we energies

231 W. Michigan Street
Milwaukee, WI 53203
www.we-energies.com

June 9, 2009

Ms. Sandra J. Paske
Secretary to the Commission
Public Service Commission of Wisconsin
Post Office Box 7854
Madison, WI 53707-7854

Dear Ms. Paske:

Application of Wisconsin Electric Power Company for a Certificate Of Public Convenience and Necessity to Construct a Wind Electric Generation Facility and Associated Electric Facilities, to be Located In Fond du Lac County, Wisconsin **6630-CE-294**

Attached is the Interim Report on the Post-Construction Bat and Bird Fatality Study at Blue Sky Green Field. The report includes data collected in the fall of 2008. Additional field work is occurring this spring, and a final report will be provided in fall of 2009.

If you have any questions regarding this project, please contact Paul Farron at (414) 221-3958.

Very truly yours,

Paul A. Farron for

Roman A. Draba
Vice President, Regulatory Affairs and Policy

cc: Mr. Scot Cullen - PSCW
Mr. James Lepinski - PSCW
Mr. Robert Norcross - PSCW
Mr. Dan Sage - PSCW
Ms. Marilyn Weiss – PSCW

Post-Construction Bat and Bird Fatality Study
Blue Sky Green Field Wind Resource Area
Fond du Lac County, Wisconsin

INTERIM REPORT
July 2008 - October 2008

Prepared for:

We Energies

Prepared by:

Jeff Gruver, Kimberly Bay and Wallace Erickson
Western **E**co**S**ystems **T**echnology**,** Inc.
2003 Central Avenue
Cheyenne, Wyoming

WEST, Inc.

June 3, 2009

EXECUTIVE SUMMARY

The Blue Sky Green Field Wind Farm began commercial operation in May of 2008. The wind farm is located near the towns of Calumet and Marshfield in Fond du Lac County, Wisconsin. The wind farm consists of 88 Vestas V-82 wind turbines that rise to approximately 397 feet (121 meters) at the highest point at the top of a turbine blade. Each wind turbine is capable of generating 1.65 MW of electricity, and the wind farm as a whole is capable of generating 145 MW of electricity, or enough to provide power to 36,000 average residences. Here, we report interim results of fatality studies at Blue Sky Green Field based on the first season of data collection. Caution should be taken when reviewing the results; these data are from one fall season and should not be extrapolated to determine a potential annual estimate.

From July 21 to October 31, 2008 we conducted the first season of a year of studies designed to estimate the number of bird and bat fatalities attributable to wind turbine operation. These dates correspond with the late-summer and fall migration periods for birds and bats, though the beginning of this period may begin as early as July 15. These studies included systematic searches at a random sample of 30 turbines at daily and weekly intervals. We also conducted trials designed to estimate potential sources of bias, including searcher efficiency and scavenger removal rates. While previous research has indicated that nearly all of the fatalities to birds and bats from wind turbine collisions occur during the late summer and fall, we will conduct a second season of fatality monitoring from March 15 to May 31, 2009, which will correspond to the spring migrating season. Based on the results from that portion of the study, we will combine both seasons and produce annual estimates of fatalities. The final report will also incorporate ancillary data such as meteorological conditions and estimates of bat activity that were recorded concurrent to the fatality searches to determine if there are correlations between these variables and the timing or number of fatalities. We do not address these analyses in this interim report.

This study represents only the fifth such study we are aware to estimate bird and bat fatalities from wind turbine operation in the Midwest, and contributes to our understanding of wind energy impacts to birds and bats. As more wind power projects are built in the region, and additional studies become available, a clearer picture of the impacts to birds and bats will emerge.

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INTRODUCTION

We Energies has developed a wind-energy facility of up to 145 megawatt (MW) capacity in Fond du Lac County, Wisconsin. The Blue Sky Green Field Wind Project (BSGF) is located approximately 15 miles (24 km) northeast of the city of Fond du Lac, Wisconsin in an area dominated largely by corn, soybean, and alfalfa fields. The wind energy project consists of 88 Vestas V82 wind turbines (Figure 1). This 1.65-MW turbine has a 262 ft (80 m) hub height and a 269 ft (82 m) rotor diameter. Total height at the tip of the blade is 397 ft (121 m). The BSGF project became fully operational in May 2008.

This report presents preliminary results of the post-construction fatality monitoring at the BSGF project that was conducted between July 21 and October 31 2008 and summarizes the fatalities that were collected during the Fall 2008 portion of the study. A second season of monitoring will be conducted from March 15 to May 31, 2009. This report is considered interim to the final report, which will be produced following the second season of fatality monitoring, and which will also assess if and how environmental factors influence mortality.

The fatality study plan for the BSGF site (Gruver et al. 2008) is designed primarily to estimate mortality caused by turbine impact to bats and birds in the project area. The study consisted of the following components: 1) standardized carcass searches in a square plot centered on select turbines; 2) searcher efficiency trials to estimate the percentage of carcasses found by searchers; and 3) carcass removal trials to estimate the length of time that a carcass remains in the field for possible detection.

The objective of the standardized carcass searches was to systematically search plots at the 30 selected turbines for bat and bird casualties that are attributable to collision with the turbines. All bird and bat fatalities during both transect surveys and incidental fatality observations (i.e. a fatality observed outside the 30 study locations) were recorded and are presented in this report.

The objective of the searcher efficiency trials was to estimate the percentage of casualties that are found by the observers. Searcher efficiency trials were conducted by placing “detection” carcasses in the same areas where carcass searches occur, and the efficiency trials were conducted periodically throughout the fall 2008. Estimates of searcher efficiency will be used to correct for detection bias by adjusting the total number of carcasses found for those missed by observers..

The objective of carcass removal trails is to estimate the likelihood a carcass is removed by scavengers as a function of time. Carcass removal includes removal by predation or scavenging, or removal by other means (e.g., cultivation, harvesting). Estimates of carcass removal will be used to correct for removal bias by adjusting the total number of carcasses found by the relative rate at which carcasses are removed from the study area. Both carcass removal and searcher efficiency trials occurred during the same period as carcass studies

METHODS

This report summarizes the monitoring that was conducted during the fall migration season (July 21-October 31, 2008). Searchers walked roads, crane pads, and bare areas around the sample turbines and crane pads from July 21-July 25 while search plots were being prepared. Carcasses found while conducting these constrained searches are included in the summary tables and totals. Because those searches differed from protocol, future estimation of total fatalities will likely be done with and without those carcasses for comparison. An additional period of monitoring that will encompass the spring migration will be conducted from March 15-May 31, 2009.

Assumptions

Levels of mortality for the wind energy facility as a whole will be estimated by searching in a predefined area around a sample of wind turbine generators on a periodic basis and recording all carcasses found. Decisions regarding the number of turbines to search and how to select them were based on the desire to extrapolate results from the sample to the wind farm as a whole. Decisions regarding the area to be searched around turbines, and the interval across which turbines were searched were based on the statistical properties of the estimator to be used and on published guidelines (Kunz et al. 2007*a*). Some of the same factors were considered in the context of the statistical properties of the estimator. For instance, the estimator takes into account the proportion of area searched as a function of distance from the turbine, as well as the distance from a turbine a carcass was found. Standard statistical procedures allow us to understand and account for the variance associated with these choices. Another sampling decision that can influence mortality estimates is the size of the search plot. We selected search plot size based on recommendations in Kunz et al. (2007*a*), strengthened by evidence from other studies that suggested that the search distance was sufficient to capture most of the fatalities (e.g., Johnson et al. 2003, Jain 2005).

Factors independent of sampling choices also contribute to uncertainty and can introduce substantial bias into estimates of wind turbine-associated mortality. Therefore, these factors must be measured and accounted for to the extent possible. Chief among these are removal of carcasses (e.g., by scavengers) before searchers have opportunity to find them, and carcasses that are present during searches but missed by searchers. Rates of carcass removal by scavengers are likely to vary with time of year, scavenger density, conspicuousness of carcasses, and other factors. If carcass removal rates are high, then fewer carcasses are available to be found during searches, and mortality estimates would be biased low. We used trials designed to estimate the rate at which carcasses are removed by scavengers to account for this source of bias. Variation in searcher efficiency comes primarily from differences in vegetative condition in search plots, color and disposition of carcasses, and individual searcher skill. Searchers are never 100% efficient, so not accounting for this variability will result in mortality estimates that are biased low. We used trials designed to estimate searcher efficiency to account for this source of bias.

When establishing the survey dates, we assumed that most fatalities occur during the migration periods for birds and bats as has been the case at other wind energy facilities (Howe et al. 2002, Arnett et al. 2008). When calculating fatality estimates, we assumed that crippling bias (mortality of animals injured by turbines but that die from those injuries at a later time) and levels of background mortality (i.e., “natural” mortality not attributable to turbines) were small. Most fatality monitoring studies at wind-energy facilities used this approach because of the relatively high costs or improbability of obtaining accurate estimates (Smallwood 2007; also see Johnson et al. 2000). Accurate estimates of crippling bias, in particular, are very difficult to obtain because crippling bias represents negative data (i.e., it represents a population of fatalities that is not seen). If a large number of animals are injured from turbine collisions but die later away from the plot, then the estimated mortality will be biased low. If levels of background mortality are high, then some of the fatalities discovered during searches may erroneously be attributed to turbine collision, resulting in an estimate that is biased high.

In the final report, when calculating the overall fatality estimates we will include all intact carcasses, scavenged carcasses, and feather spots found in search plots during scheduled searches, as well as fatalities discovered incidentally on search plots on non-scheduled search days. While this may result in a higher estimate of fatalities, our assumption is that carcasses lying in search plots would have been discovered by searchers during the next scheduled search.

Sample Size

A total of 30 wind turbine generators (WTG) was selected for study (Kunz et al. 2007*a*) using a systematic random sample to ensure that sampled plots were spread throughout the BSGF site and to allow inference to the project as a whole. Seven of the 88 turbines were considered unavailable for study *a priori,* due to landowner considerations. The remaining 81 turbines were selected by systematic randomization by ordering the turbines from northwest to southeast and randomizing the list. From that list, every 3rd turbine (81/30 ≈ 3) was selected without replacement. The first 30 turbines selected in this manner were chosen for study, while the 31st through 81st turbines on the list were available in the event that one or more of the original became unavailable.

Search Plots

Two different types of search plots were used (see Plot Condition below), but all search plots were defined by a square with sides 160 m long (25,600 m^2; 6.3 acres; 2.56 ha) centered on the turbine (Figure 3). Studies at wind farms with other large turbines (e.g., Johnson et al. 2003, Young et al. 2005) indicate that most fatalities are found within the area that is roughly equivalent to the height of the turbine hub. Most bat fatalities are generally found within an even smaller area around the turbine (Kunz et al. 2007*a*).

Plot Condition

Because most of the turbines were located in cultivated cropland (corn, soybeans, and alfalfa), searcher efficiency in search plots that extend into these crops was expected to be quite low during the growing season. Low searcher efficiency would have yielded poor and/or biased estimates of mortality. To enable efficient searching, we mowed six strips in each of 27 turbine search plots (e.g., Jain 2005), and for the remaining 3 turbines, we kept the entire 6.3 acre plot in a low-vegetative state. In corn and soybean, the mowing clipped vegetation to stems of approximately 6 inch tall. Planting row spacing (approximately 3 feet) in the corn and soybean fields resulted in mowed strips of primarily bare soil in between the mowed stubble (Figure 4). Plant spacing and growth-form were more dense in the alfalfa fields, and while mowing increased visibility for the searchers, it was not able to produce strips of primarily bare ground as in the other crops. Therefore, strips in alfalfa fields were re-mowed approximately every 2 weeks during the study.

Each mowed strip was 160 m long and 5 m wide. Two strips were centered vertically on the turbine, orthogonal to each other and the other four strips were placed horizontally at varying distances from the turbine. Half the turbines had these strips placed 10, 30, 50 and 70 m from the turbine, the other half had strips placed at 20, 40, 60 and 80 m from the turbine (see example in Figure 3). This scheme ensured that all distances from 0 to 80 m away from the turbine were sampled during searches. In addition, three randomly selected turbines had the entire 160 m by 160 m search plot maintained in a low-growth vegetative condition. In the final report, this will allow us to estimate the percentage of carcasses missed by comparing the carcasses from the turbines with managed strips to the turbines whose turbine search plots are completely mowed. In addition to searching the managed strips, that portion of the turbine access road within 80 m of the turbine and the turbine pad were searched. This portion varied by turbine and was measured for each sample plot.

Carcass Searches

The objective of the standardized carcass searches was to systematically search plots at the 30 selected turbines for bat and bird casualties that are attributable to collision with the turbines. Personnel trained in proper search techniques conducted the carcass searches. The access road within 80 m of the turbine, the turbine pad, and the managed transects were searched. 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 - 10 or more feathers found at one location indicating predation or scavenging.

In addition to carcasses, any injured bats and birds observed in search plots were recorded and treated as a fatality. All carcasses found were labeled with a unique number, bagged, and frozen for future reference and possible necropsy. A copy of the original data sheet for each carcass was placed in the bag with the frozen carcass. For all casualties found, data recorded included species, sex and age when possible, date and time collected, GPS location, condition (intact, scavenged, feather spot), distance and bearing to turbine, and any comments that may indicate cause of death. All casualties located were photographed as found.

Casualties found by carcass searchers during scheduled searches but outside the formal search area were treated following the above protocol as closely as possible. Bat and bird casualties found in non-search areas (e.g., near a BSGF turbine not included in the study) were coded as incidental discoveries and documented as much as possible in a similar fashion as those found during standard searches. These carcasses will not be included in fatality estimates.

Appropriate wildlife salvage/collection permits were obtained from the Wisconsin Department of Natural Resources and the US Fish and Wildlife Service to facilitate legal transport of injured animals and/or carcasses. Deposition of carcasses is discussed in Disposition of Data section below.

Ancillary data that may be useful during analyses were also collected. Meteorological and climate data, including precipitation, cloud ceiling level, temperature, wind speed and direction, and barometric pressure were also obtained from meteorological stations. Bat use data within the project area were collected using Anabat™ detectors (Titley Scientific™, Australia).

Search Schedule

Searches were conducted daily during the work week, with all 30 turbines searched at least once during the week. Ten of the 30 turbines were searched daily, and 20 turbines (5 per day) were searched on a 4-6 day interval (Figure 5). In this report, we refer to these turbines as “weekly turbines”. The order that searches were done was randomized so that each plot was searched at various periods during the day. For plots that consist of managed strips, searchers walked at a rate of approximately 45-60 meters/min along each transect. Searchers scanned the area on both sides out to approximately 2.5 m for casualties as they walked each transect. Everything within the search plot transects, including the turbine access road and turbine pad, was searched. For cleared plots, searchers walked parallel transects spaced 5 m apart while searching 2.5 m on either side of the transect line.

Searcher Efficiency Trials

The objective of the searcher efficiency trials was to estimate the percentage of casualties that are found by the observers. Searcher efficiency trials were conducted by placing “detection” carcasses in the same areas where carcass searches occur. Estimates of searcher efficiency were used to correct for detection bias by adjusting the total number of carcasses found for those missed by observers. Searcher efficiency trials began on August 6 and continued weekly through the end of the Fall 2008 study period. Observers conducting carcass searches did not know when the trials were being conducted or the locations where the “detection” carcasses were placed in a search plot. An attempt was also made to place carcasses in each of the various habitats being searched and in some approximation of the habitat’s aerial extent. Although many fatality studies must rely on non-native bird species such as House Sparrows, European Starlings, and Rock Pigeons, or farm-raised game bird species, Dr. Noel Cutright was able to procure sufficient numbers of native bird species that we were able to minimize or eliminate the need to rely on these other sources. Bird carcasses collected during the study were also used. During this study, some bat carcasses collected during the study were used in searcher efficiency trials. Preliminary searcher efficiency trials were conducted using bat carcasses generously provided by WDNR (D. Redell). All searcher efficiency trial carcasses were placed within the search plots being searched prior to the carcass search on the same day. Each trial carcass was discreetly marked so that it could be identified as a “detection” carcass after it was found. The number and location of the “detection” carcasses found during the carcass search was recorded. The number of carcasses available for detection during each trial was determined immediately after the trial by Dr. Cutright.

Carcass Removal Trials

Carcass removal trials were conducted during the period that carcass searches were conducted. Beginning August 18 and continuing through the end of the Fall 2008 portion of the study, an average of 20 carcasses of either birds (two different size classes) or bats was placed in a search plot and monitored for up to 30 days. By spreading trials throughout the study period, the effects of varying weather, climatic conditions, and scavenger densities were taken into account. Similar to the searcher efficiency trials, local native bird and bat species were used in the removal trials.

All removal trial carcasses were marked with small piece of colored tape on the bill or leg to avoid confusing a trial bird with a true casualty. Turbines not included in standardized searches were selected for inclusion in the removal trials, and trial carcasses were randomly located in a similar-sized plot as used to search turbines. Major habitats represented around the site's turbines were included in these trials. Trial carcasses were placed in a variety of postures to simulate a range of conditions. For example, carcasses were: 1) placed in an exposed posture (tossed randomly to one side); 2) hidden to simulate a crippled bird (e.g., placed beneath a tuft of grass), and; 3) partially hidden. Dr. Cutright monitored the trial birds over a period of up to 30 days. Carcasses were checked every day for the first four days, and then on days seven, ten, fourteen, twenty, and thirty. Carcasses that remained at the end of the trial were removed from the field.

Carcass Decomposition Trials

To help establish a baseline for estimating the length of time a carcass has been lying before being found, and to help train searchers in estimation of carcass age, we initiated a series of decomposition trials. A subset of carcasses found during daily searches that had been killed during the previous night were used. To the extent possible, carcasses were left in the same location and position that they were found. Those that risked being run over by vehicles were removed to the nearest safe location (usually the edge of the gravel crane pad) and placed in as similar a position as possible. Carcasses were photographed and technicians recorded notes about the general condition of the carcass, noting specifically the condition of the fur or feathers (both ventral and dorsal), general suppleness of the body, presence of insects, condition of the eyes, and elasticity of the wing, ear and tail membranes for bats. Technicians checked the carcasses daily, recording the information above and photographing the carcass until it was either removed by scavengers or reduced to skin and bone by insects. The results of the decomposition trials will be incorporated into the final report. We will also incorporate results in training for the spring searches.

DISPOSITION OF DATA

During the study, raw data forms were housed with the contractor conducting the study, and individual carcasses collected during the study were housed in a marked freezer at the BSGF Staging Area. Individual carcasses not used in trials in 2008 were left in the freezer and will be used in trials during the 2009 field season. A total of 26 bat carcasses (19 that were collected at BSGF during Fall 2008 searches and 7 originally received from WDNR at the beginning of the study) was transferred at the end of the Fall 2008 season to WDNR (D. Redell) for use in future studies.

RESULTS

Search Area and Habitat

Total area searched (m^2), percent area searched as a function of the maximum search area (160 x 160-m plots or 25,600 m^2), and proportion of detection types within each search plot were calculated for each plot. The proportion of area searched generally decreased as distance from the turbine increased (Table 1). Approximately 66% of possible search area between 0–10 m from the turbines was searched, while approximately 25% of the possible search area between 70–80 m from turbines was searched (Figure 6). In addition, the bare gravel of crane pads and road surfaces within 80 m of the turbine but not within a search strip were searched. Crane pad area averaged 405 m^2, while road area averaged 332 m^2.

Distance to Wooded Area

We measured the distance from each searched and unsearched turbine to the edge of the nearest wooded area. Four types of wooded areas were classified: Residential Woodlots (RW), Forested Area (FA), Field Strip (FS) and Small Tree Stand (SS), and these differed in number, size and shape. We calculated the area to perimeter ratio for each type. Field Strips and Small Tree Stands had smaller areas relative to their perimeters than Residential Woodlots and Forested Areas. Therefore, we combined these four stand types into two types labeled Small (FS and SS) and Large (RW and FA).

Searched turbines tended to be closer on average to small woodlots than unsearched turbines, but the difference was not significant ($F_{1,86}$; $P=0.166$). Searched turbines tended to be farther from a large woodlot than unsearched turbines, but again the difference was not significant ($F_{1,86}$; $P=0.203$). Mean distance to any wooded area (irrespective of size or shape) also did not differ between searched and unsearched turbines ($F_{1,86}$; $P=0.600$).

Search Schedule

Searches at turbines began on July 21, 2008 following very rainy weather during the week of July 14, when searches were scheduled to begin. Due to the amount of precipitation, farm equipment was unable to enter fields to mow search plots and strips. While waiting for soils to dry, we initiated regularly scheduled surveys at turbines but were restricted to searching essentially only the gravel road and pad areas. We searched as much area around each turbine as possible, including un-graveled and unseeded area, until search plots were mowed. Mowing was prioritized based on search schedule and condition of soils. By July 29, all strips and plots were mowed. Searches proceeded on schedule for the remainder of the study period.

During the study, daily search turbine A33 was inoperable from July 23 to September 1 due to mechanical failure of the electrical generator in the nacelle. Replacement of the generator required a large crane to be brought in and parked on the crane pad. Due to the recent amount of rain, the pad first had to be reconstructed to be able to support the crane. We continued to search the plot to the extent possible. From August 6 to August 24 an area estimated to be 1800 m^2 of the crane pad was blocked by the crane. None of the plot could be searched on August 7-8 for safety issues related to construction. Between August 25 and August 29, approximately 4200 m^2 (66%) of the plot could not be searched due to turbine blades and other equipment on the ground, and no search was conducted on August 29 due to construction. By our September 1 search, the turbine was operational, though some equipment remained on the pad blocking an area of approximately 1000 m^2. By the September 22 search, all equipment was cleared.

We completed a total of 1031 searches; 685 searches at daily turbines (mean 68.5 per turbine), and 346 searches at weekly turbines (mean 17.3 per turbine). In addition, we searched turbine B17 on weekly basis from August 26 to October 28. Turbine B17 was added to provide anecdotal information, and will not included in the fatality estimates. Given that B17 was located on a knoll and partially surrounded by mature trees, whereas most turbines were completely surrounded by agricultural fields, we added searches at B17 to investigate whether the fatalities would be appreciably different. A total of three bats and zero birds were found during searches at this site, which suggests fatality rates on par with other turbines.

Bird Fatalities

Characteristics of Bird Fatalities

In total, 30 bird carcasses were recorded during scheduled searches, with one tree swallow and one unidentified bird (feather spot) recovered incidentally (Table 2). Of these, 28 were small birds (e.g., songbirds) and 2 were large birds (e.g., crows). The two large birds were attributable to a feather-spot that contained feathers from a ring-billed gull, and a very old and decayed carcass that may have been a crow. Seven unique identifiable bird species were found at BSGF. Of these, golden-crowned kinglet (n=4; 12.9%) and tree swallow (n=2, 6.5%) were most common, followed by 5 species with one observation each. Unidentified birds accounted for 51.6% of all carcasses found. Unidentified carcasses included feather-spots (n=6), carcasses that were very old and consisted of little more than bones (n=3), and those that were too scavenged to make a positive identification. A horned lark was found injured during a search and taken to a local wildlife rehabilitation center where it later died from injuries.

Temporal Pattern of Bird Fatalities

Bird fatalities were distributed throughout the study period. There was an increase in both days with at least one bird and number of birds per day in October though the magnitude of the increase is small and its significance is equivocal (Figure 7).

Bird Fatalities across Turbines

Numbers of bird fatalities varied across turbines. Bird fatalities were found at 20 of 31 search turbines and 2 incidentals were found at non-searched turbines. Across all turbines with bird fatalities, 0.049 bird fatalities were found per search on average (Figure 8). For turbines searched weekly, small bird fatalities ranged from 0-2 at any turbine, which averages to 0.62 birds found per turbine (Figure 8.1). The range of small bird fatalities found at turbines searched daily was 0 to 3, and the average number of small bird fatalities found at these turbines was 1.8 birds per turbine (Figure 8.2). Both of the large bird remnants were found at turbines included in daily searches.

Distribution of Fatalities: Distance from Turbine

Bird fatalities were found 40.9 meters from turbines on average (Table 3). Seven of the bird fatalities were found on the gravel pad or access road, and the remainder were found at varying distances from the turbine (Figure 9). The locations of bird carcasses seemed to follow a bimodal distribution with most carcasses found either within about 20 m or greater than 60 m away from the turbine. Relatively few carcasses were found at intermediate distances.

Bat Fatalities

Characteristics of Bat Fatalities

In total, 241 bat carcasses were found between July 21 and October 31 at the Blue Sky Green Field Wind Project. Of that total, 210 were found on scheduled search plots, 183 of which were found during scheduled searches (Table 4). Six different bat species were found at BSGF. Little brown bats were most commonly found, accounting for 28.6% of all carcasses found. Silver-haired bats (22.8%), big brown bats (19.1%), and hoary bats (17.0%) also contributed to the majority of total observed fatalities at the site. Only 18 eastern red bats were found, representing 7.5% of total bats found (Figure 10). This species composition differs from what has been reported at other midwestern wind farms (Figure 10.1).

Of the 232 bats for which data were recorded, 74% were adults, 11% were juveniles and 15% were unable to be aged (Table 4.1). Approximately equal numbers of males and females were found, though for about 40% of all fatalities we were unable to establish the sex. Age and sex distributions were approximately equal between migratory and non-migratory species. Nearly twice as many of the bats identified as juveniles were migratory species, although about twice as many non-migratory as migratory species could not be aged (Table 4.2).

Distribution of Fatalities: Project

Search plots were distributed throughout the study area, with 16 search plots (5 daily, 11 weekly) in the north and 14 plots (5 daily, 9 weekly) in the south (Figure 2). Slightly more bat fatalities were found in the northern portion of the study area (Blue Sky; 54%) than were found at the southern portion (Green Field; 46%) project, and this pattern was true for both non-migratory and migratory species (Table 5).

Distribution of Fatalities: Turbines

Numbers of bat fatalities varied across turbines (Figures 11 and 11.1). Bat fatalities per turbine on weekly scheduled search plots ranged from 1 (Turbines B12 and D30) to 13 (Turbine A9), with an average of 5.24 bats found per turbine. For daily scheduled search plots, total bat fatalities per turbine ranged from 3 (Turbine A33) to 19 (Turbine B22), with an average of 10.3 bats found per turbine. Comparing searches across all turbines, Turbine A9 had the largest number of fatalities per search at 0.76. The minimum number of fatalities per search (0.06) occurred at Turbines A33, B12, and D30. (Figure 11.2)

Distribution of Fatalities: Distance from Turbine

Bat fatalities were generally found closer to turbines than were bird fatalities. The mean distance from a turbine for bat fatalities was 20.8 meters (Table 6), and the number of bat fatalities found declined smoothly as distance from turbine increased (Figure 12).

Distribution of Fatalities: Distance to Woodlot

We used linear regression to determine if there was a relationship between number of bat fatalities at a turbine and distance to nearest forest-type. Distance to wooded area, regardless of woodlot size, did not predict number of fatalities at a wind turbine. This was true when we considered all bat fatalities together and when we examined migratory and non-migratory species separately (Table 7).

Distribution of Fatalities: Temporal Patterns

Bat fatalities were recorded each month of the study, with August and September showing the highest numbers (Figure 13). However, the most common bat species fatalities found (little brown and silver-haired bats) were distributed unevenly throughout the study period (Figures 14, 15). In general, little brown bats were found in the early portion of the study, whereas silver-haired bats were more common later in the study. The timing for big brown bats was similar to little brown bats, while hoary and red bats were found sporadically throughout the study period. No fresh bats were found after October 1, although an old carcass (unidentifiable) was found on October 24.

Searcher Efficiency Trials

Searcher Detection Probability

A total of 20 bat carcasses, 16 large bird carcasses, and 86 small bird carcasses were used in searcher efficiency trials. Overall searcher efficiency for bat carcasses was estimated to be 70.0% for all trials, compared to 56.3% for large birds and 59.8% for small birds.

Carcass Removal Trials

In total, 80 carcass removal trials were conducted. We used 42 bat carcasses, 20 large birds, and 18 small birds. Scavengers removed bat carcasses after 3.9 days on average. Small birds remained for 6.6 days and large birds remained for 8.1 days on average before scavengers removed them (Figure 16).

DISCUSSION

Bird Fatalities

Of the 32 birds that were found during scheduled searches or incidentally and which were identifiable, none were raptors or species protected under Threatened or Endangered Species legislation. Of bird carcasses that were identifiable, golden–crowned kinglet was most common, followed by tree swallow (Table 2), and all the species of birds found during searches were species that have been observed as fatalities at other wind energy projects (e.g., Erickson et al. 2001),

During a concurrent study of bird use at BSGF (Cutright 2009), red-winged blackbirds were the most common species observed at point-count stations at turbines, followed by ring-billed gulls and Canada goose. None of these species were found during searches, although one of the feather-spots contained feathers from a ring-billed gull

Bat Fatalities

Species composition of fatalities at BSGF differed substantially from 3 previous midwestern studies (Figures 10, 10.1). The migratory bats (hoary, eastern red, and silver-haired bats) that seem to dominate fatalities at nearly every North American wind farm study published to date, were represented in relatively low numbers as a group at BSGF. An exception was the silver-haired bat, which was the second most abundant bat fatality at BSGF during the Fall. Based on the timing of fatalities for hoary and eastern red bats, it seems that they are either resident during the summer, or they migrate through the area in relatively small waves over a longer period. Silver-haired bats on the other hand, may not be resident in the area (or at least are not resident in large numbers), but may migrate through the area during a relatively discrete period. All but one of the silver-haired bats were found during the month of September, making it the most punctuated species in terms of timing.

It is unclear why little brown and big brown bats would appear as fatalities in relatively high numbers at this site, when they have generally been only minor contributors to fatality totals at other projects. Numbers of non-migratory bat fatalities were higher than expected at BSGF, with little brown and big brown bats contributing nearly half of the total fatalities found during the fall. In total, 69 little brown bats were found during Fall 2008, with a peak on August 13, though none were found after middle of September. Little brown bats comprised 28.6% of all fatalities recovered, a percentage that is similar to Top of Iowa (Jain 2005) and to a study from Alberta Canada (Brown and Hamilton 2002), though higher than most other published results (Arnett et al. 2008). Similarly, big brown bats comprised 20% of fatalities, which is nearly double the relative proportion found in other studies (Arnett et al. 2008). To our knowledge, non-migratory species have not been found to constitute a large proportion of fatalities at other sites (but see Brown and Hamilton 2002, and Jain 2005 where proportions of little brown bats were similar to those from this study), even though these are species with continent-wide distributions and are generally abundant throughout their range. It is possible that the existence of a large hibernaculum in an old mine in the region may play a role in concentrating species such as little brown and big brown bats. However, BSGF is located some 30 miles away from the mine. A potentially elucidating comparison would be to contrast estimates of fatalities of these species between BSGF and other recently constructed wind farms that are located closer to the mine.

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Table 1. Proportion of the area searched in 10 m distance bands at Blue Sky Green Field.

Distance (m)	Acres Searched	Total Acres	% Searched
0 to 10	1.53	2.32	65.8%
10 to 20	3.45	6.95	49.6%
20 to 30	4.30	11.60	37.1%
30 to 40	4.90	16.27	30.1%
40 to 50	5.76	20.93	27.5%
50 to 60	6.87	25.59	26.8%
60 to 70	7.74	30.24	25.6%
70 to 80	8.78	34.90	25.2%

Table 2. Summary of bird species found during fatalities studies at Blue Sky Green Field.

	Fatalities found at scheduled search plots		All Fatalities	
Species	**Total**	**% Composition**	**Total**	**% Composition**
Unidentified bird	16	53.3	17	53.1
Golden-crowned Kinglet	4	13.3	4	12.5
Tree Swallow	2	6.7	3	9.4
Savannah Sparrow	1	3.3	1	3.1
Horned Lark	1	3.3	1	3.1
Eastern Meadowlark	1	3.3	1	3.1
Cedar Waxwing	1	3.3	1	3.1
Brown-headed Cowbird	1	3.3	1	3.1
Unidentified swallow	1	3.3	1	3.1
Unidentified sparrow	1	3.3	1	3.1
Unidentified meadowlark	1	3.3	1	3.1
Overall	**30**	**100**	**32**	**100**

Table 3. Distribution of bird fatalities by distance from turbines at Blue Sky Green Field.

Distance to Turbine (m)	% Bird Fatalities
0-10	17.2
10-20	13.8
20-30	13.8
30-40	6.9
40-50	6.9
50-60	3.4
>60	37.9

Table 4. Summary of bat species found during fatalities studies at Blue Sky Green Field. All fatalities found on search plots (scheduled and incidental) were included for the fatality estimation. Carcasses found incidentally on non-scheduled plots and B17 are included in All Fatalities but will not be part of the fatality estimation.

	Fatalities found during scheduled searches		Incidental fatalities found on search plots		All Fatalities	
Species	**Total**	**% Total**	**Total**	**% Total**	**Total**	**% Total**
Little brown bat	58	31.7	8	29.6	69	28.6
Silver-haired bat	46	25.1	4	14.8	55	22.8
Big brown bat	32	17.5	8	29.6	46	19.1
Hoary bat	26	14.2	5	18.5	41	17.0
Eastern red bat	11	6.0	2	7.4	18	7.5
Myotis spp.	4	2.2	0	0.0	4	2.9
Unk small bat	5	2.7	0	0.0	7	1.7
Unk large bat	1	0.5	0	0.0	1	0.4
Total	**183**	**100**	**27**	**100**	**241**	**100**

Table 4.1. Summary of bat fatalities by age and sex at Blue Sky Green Field.

Age/Sex	Number of Bats	Proportion of Total (Proportion of Group)
Adult	**172**	**0.74**
Female	59	0.25 (0.34)
Male	57	0.24 (0.32)
Unknown	56	0.24 (0.31)
Juvenile	**26**	**0.11**
Female	10	0.04 (0.38)
Male	8	0.03 (0.31)
Unknown	8	0.03 (0.31)
Unknown	**34**	**0.15**
Female	2	0.01 (0.06)
Male	4	0.02 (0.12)
Unknown	28	0.12 (0.82)
Total	**232**	**1.00**

Table 4.2. Summary of bat fatalities by age, sex, and migratory status at Blue Sky Green Field.

	Migration Status			
Age/Sex	**Migratory**	**Non-migratory**	**Unknown**	**Total**
Adult	**85**	**86**	**1**	**172**
Female	33	26		59
Male	26	31		57
Unknown	26	29	1	56
Juvenile	**17**	**9**		**26**
Female	6	4		10
Male	5	3		8
Unknown	6	2		8
Unknown	**10**	**19**	**5**	**34**
Female	1	1		2
Male		4		4
Unknown	9	14	5	28
Total	**112**	**114**	**6**	**232**

Table 5. Distribution of bat fatalities by migration category and Project. Totals include bats found on scheduled search plots and incidentals.

Project	Migratory	Non-migratory	Unknown	All Bats
Blue Sky	60	66	4	130
Green Field	55	53	3	111
Total	**115**	**120**	**7**	**241**

Table 6. Distribution of bat fatalities by distance from turbines at Blue Sky Green Field.

Distance to Turbine (m)	% Bat Fatalities
0-10	30.4
10-20	26.3
20-30	18.4
30-40	13.8
40-50	5.5
50-60	2.8
>60	2.8

Table 7. Summary of P-values for linear regressions testing number of bat fatalities at a turbine against distance to woodlot. See Methods for descriptions of woodlot types and bat migration status. Dataset included all bats found including incidentals at non-scheduled search plots. P-values ≤ 0.05 were considered to indicate statistical significance.

Migration Status	Nearest Large Wood	Nearest Small Wood	Nearest Wood
Migratory[1]	0.97[a]	0.46[a]	0.89[a]
Non-migratory[2]	0.92[b]	0.35[b]	0.33[b]
All Bats	0.56[c]	0.41[c]	0.34[c]

1. Hoary, red and silver-haired bats
2. Little brown and big brown bats

a. $F_{1,39}$
b. $F_{1,32}$
c. $F_{1,44}$

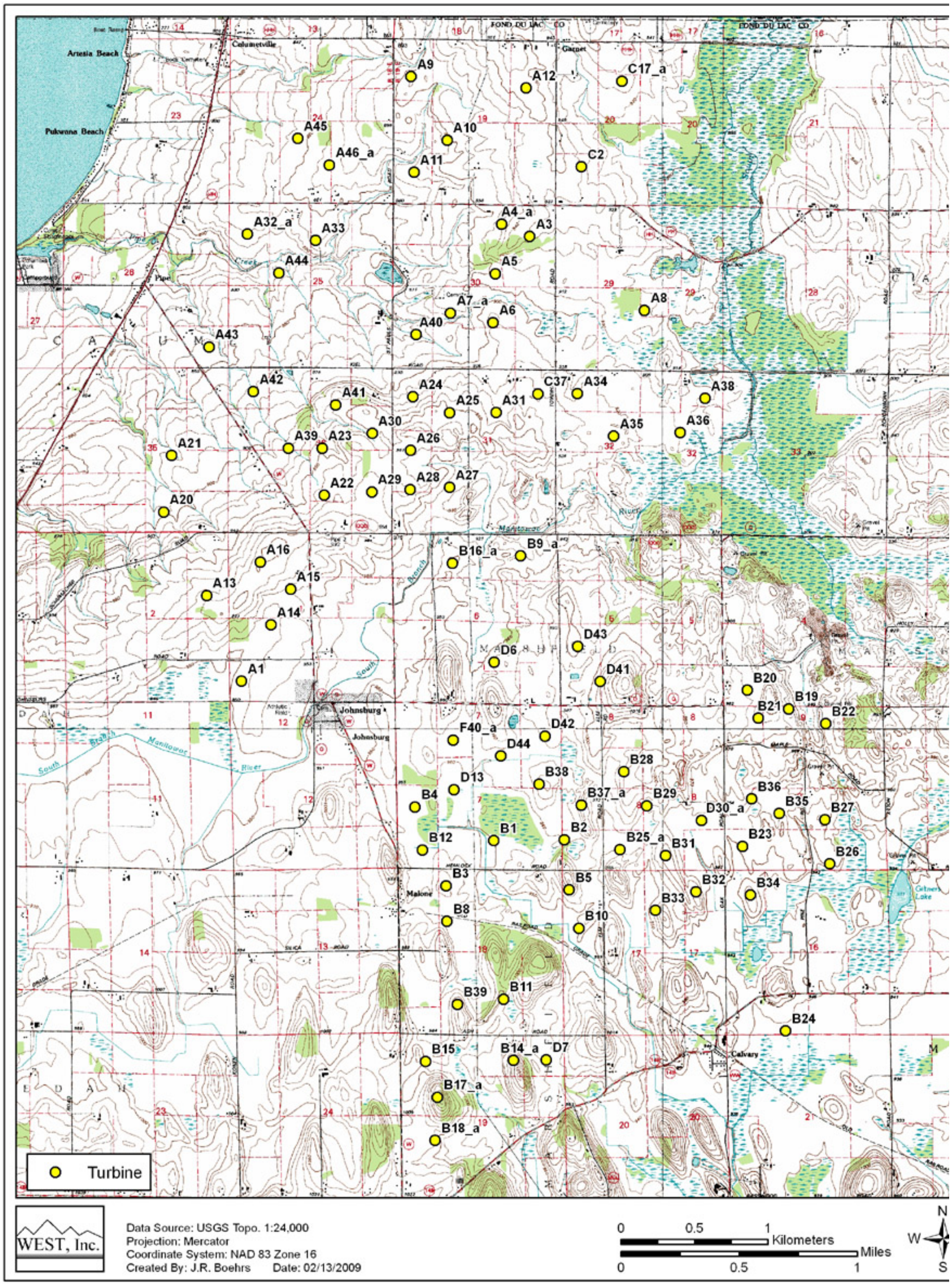

Figure 1. Map of the Blue Sky Green Field turbine locations.

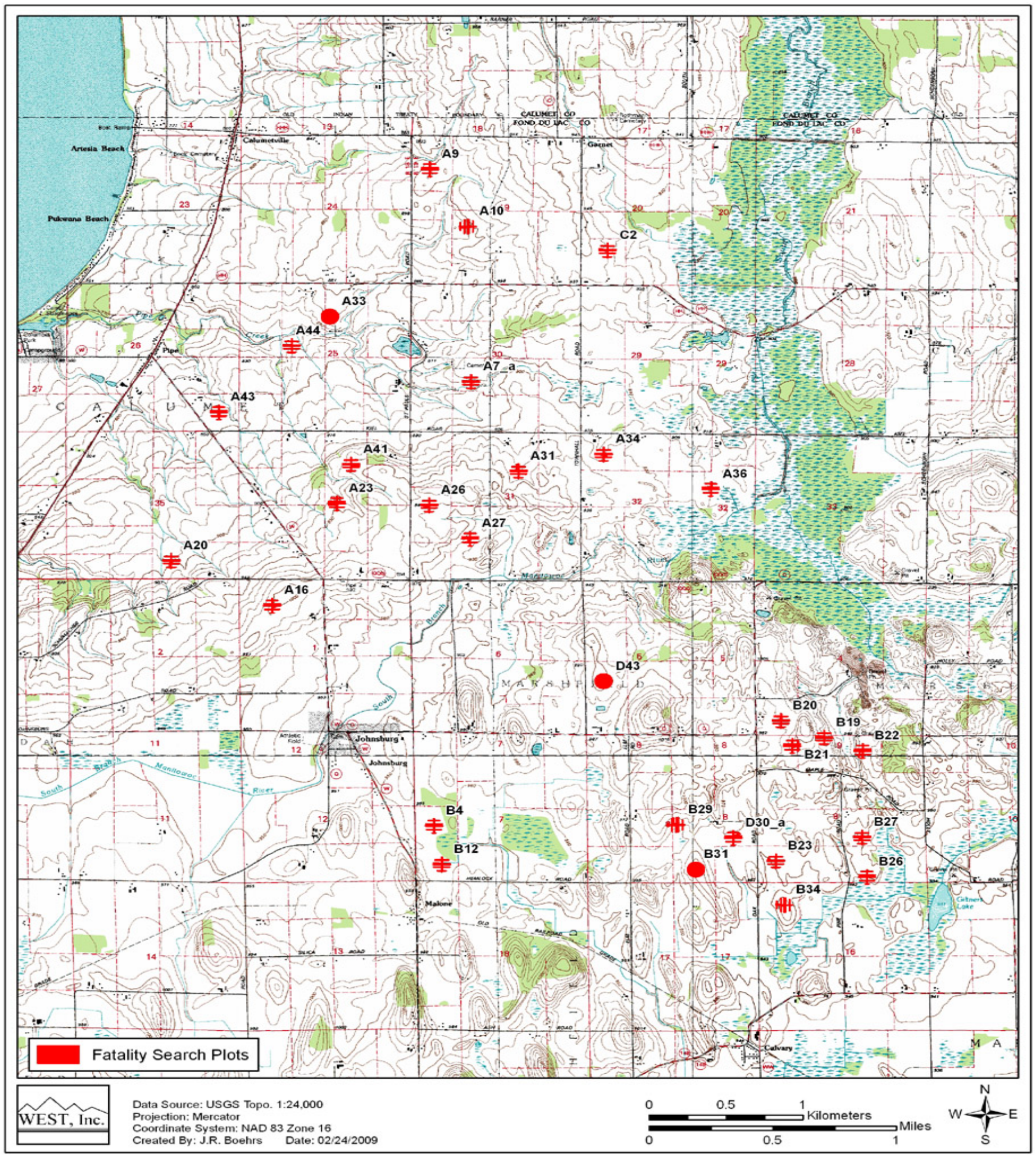

Figure 2. Map of Blue Sky Green Field turbines sampled for fatality studies. Solid circles represent turbines with the entire plot cleared. Non-solid circles represent plots with search strips mowed into the crops.

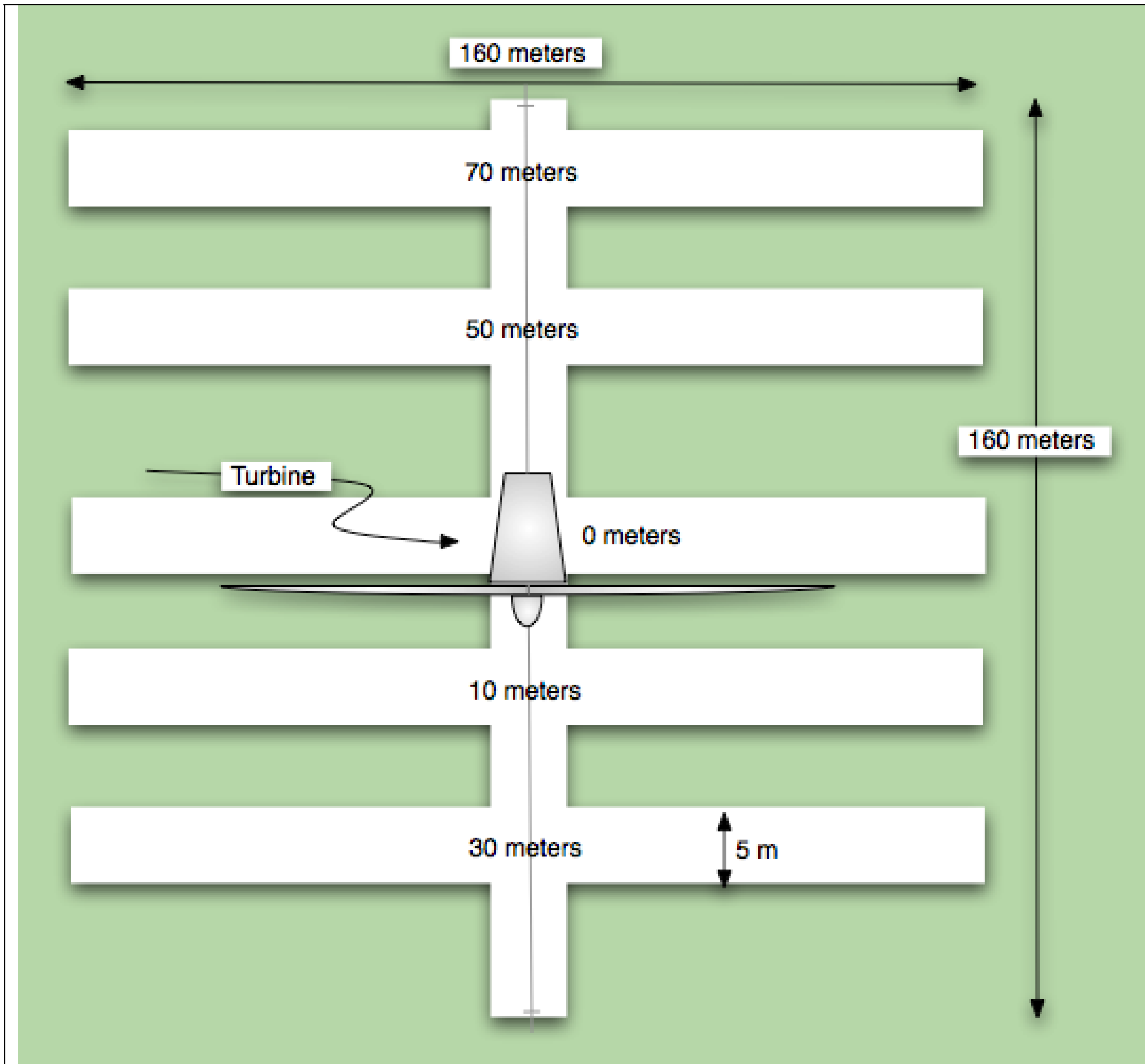

Figure 3. Example of layout of carcass search transects. Turbine pad and access road (not shown) were also searched. The area covered by road and pad varied, but was measured at each turbine searched.

Figure 4. View of a typical search strip in corn. Photo was taken on August 19, 2008, approximately 3 weeks after mowing. Some herbaceous vegetation has re-grown, but the strip remains essentially bare of vegetative cover.

Week	M	T	W	R	F
1	a	a	a	a	a
	b1				
		b2			
			b3		
				b4	
					b1
2	a	a	a	a	a
	b2				
		b3			
			b4		
				b1	
					b2
3	a	a	a	a	a
	b3				
		b4			
			b1		
				b2	
					b3
.					
.					
.					
K	a	a	a	a	a
	b4				
		b1			
			b2		
				b3	
					b4

Figure 5. Example of search schedule. Group 'a' turbines (n=10) are searched daily during the week. Group 'b' turbines (n=20) are searched on a 4-6 day interval.

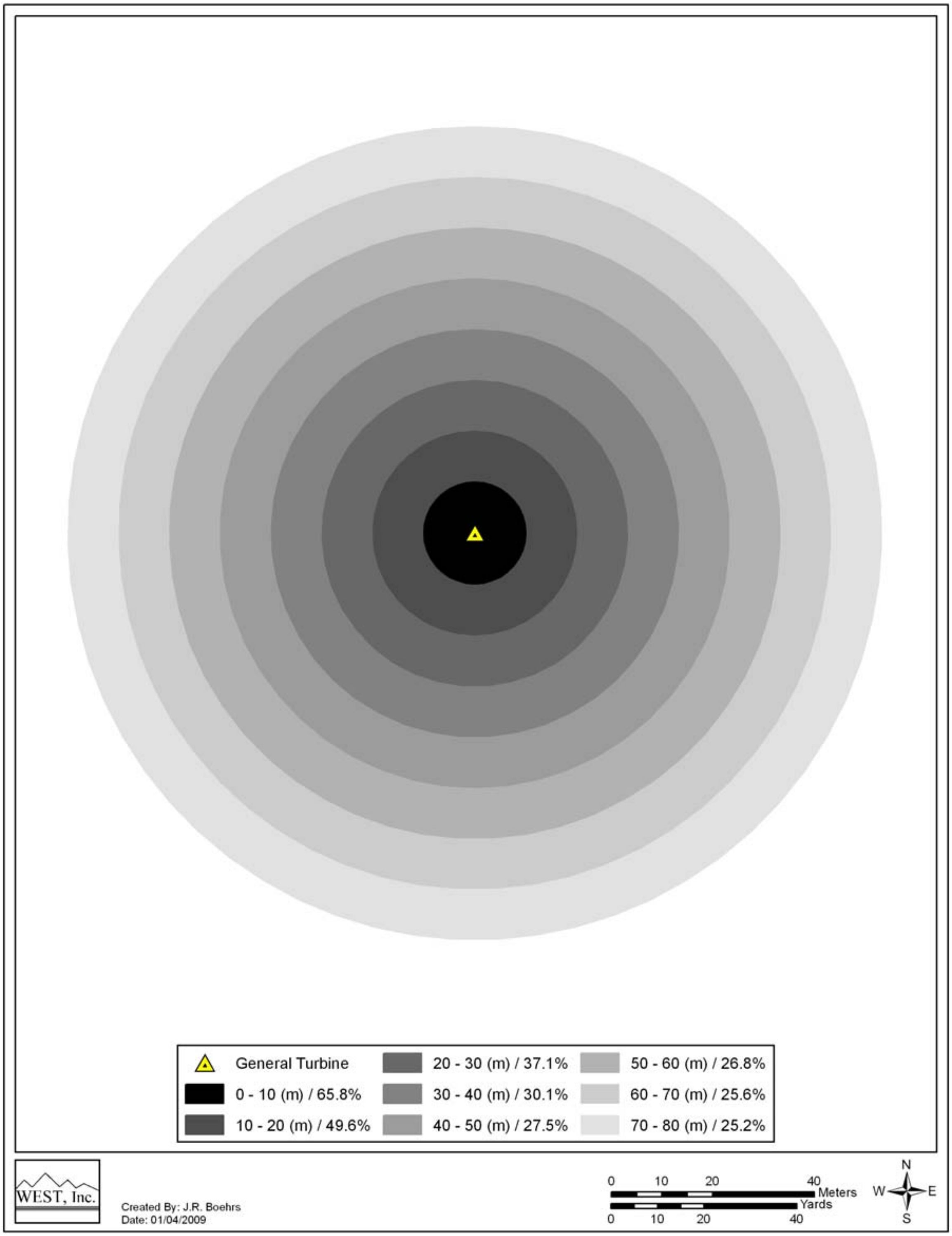

Figure 6. Fatality search area efficiency at Blue Sky Green Field.

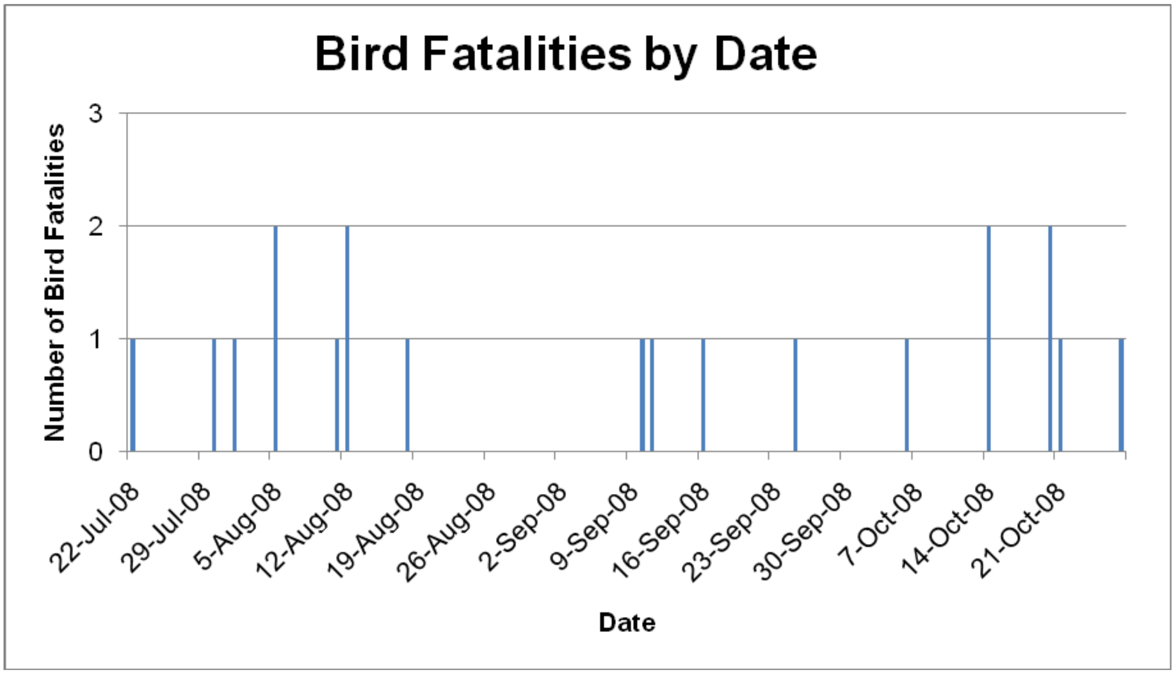

Figure 7. Bird fatalities through time at Blue Sky Green Field. This figure excludes feather spots and carcasses that were too old to reliably estimate time since death.

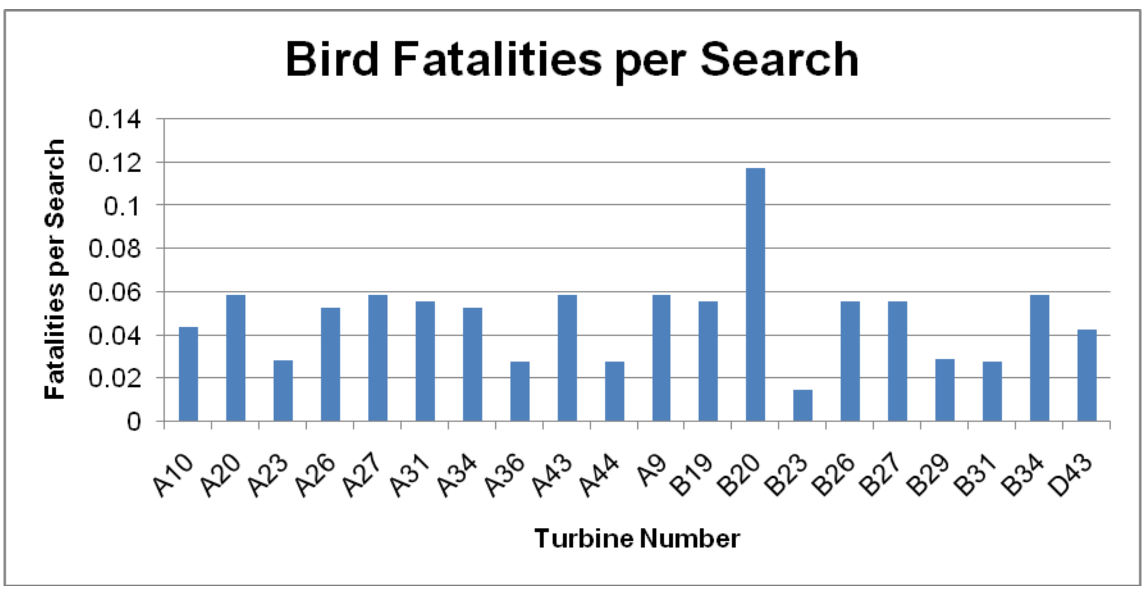

Figure 8. Bird fatalities per search for scheduled search turbines at Blue Sky Green Field.

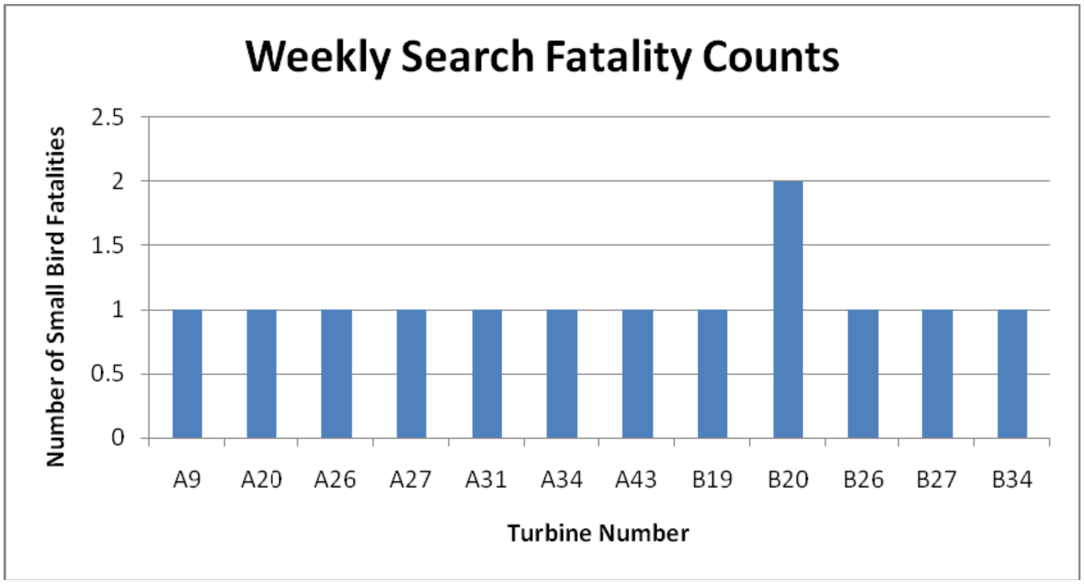

Figure 8.1. Small bird fatalities per turbine for turbines searched weekly with bird fatalities at the BSGF facility.

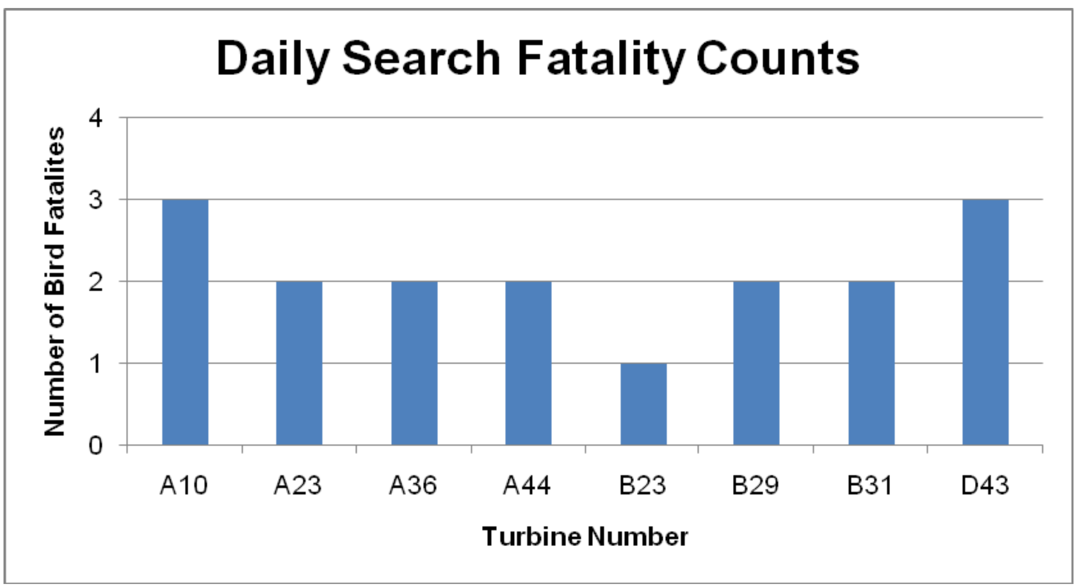

Figure 8.2. Bird fatalities per turbine for turbines searched daily at the BSGF facility.

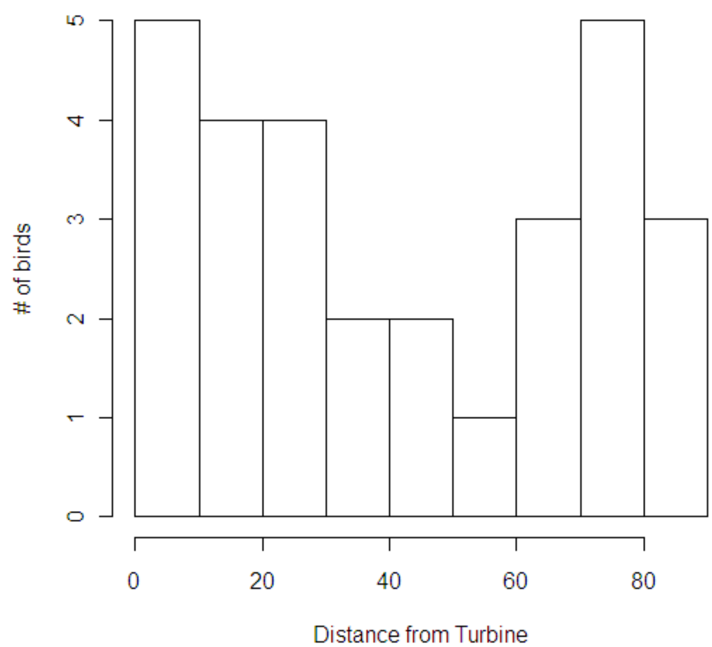

Figure 9. Distance from turbine for bird fatalities at BSGF. This figure excludes the injured horned lark that was found, as no distance information was recorded for it.

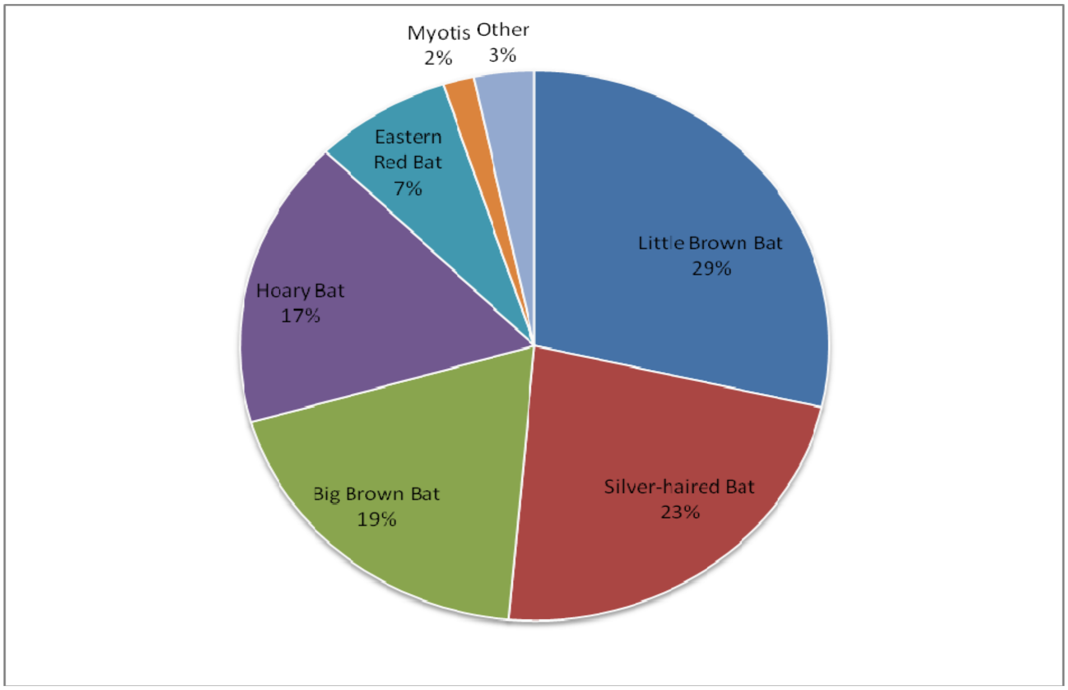

Figure 10. Distribution of bat fatalities during Fall 2008 at the BSGF facility.

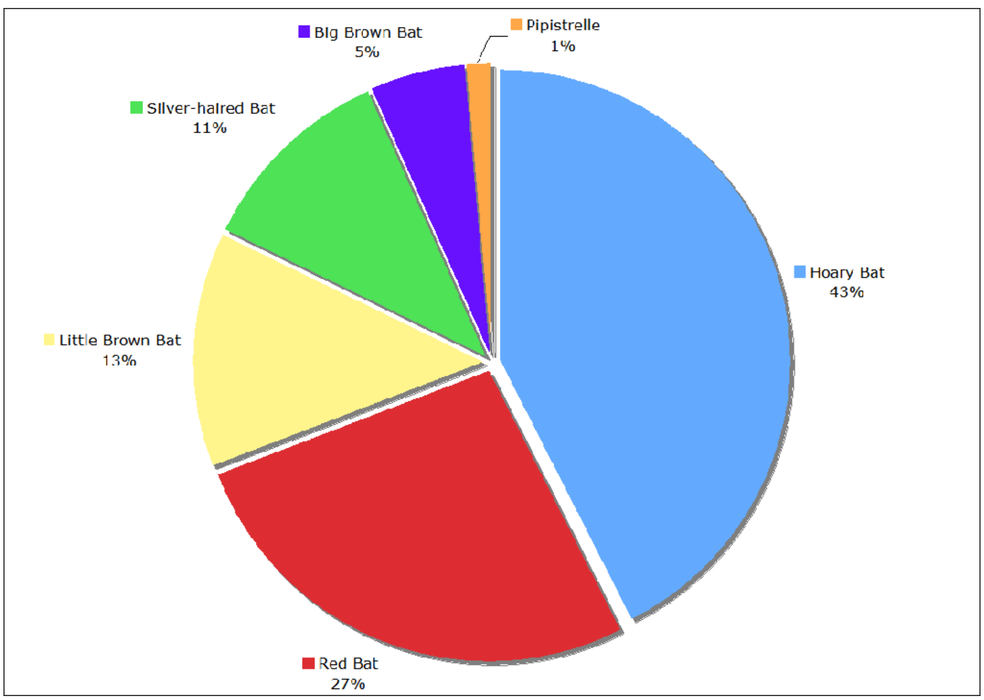

Figure 10.1. Distribution of bat fatalities at 3 midwestern wind farms with published results (adapted from Arnett et al. 2008).

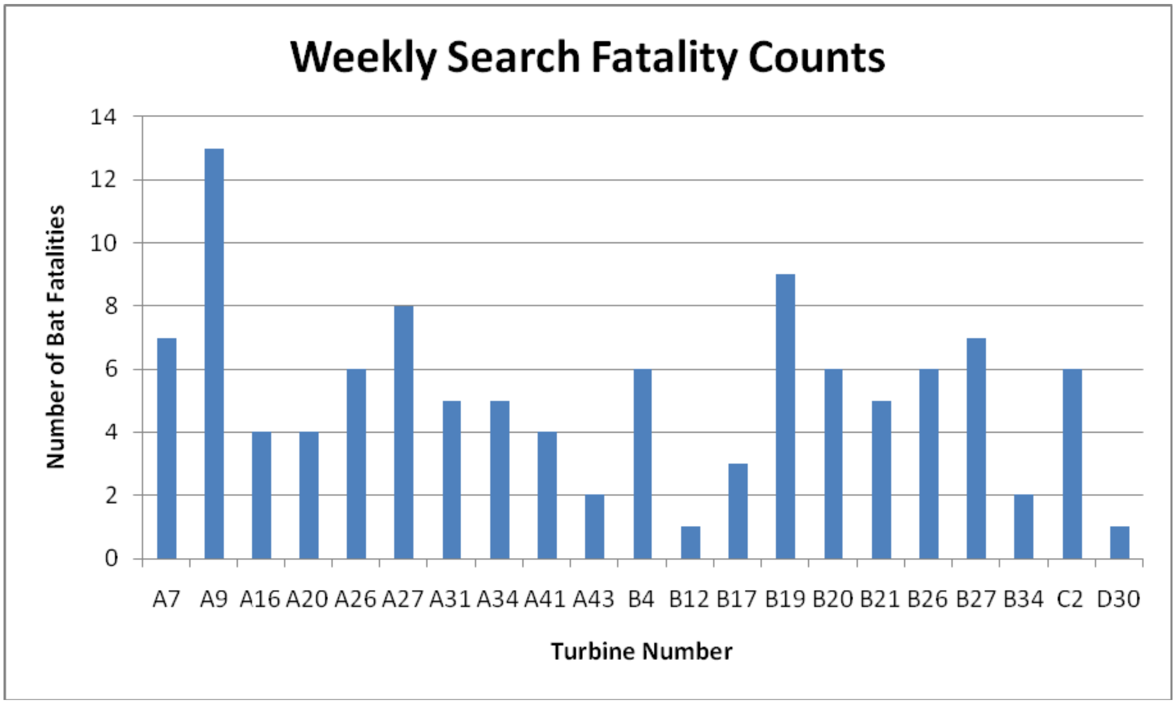

Figure 11. Bat fatalities per turbine for turbines searched weekly at the BSGF facility. Note that data from approximately weekly searches at WTG B17 are included in this and other figures below, but we did not include the 3 bats found at B17 in the adjusted fatality estimates as it was not part of the 30 scheduled search plots.

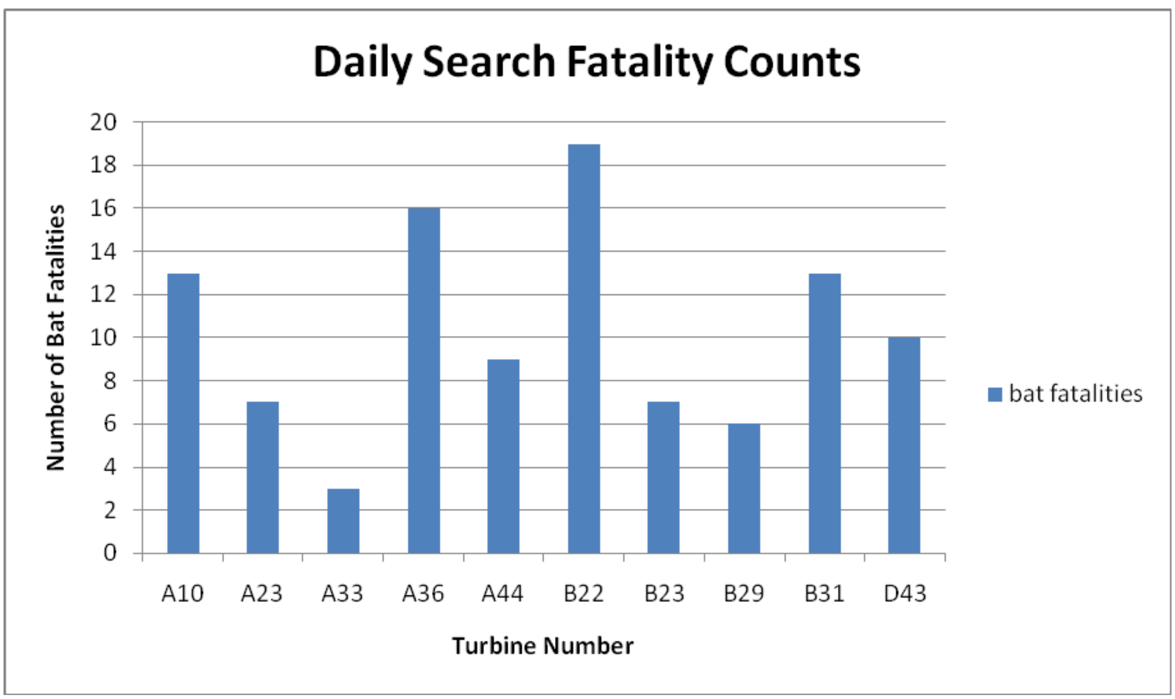

Figure 11.1. Bat fatalities at each turbine for turbines searched daily at the BSGF facility.

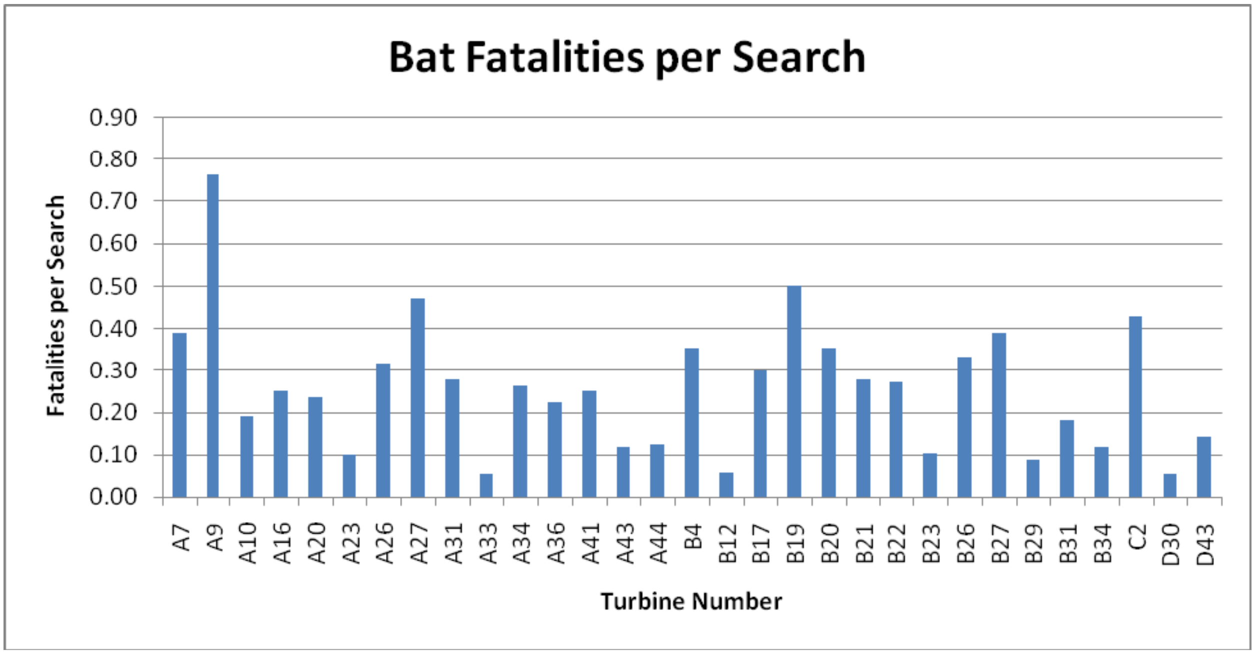

Figure 11.2. Bat fatalities per Search for scheduled search turbines at the BSGF facility.

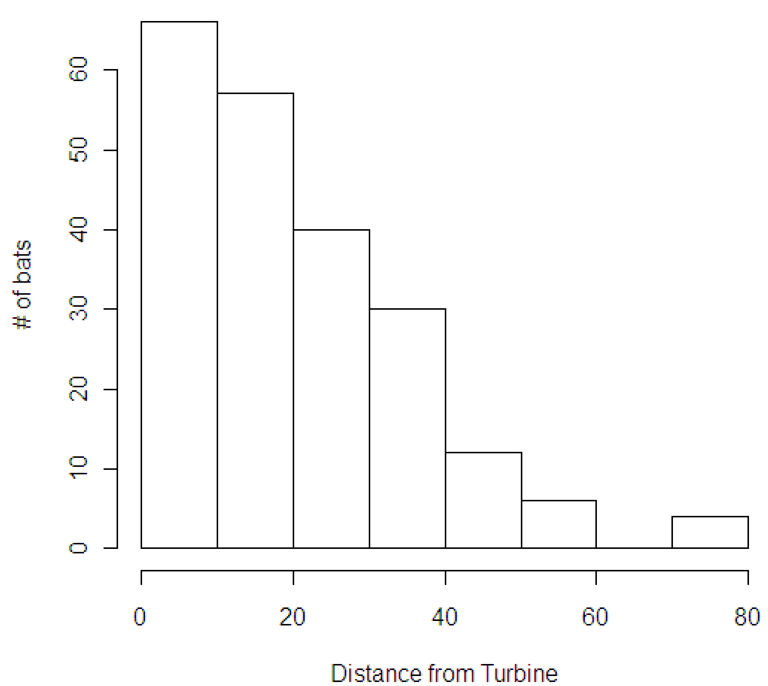

Figure 12. Distance from turbine for bat fatalities at BSGF.

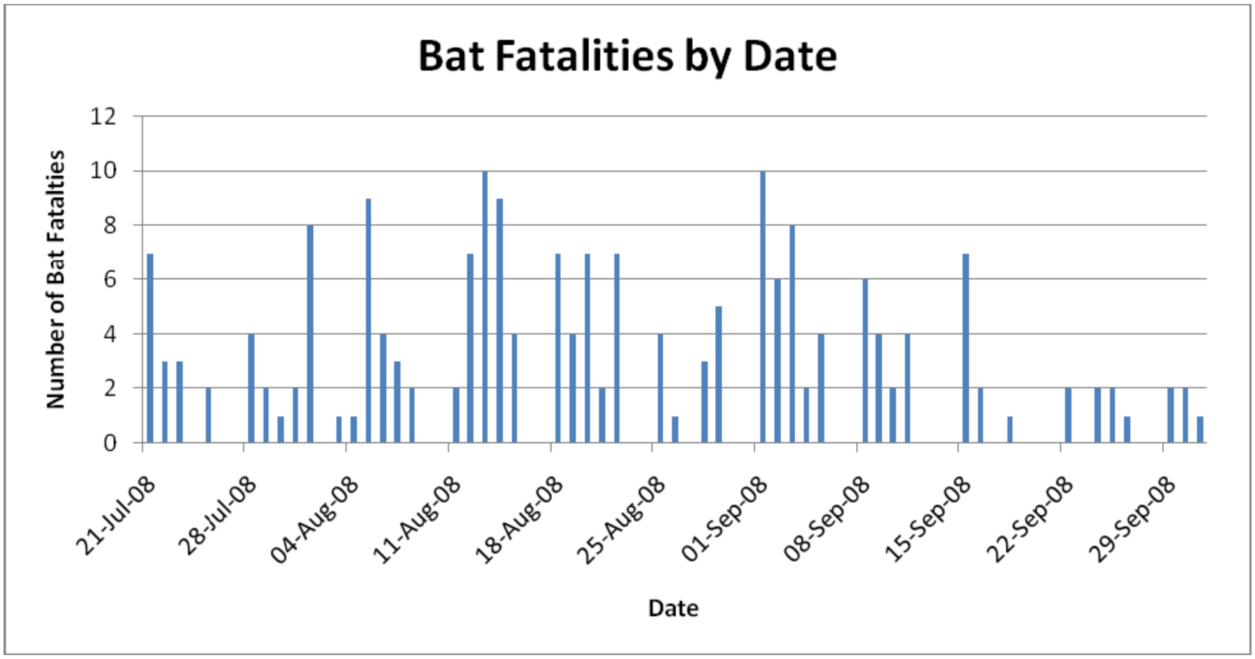

Figure 13. Bat fatalities through time at the BSGF facility.

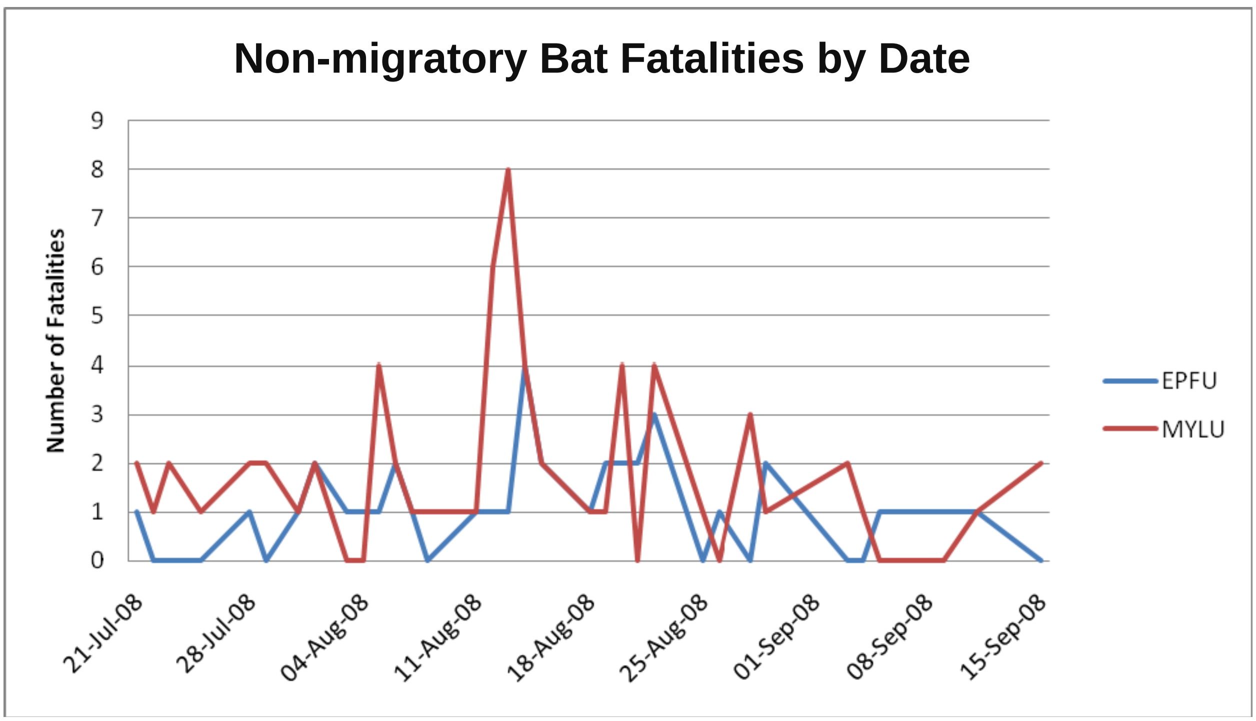

Figure 14. Little brown and big brown bat fatalities through time at the BSGF facility. EPFU = big brown bat; MYLU = little brown bat.

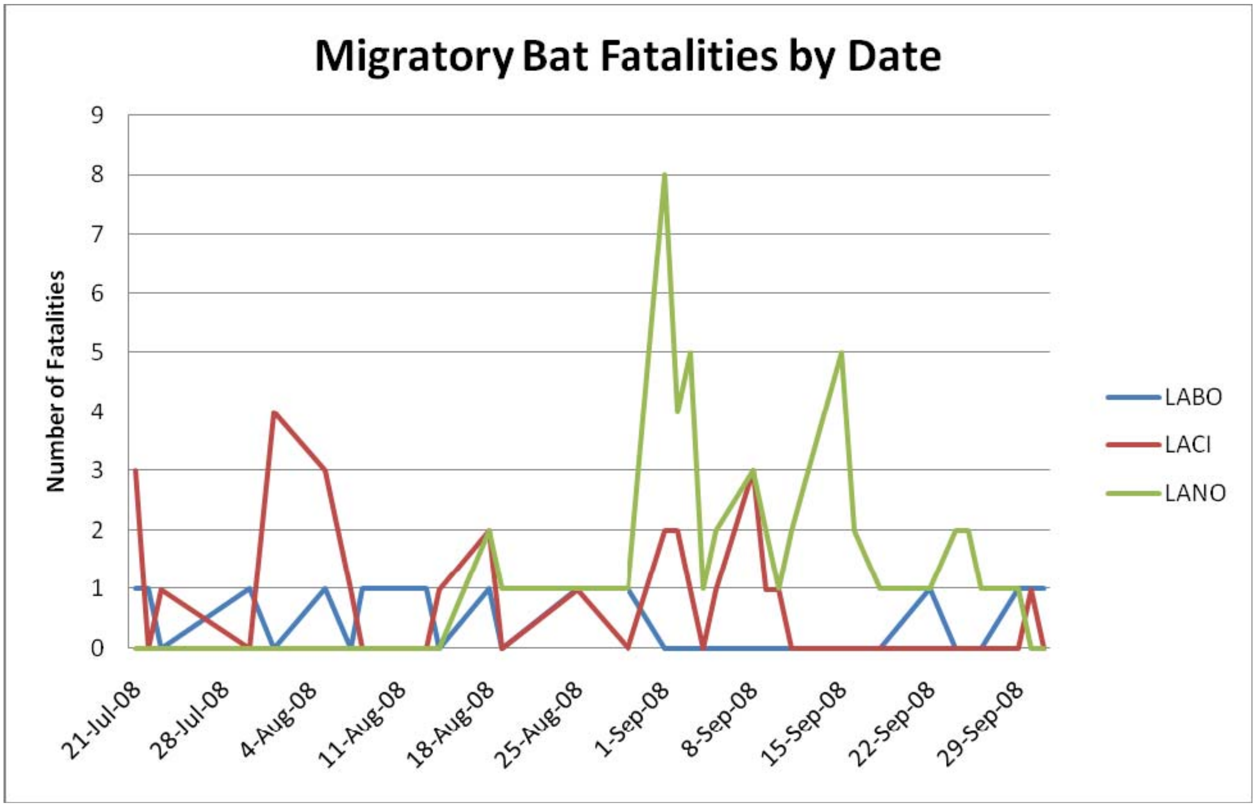

Figure 15. Migratory bat fatalities through time at the BSGF facility. LABO = eastern red bat; LACI = hoary bat; LANO = silver-haired bat.

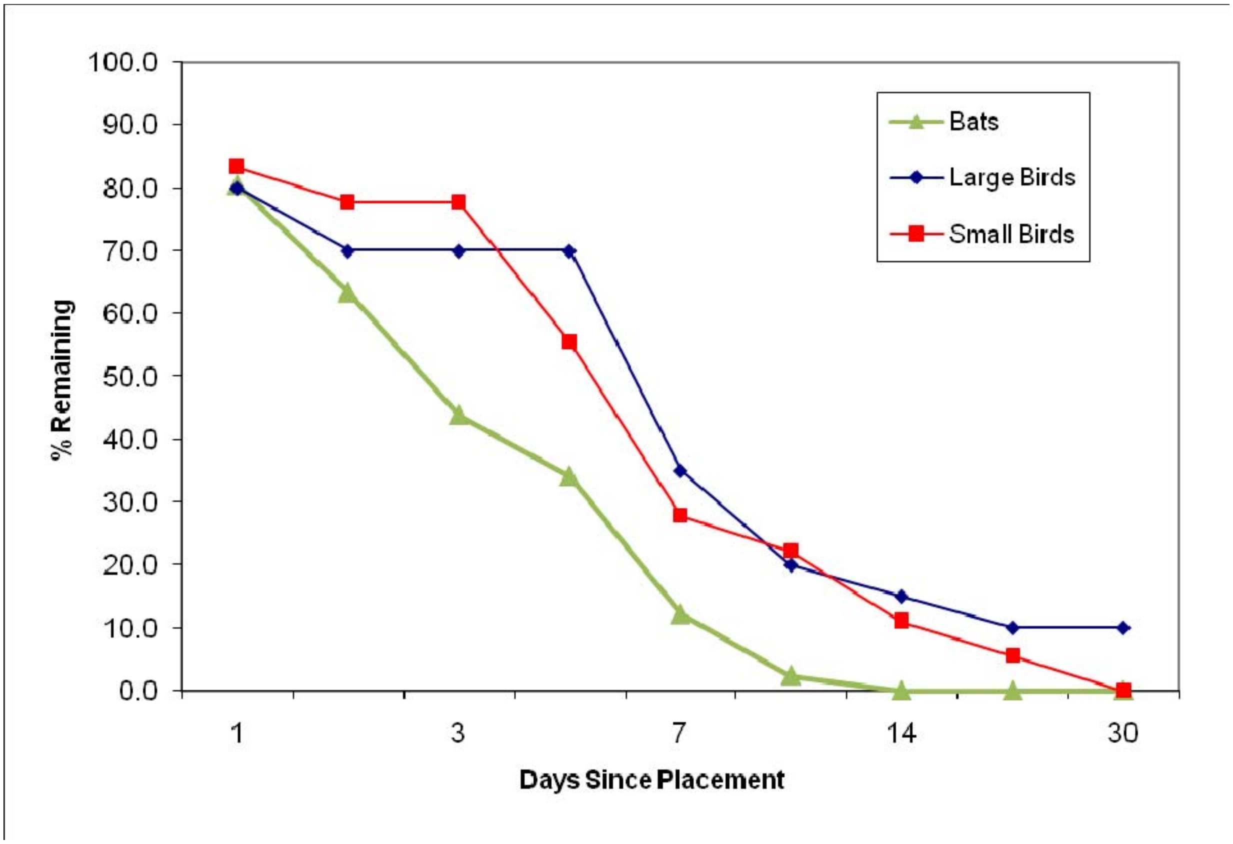

Figure 16. Scavenging results for bats, large birds, and small birds at Blue Sky Green Field.