APPENDIX J – ACOUSTIC BAT SURVEYS

Bat Activity Studies for the

Sweetland Wind Energy Project

Hand County, South Dakota

Final Report

June 1 – October 15, 2017

Prepared for:

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EXECUTIVE SUMMARY

In June 2017, Western EcoSystems Technology, Inc. initiated a bat acoustic survey for the proposed Sweetland Wind Energy Project (Project) in Hand County, South Dakota. The bat acoustic survey conducted at the Project was designed to estimate levels of bat activity throughout the Project during the summer and fall.

Acoustic surveys were conducted from June 1 to October 15, 2017, at a fixed, paired meteorological (met) tower station and at two temporary ground stations. All stations were located in grassland habitat generally representative of future turbine placement. Two fixed AnaBat® SD1 detectors were paired at the met tower, with one placed near ground level (1.5 meters [m; 5.0 feet (ft)] above ground level) and the other within the proposed rotor-swept height (45 m [148 ft]). A single AnaBat® SD1 detector was moved between the two temporary stations every two weeks during the study period.

The AnaBat unit at the fixed ground station recorded 100 bat passes on 137 detector nights for a mean (± standard error) of 0.73 ± 0.12 bat passes per detector night. The raised detector recorded 189 bat passes on 109 detector nights for a mean of 1.73 ± 0.29 per detector night. Bat pass rates were also higher at the raised detector when only comparing nights that the paired detectors were simultaneously operating. AnaBat units at temporary stations recorded 661 bat passes on 138 detector nights for a mean of 4.63 ± 0.54 bat passes per detector night.

At all stations, 55.7% of bat passes were classified as low frequency (e.g., big brown bats, hoary bats, and silver-haired bats), and 44.3% of bat passes were classified as high frequency (e.g., tri-colored bats, eastern red bats, and *Myotis* species). Hoary bats, eastern red bats, and silver-haired bats are the main casualties at other North American wind energy facilities, and it is expected these species will be the main bat casualties at the Project.

Bat activity at the fixed stations was similar between the summer and fall, peaking from August 20 – 26 (4.57 bat passes per detector night). This timing of high bat activity corresponds with the period of peak bat fatality at most wind-energy facilities and suggests most bat fatalities at the Project will occur during the late summer or early fall. The bat pass rate for the fixed ground detector during the standardized Fall Migration Period was 0.94 ± 0.19 bat passes per detector night. This activity rate was lower than the North American median (7.70 bat passes per detector night), and lower than all of the public studies from the Midwest region that have measured pre-construction bat activity and post-construction bat fatality. The Wessington Springs Wind Project, located 24 miles (mi; 38 kilometers [km]) southeast of the Project, and the Prairie Winds Wind Project, located 30 mi (48 km) south of the Project, are dominated by grassland habitat primarily used for cattle grazing and haying similar to the Project. The bat fatality rate at both projects was relatively low and decreased each year of operation, ranging from 0.41 – 1.48 bats per megawatt [MW] per year at Wessington Springs (Derby et al. 2010c, 2011a) and 0.52 – 1.23 bats/MW/year at Prairie Winds (Derby et al. 2012c, 2013a, 2014). Due to relatively low activity rates during the summer and fall at the Project, and due to the geographic proximity and habitat similarity of the Project with other active wind facilities in the

region, it is probable that bat mortality at the Project would be low and follow similar patterns as those observed at nearby facilities.

STUDY PARTICIPANTS

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REPORT REFERENCE

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INTRODUCTION

Sweetland Wind Farm, LLC (Sweetland) is proposing to develop the Sweetland Wind Energy Project (Project) in Hand County, South Dakota. Sweetland contracted Western EcoSystems Technology, Inc. (WEST) to complete a study of bat activity following the recommendations of the US Fish and Wildlife Service (USFWS) *Land-Based Wind Energy Guidelines* (USFWS 2012a) and Kunz et al. (2007b). WEST conducted acoustic monitoring surveys to estimate levels of bat activity throughout the Project during the summer and fall. The following report describes the results of acoustic monitoring surveys conducted at the Project between June 1 and October 15, 2017.

STUDY AREA

The proposed Project is located in southeastern Hand County, South Dakota, southeast of the town of Miller, and southwest of Wessington. According to the US Geological Survey (USGS) National Land Cover Database, the Project is 56.2% herbaceous (grassland) land cover (Table 1, Figure 1). The next most common land cover types are hay or pastureland (21.2%) and cultivated crops (17.7%). The remaining 4.8% of the area includes developed open space, open water, deciduous forest, emergent herbaceous wetlands, developed low intensity, developed medium intensity, and developed high intensity (Table 1, Figure 1; USGS National Land Cover Database 2011, Homer et al. 2015).

Table 1. Land cover in the Sweetland Wind Energy Project according to the US Geological Survey National Land Cover Database (2011) and Homer et al. (2015).

Land Cover	Acres	% Composition
Grassland	9,349.39	56.2
Pasture/Hay	3,533.02	21.2
Crops	2,952.61	17.7
Developed Open Space	409.44	2.5
Open Water	228.59	1.4
Deciduous Forest	127.27	0.8
Emergent Wetlands	37.09	0.2
Developed Low Intensity	3.07	<0.1
Developed Medium Intensity	0.89	<0.1
Developed High Intensity	0.22	<0.1
Total	**16,641.59**	**100**

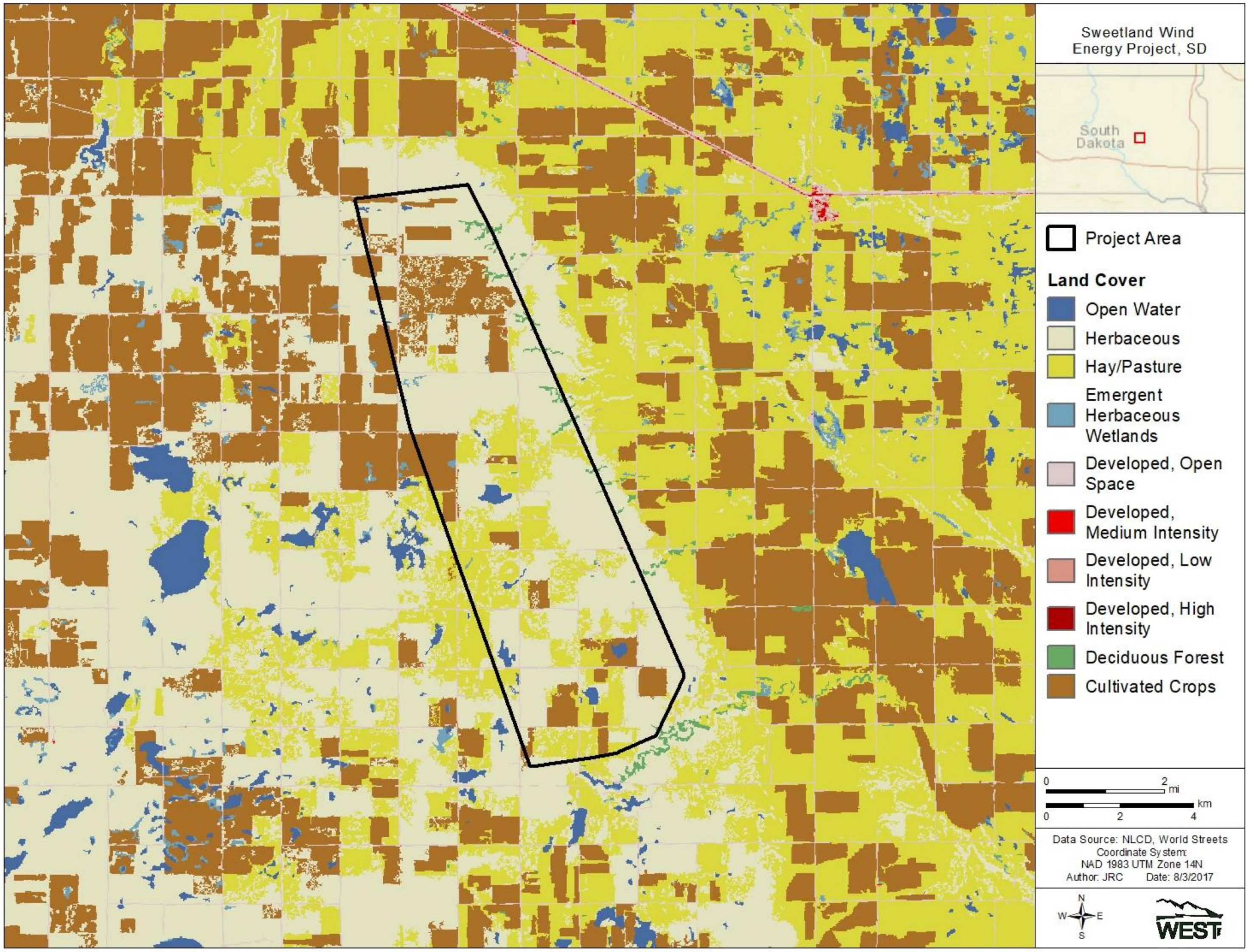

Figure 1. Land cover in the Sweetland Wind Energy Project (US Geological Survey National Land Cover Database 2011, Homer et al. 2015).

Overview of Bat Diversity

Seven species of bats potentially occur at the Project (Table 2). The northern long-eared bat (*Myotis septentrionalis*) is federally listed as threatened (USFWS 2016). None of the other species are considered sensitive in South Dakota. All of the species except for western small – footed bat (*Myotis ciliolabrum*) have been found as fatalities at wind-energy facilities (Table 2).

Table 2. Bat species with potential to occur within the Sweetland Wind Energy Project (US Fish and Wildlife Service (USFWS) 2016; International Union for Conservation of Nature 2017) categorized by echolocation call frequency.

Common Name	Scientific Name
High Frequency (>30 kHz)	
eastern red bat[1,3]	*Lasiurus borealis*
western small-footed bat	*Myotis ciliolabrum*
little brown bat[1]	*Myotis lucifugus*
northern long-eared bat[1,2]	*Myotis septentrionalis*
Low Frequency (≤30 kHz)	
big brown bat[1]	*Eptesicus fuscus*
silver-haired bat[1,3]	*Lasionycteris noctivagans*
hoary bat[1,3]	*Lasiurus cinereus*

[1] species known to have been killed at wind energy facilities;

[2] federally threatened species (USFWS 2016); and

[3] long-distance migrant.

Note: kHz = kilohertz

METHODS

Bat Acoustic Surveys

WEST conducted acoustic monitoring studies to estimate levels of bat activity throughout the Project during the study period. Although it remains unclear whether baseline acoustic data are able to adequately predict post-construction fatality (Hein et al. 2013a), ultrasonic detectors do collect information on the spatial distribution, timing, and species composition that can provide insights into the possible impacts of wind development on bats (Kunz et al. 2007a; Britzke et al. 2013) and inform potential mitigation strategies (Weller and Baldwin 2012).

Survey Stations

Three AnaBat SD1 ultrasonic bat detectors (Titley™ Scientific, Columbia, Missouri) were used during the study. Two of the detectors were paired at a meteorological (met) tower with one detector at ground level (approximately 1.5 meters [m; 5.0 feet (ft)] above ground level [AGL]) and another within the approximate rotor-swept zone (approximately 45 m [148 ft] AGL; Figure 2). Species activity levels and composition can vary with altitude (Baerwald and Barclay 2009; Collins and Jones 2009; Müeller et al. 2013). Therefore, it can be useful to monitor activity at different heights (Kunz et al. 2007a). Ground-based detectors likely detect a more complete sample of the bat species present within the Project, whereas elevated detectors may give a more accurate assessment of risk to bat species flying at rotor swept heights (Kunz et al. 2007a; Müeller et al. 2013; but see Amorim et al. 2012). The third detector was placed at two temporary acoustic monitoring stations to enhance spatial coverage of the Project. All stations were located in grassland habitat, which is the dominant land cover type (Table 1) and is representative of potential turbine locations.

Each AnaBat unit was placed inside a plastic weather-tight container that had a hole cut in the side through which the microphone extended. Each microphone was encased in a 45-degree angle poly-vinyl chloride (PVC) tube, and holes were drilled in the PVC tube to allow water to drain. The raised AnaBat microphone was elevated on the met tower using a pulley system. Standard Bat-Hat weatherproof housing was modified to use a 45-degree angle PVC elbow.

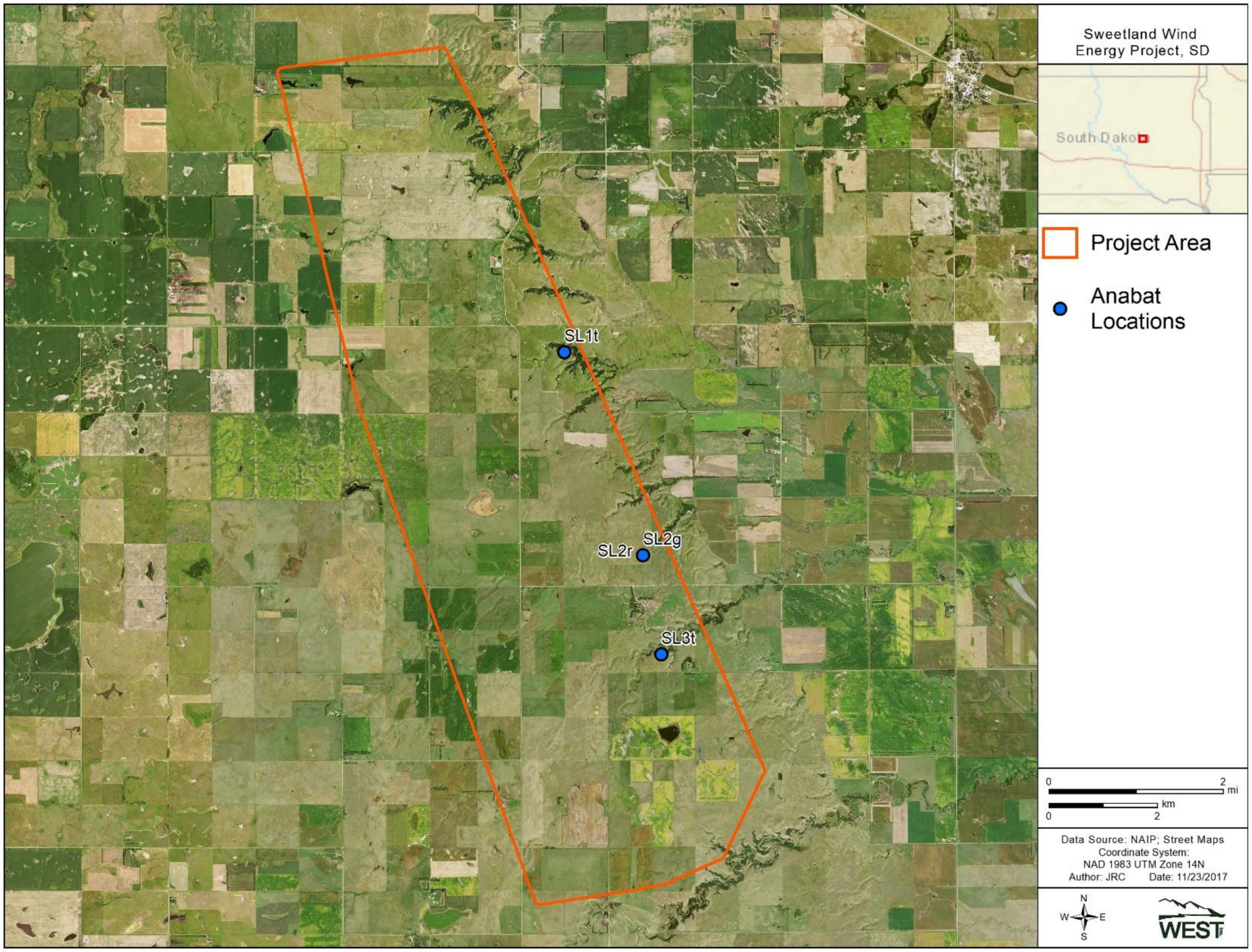

Figure 2. Location of fixed and temporary AnaBat stations in the Sweetland Wind Energy Project.

Survey Schedule

Bats were surveyed in the Project from June 1 to October 15, 2017, and detectors were programmed to turn on approximately 30 minutes (min) before sunset and turn off approximately 30 min after sunrise each night. To highlight seasonal activity patterns, the study was divided into two survey periods: summer (June 1 – August 14), and fall (August 15 – October 15). Mean bat activity was also calculated for a standardized Fall Migration Period (FMP), defined here as July 30 – October 14. The FMP was defined by WEST as a standard for comparison with activity from other wind energy facilities. During this time bats begin moving toward wintering areas, and many species of bats initiate reproductive behaviors (Cryan 2008). This period of increased landscape-scale movement and reproductive behavior is often associated with increased levels of bat fatalities at operational wind energy facilities (Arnett et al. 2008; Arnett and Baerwald 2013).

Data Collection and Call Analysis

AnaBat detectors use a broadband high-frequency microphone to detect the echolocation calls of bats. Incoming echolocation calls are digitally processed and stored on a high capacity compact flash card. The resulting files can be viewed in appropriate software (e.g., Analook©) as digital sonograms that show changes in echolocation call frequency over time. Frequency versus time displays were used to separate bat calls from other types of ultrasonic noise (e.g., wind, insects, etc.), to determine the call frequency category and, when identifiable, the species of bat that generated the calls.

To standardize acoustic sampling effort across the Project, AnaBat units were calibrated and sensitivity levels were set to six (Larson and Hayes 2000), a level that balanced the goal of recording bat calls against the need to reduce interference from other sources of ultrasonic noise (Brooks and Ford 2005).

For each survey location, bat passes were sorted into two groups based on their minimum frequency. High-frequency (HF) bats such as eastern red bats (*Lasiurus borealis*), and *Myotis* species have minimum frequencies greater than 30 kilohertz (kHz). Low frequency (LF) bats such as big brown bats (*Eptesicus fuscus*), silver-haired bats (*Lasionycteris noctivagans*), and hoary bats (*Lasiurus cinereus*) typically emit echolocation calls with minimum frequencies equal to or below 30 kHz. HF and LF species that may occur in the study area are listed in Table 2.

Statistical Analysis

The standard metric used for measuring bat activity is the number of bat passes per detector night, and this metric was used as an index of bat activity in the Project. A bat pass was defined as a sequence of at least two echolocation calls (pulses) produced by an individual bat with no pause between calls of more than one second (Fenton 1980). A detector night was defined as one detector operating for one entire night. The terms bat pass and bat call are used interchangeably. The number of bat passes per detector night was calculated for all bats, and for HF and LF bats. Bat pass rates represent indices of bat activity and do not represent numbers of individuals. The number of bat passes was determined by an experienced bat biologist using Analook.

The period of peak sustained bat activity was defined as the 7-day period with the highest average bat activity. If multiple 7-day periods equaled the peak sustained bat activity rate, all dates in these 7-day periods were reported. This and all multi-detector averages in this report were calculated as an unweighted average of total activity at each detector. Temporary stations were not sampled on a continuous basis throughout the survey period and were therefore excluded from temporal analyses.

Risk Assessment

To assess potential for bat fatalities, bat activity in the Project was compared to existing data at other wind energy facilities in the Midwest. Among studies measuring both activity and fatality rates, most data were collected during the fall using Anabat detectors placed near the ground. Therefore, to make valid comparisons to the publicly available data, this report uses the activity rate recorded at fixed, ground detectors during the FMP as a standard for comparison with activity data from other wind energy facilities. Given the relatively small number of publicly available studies and the significant ecological differences between geographically dispersed facilities, the risk assessment is qualitative, rather than quantitative.

RESULTS

Bat Acoustic Surveys

Bat activity was monitored at four sampling locations for a total of 384 detector nights between June 1 and October 15, 2017. AnaBat units were operating for 93.4% of the sampling period (Figure 3). Overall, the average bat pass rate (± standard error) was 2.93 ± 0.30 bat passes per detector night (Table 3).

Table 3. Results of acoustic bat surveys conducted at fixed and temporary stations within the Sweetland Wind Energy Project between June 1 and October 15, 2017. Passes are separated by call frequency: high frequency (HF) and low frequency (LF).

Anabat Station	Location	Type	# of HF Bat Passes	# of LF Bat Passes	Total Bat Passes	Detector-Nights	Bat Passes/ Night***
SL1t	Ground	temporary	255	255	510	74	6.89 ± 1.09
SL2g	Ground	fixed	35	65	100	137	0.73 ± 0.12
SL2r	Raised	fixed	62	127	189	109	1.73 ± 0.29
SL3t	Ground	temporary	69	82	151	64	2.36 ± 0.34
Total Fixed			**97**	**192**	**289**	**246**	**1.23 ± 0.17**
Total Temporary			**324**	**337**	**661**	**138**	**4.63 ± 0.54**
Total			**421**	**529**	**950**	**384**	**2.93 ± 0.30**

*** ± bootstrapped standard error.

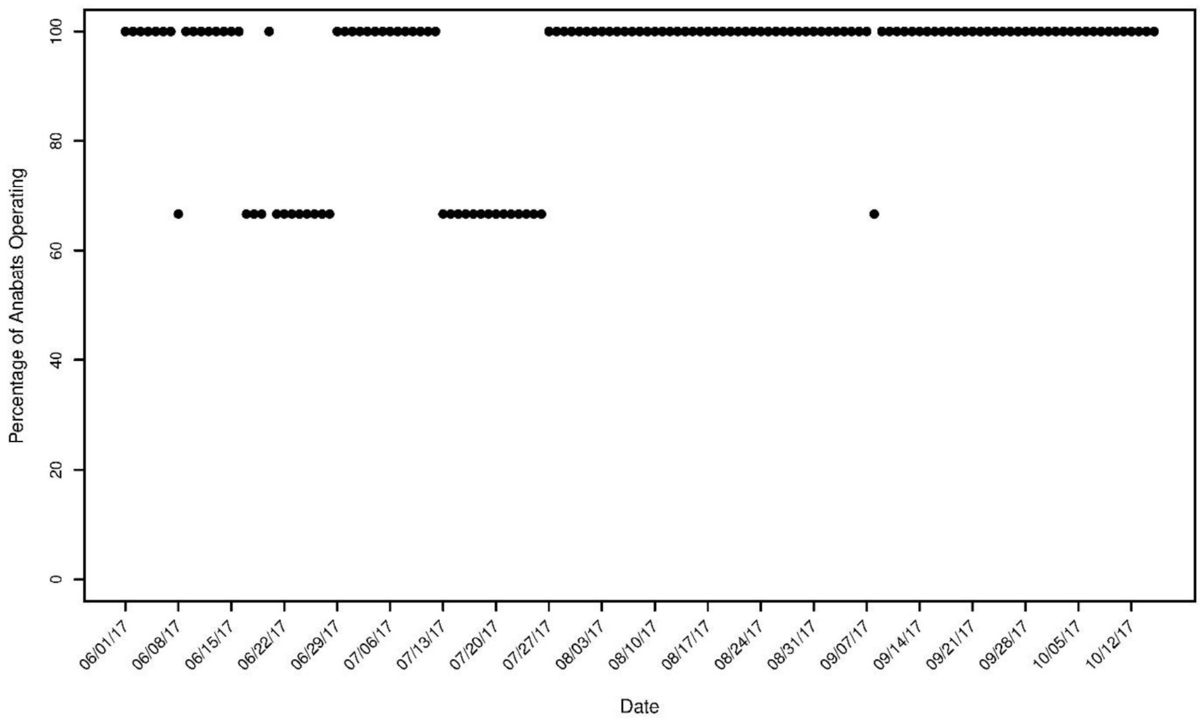

Figure 3. Operational status of bat detectors (n = 4) operating at the Sweetland Wind Energy Project during each night of the study period June 1 to October 15, 2017.

Spatial Variation

Overall, bat activity in the Project was higher at the temporary stations than at the fixed stations (Figures 4 and 5; Table 3). The AnaBat unit at the fixed ground station recorded 100 bat passes on 137 detector nights for a mean of 0.73 ± 0.12 bat passes per detector night. The raised detector recorded 189 bat passes on 109 detector nights for a mean of 1.73 ± 0.29 per detector night (Table 3). For the nights that the paired detectors were simultaneously operating (n = 109; Figure 5), bat pass rates were also higher at the raised station. AnaBat units at temporary stations recorded 661 bat passes on 138 detector nights for a mean of 4.63 ± 0.54 bat passes per detector night (Table 3).

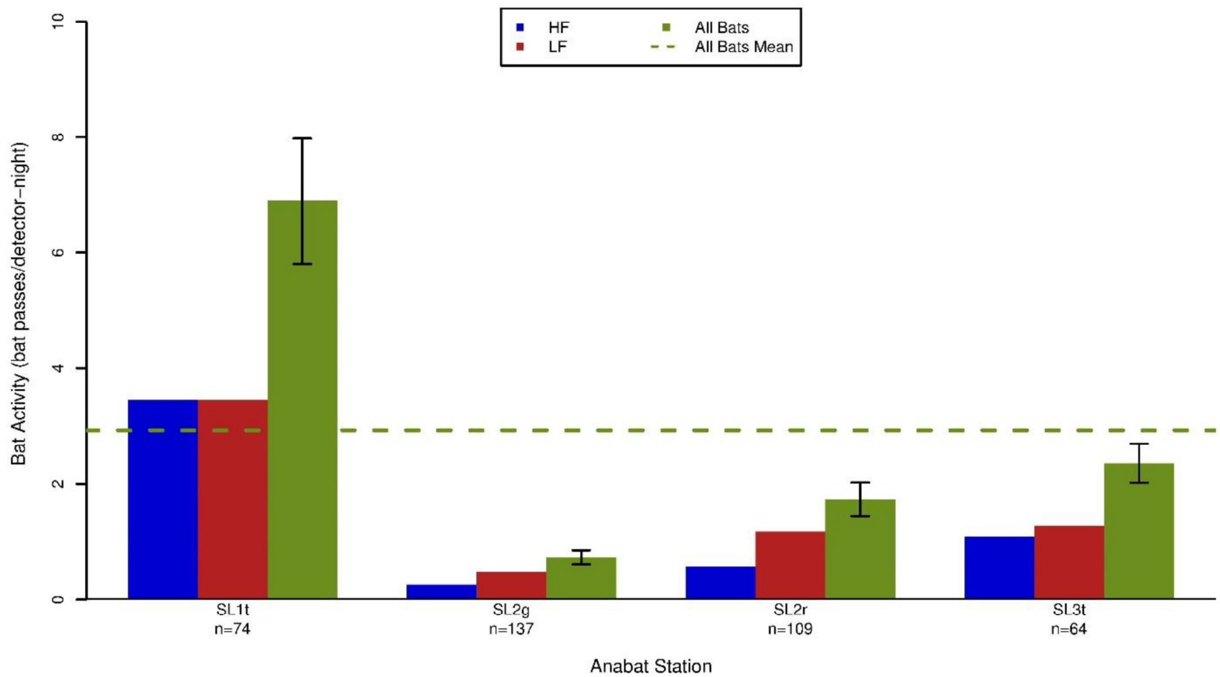

Figure 4. Number of high-frequency (HF) and low-frequency (LF) bat passes per detector night recorded at AnaBat stations in the Sweetland Wind Energy Project between June 1 and October 15, 2017. The bootstrapped standard errors are represented by the black error bars on the 'All Bats' columns.

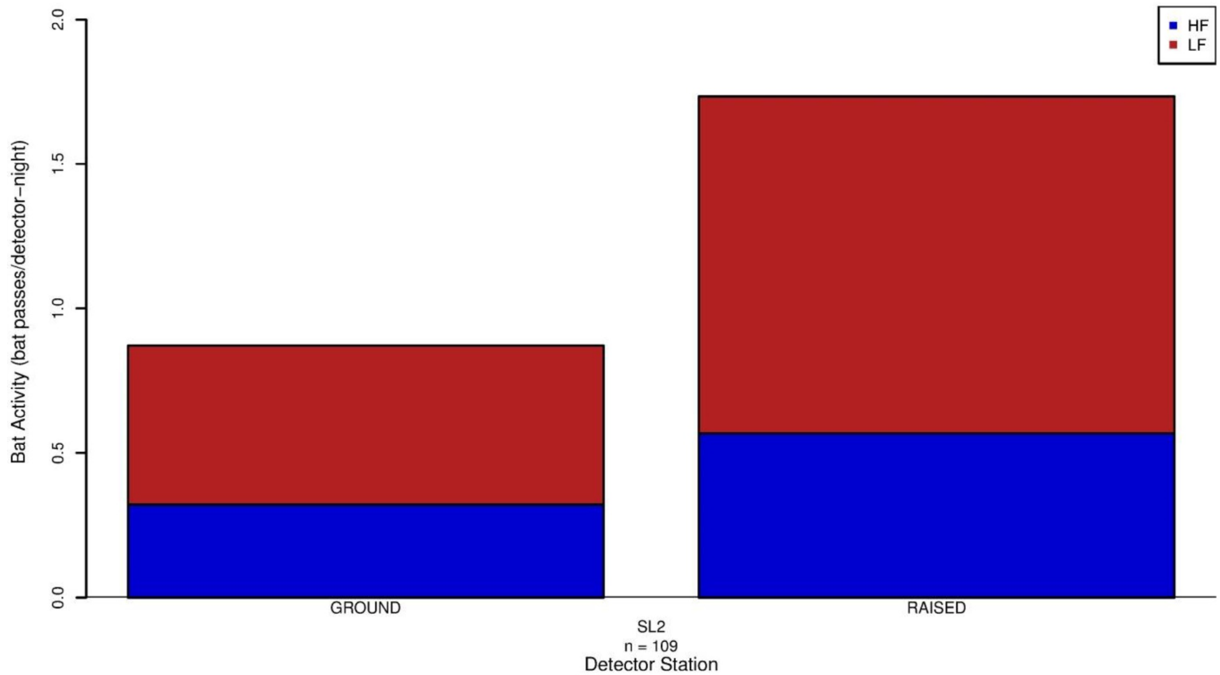

Figure 5. Number of high-frequency (HF) and low-frequency (LF) bat passes per detector night recorded at the paired AnaBat stations in the Sweetland Wind Energy Project between June 1 and October 15, 2017.

Temporal Variation

Overall bat activity at fixed stations was relatively low throughout the study period, but was slightly higher in the summer (1.38 ± 0.21 bat passes per detector-night) than in the fall (1.17 ± 0.28 bat passes per detector-night; Table 4, Figure 6). Bat activity at the ground station was slightly higher in the fall whereas bat activity at the raised stations was slightly higher in the summer. The bat pass rate for the fixed ground detector during the standardized FMP was 0.94 ± 0.19 bat passes per detector night (Table 4). Weekly acoustic activity at fixed stations was highest in July and August (Figure 7), peaking from August 20 to 26 (4.57 bat passes per detector night; Table 5, Figure 7). Bat activity gradually decreased for the remainder of the study period (Figure 7).

At paired stations (Figure 8), weekly activity was higher at the raised detector for most of the study period with the exception of early July and mid-September through early October.

Table 4. The number of bat passes per detector night recorded at fixed stations in the Sweetland Wind Energy Project during each season in 2017, separated by call frequency: high frequency (HF), low frequency (LF), and all bats (AB).

Station	Call Frequency	Summer Jun 1 – Aug 14	Fall Aug 15 – Oct 15	Fall Migration Period Jul 30 – Oct 14
SL2g	LF	0.29	0.69	0.6
	HF	0.23	0.29	0.34
	AB	0.52	0.98	0.94
SL2r	LF	1.26	1.1	1.21
	HF	0.98	0.26	0.53
	AB	2.23	1.35	1.74
Ground Totals	**LF**	**0.29 ± 0.08**	**0.69 ± 0.20**	**0.60 ± 0.16**
	HF	**0.23 ± 0.07**	**0.29 ± 0.09**	**0.34 ± 0.08**
	AB	**0.52 ± 0.12**	**0.98 ± 0.22**	**0.94 ± 0.19**
Raised Totals	**LF**	**1.26 ± 0.23**	**1.10 ± 0.37**	**1.21 ± 0.31**
	HF	**0.98 ± 0.19**	**0.26 ± 0.09**	**0.53 ± 0.11**
	AB	**2.23 ± 0.38**	**1.35 ± 0.42**	**1.74 ± 0.38**
Overall	**LF**	**0.77 ± 0.14**	**0.90 ± 0.25**	**0.90 ± 0.21**
	HF	**0.60 ± 0.10**	**0.27 ± 0.06**	**0.44 ± 0.08**
	AB	**1.38 ± 0.21**	**1.17 ± 0.28**	**1.34 ± 0.24**

Table 5. Periods of peak activity for high frequency (HF), low frequency (LF), and all bats at fixed stations in the Sweetland Wind Energy Project between June 1 and October 15, 2017.

Species Group	Start Date of Peak Activity	End Date of Peak Activity	Bat Passes per Detector Night
HF	August 6	August 12	1.29
LF	August 20	August 26	3.79
All Bats	August 20	August 26	4.57

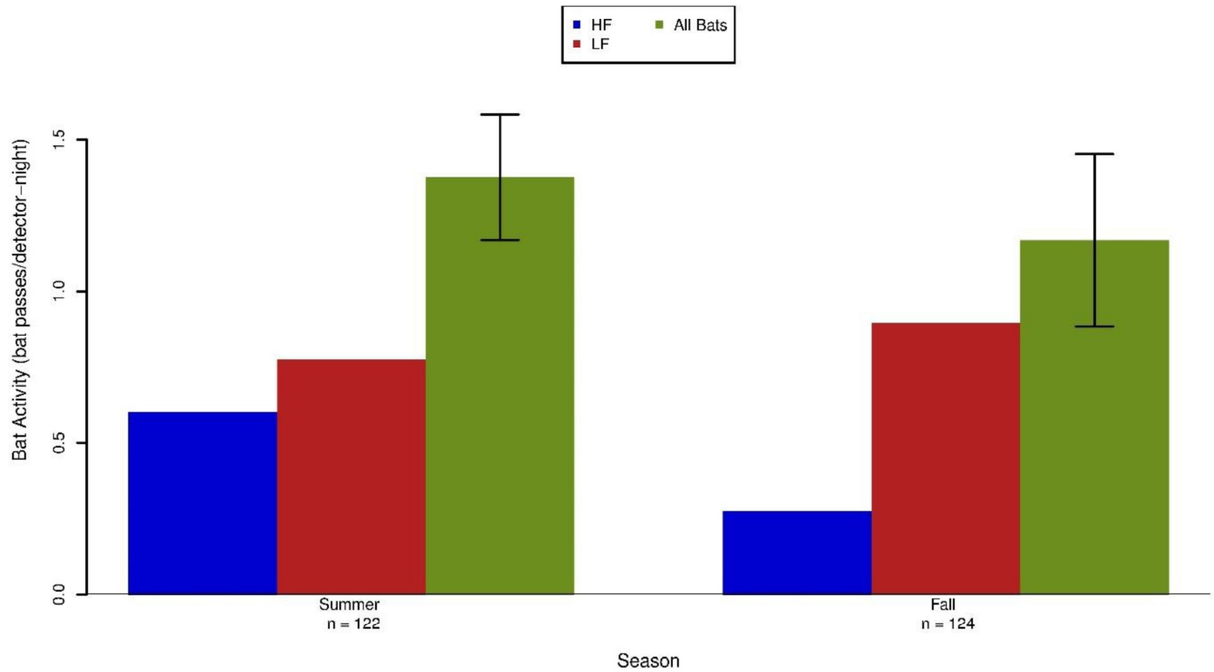

Figure 6. Seasonal bat activity by high frequency (HF), low frequency (LF), and all bats at fixed stations in the Sweetland Wind Energy Project between June 1 and October 15, 2017. The bootstrapped standard errors are represented on the 'All Bats' columns.

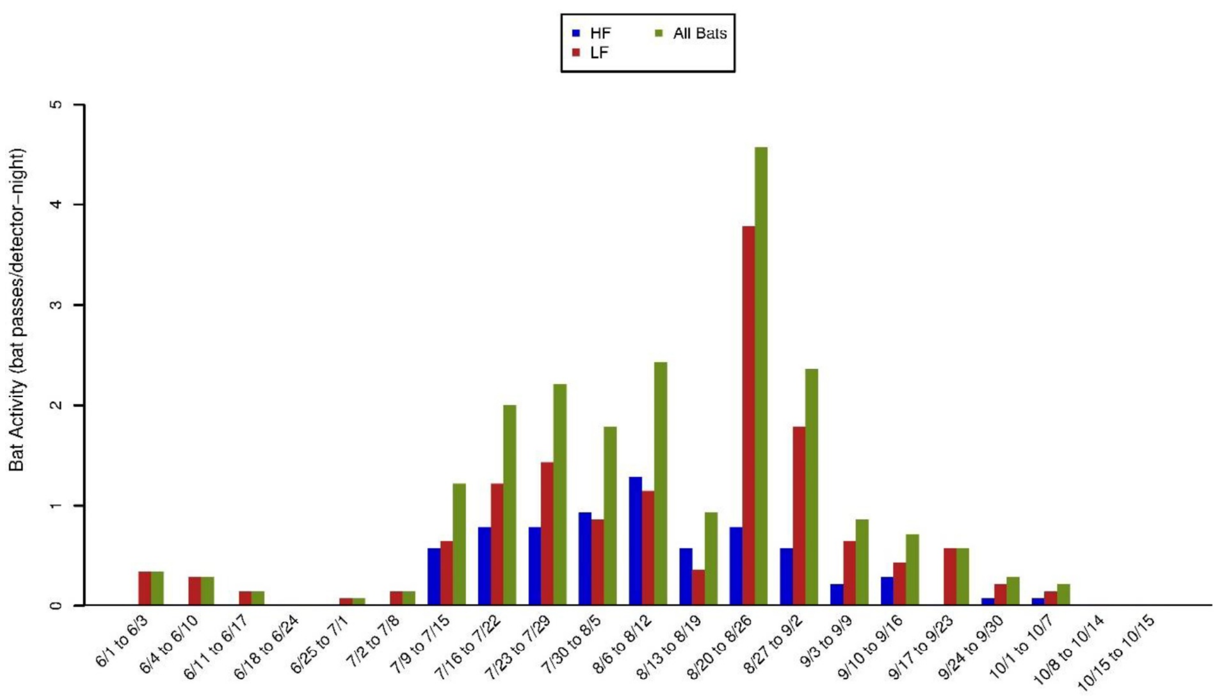

Figure 7. Weekly patterns of bat activity by high frequency (HF), low frequency (LF), and all bats at fixed stations in the Sweetland Wind Energy Project between June 1 and October 15, 2017.

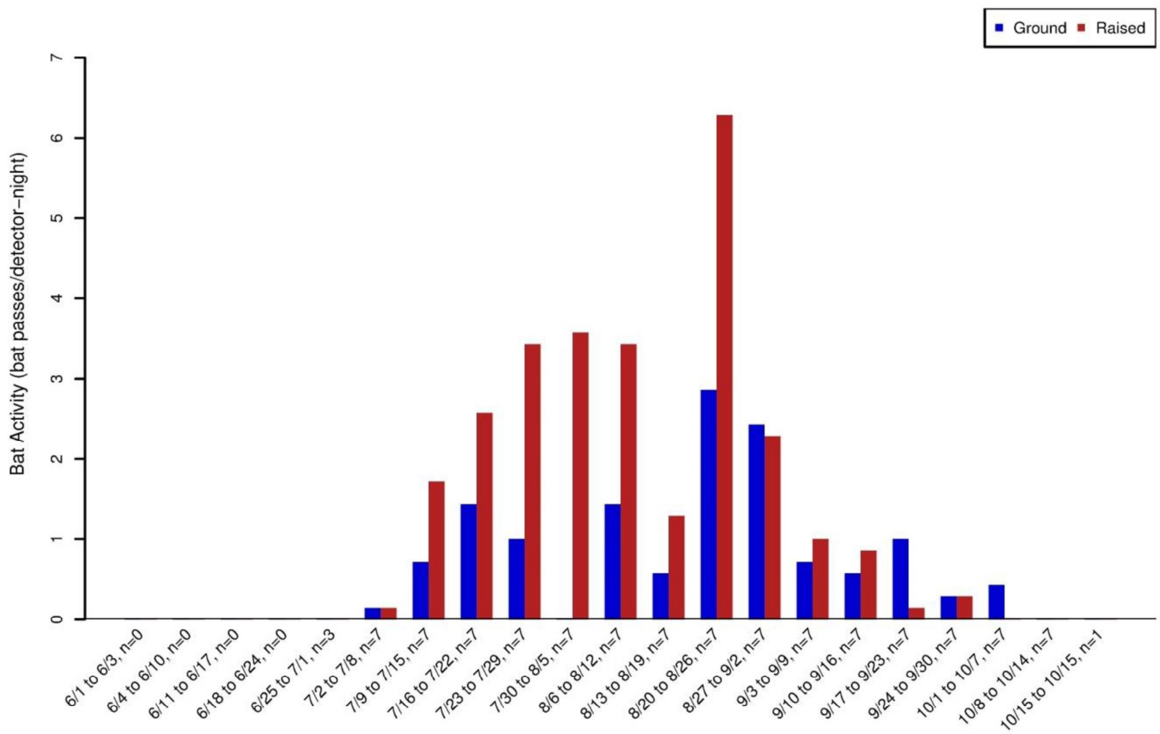

Figure 8. Weekly patterns of bat activity from June 1 to October 15, 2017, at ground and raised fixed stations at the Sweetland Wind Energy Project.

Species Composition

At all stations, 55.7% of bat passes were classified as LF, and 44.3% of bat passes were classified as HF (Tables 2 and 3). However, the proportion of LF and HF bats differed across station types. At the fixed ground and raised stations, LF and HF bat passes composed 66.4 and 33.6% of all bat passes, respectively (Table 3). At the temporary stations, 51.0% of bat passes were made by LF bats, while 49.0% were made by HF bats (Table 3).

DISCUSSION

Bat fatalities have been discovered at most wind energy facilities monitored in North America, ranging from zero (Chatfield and Bay 2014) to 40.2 bat fatalities per megawatt (MW) per year (Hein et al. 2013a; Appendix A). In 2012, an estimated 600,000 bats died as a result of interactions with wind turbines in the US (Hayes 2013). Proximate causes of bat fatalities are primarily due to collisions with moving turbine blades (Grodsky et al. 2011; Rollins et al. 2012) but to a limited extent may also be caused by barotrauma (Baerwald et al. 2008). The underlying reasons for why bats come near turbines are still largely unknown (Cryan and Barclay 2009). To date, post-construction monitoring studies of wind energy facilities show that migratory tree-roosting species (e.g., eastern red bat, hoary bat, and silver-haired bat) compose approximately 78% of reported bat fatalities; the majority of fatalities occur during the fall migration season (August and September); and most fatalities occur on nights with relatively low wind speeds (e.g., less than 6.0 meters per second; Arnett et al. 2008; Arnett and Baerwald 2013; Arnett et al. 2013a).

It is generally expected that pre-construction bat activity should be positively related to post-construction bat fatalities (Kunz et al. 2007a). However, to date, few studies of wind energy facilities have recorded both pre-construction bat passes per detector night and post-construction bat fatality rates (Appendix A). Given the limited availability of pre- and post-construction data sets, differences in protocols among studies (Ellison 2012), and significant ecological differences between geographically diverse facilities, the relationship between activity and fatalities has not yet been empirically established, though Baerwald and Barclay (2009) found a significant positive association between pass rates measured at 30 m and fatality rates for hoary and silver-haired bats across five sites in southern Alberta.

However, on a continental scale, a similar relationship has proven difficult to establish. The relatively few studies that have estimated both pre-construction activity and post-construction fatalities trend toward a positive association between activity and fatality rates, but they lack statistically significant correlations. Hein et al. (2013b) compiled data from wind projects that included both pre- and post-construction data from the same projects, as well as pre- and post-construction data from facilities within the same regions to assess if pre-construction acoustic activity predicted post-construction fatality rates. Based on data from 12 sites that had both pre- and post-construction data, they did not find a statistically significant relationship ($p=0.07$), although the trend was in the expected direction (i.e., low activity was generally associated with low fatalities and vice-versa). They concluded that pre-construction acoustic data could not currently predict bat fatalities, but acknowledged that the data set was limited and additional data may indicate a stronger relationship. Therefore, the current approach to assessing the risk to bats requires a qualitative analysis of activity levels, spatial and temporal relationships, species composition, and comparison to regional fatality patterns.

Mean bat activity during the FMP at fixed ground detectors (0.94 bat passes per detector night; Table 4) was lower than the North American median (7.7) and the majority of studies available from the Midwest region (Appendix A). Given the low bat pass rate, and that over two-thirds of bat fatality studies in the Midwest report fewer than five bat fatalities/MW/year (Appendix A; Figure 9), it is possible that similar fatality rates could be recorded at the Project.

On average, bat activity was four times higher at the temporary stations than at the fixed ground stations although this was primarily driven by station SL1t. All stations were in similar grassland habitat, and grassland is the dominant habitat type at the Project, so these data likely represent the range of bat activity across the Project. Some research suggests that bat activity in the rotor-swept zone may be more representative of bat exposure to turbines (Baerwald and Barclay 2009). At fixed stations in the Project, bat activity recorded by the raised detector (1.73 bat passes per detector night) was higher than activity recorded by the ground detector (0.73 bat passes per detector night). On nights that both detectors were operating, the raised detector also recorded more bat activity than the ground detector (Figure 5).

Approximately 56% of bat passes recorded in the Project were emitted by LF bats, suggesting a similar abundance of species such as big brown bats, silver-haired bats, and hoary bats (Table 3). LF species may become casualties because they fly at higher altitudes, as demonstrated by their greater prevalence at raised detectors (Table 3, Figure 5). Activity by HF bat species composed 44% of bat passes recorded at stations in the Project. Eastern red bats are usually the most common HF species found during carcass searches (Arnett et al. 2008; Arnett and Baerwald 2013). *Myotis* species are recorded less commonly than other species in the rotor-swept zone or as fatalities at most post-construction studies of wind energy facilities (Kunz et al. 2007a; Arnett et al. 2008), with a few notable exceptions (Kerns and Kerlinger 2004b; Jain 2005; Brown and Hamilton 2006; Gruver et al. 2009). Given that hoary bats, eastern red bats, and silver-haired bats are among the most common bat fatalities at many facilities (Arnett et al. 2008; Arnett and Baerwald 2013), it is expected that these three species would be the most common fatalities at the Project.

At fixed stations bat activity peaked during late August. This timing is consistent with peak fatality periods for most wind energy facilities in the US, and suggests that bat fatalities at the Project will be highest during late summer to early fall and may consist largely of migrating individuals. The Wessington Springs Wind Project (Wessington Springs), located approximately 24 miles (38 kilometers) southeast of the Project and the Prairie Winds Wind Project, located 30 mi (48 km) south of the Project, are dominated by grassland habitat primarily used for cattle grazing and haying with some patches of deciduous trees and open waterbodies available similar to the Project. Due to relatively low activity rates during the summer and fall at the Project, and due to the geographic proximity and habitat similarity of the Project to Wessington Springs and Prairie Winds, it is probable that bat mortality at the Project would be low and follow similar patterns as those observed at other facilities within the region (e.g., 0.41 – 1.48 bat fatalities/MW/year [Derby et al. 2010c, Derby et al. 2011a], 0.52 – 1.23 bats/MW/year [Derby et al. 2012c, 2013a, 2014]). The pre-construction bat studies completed at the Project will add to the growing body of research regarding the impacts of wind energy development on bats and will provide a valuable comparison to post-construction studies to be completed at Project.

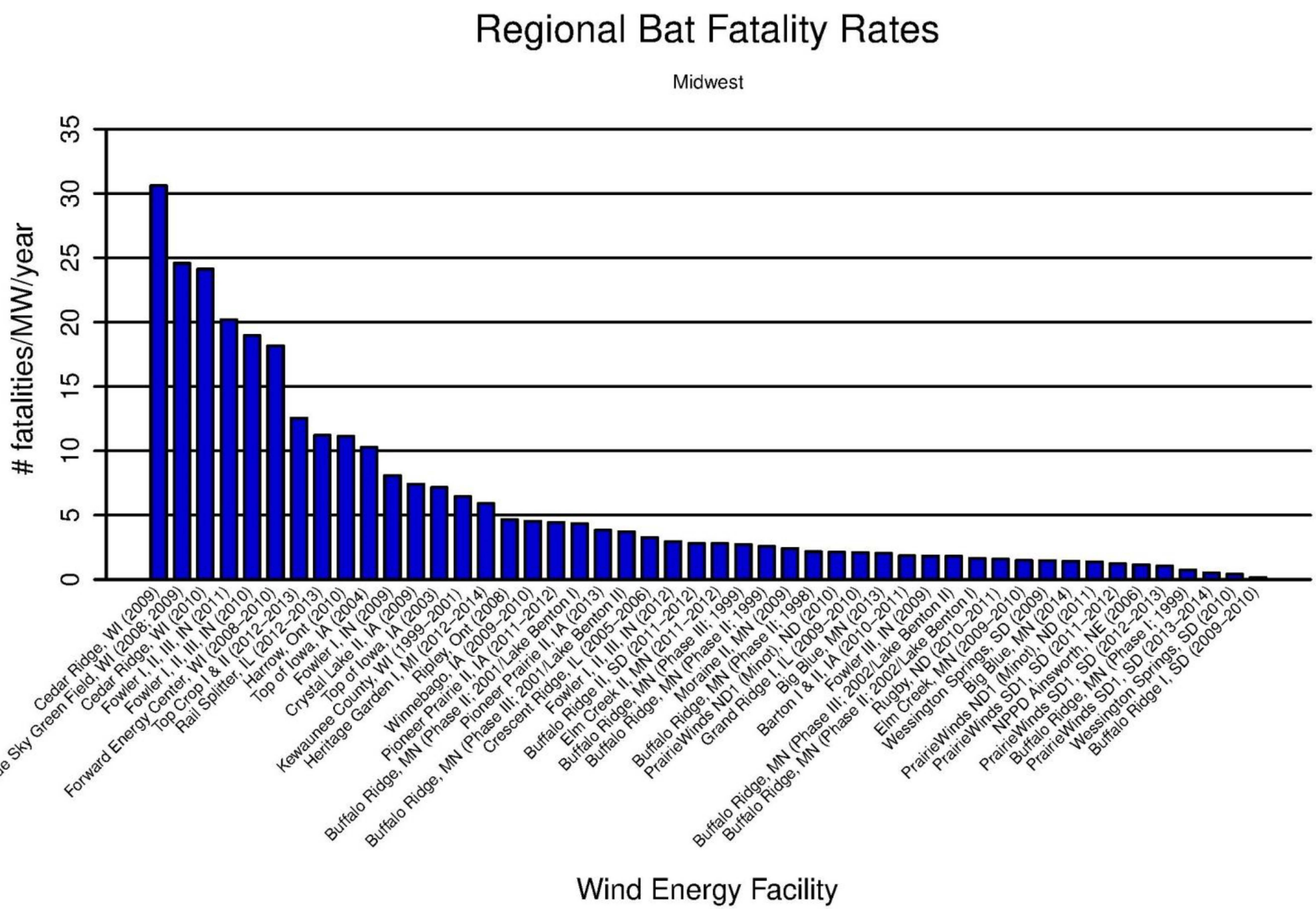

Figure 9. Fatality rates for bats (number of bats per megawatt per year) from publicly available wind energy facilities in the Midwest region of North America.

Figure 9. Fatality rates for bats (number of bats per megawatt per year) from publicly available wind energy facilities in the Midwest region of North America.

Wind Energy Facility	Reference	Wind Energy Facility	Reference	Wind Energy Facility	Reference
Cedar Ridge, WI (09)	BHE Environmental 2010	Pioneer Prairie II, IA (11-12)	Chodachek et al. 2012	Fowler III, IN (09)	Johnson et al. 2010b
Blue Sky Green Field, WI (08; 09)	Gruver et al. 2009	Buffalo Ridge, MN (Phase II; 01/Lake Benton I)	Johnson et al. 2004	Buffalo Ridge, MN (Phase III; 02/Lake Benton II)	Johnson et al. 2004
Cedar Ridge, WI (10)	BHE Environmental 2011	Foote Creek Rim, WY (Phase I; 99)	Young et al. 2003a	Milford I & II, UT (11-12)	Stantec 2012b
Fowler I, II, III, IN (11)	Good et al. 2012	Pioneer Prairie II, IA (13)	Chodachek et al. 2014	Dry Lake II, AZ (11-12)	Thompson and Bay 2012
Fowler I, II, III, IN (10)	Good et al. 2011	Buffalo Ridge, MN (Phase III; 01/Lake Benton II)	Johnson et al. 2004	Buffalo Ridge, MN (Phase II; 02/Lake Benton I)	Johnson et al. 2004
Forward Energy Center, WI (08-10)	Grodsky and Drake 2011	Dry Lake I, AZ (09-10)	Thompson et al. 2011	Rugby, ND (10-11)	Derby et al. 2011c
Top Crop I & II (12-13)	Good et al. 2013c	Crescent Ridge, IL (05-06)	Kerlinger et al. 2007	Foote Creek Rim, WY (Phase I; 01-02)	Young et al. 2003a, 2003b
Summerview, Alb (06; 07)	Baerwald 2008	Judith Gap, MT (09)	Poulton and Erickson 2010	Elm Creek, MN (09-10)	Derby et al. 2010e
Rail Splitter, IL (12-13)	Good et al. 2013b	Fowler I, II, III, IN (12)	Good et al. 2013a	Wessington Springs, SD (09)	Derby et al. 2010c
Harrow, Ont (10)	NRSI 2011	Buffalo Ridge II, SD (11-12)	Derby et al. 2012a	Big Blue, MN (14)	Fagen Engineering 2015
Summerview, Alb (05-06)	Brown and Hamilton 2006	Elm Creek II, MN (11-12)	Derby et al. 2012b	PrairieWinds ND1 (Minot), ND (11)	Derby et al. 2012d
Top of Iowa, IA (04)	Jain 2005	Buffalo Ridge, MN (Phase III; 99)	Johnson et al. 2000	PrairieWinds SD1, SD (11-12)	Derby et al. 2012c
Judith Gap, MT (06-07)	TRC 2008	Buffalo Ridge, MN (Phase II; 99)	Johnson et al. 2000	NPPD Ainsworth, NE (06)	Derby et al. 2007
Fowler I, IN (09)	Johnson et al. 2010a	Moraine II, MN (09)	Derby et al. 2010f	Foote Creek Rim, WY (Phase I; 00)	Young et al. 2003a, 2003b
Crystal Lake II, IA (09)	Derby et al. 2010b	Buffalo Ridge, MN (Phase II; 98)	Johnson et al. 2000	PrairieWinds SD1, SD (12-13)	Derby et al. 2013a
Top of Iowa, IA (03)	Jain 2005	PrairieWinds ND1 (Minot), ND (10)	Derby et al. 2011d	Buffalo Ridge, MN (Phase I; 99)	Johnson et al. 2000
Kewaunee County, WI (99-01)	Howe et al. 2002	Grand Ridge I, IL (09-10)	Derby et al. 2010a	PrairieWinds SD1, SD (13-14)	Derby et al. 2014
Heritage Garden I, MI (12-14)	Kerlinger et al. 2014	Milford I, UT (10-11)	Stantec 2011b	Wessington Springs, SD (10)	Derby et al. 2011a
Ripley, Ont (08)	Jacques Whitford 2009	Big Blue, MN (13)	Fagen Engineering 2014	Buffalo Ridge I, SD (09-10)	Derby et al. 2010d
Winnebago, IA (09-10)	Derby et al. 2010g	Barton I & II, IA (10-11)	Derby et al. 2011b		

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Appendix A: North American Fatality Summary Tables

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as bat passes per detector night. Fatality estimate given as the number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Sweetland, SD	0.94	7/30/17 – 10/14/17			
Midwest					
Cedar Ridge, WI (2009)	9.97[A,B,C,D]	7/16/07-9/30/07	30.61	41	67.6
Blue Sky Green Field, WI (2008; 2009)	7.7[A]	7/24/07-10/29/07	24.57	88	145
Cedar Ridge, WI (2010)	9.97[A,B,C,D]	7/16/07-9/30/07	24.12	41	68
Fowler I, II, III, IN (2011)	NA	NA	20.19	355	600
Fowler I, II, III, IN (2010)	NA	NA	18.96	355	600
Forward Energy Center, WI (2008-2010)	6.97	8/5/08-11/08/08	18.17	86	129
Top Crop I & II, IL (2012-2013)	NA	NA	12.55	200 (68 Phase I, 132 Phase II)	300 (102 Phase I, 198 Phase II)
Rail Splitter, IL (2012-2013)	NA	NA	11.21	67	100.5
Harrow, Ont (2010)	NA	NA	11.13	24 (four 6-turbine facilities)	39.6
Top of Iowa, IA (2004)	35.7	5/26/04-9/24/04	10.27	89	80
Fowler I, IN (2009)	NA	NA	8.09	162	301
Crystal Lake II, IA (2009)	NA	NA	7.42	80	200
Top of Iowa, IA (2003)	NA	NA	7.16	89	80
Kewaunee County, WI (1999-2001)	NA	NA	6.45	31	20.46
Heritage Garden I, MI (2012-2014)	NA	NA	5.9	14	28
Ripley, Ont (2008)	NA	NA	4.67	38	76
Winnebago, IA (2009-2010)	NA	NA	4.54	10	20
Pioneer Prairie II, IA (2011-2012)	NA	NA	4.43	62	102.3
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	2.2[B]	6/15/01-9/15/01	4.35	143	107.25
Pioneer Prairie II, IA (2013)	NA	NA	3.83	62	102.3
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	2.2[B]	6/15/01-9/15/01	3.71	138	103.5
Crescent Ridge, IL (2005-2006)	NA	NA	3.27	33	49.5
Fowler I, II, III, IN (2012)	NA	NA	2.96	355	600
Elm Creek II, MN (2011-2012)	NA	NA	2.81	62	148.8
Buffalo Ridge II, SD (2011-2012)	NA	NA	2.81	105	210
Buffalo Ridge, MN (Phase III; 1999)	NA	NA	2.72	138	103.5
Buffalo Ridge, MN (Phase II; 1999)	NA	NA	2.59	143	107.25
Moraine II, MN (2009)	NA	NA	2.42	33	49.5
Buffalo Ridge, MN (Phase II; 1998)	NA	NA	2.16	143	107.25
PrairieWinds ND1 (Minot), ND (2010)	NA	NA	2.13	80	115.5
Grand Ridge I, IL (2009-2010)	NA	NA	2.1	66	99
Big Blue, MN (2013)	NA	NA	2.04	18	36

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as bat passes per detector night. Fatality estimate given as the number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Barton I & II, IA (2010-2011)	NA	NA	1.85	80	160
Fowler III, IN (2009)	NA	NA	1.84	60	99
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	1.9[B]	6/15/02-9/15/02	1.81	138	103.5
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	1.9[B]	6/15/02-9/15/02	1.64	143	107.25
Rugby, ND (2010-2011)	NA	NA	1.6	71	149
Elm Creek, MN (2009-2010)	NA	NA	1.49	67	100
Wessington Springs, SD (2009)	NA	NA	1.48	34	51
Big Blue, MN (2014)	NA	NA	1.43	18	36
PrairieWinds ND1 (Minot), ND (2011)	NA	NA	1.39	80	115.5
PrairieWinds SD1, SD (2011-2012)	NA	NA	1.23	108	162
NPPD Ainsworth, NE (2006)	NA	NA	1.16	36	20.5
PrairieWinds SD1, SD (2012-2013)	NA	NA	1.05	108	162
Buffalo Ridge, MN (Phase I; 1999)	NA	NA	0.74	73	25
PrairieWinds SD1, SD (2013-2014)	NA	NA	0.52	108	162
Wessington Springs, SD (2010)	NA	NA	0.41	34	51
Buffalo Ridge I, SD (2009-2010)	NA	NA	0.16	24	50.4
Southern Plains					
Barton Chapel, TX (2009-2010)	NA	NA	3.06	60	120
Big Smile, OK (2012-2013)	NA	NA	2.9	66	132
Buffalo Gap II, TX (2007-2008)	NA	NA	0.14	155	233
Red Hills, OK (2012-2013)	NA	NA	0.11	82	123
Buffalo Gap I, TX (2006)	NA	NA	0.1	67	134
Southwest					
Dry Lake I, AZ (2009-2010)	8.8	4/29/10-11/10/10	3.43	30	63
Dry Lake II, AZ (2011-2012)	11.5	5/11/11-10/26/11	1.66	31	65
California					
Shiloh I, CA (2006-2009)	NA	NA	3.92	100	150
Shiloh II, CA (2010-2011)	NA	NA	3.8	75	150
Shiloh II, CA (2011-2012)	NA	NA	3.4	75	150
Shiloh II, CA (2009-2010)	NA	NA	2.6	75	150
High Winds, CA (2003-2004)	NA	NA	2.51	90	162
Dillon, CA (2008-2009)	NA	NA	2.17	45	45
Montezuma I, CA (2011)	NA	NA	1.9	16	36.8
High Winds, CA (2004-2005)	NA	NA	1.52	90	162
Alta I, CA (2011-2012)	4.42[E]	6/26/09 - 10/31/09	1.28	100	150
Montezuma II, CA (2012-2013)	NA	NA	0.91	34	78.2
Montezuma I, CA (2012)	NA	NA	0.84	16	36.8
Diablo Winds, CA (2005-2007)	NA	NA	0.82	31	20.46
Shiloh III, CA (2012-2013)	NA	NA	0.4	50	102.5
Solano III, CA (2012-2013)	NA	NA	0.31	55	128
Alite, CA (2009-2010)	NA	NA	0.24	8	24

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as bat passes per detector night. Fatality estimate given as the number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Alta I-V, CA (2013-2014)	NA	NA	0.2	290	720 (150 GE, 570 vestas)
Mustang Hills, CA (2012-2013)	NA	NA	0.1	50	150
Alta II-V, CA (2011-2012)	0.78	6/26/09 - 10/31/09	0.08	190	570
Pinyon Pines I & II, CA (2013-2014)	NA	NA	0.04	100	NA
Alta VIII, CA (2012-2013)	NA	NA	0	50	150
Pacific Northwest					
Palouse Wind, WA (2012-2013)	NA	NA	4.23	58	104.4
Biglow Canyon, OR (Phase II; 2009-2010)	NA	NA	2.71	65	150
Nine Canyon, WA (2002-2003)	NA	NA	2.47	37	48.1
Stateline, OR/WA (2003)	NA	NA	2.29	454	299
Elkhorn, OR (2010)	NA	NA	2.14	61	101
White Creek, WA (2007-2011)	NA	NA	2.04	89	204.7
Biglow Canyon, OR (Phase I; 2008)	NA	NA	1.99	76	125.4
Leaning Juniper, OR (2006-2008)	NA	NA	1.98	67	100.5
Big Horn, WA (2006-2007)	NA	NA	1.9	133	199.5
Combine Hills, OR (Phase I; 2004-2005)	NA	NA	1.88	41	41
Linden Ranch, WA (2010-2011)	NA	NA	1.68	25	50
Pebble Springs, OR (2009-2010)	NA	NA	1.55	47	98.7
Hopkins Ridge, WA (2008)	NA	NA	1.39	87	156.6
Harvest Wind, WA (2010-2012)	NA	NA	1.27	43	98.9
Elkhorn, OR (2008)	NA	NA	1.26	61	101
Vansycle, OR (1999)	NA	NA	1.12	38	24.9
Klondike III (Phase I), OR (2007-2009)	NA	NA	1.11	125	223.6
Stateline, OR/WA (2001-2002)	NA	NA	1.09	454	299
Stateline, OR/WA (2006)	NA	NA	0.95	454	299
Tuolumne (Windy Point I), WA (2009-2010)	NA	NA	0.94	62	136.6
Klondike, OR (2002-2003)	NA	NA	0.77	16	24
Combine Hills, OR (2011)	NA	NA	0.73	104	104
Hopkins Ridge, WA (2006)	NA	NA	0.63	83	150
Biglow Canyon, OR (Phase I; 2009)	NA	NA	0.58	76	125.4
Biglow Canyon, OR (Phase II; 2010-2011)	NA	NA	0.57	65	150
Hay Canyon, OR (2009-2010)	NA	NA	0.53	48	100.8
Windy Flats, WA (2010-2011)	NA	NA	0.41	114	262.2
Klondike II, OR (2005-2006)	NA	NA	0.41	50	75
Vantage, WA (2010-2011)	NA	NA	0.4	60	90
Wild Horse, WA (2007)	NA	NA	0.39	127	229
Goodnoe, WA (2009-2010)	NA	NA	0.34	47	94
Marengo II, WA (2009-2010)	NA	NA	0.27	39	70.2

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as bat passes per detector night. Fatality estimate given as the number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Biglow Canyon, OR (Phase III; 2010-2011)	NA	NA	0.22	76	174.8
Marengo I, WA (2009-2010)	NA	NA	0.17	78	140.4
Klondike IIIa (Phase II), OR (2008-2010)	NA	NA	0.14	51	76.5
Kittitas Valley, WA (2011-2012)	NA	NA	0.12	48	100.8
		Rocky Mountains			
Summerview, Alb (2006; 2007)	7.65[B]	07/15/06-07-09/30/06-07	11.42	39	70.2
Summerview, Alb (2005-2006)	NA	NA	10.27	39	70.2
Judith Gap, MT (2006-2007)	NA	NA	8.93	90	135
Foote Creek Rim, WY (Phase I; 1999)	NA	NA	3.97	69	41.4
Judith Gap, MT (2009)	NA	NA	3.2	90	135
Milford I, UT (2010-2011)	NA	NA	2.05	58	145
Milford I & II, UT (2011-2012)	NA	NA	1.67	107	160.5 (58.5 Phase I, 102 Phase II)
Foote Creek Rim, WY (Phase I; 2001-2002)	2.2[B,D]	6/15/01-9/1/01	1.57	69	41.4
Foote Creek Rim, WY (Phase I; 2000)	2.2[B,D]	6/15/00-9/1/00	1.05	69	41.4
		Southeast			
Buffalo Mountain, TN (2005)	NA	NA	39.7	18	28.98
Buffalo Mountain, TN (2000-2003)	23.7[D]		31.54	3	1.98
		Northeast			
Pinnacle, WV (2012)	NA	NA	40.2	23	55.2
Mountaineer, WV (2003)	30.09	7/15/09-10/7/09	31.69	44	66
Mount Storm, WV (2009)	NA	NA	17.53	132	264
Noble Wethersfield, NY (2010)	NA	NA	16.3	84	126
Criterion, MD (2011)	36.67[F]	4/18/10-10/15/10	15.61	28	70
Mount Storm, WV (2010)	NA	NA	15.18	132	264
Locust Ridge, PA (Phase II; 2010)	NA	NA	14.38	51	102
Locust Ridge, PA (Phase II; 2009)	NA	NA	14.11	51	102
Casselman, PA (2008)	NA	NA	12.61	23	34.5
Maple Ridge, NY (2006)	NA	NA	11.21	120	198
Cohocton/Dutch Hills, NY (2010)	NA	NA	10.32	50	125
Wolfe Island, Ont (July-December 2010)	NA	NA	9.5	86	197.8
Cohocton/Dutch Hill, NY (2009)	NA	NA	8.62	50	125
Casselman, PA (2009)	NA	NA	8.6	23	34.5
Noble Bliss, NY (2008)	NA	NA	7.8	67	100
Criterion, MD (2012)	NA	NA	7.62	28	70
Mount Storm, WV (2011)	NA	NA	7.43	132	264
Maple Ridge, NY (2012)	35.2	7/20/08-10/12/08	7.3	195	321.75
Mount Storm, WV (Fall 2008)	NA	NA	6.62	82	164

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as bat passes per detector night. Fatality estimate given as the number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Maple Ridge, NY (2007)	NA	NA	6.49	195	321.75
Wolfe Island, Ont (July-December 2009)	NA	NA	6.42	86	197.8
Criterion, MD (2013)	NA	NA	5.32	28	70
Maple Ridge, NY (2007-2008)	1.9[C]	8/1/09-09/31/09	4.96	195	321.75
Noble Clinton, NY (2009)	NA	NA	4.5	67	100
Casselman Curtailment, PA (2008)	NA	NA	4.4	23	35.4
Noble Altona, NY (2010)	16.1[C]	8/16/09-09/15/09	4.34	65	97.5
Noble Ellenburg, NY (2009)	NA	NA	3.91	54	80
Noble Bliss, NY (2009)	NA	NA	3.85	67	100
Lempster, NH (2010)	NA	NA	3.57	12	24
Noble Ellenburg, NY (2008)	2.1[C]	8/8/08-09/31/08	3.46	54	80
Noble Clinton, NY (2008)	NA	NA	3.14	67	100
Lempster, NH (2009)	24.6	4/16/12-10/23/12	3.11	12	24
Record Hill, ME (2012)	NA	NA	2.96	22	50.6
Mars Hill, ME (2007)	NA	NA	2.91	28	42
Wolfe Island, Ont (July-December 2011)	NA	NA	2.49	86	197.8
Noble Chateaugay, NY (2010)	NA	NA	2.44	71	106.5
High Sheldon, NY (2010)	NA	NA	2.33	75	112.5
Stetson Mountain II, ME (2012)	NA	NA	2.27	17	25.5
Beech Ridge, WV (2012)	NA	NA	2.03	67	100.5
Munnsville, NY (2008)	NA	NA	1.93	23	34.5
High Sheldon, NY (2011)	NA	NA	1.78	75	112.5
Stetson Mountain II, ME (2010)	28.5; 0.3[G]	7/10/09-10/15/09	1.65	17	25.5
Stetson Mountain I, ME (2009)	NA	NA	1.4	38	57
Beech Ridge, WV (2013)	NA	NA	0.58	67	100.5
Record Hill, ME (2014)	NA	NA	0.55	22	50.6
Mars Hill, ME (2008)	NA	NA	0.45	28	42
Stetson Mountain I, ME (2011)	NA	NA	0.28	38	57
Stetson Mountain I, ME (2013)	NA	NA	0.18	38	57
Rollins, ME (2012)	NA	NA	0.18	40	60
Kibby, ME (2011)	NA	NA	0.12	44	132

A = Activity rate based on pre-construction monitoring; data for all other activity and fatality rates were collected concurrently

B = Activity rate was averaged across phases and/or years

C = Activity rate based on data collected at various heights; all other activity rates are from ground-based units only

D = Activity rate calculated by WEST from data presented in referenced report

E = Average of ground-based detectors at CPC Proper (Phase I) for late summer/fall period only

F = Activity rate based on data collected from ground-based units excluding reference stations during the spring, summer and fall seasons

G = The overall activity rate of 28.5 is from reference stations located along forest edges, which may be attractive to bats; the activity rate of 0.3 is from one unit placed on a nacelle

Appendix A1 (*continued*). Wind energy facilities in North America with comparable activity and fatality data for bats. Data from the following sources:

Facility	Activity Estimate	Fatality Estimate	Facility	Activity Estimate	Fatality Estimate
Sweetland, SD	This study				
Alite, CA (09-10)		Chatfield et al. 2010	Lempster, NH (09)		Tidhar et al. 2010
Alta Wind I, CA (11-12)	Solick et al. 2010	Chatfield et al. 2012	Lempster, NH (10)		Tidhar et al. 2011
Alta Wind I-V, CA (13-14)		Chatfield et al. 2014	Linden Ranch, WA (10-11)		Enz and Bay 2011
Alta Wind II-V, CA (11-12)	Solick et al. 2010	Chatfield et al. 2012	Locust Ridge, PA (Phase II; 09)		Arnett et al.
Alta VIII, CA (12-13)		Chatfield and Bay 2014	Locust Ridge, PA (Phase II; 10)		Arnett et al.
Barton I & II, IA (10-11)		Derby et al. 2011b	Maple Ridge, NY (06)		Jain et al. 2007
Barton Chapel, TX (09-10)		WEST 2011	Maple Ridge, NY (07)		Jain et al. 2009a
Beech Ridge, WV (12)		Tidhar et al. 2013a	Maple Ridge, NY (07-08)		Jain et al. 2009b
Beech Ridge, WV (13)		Young et al. 2014a	Maple Ridge, NY (12)		Tidhar et al. 2013b
Big Blue, MN (13)		Fagen Engineering 2014	Marengo I, WA (09-10)		URS Corporation 2010b
Big Blue, MN (14)		Fagen Engineering 2015	Marengo II, WA (09-10)		URS Corporation 2010c
Big Horn, WA (06-07)		Kronner et al. 2008	Mars Hill, ME (07)		Stantec 2008a
Big Smile, OK (12-13)		Derby et al. 2013b	Mars Hill, ME (08)		Stantec 2009a
Biglow Canyon, OR (Phase I; 08)		Jeffrey et al. 2009b	Milford I, UT (10-11)		Stantec 2011b
Biglow Canyon, OR (Phase I; 09)		Enk et al. 2010	Milford I & II, UT (11-12)		Stantec 2012b
Biglow Canyon, OR (Phase II; 09-10)		Enk et al. 2011b	Montezuma I, CA (11)		ICF International 2012
Biglow Canyon, OR (Phase II; 10-11)		Enk et al. 2012b	Montezuma I, CA (12)		ICF International 2013
Biglow Canyon, OR (Phase III; 10-11)		Enk et al. 2012a	Montezuma II, CA (12-13)		Harvey & Associates 2013
Blue Sky Green Field, WI (08; 09)	Gruver 2008	Gruver et al. 2009	Moraine II, MN (09)		Derby et al. 2010f
Buffalo Gap I, TX (06)		Tierney 2007	Mount Storm, WV (Fall 08)	Young et al. 2009c	Young et al. 2009c
Buffalo Gap II, TX (07-08)		Tierney 2009	Mount Storm, WV (09)	Young et al. 2009a, 2010b	Young et al. 2009a, 2010b
Buffalo Mountain, TN (00-03)	Fiedler 2004	Nicholson et al. 2005	Mount Storm, WV (10)	Young et al. 2010a, 2011b	Young et al. 2010a, 2011b
Buffalo Mountain, TN (05)		Fiedler et al. 2007	Mount Storm, WV (11)		Young et al. 2011a, 2012a
Buffalo Ridge, MN (Phase I; 99)		Johnson et al. 2000	Mountaineer, WV (03)		Kerns and Kerlinger 2004a
Buffalo Ridge, MN (Phase II; 98)		Johnson et al. 2000	Munnsville, NY (08)		Stantec 2009b
Buffalo Ridge, MN (Phase II; 99)		Johnson et al. 2000	Mustang Hills, CA (12-13)		Chatfield and Bay 2014
Buffalo Ridge, MN (Phase II; 01/Lake Benton I)	Johnson et al. 2004	Johnson et al. 2004	Nine Canyon, WA (02-03)		Erickson et al. 2003
Buffalo Ridge, MN (Phase II; 02/Lake Benton I)	Johnson et al. 2004	Johnson et al. 2004	Noble Altona, NY (10)	Reynolds 2010c	Jain et al. 2011a
Buffalo Ridge, MN (Phase III; 99)		Johnson et al. 2000	Noble Bliss, NY (08)		Jain et al.2009c
Buffalo Ridge, MN (Phase III; 01/Lake Benton II)	Johnson et al. 2004	Johnson et al. 2004	Noble Bliss, NY (09)		Jain et al. 2010c
Buffalo Ridge, MN (Phase III; 02/Lake Benton II)	Johnson et al. 2004	Johnson et al. 2004	Noble Chateaugay, NY (10)		Jain et al. 2011b
Buffalo Ridge I, SD (09-10)		Derby et al. 2010d	Noble Clinton, NY (08)	Reynolds 2010a	Jain et al. 2009d
Buffalo Ridge II, SD (11-12)		Derby et al. 2012a	Noble Clinton, NY (09)	Reynolds 2010a	Jain et al. 2010a
Casselman, PA (08)		Arnett et al. 2009b	Noble Ellenburg, NY (08)		Jain et al. 2009e
Casselman, PA (09)		Arnett et al. 2010	Noble Ellenburg, NY (09)	Reynolds 2010b	Jain et al. 2010b
Casselman Curtailment, PA (08)		Arnett et al. 2009a	Noble Wethersfield, NY (10)		Jain et al. 2011c
Cedar Ridge, WI (09)	BHE Environmental 2008	BHE Environmental 2010	NPPD Ainsworth, NE (06)		Derby et al. 2007
Cedar Ridge, WI (10)	BHE Environmental 2008	BHE Environmental 2011	Palouse Wind, WA (12-13)		Stantec 2013a
Cohocton/Dutch Hill, NY (09)		Stantec 2010	Pebble Springs, OR (09-10)		Gritski and Kronner 2010b
Cohocton/Dutch Hills, NY (10)		Stantec 2011a	Pinnacle, WV (12)		Hein et al. 2013b
Combine Hills, OR (Phase I; 04-05)		Young et al. 2006	Pinyon Pines I&II, CA (13-14)		Chatfield and Russo 2014
Combine Hills, OR (11)		Enz et al. 2012	Pioneer Prairie I, IA (Phase II; 11-12)		Chodachek et al. 2012
Crescent Ridge, IL (05-06)		Kerlinger et al. 2007	Pioneer Prairie II, IA (13)		Chodachek et al. 2014
Criterion, MD (11)		Young et al. 2012b	PrairieWinds ND1 (Minot), ND (10)		Derby et al. 2011d
Criterion, MD (12)		Young et al. 2013	PrairieWinds ND1 (Minot), ND (11)		Derby et al. 2012d
Criterion, MD (13)		Young et al. 2014b	PrairieWinds SD1 (Crow Lake), SD (11-12)		Derby et al. 2012c

Appendix A1 (*continued*). Wind energy facilities in North America with comparable activity and fatality data for bats. Data from the following sources:

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

Appendix A2. Bat fatality estimates for North American wind-energy facilities.

Project	Bat Fatalities (Bats/Megawatt/ Year)	Predominant Habitat Type	Citation
Alite, CA (2009-2010)	0.24	Shrub/scrub & grassland	Chatfield et al. 2010
Alta I, CA (2011-2012)	1.28	Woodland, grassland, shrubland	Chatfield et al. 2012
Alta I-V, CA (2013-2014)	0.2	NA	Chatfield et al. 2014
Alta II-V, CA (2011-2012)	0.08	Desert scrub	Chatfield et al. 2012
Alta VIII, CA (2012-2013)	0	Grassland and riparian	Chatfield and Bay 2014
Barton I & II, IA (2010-2011)	1.85	Agriculture	Derby et al. 2011b
Barton Chapel, TX (2009-2010)	3.06	Agriculture/forest	WEST 2011
Beech Ridge, WV (2012)	2.03	Forest	Tidhar et al. 2013a
Beech Ridge, WV (2013)	0.58	Forest	Young et al. 2014a
Big Blue, MN (2013)	2.04	Agriculture	Fagen Engineering 2014
Big Blue, MN (2014)	1.43	Agriculture	Fagen Engineering 2015
Big Horn, WA (2006-2007)	1.9	Agriculture/grassland	Kronner et al. 2008
Big Smile, OK (2012-2013)	2.9	Grassland, agriculture	Derby et al. 2013b
Biglow Canyon, OR (Phase I; 2008)	1.99	Agriculture/grassland	Jeffrey et al. 2009b
Biglow Canyon, OR (Phase I; 2009)	0.58	Agriculture/grassland	Enk et al. 2010
Biglow Canyon, OR (Phase II; 2009-2010)	2.71	Agriculture	Enk et al. 2011b
Biglow Canyon, OR (Phase II; 2010-2011)	0.57	Grassland/shrub-steppe, agriculture	Enk et al. 2012b
Biglow Canyon, OR (Phase III; 2010-2011)	0.22	Grassland/shrub-steppe, agriculture	Enk et al. 2012a
Blue Sky Green Field, WI (2008; 2009)	24.57	Agriculture	Gruver et al. 2009
Buffalo Gap I, TX (2006)	0.1	Grassland	Tierney 2007
Buffalo Gap II, TX (2007-2008)	0.14	Forest	Tierney 2009
Buffalo Mountain, TN (2000-2003)	31.54	Forest	Nicholson et al. 2005
Buffalo Mountain, TN (2005)	39.7	Forest	Fiedler et al. 2007
Buffalo Ridge, MN (Phase I; 1999)	0.74	Agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1998)	2.16	Agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1999)	2.59	Agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	4.35	Agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	1.64	Agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase III; 1999)	2.72	Agriculture	Johnson et al. 2000

Appendix A2. Bat fatality estimates for North American wind-energy facilities.

Project	Bat Fatalities (Bats/Megawatt/ Year)	Predominant Habitat Type	Citation
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	3.71	Agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	1.81	Agriculture	Johnson et al. 2004
Buffalo Ridge I, SD (2009-2010)	0.16	Agriculture/grassland	Derby et al. 2010d
Buffalo Ridge II, SD (2011-2012)	2.81	Agriculture, grassland	Derby et al. 2012a
Casselman, PA (2008)	12.61	Forest	Arnett et al. 2009b
Casselman, PA (2009)	8.6	Forest, pasture, grassland	Arnett et al. 2010
Casselman Curtailment, PA (2008)	4.4	Forest	Arnett et al. 2009a
Cedar Ridge, WI (2009)	30.61	Agriculture	BHE Environmental 2010
Cedar Ridge, WI (2010)	24.12	Agriculture	BHE Environmental 2011
Cohocton/Dutch Hill, NY (2009)	8.62	Agriculture/forest	Stantec 2010
Cohocton/Dutch Hills, NY (2010)	10.32	Agriculture, forest	Stantec 2011a
Combine Hills, OR (Phase I; 2004-2005)	1.88	Agriculture/grassland	Young et al. 2006
Combine Hills, OR (2011)	0.73	Grassland/shrub-steppe, agriculture	Enz et al. 2012
Crescent Ridge, IL (2005-2006)	3.27	Agriculture	Kerlinger et al. 2007
Criterion, MD (2011)	15.61	Forest, agriculture	Young et al. 2012b
Criterion, MD (2012)	7.62	Forest, agriculture	Young et al. 2013
Criterion, MD (2013)	5.32	Forest, agriculture	Young et al. 2014b
Crystal Lake II, IA (2009)	7.42	Agriculture	Derby et al. 2010b
Diablo Winds, CA (2005-2007)	0.82	NA	WEST 2006, 2008
Dillon, CA (2008-2009)	2.17	Desert	Chatfield et al. 2009
Dry Lake I, AZ (2009-2010)	3.43	Desert grassland/forested	Thompson et al. 2011
Dry Lake II, AZ (2011-2012)	1.66	Desert grassland/forested	Thompson and Bay 2012
Elkhorn, OR (2008)	1.26	Shrub/scrub & agriculture	Jeffrey et al. 2009a
Elkhorn, OR (2010)	2.14	Shrub/scrub & agriculture	Enk et al. 2011a
Elm Creek, MN (2009-2010)	1.49	Agriculture	Derby et al. 2010e
Elm Creek II, MN (2011-2012)	2.81	Agriculture, grassland	Derby et al. 2012b
Foote Creek Rim, WY (Phase I; 1999)	3.97	Grassland	Young et al. 2003a
Foote Creek Rim, WY (Phase I; 2000)	1.05	Grassland	Young et al. 2003a
Foote Creek Rim, WY (Phase I; 2001-2002)	1.57	Grassland	Young et al. 2003a

Appendix A2. Bat fatality estimates for North American wind-energy facilities.

Project	Bat Fatalities (Bats/Megawatt/ Year)	Predominant Habitat Type	Citation
Forward Energy Center, WI (2008-2010)	18.17	Agriculture	Grodsky and Drake 2011
Fowler I, IN (2009)	8.09	Agriculture	Johnson et al. 2010a
Fowler I, II, III, IN (2010)	18.96	Agriculture	Good et al. 2011
Fowler I, II, III, IN (2011)	20.19	Agriculture	Good et al. 2012
Fowler I, II, III, IN (2012)	2.96	Agriculture	Good et al. 2013a
Fowler III, IN (2009)	1.84	Agriculture	Johnson et al. 2010b
Goodnoe, WA (2009-2010)	0.34	Grassland and shrub-steppe	URS Corporation 2010a
Grand Ridge I, IL (2009-2010)	2.1	Agriculture	Derby et al. 2010a
Harrow, Ont (2010)	11.13	Agriculture	Natural Resource Solutions Inc. (NRSI) 2011
Harvest Wind, WA (2010-2012)	1.27	Grassland/shrub-steppe	Downes and Gritski 2012a
Hay Canyon, OR (2009-2010)	0.53	Agriculture	Gritski and Kronner 2010a
Heritage Garden I, MI (2012-2014)	5.9	Agriculture	Kerlinger et al. 2014
High Sheldon, NY (2010)	2.33	Agriculture	Tidhar et al. 2012a
High Sheldon, NY (2011)	1.78	Agriculture	Tidhar et al. 2012b
High Winds, CA (2003-2004)	2.51	Agriculture/grassland	Kerlinger et al. 2006
High Winds, CA (2004-2005)	1.52	Agriculture/grassland	Kerlinger et al. 2006
Hopkins Ridge, WA (2006)	0.63	Agriculture/grassland	Young et al. 2007
Hopkins Ridge, WA (2008)	1.39	Agriculture/grassland	Young et al. 2009b
Judith Gap, MT (2006-2007)	8.93	Agriculture/grassland	TRC 2008
Judith Gap, MT (2009)	3.2	Agriculture/grassland	Poulton and Erickson 2010
Kewaunee County, WI (1999-2001)	6.45	Agriculture	Howe et al. 2002
Kibby, ME (2011)	0.12	Forest; commercial forest	Stantec 2012a
Kittitas Valley, WA (2011-2012)	0.12	Sagebrush-steppe, grassland	Stantec Consulting Services 2012
Klondike, OR (2002-2003)	0.77	Agriculture/grassland	Johnson et al. 2003
Klondike II, OR (2005-2006)	0.41	Agriculture/grassland	NWC and WEST 2007
Klondike III (Phase I), OR (2007-2009)	1.11	Agriculture/grassland	Gritski et al. 2010
Klondike IIIa (Phase II), OR (2008-2010)	0.14	Grassland/shrub-steppe and agriculture	Gritski et al. 2011
Leaning Juniper, OR (2006-2008)	1.98	Agriculture	Gritski et al. 2008
Lempster, NH (2009)	3.11	Grasslands/forest/rocky embankments	Tidhar et al. 2010

Appendix A2. Bat fatality estimates for North American wind-energy facilities.

Project	Bat Fatalities (Bats/Megawatt/ Year)	Predominant Habitat Type	Citation
Lempster, NH (2010)	3.57	Grasslands/forest/rocky embankments	Tidhar et al. 2011
Linden Ranch, WA (2010-2011)	1.68	Grassland/shrub-steppe, agriculture	Enz and Bay 2011
Locust Ridge, PA (Phase II; 2009)	14.11	Grassland	Arnett et al. 2011
Locust Ridge, PA (Phase II; 2010)	14.38	Grassland	Arnett et al. 2011
Maple Ridge, NY (2006)	11.21	Agriculture/forested	Jain et al. 2007
Maple Ridge, NY (2007)	6.49	Agriculture/forested	Jain et al. 2009a
Maple Ridge, NY (2007-2008)	4.96	Agriculture/forested	Jain et al. 2009b
Maple Ridge, NY (2012)	7.3	Agriculture/forested	Tidhar et al. 2013b
Marengo I, WA (2009-2010)	0.17	Agriculture	URS Corporation 2010b
Marengo II, WA (2009-2010)	0.27	Agriculture	URS Corporation 2010c
Mars Hill, ME (2007)	2.91	Forest	Stantec 2008a
Mars Hill, ME (2008)	0.45	Forest	Stantec 2009a
Milford I, UT (2010-2011)	2.05	Desert shrub	Stantec 2011b
Milford I & II, UT (2011-2012)	1.67	Desert shrub	Stantec 2012b
Montezuma I, CA (2011)	1.9	Agriculture and grasslands	ICF International 2012
Montezuma I, CA (2012)	0.84	Agriculture and grasslands	ICF International 2013
Montezuma II, CA (2012-2013)	0.91	Agriculture	Harvey & Associates 2013
Moraine II, MN (2009)	2.42	Agriculture/grassland	Derby et al. 2010f
Mount Storm, WV (Fall 2008)	6.62	Forest	Young et al. 2009c
Mount Storm, WV (2009)	17.53	Forest	Young et al. 2009a, 2010b
Mount Storm, WV (2010)	15.18	Forest	Young et al. 2010a, 2011b
Mount Storm, WV (2011)	7.43	Forest	Young et al. 2011a, 2012a
Mountaineer, WV (2003)	31.69	Forest	Kerns and Kerlinger 2004a
Munnsville, NY (2008)	1.93	Agriculture/forest	Stantec 2009b
Mustang Hills, CA (2012-2013)	0.1	Grasslands and Riparian	Chatfield and Bay 2014
Nine Canyon, WA (2002-2003)	2.47	Agriculture/grassland	Erickson et al. 2003
Noble Altona, NY (2010)	4.34	Forest	Jain et al. 2011a
Noble Bliss, NY (2008)	7.8	Agriculture/forest	Jain et al. 2009c
Noble Bliss, NY (2009)	3.85	Agriculture/forest	Jain et al. 2010c
Noble Chateaugay, NY (2010)	2.44	Agriculture	Jain et al. 2011b
Noble Clinton, NY (2008)	3.14	Agriculture/forest	Jain et al. 2009d

Appendix A2. Bat fatality estimates for North American wind-energy facilities.

Project	Bat Fatalities (Bats/Megawatt/ Year)	Predominant Habitat Type	Citation
Noble Clinton, NY (2009)	4.5	Agriculture/forest	Jain et al. 2010a
Noble Ellenburg, NY (2008)	3.46	Agriculture/forest	Jain et al. 2009e
Noble Ellenburg, NY (2009)	3.91	Agriculture/forest	Jain et al. 2010b
Noble Wethersfield, NY (2010)	16.3	Agriculture	Jain et al. 2011c
NPPD Ainsworth, NE (2006)	1.16	Agriculture/grassland	Derby et al. 2007
Palouse Wind, WA (2012-2013)	4.23	Agriculture and grasslands	Stantec 2013a
Pebble Springs, OR (2009-2010)	1.55	Grassland	Gritski and Kronner 2010b
Pinnacle, WV (2012)	40.2	Forest	Hein et al. 2013b
Pinyon Pines I & II, CA (2013-2014)	0.04	NA	Chatfield and Russo 2014
Pioneer Prairie II, IA (2011-2012)	4.43	Agriculture, grassland	Chodachek et al. 2012
Pioneer Prairie II, IA (2013)	3.83	Agriculture	Chodachek et al. 2014
PrairieWinds ND1 (Minot), ND (2010)	2.13	Agriculture	Derby et al. 2011d
PrairieWinds ND1 (Minot), ND (2011)	1.39	Agriculture, grassland	Derby et al. 2012d
PrairieWinds SD1, SD (2011-2012)	1.23	Grassland	Derby et al. 2012c
PrairieWinds SD1, SD (2012-2013)	1.05	Grassland	Derby et al. 2013a
PrairieWinds SD1, SD (2013-2014)	0.52	Grassland	Derby et al. 2014
Rail Splitter, IL (2012-2013)	11.21	Agriculture	Good et al. 2013b
Record Hill, ME (2012)	2.96	Forest	Stantec 2013b
Record Hill, ME (2014)	0.55	Forest	Stantec 2015
Red Hills, OK (2012-2013)	0.11	Grassland	Derby et al. 2013c
Ripley, Ont (2008)	4.67	Agriculture	Jacques Whitford 2009
Rollins, ME (2012)	0.18	Forest	Stantec 2013c
Rugby, ND (2010-2011)	1.6	Agriculture	Derby et al. 2011c
Shiloh I, CA (2006-2009)	3.92	Agriculture/grassland	Kerlinger et al. 2009
Shiloh II, CA (2009-2010)	2.6	Agriculture	Kerlinger et al. 2010, 2013a
Shiloh II, CA (2010-2011)	3.8	Agriculture	Kerlinger et al. 2013a
Shiloh II, CA (2011-2012)	3.4	Agriculture	Kerlinger et al. 2013a
Shiloh III, CA (2012-2013)	0.4	NA	Kerlinger et al. 2013b
Solano III, CA (2012-2013)	0.31	NA	AECOM 2013
Stateline, OR/WA (2001-2002)	1.09	Agriculture/grassland	Erickson et al. 2004
Stateline, OR/WA (2003)	2.29	Agriculture/grassland	Erickson et al. 2004

Appendix A2. Bat fatality estimates for North American wind-energy facilities.

Project	Bat Fatalities (Bats/Megawatt/ Year)	Predominant Habitat Type	Citation
Stateline, OR/WA (2006)	0.95	Agriculture/grassland	Erickson et al. 2007
Stetson Mountain I, ME (2009)	1.4	Forest	Stantec 2009c
Stetson Mountain I, ME (2011)	0.28	Forest	Normandeau Associates 2011
Stetson Mountain I, ME (2013)	0.18	Forest	Stantec 2014
Stetson Mountain II, ME (2010)	1.65	Forest	Normandeau Associates 2010
Stetson Mountain II, ME (2012)	2.27	Forest	Stantec 2013d
Summerview, Alb (2005-2006)	10.27	Agriculture	Brown and Hamilton 2006
Summerview, Alb (2006; 2007)	11.42	Agriculture/grassland	Baerwald 2008
Top Crop I & II, IL (2012-2013)	12.55	Agriculture	Good et al. 2013c
Top of Iowa, IA (2003)	7.16	Agriculture	Jain 2005
Top of Iowa, IA (2004)	10.27	Agriculture	Jain 2005
Tuolumne (Windy Point I), WA (2009-2010)	0.94	Grassland/shrub-steppe, agriculture and forest	Enz and Bay 2010
Vansycle, OR (1999)	1.12	Agriculture/grassland	Erickson et al. 2000
Vantage, WA (2010-2011)	0.4	Shrub-steppe, grassland	Ventus Environmental Solutions 2012
Wessington Springs, SD (2009)	1.48	Grassland	Derby et al. 2010c
Wessington Springs, SD (2010)	0.41	Grassland	Derby et al. 2011a
White Creek, WA (2007-2011)	2.04	Grassland/shrub-steppe, agriculture	Downes and Gritski 2012b
Wild Horse, WA (2007)	0.39	Grassland	Erickson et al. 2008
Windy Flats, WA (2010-2011)	0.41	Grassland/shrub-steppe, agriculture	Enz et al. 2011
Winnebago, IA (2009-2010)	4.54	Agriculture/grassland	Derby et al. 2010g
Wolfe Island, Ont (July-December 2009)	6.42	Grassland	Stantec Ltd. 2010
Wolfe Island, Ont (July-December 2010)	9.5	Grassland	Stantec Ltd. 2011
Wolfe Island, Ont (July-December 2011)	2.49	Grassland	Stantec Ltd. 2012

Bat Activity Studies for the
Sweetland Wind Energy Project
Hand County, South Dakota

Final Report

May 7 – October 15, 2018

Prepared for:

Sweetland Wind Farm, LLC

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December 14, 2018

WEST Inc.

EXECUTIVE SUMMARY

In May 2018, Western EcoSystems Technology, Inc. initiated a second year of bat acoustic surveys for the proposed Sweetland Wind Energy Project (Project) in Hand County, South Dakota. The bat acoustic survey reported here was designed to estimate levels of bat activity throughout the Project during the summer and fall of 2018.

Acoustic surveys were conducted from May 7 to October 15, 2018, at a fixed, paired meteorological (met) tower station and at two temporary ground stations. All stations were located predominately in grassland habitat generally representative of future turbine placement. Two fixed AnaBat SD1 and SD2 detectors were paired at a met tower, with one placed near ground level (1.5 meters [m; 5.0 feet (ft)] above ground level) and the other within the proposed rotor-swept height (45 m [148 ft]). A single AnaBat detector was moved between the two temporary stations every two weeks during the study period.

The AnaBat unit at the fixed ground station recorded 106 bat passes on 140 detector nights for a mean of 0.76 ± 0.13 bat passes per detector night. The raised detector recorded 152 bat passes on 161 detector nights for a mean of 0.94 ± 0.14 bat passes per detector night. Bat pass rates were similar between the ground and raised detector when only comparing nights that the paired detectors were simultaneously operating. AnaBat units at temporary stations recorded 1,051 bat passes on 139 detector nights for a mean of 6.40 ± 1.18 bat passes per detector night. Temporary stations were located near forested drainages, which may have attracted bats for roosting or foraging opportunities.

At all stations, 72.6% of bat passes were classified as calls from low frequency species (e.g., big brown bats, hoary bats, and silver-haired bats), and 27.4% of bat passes were classified as calls from high frequency species (e.g., eastern red bats, and *Myotis* species). Hoary bats, eastern red bats, and silver-haired bats are the most numerous casualties reported at North American wind energy facilities, and it is expected these species will likely be the most numerous bat casualties at the Project.

Bat activity at the fixed stations peaked from August 10 - 16 (4.00 bat passes/detector night) with a secondary peak in mid-September. This timing of higher bat activity corresponds with the period of peak bat fatality at most wind-energy facilities and suggests most bat fatalities at the Project will occur during the late summer or early fall. The bat pass rate for the fixed ground detector during the standardized Fall Migration Period was 1.21 ± 0.26 bat passes/detector night. This activity rate was lower than the North American median (7.7 bat passes/detector night), and lower than other publicly available studies from the Midwest region that have measured pre-construction bat activity and post-construction bat fatality. The Wessington Springs Wind Project, located 24 miles (mi; 38 kilometers [km]) southeast of the Project, and the PrairieWinds Wind Project, located 30 mi (48 km) south of the Project, are dominated by grassland habitat primarily used for cattle grazing and haying similar to the Project. The bat fatality rate at both projects was relatively low and decreased each year of operation, ranging

from 0.41 – 1.48 bats per megawatt [MW] per year at Wessington Springs and 0.52 – 1.23 bats/MW/year at Prairie Winds.

The results reported here are consistent with the rate, timing, and species composition of bat activity found during the 2017 bat acoustic surveys at the Project. Due to relatively low activity rates reported during the summer and fall at the Project, and due to the geographic proximity and habitat similarity of the Project with other operating wind facilities in the region, it is assumed that bat mortality at the Project would be relatively low and follow similar patterns as those observed at nearby facilities.

STUDY PARTICIPANTS

Western EcoSystems Technology

Chris Fritchman	Project Manager
Donald Solick	Bat Biologist
Larisa Bishop-Boros	Bat Biologist
Zoe Gustafson	Statistician
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Wendy Bragg	Field Technician

REPORT REFERENCE

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INTRODUCTION

Sweetland Wind Farm, LLC (Sweetland) is proposing to develop the Sweetland Wind Energy Project (Project) in Hand County, South Dakota. Sweetland contracted Western EcoSystems Technology, Inc. (WEST) to complete a study of bat activity following the recommendations of the US Fish and Wildlife Service (USFWS) *Land-Based Wind Energy Guidelines* (USFWS 2012) and Kunz et al. (2007b). WEST conducted two years of acoustic monitoring surveys to estimate levels of bat activity throughout the Project during the summer and fall. Results from the 2017 field season are reported in Fritchman et al. (2018). The following report describes the results of acoustic monitoring surveys conducted at the Project between May 7 and October 15, 2018.

STUDY AREA

The proposed Project is located in southeastern Hand County, South Dakota, southeast of the town of Miller, and southwest of Wessington. According to the US Geological Survey (USGS) National Land Cover Database (NLCD), the Project is 54.3% herbaceous (grassland) land cover (Table 1, Figure 1). The next most common land cover types are cultivated crops (21.1%) and hay or pastureland (19.3%). Bats likely forage over these dominant land types, as well as around deciduous forest (1.3%) and over open water (1.2%) and wetlands (about 0.4%). Bats are most likely to roost in deciduous forest and developed areas (3.7%). The remaining land cover types each compose less than 0.1% of the Project and is composed of shrub/scrub and barren land (Table 1, Figure 1; USGS NLCD 2011, Homer et al. 2015).

Table 1. Land cover in the Sweetland Wind Energy Project, Hand County, South Dakota.

Land Cover	Acres	% Composition
Herbaceous (Grassland)	12,230.01	54.3
Cultivated Crops	4,744.64	21.1
Hay/Pasture	4,359.54	19.3
Developed	556.41	2.5
Deciduous Forest	286.24	1.3
Open Water	265.03	1.2
Emergent Herbaceous Wetlands	88.66	0.4
Shrub/Scrub	3.11	<0.1
Woody Wetlands	2.22	<0.1
Barren Land	2.22	<0.1
Total*	**22,538.08**	**100**

Source: US Geological Survey National Land Cover Database 2011, Homer et al. 2015.
* Sums may not total values shown due to rounding.

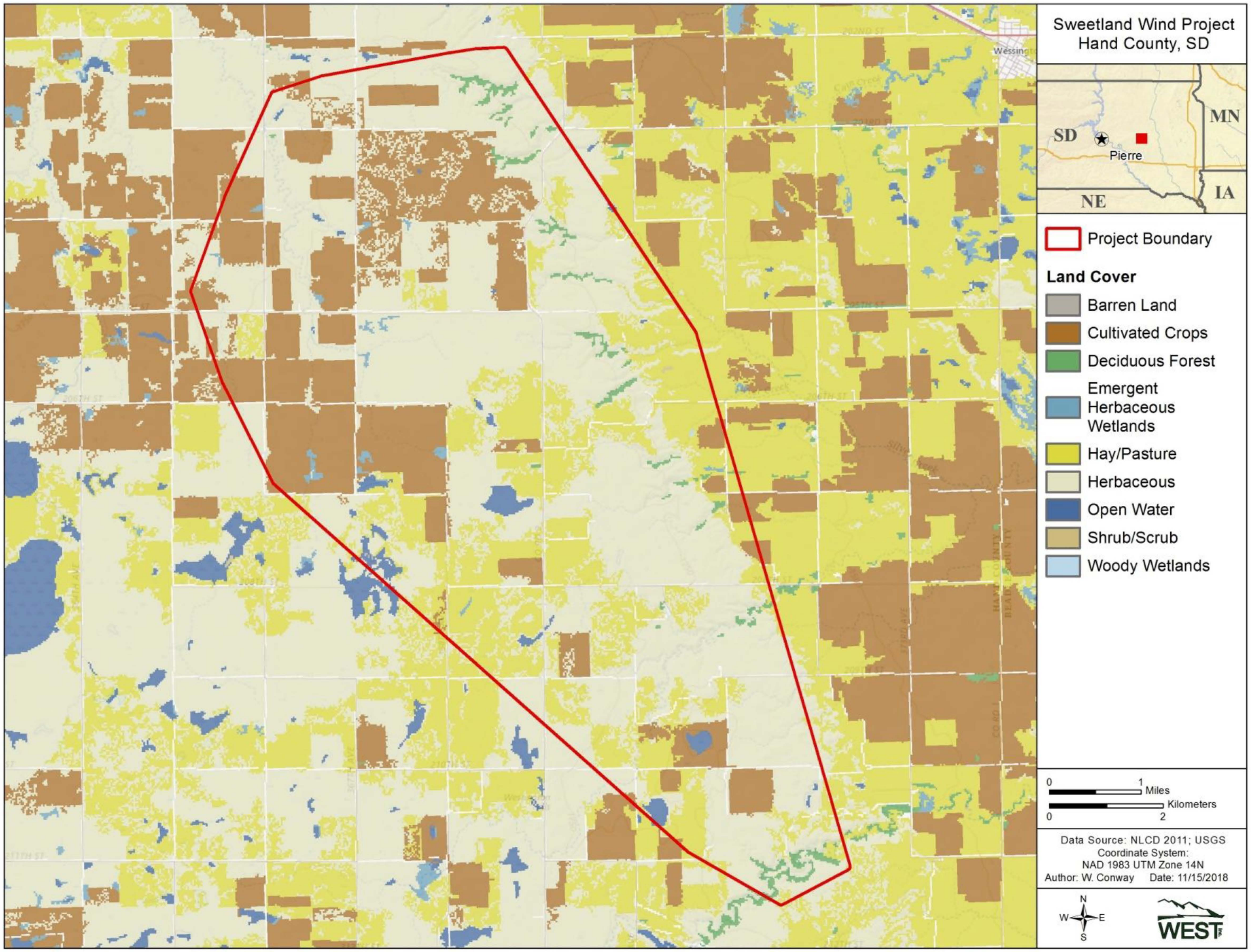

Figure 1. Land cover types within the Sweetland Wind Energy Project, Hand County, South Dakota (US Geological Survey National Land Cover Database 2011, Homer et al. 2015).

Overview of Bat Diversity

Seven species of bats potentially occur at the Project (Table 2). The northern long-eared bat (*Myotis septentrionalis*) is federally listed as threatened (USFWS 2015). None of the other species are considered sensitive in South Dakota as identified in the 2014 *South Dakota State Wildlife Action Plan* (South Dakota Game, Fish and Park [SDGFP 2014]) . All of the species except for western small-footed bat (*Myotis ciliolabrum*) have been found as fatalities at wind-energy facilities (Table 2).

Table 2. Bat species with potential to occur within the Sweetland Wind Energy Project, Hand County, South Dakota, categorized by echolocation call frequency.

Common Name	Scientific Name
High Frequency (>30 kHz)	
eastern red bat[a,b]	*Lasiurus borealis*
western small-footed bat	*Myotis ciliolabrum*
little brown bat[a]	*Myotis lucifugus*
northern long-eared bat[a,c]	*Myotis septentrionalis*
Low Frequency (≤30 kHz)	
big brown bat[a]	*Eptesicus fuscus*
silver-haired bat[a,b]	*Lasionycteris noctivagans*
hoary bat[a,c]	*Lasiurus cinereus*

[a] species known to have been killed at wind energy facilities (species found as fatalities reported by American Wind Wildlife Institute 2018);

[b] long-distance migrant; and

[c] federally threatened species (USFWS 2015).

Note: kHz = kilohertz

Range information from International Union for Conservation of Nature 2017, US Fish and Wildlife Service 2017.

METHODS

Bat Acoustic Surveys

WEST conducted acoustic monitoring to estimate levels of bat activity throughout the Project during the study period. Although it remains unclear whether baseline acoustic data are able to adequately predict post-construction fatality (Hein et al. 2013a), ultrasonic detectors do collect information on the spatial distribution, timing, and species composition of bats that can provide insights into the possible impacts of wind development (Kunz et al. 2007a, Britzke et al. 2013, Loeb et al. 2015) and inform potential mitigation strategies (Weller and Baldwin 2012).

Survey Stations

Three AnaBat™ SD1 and SD2 ultrasonic bat detectors (Titley Scientific™, Columbia, Missouri) were used during the study. Two of the detectors were paired at a meteorological (met) tower with one detector at ground level (approximately 1.5 meters [m; 5.0 feet (ft)] above ground level [AGL]; SL2g) and another within the approximate rotor-swept zone (approximately 45 m [148 ft] AGL; SL2r; Figure 2). Species activity levels and composition can vary with altitude (Baerwald and Barclay 2009, Collins and Jones 2009, Müeller et al. 2013). Therefore, it can be useful to monitor activity at different heights (Kunz et al. 2007a). Ground-based detectors likely detect a more complete sample of the bat species present within the Project, whereas elevated detectors may give a more accurate assessment of risk to bat species flying at rotor swept heights (Kunz et al. 2007a, Müeller et al. 2013; but see Amorim et al. 2012). The third detector was moved between two temporary acoustic monitoring stations (SL1t and SL3t) every 14 days to enhance spatial coverage of the Project (Figure 2). All stations were located predominately in herbaceous habitat, which is the most common land cover type (Table 1) and is representative of potential turbine locations. Temporary stations SL1t and SL3t were also located near forested drainages.

Each AnaBat unit was placed inside a plastic weather-tight container that had a hole cut in the side through which the microphone extended. Each microphone was encased in a 45-degree angle poly-vinyl chloride (PVC) tube, and holes were drilled in the PVC tube to allow water to drain. The raised AnaBat microphone was elevated on the met tower using a pulley system. Standard Bat-Hat (EME Systems, Berkley, California) weatherproof housing was modified to use a 45-degree angle PVC elbow.

Survey Schedule

Bats were surveyed in the Project from May 7 to October 15, 2018, and detectors were programmed to turn on approximately 30 minutes (min) before sunset and turn off approximately 30 min after sunrise each night. To highlight seasonal activity patterns, the study was divided into two survey periods: summer (May 7 – August 14), and fall (August 15 – October 15). Mean bat activity was also calculated for a standardized Fall Migration Period (FMP), defined here as July 30 – October 14. The FMP was defined by WEST as a standard for comparison with activity from other wind energy facilities. During this time bats begin moving toward wintering areas, and many species of bats initiate reproductive behaviors (Cryan 2008). This period of increased landscape-scale movement and reproductive behavior is often associated with increased levels of bat fatalities at operational wind energy facilities (Arnett et al. 2008, Arnett and Baerwald 2013, Barclay et al. 2017).

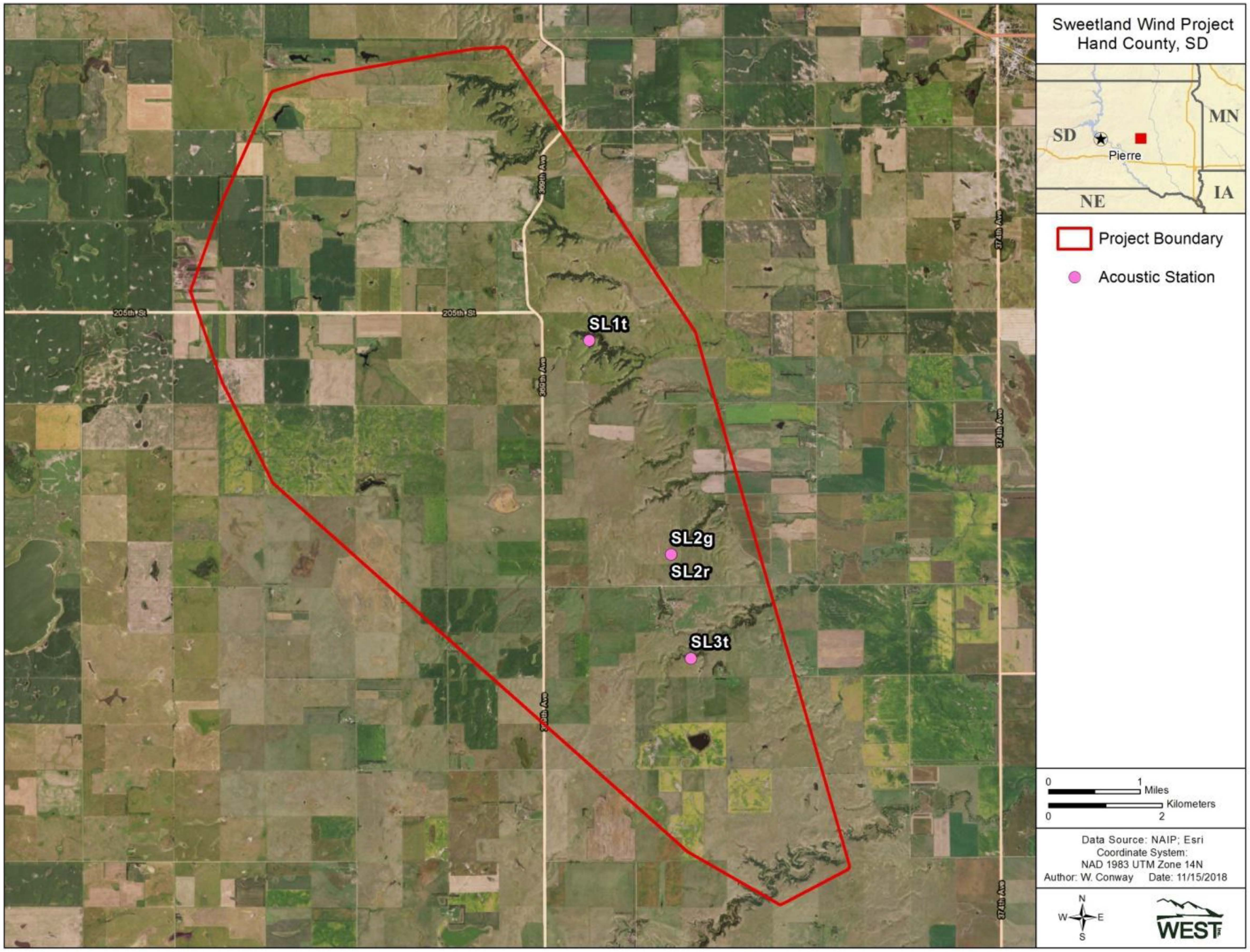

Figure 2. Location of bat monitoring stations in the Sweetland Wind Energy Project, Hand County, South Dakota.

Data Collection and Call Analysis

AnaBat detectors use a broadband high-frequency (HF) microphone to detect the echolocation calls of bats. Incoming echolocation calls are digitally processed and stored on a high-capacity compact flash card. The resulting files can be viewed in appropriate software (e.g., AnaLook©) as digital sonograms that show changes in echolocation call frequency over time. Frequency versus time displays were used to separate bat calls from other types of ultrasonic noise (e.g., wind, insects), to determine the call frequency category and, when identifiable, the species of bat that generated the calls. To standardize acoustic sampling effort across the Project, AnaBat units were calibrated and sensitivity levels were set to six (Larson and Hayes 2000), a level that balanced the goal of recording bat calls against the need to reduce interference from other sources of ultrasonic noise (Brooks and Ford 2005).

For each survey location, bat passes were sorted into two groups based on their minimum call frequency. HF bats, such as eastern red bats (*Lasiurus borealis*) and most *Myotis* species, have minimum frequencies greater than 30 kilohertz (kHz). Low-frequency (LF) bats, such as big brown bats (*Eptesicus fuscus*), silver-haired bats (*Lasionycteris noctivagans*), and hoary bats (*Lasiurus cinereus*), typically emit echolocation calls with minimum frequencies below 30 kHz. HF and LF species that may occur in the study area are listed in Table 2.

Statistical Analysis

The standard metric used for measuring bat activity is the number of bat passes per detector night, and this metric was used as an index of bat activity in the Project. A bat pass was defined as a sequence of at least two echolocation calls (pulses) produced by an individual bat with no pause between calls of more than one second (Fenton 1980). A detector night was defined as one detector operating for one entire night. The terms bat pass and bat call are used interchangeably. The number of bat passes per detector night was calculated for all bats and for HF and LF bats. Bat pass rates represent indices of bat activity and do not represent numbers of individuals. The number of bat passes was determined by an experienced bat biologist using AnaLook.

The period of peak sustained bat activity was defined as the 7-day period with the highest average bat activity. If multiple 7-day periods equaled the peak sustained bat activity rate, all dates in these 7-day periods were reported. This and all multi-detector averages in this report were calculated as an unweighted average of total activity at each detector. Temporary stations were not sampled on a continuous basis throughout the survey period and were therefore excluded from temporal analyses.

Risk Assessment

To assess potential for bat fatalities, bat activity in the Project was compared to existing data at other wind energy facilities in the Midwest. Among studies measuring both activity and fatality rates, most data were collected during the fall using AnaBat detectors placed near the ground. Therefore, to make valid comparisons to the publicly available data, this report uses the activity rate recorded at fixed, ground detectors during the FMP as a standard for comparison with activity data from other wind energy facilities. Given the relatively small number of publicly available studies and the significant ecological differences between geographically dispersed facilities, the risk assessment is qualitative, rather than quantitative.

RESULTS

Bat Acoustic Surveys

Bat activity was monitored at four sampling locations for a total of 440 detector nights between May 7 and October 15, 2018. AnaBat units were operating for 90.3% of the sampling period (Figure 3). Overall, the average bat pass rate (± standard error) was 3.63 ± 0.62 bat passes per detector night (Table 3).

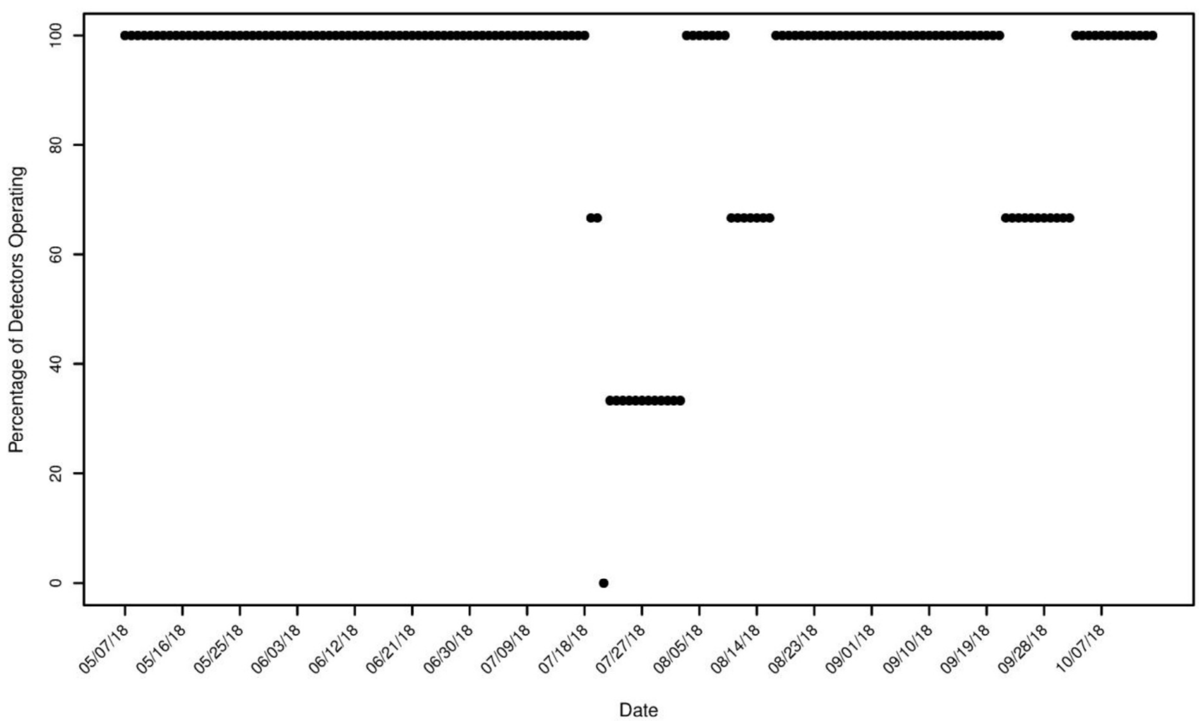

Figure 3. Operational status of bat detectors (n=4) operating at the Sweetland Wind Energy Project, Hand County, South Dakota, during each night of the study period from May 7 – October 15, 2018.

Table 3. Results of acoustic bat surveys conducted at monitoring stations within the Sweetland Wind Energy Project, Hand County, South Dakota, from May 7 to October 15, 2018. Passes were separated by call frequency: high frequency (HF) and low frequency (LF).

AnaBat Station	Location	Type	# of HF Bat Passes	# of LF Bat Passes	Total Bat Passes	Detector-Nights	Bat Passes/ Night [a]
SL1t	ground	temporary	301	685	986	85	11.60 ± 2.13
SL2g	ground	fixed	14	92	106	140	0.76 ± 0.13
SL2r	raised	fixed	23	129	152	161	0.94 ± 0.14
SL3t	ground	temporary	21	44	65	54	1.20 ± 0.22
Total Fixed			**37**	**221**	**258**	**301**	**0.85 ± 0.13**
Total Temporary			**322**	**729**	**1,051**	**139**	**6.40 ± 1.18**
Total			**359**	**950**	**1,309**	**440**	**3.63 ± 0.62**

[a] ± bootstrapped standard error.

Spatial Variation

Overall, bat activity in the Project was higher at the temporary stations than at the fixed stations (Figure 4, Table 3). Activity was higher at station SL1t, which recorded 11.60 bat passes/detector-night (Table 3). The AnaBat unit at the fixed ground station recorded 106 bat passes on 140 detector-nights, for a mean of 0.76 ± 0.13 bat passes/detector night. The raised detector recorded 152 bat passes on 161 detector-nights for a mean of 0.94 ± 0.14 bat passes/detector night (Table 3). For the nights that the paired detectors were simultaneously operating (n = 140; Figure 5), bat pass rates were nearly equal between the ground and raised detectors. AnaBat units at temporary stations recorded 1,051 bat passes on 139 detector-nights for a mean of 6.40 ± 1.18 bat passes/detector-night (Table 3).

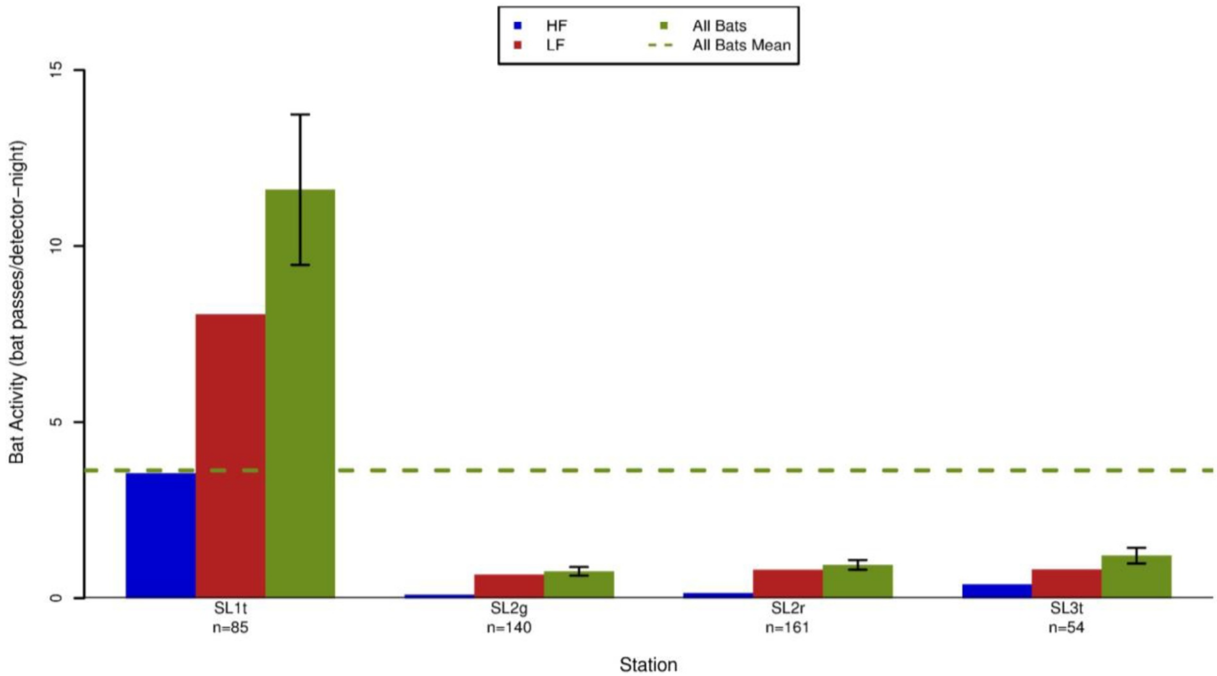

Figure 4. Number of high-frequency (HF) and low-frequency (LF) bat passes per detector-night recorded at detectors within the Sweetland Wind Energy Project, Hand County, South Dakota, between May 7 – October 15, 2018. The bootstrapped standard errors are represented by the black error bars on the 'All Bats' columns.

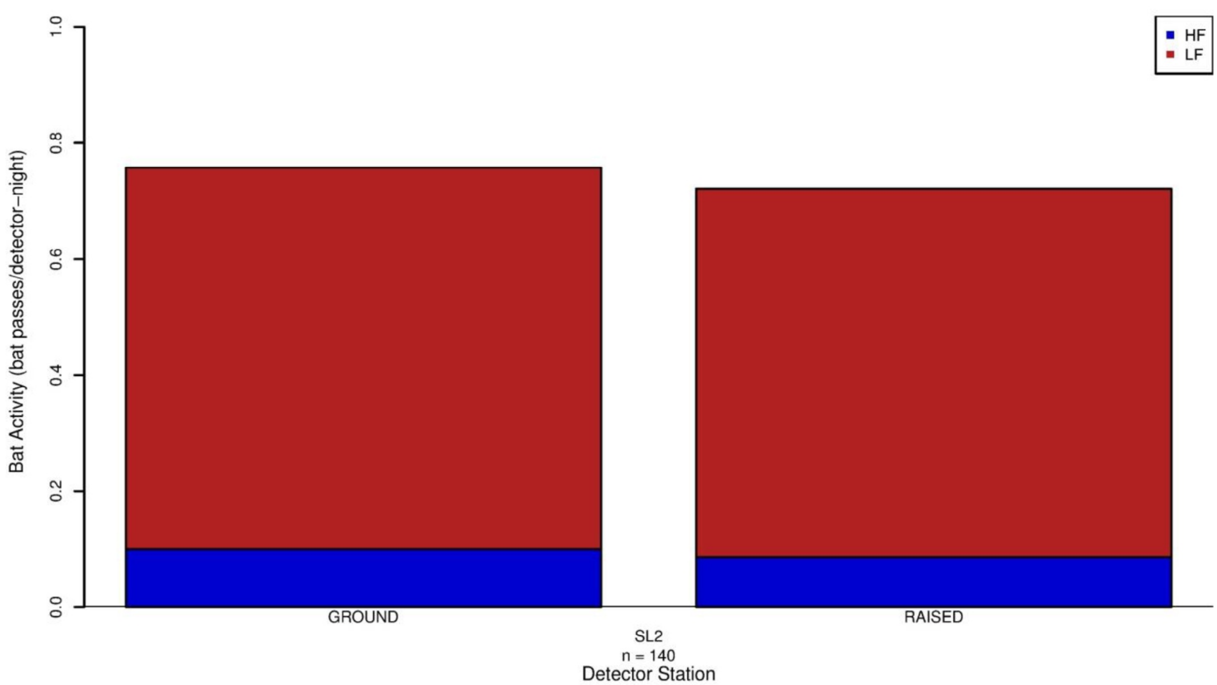

Figure 5. Number of high-frequency (HF) and low-frequency (LF) bat passes per detector-night recorded at paired detectors within the Sweetland Wind Energy Project, Hand County, South Dakota, between May 7 – October 15, 2018.

Temporal Variation

Overall bat activity at fixed stations was relatively low throughout the study period, but was slightly higher in the fall (1.30 ± 0.24 bat passes/detector-night) than in the summer (0.53 ± 0.09 bat passes/detector-night; Table 4, Figure 6). The bat pass rate for the fixed ground detector during the standardized FMP was 1.21 ± 0.26 bat passes/detector night (Table 4). Weekly acoustic activity at fixed stations was highest from late July to mid-September (Figure 7), peaking from August 10 to 16 (4.00 bat passes per detector night; Table 5, Figure 7). Bat activity abruptly decreased for the remainder of the study period (Figure 7). At paired stations (Figure 8), weekly activity was similar between the ground and raised detectors for most of the study period.

Table 4. The number of bat passes per detector-night recorded at detector stations within the Sweetland Wind Energy Project, Hand County, South Dakota, during each season, separated by call frequency: high-frequency (HF), low-frequency (LF), and all bats (AB).

AnaBat Station	Call Frequency	Summer May 7 – August 14	Fall Aug 15 – October 15	Fall Migration Period Jul 30 – October 14
SL2g	LF	0.30	1.13	1.03
	HF	0.02	0.20	0.18
	AB	0.32	1.33	1.21
SL2r	LF	0.59	1.15	1.30
	HF	0.15	0.13	0.23
	AB	0.74	1.27	1.53
Ground Totals	**LF**	**0.30 ± 0.07**	**1.13 ± 0.26**	**1.03 ± 0.24**
	HF	**0.02 ± 0.02**	**0.20 ± 0.07**	**0.18 ± 0.07**
	AB	**0.32 ± 0.07**	**1.33 ± 0.27**	**1.21 ± 0.26**
Raised Totals	**LF**	**0.59 ± 0.12**	**1.15 ± 0.25**	**1.30 ± 0.25**
	HF	**0.15 ± 0.06**	**0.13 ± 0.05**	**0.23 ± 0.08**
	AB	**0.74 ± 0.17**	**1.27 ± 0.27**	**1.53 ± 0.29**
Overall	**LF**	**0.44 ± 0.07**	**1.14 ± 0.23**	**1.16 ± 0.21**
	HF	**0.09 ± 0.03**	**0.16 ± 0.05**	**0.21 ± 0.05**
	AB	**0.53 ± 0.09**	**1.30 ± 0.24**	**1.37 ± 0.23**

Sums may not equal values shown due to rounding.

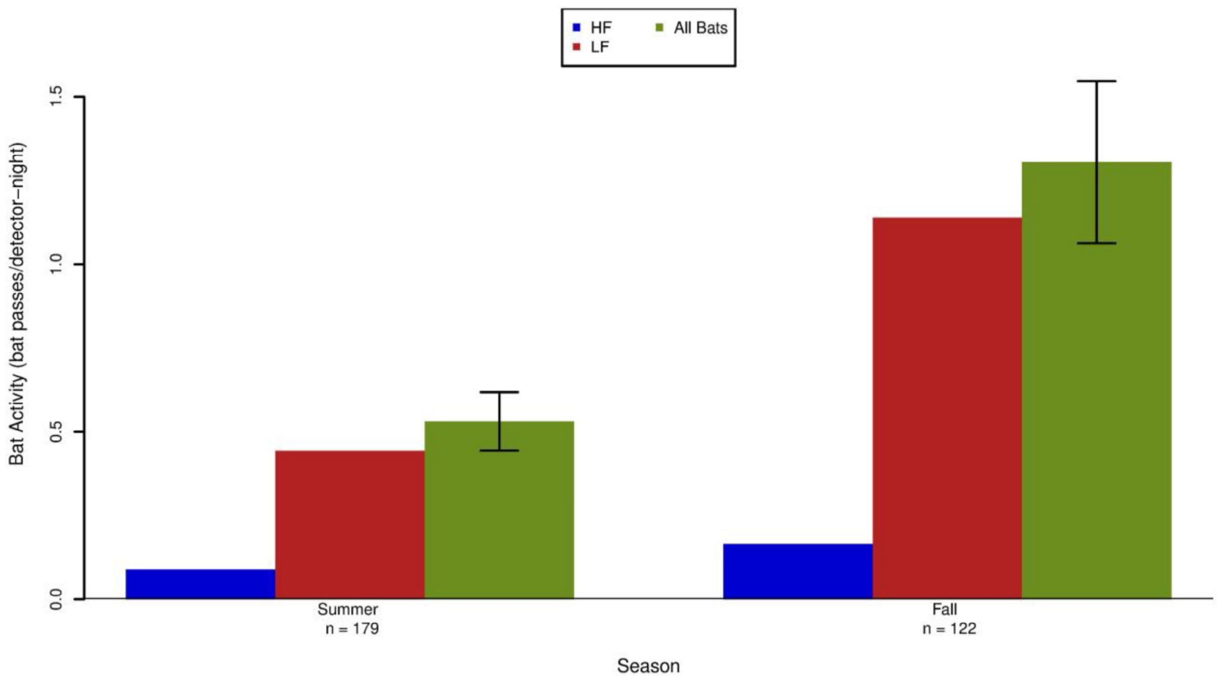

Figure 6. Seasonal bat activity by high frequency (HF), low frequency (LF), and all bats at fixed stations in the Sweetland Wind Energy Project, Hand County, South Dakota, between May 7 – October 15, 2018. The bootstrapped standard errors are represented on the 'All Bats' columns.

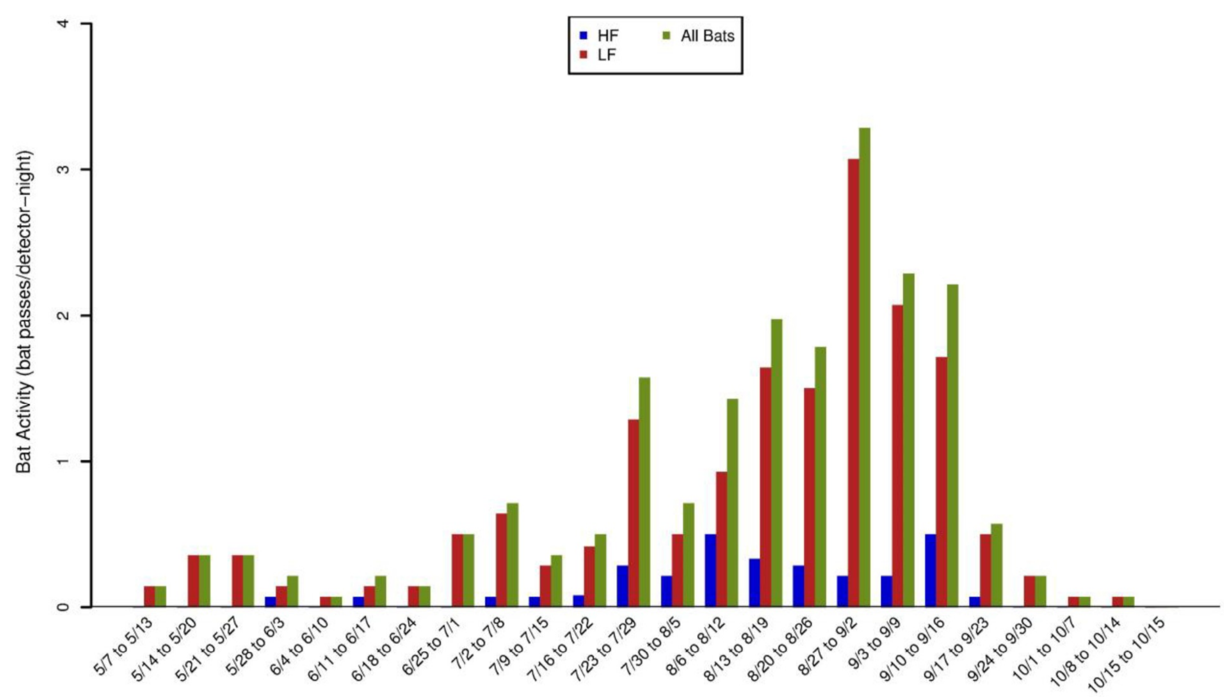

Figure 7. Weekly patterns of bat activity by high frequency (HF), low frequency (LF), and all bats at fixed stations in the Sweetland Wind Energy Project between May 7 – October 15, 2018.

Table 5. Periods of peak activity for low-frequency (LF) bats and all bats at fixed stations in the Sweetland Wind Energy Project, Hand County, South Dakota between May 7 – October 15, 2018. Peak activity was not calculated for high-frequency bats due to relatively low activity rates (less than 1.0 bat pass/detector-night).

Frequency Group	Start Date of Peak Activity	End Date of Peak Activity	Bat Passes/Detector-Night
LF	August 10	August 16	3.14
All Bats	August 10	August 16	4.00

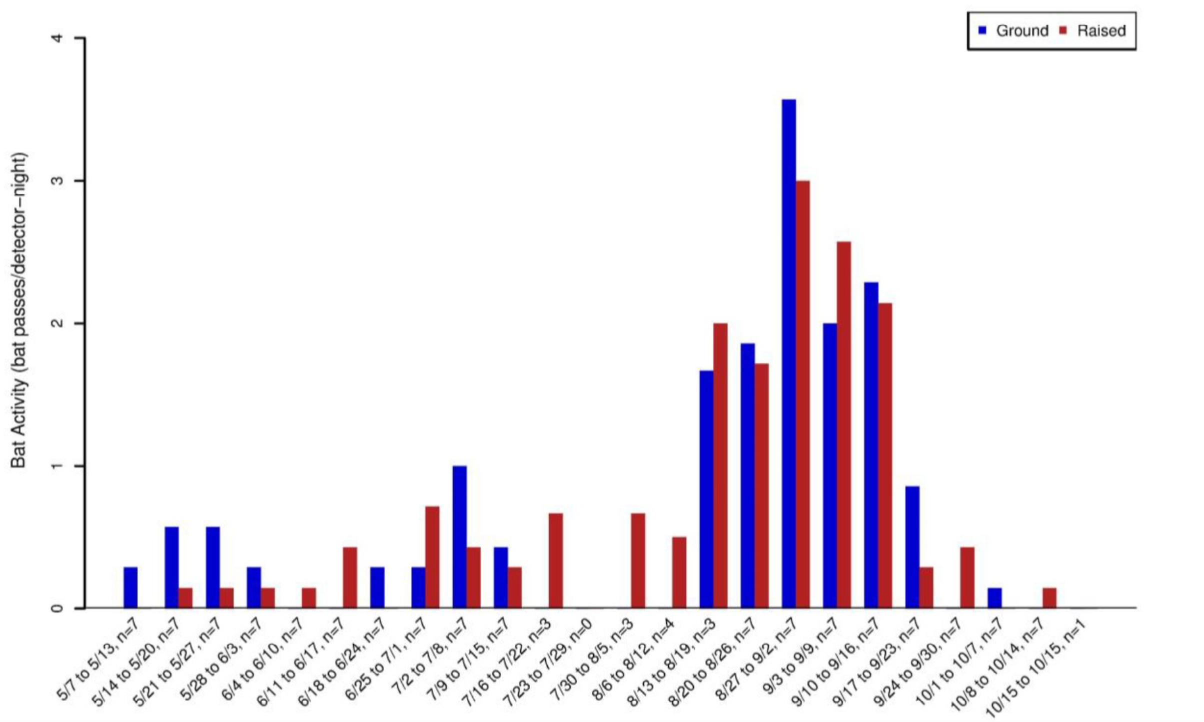

Figure 8. Weekly patterns of bat activity from May 7 – October 15, 2018, at ground and raised fixed stations at the Sweetland Wind Energy Project, Hand County, South Dakota.

Species Composition

At all stations, 72.6% of bat passes were classified as LF, and 27.4% of bat passes were classified as HF (Tables 2 and 3). Activity by LF bats was higher at all stations (Table 3, Figures 4 and 5), and throughout the study period (Figure 7).

DISCUSSION

Bat fatalities have been discovered at most wind energy facilities monitored in North America, with fatality estimates ranging from zero to 49.70 bat fatalities per megawatt (MW) per year (American Wind Wildlife Institute [AWWI] 2018). A summary of 202 studies at 137 wind energy facilities in the U.S. found that the majority reported fewer than five bat fatalities/MW/year, with a nationwide median of 2.66 bat fatalities/MW/year (AWWI 2018). In 2012, an estimated 600,000 bats died as a result of interactions with wind turbines in the US (Hayes 2013). Wind development may pose a threat to populations of migratory bats in particular. Projection models estimate that populations of hoary bats could decline as much as 90% in the next 50 years (Frick et al. 2017). Proximate causes of bat fatalities are primarily due to collisions with moving turbine blades (Grodsky et al. 2011, Rollins et al. 2012) but to a limited extent may also be caused by barotrauma (Baerwald et al. 2008). The underlying reasons for why bats come near turbines are still largely unknown (Cryan and Barclay 2009, Barclay et al. 2017). To date, post-construction monitoring studies of wind energy facilities in the US show that a) migratory tree-roosting species (e.g., eastern red bat, hoary bat, and silver-haired bat) compose approximately 72% of reported bat fatalities; b) the majority of fatalities occur during the fall migration season (August and September); and c) most fatalities occur on nights with relatively low wind speeds (e.g., less than 6.0 m/second (20 ft/second; Arnett et al. 2008, 2013; Arnett and Baerwald 2013; Thompson et al. 2017; AWWI 2018).

It is generally expected that pre-construction bat activity is positively related to post-construction bat fatalities (Kunz et al. 2007b). However, to date, relatively few studies of wind energy facilities that have recorded both bat activity and bat fatality rates are available (Appendix A). Complicating matters, recent evidence suggests that the most numerous of the species found as fatalities at wind turbines (hoary bats) sometimes fly without echolocation (Corcoran and Weller 2018) and therefore might not be recorded on ultrasonic detectors. Given the comparatively limited availability of pre- and post-construction data sets, differences in protocols among studies (Ellison 2012), and significant ecological differences between geographically diverse facilities, the relationship between activity and fatalities has not yet been empirically established (Hein et al. 2013a), though Baerwald and Barclay (2009) found a significant positive association between pass rates measured at 30 m (98 ft) and fatality rates for hoary and silver-haired bats across five sites in southern Alberta.

However, on a continental scale, a similar relationship has proven difficult to establish. The relatively few studies that have estimated both pre-construction activity and post-construction fatalities trend toward a positive association between activity and fatality rates, but they lack statistically significant correlations. Hein et al. (2013a) compiled data from wind projects that included both pre- and post-construction activity and fatality data to assess if pre-construction acoustic activity predicted post-construction fatality rates. Based on data from 12 sites that had both pre- and post-construction data, they did not find a statistically significant relationship ($p=0.07$), although the trend was in the expected direction (i.e., relatively low activity was generally associated with lower mortality and vice-versa). They concluded therefore, that pre-construction acoustic data could not currently predict bat fatalities, but acknowledged that the data set was limited and additional data may indicate a stronger relationship. Therefore, the current approach to assessing the risk to bats requires a qualitative analysis of activity levels, spatial and temporal relationships, species composition, and comparison to regional fatality patterns.

Compared to the results from acoustic bat surveys at the Project during 2017 (Fritchman et al. 2018), similar bat activity rates and patterns in timing and species composition were found during this study. As such, similar expectations of fatality rates, timing, and species affected after construction are consistent between studies. Mean bat activity during the FMP at fixed ground detectors (1.21 bat passes per detector night; Table 4) was lower than the North American median (7.7; Appendix A) and all of studies publicly available from the Midwest region (Appendix A). Given the relatively low bat pass rate, and that over two-thirds (69.1%) of bat fatality studies in the Midwest report fewer than five bat fatalities/MW/year (Appendix A; Figure 9), it is possible that similar fatality rates could be recorded at the Project.

On average, bat activity was nearly eight times higher at the temporary stations than at the fixed ground stations, although this was primarily driven by station SL1t. Both temporary stations SL1t and SL3t were located near forested drainages that bats may have used for roosting or foraging. All stations were in grassland habitat, and grassland is the dominant habitat type at the Project, so these data likely represent the range of bat activity across the Project. A review of 40 US studies found that bat mortality may be inversely related to the percent grassland cover surrounding wind facilities (Thompson et al. 2017). That is, the more open the landscape, the less risk of turbine collisions by bats. However, exceptions to this pattern exist (e.g., Jain 2005, Arnett and Baerwald 2013) and it may not be applicable to all regions (Thompson et al. 2017).

Approximately 73% of bat passes recorded in the Project were emitted by LF bats, suggesting a greater abundance of species such as big brown bats, silver-haired bats, and hoary bats (Table 3). LF species may become casualties because these species fly at higher altitudes, as demonstrated by their greater prevalence of LF bat calls at the raised detector (Table 3, Figure 5). Activity by HF bat species composed about 27% of bat passes recorded at stations in the Project. Eastern red bats are usually the most common HF species found during carcass searches (Arnett et al. 2008, Arnett and Baerwald 2013). *Myotis* species are recorded less commonly than other species in the rotor-swept zone or as fatalities at most post-construction studies of wind energy facilities (Kunz et al. 2007a, Arnett et al. 2008), with a few notable exceptions (Kerns and Kerlinger 2004, Jain 2005, Brown and Hamilton 2006a, Gruver et al. 2009). Given that hoary bats, eastern red bats, and silver-haired bats are among the most common bat fatalities at many facilities (Arnett et al. 2008, Arnett and Baerwald 2013), it is expected that these three species would likely be the most common fatalities found at the Project.

At fixed stations, bat activity peaked during mid-August to mid-September. This timing is consistent with peak fatality periods for most wind energy facilities in the US, and suggests that bat fatalities at the Project will likely be highest during late summer to early fall and may consist largely of migrating individuals. The Wessington Springs Wind Project (Wessington Springs), located approximately 24 miles (mi; 38 kilometers [km]) southeast of the Project (Derby et al. 2010c, 2011a) and the PrairieWinds Wind Project, located 30 mi (48 km) south of the Project (Derby et al. 2012c, 2013a, 2014), are dominated by grassland habitat primarily used for cattle (*Bos taurus*) grazing and haying, with some patches of deciduous trees and open waterbodies available, similar to the Project. Due to relatively low activity rates during the summer and fall at the Project, and due to the geographic proximity and habitat similarity of the Project to

Wessington Springs and PrairieWinds, it is assumed that bat mortality at the Project would be relativley low and follow similar patterns as those observed at other facilities within the region (e.g., 0.41 – 1.48 bat fatalities/MW/year [Derby et al. 2010c, 2011a], 0.52 – 1.23 bats/MW/year [Derby et al. 2012c, 2013a, 2014]; Figure 9). The pre-construction bat studies completed at the Project will add to the growing body of research regarding the impacts of wind energy development on bats and may provide a valuable comparison to post-construction studies to be completed at Project.

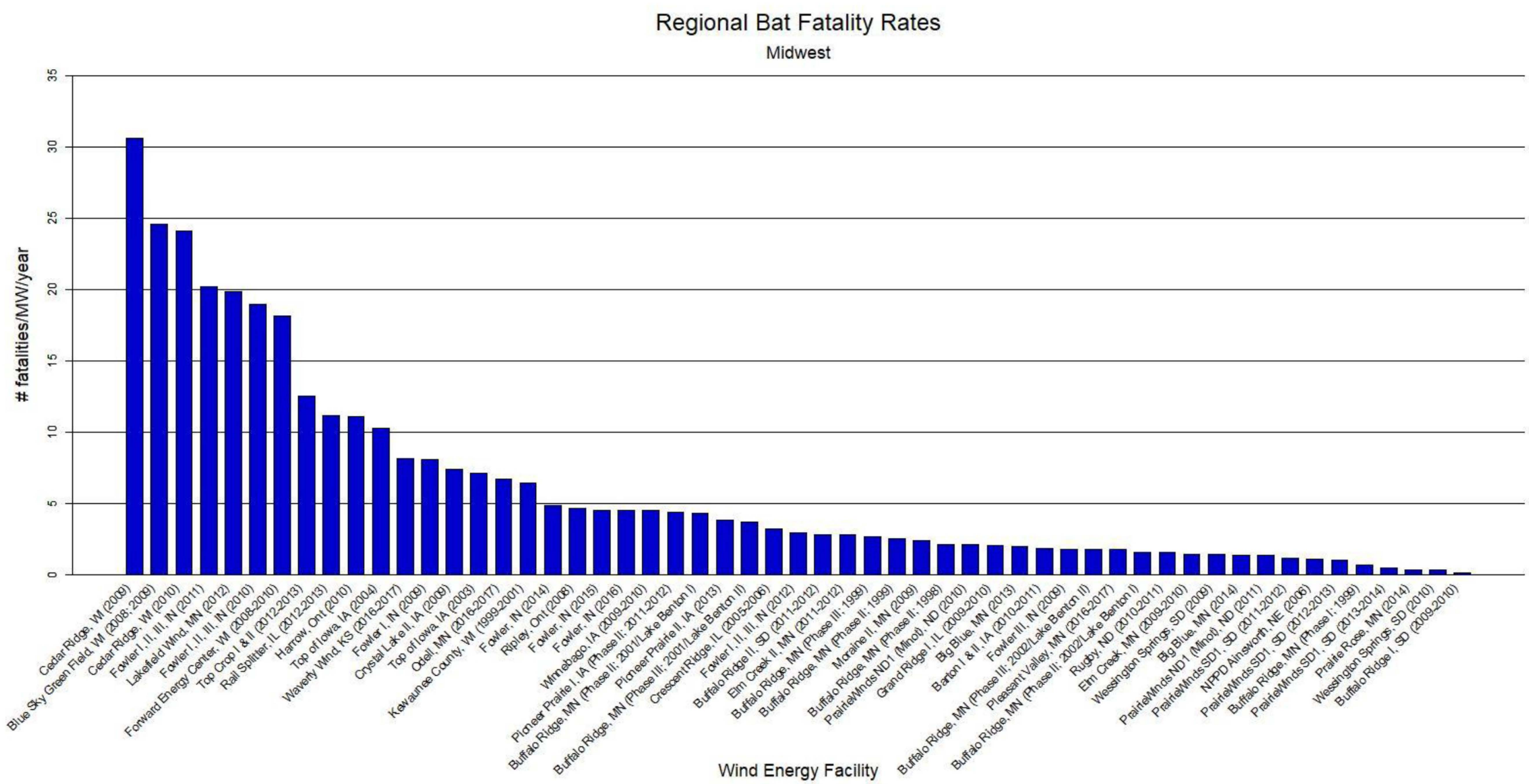

Figure 9. Fatality rates for bats (number of bats per megawatt per year) from publicly available studies at wind energy facilities in the Midwest region of North America.

Figure 9 (*continued*). Fatality rates for bats (number of bats per megawatt per year) from publicly available studies at wind energy facilities in the Midwest region of North America.

Facility Study	Citation	Facility Study	Citation
Cedar Ridge, WI (2009)	BHE Environmental 2010	Buffalo Ridge II, SD (2011-2012)	Derby et al. 2012a
Blue Sky Green Field, WI (2008; 2009)	Gruver et al. 2009	Elm Creek II, MN (2011-2012)	Derby et al. 2012b
Cedar Ridge, WI (2010)	BHE Environmental 2011	Buffalo Ridge, MN (Phase III; 1999)	Johnson et al. 2000
Fowler I, II, III, IN (2011)	Good et al. 2012	Buffalo Ridge, MN (Phase II; 1999)	Johnson et al. 2000
Lakefield Wind, MN (2012)	Minnesota Public Utilities Commission 2012	Moraine II, MN (2009)	Derby et al. 2010f
Fowler I, II, III, IN (2010)	Good et al. 2011	Buffalo Ridge, MN (Phase II; 1998)	Johnson et al. 2000
Forward Energy Center, WI (2008-2010)	Grodsky and Drake 2011	PrairieWinds ND1 (Minot), ND (2010)	Derby et al. 2011d
Top Crop I & II, IL (2012-2013)	Good et al. 2013c	Grand Ridge I, IL (2009-2010)	Derby et al. 2010a
Rail Splitter, IL (2012-2013)	Good et al. 2013b	Big Blue, MN (2013)	Fagen Engineering 2014
Harrow, Ont (2010)	Natural Resources Solutions Inc. 2011	Barton I & II, IA (2010-2011)	Derby et al. 2011b
Top of Iowa, IA (2004)	Jain 2005	Fowler III, IN (2009)	Johnson et al. 2010b
Waverly Wind, KS (2016-2017)	Tetra Tech 2017a	Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	Johnson et al. 2004
Fowler I, IN (2009)	Johnson et al. 2010a	Pleasant Valley, MN (2016-2017)	Tetra Tech 2017b
Crystal Lake II, IA (2009)	Derby et al. 2010b	Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	Johnson et al. 2004
Top of Iowa, IA (2003)	Jain 2005	Rugby, ND (2010-2011)	Derby et al. 2011c
Odell, MN (2016-2017)	Chodachek and Gustafson 2018	Elm Creek, MN (2009-2010)	Derby et al. 2010e
Kewaunee County, WI (1999-2001)	Howe et al. 2002	Wessington Springs, SD (2009)	Derby et al. 2010c
Fowler, IN (2014)	Good et al. 2015	Big Blue, MN (2014)	Fagen Engineering 2015
Ripley, Ont (2008)	Jacques Whitford 2009	PrairieWinds ND1 (Minot), ND (2011)	Derby et al. 2012d
Fowler, IN (2015)	Good et al. 2016	PrairieWinds SD1, SD (2011-2012)	Derby et al. 2012c
Fowler, IN (2016)	Good et al. 2017	NPPD Ainsworth, NE (2006)	Derby et al. 2007
Winnebago, IA (2009-2010)	Derby et al. 2010g	PrairieWinds SD1, SD (2012-2013)	Derby et al. 2013a
Pioneer Prairie I, IA (Phase II; 2011-2012)	Chodachek et al. 2012	Buffalo Ridge, MN (Phase I; 1999)	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	Johnson et al. 2004	PrairieWinds SD1, SD (2013-2014)	Derby et al. 2014
Pioneer Prairie II, IA (2013)	Chodachek et al. 2014	Prairie Rose, MN (2014)	Chodachek et al. 2015
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	Johnson et al. 2004	Wessington Springs, SD (2010)	Derby et al. 2011a
Crescent Ridge, IL (2005-2006)	Kerlinger et al. 2007	Buffalo Ridge I, SD (2009-2010)	Derby et al. 2010d
Fowler I, II, III, IN (2012)	Good et al. 2013a		

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Appendix A. North American Bat Fatality Summary Tables

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as the bat passes per detector night. Fatality estimate given as the number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Sweetland, SD	1.21	7/30/18-10/14/18			
Midwest					
Cedar Ridge, WI (2009)	9.97[A,B,C,D]	7/16/07-9/30/07	30.61	41	67.6
Blue Sky Green Field, WI (2008; 2009)	7.7[A]	7/24/07-10/29/07	24.57	88	145
Cedar Ridge, WI (2010)	9.97[A,B,C,D]	7/16/07-9/30/07	24.12	41	68
Fowler I, II, III, IN (2011)	NA	NA	20.19	355	600
Lakefield Wind, MN (2012)	NA	NA	19.87	137	205.5
Fowler I, II, III, IN (2010)	NA	NA	18.96	355	600
Forward Energy Center, WI (2008-2010)	6.97	8/5/08-11/08/08	18.17	86	129
Top Crop I & II, IL (2012-2013)	NA	NA	12.55	200 (68 Phase I, 132 Phase II)	300 (102 Phase I, 198 Phase II)
Rail Splitter, IL (2012-2013)	NA	NA	11.21	67	100.5
Harrow, Ont (2010)	NA	NA	11.13	24 (four 6-turbine facilities)	39.6
Top of Iowa, IA (2004)	35.7	5/26/04-9/24/04	10.27	89	80
Waverly Wind, KS (2016-2017)	NA	NA	8.2	95	199
Fowler I, IN (2009)	NA	NA	8.09	162	301
Crystal Lake II, IA (2009)	NA	NA	7.42	80	200
Top of Iowa, IA (2003)	NA	NA	7.16	89	80
Odell, MN (2016-2017)	NA	NA	6.74	100	200
Kewaunee County, WI (1999-2001)	NA	NA	6.45	31	20.46
Fowler, IN (2014)	NA	NA	4.86	355	600
Ripley, Ont (2008)	NA	NA	4.67	38	76
Winnebago, IA (2009-2010)	NA	NA	4.54	10	20
Fowler, IN (2016)	NA	NA	4.54	420	750
Fowler, IN (2015)	NA	NA	4.54	420	NA
Pioneer Prairie I, IA (Phase II; 2011-2012)	NA	NA	4.43	62	102.3
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	2.2[B]	6/15/01-9/15/01	4.35	143	107.25
Pioneer Prairie II, IA (2013)	NA	NA	3.83	62	102.3
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	2.2[B]	6/15/01-9/15/01	3.71	138	103.5
Crescent Ridge, IL (2005-2006)	NA	NA	3.27	33	49.5
Fowler I, II, III, IN (2012)	NA	NA	2.96	355	600
Elm Creek II, MN (2011-2012)	NA	NA	2.81	62	148.8
Buffalo Ridge II, SD (2011-2012)	NA	NA	2.81	105	210
Buffalo Ridge, MN (Phase III; 1999)	NA	NA	2.72	138	103.5
Buffalo Ridge, MN (Phase II; 1999)	NA	NA	2.59	143	107.25
Moraine II, MN (2009)	NA	NA	2.42	33	49.5
Buffalo Ridge, MN (Phase II; 1998)	NA	NA	2.16	143	107.25
PrairieWinds ND1 (Minot), ND (2010)	NA	NA	2.13	80	115.5
Grand Ridge I, IL (2009-2010)	NA	NA	2.1	66	99

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as the bat passes per detector night. Fatality estimate given as the number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Big Blue, MN (2013)	NA	NA	2.04	18	36
Barton I & II, IA (2010-2011)	NA	NA	1.85	80	160
Fowler III, IN (2009)	NA	NA	1.84	60	99
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	1.9[B]	6/15/02-9/15/02	1.81	138	103.5
Pleasant Valley, MN (2016-2017)	NA	NA	1.8	100	200
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	1.9[B]	6/15/02-9/15/02	1.64	143	107.25
Rugby, ND (2010-2011)	NA	NA	1.6	71	149
Elm Creek, MN (2009-2010)	NA	NA	1.49	67	100
Wessington Springs, SD (2009)	NA	NA	1.48	34	51
Big Blue, MN (2014)	NA	NA	1.43	18	36
PrairieWinds ND1 (Minot), ND (2011)	NA	NA	1.39	80	115.5
PrairieWinds SD1, SD (2011-2012)	NA	NA	1.23	108	162
NPPD Ainsworth, NE (2006)	NA	NA	1.16	36	20.5
PrairieWinds SD1, SD (2012-2013)	NA	NA	1.05	108	162
Buffalo Ridge, MN (Phase I; 1999)	NA	NA	0.74	73	25
PrairieWinds SD1, SD (2013-2014)	NA	NA	0.52	108	162
Prairie Rose, MN (2014)	NA	NA	0.41	119	200
Wessington Springs, SD (2010)	NA	NA	0.41	34	51
Buffalo Ridge I, SD (2009-2010)	NA	NA	0.16	24	50.4
Southern Plains					
Barton Chapel, TX (2009-2010)	NA	NA	3.06	60	120
Big Smile, OK (2012-2013)	NA	NA	2.9	66	132
Buffalo Gap II, TX (2007-2008)	NA	NA	0.14	155	233
Red Hills, OK (2012-2013)	NA	NA	0.11	82	123
Buffalo Gap I, TX (2006)	NA	NA	0.1	67	134
Southwest					
Spring Valley, NV (2012-2013)	NA	NA	3.73	NA	NA
Dry Lake I, AZ (2009-2010)	8.8	4/29/10-11/10/10	3.43	30	63
Dry Lake II, AZ (2011-2012)	11.5	5/11/11-10/26/11	1.66	31	65
California					
Hatchet Ridge, CA (2012)	NA	NA	5.22	44	101
Hatchet Ridge, CA (2012-2013)	NA	NA	4.2	44	NA
Shiloh I, CA (2006-2009)	NA	NA	3.92	100	150
Shiloh II, CA (2010-2011)	NA	NA	3.8	75	150
Shiloh II, CA (2011-2012)	NA	NA	3.4	75	150
Shiloh II, CA (2009-2010)	NA	NA	2.6	75	150
High Winds, CA (2003-2004)	NA	NA	2.51	90	162
Hatchet Ridge, CA (2011)	NA	NA	2.23	44	101
Lower West, CA (2012-2013)	NA	NA	2.17	7	14
Dillon, CA (2008-2009)	NA	NA	2.17	45	45
Montezuma I, CA (2011)	NA	NA	1.9	16	36.8
High Winds, CA (2004-2005)	NA	NA	1.52	90	162
Alta Wind I, CA (2011-2012)	4.42[E]	6/26/09-10/31/09	1.28	100	150
Lower West, CA (2014-2015)	NA	NA	1.13	7	14
Montezuma II, CA (2012-2013)	NA	NA	0.91	34	78.2
Montezuma I, CA (2012)	NA	NA	0.84	16	36.8

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as the bat passes per detector night. Fatality estimate given as the number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Diablo Winds, CA (2005-2007)	NA	NA	0.82	31	20.46
Alta X, CA (2015-2016)	NA	NA	0.8	48	137
Alta I, CA (2015-2016)	NA	NA	0.7	290	720
Alta X, CA (2014-2015)	NA	NA	0.42	48	137
Shiloh III, CA (2012-2013)	NA	NA	0.4	50	102.5
Alta I, CA (2013-2014)	NA	NA	0.36	290	720
Mustang Hills, CA (2016-2017)	NA	NA	0.33	100	300
Solano III, CA (2012-2013)	NA	NA	0.31	55	128
Alite, CA (2009-2010)	NA	NA	0.24	8	24
Pacific Wind, CA (2014-2015)	NA	NA	0.21	70	144
Cameron Ridge/Section 15, CA (2015-2016)	NA	NA	0.19	34	102
Pinyon Pines I & II, CA (2015-2016)	NA	NA	0.18	100	300
Alta VIII, CA (2014-2015)	NA	NA	0.17	100	300
Cameron Ridge/Section 15, CA (2014-2015)	NA	NA	0.15	34	102
Mustang Hills, CA (2012-2013)	NA	NA	0.1	50	150
Alta Wind II-V, CA (2011-2012)	0.78	6/26/09-10/31/09	0.08	190	570
Pinyon Pines I & II, CA (2013-2014)	NA	NA	0.04	100	NA
Windstar, CA (2012-2013)	NA	NA	0	53	106
Lower West, CA (2016-2017)	NA	NA	0	7	14
Pacific Wind, CA (2015-2016)	NA	NA	0	70	144
Alta VIII, CA (2012-2013)	NA	NA	0	50	150
Rising Tree, CA (2017-2018)	NA	NA	0	60	198
Mustang Hills, CA (2014-2015)	NA	NA	0	100	300
Alta II-V, CA (2013-2014)	NA	NA	0	290	720
Alta II-V, CA (2015-2016)	NA	NA	0	290	720
Pacific Northwest					
Palouse Wind, WA (2012-2013)	NA	NA	4.23	58	104.4
Biglow Canyon, OR (Phase II; 2009-2010)	NA	NA	2.71	65	150
Nine Canyon, WA (2002-2003)	NA	NA	2.47	37	48.1
Stateline, OR/WA (2003)	NA	NA	2.29	454	299
Tucannon River, WA (2015)	NA	NA	2.22	116	267
Elkhorn, OR (2010)	NA	NA	2.14	61	101
White Creek, WA (2007-2011)	NA	NA	2.04	89	204.7
Biglow Canyon, OR (Phase I; 2008)	NA	NA	1.99	76	125.4
Leaning Juniper, OR (2006-2008)	NA	NA	1.98	67	100.5
Chopin, OR (2016-2017)	NA	NA	1.9	6	10
Big Horn, WA (2006-2007)	NA	NA	1.9	133	199.5
Combine Hills, OR (Phase I; 2004-2005)	NA	NA	1.88	41	41
Linden Ranch, WA (2010-2011)	NA	NA	1.68	25	50
Pebble Springs, OR (2009-2010)	NA	NA	1.55	47	98.7
Hopkins Ridge, WA (2008)	NA	NA	1.39	87	156.6
Harvest Wind, WA (2010-2012)	NA	NA	1.27	43	98.9
Elkhorn, OR (2008)	NA	NA	1.26	61	101
Vansycle, OR (1999)	NA	NA	1.12	38	24.9

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as the bat passes per detector night. Fatality estimate given as the number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Klondike III (Phase I), OR (2007-2009)	NA	NA	1.11	125	223.6
Stateline, OR/WA (2001-2002)	NA	NA	1.09	454	299
Stateline, OR/WA (2006)	NA	NA	0.95	454	299
Tuolumne (Windy Point I), WA (2009-2010)	NA	NA	0.94	62	136.6
Klondike, OR (2002-2003)	NA	NA	0.77	16	24
Combine Hills, OR (2011)	NA	NA	0.73	104	104
Hopkins Ridge, WA (2006)	NA	NA	0.63	83	150
Biglow Canyon, OR (Phase I; 2009)	NA	NA	0.58	76	125.4
Biglow Canyon, OR (Phase II; 2010-2011)	NA	NA	0.57	65	150
Hay Canyon, OR (2009-2010)	NA	NA	0.53	48	100.8
Windy Flats, WA (2010-2011)	NA	NA	0.41	114	262.2
Klondike II, OR (2005-2006)	NA	NA	0.41	50	75
Vantage, WA (2010-2011)	NA	NA	0.4	60	90
Wild Horse, WA (2007)	NA	NA	0.39	127	229
Goodnoe, WA (2009-2010)	NA	NA	0.34	47	94
Marengo II, WA (2009-2010)	NA	NA	0.27	39	70.2
Biglow Canyon, OR (Phase III; 2010-2011)	NA	NA	0.22	76	174.8
Marengo I, WA (2009-2010)	NA	NA	0.17	78	140.4
Klondike IIIa (Phase II), OR (2008-2010)	NA	NA	0.14	51	76.5
Kittitas Valley, WA (2011-2012)	NA	NA	0.12	48	100.8
Rocky Mountains					
Summerview, Alb (2006; 2007)	7.65[B]	07/15/06-07-09/30/06-07	11.42	39	70.2
Summerview, Alb (2005-2006)	NA	NA	10.27	39	70.2
Judith Gap, MT (2006-2007)	NA	NA	8.93	90	135
Foote Creek Rim I, WY (1999)	NA	NA	3.97	69	41
Judith Gap, MT (2009)	NA	NA	3.2	90	135
Top of the World, WY (2010-2011)	NA	NA	2.74	110	200
Top of the World, WY (2011-2012)	NA	NA	2.43	110	200
Top of the World, WY (2012-2013)	NA	NA	2.34	110	200
Milford I, UT (2010-2011)	NA	NA	2.05	58	145
Milford I & II, UT (2011-2012)	NA	NA	1.67	107	160.5 (58.5 Phase I, 102 Phase II)
Foote Creek Rim I, WY (2001-2002)	2.2[A,B]	6/15/01-9/1/01	1.57	69	41
Foote Creek Rim I, WY (2000)	2.2[A,B]	6/15/00-9/1/00	1.05	69	41
Southeast					
Buffalo Mountain, TN (2005)	NA	NA	39.7	18	28.98
Buffalo Mountain, TN (2000-2003)	23.7[D]	NA	31.54	3	1.98
Northeast					
Pinnacle, WV (2012)	NA	NA	40.2	23	55.2
Mountaineer, WV (2003)	NA	NA	31.69	44	66
Mount Storm, WV (2009)	30.09	7/15/09-10/7/09	17.53	132	264
Noble Wethersfield, NY (2010)	NA	NA	16.3	84	126

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as the bat passes per detector night. Fatality estimate given as the number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Criterion, MD (2011)	NA	NA	15.61	28	70
Mount Storm, WV (2010)	36.67[F]	4/18/10-10/15/10	15.18	132	264
Locust Ridge, PA (Phase II; 2010)	NA	NA	14.38	51	102
Locust Ridge, PA (Phase II; 2009)	NA	NA	14.11	51	102
Casselman, PA (2008)	NA	NA	12.61	23	34.5
Maple Ridge, NY (2006)	NA	NA	11.21	120	198
Cohocton/Dutch Hills, NY (2010)	NA	NA	10.32	50	125
Howard, NY (2012)	NA	NA	10	27	54
Wolfe Island, Ont (July-December 2010)	NA	NA	9.5	86	197.8
Cohocton/Dutch Hill, NY (2009)	NA	NA	8.62	50	125
Casselman, PA (2009)	NA	NA	8.6	23	34.5
Noble Bliss, NY (2008)	NA	NA	7.8	67	100
Criterion, MD (2012)	NA	NA	7.62	28	70
Mount Storm, WV (2011)	NA	NA	7.43	132	264
Maple Ridge, NY (2012)	NA	NA	7.3	195	321.75
Mount Storm, WV (Fall 2008)	35.2	7/20/08-10/12/08	6.62	82	164
Maple Ridge, NY (2007)	NA	NA	6.49	195	321.75
Wolfe Island, Ont (July-December 2009)	NA	NA	6.42	86	197.8
Roth Rock, MD (2011)	NA	NA	6.24	20	50
Steel Winds I & II, NY (2013)	NA	NA	6.14	14	35
Criterion, MD (2013)	NA	NA	5.32	28	70
Maple Ridge, NY (2007-2008)	NA	NA	4.96	195	321.75
Noble Clinton, NY (2009)	1.9[C]	8/1/09-09/31/09	4.5	67	100
Casselman Curtailment, PA (2008)	NA	NA	4.4	23	35.4
Noble Altona, NY (2010)	NA	NA	4.34	65	97.5
Noble Ellenburg, NY (2009)	16.1[C]	8/16/09-09/15/09	3.91	54	80
Noble Bliss, NY (2009)	NA	NA	3.85	67	100
Lempster, NH (2010)	NA	NA	3.57	12	24
Noble Ellenburg, NY (2008)	NA	NA	3.46	54	80
Noble Clinton, NY (2008)	2.1[C]	8/8/08-09/31/08	3.14	67	100
Lempster, NH (2009)	NA	NA	3.11	12	24
Record Hill, ME (2012)	24.6	4/16/12-10/23/12	2.96	22	50.6
Mars Hill, ME (2007)	NA	NA	2.91	28	42
Wolfe Island, Ont (July-December 2011)	NA	NA	2.49	86	197.8
Noble Chateaugay, NY (2010)	NA	NA	2.44	71	106.5
High Sheldon, NY (2010)	NA	NA	2.33	75	112.5
Stetson Mountain II, ME (2012)	NA	NA	2.27	17	25.5
Howard, NY (2013)	NA	NA	2.13	27	54
Beech Ridge, WV (2012)	NA	NA	2.03	67	100.5
Munnsville, NY (2008)	NA	NA	1.93	23	34.5
High Sheldon, NY (2011)	NA	NA	1.78	75	112.5
Groton, NH (2015)	NA	NA	1.74	24	48
Stetson Mountain II, ME (2010)	NA	NA	1.65	17	25.5
Groton, NH (2014)	NA	NA	1.63	NA	48
Bull Hill, ME (2013)	NA	NA	1.62	19	34
Stetson Mountain I, ME (2009)	28.5; 0.3[G]	7/10/09-10/15/09	1.4	38	57

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as the bat passes per detector night. Fatality estimate given as the number of fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Cohocton/Dutch Hill, NY (2013)	NA	NA	1.37	50	125
Groton, NH (2013)	NA	NA	1.31	24	48
Record Hill, ME (2016)	NA	NA	1.25	22	51
Stetson II, ME (2014)	NA	NA	0.83	17	26
Beech Ridge, WV (2013)	NA	NA	0.58	67	100.5
Record Hill, ME (2014)	NA	NA	0.55	22	50.6
Oakfield, ME (2017)	NA	NA	0.51	48	148
Mars Hill, ME (2008)	NA	NA	0.45	28	42
Rollins, ME (2014)	NA	NA	0.33	40	60
Spruce Mountain Wind Project, ME (2014)	NA	NA	0.31	10	20
Hancock, ME (2017)	NA	NA	0.3	17	51
Stetson Mountain I, ME (2011)	NA	NA	0.28	38	57
Bingham Wind Project, ME (2017)	NA	NA	0.23	56	185
Stetson Mountain I, ME (2013)	NA	NA	0.18	38	57
Rollins, ME (2012)	NA	NA	0.18	40	60
Kibby, ME (2011)	NA	NA	0.12	44	132

A = Activity rate based on pre-construction monitoring; data for all other activity and fatality rates were collected concurrently

B = Activity rate was averaged across phases and/or years

C = Activity rate based on data collected at various heights; all other activity rates are from ground-based units only

D = Activity rate calculated by Western EcoSystems Technology, Inc. from data presented in referenced report

E = Average of ground-based detectors at CPC Proper (Phase I) for late summer/fall period only

F = Activity rate based on data collected from ground-based units excluding reference stations during the spring, summer and fall seasons

G = The overall activity rate of 28.5 is from reference stations located along forest edges, which may be attractive to bats; the activity rate of 0.3 is from one unit placed on a nacelle

Appendix A1 (*continued*). Wind energy facilities in North America with comparable activity and fatality data for bats. Data from the following sources:

Facility	Activity Estimate	Fatality Estimate	Facility	Activity Estimate	Fatality Estimate
Sweetland, SD	**This study**				
Alite, CA (2009-2010)		Chatfield et al. 2010	Linden Ranch, WA (2010-2011)		Enz and Bay 2011
Alta Wind I, CA (2011-2012)	Solick et al. 2010	Chatfield et al. 2012	Locust Ridge, PA (Phase II; 2009)		Arnett et al. 2011
Alta Wind I, CA (2013-2014)		Chatfield et al. 2014	Locust Ridge, PA (Phase II; 2010)		Arnett et al. 2011
Alta I, CA (2015-2016)		Thompson et al. 2016a	Lower West, CA (2012-2013)		Levenstein and Bay 2013a
Alta Wind II-V, CA (2011-2012)	Solick et al. 2010	Chatfield et al. 2012	Lower West, CA (2014-2015)		Levenstein and DiDonato 2015
Alta II-V, CA (2013-2014)		Chatfield et al. 2014	Lower West, CA (2016-2017)		WEST 2017b
Alta II-V, CA (2015-2016)		Thompson et al. 2016a	Maple Ridge, NY (2006)		Jain et al. 2007
Alta VIII, CA (2012-2013)		Chatfield and Bay 2014	Maple Ridge, NY (2007)		Jain et al. 2009a
Alta VIII, CA (2014-2015)		Western EcoSystems Technology, Inc. (WEST) 2016c	Maple Ridge, NY (2007-2008)		Jain et al. 2009b
Alta X, CA (2014-2015)		Chatfield et al. 2015	Maple Ridge, NY (2012)		Tidhar et al. 2013b
Alta X, CA (2015-2016)		Thompson et al. 2016b	Marengo I, WA (2009-2010)		URS 2010b
Barton I & II, IA (2010-2011)		Derby et al. 2011b	Marengo II, WA (2009-2010)		URS 2010c
Barton Chapel, TX (2009-2010)		WEST 2011	Mars Hill, ME (2007)		Stantec 2008a
Beech Ridge, WV (2012)		Tidhar et al. 2013a	Mars Hill, ME (2008)		Stantec 2009a
Beech Ridge, WV (2013)		Young et al. 2014a	Milford I, UT (2010-2011)		Stantec 2011b
Big Blue, MN (2013)		Fagen Engineering 2014	Milford I & II, UT (2011-2012)		Stantec 2012b
Big Blue, MN (2014)		Fagen Engineering 2015	Montezuma I, CA (2011)		ICF International 2012
Big Horn, WA (2006-2007)		Kronner et al. 2008	Montezuma I, CA (2012)		ICF International 2013
Big Smile, OK (2012-2013)		Derby et al. 2013b	Montezuma II, CA (2012-2013)		Harvey & Associates 2013
Biglow Canyon, OR (Phase I; 2008)		Jeffrey et al. 2009b	Moraine II, MN (2009)		Derby et al. 2010f
Biglow Canyon, OR (Phase I; 2009)		Enk et al. 2010	Mount Storm, WV (Fall 2008)	Young et al. 2009c	Young et al. 2009c
Biglow Canyon, OR (Phase II; 2009-2010)		Enk et al. 2011b	Mount Storm, WV (2009)	Young et al. 2009a, 2010b	Young et al. 2009a, 2010b
Biglow Canyon, OR (Phase II; 2010-2011)		Enk et al. 2012b	Mount Storm, WV (2010)	Young et al. 2010a, 2011b	Young et al. 2010a, 2011b

Appendix A1 (*continued*). Wind energy facilities in North America with comparable activity and fatality data for bats. Data from the following sources:

Facility	Activity Estimate	Fatality Estimate	Facility	Activity Estimate	Fatality Estimate
Biglow Canyon, OR (Phase III; 2010-2011)		Enk et al. 2012a	Mount Storm, WV (2011)		Young et al. 2011a, 2012a
Bingham Wind Project, ME (2017)		TRC 2017a	Mountaineer, WV (2003)		Kerns and Kerlinger 2004
Blue Sky Green Field, WI (2008; 2009)	Gruver 2008	Gruver et al. 2009	Munnsville, NY (2008)		Stantec 2009b
Buffalo Gap I, TX (2006)		Tierney 2007			
Buffalo Gap II, TX (2007-2008)		Tierney 2009	Mustang Hills, CA (2012-2013)		Chatfield and Bay 2014
Buffalo Mountain, TN (2000-2003)	Fiedler 2004	Nicholson et al. 2005	Mustang Hills, CA (2014-2015)		WEST 2016c
Buffalo Mountain, TN (2005)		Fiedler et al. 2007	Mustang Hills, CA (2016-2017)		WEST 2018
Buffalo Ridge, MN (Phase I; 1999)		Johnson et al. 2000	Nine Canyon, WA (2002-2003)		Erickson et al. 2003
Buffalo Ridge, MN (Phase II; 1998)		Johnson et al. 2000	Noble Altona, NY (2010)		Jain et al. 2011a
Buffalo Ridge, MN (Phase II; 1999)		Johnson et al. 2000	Noble Bliss, NY (2008)		Jain et al.2009c
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	Johnson et al. 2004	Johnson et al. 2004	Noble Bliss, NY (2009)		Jain et al. 2010c
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	Johnson et al. 2004	Johnson et al. 2004	Noble Chateaugay, NY (2010)		Jain et al. 2011b
Buffalo Ridge, MN (Phase III; 1999)		Johnson et al. 2000	Noble Clinton, NY (2008)	Reynolds 2010a	Jain et al. 2009d
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	Johnson et al. 2004	Johnson et al. 2004	Noble Clinton, NY (2009)	Reynolds 2010a	Jain et al. 2010a
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	Johnson et al. 2004	Johnson et al. 2004	Noble Ellenburg, NY (2008)		Jain et al. 2009e
Buffalo Ridge I, SD (2009-2010)		Derby et al. 2010d	Noble Ellenburg, NY (2009)	Reynolds 2010b	Jain et al. 2010b
Buffalo Ridge II, SD (2011-2012)		Derby et al. 2012a	Noble Wethersfield, NY (2010)		Jain et al. 2011c
Bull Hill, ME (2013)		Stantec Consulting (Stantec) 2014a	NPPD Ainsworth, NE (2006)		Derby et al. 2007
Cameron Ridge/Section 15, CA (2014-2015)		WEST 2016b	Oakfield, ME (2017)		TRC 2018
Cameron Ridge/Section 15, CA (2015-2016)		Rintz and Thompson 2017	Odell, MN (2016-2017)		Chodachek and Gustafson 2018
Casselman, PA (2008)		Arnett et al. 2009b	Pacific Wind, CA (2014-2015)		WEST 2016a
Casselman, PA (2009)		Arnett et al. 2010	Pacific Wind, CA (2015-2016)		WEST 2017a
Casselman Curtailment, PA (2008)		Arnett et al. 2009a	Palouse Wind, WA (2012-2013)		Stantec 2013a
Cedar Ridge, WI (2009)	BHE Environmental 2008	BHE Environmental 2010	Pebble Springs, OR (2009-2010)		Gritski and Kronner 2010b
Cedar Ridge, WI (2010)	BHE Environmental 2008	BHE Environmental 2011	Pinnacle, WV (2012)		Hein et al. 2013b
Chopin, OR (2016-2017)		Hallingstad and Riser-Espinoza 2017	Pinyon Pines I & II, CA (2013-2014)		Chatfield and Russo 2014

Appendix A1 (*continued*). Wind energy facilities in North America with comparable activity and fatality data for bats. Data from the following sources:

Facility	Activity Estimate	Fatality Estimate	Facility	Activity Estimate	Fatality Estimate
Cohocton/Dutch Hill, NY (2009)		Stantec 2010	Pinyon Pines I & II, CA (2015-2016)		Rintz and Starcevich 2016
Cohocton/Dutch Hills, NY (2010)		Stantec 2011a	Pioneer Prairie I, IA (Phase II; 2011-2012)		Chodachek et al. 2012
Cohocton/Dutch Hill, NY (2013)		Stantec 2014b	Pioneer Prairie II, IA (2013)		Chodachek et al. 2014
Combine Hills, OR (Phase I; 2004-2005)		Young et al. 2006	Pleasant Valley, MN (2016-2017)		Tetra Tech 2017b
Combine Hills, OR (2011)		Enz et al. 2012	Prairie Rose, MN (2014)		Chodachek et al. 2015
Crescent Ridge, IL (2005-2006)		Kerlinger et al. 2007	PrairieWinds ND1 (Minot), ND (2010)		Derby et al. 2011d
Criterion, MD (2011)		Young et al. 2012b	PrairieWinds ND1 (Minot), ND (2011)		Derby et al. 2012d
Criterion, MD (2012)		Young et al. 2013	PrairieWinds SD1, SD (2011-2012)		Derby et al. 2012c
Criterion, MD (2013)		Young et al. 2014b	PrairieWinds SD1, SD (2012-2013)		Derby et al. 2013a
Crystal Lake II, IA (2009)		Derby et al. 2010b	PrairieWinds SD1, SD (2013-2014)		Derby et al. 2014
Diablo Winds, CA (2005-2007)		WEST 2006, 2008	Rail Splitter, IL (2012-2013)		Good et al. 2013b
Dillon, CA (2008-2009)		Chatfield et al. 2009	Record Hill, ME (2012)	Stantec 2008b	Stantec 2013b
Dry Lake I, AZ (2009-2010)	Thompson et al. 2011	Thompson et al. 2011	Record Hill, ME (2014)		Stantec 2015a
Dry Lake II, AZ (2011-2012)	Thompson and Bay 2012	Thompson and Bay 2012	Record Hill, ME (2016)		Stantec 2017
Elkhorn, OR (2008)		Jeffrey et a. 2009a	Red Hills, OK (2012-2013)		Derby et al. 2013c
Elkhorn, OR (2010)		Enk et al. 2011a	Ripley, Ont (2008)		Jacques Whitford 2009
Elm Creek, MN (2009-2010)		Derby et al. 2010e	Rising Tree, CA (2017-2018)		Chatfield et al. 2018
Elm Creek II, MN (2011-2012)		Derby et al. 2012b	Rollins, ME (2012)		Stantec 2013c
Foote Creek Rim I, WY (1999)		Young et al. 2003	Rollins, ME (2014)		Stantec 2015b
Foote Creek Rim I, WY (2000)	Gruver 2002	Young et al. 2003	Roth Rock, MD (2011)		Atwell, LLC 2012
Foote Creek Rim I, WY (2001-2002)	Gruver 2002	Young et al. 2003	Rugby, ND (2010-2011)		Derby et al. 2011c
Forward Energy Center, WI (2008-2010)	Watt and Drake 2011	Grodsky and Drake 2011	Shiloh I, CA (2006-2009)		Kerlinger et al. 2009
Fowler I, IN (2009)		Johnson et al. 2010a	Shiloh II, CA (2009-2010)		Kerlinger et al. 2010, 2013a
Fowler I, II, III, IN (2010)		Good et al. 2011	Shiloh II, CA (2010-2011)		Kerlinger et al. 2013a
Fowler I, II, III, IN (2011)		Good et al. 2012	Shiloh II, CA (2011-2012)		Kerlinger et al. 2013a
Fowler I, II, III, IN (2012)		Good et al. 2013a	Shiloh III, CA (2012-2013)		Kerlinger et al. 2013b
Fowler III, IN (2009)		Johnson et al. 2010b	Solano III, CA (2012-2013)		AECOM 2013
Fowler, IN (2014)		Good et al. 2015	Spring Valley, NV (2012-2013)		WEST 2014

Appendix A1 (*continued*). Wind energy facilities in North America with comparable activity and fatality data for bats. Data from the following sources:

Facility	Activity Estimate	Fatality Estimate	Facility	Activity Estimate	Fatality Estimate
Fowler, IN (2015)		Good et al. 2016	Spruce Mountain Wind Project, ME (2014)		Tetra Tech 2015
Fowler, IN (2016)		Good et al. 2017	Stateline, OR/WA (2001-2002)		Erickson et al. 2004
Goodnoe, WA (2009-2010)		URS Corporation (URS) 2010a	Stateline, OR/WA (2003)		Erickson et al. 2004
Grand Ridge I, IL (2009-2010)		Derby et al. 2010a	Stateline, OR/WA (2006)		Erickson et al. 2007
Groton, NH (2013)		Stantec and WEST 2014	Steel Winds I & II, NY (2013)		Stantec 2014c
Groton, NH (2014)		Stantec and WEST 2015a	Stetson II, ME (2014)		Stantec 2015c
Groton, NH (2015)		Stantec and WEST 2015b	Stetson Mountain I, ME (2009)	Stantec 2009c	Stantec 2009c
Hancock, ME (2017)		TRC 2017b	Stetson Mountain I, ME (2011)		Normandeau Associates 2011
Harrow, Ont (2010)		Natural Resources Solutions Inc. (NRSI) 2011	Stetson Mountain I, ME (2013)		Stantec 2014d
Harvest Wind, WA (2010-2012)		Downes and Gritski 2012a	Stetson Mountain II, ME (2010)		Normandeau Associates 2010
Hatchet Ridge, CA (2011)		Tetra Tech 2013	Stetson Mountain II, ME (2012)		Stantec 2013d
Hatchet Ridge, CA (2012)		Tetra Tech 2013	Summerview, Alb (2005-2006)		Brown and Hamilton 2006b
Hatchet Ridge, CA (2012-2013)		Tetra Tech 2014	Summerview, Alb (2006; 2007)	Baerwald 2008	Baerwald 2008
Hay Canyon, OR (2009-2010)		Gritski and Kronner 2010a	Top Crop I & II, IL (2012-2013)		Good et al. 2013c
High Sheldon, NY (2010)		Tidhar et al. 2012a	Top of Iowa, IA (2003)		Jain 2005
High Sheldon, NY (2011)		Tidhar et al. 2012b	Top of Iowa, IA (2004)	Jain 2005	Jain 2005
High Winds, CA (2003-2004)		Kerlinger et al. 2006	Top of the World, WY (2010-2011)		Rintz and Bay 2012
High Winds, CA (2004-2005)		Kerlinger et al. 2006	Top of the World, WY (2011-2012)		Rintz and Bay 2013
Hopkins Ridge, WA (2006)		Young et al. 2007	Top of the World, WY (2012-2013)		Rintz and Bay 2014
Hopkins Ridge, WA (2008)		Young et al. 2009b	Tucannon River, WA (2015)		Hallingstad et al. 2016
Howard, NY (2012)		Tidhar et al. 2013c	Tuolumne (Windy Point I), WA (2009-2010)		Enz and Bay 2010
Howard, NY (2013)		Lukins et al. 2014	Vansycle, OR (1999)		Erickson et al. 2000
Judith Gap, MT (2006-2007)		TRC Environmental Corporation 2008	Vantage, WA (2010-2011)		Ventus Environmental Solutions 2012
Judith Gap, MT (2009)		Poulton and Erickson 2010	Waverly Wind, KS (2016-2017)		Tetra Tech 2017a
Kewaunee County, WI (1999-2001)		Howe et al. 2002	Wessington Springs, SD (2009)		Derby et al. 2010c
Kibby, ME (2011)		Stantec 2012a	Wessington Springs, SD (2010)		Derby et al. 2011a

Appendix A1 (*continued*). Wind energy facilities in North America with comparable activity and fatality data for bats. Data from the following sources:

Facility	Activity Estimate	Fatality Estimate	Facility	Activity Estimate	Fatality Estimate
Kittitas Valley, WA (2011-2012)		Stantec Consulting Services 2012	White Creek, WA (2007-2011)		Downes and Gritski 2012b
Klondike, OR (2002-2003)		Johnson et al. 2003	Wild Horse, WA (2007)		Erickson et al. 2008
Klondike II, OR (2005-2006)		Northwest Wildlife Consultants (NWC) and WEST 2007	Windstar, CA (2012-2013)		Levenstein and Bay 2013b
Klondike III (Phase I), OR (2007-2009)		Gritski et al. 2010	Windy Flats, WA (2010-2011)		Enz et al. 2011
Klondike IIIa (Phase II), OR (2008-2010)		Gritski et al. 2011	Winnebago, IA (2009-2010)		Derby et al. 2010g
Lakefield Wind, MN (2012)		Minnesota Public Utilities Commission 2012	Wolfe Island, Ont (July-December 2009)		Stantec Ltd. 2010
Leaning Juniper, OR (2006-2008)		Gritski et al. 2008	Wolfe Island, Ont (July-December 2010)		Stantec Ltd. 2011
Lempster, NH (2009)		Tidhar et al. 2010	Wolfe Island, Ont (July-December 2011)		Stantec Ltd. 2012
Lempster, NH (2010)		Tidhar et al. 2011			

Appendix A2. Bat fatality estimates for North American wind-energy facilities.

Study	Bat Fatalities (Bats/Megawatt/ Year)	Predominant Habitat Type	Citation
Alite, CA (2009-2010)	0.24	Shrub/scrub & grassland	Chatfield et al. 2010
Alta I, CA (2011-2012)	1.28	Woodland, grassland, shrubland	Chatfield et al. 2012
Alta I, CA (2013-2014)	0.36	NA	Chatfield et al. 2014
Alta I, CA (2015-2016)	0.7	NA	Thompson et al. 2016a
Alta II-V, CA (2011-2012)	0.08	Desert scrub	Chatfield et al. 2012
Alta II-V, CA (2013-2014)	0	NA	Chatfield et al. 2014
Alta II-V, CA (2015-2016)	0	NA	Thompson et al. 2016a
Alta VIII, CA (2012-2013)	0	Grassland and riparian	Chatfield and Bay 2014
Alta VIII, CA (2014-2015)	0.17	NA	Western EcoSystems Technology, Inc. (WEST) 2016c
Alta X, CA (2014-2015)	0.42	NA	Chatfield et al. 2015
Alta X, CA (2015-2016)	0.8	Desert scrub	Thompson et al. 2016b
Barton I & II, IA (2010-2011)	1.85	Agriculture	Derby et al. 2011b
Barton Chapel, TX (2009-2010)	3.06	Agriculture/forest	WEST 2011
Beech Ridge, WV (2012)	2.03	Forest	Tidhar et al. 2013a
Beech Ridge, WV (2013)	0.58	Forest	Young et al. 2014a
Big Blue, MN (2013)	2.04	Agriculture	Fagen Engineering 2014
Big Blue, MN (2014)	1.43	Agriculture	Fagen Engineering 2015
Big Horn, WA (2006-2007)	1.9	Agriculture/grassland	Kronner et al. 2008
Big Smile, OK (2012-2013)	2.9	Grassland, agriculture	Derby et al. 2013b
Biglow Canyon, OR (Phase I; 2008)	1.99	Agriculture/grassland	Jeffrey et al. 2009b
Biglow Canyon, OR (Phase I; 2009)	0.58	Agriculture/grassland	Enk et al. 2010
Biglow Canyon, OR (Phase II; 2009-2010)	2.71	Agriculture	Enk et al. 2011b
Biglow Canyon, OR (Phase II; 2010-2011)	0.57	Grassland/shrub-steppe, agriculture	Enk et al. 2012b
Biglow Canyon, OR (Phase III; 2010-2011)	0.22	Grassland/shrub-steppe, agriculture	Enk et al. 2012a
Bingham Wind Project, ME (2017)	0.23	NA	TRC 2017a
Blue Sky Green Field, WI (2008; 2009)	24.57	Agriculture	Gruver et al. 2009
Buffalo Gap I, TX (2006)	0.1	Grassland	Tierney 2007
Buffalo Gap II, TX (2007-2008)	0.14	Forest	Tierney 2009
Buffalo Mountain, TN (2000-2003)	31.54	Forest	Nicholson et al. 2005

Appendix A2. Bat fatality estimates for North American wind-energy facilities.

Study	Bat Fatalities (Bats/Megawatt/ Year)	Predominant Habitat Type	Citation
Buffalo Mountain, TN (2005)	39.7	Forest	Fiedler et al. 2007
Buffalo Ridge, MN (Phase I; 1999)	0.74	Agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1998)	2.16	Agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1999)	2.59	Agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	4.35	Agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	1.64	Agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase III; 1999)	2.72	Agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	3.71	Agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	1.81	Agriculture	Johnson et al. 2004
Buffalo Ridge I, SD (2009-2010)	0.16	Agriculture/grassland	Derby et al. 2010d
Buffalo Ridge II, SD (2011-2012)	2.81	Agriculture, grassland	Derby et al. 2012a
Bull Hill, ME (2013)	1.62	Forest	Stantec Consulting (Stantec) 2014a
Cameron Ridge/Section 15, CA (2014-2015)	0.15	NA	WEST 2016b
Cameron Ridge/Section 15, CA (2015-2016)	0.19	NA	Rintz and Thompson 2017
Casselman, PA (2008)	12.61	Forest	Arnett et al. 2009b
Casselman, PA (2009)	8.6	Forest, pasture, grassland	Arnett et al. 2010
Casselman Curtailment, PA (2008)	4.4	Forest	Arnett et al. 2009a
Cedar Ridge, WI (2009)	30.61	Agriculture	BHE Environmental 2010
Cedar Ridge, WI (2010)	24.12	Agriculture	BHE Environmental 2011
Chopin, OR (2016-2017)	1.9	Agriculture	Hallingstad and Riser-Espinoza 2017
Cohocton/Dutch Hill, NY (2009)	8.62	Agriculture/forest	Stantec 2010
Cohocton/Dutch Hills, NY (2010)	10.32	Agriculture/forest	Stantec 2011a
Cohocton/Dutch Hill, NY (2013)	1.37	Agriculture, forest	Stantec 2014b
Combine Hills, OR (Phase I; 2004-2005)	1.88	Agriculture/grassland	Young et al. 2006
Combine Hills, OR (2011)	0.73	Grassland/shrub-steppe, agriculture	Enz et al. 2012

Appendix A2. Bat fatality estimates for North American wind-energy facilities.

Study	Bat Fatalities (Bats/Megawatt/ Year)	Predominant Habitat Type	Citation
Crescent Ridge, IL (2005-2006)	3.27	Agriculture	Kerlinger et al. 2007
Criterion, MD (2011)	15.61	Forest, agriculture	Young et al. 2012b
Criterion, MD (2012)	7.62	Forest, agriculture	Young et al. 2013
Criterion, MD (2013)	5.32	Forest, agriculture	Young et al. 2014b
Crystal Lake II, IA (2009)	7.42	Agriculture	Derby et al. 2010b
Diablo Winds, CA (2005-2007)	0.82	NA	WEST 2006, 2008
Dillon, CA (2008-2009)	2.17	Desert	Chatfield et al. 2009
Dry Lake I, AZ (2009-2010)	3.43	Desert grassland/forested	Thompson et al. 2011
Dry Lake II, AZ (2011-2012)	1.66	Desert grassland/forested	Thompson and Bay 2012
Elkhorn, OR (2008)	1.26	Shrub/scrub & agriculture	Jeffrey et a. 2009a
Elkhorn, OR (2010)	2.14	Shrub/scrub & agriculture	Enk et al. 2011a
Elm Creek, MN (2009-2010)	1.49	Agriculture	Derby et al. 2010e
Elm Creek II, MN (2011-2012)	2.81	Agriculture, grassland	Derby et al. 2012b
Foote Creek Rim I, WY (1999)	3.97	Grassland	Young et al. 2003
Foote Creek Rim I, WY (2000)	1.05	Grassland	Young et al. 2003
Foote Creek Rim I, WY (2001-2002)	1.57	Grassland	Young et al. 2003
Forward Energy Center, WI (2008-2010)	18.17	Agriculture	Grodsky and Drake 2011
Fowler I, IN (2009)	8.09	Agriculture	Johnson et al. 2010a
Fowler I, II, III, IN (2010)	18.96	Agriculture	Good et al. 2011
Fowler I, II, III, IN (2011)	20.19	Agriculture	Good et al. 2012
Fowler I, II, III, IN (2012)	2.96	Agriculture	Good et al. 2013a
Fowler III, IN (2009)	1.84	Agriculture	Johnson et al. 2010b
Fowler, IN (2014)	4.86	Agriculture	Good et al. 2015
Fowler, IN (2015)	4.54	Agriculture	Good et al. 2016
Fowler, IN (2016)	4.54	Agriculture	Good et al. 2017
Goodnoe, WA (2009-2010)	0.34	Grassland and shrub-steppe	URS Corporation (URS) 2010a
Grand Ridge I, IL (2009-2010)	2.1	Agriculture	Derby et al. 2010a
Groton, NH (2013)	1.31	Foothills, forest	Stantec and WEST 2014
Groton, NH (2014)	1.63	Foothills, forest	Stantec and WEST 2015a
Groton, NH (2015)	1.74	Foothills, forest	Stantec and WEST 2015b
Hancock, ME (2017)	0.3	Gravel, grassland	TRC 2017b

Appendix A2. Bat fatality estimates for North American wind-energy facilities.

Study	Bat Fatalities (Bats/Megawatt/ Year)	Predominant Habitat Type	Citation
Harrow, Ont (2010)	11.13	Agriculture	Natural Resources Solutions Inc. 2011
Harvest Wind, WA (2010-2012)	1.27	Grassland/shrub-steppe	Downes and Gritski 2012a
Hatchet Ridge, CA (2011)	2.23	NA	Tetra Tech 2013
Hatchet Ridge, CA (2012)	5.22	NA	Tetra Tech 2013
Hatchet Ridge, CA (2012-2013)	4.2	NA	Tetra Tech 2014
Hay Canyon, OR (2009-2010)	0.53	Agriculture	Gritski and Kronner 2010a
High Sheldon, NY (2010)	2.33	Agriculture	Tidhar et al. 2012a
High Sheldon, NY (2011)	1.78	Agriculture	Tidhar et al. 2012b
High Winds, CA (2003-2004)	2.51	Agriculture/grassland	Kerlinger et al. 2006
High Winds, CA (2004-2005)	1.52	Agriculture/grassland	Kerlinger et al. 2006
Hopkins Ridge, WA (2006)	0.63	Agriculture/grassland	Young et al. 2007
Hopkins Ridge, WA (2008)	1.39	Agriculture/grassland	Young et al. 2009b
Howard, NY (2012)	10	Agriculture	Tidhar et al. 2013c
Howard, NY (2013)	2.13	Agriculture	Lukins et al. 2014
Judith Gap, MT (2006-2007)	8.93	Agriculture/grassland	TRC Environmental Corporation 2008
Judith Gap, MT (2009)	3.2	Agriculture/grassland	Poulton and Erickson 2010
Kewaunee County, WI (1999-2001)	6.45	Agriculture	Howe et al. 2002
Kibby, ME (2011)	0.12	Forest; commercial forest	Stantec 2012a
Kittitas Valley, WA (2011-2012)	0.12	Sagebrush-steppe, grassland	Stantec Consulting Services 2012
Klondike, OR (2002-2003)	0.77	Agriculture/grassland	Johnson et al. 2003
Klondike II, OR (2005-2006)	0.41	Agriculture/grassland	Northwest Wildlife Consultants (NWC) and WEST 2007
Klondike III (Phase I), OR (2007-2009)	1.11	Agriculture/grassland	Gritski et al. 2010
Klondike IIIa (Phase II), OR (2008-2010)	0.14	Grassland/shrub-steppe and agriculture	Gritski et al. 2011
Lakefield Wind, MN (2012)	19.87	Agriculture	Minnesota Public Utilities Commission 2012
Leaning Juniper, OR (2006-2008)	1.98	Agriculture	Gritski et al. 2008
Lempster, NH (2009)	3.11	Grasslands/forest/rocky embankments	Tidhar et al. 2010
Lempster, NH (2010)	3.57	Grasslands/forest/rocky embankments	Tidhar et al. 2011
Linden Ranch, WA (2010-2011)	1.68	Grassland/shrub-steppe, agriculture	Enz and Bay 2011

Appendix A2. Bat fatality estimates for North American wind-energy facilities.

Study	Bat Fatalities (Bats/Megawatt/ Year)	Predominant Habitat Type	Citation
Locust Ridge, PA (Phase II; 2009)	14.11	Grassland	Arnett et al. 2011
Locust Ridge, PA (Phase II; 2010)	14.38	Grassland	Arnett et al. 2011
Lower West, CA (2012-2013)	2.17	NA	Levenstein and Bay 2013a
Lower West, CA (2014-2015)	1.13	NA	Levenstein and DiDonato 2015
Lower West, CA (2016-2017)	0	Desert scrub, Joshua tree	WEST 2017b
Maple Ridge, NY (2006)	11.21	Agriculture/forested	Jain et al. 2007
Maple Ridge, NY (2007-2008)	4.96	Agriculture/forested	Jain et al. 2009a
Maple Ridge, NY (2007)	6.49	Agriculture/forested	Jain et al. 2009b
Maple Ridge, NY (2012)	7.3	Agriculture/forested	Tidhar et al. 2013b
Marengo I, WA (2009-2010)	0.17	Agriculture	URS 2010b
Marengo II, WA (2009-2010)	0.27	Agriculture	URS 2010c
Mars Hill, ME (2007)	2.91	Forest	Stantec 2008a
Mars Hill, ME (2008)	0.45	Forest	Stantec 2009a
Milford I, UT (2010-2011)	2.05	Desert shrub	Stantec 2011b
Milford I & II, UT (2011-2012)	1.67	Desert shrub	Stantec 2012b
Montezuma I, CA (2011)	1.9	Agriculture and grasslands	ICF International 2012
Montezuma I, CA (2012)	0.84	Agriculture and grasslands	ICF International 2013
Montezuma II, CA (2012-2013)	0.91	Agriculture	Harvey & Associates 2013
Moraine II, MN (2009)	2.42	Agriculture/grassland	Derby et al. 2010f
Mount Storm, WV (Fall 2008)	6.62	Forest	Young et al. 2009c
Mount Storm, WV (2009)	17.53	Forest	Young et al. 2009a, 2010b
Mount Storm, WV (2010)	15.18	Forest	Young et al. 2010a, 2011b
Mount Storm, WV (2011)	7.43	Forest	Young et al. 2011a, 2012a
Mountaineer, WV (2003)	31.69	Forest	Kerns and Kerlinger 2004
Munnsville, NY (2008)	1.93	Agriculture/forest	Stantec 2009b
Mustang Hills, CA (2012-2013)	0.1	Grasslands and riparian	Chatfield and Bay 2014
Mustang Hills, CA (2014-2015)	0	Na	WEST 2016c
Mustang Hills, CA (2016-2017)	0.33	Desert scrub, Joshua tree	WEST 2018
Nine Canyon, WA (2002-2003)	2.47	Agriculture/grassland	Erickson et al. 2003
Noble Altona, NY (2010)	4.34	Forest	Jain et al. 2011a

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Study	Bat Fatalities (Bats/Megawatt/ Year)	Predominant Habitat Type	Citation
Noble Bliss, NY (2008)	7.8	Agriculture/forest	Jain et al.2009c
Noble Bliss, NY (2009)	3.85	Agriculture/forest	Jain et al. 2010c
Noble Chateaugay, NY (2010)	2.44	Agriculture	Jain et al. 2011b
Noble Clinton, NY (2008)	3.14	Agriculture/forest	Jain et al. 2009d
Noble Clinton, NY (2009)	4.5	Agriculture/forest	Jain et al. 2010a
Noble Ellenburg, NY (2008)	3.46	Agriculture/forest	Jain et al. 2009e
Noble Ellenburg, NY (2009)	3.91	Agriculture/forest	Jain et al. 2010b
Noble Wethersfield, NY (2010)	16.3	Agriculture	Jain et al. 2011c
NPPD Ainsworth, NE (2006)	1.16	Agriculture/grassland	Derby et al. 2007
Oakfield, ME (2017)	0.51	Grassland	TRC 2018
Odell, MN (2016-2017)	6.74	Agriculture	Chodachek and Gustafson 2018
Pacific Wind, CA (2014-2015)	0.21	NA	WEST 2016a
Pacific Wind, CA (2015-2016)	0	NA	WEST 2017a
Palouse Wind, WA (2012-2013)	4.23	Agriculture and grasslands	Stantec 2013a
Pebble Springs, OR (2009-2010)	1.55	Grassland	Gritski and Kronner 2010b
Pinnacle, WV (2012)	40.2	Forest	Hein et al. 2013b
Pinyon Pines I & II, CA (2013-2014)	0.04	NA	Chatfield and Russo 2014
Pinyon Pines I & II, CA (2015-2016)	0.18	NA	Rintz and Starcevich 2016
Pioneer Prairie I, IA (Phase II; 2011-2012)	4.43	Agriculture, grassland	Chodachek et al. 2012
Pioneer Prairie II, IA (2013)	3.83	Agriculture	Chodachek et al. 2014
Pleasant Valley, MN (2016-2017)	1.8	NA	Tetra Tech 2017b
Prairie Rose, MN (2014)	0.41	Agriculture	Chodachek et al. 2015
PrairieWinds ND1 (Minot), ND (2010)	2.13	Agriculture	Derby et al. 2011d
PrairieWinds ND1 (Minot), ND (2011)	1.39	Agriculture, grassland	Derby et al. 2012d
PrairieWinds SD1, SD (2011-2012)	1.23	Grassland	Derby et al. 2012c
PrairieWinds SD1, SD (2012-2013)	1.05	Grassland	Derby et al. 2013a
PrairieWinds SD1, SD (2013-2014)	0.52	Grassland	Derby et al. 2014
Rail Splitter, IL (2012-2013)	11.21	Agriculture	Good et al. 2013b
Record Hill, ME (2012)	2.96	Forest	Stantec 2013b
Record Hill, ME (2014)	0.55	Forest	Stantec 2015a
Record Hill, ME (2016)	1.25	Forest	Stantec 2017

Appendix A2. Bat fatality estimates for North American wind-energy facilities.

Study	Bat Fatalities (Bats/Megawatt/ Year)	Predominant Habitat Type	Citation
Red Hills, OK (2012-2013)	0.11	Grassland	Derby et al. 2013c
Ripley, Ont (2008)	4.67	Agriculture	Jacques Whitford 2009
Rising Tree, CA (2017-2018)	0	Desert scrub, woodland	Chatfield et al. 2018
Rollins, ME (2012)	0.18	Forest	Stantec 2013c
Rollins, ME (2014)	0.33	Gravel	Stantec 2015b
Roth Rock, MD (2011)	6.24	Rocky	Atwell, LLC 2012
Rugby, ND (2010-2011)	1.6	Agriculture	Derby et al. 2011c
Shiloh I, CA (2006-2009)	3.92	Agriculture/grassland	Kerlinger et al. 2009
Shiloh II, CA (2009-2010)	2.6	Agriculture	Kerlinger et al. 2010, 2013a
Shiloh II, CA (2010-2011)	3.8	Agriculture	Kerlinger et al. 2013a
Shiloh II, CA (2011-2012)	3.4	Agriculture	Kerlinger et al. 2013a
Shiloh III, CA (2012-2013)	0.4	NA	Kerlinger et al. 2013b
Solano III, CA (2012-2013)	0.31	NA	AECOM 2013
Spring Valley, NV (2012-2013)	3.73	Grassland, shrub steppe	WEST 2014
Spruce Mountain Wind Project, ME (2014)	0.31	NA	Tetra Tech 2015
Stateline, OR/WA (2001-2002)	1.09	Agriculture/grassland	Erickson et al. 2004
Stateline, OR/WA (2003)	2.29	Agriculture/grassland	Erickson et al. 2004
Stateline, OR/WA (2006)	0.95	Agriculture/grassland	Erickson et al. 2007
Steel Winds I & II, NY (2013)	6.14	Steel Winds I: grassland, shrub forest; Steel Winds II: gravel, steel slag	Stantec 2014c
Stetson II, ME (2014)	0.83	Forest	Stantec 2015c
Stetson Mountain I, ME (2009)	1.4	Forest	Stantec 2009c
Stetson Mountain I, ME (2011)	0.28	Forest	Normandeau Associates 2011
Stetson Mountain I, ME (2013)	0.18	Forest	Stantec 2014d
Stetson Mountain II, ME (2010)	1.65	Forest	Normandeau Associates 2010
Stetson Mountain II, ME (2012)	2.27	Forest	Stantec 2013d
Summerview, Alb (2005-2006)	10.27	Agriculture	Brown and Hamilton 2006b
Summerview, Alb (2006; 2007)	11.42	Agriculture/grassland	Baerwald 2008
Top Crop I & II, IL (2012-2013)	12.55	Agriculture	Good et al. 2013c
Top of Iowa, IA (2003)	7.16	Agriculture	Jain 2005
Top of Iowa, IA (2004)	10.27	Agriculture	Jain 2005

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Study	Bat Fatalities (Bats/Megawatt/ Year)	Predominant Habitat Type	Citation
Top of the World, WY (2010-2011)	2.74	Scrub-shrub, grassland	Rintz and Bay 2012
Top of the World, WY (2011-2012)	2.43	Scrub-shrub, grassland	Rintz and Bay 2013
Top of the World, WY (2012-2013)	2.34	Scrub-shrub, grassland	Rintz and Bay 2014
Tucannon River, WA (2015)	2.22	Agriculture	Hallingstad et al. 2016
Tuolumne (Windy Point I), WA (2009-2010)	0.94	Grassland/shrub-steppe, agriculture and forest	Enz and Bay 2010
Vansycle, OR (1999)	1.12	Agriculture/grassland	Erickson et al. 2000
Vantage, WA (2010-2011)	0.4	Shrub-steppe, grassland	Ventus Environmental Solutions 2012
Waverly Wind, KS (2016-2017)	8.2	NA	Tetra Tech 2017a
Wessington Springs, SD (2009)	1.48	Grassland	Derby et al. 2010c
Wessington Springs, SD (2010)	0.41	Grassland	Derby et al. 2011a
White Creek, WA (2007-2011)	2.04	Grassland/shrub-steppe, agriculture	Downes and Gritski 2012b
Wild Horse, WA (2007)	0.39	Grassland	Erickson et al. 2008
Windstar, CA (2012-2013)	0	NA	Levenstein and Bay 2013b
Windy Flats, WA (2010-2011)	0.41	Grassland/shrub-steppe, agriculture	Enz et al. 2011
Winnebago, IA (2009-2010)	4.54	Agriculture/grassland	Derby et al. 2010g
Wolfe Island, Ont (July-December 2009)	6.42	Grassland	Stantec Consulting Ltd. (Stantec Ltd.) 2010
Wolfe Island, Ont (July-December 2010)	9.5	Grassland	Stantec Ltd. 2011
Wolfe Island, Ont (July-December 2011)	2.49	Grassland	Stantec Ltd. 2012