Bat Acoustic Survey Report for the Crocker Wind Farm Clark County, South Dakota

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April 14 – October 27, 2016

Prepared for:

Crocker Wind Farm, LLC

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EXECUTIVE SUMMARY

In April 2016, Western EcoSystems Technology, Inc. initiated a bat acoustic survey for the proposed Crocker Wind Farm (Project) in Clark County, South Dakota. The bat acoustic survey conducted at the Project was designed to estimate levels of bat activity throughout the Project during spring, summer, and fall.

Acoustic surveys were conducted using SM3 bat detectors from April 14 to October 27, 2016, at two meteorological tower stations located in agricultural fields. The paired ground and raised met tower stations recorded a combined mean (± standard error) of 1.84 ± 0.22 bat passes per detector-night. Detectors at fixed ground stations recorded 448 bat passes on 265 detector-nights for a mean (± standard error) of 1.84 ± 0.23 bat passes per detector-night. Raised stations recorded a similar number (455) of bat passes on 265 detector nights for a mean of 1.83 ± 0.24 per detector-night.

Low-frequency bat species, such as hoary bats and silver-haired bats, composed nearly 67% of bat passes overall. Four bat species and the *Myotis* group were identified at each of the four full-spectrum SM3 stations using the auto-classifier component of Kaleidoscope 3.1.7. Big brown bats were the least commonly recorded and hoary bats were the most commonly recorded species, present on 31% of detector nights.

Bat activity was also highest in the fall, peaking in early August. Activity during the standardized Fall Migration Period was 2.80 ± 0.42 bat passes per detector-night at ground met tower stations. Most wind energy facilities in the Midwest region have reported fewer than five bat fatalities/megawatt (MW)/year (1.64 – 4.35 bats/MW/year). The results from this study suggest that bat fatality rates at the Project may be fewer than five bats/MW/year, occur mainly in the fall, and mainly be composed of low-frequency species such as hoary bats and silver-haired bats.

STUDY PARTICIPANTS

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REPORT REFERENCE

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INTRODUCTION

Crocker Wind Farm, LLC is considering the development of the Crocker Wind Farm (Project) in Clark County, South Dakota. Crocker Wind Farm, LLC contracted Western EcoSystems Technology, Inc. (WEST) to complete a study of bat activity following the recommendations of the U.S. Fish and Wildlife Service (USFWS) Land-based Wind Energy Guidelines (USFWS 2012a) and Kunz et al. (2007a). WEST conducted acoustic monitoring surveys to estimate levels of bat activity throughout the Project during the spring, summer, and fall. The following report describes the results of acoustic monitoring surveys conducted at the Project between April 14 and October 27, 2016.

STUDY AREA

The proposed Project is approximately 31,131 acres (48.6 square miles) in size and lies just southwest of Bradley, South Dakota, in Clark County (Figure 1, Table 1). The landscape within the Project is flat to rolling with elevation ranges from 1,486.3 – 1,918.6 feet ([ft]; 453 – 585 meters [m]). Historically, the Project's landscape was dominated by grasslands but has since been converted largely to agricultural use with crop production and livestock grazing the primary practices. Trees and shrubs can be found around farmsteads, within planted shelter belts, and along/within drainages. Wetlands and lakes are scattered throughout the Project, with some being man-made.

Hay and pasturelands are the most abundant land cover/land use within the Project, making up nearly 37% of the area, followed by herbaceous plants (33%). The majority of the remaining landscape is comprised of cultivated crops (16%), open water (10%), and developed open space (2%). Small amounts (<0.5%) of deciduous forest, emergent herbaceous wetlands, shrub/scrub, developed low, medium, and high intensity lands, and woody wetlands are also present within the Project (Fry et al. 2011; Figure 1). Common agricultural crops include hay, corn, and soybeans.

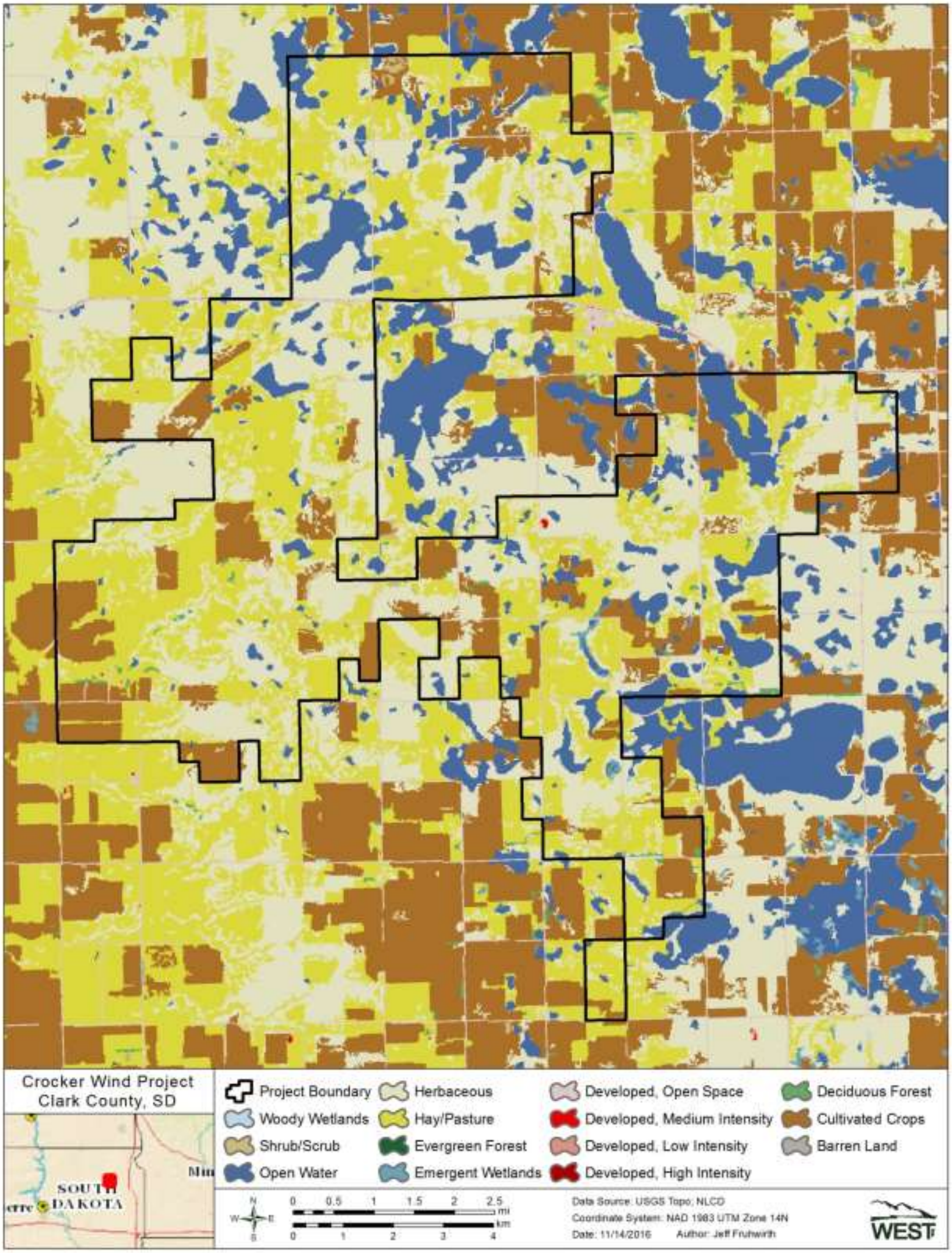

Figure 1. Land cover in the Crocker Wind Farm (USGS NLCD 2001).

Table 1. Land cover in the Crocker Wind Farm according to the United States Geological Survey National Land Cover Dataset (2001).

Land Cover	Acres	% Composition
Hay/Pasture	11,441.2	36.8%
Herbaceous	10,357.0	33.3%
Cultivated Crops	5,030.2	16.2%
Open Water	3,253.6	10.5%
Developed, Open Space	697.9	2.2%
Deciduous Forest	140.5	0.5%
Emergent Herbaceous Wetlands	103.2	0.3%
Shrub/Scrub	83.4	0.3%
Developed, Low Intensity	16.6	0.1%
Developed, Medium Intensity	4.2	0.0%
Woody Wetlands	2.2	0.0%
Developed, High Intensity	1.0	0.0%
Total	**31,131.1**	**100.00%**

Overview of Bat Diversity

Six species of bats potentially occur at the Project and all six species are known to have been killed at wind energy facilities (Table 2). *Myotis septentrionalis*, the northern long-eared bat (NLEB), is federally listed as threatened (USFWS 2016); the habitat analysis and summer presence/absence NLEB survey results are covered in a separate report. The NLEB and silver-haired bat are considered rare in the state by the South Dakota Natural Heritage Program (SDGFP 2016, Table 2).

Table 2. Bat species with potential to occur within the Crocker Wind Farm (IUCN 2009; USFWF 2016 categorized by echolocation call frequency.

Common Name	Scientific Name
High-Frequency (> 30 kHz)	
eastern red bat[1,2]	*Lasiurus borealis*
little brown bat[1]	*Myotis lucifugus*
northern long-eared bat[1,3,4]	*Myotis septentrionalis*
Low-Frequency (< 30 kHz)	
big brown bat[1]	*Eptesicus fuscus*
silver-haired bat[1,2,4]	*Lasionycteris noctivagans*
hoary bat[1,2]	*Lasiurus cinereus*

[1] species known to have been killed at wind energy facilities;
[2] long-distance migrant;
[3] federally threatened species (USFWS 2016); and
[4] state-listed as rare (SDGPF 2016).

White-Nose Syndrome

Bats that hibernate in North America are being severely impacted by white-nose syndrome (WNS), an infectious mycosis in which bats are infected with a psychrophilic fungus from Europe (*Pseudogymnoascus* [formerly *Geomyces*] *destructans*) that is thought to act as a chronic disturbance during hibernation (USGS 2010; Minnis and Lindner 2013). Infected bats arouse frequently from hibernation, leading to premature loss of fat reserves and atypical behavior, which in turn leads to starvation prior to spring emergence (Boyles and Willis 2010; Reeder et al. 2012; Warnecke et al. 2012). WNS was first discovered in New York State in 2006 and by 2013 had rapidly spread to over 115 caves and mines and is now confirmed in 29 states and the causative fungus has been identified in an additional 3 states. To date, the full WNS has spread north into five Canadian provinces, reaching as far south as Alabama and as far west as Washington (Heffernan 2016). It is estimated that between 5.7 and 6.7 million bats have died as a result of WNS (USFWS 2012b). WNS is the primary reason the USFWS recently listed the NLEB as threatened under the Endangered Species Act (USFWS 2015), and is currently reviewing the status of the little brown bat. Neither WNS nor the causative fungal agent have been detected as of 2016 in South Dakota; however the fungus has been detected in the neighboring states of Minnesota, Iowa, and Nebraska.

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 adequate to 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 risk of wind development on bats (Kunz et al. 2007a; Britzke et al. 2013) and inform potential mitigation strategies (Weller and Baldwin 2012).

Survey Stations

Two Song Meter SM3 full-spectrum ultrasonic detectors (hereafter “SM3”; Wildlife Acoustics, Concord, MA) were used during the study. Each SM3 detector is equipped with two microphone ports. The SM3 detectors were placed at meteorological (met) towers with one microphone at ground level (approximately 3 m [10 ft] above ground level) and another at the proposed rotor-swept height (approximately 45 m [148 ft] above ground level; 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. 2007b). Ground-based microphones likely detect a more complete sample of the bat species present within the Project, whereas elevated microphones may give a more accurate assessment of risk to bat species flying at rotor swept heights (Kunz et al. 2007b; Müeller et al. 2013; but see Amorim et al. 2012). Both met tower stations were located in agricultural habitat (Figure 2) and are representative of potential turbine locations.

The SM3 detectors and external batteries deep-cycle were housed inside large tool-boxes for protection from livestock and wildlife. The ground microphone was raised on polyvinyl chloride (commonly PVC) pole to improve the quality of sound recordings for species identification. Raised SM3 microphones were elevated on met towers using a pulley system. The SM3 microphone is weather resistant, and does not require protection, however, the microphone was oriented parallel to the ground to minimize the potential for rain damage.

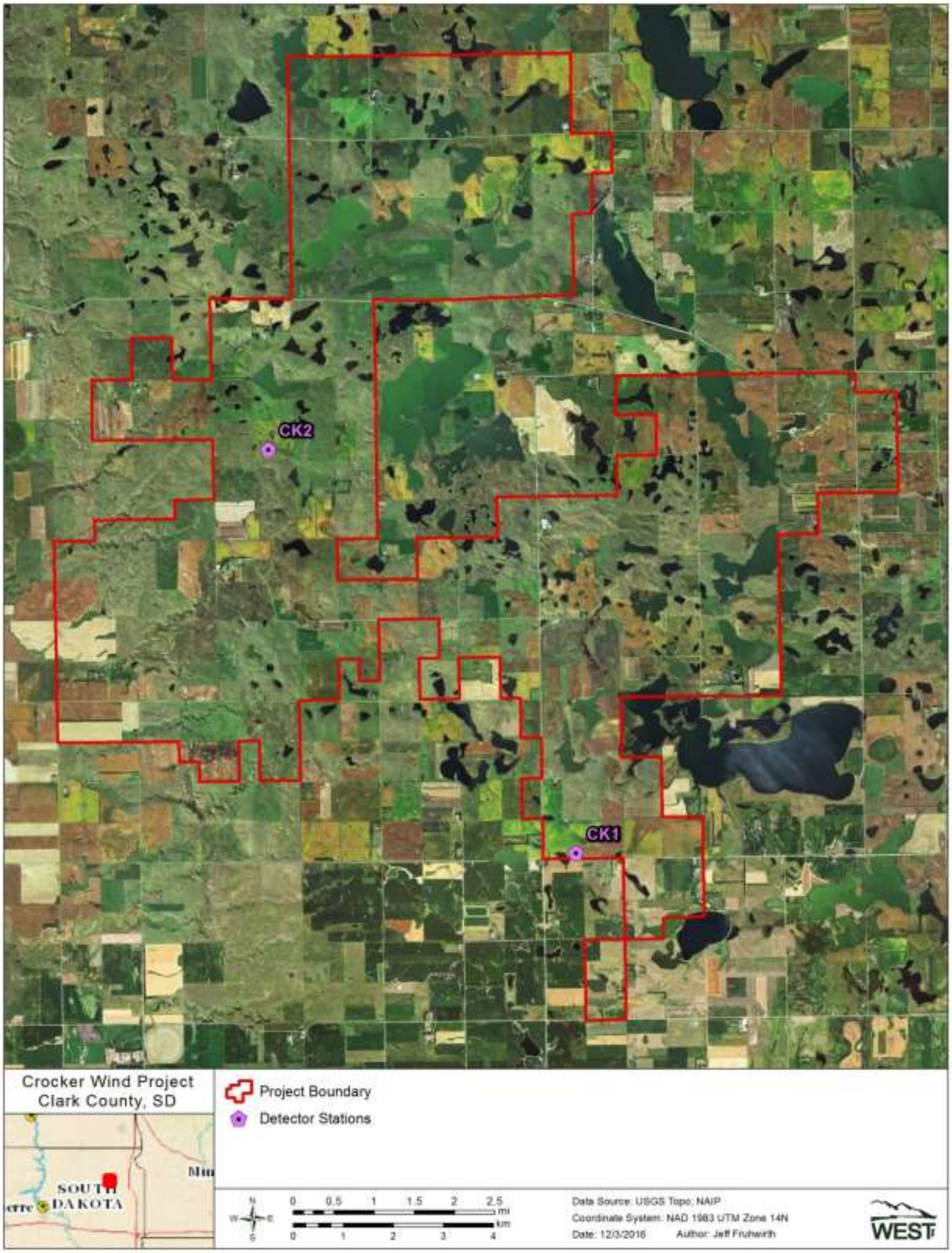

Figure 2. Location of met tower stations in the Crocker Wind Farm.

Survey Schedule

Bats were surveyed in the Project from April 14 to October 27, 2016, and detectors were programmed to turn on approximately 30 minutes before sunset and turn off approximately 30 minutes after sunrise each night. To highlight seasonal activity patterns, the study was divided into three survey periods: spring (April 14 – May 31), summer (June 1 – July 31), and fall (August 1 – October 27). 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

The Song Meter SM3 is a full-spectrum bat detector that records complete acoustic waveforms by sampling sound waves at 192 kilohertz (kHz). This high sampling rate enables the detector to record sound amplitude data at all frequencies up to 96 kHz and to make high resolution recordings. The high quality recordings produced by the SM3 detector provide more information for making species identifications than SM3 detectors at the cost of higher data storage requirements and slower data analysis.

Identification of calls was completed with the automated identification feature in program Kaleidoscope 3.1.7 (Wildlife Acoustics, Concord, Massachusetts) using the Bats of North America classifier 2.1.0. It utilizes Hidden Markov Models and other statistical methods known for their application in temporal pattern recognition such as speech analysis, handwriting analysis, and DNA sequencing (Agranat 2012). Despite the capabilities of Kaleidoscope, many bat passes cannot be identified with certainty, either because only call fragments were recorded due to the distance between the bat and microphone or because many bat species produce similar calls with overlapping call characteristics that often cannot be distinguished. The Kaleidoscope output was used to generate a list of species that may have been present in the Project.

The full-spectrum data recorded by the SM3 were also transformed into zero-crossing data using the program Kaleidoscope 3.1.7 (Wildlife Acoustics, Inc., Concord, Massachusetts), allowing data to be viewed in Analook© software 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.) and to determine the call frequency category.

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, evening bats, and *Myotis* species have minimum frequencies greater than 30 kHz. Low-frequency (LF) bats such as big brown bats, silver-haired bats, and hoary bats 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 area. 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. 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 seven-day period with the highest average bat activity. If multiple seven-day periods equaled the peak sustained bat activity rate, all dates in these seven-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.

Risk Assessment

To assess the likelihood of relatively low or relatively high bat fatalities, bat activity recorded in the Project was compared to existing data at other wind energy facilities in the Midwest and Rocky Mountains. 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. Among studies measuring both activity and fatality rates, most data were collected during the fall using AnaBat detectors placed near the ground. To make comparisons to the existing publicly available data, this report uses the activity rate recorded at ground-level met tower SM3 stations during the FMP as a standard for comparison with activity data from other wind energy facilities. However, full-spectrum detectors such as the SM3 units used at Crocker typically record more bat passes per detector-night on average than AnaBat (zero-cross) units, so direct comparison between activity rates should be done with caution.

Given the differences in microphone sensitivity and data processing algorithms between full-spectrum and zero-cross detectors, activity levels recorded by SM3 detectors (used at Crocker) are not readily comparable to activity recorded by AnaBat detectors because the two detectors sample a different volume of airspace and process the data differently (Solick et al. 2011, Adams et al. 2012). Although the detection range of ultrasonic detectors depends on a number of factors (e.g., echolocation call characteristics, microphone sensitivity, habitat, the orientation of the bat, atmospheric conditions; Limpens and McCracken 2004), the SM2 detector (similar to the SM3 detector used at Crocker) was shown to detect signals at a greater distance than the zero-cross AnaBat detector (Adams et al. 2012). Under controlled conditions, the detection range for playback of synthetic echolocation calls for 55 kHz signals (HF) was similar for SM2 and AnaBat detectors (approximately 7 m [23 ft]), while for 25 kHz signals (LF) the detection range for AnaBat and SM2 detectors was approximately 15 m (49 ft) and 22 m (72 ft), respectively (Adams et al. 2012), meaning that, all else equal, the full-spectrum detector is likely to record more bat calls than the zero-cross detector (i.e., an SM3 unit such as used at Crocker generally would be expected to record higher number of calls per detector night than an AnaBat in the same location).

RESULTS

Bat Acoustic Surveys

Bat activity was monitored at two paired sampling locations for a total of 530 detector-nights between April 14 and October 27, 2016 (Table 3). SM3 units were operating for 78.2% of the sampling period (Figure 3). The primary causes of lost data were equipment malfunctions and data transfer errors. SM3 units overall recorded 903 bat passes for a mean of 1.84 ± 0.22 bat passes per detector night (Table 3).

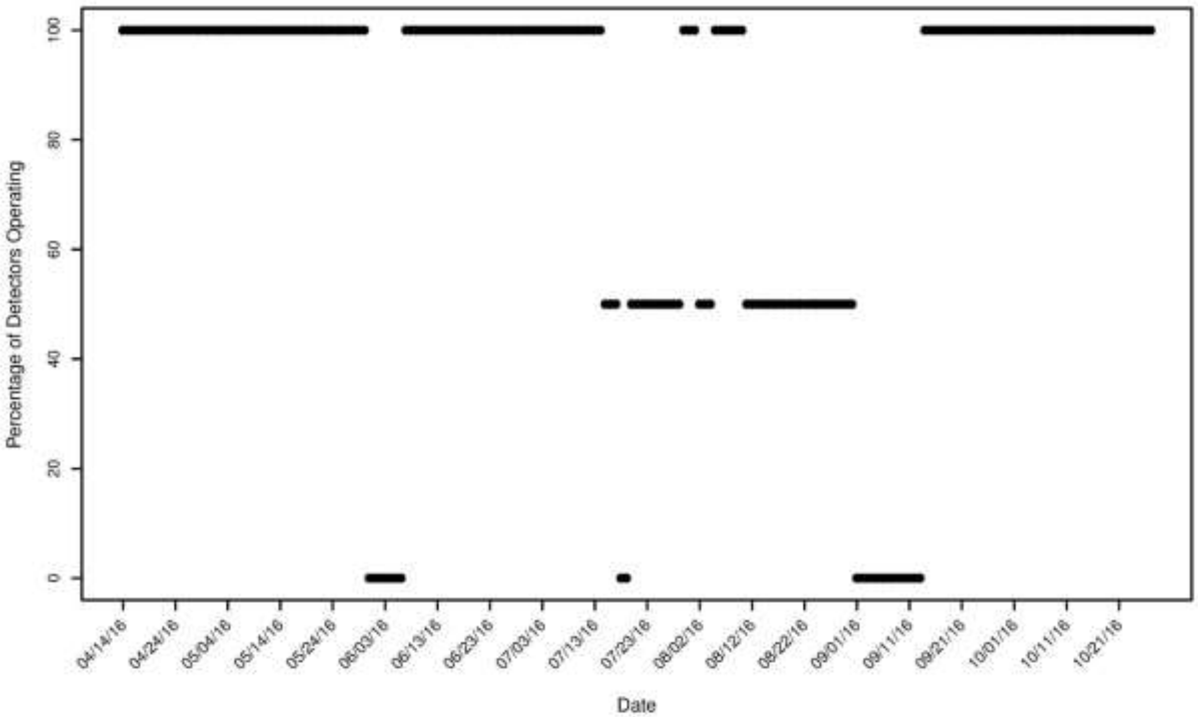

Figure 3. Operational status of bat microphones (n = 4) operating at the Crocker Wind Farm during each night of the study period April 14 to October 27, 2016.

Spatial Variation

SM3 units at ground met tower stations recorded 448 bat passes on 265 detector-nights for a mean (± standard error) of 1.84 ± 0.23 bat passes per detector-night. Raised stations recorded similar activity with 455 bat passes on 265 detector-nights for a mean of 1.83 ± 0.24 bat passes per detector-night (Table 3, Figure 4). At the paired stations, the ground detector at station CK1 recorded slightly more bat passes than the raised detector, while the opposite occurred at CK2 (Figure 5). It should be noted that, given the increased detection distance for full-spectrum microphones, it is possible that bats flying near met towers were recorded simultaneously by both ground and raised microphones.

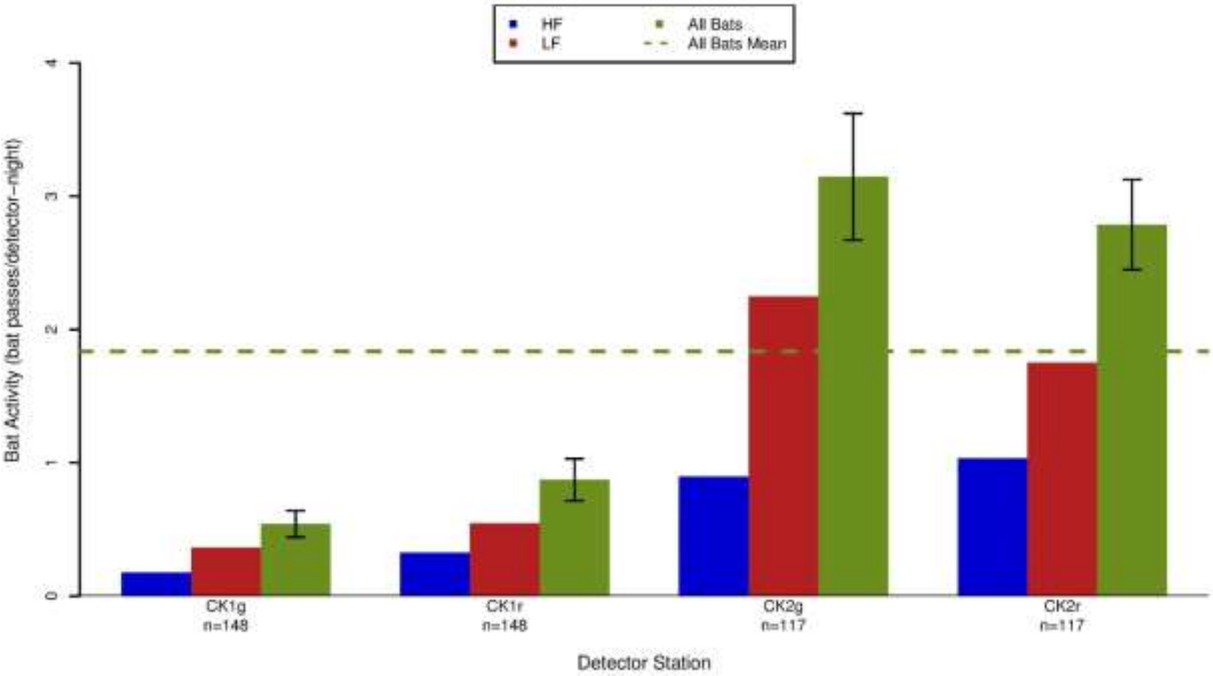

Figure 4. Number of high-frequency (HF) and low-frequency (LF) bat passes per detector-night recorded at SM3 met tower stations in the Crocker Wind Farm from April 14 to October 27, 2016. The bootstrapped standard errors are represented by the black error bars on the 'All Bats' columns.

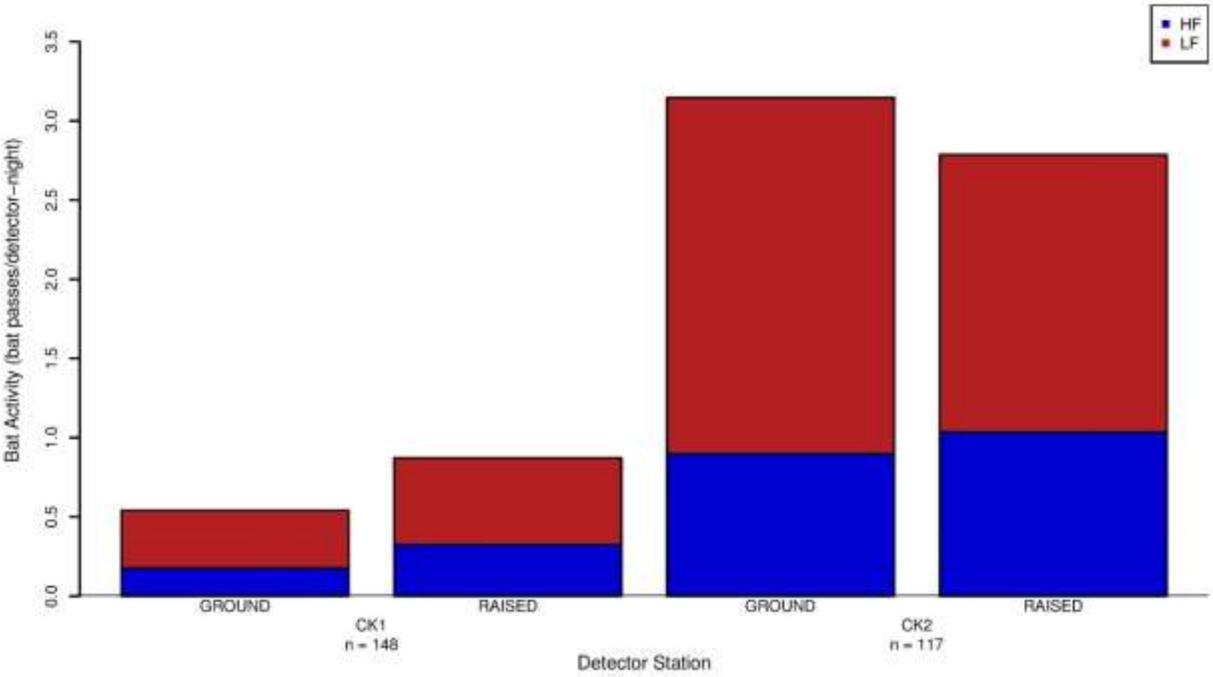

Figure 5. Number of high-frequency (HF) and low-frequency (LF) bat passes per detector-night recorded at paired SM3 stations in the Crocker Wind Farm from April 14 to October 27, 2016.

Table 3. Results of acoustic bat surveys conducted at met tower stations within the Crocker Wind Farm from April 14 to October 27, 2016. Passes are separated by call frequency: high-frequency (HF) and low-frequency (LF).

SM3 Station	Type	Habitat	# of HF Bat Passes	# of LF Bat Passes	Total Bat Passes	Detector- Nights	Bat Passes/ Night***
CK1g	ground	cropland	26	54	80	148	0.54 ± 0.10
CK1r	raised	cropland	48	81	129	148	0.87 ± 0.16
CK2g	ground	cropland	105	263	368	117	3.15 ± 0.48
CK2r	raised	cropland	121	205	326	117	2.79 ± 0.34
Total Ground Met Tower Stations			**131**	**317**	**448**	**265**	**1.84 ± 0.23**
Total Raised Met Tower Stations			**169**	**286**	**455**	**265**	**1.83 ± 0.24**
Total			**300**	**603**	**903**	**530**	**1.84 ± 0.22**

***± bootstrapped standard error.

Temporal Variation

Bat activity at both met tower stations was highest in the fall (Table 4; Figure 6). Weekly acoustic activity at met towers was relatively low from April through mid-July, with activity increasing in late July and peaking in early August (9.80 bat passes per detector-night; Table 5). Activity decreased in late August through the end of the study period (Figure 7). At paired stations weekly activity was similar between ground and raised microphones throughout the study period (Figure 8).

Table 4. The number of bat passes per detector-night recorded at met tower stations in the Crocker Wind Farm during each season in 2016, separated by call frequency: high-frequency (HF), low-frequency (LF), and all bats (AB).

Station	Call Frequency	Spring April 14 – May 31	Summer June 1 – Jul 31	Fall Aug 1 – Oct 27	Fall Migration Period Jul 30 – Oct 14
CK1g	LF	0.38	0.26	0.43	0.51
	HF	0.02	0.19	0.29	0.38
	AB	0.4	0.44	0.72	0.89
CK1r	LF	0.34	0.47	0.78	1.04
	HF	0	0.14	0.72	0.91
	AB	0.34	0.6	1.5	1.96
CK2g	LF	NA	1.94	2.47	3.3
	HF	NA	0.63	1.09	1.4
	AB	NA	2.57	3.56	4.7
CK2r	LF	NA	1.51	1.93	2.56
	HF	NA	0.96	1.09	1.39
	AB	NA	2.47	3.01	3.95
Ground Total	**LF**	**0.38 ± 0.11**	**1.10 ± 0.21**	**1.45 ± 0.25**	**1.90 ± 0.31**
	HF	**0.02 ± 0.02**	**0.41 ± 0.09**	**0.69 ± 0.13**	**0.89 ± 0.16**
	AB	**0.40 ± 0.11**	**1.51 ± 0.27**	**2.14 ± 0.34**	**2.80 ± 0.42**
Raised Total	**LF**	**0.34 ± 0.10**	**0.99 ± 0.23**	**1.35 ± 0.25**	**1.80 ± 0.29**
	HF	**0.00 ± 0.00**	**0.55 ± 0.13**	**0.91 ± 0.17**	**1.15 ± 0.20**
	AB	**0.34 ± 0.10**	**1.54 ± 0.33**	**2.26 ± 0.39**	**2.95 ± 0.45**
Overall	**LF**	**0.36 ± 0.09**	**1.04 ± 0.20**	**1.40 ± 0.26**	**1.85 ± 0.31**
	HF	**0.01 ± 0.01**	**0.48 ± 0.10**	**0.80 ± 0.14**	**1.02 ± 0.17**
	AB	**0.37 ± 0.09**	**1.52 ± 0.27**	**2.20 ± 0.38**	**2.88 ± 0.45**

Table 5. Periods of peak activity for high-frequency (HF), low-frequency (LF), and all bats at met tower stations in the Crocker Wind Farm for the study period April 14 to October 27, 2016.

Species Group	Start Date of Peak Activity	End Date of Peak Activity	Bat Passes per Detector-Night
HF	August 1	August 7	3.06
LF	August 9	August 15	6.77
All Bats	August 9	August 15	9.80

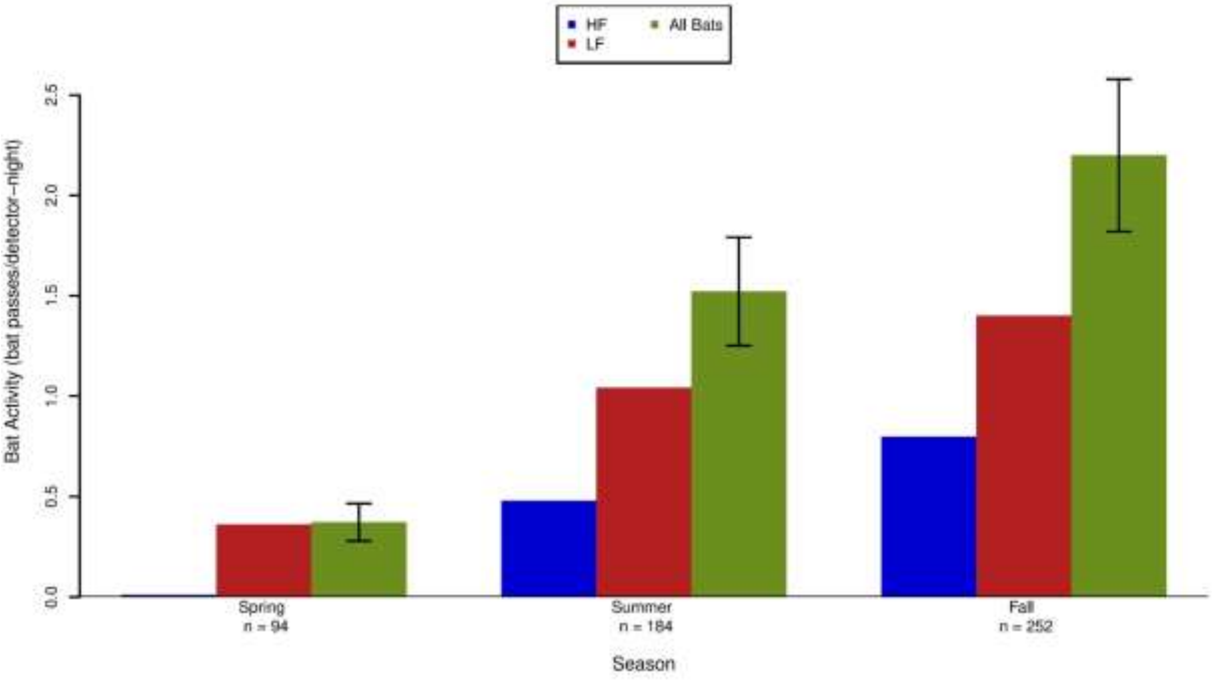

Figure 6. Seasonal bat activity by high-frequency (HF), low-frequency (LF), and all bats at met tower stations in the Crocker Wind Farm from April 14 to October 27, 2016. The bootstrapped standard errors are represented on the 'All Bats' columns.

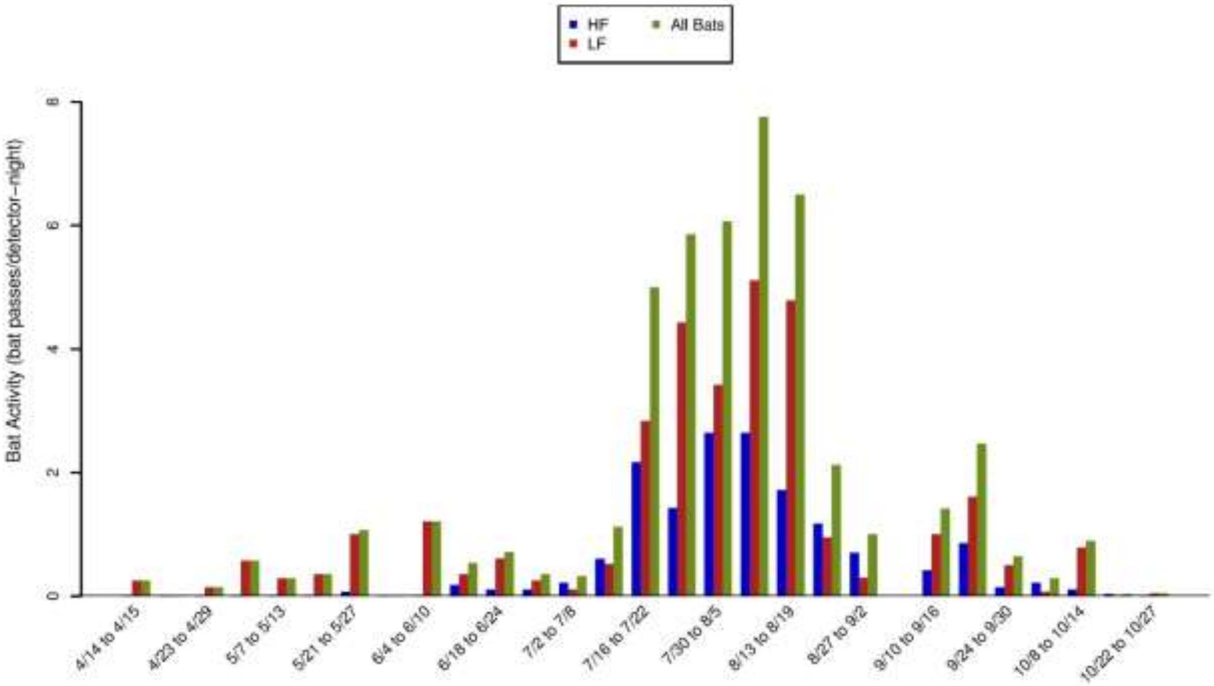

Figure 7. Weekly patterns of bat activity by high-frequency (HF), low-frequency (LF), and all bats at met tower stations in the Crocker Wind Farm for the study period April 14 to October 27, 2016.

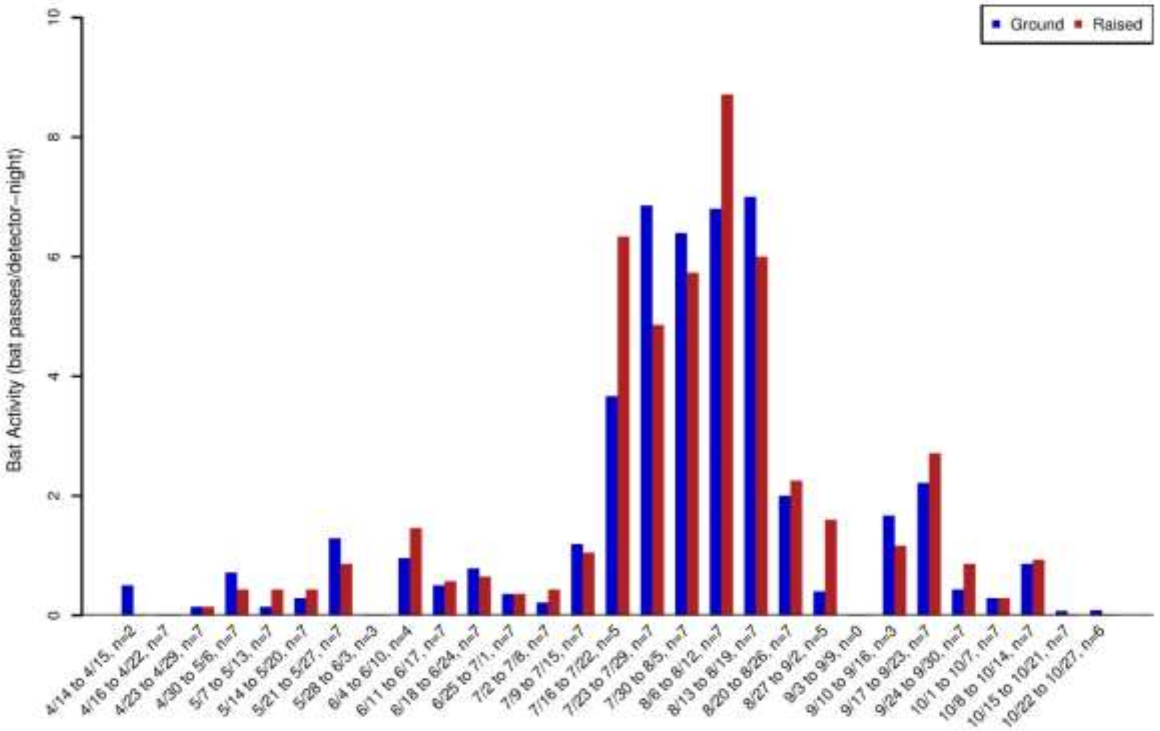

Figure 8. Weekly patterns of bat activity recorded by paired SM3 detectors at ground and raised met tower stations in the Crocker Wind Farm from April 14 – October 27, 2016.

Species Composition

Low-frequency bats (e.g., big brown bats, hoary bats, and silver-haired bats; Table 2) were the most commonly recorded species (66.8%) among all stations (Table 3), suggesting that these species are relatively more abundant than HF species in the Project Area. High-frequency bats (e.g., tri-colored bats, eastern red bats, and *Myotis* species) composed 33.2% of bat passes recorded at met tower stations (Table 2, Table 3). Overall and LF bat activity peaked between August 9 and 15 whereas HF bat activity peaked slightly earlier from August 1 – 7 (Table 5, Figure 7).

Four individual bat species and the *Myotis* group were identified at each of the four detectors using the auto-classifier component of Kaleidoscope 3.1.7 (Table 6). The hoary bat was the most frequently recorded species overall, present on 31% of detector-nights, while the big brown bat was the least frequently recorded species overall, present on just 7% of operational detector-nights. *Myotis* group presence was highest at CK2g where this group was present on 24% of detector-nights.

Table 6. The number (percent) of presence/absence dates for detector-nights with bat species present by station recorded by the SM3 full-spectrum detectors at the Crocker Wind Farm using Kaleidoscope 3.1.7

Common Name	CK1g	CK1r	CK2g	CK2r	Total
High-Frequency (> 30 kHz)					
eastern red bat	14 (9)	26 (18)	33 (28)	30 (26)	103 (19)
Myotis species	10 (7)	14 (9)	28 (24)	15 (13)	67 (13)
Low-Frequency (< 30 kHz)					
big brown bat	7 (5)	14 (9)	11 (9)	6 (5)	38 (7)
hoary bat	24 (16)	43 (29)	48 (41)	50 (43)	165 (31)
silver-haired bat	29 (20)	42 (28)	34 (29)	31 (26)	136 (26)

DISCUSSION

Bat fatalities have been discovered at most wind energy facilities monitored in North America, ranging from 0 (Chatfield and Bay 2014) to 40.2 bat fatalities/megawatt (MW)/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 U.S. (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 a) migratory tree-roosting species (e.g., eastern red bat [*Lasiurus borealis*], hoary bat [*Lasiurus cinereus*], and silver-haired bat [*Lasionycteris noctivagans*]) compose approximately 78% 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., < 6.0 m/s; Arnett et al. 2008; Arnett and Baerwald 2013; Arnett et al. 2013).

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 publicly available studies documenting bat passes per detector-night at proposed wind energy facilities are available to compare to publicly available studies reporting 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 Hein et al. (2013a), 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. (2013a) 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 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.

Mean bat activity during the FMP at ground met tower station SM3 detectors (2.80 ± 0.42 bat passes per detector-night; Table 4) was lower than rates established at other upper Midwest wind projects using AnaBat units (which generally record fewer bat passes). Anabat-derived bat activity rate estimates include the national median (7.68) and the majority of studies available from the Midwest (6.97) and Rocky Mountains (2.2; Appendix A). Although it is expected that bat activity data collected using SM3 detectors is not directly comparable with activity data from the studies in Appendix A, all of which used AnaBat detectors, it is assumed that SM3 detectors would detect more bat calls due to a greater detection distance and the fact that noise from insects or other sources does not inhibit detection of bats for full-spectrum detectors (Adams et al. 2012). Therefore, the activity data collected by SM3 detectors in this study provides a conservative risk assessment, and the fact that even with the SM3 units the bat passes were low indicates a relatively low use site.

Overall bat activity was highest within the Project during the fall peaking in early to mid-August. This timing is close to peak fatality periods for most wind energy facilities in the U.S. (Arnett et al. 2008), and suggests that bat fatalities at the Project will be highest during the fall and may consist largely of migrating individuals.

Activity by LF bat species composed nearly 67% of bat passes recorded in the Project. Hoary and silver-haired bats are usually the most common LF species found during carcass searches (Arnett et al. 2008; Arnett and Baerwald 2013). Activity by HF bats composed approximately 33% of bat passes recorded at all stations, suggesting lower relative abundance of species such as eastern red bats and *Myotis* species. *Myotis* are recorded less commonly than other species as fatalities at most post-construction studies of wind energy facilities (Kunz et al. 2007b; Arnett et al. 2008), with a few notable exceptions (Kerns and Kerlinger 2004; Jain 2005; Brown and Hamilton 2006a; Gruver et al. 2009a). 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.

The closest operating wind-energy facility to the Project with public post-construction fatality data is the Buffalo Ridge II Wind Facility, located approximately 60 miles from the Project in Brookings County, South Dakota. At Buffalo Ridge II the pre-construction bat activity rate was a relatively low rate of 1.75 bats/detector-night (Derby et al. 2008) and the casualty rate was also relatively low at 2.81 bats/MW/study period (Derby et al. 2012a). Due to the similar low rates of pre-construction bat activity, it is possible that Crocker will have similarly low fatality rates, although the habitat at Buffalo Ridge II (primarily corn and soybeans, with limited water features and limited wooded habitat) is somewhat different than Crocker (primarily grassland, with more prevalence of wetlands and open water, also with limited wooded habitat). 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.

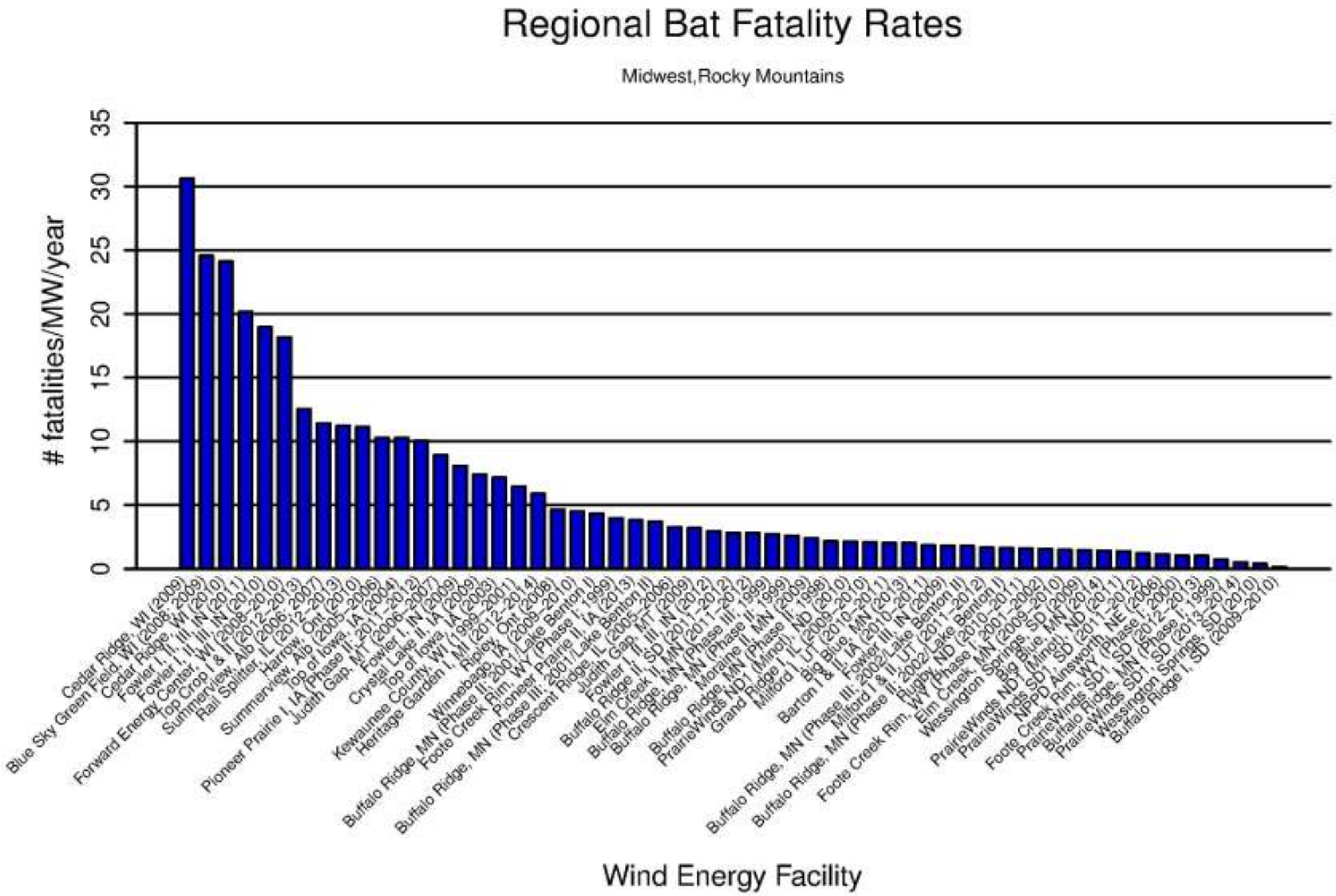

Figure 9. Fatality rates for bats (number of bats per MW per year) from publicly-available wind energy facilities in the Midwest and Rocky Mountains regions of North America.

Figure 9. (continued) Fatality rates for bats (number of bats per MW per year) from publicly-available wind energy facilities in the Midwest and Rocky Mountains regions of North America.

Data from the following sources

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

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