2012 Post-Construction Monitoring Study
Criterion Wind Project
Garrett County, Maryland

April – November 2012

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NATURAL RESOURCES ◆ SCIENTIFIC SOLUTIONS

EXECUTIVE SUMMARY

Criterion Power Partners, LCC, (CPP) completed construction and initiated operation of the Criterion Wind Project in Garrett County, Maryland in 2010. The project includes 28, 2.5 megawatt wind turbine generators for a total generating capacity of 70 MW. Beginning in April 2011, Criterion initiated the first year of post-construction monitoring surveys to estimate the impacts of project operations on bird and bat species. The second year of post-construction monitoring was conducted beginning in April 2012 and followed the protocol designated as part of the Habitat Conservation Plan (HCP) prepared for the project in application for an Incidental Take Permit.

The primary objectives of the 2012 monitoring study was to determine (1) the level of bird and bat mortality attributable to collisions with wind turbines for the entire facility for the study period, and (2) determine the effectiveness of turbine operational adjustments implemented as part of the project HCP. The monitoring study consisted of four components: 1) standardized carcass surveys of project 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 bird and bat species calculated by correcting survey results for potential biases (e.g., area searched, searcher efficiency, carcass removal).

The monitoring study period was from April 1 to November 15, 2012. Search plots were established around 14 turbines (50%) in the project and the carcass search schedule was for weekly searches at the selected turbines, weather and safety permitting. Search plots varied in shape and size due to habitat constraints, but in most cases areas up to approximately 40-50 m (~130-165 ft) from the turbines were cleared of vegetation for access and construction purposes and this area was used as the search plot. Parallel transects were spaced and delineated approximately 5 m (~16 ft) apart within the search plot and surveyors systematically walked the transects while scanning the ground for fatalities or injured birds or bats.

During the study, 28 birds representing 12 species and 82 bats representing five species were found either during standardized carcass searches or incidentally during the study period. The most commonly found bird species were red-eyed vireo and golden-crowned kinglet, while eastern red bat and hoary bat accounted for the majority of the bat fatalities found. Bird and bat fatalities were spread throughout the entire survey period and throughout the entire project with the number of fatalities peaking for both birds and bats in the fall.

A total of 275 bird carcasses and 200 bat carcasses were placed for searcher efficiency trials over the study period. Searcher efficiency was estimated for the first half of the study period (April 5 to July 15 – labeled the spring) and the second half (July 16-November 15 – labeled the fall) to investigate potential changes over time. For small birds searcher efficiency was 0.75 in spring and 0.48 in fall, for large birds was 1.00 in both spring and fall, and for bats was 0.65 in

spring and 0.49 in fall. A total of 489 carcasses were placed for carcass removal trials. For small birds, mean carcass removal was 7.17 days in the spring and 5.37 days in the fall. For large birds, mean carcass removal was 5.77 days in the spring and 4.31 days. For bats, mean carcass removal was 6.70 days in the spring and 4.59 days in the fall.

For small birds, the probability that a carcass would remain in the search plot and be found by a searcher was 0.50 in the spring and 0.29 in the fall. For large birds, the probability that a carcass would remain in the search plot and be found was 0.54 in the spring and 0.46 in the fall. For bats, the probability that a carcass would remain in the search plot and be found was 0.43 in the spring and 0.26 in the fall.

Fatality estimates were adjusted based on the corrections for carcass removal, observer detection bias, and the area searched to account for carcasses potentially falling outside the plot. Combining both spring and fall estimates, the overall adjusted estimate for small birds was 4.19 small birds per turbine for the study period or 1.68 small birds per MW. For large birds the overall adjusted fatality estimate was 1.28 large birds per turbine for the study period or 0.51 large birds per MW. The fatality estimate for all birds combined was 5.47 birds per turbine or 2.19 birds per MW for the study period. For bats the overall estimate fatality estimate was 19.50 bats per turbine for the study period or 7.80 bats per MW.

During the period from July 15 to October 15, the Project implemented turbine operation adjustment to minimize the impacts to bats from the turbines. Specifically, the turbine blades were feathered when wind speeds were 5.0 meters per second or below to minimize the rotor speed to approximately 2 rotations per minute (RPM) or less. This measure is part of the conservation plan that CPP has committed to in the Project HCP. The overall bat mortality measured during the study was 19.50 bats per turbine. The bat mortality rate in 2011 for a similar study period was 39.03 bats per turbine. The turbine operation constraints in 2012 resulted in approximately a 51% reduction in bat mortality. To further investigate the effects of the turbine operations, the study results were analyzed for the period when the adjustments were in place, nights of July 15 through October 15 for both 2011 and 2012. Bat mortality for the period from July 15 to October 15 for 2011 and 2012 was 29.16 bats per turbine and 11.38 bats per turbine respectively. During this period the turbine adjustments resulted in approximately a 62% reduction in bat mortality.

REPORT REFERENCE

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ACKNOWLEDGEMENTS

This study was the second year of post-construction monitoring of the Criterion Wind Project to fulfill commitments of Criterion Power Partners (CPP) to the State of Maryland, Public Service Commission to monitor the site for three years. While the project gained a waiver from acquiring a Certificate of Public Convenience and Necessity (CPCN), CPP has committed to monitoring for a three year period. In addition, this study was implemented according to the commitments within the Project Habitat Conservation Plan (HCP). CPP intends to monitor for one more year in 2013 for three consecutive years and for at least three additional years at approximately a 5-year interval under the HCP.

The staff and crew of the Criterion Wind Project were extremely helpful in implementing the monitoring study. We wish to thank all the CPP personnel who facilitated completion of the study including: Ed Tracey, Von Abernethy, Don Shilobod, Randall Smallman, Lisa Taylor-Horvath, Brad Rush, Billy Bentley, Jeff Bailey, and Jeremy Bosley. We also appreciate the support and hospitality of the private landowners that allowed access to their lands for this study.

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INTRODUCTION

Criterion Power Partners, LLC (CPP), a wholly owned subsidiary of Constellation Energy, completed construction and initiated operation of the Criterion Wind Project (CWP; Project) in 2010. The Project is located in Garrett County, Maryland. CPP in coordination with the U.S. Fish and Wildlife Service (USFWS) has developed a Habitat Conservation Plan (HCP) in application for an Incidental Take Permit (ITP) for potential take of the endangered Indiana bat (*Myotis sodalis*). In 2011, during the HCP development, CPP monitored the project according to a protocol to detect take of Indiana bat if it were to occur (Young et al. 2012). No take of Indiana bat was detected in 2011. In 2012, CPP began implementing the draft HCP and operated the project according to the commitments in the conservation plan, specifically the turbine operation measures designed to minimize impacts to bats from the turbines. During the period July 15 to October 15, the turbine blades were feathered to minimize rotation to less than 2 rotations per minute (RPM) during periods when wind speeds were equal to or less than 5.0 meters per sec (m/sec). In addition, CPP monitored the project according to the HCP monitoring plan (see Appendix D of the HCP). This report is for the first year of monitoring as detailed in the draft HCP and the second year of monitoring of the project overall.

The primary objective of the monitoring study was to (1) estimate the level of bird and bat mortality attributable to wind turbines at the facility for the period of study, and (2) determine the effectiveness of turbine operational adjustments implemented as part of the project HCP. The methods for the fatality study are broken into four primary components: 1) standardized carcass surveys of 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 remains in the field for possible detection; and 4) adjusted fatality estimates for bird and bat species calculated by correcting survey results for potential biases (e.g., area searched, searcher efficiency, carcass removal).

STUDY AREA

The CWP is located east of the town of Oakland in Garrett County, Maryland (Figure 1). The Project is a 70 MW wind energy facility consisting of 28 2.5 megawatt (MW) wind turbine generators and is situated along the ridge of Backbone Mountain extending to the northeast from Allegheny Heights for approximately five miles (Figure 1). The topography of the Project area is steeply sloping on the western side of the ridge and relatively gently sloping on the eastern side; and the ridgeline maintains an elevation of approximately 3,200 ft (975 m) above mean sea level. The CWP falls within the Ridge and Valley province of the Central Appalachian Ecoregion. This region is characterized by heavily forested, steep ridges that alternate with folded sandstone crests and limestone plateaus. The Project is situated on largely undeveloped, previously logged forestland interspersed with some open farmland and consists of rugged terrain traversed with old logging roads and dotted with seasonally used camps. Land use in the vicinity of the Project is dominated by forest and agriculture, consistent with the rural character of Garrett County.

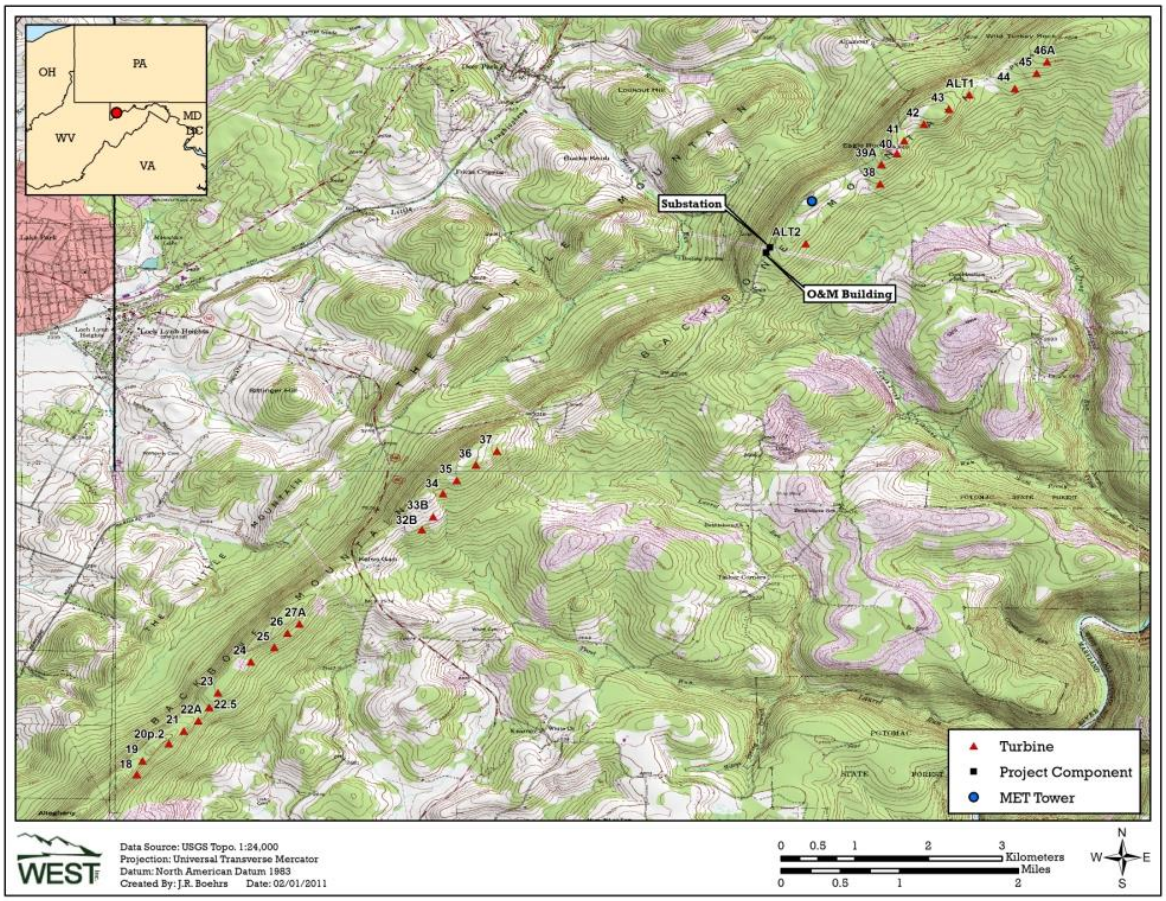

Figure 1. Location of the Criterion Wind Project.

For the area encompassed by a one-mile radius around the turbines, approximately 80% is composed of deciduous forest, while 12% is hay/pasture (Figure 2). Other land use types make up less than 5% of the total land cover.

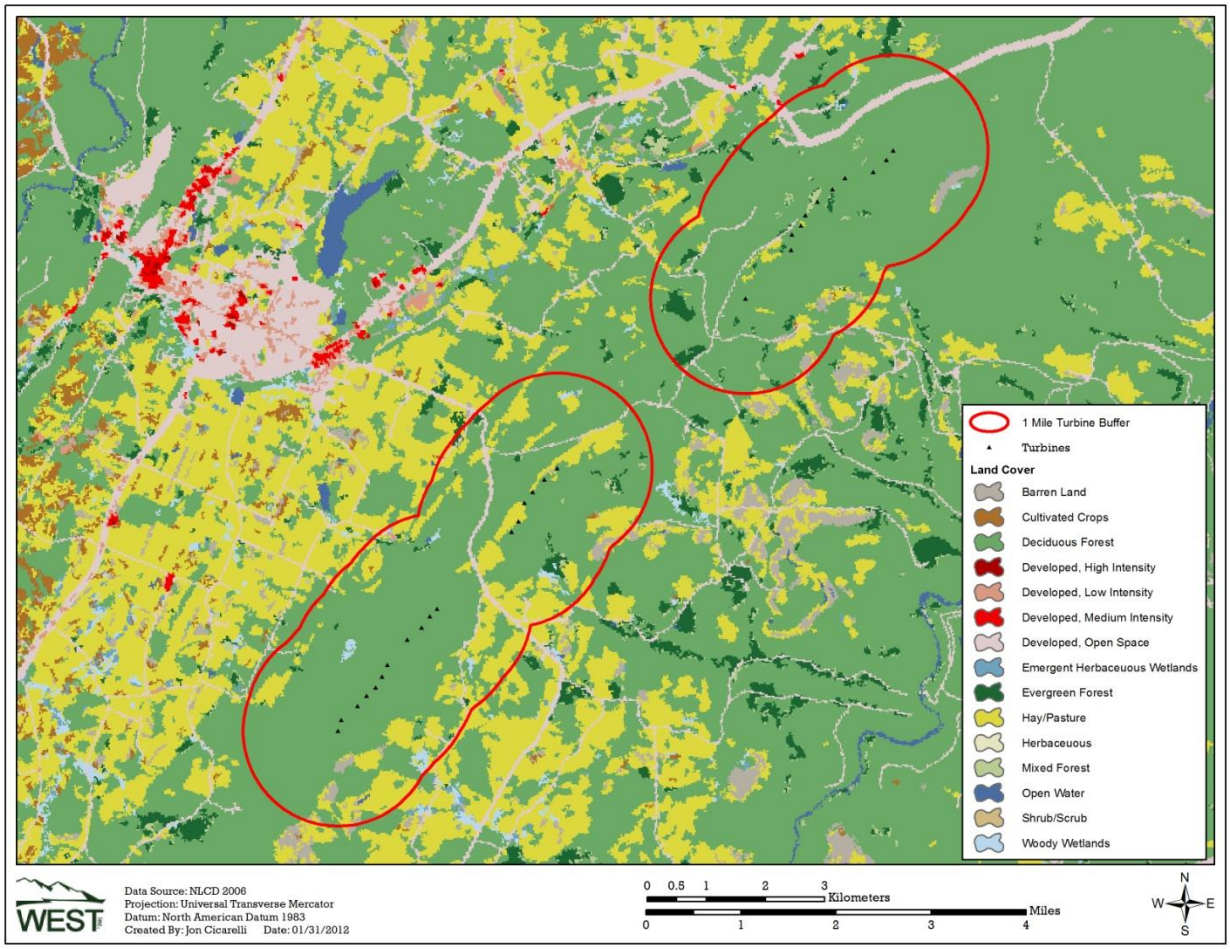

Figure 2. Land use/land cover within and surrounding the Criterion Wind Project area.

METHODS

Avian and Bat Mortality Surveys

The field and analytical methods for the monitoring study were broken into four primary components: 1) standardized carcass searches; 2) searcher efficiency trials; 3) carcass removal trials; and 4) data analysis to determine adjusted fatality estimates for bird and bat species.

There are three scenarios under which casualties could be found during the study period: 1) during the standardized carcass searches; 2) while observers were on site, but not conducting a standardized search (an incidental find); and 3) by facility personnel or others on site for other purposes, such as turbine maintenance. Casualties found by study personnel, regardless of timing (i.e., during a standardized survey or not), were recorded using the methods described below. All casualties found within a search plot, even if outside of the standard survey period, were included in the dataset under the assumption that these casualties would have been found during standardized searches. Carcasses were also included in the fatality estimate when the cause of death was not apparent.

Search Plots and Sample Size

Search plots were established around 14 turbines (50%) and were delineated in the field with a GPS for detailed mapping. Due to the variable nature of the topography and habitat in the CWP, the cleared area around turbines varied in shape and size. In most cases areas up to approximately 40-50 m (~130-165 ft) from the turbines were generally cleared of vegetation for access and construction purposes. Given the difficulty in finding birds and bats within thick shrub cover or forested areas, the search area was limited to the cleared areas around the turbines. Efforts were made to maximize the search plots but searches were not conducted in forested areas or areas with steep rocky slopes or waste rock piles from construction.

The shape of the search plots was variable due primarily to the size of the area cleared for construction. Because the habitat within the Project is a mosaic of forested, farmland, and cleared areas, search plots were delineated as the area around each turbine that is clear of thick vegetation and is not forested, excessively steep, or with waste rock spoils. To the extent possible, the area within 40 m of each turbine was delineated as the search plot, but each plot was not greater than an 80m x 80m square (40 m radius, approximately 6400 m^2) centered on the turbine. Parallel transects were spaced approximately 5 m (~16 ft) apart within the search plot and delineated with colored flagging.

Standardized Carcass Surveys

The objective of the standardized searches was to systematically search the project for bird and bat casualties that were attributable to collision with the turbines. Standardized carcass surveys were conducted weekly at the 14 turbines throughout the study period (April 1 – November 15). Personnel trained in proper search techniques conducted the searches. During a carcass search, searchers walked at a rate of approximately 45-60 m/min (~145 to 195 ft/min) along each transect in the search plot searching both sides out to approximately 2 to 3 m (~7 to 10 ft).

Search area and speed were occasionally adjusted during any given search for the searcher to investigate potential casualties. With the weekly search interval and to spread the standardized searches over time, 2 or 3 turbines were searched each day for five consecutive days. The same turbines were searched on each day of the week to maintain a seven-day interval between searches at a given turbine. The order in which the 2-3 turbines were visited on the specified search day was varied over the course of the study so that any given turbine was not always searched at the same time of day.

All bird and bat casualties located within the search areas, regardless of species, were recorded and a cause of death determined, if possible, based on field inspection of the carcass. The condition of each carcass found was recorded using the following categories:

- Intact - a carcass that is completely intact, is not badly decomposed, and shows no sign of being fed upon by a predator or scavenger.

- Scavenged - an entire carcass, which shows 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 has been heavily infested by insects.

- Feather Spot - ten or more feathers or two or more primaries at one location indicating a bird fatality had been there.

All carcasses were labeled with a unique number, bagged and frozen for future reference and possible further analysis (e.g., genetic determination of species if needed). A copy of the data sheet for each carcass was maintained, bagged and frozen with the carcass at all times. For all casualties found, data recorded included species, sex and age when possible, date and time collected, GPS location, condition (above), and any comments that indicated possible cause of death. All casualties were photographed as found and plotted on a map of the study area showing the location of the wind turbines and associated facilities such as overhead power lines and met towers. In addition to carcasses, any injured bird or bat observed in the search plots was recorded and treated as a casualty. Dominant vegetation cover and visibility index within a 1-m (~3-ft) radius of the carcass location were also recorded.

Casualties found outside the formal search area by carcass search technicians were treated following the above protocol as closely as possible. Casualties observed in non-search areas 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. Casualties where the cause of death was not apparent were included in the fatality estimates. Casualties found by maintenance personnel and others not conducting the formal searches were similarly documented and included in the overall dataset.

Searcher Efficiency Trials

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

Personnel conducting carcass surveys did not know when searcher efficiency trials were being conducted or the location of trial carcasses. Carcasses used for searcher efficiency trials were non-native/non-protected species [e.g., house sparrows (*Passer domesticus*) and rock pigeon (*Columba livia*)] and carcasses found during the 2011 study and allowed by permit (e.g., warblers, vireos, and thrushes). Carcasses of non-*Myotis* bat species, including hoary bat (*Lasiurus cinereus*), eastern red bat (*Lasiurus borealis*), and silver-haired bat (*Lasionycteris noctivagans*), recovered during the study were used in the searcher efficiency trials.

All trial carcasses were placed at pre-determined, randomly-selected locations within search plots prior to the standardized carcass searches on the same day. Carcasses were dropped from shoulder or waist height to simulate a falling bird or bat. Each trial carcass was discreetly marked so that it could be identified as a study carcass after it was found. Efforts were made to insure that no signs or clues to the locations of the carcasses were left by the person placing the carcasses.

The number and location of the searcher efficiency carcasses found during the carcass surveys was 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 or by reference to the carcass placement data sheet for the numbers and location. A carcass missed by the searcher but retrieved following the trial, was determined to be available but undetected. A carcass missed by the searcher and not subsequently found after the trial was determined to be unavailable.

Carcass Removal Trials

The objective of carcass removal trails was to estimate the average length of time a carcass remained in the study area and was potentially detectable. Carcass removal includes removal by predation or scavenging, or removal by other means, such as mowing. 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.

Trial carcasses were distributed throughout the study period in a staggered fashion to incorporate the effects of varying weather, climatic conditions, scavenger densities, and other factors that could influence carcass removal. Trial species composition was similar to those used for searcher efficiency trials (see above).

A typical carcass removal trial occurred over a seven to 14-day period unless all trial carcasses were removed sooner. For each trial, between one and four carcasses were placed at pre-determined, randomly-selected locations within search plots of randomly selected turbines. Trial carcasses were dropped from shoulder or waist height to simulate a falling bird or bat. Carcasses were checked daily for the first seven days and then checked on Day 10 and Day 14, after which any remaining evidence of the carcass was removed. This schedule varied somewhat depending on weather and coordination with the other survey work. Removal trial carcasses were marked discreetly (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 carcass removal trial.

Statistical Analysis

The total bird and bat mortality attributable to the project was estimated by adjusting the observed number of casualties for removal bias (length of stay in the field), searcher efficiency bias (percent found), and distribution around the turbine to account for casualties that may have fallen outside the survey plot.

The study period was divided into two “seasons”, spring and fall. Spring was defined as the period from April 5 to July 15 and fall was July 16 to November 15. These periods encompass bird and bat seasonal migration periods and the summer breeding season.

For carcasses where the cause of death was not apparent, the assumption that the fatality was a wind turbine related casualty was made for the analysis. This approach likely leads to an overestimate of the true number of facility-related fatalities, but provides a conservative estimate of total project related mortality.

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 sheets for completeness, accuracy, and legibility. A sample of records from an electronic database was compared to the raw data sheets 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, 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 sheets, field notebooks, and electronic data files were retained for reference.

Fatality Surveys

Casualty Estimates

Estimates of facility-related fatalities are based on:

(1) Observed number of carcasses found during standardized searches during the study period 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 carcass is expected to remain in the study area and be available for detection by the searchers during removal trials; and

(3) Searcher efficiency expressed as the proportion of planted carcasses found by searchers during searcher efficiency trials.

Fatality estimates were provided for five categories: 1) small birds, 2) large birds, 3) all birds, and 4) 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 is either unknown or is 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 remain in the study area after 30 days
- se standard error (square of the sample variance of the mean)
- t_i the time (in days) a carcass remains in the study area before it is removed, as determined by the removal trials
- $\bar{t}$ the average time (in days) a carcass remains in the study area before it is removed, as determined by the removal trials
- d the total number of carcasses placed in searcher efficiency 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 is both available to be found during a search and is 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 is:

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

Estimation of Carcass Non-Removal Rates

Estimates of carcass non-removal rates are used to adjust carcass counts for removal bias. Mean carcass removal time ($\bar{t}$) is the average length of time a carcass remains in the study area before it is removed:

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

Estimation of Searcher Efficiency Rates

Searcher efficiency rates are expressed as *p,* the proportion of trial carcasses that are detected by searchers in the searcher efficiency trials. These rates will be estimated by carcass size and season.

Estimation of Facility-Related Fatality Rates

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

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

where $\hat{\pi}$ includes adjustments for both carcass removal (from scavenging and other means) and searcher efficiency bias. Carcass removal and searcher efficiency biases were calculated for each season to estimate seasonal $\hat{\pi}$.

$\hat{\pi}$ is 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 final reported estimates of *m* and associated standard errors and 90% confidence intervals were calculated using bootstrapping (Manly 2006). 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 are calculated. A total of 5,000 bootstrap samples were used. The reported estimates are the mathematical means of the 5,000 bootstrap estimates. The standard deviation of the bootstrap estimates is the estimated standard error. The lower 5th and upper 95th percentiles of the 15,000 bootstrap estimates are estimates of the lower limit and upper limit of 90% confidence intervals.

Turbine Operations Analysis

To evaluate the effectiveness of the turbine operation constraints at reducing bat mortality two comparisons were made: (1) all bat mortality for the entire study period was compared to the results from 2011 for the entire study period and (2) bat mortality for just the period when the turbine operation adjustments were made (nights of July 15 through October 15) was compared to the similar period in 2011. The 2011 data set was parsed for the results from July 16 to October 16 period and analyzed according to the above statistical methods.

RESULTS

Monitoring surveys began on April 1 and continued through November 15, 2012[1].

Avian and Bat Fatality Surveys

Fourteen wind turbines were searched on an approximately weekly basis over the course of the monitoring period, for a total of 417 turbine searches. Some searches were missed occasionally due to unsafe weather conditions or other safety concerns such as turbine maintenance[1]. The shape of the search plots was variable due primarily to the size of the area cleared for construction. The maximum distance searched from any one turbine was approximately 50 m (~165 ft, Table 1). The percentage of the total area searched decreased with distance from the turbine due to the constraints of the irregular search plots (Table 1).

[1] Inclement weather, in particular heavy snow cover that compromised site access and safety, interrupted the surveys during the period October 30 to November 06, 2012.

Table 1. Proportion of plots searched within the Criterion Wind Energy Project.

Distance (m)	Total Area (sq. m)	Area Searched (sq. m)	Percent Area Searched
10	4,394.08	4,203.96	95.67
20	13,182.24	11,313,90	85.83
30	21,970.40	15,739.51	71.64
40	30,758.57	16,618.25	54.03
50	39,546.73	13,787.60	34.86
60	48,334.89	8,760.51	18.12
70	57,123.05	3,892.63	6.81
80	65,911.21	866.78	1.32
90	74,699.37	248.09	0.33
100	83,487.54	9.34	0.01

A total of 28 bird (22 small birds and 6 large birds) and 82 bat casualties were found during standardized carcass surveys or incidentally (Table 2). A full listing of casualties found and the locations of casualties are presented in Appendix A and Appendix B.

Bird Fatalities

During the standardized carcass searches, 14 birds comprising 5 identifiable species and 4 unknown species were found (Table 2). The most commonly found bird species were red-eyed vireo (*Vireo olivaceus*) and golden-crowned kinglet (*Dendroica striata*) (Table 2). One unidentified raptor feather spot was found during scheduled surveys, and was the only raptor found during the monitoring period. An additional 14 carcasses were found incidentally within the search plots or at other turbines not included in the study (Table 2).

The greatest number of bird fatalities were found at Turbine ALT2 (4 carcasses) and Turbines 24 and 44 (3 carcasses) (Figure 3). Of the bird fatalities, 88.8% were found within 50 m (~164 ft) of the turbines (Table 3 and Figure 4). Most of the bird fatalities occurred during the fall season in the period from October 4 to November 8 (Figure 5).

Table 2. Total number and species composition of bird and bat casualties found at the CWP.

Species	Casualties during Scheduled Searches		Incidental Casualties at Search Plots*		Other Incidentals		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Birds								
golden-crowned kinglet	3	21.4	1	20.0	0	0	4	14.3
red-eyed vireo	3	21.4	0	0	1	11.1	4	14.3
gadwall	2	14.3	0	0	0	0	2	7.1
American redstart	1	7.1	1	20.0	0	0	2	7.1
rose-breasted grosbeak	1	7.1	0	0	0	0	1	3.6
unidentified bird (small)	1	7.1	0	0	0	0	1	3.6
unidentified large bird	1	7.1	0	0	0	0	1	3.6
unidentified raptor	1	7.1	0	0	0	0	1	3.6
unidentified warbler	1	7.1	0	0	0	0	1	3.6
ruby-throated hummingbird	0	0	1	20.0	1	11.1	2	7.1
unidentified vireo	0	0	1	20.0	0	0	1	3.6
white-throated sparrow	0	0	1	20.0	0	0	1	3.6
turkey vulture	0	0	0	0	2	22.2	2	7.1
black-throated blue warbler	0	0	0	0	1	11.1	1	3.6
blue-headed vireo	0	0	0	0	1	11.1	1	3.6
magnolia warbler	0	0	0	0	1	11.1	1	3.6
Philadelphia vireo	0	0	0	0	1	11.1	1	3.6
unidentified passerine	0	0	0	0	1	11.1	1	3.6
Overall Birds	**14**	**100**	**5**	**100.0**	**9**	**100**	**28**	**100**
Bats								
eastern red bat	26	65.0	6	31.6	12	52.2	44	53.7
hoary bat	10	25.0	9	47.4	8	34.8	27	32.9
big brown bat	2	5.0	0	0	1	4.3	3	3.7
silver-haired bat	1	2.5	4	21.1	1	4.3	6	7.3
tricolored bat	1	2.5	0	0	0	0	1	1.2
unidentified bat	0	0	0	0	1	4.3	1	1.2
Overall Bats	**40**	**100**	**19**	**100**	**23**	**100**	**82**	**100**

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

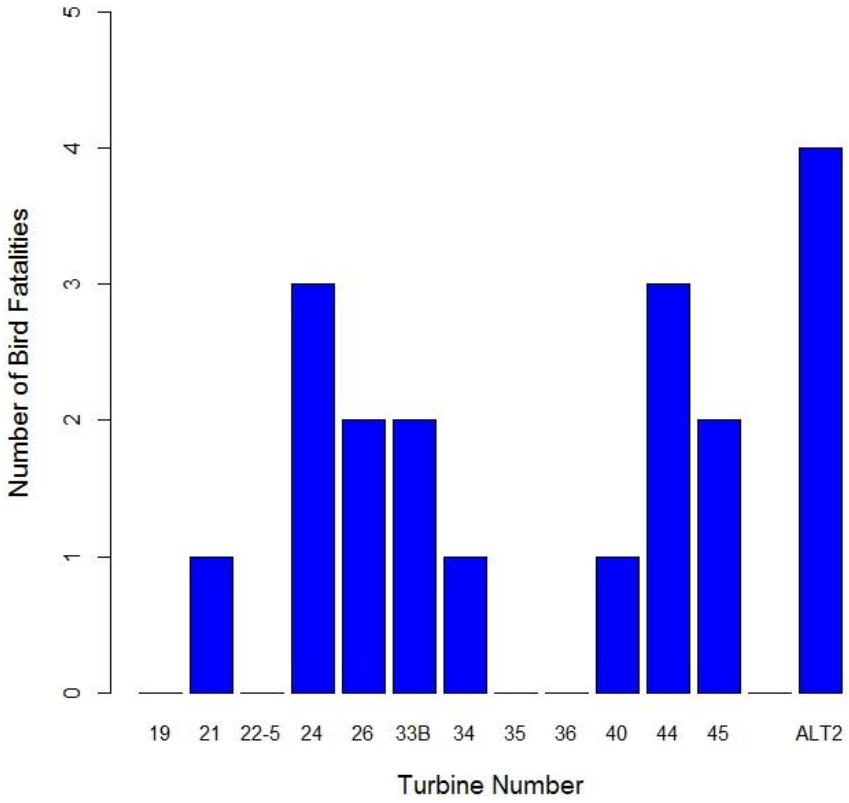

Figure 3. Number of bird fatalities by turbine at the CWP.

Table 3. Distribution of distances of bird and bat casualties from turbines.

Distance to Turbine (m)	Percent of Bird Casualties	Cumulative Percent of Birds	Percent of Bat Casualties	Cumulative Percent of Bats
0 to 10	11.1	11.1	18.6	18.6
10 to 20	22.2	33.3	39.0	57.6
20 to 30	11.1	44.4	8.5	66.1
30 to 40	22.2	66.6	23.7	89.8
40 to 50	22.2	88.8	6.8	96.6
50 to 60	0	88.8	0	96.6
60 to 70	5.6	94.4	1.7	98.3
70 to 80	5.6	100	0	98.3
>80	0	100	1.7	100

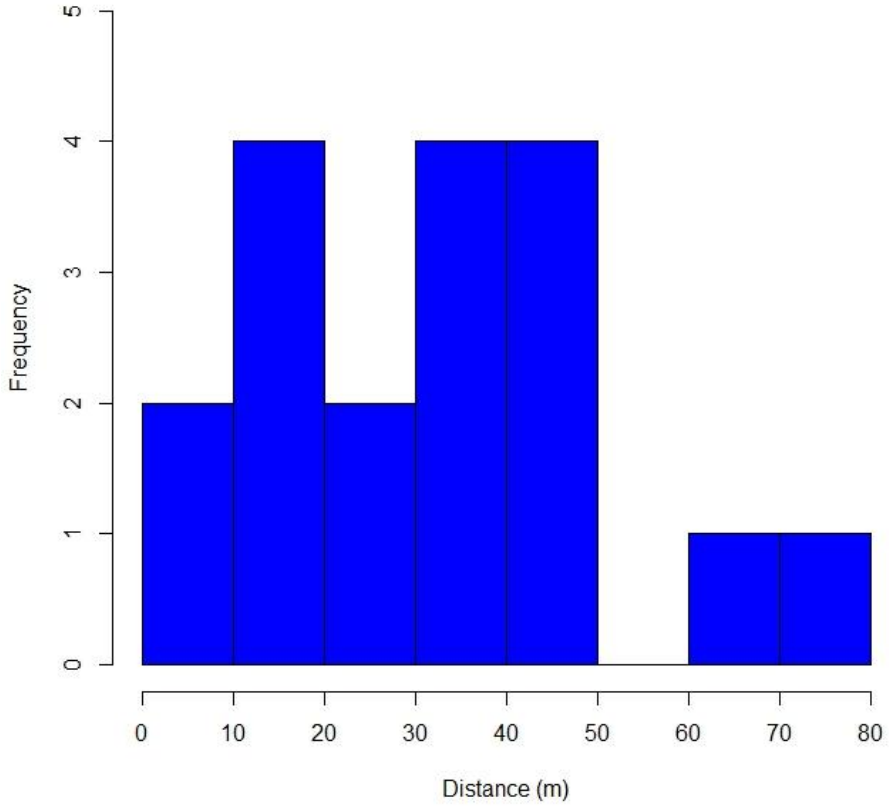

Figure 4. Distance of bird casualties from the turbine.

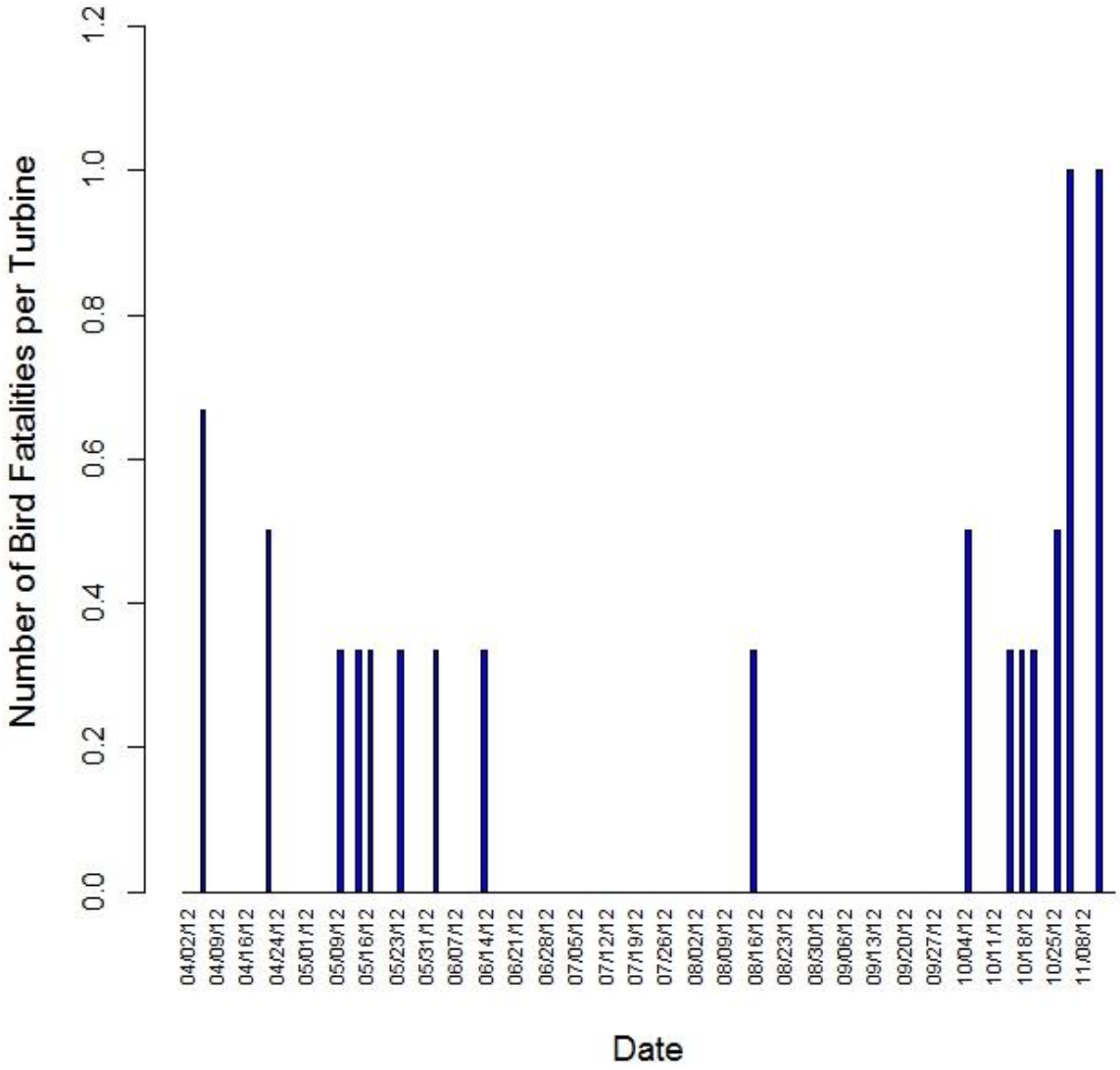

Figure 5. Timing of bird fatalities over the study period.

Bat Fatalities

A total of 40 bat fatalities were found during scheduled turbine searches, representing five identifiable species (Table 2). The bat species most commonly found during searches were eastern red bat (*Lasiurus borealis*) and hoary bat (*L. cinereus*) (Table 3). Other bat species found during the scheduled searches included silver-haired bat (*Lasionycteris noctivagans*), tricolored bat (*Pipistrellus subflavus*), and big brown bat (*Eptesicus fuscus*). No Myotis species bats were found during the study. One unknown bat was found incidentally by CWP maintenance personal. The unknown bat carcass was observed adhered to a turbine blade at turbine that was not included in the standardized carcass searches and could not be retrieved.

The greatest number of bat fatalities was found at Turbine 44 (12 carcasses), followed by Turbines 34 (9 carcasses) and 40 (8 carcasses; Figure 6). The number of fatalities found at all other turbines ranged from 0 to 6 carcasses. Bats were typically found closer to the turbines than bird fatalities with 96.6%) of all bat fatalities was found within 50 m (~164 ft) of the turbine (Table 3, Figure 7). Bat fatalities were highest during the period July 5 to October 4 (Figure 8).

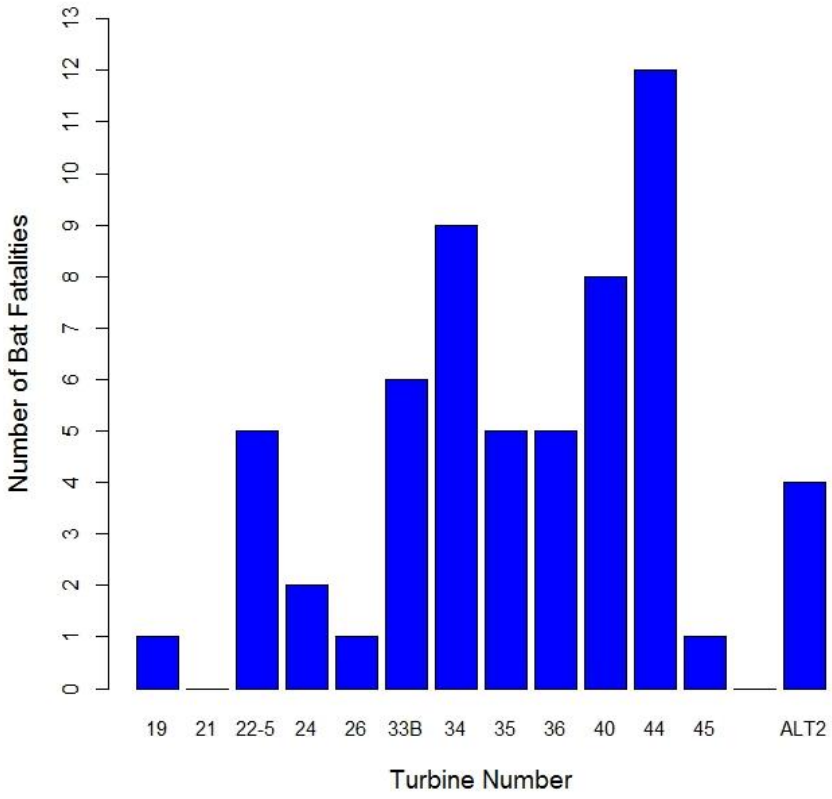

Figure 6. Number of bat fatalities by turbine at the CWP.

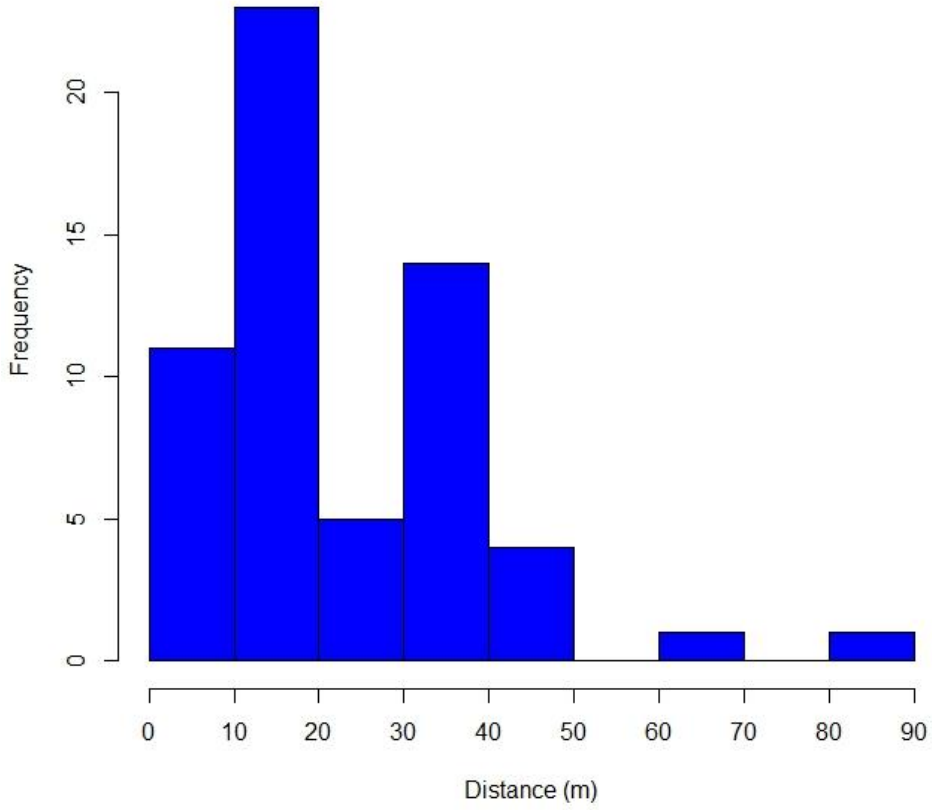

Figure 7. Distance of bat fatalities from the turbine.

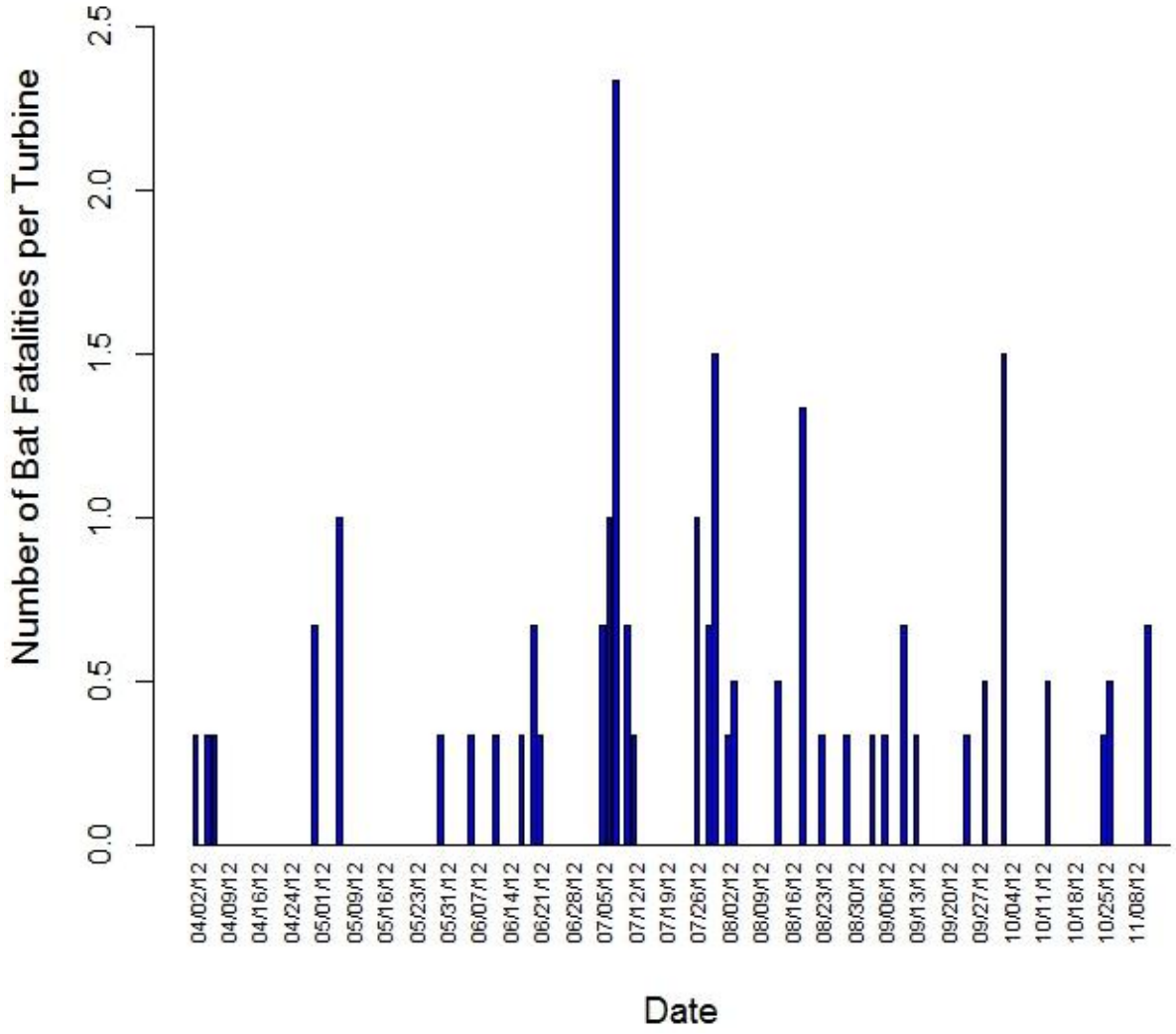

Figure 8. Timing of bat fatalities over the study period.

Searcher Efficiency Trials

A total of 175 small bird carcasses, 100 large bird carcasses, and 200 bat carcasses were placed throughout the project area for the searcher efficiency trials (Table 4). The overall searcher efficiency rate for small birds was 61.1%, for large birds was 100%, and for bats was 55.7% (Table 4). Searcher efficiency for small birds was 0.75 in spring and 0.48 in fall (Table 5). Searcher efficiency for large birds was 1.00 in both spring and fall. Searcher efficiency for bats was 0.65 in spring and 0.49 in fall (Table 5).

Table 4. Searcher efficiency results at the CWP as a function of carcass size.

Size	Date	Number Placed	Number Available	Number Found	Percent Found
	4/2/2012	1	1	0	0
	4/3/2012	2	2	2	100
	4/5/2012	2	2	1	50.0
	4/6/2012	1	0	0	N/A
	4/10/2012	1	1	1	100
	4/12/2012	2	2	2	100
	4/16/2012	2	2	1	50.0
	4/17/2012	1	1	0	0
	4/20/2012	2	2	2	100
	4/25/2012	1	1	1	100
	4/26/2012	2	2	2	100
	4/27/2012	1	1	1	100
	5/2/2012	1	1	1	100
	5/3/2012	2	2	2	100
	5/4/2012	4	0	0	N/A
	5/7/2012	1	0	0	N/A
	5/8/2012	2	1	1	100
	5/9/2012	4	2	2	100
	5/14/2012	5	5	4	80.0
	5/16/2012	3	3	2	66.7
	5/17/2012	3	3	2	66.7
	5/21/2012	2	1	1	100
	5/22/2012	2	1	1	100
	5/23/2012	3	3	2	66.7
	5/30/2012	1	1	1	100
	5/31/2012	4	4	4	100
	6/1/2012	2	1	1	100
	6/5/2012	2	2	2	100
	6/7/2012	1	0	0	N/A
	6/13/2012	2	2	1	50.0
	6/14/2012	3	2	1	50.0
	6/29/2012	3	3	2	66.7
	7/5/2012	1	0	0	N/A
Small Birds	7/6/2012	2	1	1	100

	7/9/2012	5	3	1	33.3
	7/10/2012	1	1	0	0
	7/12/2012	2	1	0	0
	7/18/2012	4	3	1	33.3
	7/19/2012	1	1	0	0
	7/20/2012	1	1	0	0
	7/23/2012	1	1	1	100
	7/24/2012	1	0	0	N/A
	7/25/2012	3	2	2	100
	8/1/2012	1	1	1	100
	8/2/2012	3	1	0	0
	8/6/2012	2	1	1	100
	8/8/2012	3	2	0	0
	8/9/2012	3	0	0	N/A
	8/15/2012	3	3	1	33.3
	8/16/2012	1	1	1	100
	8/17/2012	2	2	2	100
	8/21/2012	1	1	1	100
	8/22/2012	3	2	1	50.0
	8/24/2012	2	1	0	0
	8/27/2012	1	1	0	0
	8/28/2012	3	0	0	N/A
	8/29/2012	1	1	1	100
	9/4/2012	3	3	2	66.7
	9/5/2012	4	3	1	33.3
	9/6/2012	2	0	0	N/A
	9/10/2012	1	1	1	100
	9/12/2012	4	3	1	33.3
	9/17/2012	5	3	0	0
	9/19/2012	1	1	0	0
	9/24/2012	4	3	1	33.3
	9/25/2012	6	5	2	40.0
	9/27/2012	2	2	1	50.0
	10/2/2012	4	2	2	100
	10/4/2012	2	2	2	100
	10/10/2012	2	1	0	0
	10/11/2012	2	1	0	0
	10/16/2012	3	3	0	0
	10/17/2012	3	1	1	100
	10/23/2012	1	1	1	100
	10/24/2012	1	1	1	100
	10/25/2012	1	0	0	N/A
	11/12/2012	1	1	1	100
	11/14/2012	1	1	1	100
	11/15/2012	3	3	1	33.3
Overall Small Birds		**175**	**126**	**77**	**61.1**
	4/2/2012	1	1	1	100
Large Birds	4/3/2012	1	1	1	100

4/5/2012	1	1	1	100
4/6/2012	2	2	2	100
4/17/2012	1	1	1	100
4/20/2012	2	2	2	100
4/25/2012	3	3	3	100
4/26/2012	2	2	2	100
5/2/2012	1	1	1	100
5/3/2012	1	1	1	100
5/4/2012	1	0	0	N/A
5/7/2012	1	0	0	N/A
5/8/2012	1	1	1	100
5/9/2012	1	0	0	N/A
5/14/2012	2	2	2	100
5/17/2012	1	1	1	100
5/21/2012	2	2	2	100
5/22/2012	1	1	1	100
5/30/2012	1	1	1	100
5/31/2012	1	1	1	100
6/1/2012	1	1	1	100
6/5/2012	1	1	1	100
6/6/2012	1	1	1	100
6/7/2012	3	1	1	100
6/14/2012	1	1	1	100
6/15/2012	1	0	0	N/A
6/19/2012	2	1	1	100
7/4/2012	2	0	0	N/A
7/5/2012	2	2	2	100
7/9/2012	2	2	2	100
7/10/2012	2	2	2	100
7/18/2012	2	2	2	100
7/19/2012	2	1	1	100
8/1/2012	3	3	3	100
8/2/2012	2	2	2	100
8/8/2012	3	2	2	100
8/9/2012	2	1	1	100
8/15/2012	4	4	4	100
8/16/2012	3	3	3	100
8/22/2012	1	1	1	100
8/24/2012	2	2	2	100
8/27/2012	1	1	1	100
8/28/2012	2	0	0	N/A
8/29/2012	1	1	1	100
9/5/2012	2	2	2	100
9/6/2012	1	0	0	N/A
9/11/2012	1	1	1	100
9/17/2012	1	1	1	100
9/19/2012	1	1	1	100
9/21/2012	1	1	1	100

	9/24/2012	1	1	1	100
	9/27/2012	1	1	1	100
	10/1/2012	2	0	0	N/A
	10/4/2012	2	2	2	100
	10/9/2012	1	1	1	100
	10/10/2012	1	1	1	100
	10/11/2012	4	3	3	100
	10/17/2012	2	0	0	N/A
	10/23/2012	2	2	2	100
	10/24/2012	1	1	1	100
	10/25/2012	1	1	1	100
	11/8/2012	1	1	1	100
	11/12/2012	1	1	1	100
Overall Large Birds		**100**	**80**	**80**	**100**
	4/2/2012	2	2	2	100
	4/3/2012	1	1	1	100
	4/5/2012	2	2	1	50.0
	4/6/2012	2	2	2	100
	4/10/2012	2	2	1	50.0
	4/12/2012	1	1	1	100
	4/16/2012	2	1	0	0
	4/17/2012	3	3	3	100
	4/20/2012	1	1	1	100
	4/25/2012	2	2	1	50.0
	4/26/2012	3	3	3	100
	4/27/2012	2	2	2	100
	5/2/2012	2	2	0	0
	5/3/2012	3	1	1	100
	5/7/2012	3	1	1	100
	5/8/2012	1	1	0	0
	5/14/2012	1	1	0	0
	5/16/2012	2	2	2	100
	5/17/2012	2	2	2	100
	5/22/2012	4	4	2	50.0
	5/23/2012	3	1	0	0
	5/30/2012	2	0	0	N/A
	5/31/2012	2	2	1	50.0
	6/1/2012	2	1	1	100
	6/5/2012	4	0	0	N/A
	6/6/2012	3	3	1	33.3
	6/7/2012	1	1	0	0
	6/13/2012	5	5	3	60.0
	6/14/2012	3	3	2	66.7
	6/15/2012	1	0	0	N/A
	6/19/2012	3	0	0	N/A
	6/20/2012	1	0	0	N/A
	6/29/2012	3	2	2	100
Bats	7/4/2012	3	0	0	N/A

7/5/2012	2	2	1	50.0
7/6/2012	2	2	0	0
7/10/2012	1	0	0	N/A
7/12/2012	1	1	1	100
7/18/2012	1	1	0	0
7/19/2012	3	3	1	33.3
7/20/2012	2	1	1	100
7/23/2012	4	3	1	33.3
7/24/2012	3	1	0	0
7/25/2012	3	0	0	N/A
8/1/2012	2	1	0	0
8/2/2012	4	3	2	66.7
8/6/2012	1	0	0	N/A
8/8/2012	1	0	0	N/A
8/16/2012	4	2	2	100
8/17/2012	3	2	1	50.0
8/21/2012	4	4	2	50.0
8/22/2012	2	2	0	0
8/24/2012	1	1	0	0
8/27/2012	2	1	1	100
8/28/2012	2	0	0	N/A
8/29/2012	2	2	1	50.0
9/4/2012	1	1	1	100
9/5/2012	1	1	1	100
9/6/2012	3	0	0	N/A
9/10/2012	5	4	1	25.0
9/11/2012	3	3	1	33.3
9/12/2012	3	2	2	100
9/17/2012	1	1	1	100
9/19/2012	3	3	1	33.3
9/21/2012	3	2	1	50.0
9/24/2012	1	0	0	N/A
9/25/2012	1	1	1	100
9/27/2012	1	1	1	100
10/1/2012	2	2	0	0
10/2/2012	1	1	0	0
10/4/2012	2	2	1	50.0
10/9/2012	2	2	2	100
10/10/2012	1	0	0	N/A
10/11/2012	2	1	0	0
10/16/2012	3	3	1	33.3
10/17/2012	1	0	0	N/A
10/18/2012	4	2	1	50.0
10/23/2012	3	3	0	0
10/24/2012	4	3	1	33.3
10/25/2012	5	4	2	50.0
10/29/2012	5	4	2	50.0
11/5/2012	3	0	0	N/A

11/8/2012	3	2	1	50.0
11/12/2012	4	4	4	100
11/14/2012	1	1	1	100
11/15/2012	1	1	1	100
Overall Bats	**200**	**140**	**78**	**55.7**

Table 6. Searcher efficiency estimates for the CWP for the spring and fall periods.

	Spring		Fall	
Parameter	**Mean**	**90% CL**	**Mean**	**90% CL**
Observer Detection				
p (small birds)	0.75	0.67 - 0.83	0.48	0.38 – 0.59
p (large birds)	1.00	1.00 – 1.00	1.00	1.00 - 1.00
p (bats)	0.65	0.54 - 0.75	0.49	0.40 - 0.58

Carcass Removal Trials

A total of 489 carcasses (99 large birds, 192 small birds, and 198 bats) were placed in the project area throughout the study period for carcass removal trials. By Day 5, approximately 40% of all small bird and bat carcasses remained and approximately 25% of large bird carcasses remained (Figure 9). By Day 10, approximately 25% of all small bird and bat carcasses remained and approximately 15% of large bird carcasses remained (Figure 9). At Day 14, when trial carcasses were removed, approximately 20% of small birds, 15% of bats and large bird carcasses remained (Figure 9). For small birds, mean carcass removal was 7.17 days (90% CI 5.91-8.49) in the spring and 5.37 days (90% CI 4.32-6.53) in the fall. For large birds, mean carcass removal was 5.77 days (90% CI 3.93-8.03) in the spring and 4.31 days (90% CI 2.81-6.14). For bats, mean carcass removal was 6.70 days (90% CI 5.44-8.05) in the spring and 4.59 days (90% CI 3.66-5.67) in the fall.

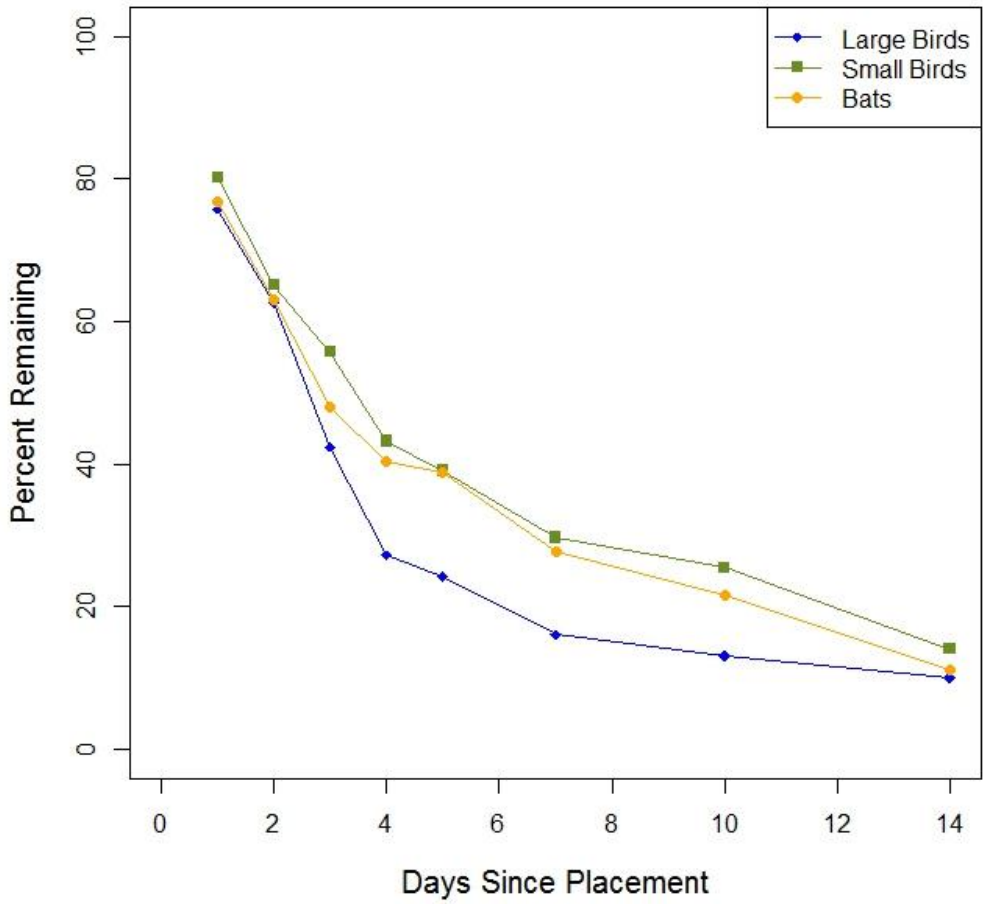

Figure 9. Carcass removal rates at the CWP.

Adjusted Fatality Estimates

Fatality estimates and 90% confidence intervals were calculated for birds and bats by season due to differences in searcher efficiency and carcass removal between the two seasons (Tables 7 and 8). The fatality estimates are adjusted based on the corrections for carcass removal, observer detection bias, and the search area correction factor. For small birds, the probability that a carcass would remain in the search plot and be found by a searcher was 0.50 in the spring and 0.29 in the fall (Table 7). For large birds, the probability that a carcass would remain in the search plot and be found was 0.54 in the spring and 0.46 in the fall (Table 7). For bats, the probability that a carcass would remain in the search plot and be found was 0.43 in the spring and 0.26 in the fall (Table 8).

Table 7. Adjusted bird fatality estimates for the CWP for the spring and fall periods.

	Spring		Fall	
Parameter	**Mean**	**CL**	**Mean**	**CL**
Observed Fatality Rates (Fatalities/turbine/study period)				
Small birds	0.50	0.14 - 1.00	0.43	0.14 – 0.71
Large birds	0.14	0.00 - 0.29	0.14	0.00 - 0.43
All birds	0.64	0.21 - 1.14	0.57	0.21 – 0.93
Average Probability of Carcass Availability and Detected				
Small birds	0.50	0.43 - 0.56	0.29	0.22 - 0.36
Large birds	0.54	0.44 - 0.64	0.46	0.34 - 0.57
Search Area Adjustment				
Small birds	1.67	-	1.67	-
Large birds	2.19	-	2.19	-
Adjusted Fatality Estimates (Fatalities/turbine/study period)				
Small birds	1.66	0.41 – 3.44	2.44	0.94 – 4.38
Large birds	0.57	0.00 – 1.27	0.67	0.00 – 2.01
All birds	2.23	0.77 – 4.12	3.11	1.34 – 5.48

Table 8. Adjusted bat fatality estimate for the CWP for the spring and fall periods.

	Spring		Fall	
Parameter	**Mean**	**CL**	**Mean**	**CL**
Observed Fatality Rates (Fatalities/turbine/study period)				
Bats	1.86	1.14 - 2.64	2.21	1.14 – 3.57
Average Probability of Carcass Availability and Detected				
Bats	0.43	0.35 – 0.50	0.26	0.20 – 0.33
Search Area Adjustment				
Bats	1.50	-	1.50	-
Adjusted Fatality Estimates (Fatalities/turbine/study period)				
Bats	6.46	3.89 – 9.79	12.60	6.16 – 21.96

Overall fatality rates were calculated by combining the two seasonal estimates. The estimated fatality rate for small birds was 4.10 fatalities per turbine per study period, large birds 1.24, all birds 5.34, and bats 19.06 (Table 9). Based on the 2.5 MW capacities of the turbines at the site, the estimated fatality rate for small birds was 1.64 birds per MW per study period; 0.50 for large birds; 2.14 for all birds combined; and 7.62 bats per MW per study period (Table 9).

Table 9. Overall adjusted bird and bat fatality estimates for the CWP for the entire study period.

	Corrected Fatality Estimate
Number of fatalities/turbine/study period	
Small Birds	4.10 (2.04-6.69)
Large Birds	1.24 (0.26-2.76)
All Birds	5.34 (2.94-8.30)
Bats	19.06 (11.95-28.84)
Number of fatalities/MW/study period	
Small Birds	1.64 (0.82-2.67)
Large Birds	0.50 (0.10-1.11)
All Birds	2.14 (1.18-3.32)
Bats	7.62 (4.78-11.53)

Turbine Operations Analysis

Fatality estimates and 90% confidence intervals were calculated for bats for the period from July 16 to October 16[2] for both 2012 and 2011 (Young et al. 2012). Adjusted overall bat mortality during this period for 2012 was 10.97 bats per turbine and for 2011 was 28.78 bats per turbine (Table 10).

Table 10. Adjusted bat fatality estimate for the CWP for the period July 15 to October 15 for 2012 and 2011.

	2012		2011	
Parameter	**Mean**	**CL**	**Mean**	**CL**
Observed Fatality Rates (Fatalities/turbine/study period)				
Bats	1.94	0.85 – 3.28	18.07	15.35 – 20.97
Average Probability of Carcass Availability and Detected				
Bats	0.26	0.20 – 0.33	0.83	0.74 – 0.90
Search Area Adjustment				
Bats	1.50	-	1.34	-
Adjusted Fatality Estimates (Fatalities/turbine/study period)				
Bats	10.97	4.81 – 20.19	28.78	24.09 – 35.17

[2] The turbine operational adjustments in 2012 were begun the night of July 15-16 and discontinued after the night of October 15-16.

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, carcass removal rates, and area searched biases. 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 incorporates several assumptions or factors that affect the results of the fatality estimates. First, all casualties found within the standardized search plots during the study were included in the analysis. Second, it was assumed that all casualties found during the study were due to collision with wind turbines. True cause of death may be unknown for many of the fatalities, especially if they have been scavenged or are heavily decomposed. It is possible that some of the bird fatalities were caused by predators (e.g., feather spots are often left behind at the site of a raptor kill) or other natural causes (e.g., disease, background mortality). However, it is typically thought that most, if not all, of the bat fatalities are due to collisions with the turbines.

The search plot distance for this study was selected based on constraints from habitat in the study area. Typically the area out to 40-50 m from the turbine was cleared to accommodate construction of the turbine. The search plot for any given turbine was typically defined by this cleared area. For this study this search plot appeared adequate based on the distribution of fatalities as a function of distance from turbines (see Figures 4 and 7). For both birds and bats >89-97% of the casualties were located within 50 m of the turbine and only a small percentage of bird and bat fatalities were located beyond 50 m of the turbine (see Tables 7 and 8).

Other potential biases are associated with the experimental carcasses used in searcher efficiency and carcass removal trials and whether or not they are representative of actual carcasses. This may occur if the types of birds used are larger or smaller than the carcasses of actual fatalities or more or less cryptic in color and appearance than the actual fatalities. For this study, house sparrows, rock pigeons and carcasses found during the previous year (2011) and this year 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 provide a reasonable representation of searcher efficiency and carcass removal rates for birds as a group. Bats carcasses retrieved during the study (both 2011 and this year) were used to estimate search efficiency and carcass removal for bats specifically, thus providing a reasonable representation of these biases for bats.

Turbine Operations Analysis

During 2012, CPP implemented conservation measures described in the HCP being prepared for the project. Specifically, CPP operated the turbines in the CWP by feathering the blades to minimize rotation to less than 2 rpm during nighttime periods when wind speeds were below 5.0 m/s from the night of July 15 through the night of October 15. Numerous monitoring studies throughout the U.S. have documented this period as the time of year when most of the bat

fatalities occur at wind projects. In addition, other studies (e.g., Arnett et al. 2009, Good et al. 2011) have shown that raising the cut-in speed of wind turbines (the wind speed at which the turbine begins producing electricity to the grid) is an effective measure at reducing bat mortality.

The HCP for the CWP has committed CPP to achieving a 50% reduction in overall bat mortality as a measure to minimize the potential take of Indiana bat from the project. No take of Indiana bat has been documented either during the 2011 monitoring study or this year of monitoring. The results of the analysis of bat mortality when compared to last year showed that approximately a 51% reduction in bat mortality was achieved for the entire study period (April 1 to November 15) compared to the study results in 2011 and an approximately 62% reduction in bat mortality was achieved through the turbine operation adjustments for the period from July 15 to October 15 (see Table 10).

Comparison with Regional Data

Bird fatality estimates based on publically available information for regional wind energy facilities ranged from 2.2 birds per turbine per study period (Locust Ridge, PA) to 16.0 birds per turbine per study period (Criterion, MD 2011). The estimated bird fatality rate at CWP, 5.3 birds per turbine or 0.8 birds per 1000 m^2 of RSA for this study period was on the low end of the range for facilities where monitoring study results are available within approximately a 40-mile radius of the project (Table 11). To standardize the estimates from these studies to area of risk as defined by the rotor-swept area (RSA), the estimated mortality was calculated per 1000 m^2 of RSA (Table 11).

Publically available bat fatality estimates from other regional wind projects ranged from 12.9 bats per turbine per study period (Casselman, PA) to 47.5 bats per turbine per study period (Mountaineer, WV) (Table 12). The standardized estimated bat fatality rate at CWP of 2.8 bats per 1000 m^2 of RSA for the study period is lower than bat mortality estimates from projects where monitoring study results are available within approximately a 40-mile radius of the CWP (Table 12); however, it should be noted that during this study the turbine operational adjustments were implemented at the site according to measures identified in the HCP in order to minimize bat mortality.

Species composition of fatalities at the CWP is similar to that at most other wind energy facilities, in that more than 90% of identified bat fatalities were comprised of the three migratory tree bat species, namely hoary bat, eastern red bat, and silver-haired bat (see Table 2). Based on the timing of fatalities for these species most of the fatalities were apparently fall migrants through the site or occurred during what is considered the late summer swarming (mating) period, as is the case at virtually all other wind energy facilities in North America (Johnson 2005, Arnett et al. 2008).

Table 11. Summary of bird casualties from post-construction fatality monitoring studies conducted at wind-energy facilities in the CWP region.

Project Name, State	Project size (No. of Turbines)	No. of Turbine Searches	Estimated # birds/turbine / study period[1]	Estimated # birds/1000 m^2 RSA/study period	90% CI	Study Year	Reference
Criterion, MD	28	417	5.3	0.8	0.4 - 1.2	2012	This study
Criterion, MD	28	5,316	16.0	2.3	1.6 - 3.4	2011	Young et al. 2012
Mountaineer, WV	44	998	4.0	1.0	0.6 - 2.0	2003	Kerns & Kerlinger 2004
Casselman, PA	23	2,040	4.7[2]	1.0[2]	0.3 - 3.0[3]	2008	Arnett *et al.* 2009
Casselman, PA	23	nr	4.3	0.9	0.6 - 1.4[3]	2009	Capouillez and Mumma 2010
Locust Ridge, PA	51	nr	4.1	0.8	0.3 - 2.6[3]	2009	Arnett et al. 2011
Locust Ridge, PA	51	nr	2.2	0.4	0.1 - 0.8[3]	2010	Arnett et al. 2011
Mt Storm, WV	132	2,520	8.7[4]	1.7[4]	1.0 - 2.5	2009	Young *et al*. 2009b, 2010a
Mt Storm, WV	132	4,401	6.7[4]	1.3[4]	0.8 - 2.0	2010	Young *et al.* 2010b, 2011a
Mt Storm, WV	132	3,794	8.0[4]	1.6[4]	1.3 - 2.5	2011	Young *et al*. 2011b, 2012

nr = not reported
RSA equivalent was determined by dividing the total estimated bird mortality by total RSA for the project as determined by the rotor dimensions for the specific turbines at that site
[1]study period is approximately the period from April through October which is similar to the monitoring period for CWP [2]based on the Huso estimator; [3]estimated based on the reported as 95% CI. ; [4]estimate was derived by combining the results from two non-overlapping study periods (spring and fall) which used the same study plots

Table 12. Summary of bat casualties from post-construction fatality monitoring studies conducted at wind-energy facilities in the CWP region.

Project Name, State	Project size (No. of Turbines)	No. of Turbine Searches	Estimated # bats/turbine/ study period[1]	Estimated # bats/1000 m^2 RSA/study period[1]	90% CI	Study Year	Reference
Criterion, MD	28	417	19.1	2.8	1.8 - 4.2	2012	This study
Criterion, MD	28	5,316	39.0	5.7	5.1 - 6.8	2011	Young et al. 2012
Mountaineer, WV	44	998	47.5	11.7	7.8 - 22.5	2003	Kerns & Kerlinger 2004
Casselman, PA	23	2,040	18.9	4.1[2]	3.3 - 4.9[3]	2008	Arnett *et al.* 2009
Casselman, PA	23	nr	12.9	2.8	2.1 - 3.5[3]	2009	Capouillez & Mumma 2010
Locust Ridge, PA	51	nr	30.9	5.9	5.2 - 6.6[3]	2009	Arnett et al. 2011
Locust Ridge, PA	51	nr	32.2	6.1	5.2 - 7.0[3]	2010	Arnett et al. 2011
Mt Storm, WV	132	2,520	28.6	5.7[4]	3.7 - 8.1	2009	Young *et al*. 2009b, 2010a
Mt Storm, WV	132	4,401	32.4	6.4[4]	5.3 - 8.6	2010	Young *et al.* 2010b, 2011a
Mt Storm, WV	132	3,794	14.9	3.0[4]	2.4 - 3.6	2011	Young *et al*. 2011b, 2012

nr = not reported
RSA equivalent was determined by dividing the total estimated bird mortality by total RSA for the project as determined by the rotor dimensions for the specific turbines at that site
[1]study period is approximately the period from April through October which is similar to the monitoring period for CWP [2]based on the Huso estimator; [3]estimated based on the reported as 95% CI. ; [4]estimate was derived by combining the results from two non-overlapping study periods (spring and fall) which used the same study plots

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Appendix A. Complete fatality listing for the Criterion Wind Project

Appendix A. Complete fatality listing for the Criterion Wind Energy Facility.

Date	Common Name	Turbine	Distance from Turbine (m)	Type of Find	Search Type	Condition
4 /1 /2012	turkey vulture	22A	21	incidental find	Weekly	partial
4 /2 /2012	hoary bat	33B	9	incidental find	Weekly	complete
4 /4 /2012	eastern red bat	36	81	incidental find	Weekly	complete
4 /5 /2012	unidentified bird (small)	ALT2	27	carcass search	Weekly	partial
4 /5 /2012	golden-crowned kinglet	ALT2	32	carcass search	Weekly	scavenged
4 /5 /2012	hoary bat	ALT2	47	carcass search	Weekly	scavenged
4 /20/2012	unidentified large bird	26	33	carcass search	Weekly	feather spot
4 /26/2012	hoary bat	43	21	incidental find	Weekly	complete
4 /30/2012	tricolored bat	40	5	carcass search	Weekly	complete
4 /30/2012	eastern red bat	34	9	carcass search	Weekly	complete
5 /1 /2012	unidentified passerine	41	33	incidental find	Weekly	feather spot
5 /7 /2012	hoary bat	43	18	incidental find	Weekly	complete
5 /7 /2012	hoary bat	44	19	incidental find	Weekly	complete
5 /10/2012	red-eyed vireo	ALT2	21	carcass search	Weekly	complete
5 /14/2012	ruby-throated hummingbird	O&M		incidental find	Weekly	complete
5 /15/2012	red-eyed vireo	21	14	carcass search	Weekly	scavenged
5 /16/2012	hoary bat	42	50	incidental find	Weekly	complete
5 /17/2012	American redstart	ALT2	17	carcass search	Weekly	partial
5 /23/2012	red-eyed vireo	41	21	incidental find	Weekly	complete
5 /24/2012	rose-breasted grosbeak	24	34	carcass search	Weekly	scavenged
5 /30/2012	eastern red bat	35	36	carcass search	Weekly	complete
6 /1 /2012	eastern red bat	42	12	incidental find	Weekly	complete
6 /4 /2012	ruby-throated hummingbird	34		incidental find	Weekly	complete
6 /6 /2012	silver-haired bat	40	12	incidental find	Weekly	complete
6 /12/2012	hoary bat	36	6	carcass search	Weekly	complete
6 /14/2012	hoary bat	43	5	incidental find	Weekly	complete
6 /14/2012	unidentified raptor	33B	17	carcass search	Weekly	feather spot
6 /18/2012	hoary bat	22-5	31	carcass search	Weekly	complete
6 /20/2012	hoary bat	19	6	carcass search	Weekly	complete
6 /20/2012	big brown bat	35	13	carcass search	Weekly	complete

Appendix A. Complete fatality listing for the Criterion Wind Energy Facility.

Date	Common Name	Turbine	Distance from Turbine (m)	Type of Find	Search Type	Condition
6 /21/2012	unidentified bat	32	0	incidental find	Weekly	partial
6 /21/2012	hoary bat	ALT2	14	carcass search	Weekly	complete
6 /28/2012	hoary bat	42	27	incidental find	Weekly	complete
7 /5 /2012	eastern red bat	ALT2	37	carcass search	Weekly	complete
7 /5 /2012	eastern red bat	33B	44	carcass search	Weekly	complete
7 /6 /2012	eastern red bat	38	5	incidental find	Weekly	complete
7 /6 /2012	eastern red bat	45	15	incidental find	Weekly	scavenged
7 /6 /2012	hoary bat	34	21	incidental find	Weekly	complete
7 /6 /2012	eastern red bat	41	47	incidental find	Weekly	complete
7 /9 /2012	eastern red bat	40	6	carcass search	Weekly	complete
7 /9 /2012	hoary bat	34	12	carcass search	Weekly	complete
7 /9 /2012	big brown bat	40	12	carcass search	Weekly	complete
7 /9 /2012	eastern red bat	34	14	carcass search	Weekly	complete
7 /9 /2012	eastern red bat	40	17	carcass search	Weekly	complete
7 /9 /2012	hoary bat	46	17	incidental find	Weekly	complete
7 /9 /2012	hoary bat	40	26	carcass search	Weekly	complete
7 /9 /2012	eastern red bat	34	35	carcass search	Weekly	complete
7 /11/2012	eastern red bat	36	5	carcass search	Weekly	scavenged
7 /11/2012	eastern red bat	25	7	incidental find	Weekly	complete
7 /11/2012	big brown bat	25	13	incidental find	Weekly	complete
7 /11/2012	eastern red bat	43	26	incidental find	Weekly	complete
7 /11/2012	hoary bat	24	43	incidental find	Weekly	complete
7 /12/2012	eastern red bat	24	35	carcass search	Weekly	scavenged
7 /26/2012	eastern red bat	34	13	incidental find	Weekly	complete
7 /26/2012	hoary bat	33B	15	carcass search	Weekly	complete
7 /26/2012	eastern red bat	33B	16	carcass search	Weekly	complete
7 /26/2012	eastern red bat	43	49	incidental find	Weekly	complete
7 /30/2012	eastern red bat	35	26	incidental find	Weekly	complete
7 /30/2012	eastern red bat	22-5	32	carcass search	Weekly	complete
7 /31/2012	eastern red bat	44	8	carcass search	Weekly	complete

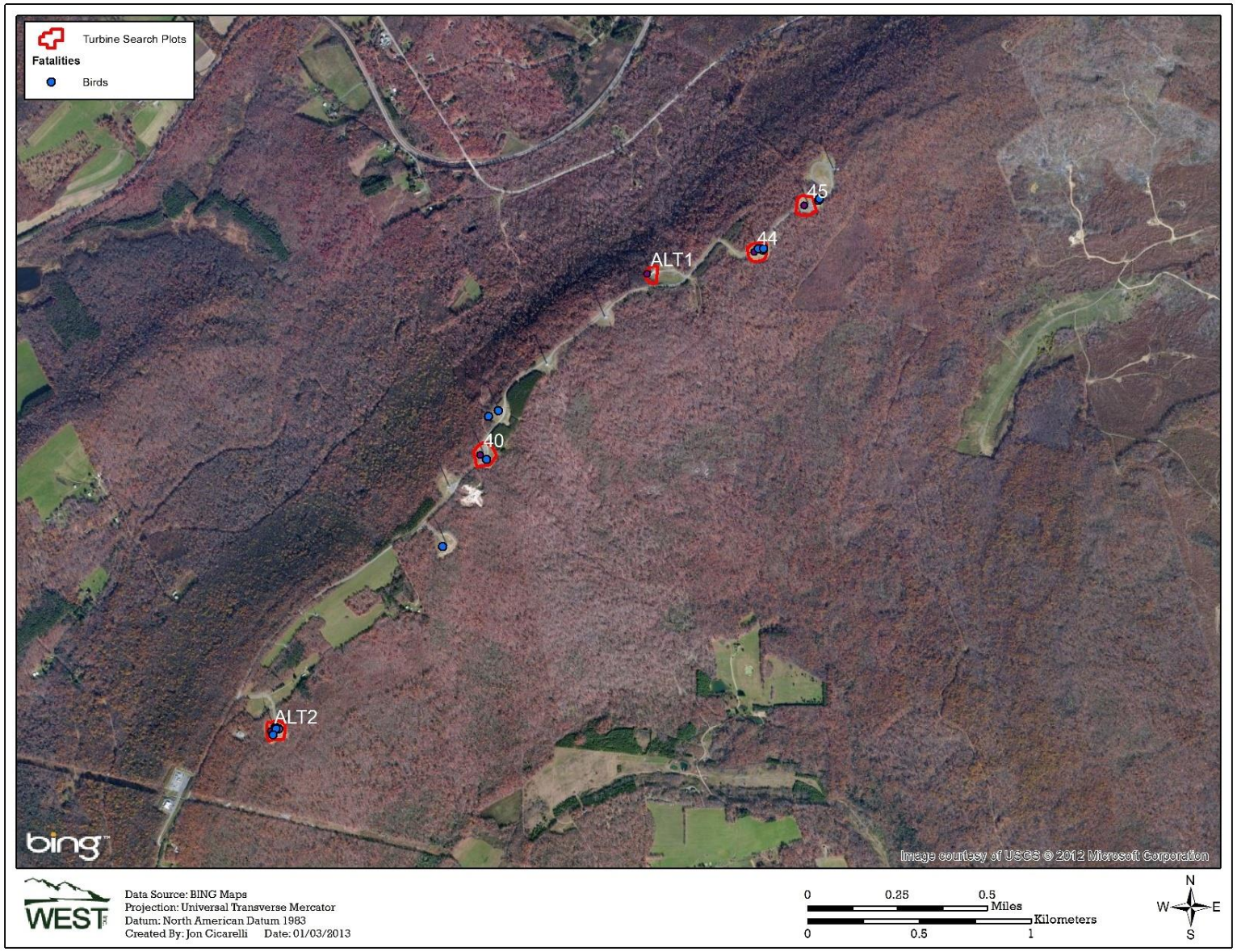
Appendix A. Complete fatality listing for the Criterion Wind Energy Facility.

Date	Common Name	Turbine	Distance from Turbine (m)	Type of Find	Search Type	Condition
7 /31/2012	eastern red bat	44	26	carcass search	Weekly	complete
7 /31/2012	eastern red bat	44	35	carcass search	Weekly	complete
7 /31/2012	hoary bat	41	52	incidental find	Weekly	complete
8 /2 /2012	eastern red bat	ALT2	1	carcass search	Weekly	scavenged
8 /3 /2012	hoary bat	34	19	incidental find	Weekly	complete
8 /3 /2012	eastern red bat	22A	31	incidental find	Weekly	scavenged
8 /14/2012	eastern red bat	44	32	carcass search	Weekly	complete
8 /16/2012	eastern red bat	23	14	incidental find	Weekly	scavenged
8 /16/2012	eastern red bat	41	19	incidental find	Weekly	complete
8 /16/2012	American redstart	45	66	incidental find	Weekly	complete
8 /20/2012	turkey vulture	38	0	incidental find	Weekly	complete
8 /20/2012	eastern red bat	46	13	incidental find	Weekly	complete
8 /20/2012	hoary bat	44	14	incidental find	Weekly	complete
8 /20/2012	eastern red bat	40	17	carcass search	Weekly	complete
8 /20/2012	eastern red bat	33B	26	incidental find	Weekly	complete
8 /20/2012	hoary bat	22-5	39	carcass search	Weekly	complete
8 /23/2012	hoary bat	22-5	61	incidental find	Weekly	complete
8 /27/2012	eastern red bat	38	12	incidental find	Weekly	complete
8 /27/2012	eastern red bat	46	13	incidental find	Weekly	complete
8 /29/2012	eastern red bat	35	16	carcass search	Weekly	complete
9 /4 /2012	hoary bat	22A	26	incidental find	Weekly	complete
9 /4 /2012	eastern red bat	44	31	carcass search	Weekly	complete
9 /6 /2012	eastern red bat	33B	7	carcass search	Weekly	scavenged
9 /10/2012	black-throated blue warbler	32	13	incidental find	Weekly	complete
9 /11/2012	eastern red bat	36	1	carcass search	Weekly	complete
9 /11/2012	hoary bat	44	17	carcass search	Weekly	complete
9 /13/2012	silver-haired bat	18	12	incidental find	Weekly	complete
9 /13/2012	silver-haired bat	34	14	incidental find	Weekly	complete
9 /20/2012	Philadelphia vireo	22A	40	incidental find	Weekly	complete
9 /24/2012	blue-headed vireo	20	3	incidental find	Weekly	complete

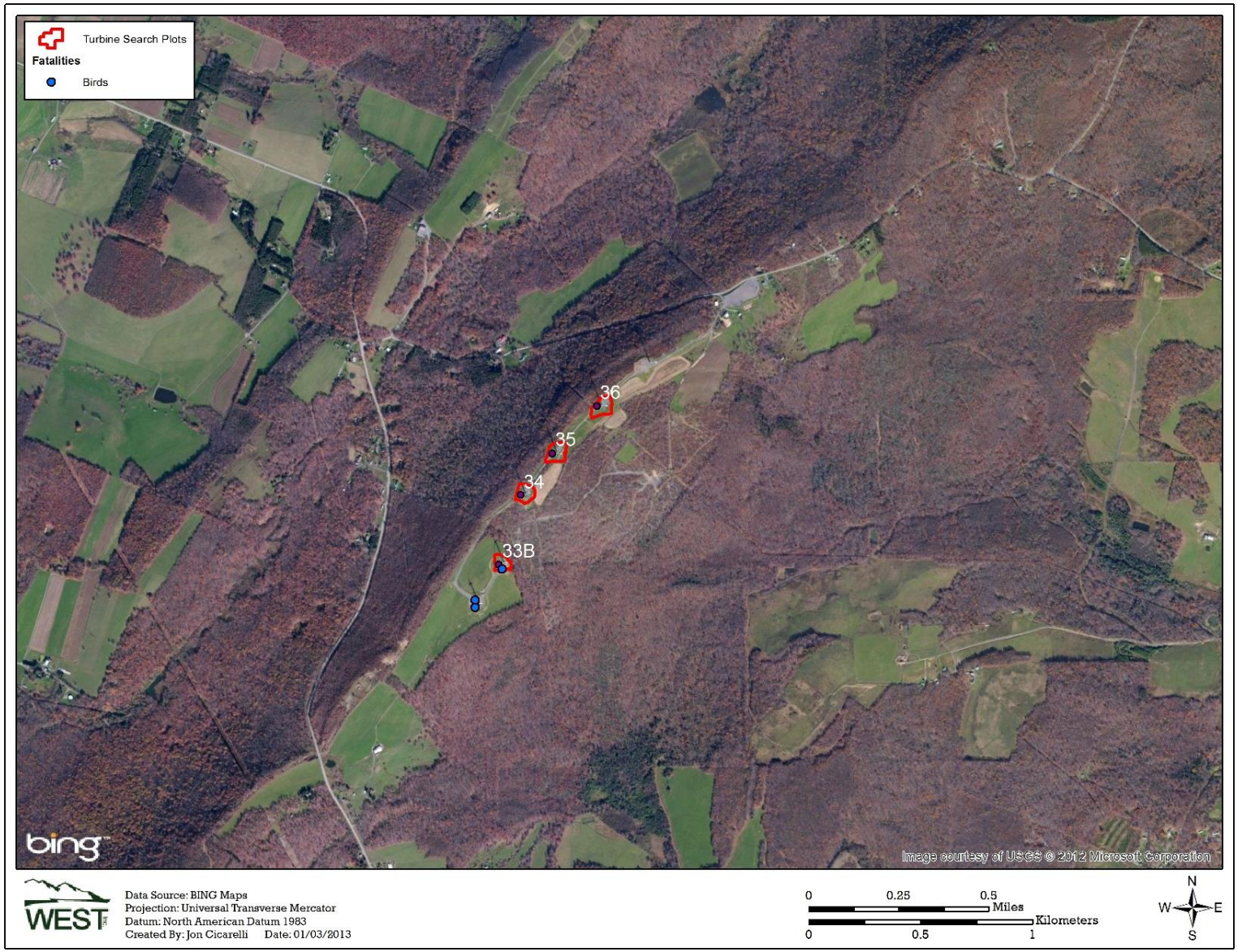
Appendix A. Complete fatality listing for the Criterion Wind Energy Facility.

Date	Common Name	Turbine	Distance from Turbine (m)	Type of Find	Search Type	Condition
9 /25/2012	silver-haired bat	44	42	carcass search	Weekly	scavenged
9 /28/2012	hoary bat	44	12	incidental find	Weekly	complete
9 /28/2012	magnolia warbler	32	17	incidental find	Weekly	scavenged
10/3 /2012	silver-haired bat	44	16	incidental find	Weekly	complete
10/3 /2012	eastern red bat	35	32	carcass search	Weekly	complete
10/3 /2012	silver-haired bat	44	36	incidental find	Weekly	complete
10/5 /2012	red-eyed vireo	26	42	carcass search	Weekly	complete
10/12/2012	eastern red bat	26	14	carcass search	Weekly	complete
10/16/2012	white-throated sparrow	33B	34	incidental find	Weekly	complete
10/18/2012	unidentified warbler	24	6	carcass search	Weekly	scavenged
10/22/2012	golden-crowned kinglet	45	75	incidental find	Weekly	complete
10/25/2012	hoary bat	34	16	incidental find	Weekly	complete
10/26/2012	eastern red bat	36	13	incidental find	Weekly	complete
10/26/2012	unidentified vireo	24	13	incidental find	Weekly	partial
11/5 /2012	golden-crowned kinglet	40	7	carcass search	Weekly	complete
11/12/2012	eastern red bat	22-5	35	carcass search	Weekly	complete
11/12/2012	eastern red bat	40	40	carcass search	Weekly	complete
11/13/2012	gadwall	44	43	carcass search	Weekly	complete
11/13/2012	golden-crowned kinglet	44	45	carcass search	Weekly	scavenged
11/13/2012	gadwall	44	46	carcass search	Weekly	complete

Appendix B. Locations of Casualties found during the 2011 monitoring study at CWP.

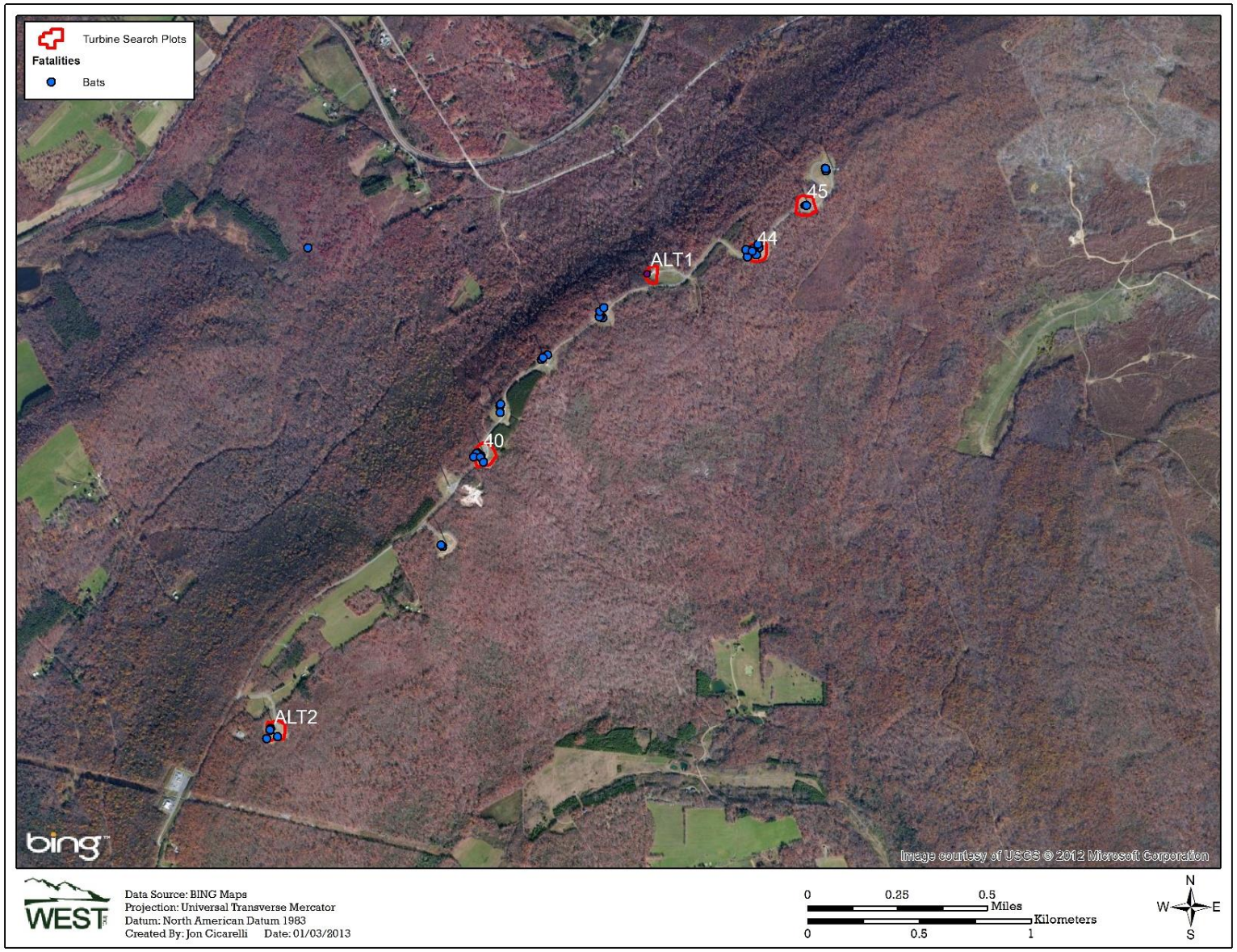


Search plots and locations of bird casualties found in the northern portion of the CWP.



Search plots and locations of bird casualties found in the central portion of the CWP.

Search plots and locations of bird casualties found in the southern portion of the CWP.



Search plots and locations of bat casualties found in the northern portion of the CWP.

Search plots and location of bat casualties found in the central portion of the CWP.

Search plots and locations of bat casualties found in the southern portion of the CWP.