 100 m	7 months	Weekly

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
Stateline, OR/WA (2001-2002)	454	299	50	124	minimum 126 m x 126 m	17 months	Bi-weekly, monthly
Stateline, OR/WA (2003)	454	299	50	153	minimum 126 m x 126 m	1 year	Bi-weekly, monthly
Stateline, OR/WA (2006)	454	299	50	39	variable turbine strings	1 year	Bi-weekly
Steel Winds I & II, NY (2012)	14	35	80	8 (1 was just gravel pad)	120m x 120m	6 months	Weekly, bi-weekly (November only)
Steel Winds I, NY (2007)	8	20	80	8	176m x 176m	6.5 months	Every 10 days (spring, fall) every 21 days (summer)
Stetson Mountain I, ME (2009)	38	57	80	19	76-m diameter	27 weeks (spring, summer, fall)	Weekly
Stetson Mountain I, ME (2011)	38	57	80	19	79.45x79.45m	6 months	Weekly
Stetson Mountain I, ME (2013)	38	57	80	19	76 m diameter	6 months	Weekly
Stetson Mountain II, ME (2010)	17	25.5	80	17	74.5x74.5m	6 months	Weekly (3 turbines twice a week)
Stetson Mountain II, ME (2012)	17	25.5	80	17	laydown area and road up to 60m	6 months	Weekly
Summerview, Alb (2005-2006)	39	70.2	67	39	140 m x 140 m	1 year	Weekly, bi-weekly (May to July, September)
Summerview, Alb (2006; 2007)	39	70.2	65	39	52-m radius; 2 spiral transects 7 m apart	Summer, fall (2 years)	Daily (10 turbines), weekly (29 turbines)
Tehachapi, CA (1996-1998)	3300	n/a	14.7 to 57.6	201	50-m radius	20 months	Quarterly

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
Top Crop I & II, IL (2012-2013)	68 (phase I) 132 (phase (II)	300 (102 (phase I) 198 (phase II))	65 (phase I) 80 (phase II)	100	61 m radius	1 year	Weekly (spring, summer, and fall) and bi-weekly (winter)
Top of Iowa, IA (2003)	89	80	71.6	26	76 m x 76 m	Spring, summer, fall	Once every 2 to 3 days
Top of Iowa, IA (2004)	89	80	71.6	26	76 m x 76 m	Spring, summer, fall	Once every 2 to 3 days
Tuolumne (Windy Point I), WA (2009-2010)	62	136.6	80	21	180 m x 180 m	1 year	Monthly throughout the year, a sub-set of 10 turbines were also searched weekly during the spring, summer, and fall
Vansycle, OR (1999)	38	24.9	50	38	126 m x 126 m	1 year	Monthly
Vantage, WA (2010-2011)	60	90	80	30	240 m x 240 m	1 year	Monthly, a subset of 10 searched weekly during migration
Vasco, CA (2012-2013)	34	78.2	80	34	105 m radius	1 year	Weekly, monthly
Wessington Springs, SD (2009)	34	51	80	20	200 m x 200 m	Spring, summer, fall	Bi-monthly
Wessington Springs, SD (2010)	34	51	80	20	200 m x 200 m	8 months	Bi-weekly (spring, summer, fall)
White Creek, WA (2007-2011)	89	204.7	80	89	180 m x 180 m & 240 m x 240 m	4 years	Twice a week, weekly and monthly
Wild Horse, WA (2007)	127	229	67	64	110 m from two turbines in plot	1 year	Monthly, weekly (fall, spring migration at 16 turbines)
Windy Flats, WA (2010-2011)	114	262.2	80	36 (plus 1 MET tower)	180 m x 180 m (120m at MET tower)	1 year	Monthly (spring, summer, fall, and winter), weekly (spring and fall migration)
Winnebago, IA (2009-2010)	10	20	78	10	200 m x 200 m	1 year	Weekly (migratory), monthly (non-migratory)

Appendix C5. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total MW	Tower Size (m)	Number Turbines Searched	Plot Size	Length of Study	Survey Frequency
Wolfe Island, Ont (May-June 2009)	86	197.8	80	86	60-m radius	Spring	43 twice weekly, 43 weekly
Wolfe Island, Ont (July-December 2009)	86	197.8	80	86	60-m radius	Summer, fall	43 twice weekly, 43 weekly
Wolfe Island, Ont (January-June 2010)	86	197.8	80	86	60-m radius	6 months	43 twice weekly, 43 weekly
Wolfe Island, Ont (July-December 2010)	86	197.8	80	86	50-m radius	6 months	43 twice weekly, 43 weekly
Wolfe Island, Ont (January-June 2011)	86	197.8	80	86	50-m radius	6 months	43 twice weekly, 43 weekly
Wolfe Island, Ont (July-December 2011)	86	197.8	80	86	50-m radius	6 months	43 twice weekly, 43 weekly
Wolfe Island, Ont (January-June 2012)	86	197.8	NA	86	50-m radius	NA	1/2 searched twice weekly, 1/2 searched weekly

Appendix C5 (*continued*). All post-construction monitoring studies, project characteristics, and select study methodology.

Data from the following sources:

Project, Location	Reference	Project, Location	Reference
Alite, CA (09-10)	Chatfield et al. 2010	Marengo I, WA (09-10)	URS Corporation 2010b
Alta Wind I, CA (11-12)	Chatfield et al. 2012	Marengo II, WA (09-10)	URS Corporation 2010c
Alta Wind I-V, CA (13-14)	Chatfield et al. 2014	Mars Hill, ME (07)	Stantec 2008a
Alta Wind II-V, CA (11-12)	Chatfield et al. 2012	Mars Hill, ME (08)	Stantec 2009a
Alta VIII, CA (12-13)	Chatfield and Bay 2014	McBride, Alb (04)	Brown and Hamilton 2004
Barton I & II, IA (10-11)	Derby et al. 2011a	Melancthon, Ont (Phase I; 07)	Stantec Ltd. 2008
Barton Chapel, TX (09-10)	WEST 2011	Meyersdale, PA (04)	Arnett et al. 2005
Beech Ridge, WV (12)	Tidhar et al. 2013b	Milford I, UT (10-11)	Stantec 2011b
Beech Ridge, WV (13)	Young et al. 2014b	Milford I & II, UT (11-12)	Stantec 2012b
Big Blue, MN (13)	Fagen Engineering 2014	Montezuma I, CA (11)	ICF International 2012
Big Blue, MN (14)	Fagen Engineering 2015	Montezuma I, CA (12)	ICF International 2013
Big Horn, WA (06-07)	Kronner et al. 2008	Montezuma II, CA (12-13)	Harvey & Associates 2013
Big Smile, OK (12-13)	Derby et al. 2013b	Moraine II, MN (09)	Derby et al. 2010d
Biglow Canyon, OR (Phase I; 08)	Jeffrey et al. 2009a	Mount Storm, WV (Fall 08)	Young et al. 2009b
Biglow Canyon, OR (Phase I; 09)	Enk et al. 2010	Mount Storm, WV (09)	Young et al. 2009a, 2010b
Biglow Canyon, OR (Phase II; 09-10)	Enk et al. 2011a	Mount Storm, WV (10)	Young et al. 2010a, 2011b
Biglow Canyon, OR (Phase II; 10-11)	Enk et al. 2012b	Mount Storm, WV (11)	Young et al. 2011a, 2012b
Biglow Canyon, OR (Phase III; 10-11)	Enk et al. 2012a	Mountaineer, WV (03)	Kerns and Kerlinger 2004
Blue Sky Green Field, WI (08; 09)	Gruver et al. 2009	Mountaineer, WV (04)	Arnett et al. 2005
Buena Vista, CA (08-09)	Insignia Environmental 2009	Munnsville, NY (08)	Stantec 2009b
Buffalo Gap I, TX (06)	Tierney 2007	Mustang Hills, CA (12-13)	Chatfield and Bay 2014
Buffalo Gap II, TX (07-08)	Tierney 2009	Nine Canyon, WA (02-03)	Erickson et al. 2003a
Buffalo Mountain, TN (00-03)	Nicholson et al. 2005	Nine Canyon II, WA (04)	Erickson et al. 2005
Buffalo Mountain, TN (05)	Fiedler et al. 2007	Noble Altona, NY (10)	Jain et al. 2011b
Buffalo Ridge, MN (94-95)	Osborn et al. 1996, 2000	Noble Altona, NY (11)	Kerlinger et al. 2011b
Buffalo Ridge, MN (Phase I; 96)	Johnson et al. 2000	Noble Bliss, NY (08)	Jain et al.2009e
Buffalo Ridge, MN (Phase I; 97)	Johnson et al. 2000	Noble Bliss, NY (09)	Jain et al. 2010a
Buffalo Ridge, MN (Phase I; 98)	Johnson et al. 2000	Noble Bliss/Wethersfield, NY (11)	Kerlinger et al. 2011a
Buffalo Ridge, MN (Phase I; 99)	Johnson et al. 2000	Noble Chateaugay, NY (10)	Jain et al. 2011c
Buffalo Ridge, MN (Phase II; 98)	Johnson et al. 2000	Noble Clinton, NY (08)	Jain et al. 2009c
Buffalo Ridge, MN (Phase II; 99)	Johnson et al. 2000	Noble Clinton, NY (09)	Jain et al. 2010b
Buffalo Ridge, MN (Phase II; 01/Lake Benton I)	Johnson et al. 2004	Noble Ellenburg, NY (08)	Jain et al. 2009b
Buffalo Ridge, MN (Phase II; 02/Lake Benton I)	Johnson et al. 2004	Noble Ellenburg, NY (09)	Jain et al. 2010c
Buffalo Ridge, MN (Phase III; 99)	Johnson et al. 2000	Noble Wethersfield, NY (10)	Jain et al. 2011a
Buffalo Ridge, MN (Phase III; 01/Lake Benton II)	Johnson et al. 2004	NPPD Ainsworth, NE (06)	Derby et al. 2007
Buffalo Ridge, MN (Phase III; 02/Lake Benton II)	Johnson et al. 2004	Oklahoma Wind Energy Center, OK (04; 05)	Piorkowski and O'Connell 2010
Buffalo Ridge I, SD (09-10)	Derby et al. 2010b	Pacific, CA (12-13)	Sapphos 2014
Buffalo Ridge II, SD (11-12)	Derby et al. 2012a	Palouse Wind, WA (12-13)	Stantec 2013a
Casselman, PA (08)	Arnett et al. 2009b	Pebble Springs, OR (09-10)	Gritski and Kronner 2010b
Casselman, PA (09)	Arnett et al. 2010	Pine Tree, CA (09-10, 11)	BioResource Consultants 2012
Casselman Curtailment, PA (08)	Arnett et al. 2009a	Pinnacle, WV (12)	Hein et al. 2013a
Castle River, Alb. (01)	Brown and Hamilton 2006a	Pinnacle Operational Mitigation Study (12)	Hein et al. 2013b
Castle River, Alb. (02)	Brown and Hamilton 2006a	Pinyon Pines I & II, CA (13-14)	Chatfield and Russo 2014
Cedar Ridge, WI (09)	BHE Environmental 2010	Pioneer Prairie I, IA (Phase II; 11-12)	Chodachek et al. 2012
Cedar Ridge, WI (10)	BHE Environmental 2011	Pioneer Prairie II, IA (13)	Chodachek et al. 2014
Cohocton/Dutch Hill, NY (09)	Stantec 2010	Pioneer Trail, IL (12-13)	ARCADIS 2013
Cohocton/Dutch Hills, NY (10)	Stantec 2011a	Prairie Rose, MN (14)	Chodachek et al. 2015
Combine Hills, OR (Phase I; 04-05)	Young et al. 2006	PrairieWinds ND1 (Minot), ND (10)	Derby et al. 2011c
Combine Hills, OR (11)	Enz et al. 2012	PrairieWinds ND1 (Minot), ND (11)	Derby et al. 2012c
Condon, OR	Fishman Ecological Services 2003	PrairieWinds SD1 (Crow Lake), SD (11-12)	Derby et al. 2012d
Crescent Ridge, IL (05-06)	Kerlinger et al. 2007	PrairieWinds SD1 (Crow Lake), SD (12-13)	Derby et al. 2013a
Criterion, MD (11)	Young et al. 2012a	PrairieWinds SD1 (Crow Lake), SD (13-14)	Derby et al. 2014b
Criterion, MD (12)	Young et al. 2013	Rail Splitter, IL (12-13)	Good et al. 2013b
Criterion, MD (13)	Young et al. 2014a	Record Hill, ME (12)	Stantec 2013b
Crystal Lake II, IA (09)	Derby et al. 2010a	Record Hill, ME (14)	Stantec 2015
Diablo Winds, CA (05-07)	WEST 2006, 2008	Red Canyon, TX (06-07)	Miller 2008
Dillon, CA (08-09)	Chatfield et al. 2009	Red Hills, OK (12-13)	Derby et al. 2013c
Dry Lake I, AZ (09-10)	Thompson et al. 2011	Ripley, Ont (08)	Jacques Whitford 2009
Dry Lake II, AZ (11-12)	Thompson and Bay 2012	Ripley, Ont (08-09)	Golder Associates 2010
Elkhorn, OR (08)	Jeffrey et a. 2009b	Rollins, ME (12)	Stantec 2013c
Elkhorn, OR (10)	Enk et al. 2011b	Roth Rock, MD (11)	Atwell 2012
Elm Creek, MN (09-10)	Derby et al. 2010c	Rugby, ND (10-11)	Derby et al. 2011b
Elm Creek II, MN (11-12)	Derby et al. 2012b	San Gorgonio, CA (97-98; 99-00)	Anderson et al. 2005
Erie Shores, Ont. (06)	James 2008	Searsburg, VT (97)	Kerlinger 2002a
Foote Creek Rim, WY (Phase I; 99)	Young et al. 2003b	Sheffield, VT (12)	Martin et al. 2013

Appendix C5 (*continued*). All post-construction monitoring studies, project characteristics, and select study methodology.

Data from the following sources:

Project, Location	Reference	Project, Location	Reference
Foote Creek Rim, WY (Phase I; 00)	Young et al. 2003b	Sheffield Operational Mitigation Study (12)	Martin et al. 2013
Foote Creek Rim, WY (Phase I; 01-02)	Young et al. 2003b	Shiloh I, CA (06-09)	Kerlinger et al. 2009
Forward Energy Center, WI (08-10)	Grodsky and Drake 2011	Shiloh II, CA (09-10)	Kerlinger et al. 2010
Fowler I, IN (09)	Johnson et al. 2010a	Shiloh II, CA (10-11)	Kerlinger et al. 2013a
Fowler I, II, III, IN (10)	Good et al. 2011	Shiloh III, CA (12-13)	Kerlinger et al. 2013b
Fowler I, II, III, IN (11)	Good et al. 2012	SMUD Solano, CA (04-05)	Erickson and Sharp 2005
Fowler I, II, III, IN (12)	Good et al. 2013c	Solano III, CA (12-13)	AECOM 2013
Fowler III, IN (09)	Johnson et al. 2010b	Spruce Mountain, ME (12)	Tetra Tech 2013
Goodnoe, WA (09-10)	URS Corporation 2010a	Stateline, OR/WA (01-02)	Erickson et al. 2004
Grand Ridge I, IL (09-10)	Derby et al. 2010g	Stateline, OR/WA (03)	Erickson et al. 2004
Harrow, Ont (10)	Natural Resource Solutions 2011	Stateline, OR/WA (06)	Erickson et al. 2007
Harvest Wind, WA (10-12)	Downes and Gritski 2012a	Steel Winds I, NY (07)	Grehan 2008
Hay Canyon, OR (09-10)	Gritski and Kronner 2010a	Steel Winds I & II, NY (12)	Stantec 2013d
Heritage Garden I, MI (12-14)	Kerlinger et al. 2014	Stetson Mountain I, ME (09)	Stantec 2009c
High Sheldon, NY (10)	Tidhar et al. 2012a	Stetson Mountain I, ME (11)	Normandeau Associates 2011
High Sheldon, NY (11)	Tidhar et al. 2012b	Stetson Mountain I, ME (13)	Stantec 2014
High Winds, CA (03-04)	Kerlinger et al. 2006	Stetson Mountain II, ME (10)	Normandeau Associates 2010
High Winds, CA (04-05)	Kerlinger et al. 2006	Stetson Mountain II, ME (12)	Stantec 2013e
Hopkins Ridge, WA (06)	Young et al. 2007	Summerview, Alb (05-06)	Brown and Hamilton 2006b
Hopkins Ridge, WA (08)	Young et al. 2009c	Summerview, Alb (06; 07)	Baerwald 2008
Jersey Atlantic, NJ (08)	NJAS 2008a, 2008b, 2009	Tehachapi, CA (96-98)	Anderson et al. 2004
Judith Gap, MT (06-07)	TRC 2008	Top Crop I & II, IL (12-13)	Good et al. 2013a
Judith Gap, MT (09)	Poulton and Erickson 2010	Top of Iowa, IA (03)	Jain 2005
Kewaunee County, WI (99-01)	Howe et al. 2002	Top of Iowa, IA (04)	Jain 2005
Kibby, ME (11)	Stantec 2012a	Tuolumne (Windy Point I), WA (09-10)	Enz and Bay 2010
Kittitas Valley, WA (11-12)	Stantec Consulting 2012	Vansycle, OR (99)	Erickson et al. 2000a
Klondike, OR (02-03)	Johnson et al. 2003b	Vantage, WA (10-11)	Ventus Environmental Solutions 2012
Klondike II, OR (05-06)	NWC and WEST 2007	Vasco, CA (12-13)	Brown et al. 2013
Klondike III (Phase I), OR (07-09)	Gritski et al. 2010	Wessington Springs, SD (09)	Derby et al. 2010f
Klondike IIIa (Phase II), OR (08-10)	Gritski et al. 2011	Wessington Springs, SD (10)	Derby et al. 2011d
Lakefield Wind, MN (12)	MPUC 2012	White Creek, WA (07-11)	Downes and Gritski 2012b
Leaning Juniper, OR (06-08)	Gritski et al. 2008	Wild Horse, WA (07)	Erickson et al. 2008
Lempster, NH (09)	Tidhar et al. 2010	Windy Flats, WA (10-11)	Enz et al. 2011
Lempster, NH (10)	Tidhar et al. 2011	Winnebago, IA (09-10)	Derby et al. 2010e
Linden Ranch, WA (10-11)	Enz and Bay 2011	Wolfe Island, Ont (May-June 09)	Stantec Ltd. 2010a
Locust Ridge, PA (Phase II; 09)	Arnett et al. 2011	Wolfe Island, Ont (July-December 09)	Stantec Ltd. 2010b
Locust Ridge, PA (Phase II; 10)	Arnett et al. 2011	Wolfe Island, Ont (January-June 10)	Stantec Ltd. 2011a
Madison, NY (01-02)	Kerlinger 2002b	Wolfe Island, Ont (July-December 10)	Stantec Ltd. 2011b
Maple Ridge, NY (06)	Jain et al. 2007	Wolfe Island, Ont (January-June 11)	Stantec Ltd. 2011c
Maple Ridge, NY (07)	Jain et al. 2009a	Wolfe Island, Ont (July-December 11)	Stantec Ltd. 2012
Maple Ridge, NY (07-08)	Jain et al. 2009d	Wolfe Island, Ont (January-June 12)	Stantec Ltd. 2014
Maple Ridge, NY (12)	Tidhar et al. 2013a		