Bat Activity Surveys for the Rail Tie Wind Project, Albany County, Wyoming

Final Report

April 16 – October 16, 2019

Prepared for:

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EXECUTIVE SUMMARY

In April of 2019, Western EcoSystems Technology, Inc. initiated bat acoustic surveys for the proposed Rail Tie Wind Project (Project) in Albany County, Wyoming. The bat activity acoustic surveys were designed to estimate levels of bat activity throughout the Project area during spring, summer, and fall, to evaluate the species composition within the Project, and to conduct North American Bat Monitoring (NABat) surveys to inventory bat species that occur in the proposed Project Area. Additionally, comparisons are made to historic bat acoustic data within the Project Area where possible.

To determine bat activity rates, acoustic surveys were conducted from April 16 – October 16, 2019 at two fixed monitoring stations located in herbaceous grassland shrub/scrub habitat, which is the dominant land cover type within the Project area and is, therefore, representative of future turbine placement. The ultrasonic microphone for each Wildlife Acoustics Song Meter SM3BAT (SM3) detector was placed near the ground at 5.0 feet (ft; 1.5 meters [m]). All SM3 detectors recorded a combined mean (± standard error) of 8.77 ± 0.70 bat passes per detector-night.

Bat activity varied substantially between seasons with low activity in the spring and higher activity in summer and fall. Weekly activity was highest between late July and late September, with bat activity peaking in mid-August. Nearly 69% of bat passes were classified as low frequency (e.g., mostly hoary bat and silver-haired bat), and 31% of bat passes were classified as high frequency (mostly little brown bat and eastern red bat passes). No state or federally listed species were documented.

Between June 27 and July 1, 2019 NABat acoustic surveys were conducted at four quadrants of a grid assigned on a national level over four nights. Automated species identification software, Kaleidoscope Pro 5.1.0 identified 13 of the 14 potentially occurring species, and an experienced bat biologist's qualitative review identified seven bat species present in the proposed Project Area as well as calls within the 30 kHz and 40 kHz *Myotis* frequency group, the high frequency group, low frequency group, and general *Myotis* group that could not be identified to species-level due to insufficient pulses or poor call quality. Hoary bat passes were the dominant species qualitatively labeled, accounting for 13.7% of the bat calls, followed by silver-haired (3.2%).

Most wind energy facilities in the United States Rocky Mountain region have reported fewer than five bat fatalities/megawatt (MW)/year, including the Foote Creek Rim Wind Facility in Wyoming, located approximately 70 miles (113 kilometers) northwest of the Project and the Top of the World Wind Project located approximately 131 miles (211 kilometers) north of the Project. Bat casualty rates at Foote Creek Rim I were relatively low, at 1.57 and 1.05 bats/MW/year (2001 − 2002 and 2000 respectively) and at Top of the World, Wyoming, ranged from 2.34 bats/MW/year in 2012 – 2013 to 2.74 in 2010 – 2011. Based on this and Project acoustic data, it is expected that if bat fatalities occur at the Project they may be mainly in the fall, and be composed primarily of low-frequency species such as hoary bats and silver-haired bats followed by little brown bats, similar

to other facilities in the region. The pre-construction bat studies completed in the proposed Project Area will add to the growing body of research regarding the impacts of wind energy development on bats.

STUDY PARTICIPANTS

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REPORT REFERENCE

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INTRODUCTION

ConnectGen Albany County LLC (ConnectGen) is developing the proposed Rail Tie Wind Project (Project) in southeastern Albany County, Wyoming. Western EcoSystems Technology, Inc. (WEST) was contracted to complete a study of bat activity in coordination with the Wyoming Game and Fish Department (WGFD) recommendations (WGFD 2019b) and following the recommendations of the US Fish and Wildlife Service (USFWS) *Land-based Wind Energy Guidelines* (USFWS 2012a), Kunz et al. (2007a), and the Wyoming Game and Fish Habitat Protection Program recommendations. Objectives of the bat acoustic monitoring study were to:

1) determine bat activity spatially and assess areas of higher use within the Project;
2) determine seasonal and temporal variation in bat activity;
3) compare peak activity in the Project to historic peak activity acoustic data;
4) evaluate the species composition within the Project;
5) determine presence of listed species in the Project.

Additionally, North American Bat Monitoring (NABat) surveys were conducted to document species occurrence in the Project Area through qualitative call verification of automated species classifications during the summer maternity season, in compliance with WGFD recommendations in the April 12, 2019 coordination letter (WGFD 2019a). This report describes the results of the acoustic monitoring surveys conducted within the proposed Project Area between April 16 and October 16, 2019.

Previously, WEST completed pre-construction bat acoustic activity surveys for Shell WindEnery's (Shell Wind) proposed 11,125 acre (ac; 4,502 hectare [ha]) Hermosa West Wind Farm Project (Hermosa Project) before development efforts were abandoned in 2014. WEST collected bat acoustic data from July 2009 – November 2009 (Taylor et al. 2010) in the western portion of the Hermosa Project which overlaps with the current Project boundary. The studies were included in the Western Area Power Administration (WAPA) Draft Environmental Impact Statement (DEIS) for the Project (WAPA 2012). This report provides relevant comparisons to the historic 2009 and 2010 data where possible.

STUDY AREA

ConnectGen's proposed 26,041-ac (10,538-ha) Project Area is located near the town of Tie Siding and is situated along the Colorado-Wyoming border (Figure 1). The Project Area is at an approximate elevation of 7,700 feet (ft; 2,347 meters [m]) and is bisected by US Highway 287. Most of the Project Area is private land with approximately 5,000 ac (2,023 ha) of State land. The Project Area primarily consists of low mountain slopes with ponderosa pine (*Pinus ponderosa*) and lodgepole pine (*P. contorta*) habitat, with rock outcroppings and some rocky cliffs, and nearly level floodplains with grassland, shrub steppe, and rangeland habitat. According to the National Land Cover Database (Yang et al. 2018, Multi-Resolution Land Characteristics 2019), the Project area is dominated by shrub/scrub (16,711.9 ac [6,763.1 ha; 64.2%]) followed by herbaceous grassland (7,949.0 ac [3,216.8 ha; 30.5%]; Table 1, Figure 2). Evergreen forest (approximately 2.5% of the land cover), emergent herbaceous wetlands (2.1%), and woody wetlands (0.5%) provide bat foraging and roosting habitat (Table 1, Figure 2). Developed open space, open water, deciduous forest, barren land, and developed low and medium intensity land each compose less than 0.3% of the Project Area. Forested areas and rocky outcrops provide potential roosting habitat for bats, and the open water and wetlands provide good foraging and drinking habitat for bats.

Table 1. Land cover types, coverage, and percent (%) composition within the Rail Tie Wind Project, Albany County, Wyoming.

Land Cover Type	Coverage Acres	% Composition
Shrub/Scrub	16,711.9	64.2
Herbaceous Grassland	7,949.0	30.5
Evergreen Forest	641.9	2.5
Emergent Herbaceous Wetlands	554.7	2.1
Woody Wetlands	120.3	0.5
Developed, Open Space	48.3	0.2
Deciduous Forest	5.7	<0.1
Barren Land	5.0	<0.1
Developed, Low Intensity	4.0	<0.1
Open Water	0.2	<0.1
Developed, Medium Intensity	0.1	<0.1
Total	**26,041.1**	**100**

Source: National Land Cover Database (Yang et al. 2018, Multi-Resolution Land Characteristics 2019).

Note: Sums may not equal totals shown due to rounding.

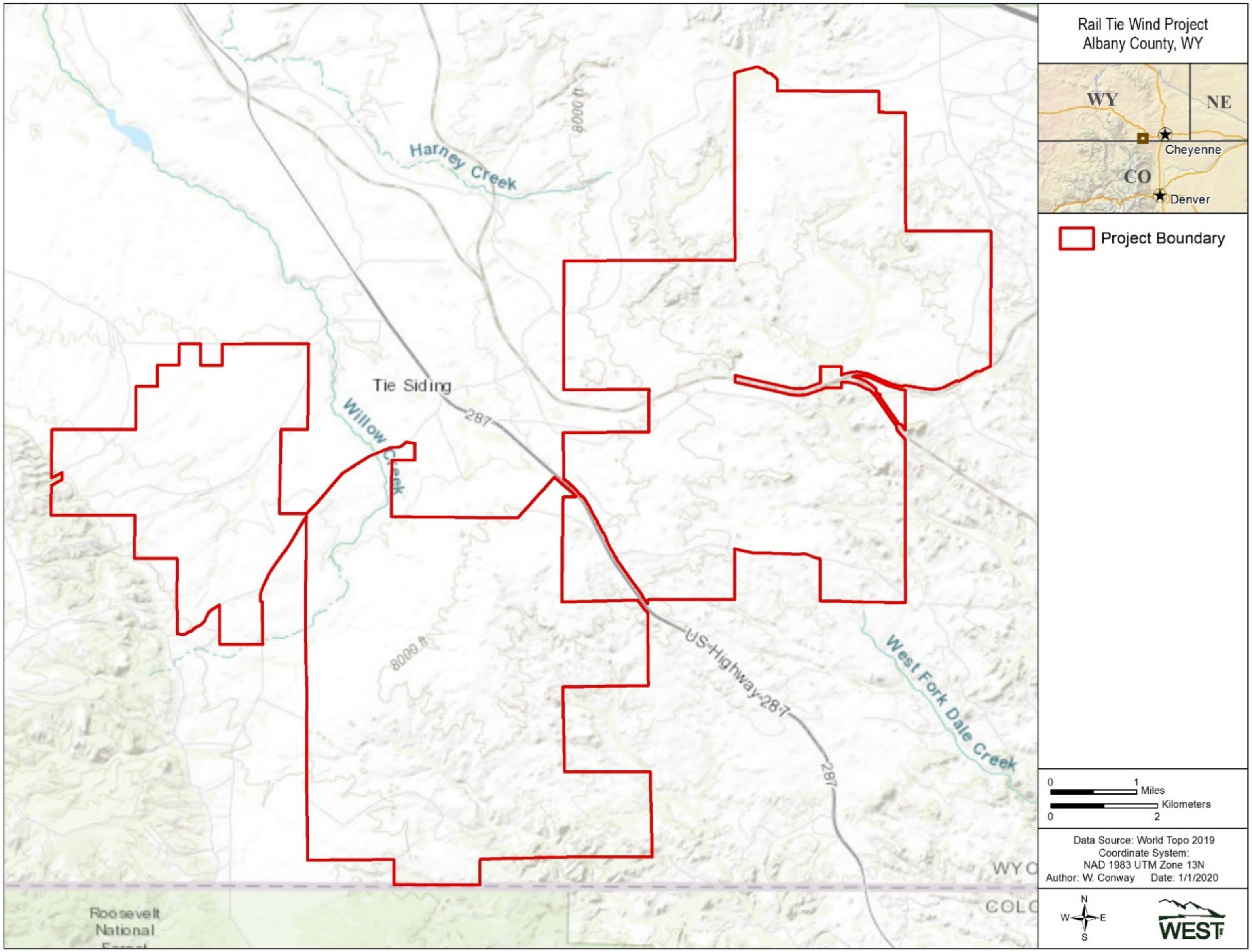


Figure 1. Location of the proposed Rail Tie Wind Project, Albany County, Wyoming.

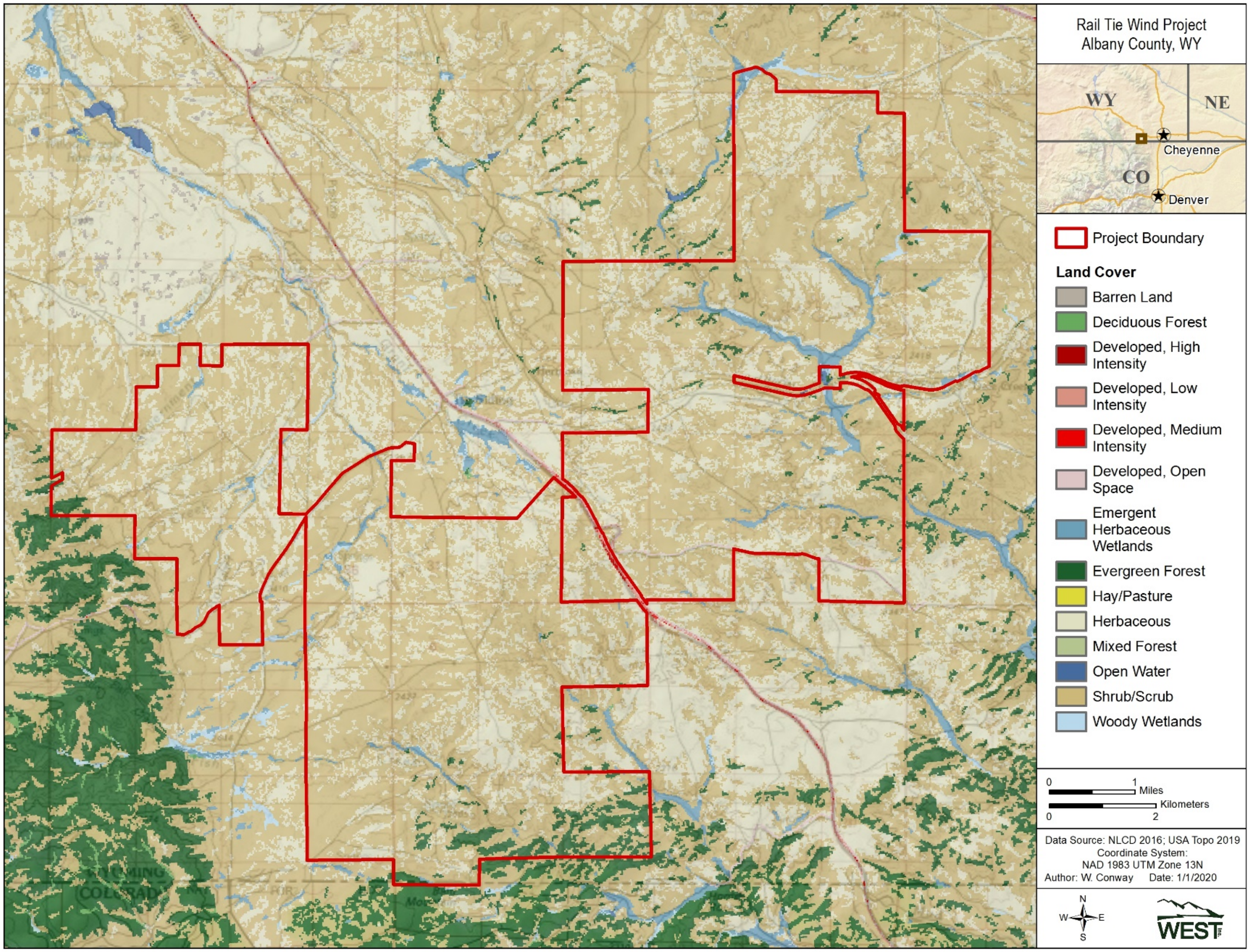


Figure 2. Land cover types and coverage within the proposed Rail Tie Wind Project, Albany County, Wyoming (Yang et al. 2018, Multi-Resolution Land Characteristics 2019).

Overview of Bat Diversity

Of the eighteen bat species that have been documented in Wyoming (Hester and Grenier 2005), fourteen species have some potential to occur within the Project area (Table 2). The northern long-eared bat (*Myotis septentrionalis*; NLEB) is federally listed as threatened, although take by operating wind projects is exempt from the Federal Endangered Species Act of 1973 (ESA) take prohibitions (80 Federal Register [FR] 17974 [April 2, 2015], 81 FR 1900 [January 14, 2016]; USFWS 2016). Wyoming marks the western extent of the NLEB range and the species has been documented almost exclusively in the Bear Lodge Mountains and Black Hills in the northeastern portion of the state (Abernethy 2019). The NLEB statewide range is limited to three counties in northeastern Wyoming (Crook, Campbell, and Weston counties). The species Area of Influence, which typically encompasses larger areas than the known occurrences (due to the direct and indirect effects development can cause to the species and the habitat they rely on) is also limited to these three counties (USFWS 2019). The closest Area of Influence is approximately 163 miles (mi; 262 kilometers [km]) north of the Project (USFWS 2019). NLEB do not migrate great distances and summer habitat is usually less than 56 km from winter hibernacula (Caceres and Barclay 2000). However, the NLEB has possibly been documented outside the Area of Influence; in August 2015 WGFD reported the mist-net capture of a NLEB in LaBonte Canyon, on the northern border of Albany County (Reeves 2017) although no further mist-net attempts in this area resulted in a NLEB capture and there is no photographic or genetic confirmation that this individual was correctly identified as a NLEB (Abernethy pers. comm., 2020). Neither of these captures changed the expected occurrence range or Areas of Influence for the state (USFWS 2019, Reeves 2017). Historically within Wyoming, the NLEB was known exclusively from areas dominated by Ponderosa pine (*Pinus ponderosa*) forest (Abernethy 2015) but recently NLEB were found to prefer aspen (*Populus spp.*) maternity roosts (61.5% of documented roosts) followed by ponderosa pine (30.8%) and bur oak (*Quercus macrocarpa*; 7.7%) in the black hills of Wyoming (WYBWG 2019). Less than 1% of the Project contains Ponderosa pine and aspen habitat so the Project is unlikely to be suitable even if it were within the species range. However, the western range of the NLEB has been expanding in recent years. In 2019, USFWS NLEB presence/probable absence surveys at oil and gas projects in Wyoming documented three acoustic calls but no captures (WYBWG 2019) and in 2019 the NLEB range was extended an additional 100 km into Montana through capture surveys (WYBWG 2019). Therefore qualitative review of acoustic data in the eastern portion of the Wyoming was recommended although the NLEB is unlikely to occur within the Project Area because it is not known to be a County resident and no Areas of Influence occur in the Project County or in any adjacent counties (USFWS 2019).

Eastern red bats (*Lasiurus borealis*), western small-footed bats (*Myotis ciliolabrum*), western long-eared bats (*M. evotis*), little brown bats (*M. lucifugus*), NLEB, long-legged bats (*M. volans*), spotted bat (*Euderma maculatum*), pallid bat (*Antrozous pallidus*), Townsend's big-eared bat (*Corynorhinus townsendii*), and fringed bats (*M. thysanodes*) are considered Species of Greatest Conservation Concern by the WGFD (2017). Ten of the 14 potentially occurring species are known wind energy facility fatalities (Table 2).

Table 2. Bat species with potential to occur within the proposed Rail Tie Wind Project, Albany County, Wyoming categorized by echolocation call frequency.

Common Name	Scientific Name
High-Frequency (≥30 kHz)	
eastern red bat[1,2,3]	*Lasiurus borealis*
little brown bat[1,2]	*Myotis lucifugus*
long-legged bat[1,2]	*Myotis volans*
northern long-eared bat[1,2,4]	*Myotis septentrionalis*
western long-eared bat[1,2]	*Myotis evotis*
western small-footed bat[1,2]	*Myotis ciliolabrum*
Low Frequency (15 – 29 kHz)	
big brown bat[1]	*Eptesicus fuscus*
fringed bat[2]	*Myotis thysanodes*
hoary bat[1,3]	*Lasiurus cinereus*
pallid bat[2]	*Antrozous pallidus*
silver-haired bat[1,3]	*Lasionycteris noctivagans*
Townsend's big-eared bat[2]	*Corynorhinus townsendii*
Very Low Frequency (<15 kHz)	
big free-tailed bat[1,3]	*Nyctinomops macrotis*
spotted bat[2,3]	*Euderma maculatum*

[1] Species known to have been killed at wind energy facilities (SWCA Environmental Consultants 2015, American Wind Wildlife Institute 2018).

[2] Species of Greatest Conservation Need (Wyoming Game and Fish Department 2017).

[3] Long-distance migrant.

[4] Federally listed as threatened under the Endangered Species Act of 1973.

Sources: International Union for Conservation of Nature 2017, US Fish and Wildlife Service 2019.

Khz = kilohertz.

White-Nose Syndrome

Hibernating bats 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*) 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 can lead to starvation prior to spring emergence (Boyles and Willis 2010, Reeder et al. 2012, Warnecke et al. 2012). Data suggests that between 5.7 and 6.7 million bats died as a result of WNS by 2012 (USFWS 2012b). WNS is the primary reason the USFWS recently listed the northern long-eared bat as threatened under the ESA (USFWS 2015). WNS was first discovered in New York State in 2006 (Frick et al. 2010a) and the disease has spread to 33 states and seven Canadian provinces (White-Nose Syndrome Response Team 2019), reaching as far south as Alabama, as far north as Newfoundland, and as far west as Washington (Heffernan 2016, White-Nose Syndrome Response Team 2019). Recently, the causative fungus was identified in an additional five states, including Wyoming, Texas, Mississippi, North Dakota, and California, (White-Nose Syndrome Response Team 2019) and low fungal levels were possibly detected in New Mexico and Arizona (National Park Service 2019, New Mexico Game and Fish Department 2019). In Wyoming, the fungus was first detected from skin-swab samples collected from a little brown bat at Fort Laramie National Historic Site in Goshen County on May 16, 2018 (WGFD

2018). The Fort Laramie National Historic Site is approximately 88 mi (141 km) to the northeast of the Project in Goshen County.

METHODS

Bat Activity Surveys

WEST conducted acoustic monitoring studies to estimate levels of bat activity throughout the proposed Project Area from April 16 − October 16, 2019 consistent with the dates recommended by the WGFD (2019a).

Survey Stations

Two full-spectrum Song Meter SM3BAT ultrasonic detectors (SM3; Wildlife Acoustics, Maynard, Massachusetts) were used during the study. SM3 detectors were placed in habitat representative of future turbine locations, one on the north side and one on the south side of the Project area (Figure 3). All stations were located in herbaceous grassland shrub/scrub habitat, which are the dominant land cover types (Table 1). Station RT1g was also placed near rocky outcrop features representative of habitat in the northern Project area. Because no meteorological (met) towers are located on the site for raised station sampling, only one microphone was used at each location to sample ground level bat activity (ground station; approximately 5.0 ft [1.5 m] above ground level [AGL]). Microphones at ground stations likely detect a more complete sample of the bat species present within the Project area although it can be useful to monitor activity at different heights when possible (Kunz et al. 2007a, Collins and Jones 2009, Müeller et al. 2013, Roemer et al. 2017). The SM3 microphones are weatherproof, and were secured atop a 5.0 ft bamboo pole at ground stations.

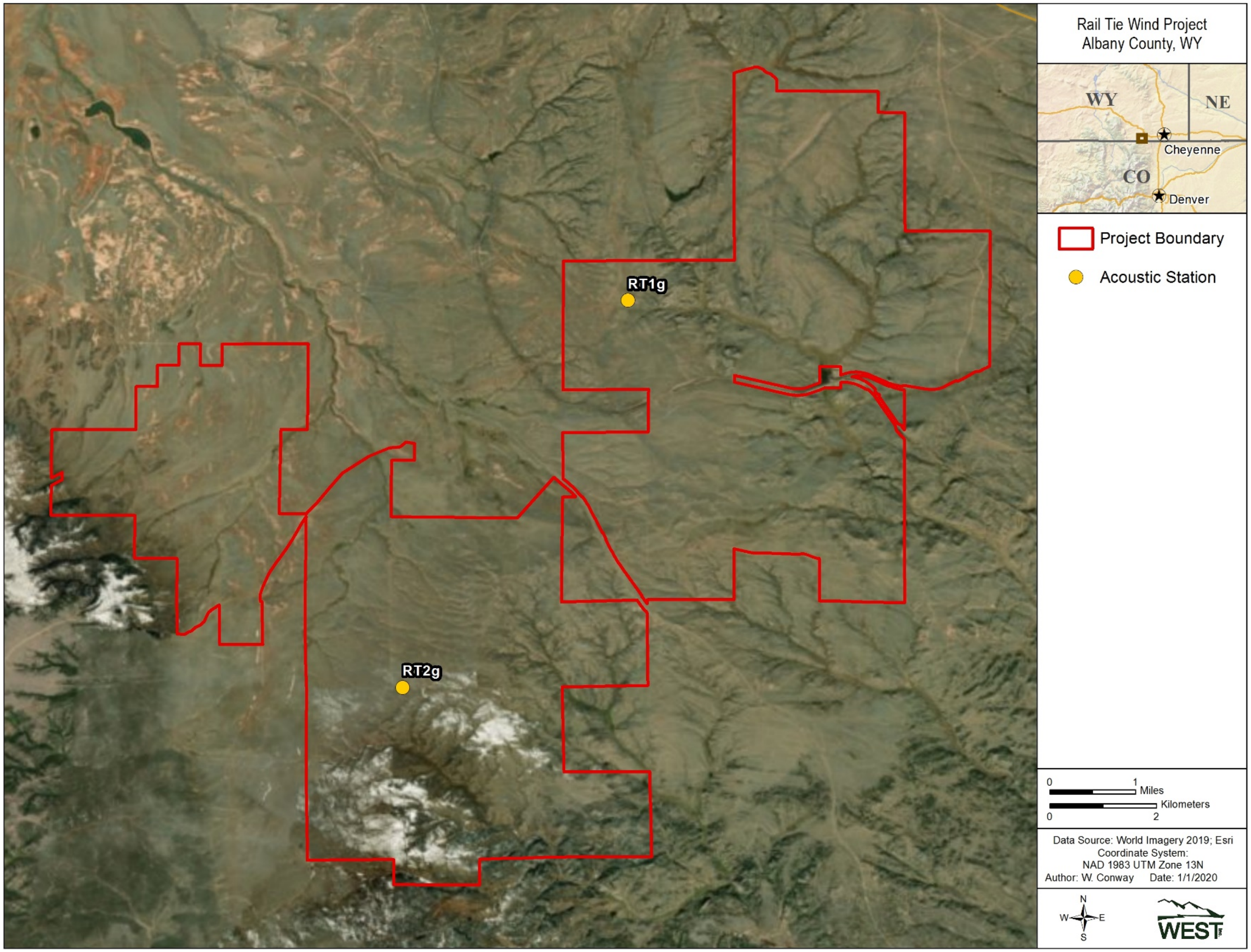


Figure 3. Location of bat monitoring stations within the proposed Rail Tie Wind Project, Albany County, Wyoming.

Survey Schedule

Bat activity surveys were conducted from April 16 – October 16, 2019, and detectors were programmed to turn on 30 minutes (min) before sunset and turn off 30 min after sunrise each night. To highlight seasonal activity patterns, the study was divided into three survey periods: spring (April 16 – May 31), summer (June 1 – August 15), and fall (August 16 – October 16). Mean bat activity was also calculated for a standardized Fall Migration Period (FMP), defined here as July 30 – October 14. WEST defined the FMP as a standard for comparison with activity from other wind projects. 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, Cryan 2008, Arnett and Baerwald 2013, Barclay et al. 2017).

Data Collection and Call Analysis

The SM3 is a full-spectrum bat detector that records complete acoustic waveforms by sampling sound waves at a rate of 256 kilohertz (kHz). This high sampling rate enables the detector to make high-resolution recordings of sound amplitude data at all frequencies up to 128 kHz. Full-spectrum data were transformed into zero-crossing data using the program Kaleidoscope Pro 5.1.0 (Kaleidoscope; Wildlife Acoustics, 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, rain, insects) and to determine the call frequency category. The terms “bat pass” and “bat call” are used interchangeably. 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, Gannon et al. 2003).

For each station, bat passes were sorted into three groups based on their minimum call frequency. High-frequency (HF) bats, such as eastern red bats, have minimum frequencies greater than or equal to 30 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 from 15 – 30 kHz. Very low-frequency (VLF) bats, such as big free-tailed bats and spotted bats, typically emit echolocation calls below 15 kHz. Table 2 lists HF, LF, and VLF species that could occur within the Project.

Zero cross calls confirmed to be bat passes were then run through the automated identification feature in Kaleidoscope using the Bats of North America classifier 5.1.0 at the neutral sensitivity setting. These settings and versions are approved by the USFWS for acoustic analysis of sensitive species. Kaleidoscope utilizes Hidden Markov Models and other statistical methods known for their application in temporal pattern recognition such as speech analysis, handwriting analysis, and deoxyribonucleic acid (DNA) sequencing (Agranat 2012). Despite the capabilities of Kaleidoscope, many bat passes cannot be identified with absolute 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. Therefore, automated call identification is imperfect, and each identification has an associated error rate (USFWS 2013). In addition, the error rates associated with Kaleidoscope identifications of *unknown* bat calls have not been characterized. For these reasons, the results of the Kaleidoscope analysis can be misleading and should be viewed with caution. Because of Kaleidoscope's limitations, the output was used to generate a list of species that may have been present in the Project area. Kaleidoscope did not have the ability to identify calls by the big free-tailed bat (*Nyctinomops macrotis*) at the time analyses were conducted, so this species was only looked for manually during call labeling. In addition, a qualified biologist with extensive acoustic identification experience (Larisa Bishop-Boros) qualitatively examined all individual calls identified as northern long-eared bat by automated identification software because it is the only federally listed species that could potentially occur in the Project Area. If call sequences were not characteristic of northern long-eared bat or contained distinct calls produced by a different species, or were of insufficient quality, they were reclassified. Qualitative call review was only conducted for the federally-listed northern long-eared bat.

Statistical Analysis

The standard metric used for measuring bat activity is the number of bat passes per detector-night; this metric was used as an index of bat activity in the Project area. A detector-night was defined as one detector operating for one entire night. Bat passes per detector-night were calculated for all bats, HF bats, and LF bats. Bat pass rates represent indices of bat activity and do not represent numbers of individuals. An experienced bat biologist (L. Bishop-Boros) determined the number of bat passes 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.

North American Bat Surveys

At the recommendation of the WGFD, WEST conducted acoustic monitoring studies to identify species occurrence for the NABat from June 27 – July 1, 2019 at grid 18045.

North American Bat Stations

NABat is a national protocol that provides monitoring of local bat populations and region-wide bat population trends. Four SM3 detectors were placed within a 6.2 x 6.2 mile (mi; 10.0 x 10.0 kilometer [km]) NABat grid section that overlapped the proposed Project Area (Table 3, Figure 4) between June 27 and July 1, 2019. Each detector was located in a separate 3.1 x 3.1 mi (5.0 x 5.0 km) quadrant within the grid, representing the northeast, northwest, southeast, and southwest quadrants of the grid section. The northeast and northwest detectors were placed in grassland habitat representative of those quadrants; however, the northeast detector was placed near a stock pond (Appendix A). The southwest detector was placed near a running stream near rocky outcrop habitat; habitat features likely to attract bats. Microphones on audio cables were mounted approximately 5.0 ft AGL following the NABat protocol.

Table 3. Location and site description of 2019 North American Bat Monitoring Program survey sites at the proposed Rail Tie Wind Project.

Site ID	UTM Zone*	Easting	Northing	Site Description**
NE	13	463426	4545450	Rocky outcrops and cliffs, stream with trees
NW	13	458971	4542864	Steep ridge with trees across from rocky outcrop above stream
SE	13	465125	4538708	Open pond with herbaceous grassland
SW	13	459474	4539245	State land with trees and some exposed rock

*Collected using North American Datum 1983.

UTM = Universal Transverse Mercator.

**All sites in herbaceous grassland or shrub/scrub as classified by NLCD (Yang et al. 2018, Multi-Resolution Land Characteristics 2019).

Data Collection and Call Analysis

For the NABat surveys, the SM3s were set to record at 18:00 until 08:00 to capture all bat calls within 30 min before sunset until 30 min after sunrise. The SM3s were set using a trigger window of five seconds and a maximum file length of 15 seconds. SMM-U1 microphones with no wind screens were used for data collection. All microphones were tested using an ultrasonic calibrator from Wildlife Acoustics and determined to meet factory threshold prior to deployment.

Identification of calls was completed with the automated identification feature in Kaleidoscope using the Bats of North America classifier 5.1.0 at the neutral sensitivity setting. These settings and versions are approved by the USFWS for acoustic analysis of sensitive species. Despite the capabilities of Kaleidoscope, many bat passes cannot be identified with absolute 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. Because of Kaleidoscope's limitations, the output was used to generate a list of species that could have been present in the Project area and an experienced bat biologist reviewed all bat calls for accuracy. An experienced bat biologist (L. Bishop-Boros) qualitatively identified all recorded NABat echolocation calls through visual comparison of echolocation call metrics (e.g., minimum frequency, slope, duration) to reference calls of known bats (O'Farrell et al. 1999, Murray et al. 2001, Yates and Muzika 2006). Kaleidoscope does not have the ability to identify the big free-tailed bat, so this species was only looked for manually rather than initially through automated classification (Kaleidoscope) like most of the bat passes.

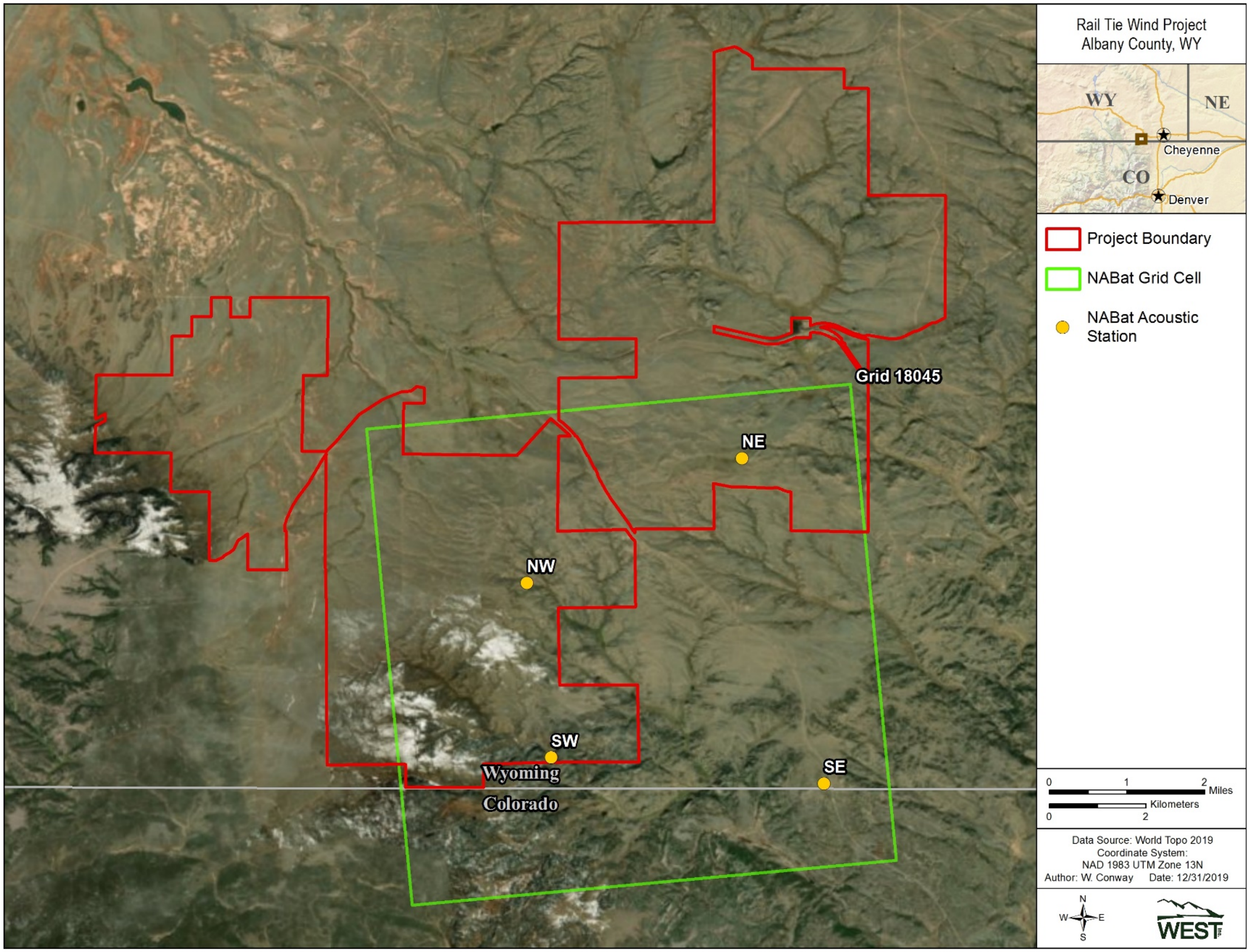


Figure 4. Location of North American Bat Monitoring (NABat) grid and stations within the proposed Rail Tie Wind Project, Albany County, Wyoming.

RESULTS

Bat Activity Surveys

Bat activity was monitored at two stations for 368 detector-nights between April 16 and October 16, 2019. Detectors and microphones were operating for 100% of the sampling period (Figure 5).

Spatial Variation

Station RT1g recorded the most bat passes per detector-night (9.67 ± 0.92) and station RT2g recorded the fewest bat passes per detector-night (7.87 ± 0.62; Table 4, Figure 5). No VLF bat passes were recorded during the survey.

Table 4. Results of acoustic bat surveys conducted at monitoring stations within the Rail Tie Wind Project, Albany County, Wyoming from April 16 – October 16, 2019. Passes are separated by call frequency: high frequency (HF) and low frequency (LF).

Station	Location	# of HF Bat Passes	# of LF Bat Passes	Total Bat Passes	Detector-Nights	Bat Passes/ Night[1]
RT1g	ground	688	1,092	1,780	184	9.67 ± 0.92
RT2g	ground	325	1,123	1,448	184	7.87 ± 0.62
Total (%)		**1,013 (31.4)**	**2,215 (68.6)**	**3,228**	**368**	**8.77 ± 0.70**

[1] ± bootstrapped standard error.

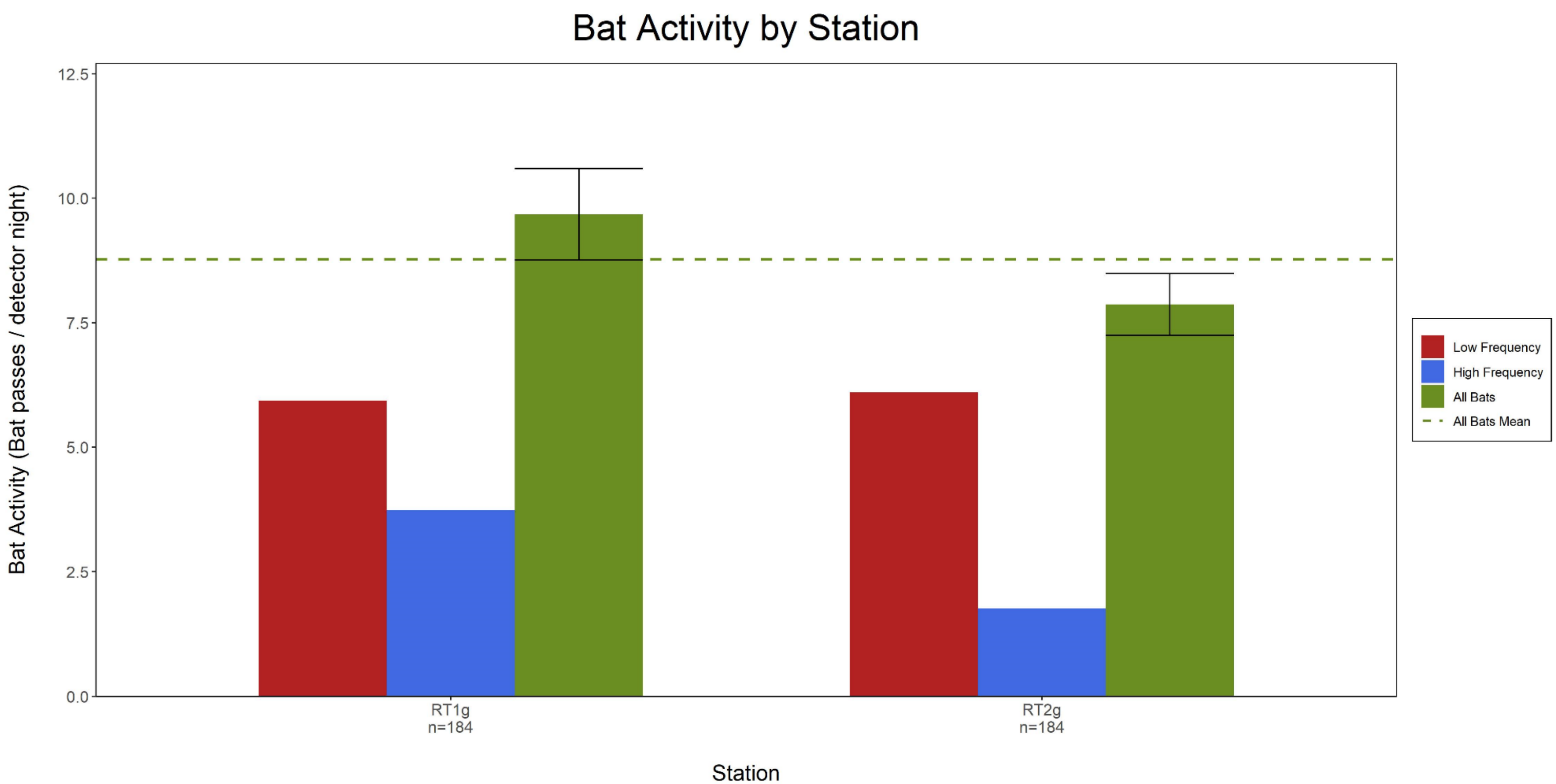


Figure 5. Number of high-frequency and low-frequency bat passes per detector-night recorded at detectors within the proposed Rail Tie Wind Project, Albany County, Wyoming between April 16 and October 16, 2019. The bootstrapped standard errors are represented by the black error bars on the 'All Bats' columns.

Temporal Variation

Bat activity at the survey stations was relatively low in the spring and higher in summer and fall (Table 5, Figure 6). Bat activity was 12.14 bat passes per detector-night during the FMP (Table 5). Weekly acoustic activity was relatively low at the start of the study period, before increasing in late June (Figure 7). Weekly bat activity was highest between late July and late September (Figure 7), peaking from August 13 − 19 (26.36 bat passes per detector-night; Table 6). Weekly activity steadily decreased from late August through mid-October until the last night of the survey when activity peaked (Figure 7). The last night of the survey was reviewed and found to be primarily calls produced by silver-haired bats, in addition to several hoary bat pulses.

Table 5. The number of bat passes per detector-night recorded at monitoring detector stations within the proposed Rail Tie Wind Project, Albany County, Wyoming during each season, separated by call frequency: high frequency (HF), low frequency (LF), and all bats (AB).

Station	Call Frequency	Spring April 16 – May 31	Summer June 1 – Aug 15	Fall Aug 16 – Oct 16	FMP Jul 30 – Oct 14
RT1g	LF	0.72	6.83	8.71	9.43
	HF	0.28	6.17	3.32	4.38
	AB	1.00	13.00	12.03	13.81
RT2g	LF	0.67	8.49	7.21	8.23
	HF	0.26	2.87	1.53	2.23
	AB	0.93	11.36	8.74	10.47
Overall	**LF**	**0.70 ± 0.20**	**7.66 ± 0.82**	**7.96 ± 0.95**	**8.83 ± 0.72**
	HF	**0.27 ± 0.08**	**4.52 ± 0.33**	**2.43 ± 0.43**	**3.31 ± 0.41**
	AB	**0.97 ± 0.25**	**12.18 ± 1.03**	**10.39 ± 1.09**	**12.14 ± 0.95**

FMP = Fall Migration Period.

Table 6. Periods of peak activity for high frequency (HF), low frequency (LF), and all bats at the proposed Rail Tie Wind Project, Albany County, Wyoming from April 16 – October 16, 2019.

Species Group	Start Date of Peak Activity	End Date of Peak Activity	Bat Passes per Detector-Night
HF	July 14 & August 18	July 20 & August 24	7.14
LF	August 13	August 19	20.14
All Bats	August 13	August 19	26.36

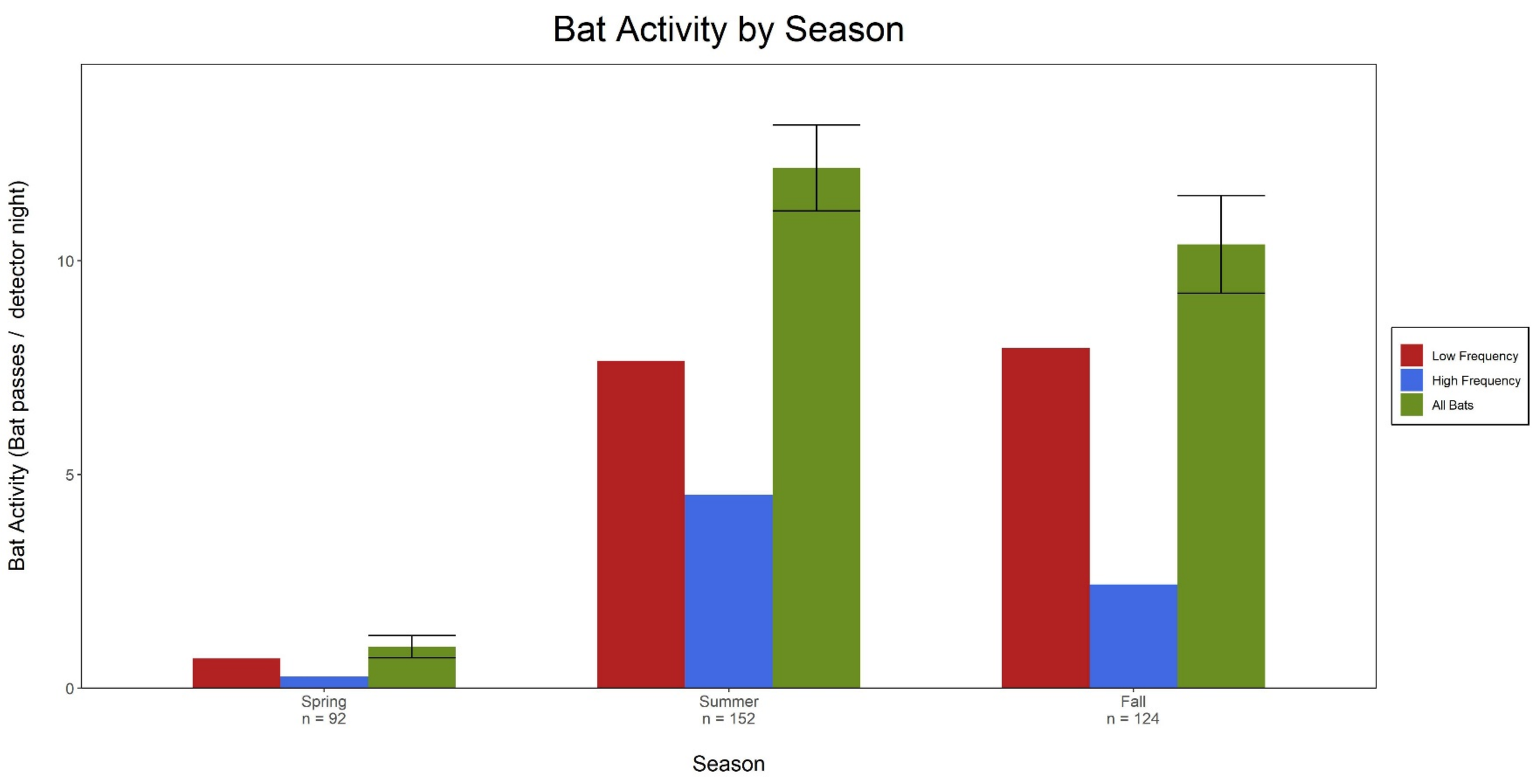


Figure 6. Seasonal bat activity by high-frequency, low-frequency), and all bats at the proposed Rail Tie Wind Project, Albany County, Wyoming from April 16 – October 16, 2019. The bootstrapped standard errors are represented on the 'All Bats' columns (black bar).

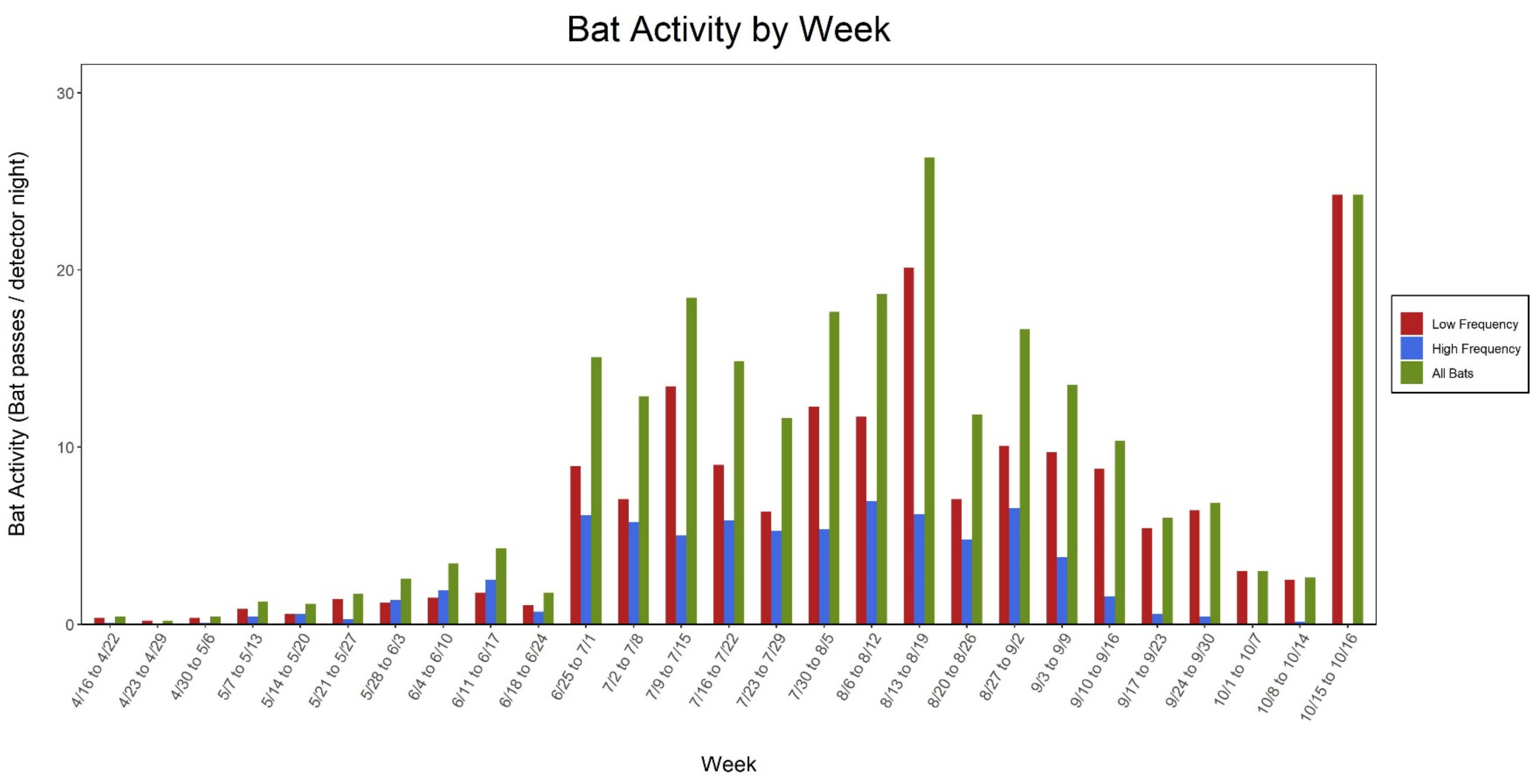


Figure 7. Weekly patterns of bat activity by high-frequency, low-frequency, and all bats at the proposed Rail Tie Wind Project, Albany County, Wyoming from April 16 – October 16, 2019.

Species Composition

Of the total bat passes recorded, 68.6% were classified as LF (e.g., big brown bats, hoary bats, and silver-haired bats), and 31.4% of bat passes were classified as HF (e.g., eastern red bats; Table 2, Table 7). HF bat activity had two periods of peak activity with the same bat activity rate (7.14 bat passes per-detector night), once in mid-July and once in late August (Table 6).

Out of verified bat calls (excluding noise), Kaleidoscope identified calls of 11 bat species that have the potential to occur within the Project area (Tables 2 and 7) although Kaleidoscope does not have the ability to identify the big free-tailed bat and none were detected during manual review. The hoary bat and the silver-haired bat were the species recorded on the most nights, present on 56% and 52% of overall detector nights respectively, and these species were also the most commonly recorded at each station. Overall, little brown bat (37%) and eastern red bat (35%) passes were the third and fourth most commonly recorded although little brown bats were recorded on a greater percentage of detector-nights at RT2g whereas these species were both recorded 45% of detector-nights at RT1g. The big brown bat was the fifth most frequently identified species (18% of detector-nights) followed by the western small-footed bat (16% of detector nights). Other detected species included the long-legged bat (11%) and pallid bat (2%; Table 7). Kaleidoscope identified five calls from station RT2g as potential northern long-eared bats. None of these calls were confirmed to be northern long-eared bat passes upon qualitative review, and all calls were reclassified as high frequency unknown species, because all calls have a curvilinear rather than linear shape, with a minimum slope of the call, bandwidth (total range of frequency that the call sweeps through), and Fmax (the frequency where the power is greatest) that are too low for NLEB. No Townsend's big-eared bat or spotted bat passes were identified by Kaleidoscope and fringed bat passes were identified just once at RT2g (Table 7). Western long-eared bats were identified twice at each station.

Table 7. The number (percent) of presence/absence dates for detector nights with bat species present by station recorded by the Wildlife Acoustics SM3 detectors at the proposed Rail Tie Wind Project using Kaleidoscope 5.1.0 from April 16 – October 16, 2019.

Common Name	RT1g	RT2g	Total
High Frequency (≥30 kHz)			
eastern red bat	82 (45)	48 (26)	130 (35)
little brown bat	82 (45)	55 (30)	137 (37)
long-legged bat	18 (10)	21 (11)	39 (11)
northern long-eared bat	0 (0)	5 (3)	5 (1)
western long-eared bat	2 (1)	2 (1)	4 (1)
western small-footed bat	35 (19)	25 (14)	60 (16)
Low Frequency (15 – 29 kHz)			
big brown bat	51 (28)	16 (9)	67 (18)
fringed bat	0 (0)	1 (1)	1 (0)
hoary bat	97 (53)	109 (59)	206 (56)
pallid bat	4 (2)	2 (1)	6 (2)
silver-haired bat	86 (47)	105 (57)	191 (52)
Townsend's big-eared bat	0 (0)	0 (0)	0 (0)
Very Low Frequency (<15 kHz)			
spotted bat	0 (0)	0 (0)	0 (0)

Table 7. The number (percent) of presence/absence dates for detector nights with bat species present by station recorded by the Wildlife Acoustics SM3 detectors at the proposed Rail Tie Wind Project using Kaleidoscope 5.1.0 from April 16 – October 16, 2019.

Common Name	RT1g	RT2g	Total

kHz = kilohertz.

North American Bat Surveys

The four stations deployed concurrently for NABat surveys were 100% operational. Kaleidoscope identified 2,271 bat calls, 777 of which were identified to 13 species that potentially occur within the Project area (Tables 2, 7, and 8). Kaleidoscope does not have the ability to label the fourteenth potential species, the big free-tailed bat. A qualified bat biologist verified calls, reclassifying 2,077 of them, including reviewing 1,494 calls that Kaleidoscope could not identify to species (Tables 8 and 9). Only seven species and 1,205 files were identified as bat passes during qualitative review. Hoary bat passes were the main species labeled of calls qualitatively identified to species-level, composing 13.7% of all bat calls. Silver-haired bats and big brown bats were the next most commonly detected species, composing 3.2% and 1.2% of calls, respectively (Table 10). Only one call by an eastern red bat, two calls by little brown bat, four calls by fringed bat, and seven by western long-eared bat were detected (Table 10). The remaining calls were classified as unknown HF bats (39.8% of bat passes), unknown LF bats (30.4%), 40 kHz Myotis group (10.4%), 30 kHz Myotis group (1 call; Table 10). No calls were identified as pallid bat, Townsend's big-eared bats, long-legged bat, northern long-eared bat, spotted bat, or western small-footed bat (Table 10), nor were any big free-tailed bat passes incidentally identified during qualitative review of Kaleidoscope-labeled calls. A single bat pass at the northwest station was identified as a potential northern long-eared bat call by Kaleidoscope, but determined to be an unknown *Myotis* species upon qualitative call review.

Table 8. Number of bat calls identified by Kaleidoscope during 2019 North American Bat Monitoring Program survey sites at the proposed Rail Tie Wind Project.

Survey Site	Total Bat Calls	Calls Identified	Detector-Nights
NE	1,614	359	4
NW	298	191	4
SE	193	115	4
SW	166	112	4
Total	**2,271**	**777**	**16**

Table 9. Number of bat calls and species identified by Kaleidoscope and qualitative review at each station during 2019 North American Bat Monitoring Program survey sites at the proposed Rail Tie Wind Project.

	Kaleidoscope		Qualitative Review	
Survey Site	Total Bat calls	# Species Identified	Total Bat calls	# Species Identified
NE	1,614	10	524	5
NW	298	10	315	3
SE	193	10	199	4
SW	166	10	167	3
Total	**2,271**	**13**	**1,205**	**7**

Table 10. Species summaries after qualitative review of all Kaleidoscope Pro 5.1.0 auto classification of 2019 North American Bat surveys.

Site ID	NE	NW	SE	SW	Total
COTO	0	0	0	0	0
EPFU	0	0	14	0	14
LABO	1	0	0	0	1
LACI	107	10	7	41	165
LANO	8	4	10	17	39
30 kHz *Myotis*	0	0	0	1	1
40 kHz *Myotis*	37	83	1	4	125
MYSP	0	1	0	0	1
MYEV	1	1	5	0	7
MYCI	0	0	0	0	0
MYLU	2	0	0	0	2
MYSE	0	0	0	0	0
MYTH	0	0	0	4	4
MYVO	0	0	0	0	0
HF	193	191	65	30	479
HF2	1	0	0	0	1
LF	174	25	96	70	365
LF2	0	0	1	0	1
Total	**524**	**315**	**199**	**167**	**1,205**

COTO=Townsend's big-eared bat; EPFU=Big brown bat; LABO=Eastern red bat; LACI=Hoary bat; LANO=Silver-haired bat; MYCI = Western small-footed bat, MYEV = Western long-eared bat; MYLU=Little Brown Bat; MYSE=Northern long-eared bat; MYSP = unknown Myotis species; MYTH = Fringed bat, MYVO = long-legged bat; HF= High-Frequency Bat (>30 kHz); HF2 = second HF bat pass detected in single file; LF= Low-Frequency Bat (≤30 kHz), 30 kHz Myotis = Myotis in the 30 kHz frequency range such as MYEV; 40 kHz Myotis = Myotis in the 40 kHz frequency range (such as MYCI, MYVO, MYLU); LF2 = second

DISCUSSION

Acoustic surveys for bats were first recommended as a risk assessment tool soon after large-scale bat fatality events at wind facilities were first documented (Arnett et al. 2005). The timing of highest bat activity was consistent with peak fatality periods at wind energy facilities (Johnson et al. 2004, Arnett et al. 2008), and it was assumed the magnitude of pre-construction bat activity would similarly predict the magnitude of post-construction bat fatalities (Kunz et al. 2007b). At first, the general trend was that projects with low bat activity tended to have low bat fatality rates (Gruver 2002, Johnson et al. 2004), and vice versa (Fielder 2004, Arnett et al. 2005, Koford et al. 2005). However, Hein et al. (2013) analyzed data from 12 wind projects that paired bat activity and fatality results and found a weak, non-significant correlation where bat activity rates explained 22% of the variation in bat fatality rates. Hien et al. (2013) concluded bat acoustic data provided limited inference into predicting bat fatality rates, but acknowledged the available data were limited and had been collected using different methods. WEST recently conducted an analysis of data from 44 standardized fatality monitoring studies in the US and found pre-construction bat activity did not predict post-construction bat fatality rates by season, by detector height, or by region of the country (Solick et al. 2019). Currently, the best predictor of risk to bats at a proposed wind facility is likely the known fatality rates at neighboring wind energy facilities with similar habitat. Although pre-construction bat activity is not strongly correlated with post-construction bat fatality (Solick et al. 2019), pre-construction acoustic surveys still provide useful information about spatial use in the development area, seasonal activity peaks, and species composition.

Spatial Variation

Both bat activity survey detectors were located in open herbaceous grassland habitat primarily used for cattle grazing and representative of areas where turbines are likely to be sited. Lower bat activity is typically associated with open habitat relative to habitat near open water, forested, rocky outcrops, or riparian habitats that have the tendency to attract bats for foraging and roosting opportunities (Brooks and Ford 2005). Station RT1g recorded the most bat passes per detector-night and this is likely because station RT1g was also placed near rocky outcrop features representative of habitat in the northern Project area, whereas RT2g in the southern Project area was limited to open herbaceous grassland habitat. Little brown bats were the third most commonly recorded species at RT2g, whereas eastern red bats were the third most commonly recorded species at RT1g. In Wyoming, little brown bats will commonly use sagebrush landscapes particularly when there is pine with small rocky outcrop hills present. Female little brown bats leave maternity roosts and fly to transitional rock roosts near water which provide suitable habitat (WBWG 2019). The rocky outcrops at station RT2g likely provided better *Myotis* habitat than the open grassland habitat and resulted in higher *Myotis* activity. A review of 40 US studies found that bat mortality might 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).

At NABat stations up to ten times as many bat calls (1,614) were recorded at the NE station, which was located near a pond. The other NABat stations were located near small moving creeks or ephemeral flows. A pond may be a more attractive drinking resource for bats because the water surface is flat and smooth, allowing for close flight and drinking. This pond was one of the larger accessible drinking sources available in the Project, and had water during the NABat monitoring period. Ponds also attract insects and can increase foraging opportunities (Racey 1998, Grindal et al. 1999). It is possible that this period of relatively high bat activity coincided with an insect hatch at the pond.

Temporal Variation

Overall bat activity was lowest in the spring and highest during the fall in 2019, peaking in mid-August in both 2019 and 2009 and during the first week of September, in 2010 (WAPA 2012). This timing is also consistent with peak fatality periods for most wind energy facilities in the US (American Wind Wildlife Institute [AWWI] 2018), and suggests bat fatalities at the Project may be highest during the fall migration and low during the spring migratory season.

Species Composition

Activity by LF bat species composed 68.6% of bat passes recorded at stations in the Project area in 2019, 55% of bat passes in 2010, and 48% of bat passes in 2009 (WAPA 2012, Taylor et al.

2010). Kaleidoscope and qualitative identification indicated LF species hoary bats and silver-haired bats were the main species detected during activity surveys as well as in early July during the NABat surveys, and two HF species, the little brown bat and eastern red bat, were the third and fourth most frequently detected species during activity surveys. Given that hoary bats, silver-haired bats, and eastern red bats are among the most common bat fatalities at many facilities (Arnett et al. 2008, Arnett and Baerwald 2013, AWWI 2018), and hoary bats, little brown bats, silver-haired bats, and eastern red bats are the most common bat fatalities in Wyoming (Young et al. 2003a, Rintz and Bay 2012, 2013, 2014), it is expected these four species would be the most common fatalities at the Project.

During the acoustic activity monitoring in the fall, calls on the last night of the survey were reviewed and determined to be primarily silver-haired bats (and some hoary bats) indicating a late migratory activity pulse. This is likely because it snowed until July at the Project in 2019 and may have caused bats to migrate later than usual to their summer reproductive grounds (Racey and Speakman 1987, Frick et al. 2010b, Lučan et al. 2013, Bishop-Boros 2014, Weather Underground 2019). As a result, bats may also migrate back to winter habitat at a later date than average, because reproduction would have occurred at a later date requiring more time for juveniles to become volant and both juveniles and females that reproduced to accumulate stored fat before the fall migration (Racey 1973, Racey and Swift 1981, Bishop-Boros 2014). The Project also had a week of below freezing weather with snow in mid-October (Weather Underground 2019) that likely forced bats to induce torpor to conserve energy before continuing their migration south (Bishop-Boros 2014) which may explain the later pulse of migratory activity observed the last night of the survey and may not be observed in years with typical weather patterns.

During activity surveys, Kaleidoscope identified calls of 11 of the 14 bat species that have the potential to occur within the Project area although Kaleidoscope does not have the ability to identify one of these (the big free-tailed bat). No big free-tailed bat passes were identified during qualitative review. The Townsend’s big-eared bat and spotted bat were the only species’ not identified by Kaleidoscope during the six month activity surveys although Kaleidoscope identified two Townsend’s big-eared bat passes and 11 spotted bat passes during NABat surveys in addition to the other 11 potentially identifiable species. During qualitative call review of NABat summer maternity season data, only seven species were confirmed in the Project: the big brown bat, eastern red bat, hoary bat, silver-haired bat, western long-eared bat, little brown bat, and fringed bat. Kaleidoscope identified five calls from station RT2g and one call from the northwest NABat station as potential federally threatened northern long-eared bat passes. Although no northern long-eared bat passes were confirmed at the Project through qualitative call review, little brown bats were the third most commonly identified species by Kaleidoscope at the Project and are the fourth most common fatality in the Rocky Mountain region (WEST 2019). The fungus that causes WNS was recently detected on little brown bats 88 miles (141 km) northeast of the Project and WNS is the primary reason the USFWS listed the northern long-eared bat as threatened under the 4(d) rule (81 FR 1900 [January 14, 2016]), and is the reason the status of the little brown bat is currently under review.

Bat Activity

Overall bat activity at the Project in 2019 at ground-based stations was 8.77 bat passes per detector-night and the overall FMP rate was 8.83 using SM3 detectors whereas activity was 2.22 in fall 2009 and 2.66 bat passes per detector-night overall in 2010, both historic rates using a single fixed ground-based AnaBat detector in representative habitat (WAPA and ShellWind 2012). Traditionally zero-cross AnaBat detectors have been used for bat activity surveys, but with the advancement in technology newer detectors including the SM3 that record in full spectrum have become available and are more reliable. 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 the Project) 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). Meaning, all else being equal, the full-spectrum detector is likely to record more bat calls than the zero-cross detector (i.e., an SM3 unit such as that used at the Project generally would be expected to record a higher number of calls per detector night than an AnaBat in the same location). Therefore, the 2019 activity data collected by SM3 detectors in this study likely recorded higher activity than the historic acoustic data because of the detector type.

Although bat activity at the Project area in 2019 is higher than the few publically available bat activity wind projects in Wyoming and the historic Hermosa Project data; the older technology used at these historic projects likely limited the number of bat passes recorded. Due to these differences, all comparisons should be made with caution and, instead, the best predictors of risk may be the known fatality rates at neighboring wind energy facilities, especially if habitat is similar. Over two-thirds of bat fatality studies in the Rocky Mountain region report fewer than five bat fatalities/MW/year, and it is possible similar fatality rates could be recorded at the Project (Figure 8). The closest operating wind-energy facility to the Project with public post-construction fatality data is Foote Creek Rim I, located approximately 50 mi (80 km) northwest from the Project and the Top of the World Wind Project located approximately 131 miles (211 kilometers) north of the Project. These projects are located in landscapes dominated by sagebrush-steppe habitat. Bat fatality rates at Foote Creek Rim have ranged from 1.56–3.96 bats/MW/study period (Young et al. 2003), and at Top of the World have ranged from 2.34 bats/MW/year in 2012 – 2013 to 2.74 in 2010 – 2011 (Rintz and Bay 2012, 2013, 2014). Based on the activity patterns recorded at the Project and the fatality rates at nearby facilities, it is expected that if bat fatalities occur, they would be highest during the fall, and be composed mainly of hoary bats and silver-haired bats.

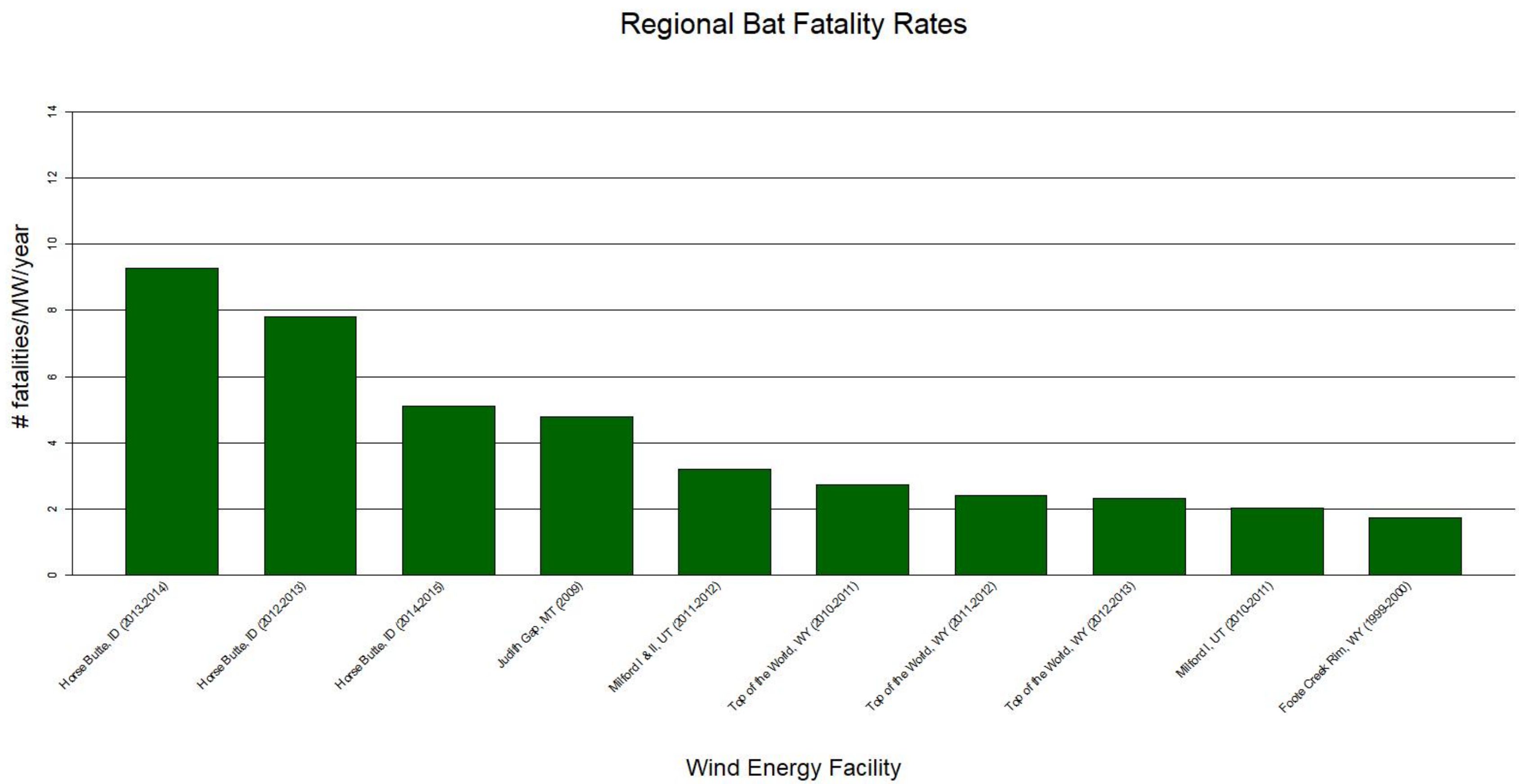


Figure 8. Fatality rates for bats (number of bats/megawatt [MW]/ year) from publicly available studies at wind energy facilities in the United States Rocky Mountain region of North America.

Figure 8 (*continued*). Fatality rates for bats (number of bats/megawatt/year) from publicly available studies at wind energy facilities in the Rocky Mountain region of North America.

Data from the following sources:

Wind Energy Facility	Bat fatalities/MW/year	Reference
Horse Butte, ID (2013-2014)	9.27	SWCA Environmental Consultants 2015
Horse Butte, ID (2012-2013)	7.80	SWCA Environmental Consultants 2015
Horse Butte, ID (2014-2015)	5.12	SWCA Environmental Consultants 2015
Judith Gap, MT (2009)	4.80	Poulton and Erickson 2010
Foote Creek Rim, WY (1998-1999)	3.96	Young et al. 2003
Milford I & II, UT (2011-2012)	3.20	Stantec Consulting, Inc (Stantec) 2012
Top of the World, WY (2010-2011)	2.74	Rintz and Bay 2012
Top of the World, WY (2011-2012)	2.43	Rintz and Bay 2013
Top of the World, WY (2012-2013)	2.34	Rintz and Bay 2014
Milford I, UT (2010-2011)	2.05	Stantec 2011
Foote Creek Rim, WY (1999-2000)	1.73	Young et al. 2003
Foote Creek Rim, WY (2001-2002)	1.56	Young et al. 2003

REFERENCES

80 Federal Register (FR) 63: 17974-18033. 2015. Endangered and Threatened Wildlife and Plants; Threatened Species Status for the Northern Long-Eared Bat with 4(d) Rule; Final Rule, and Interim Rule with Request for Comments. 50 CFR 17. Department of the Interior Fish and Wildlife Service. 80 FR 17974. April 2, 2015. Available online: http://www.fws.gov/midwest/endangered/mammals/nleb/pdf/FRnlebFinalListing02April2015.pdf

81 Federal Register (FR) 9: 1900-1922. 2016. Endangered and Threatened Wildlife and Plants; 4(d) Rule for the Northern Long-Eared Bat; Final Rule. 50 CFR 17. Department of the Interior, Fish and Wildlife Service. 81 FR 1900. January 14, 2016. Available online: http://www.fws.gov/Midwest/endangered/mammals/nleb/pdf/FRnlebFinal4dRule14Jan2016.pdf

Abernethy, I.M., M.D. Andersen, and D.A. Keinath. 2015. Bats of Wyoming year 4 report. Prepared for the USDI Bureau of Land Management by the Wyoming Natural Diversity Database, University of Wyoming, Laramie, Wyoming.

Abernethy, I.M., 2019. Bats of Wyoming 2018 project report. Prepared for the USDI Bureau of Land Management by the Wyoming Natural Diversity Database, University of Wyoming, Laramie, Wyoming.

Adams, A. M., M. K. Jantzen, R. M. Hamilton, and M. B. Fenton. 2012. Do You Hear What I Hear? Implications of Detector Selection for Acoustic Monitoring of Bats. Methods in Ecology and Evolution 3(6): 992-998. doi: 10.1111/j.2041-210X.2012.00244.x.

Agranat, I. 2012. Bat Species Identification from Zero Crossing and Full Spectrum Echolocation Calls Using Hmms, Fisher Scores, Unsupervised Clustering and Balanced Winnow Pairwise Classifiers. Wildlife Acoustics, Inc., Concord, Massachusetts. Available online: http://www.wildifecoustics.com/images/documentation/Classification%20of%20Bat%20Echolocation%20Calls%20FINAL%2020120913A.pdf

American Wind Wildlife Institute (AWWI). 2018. Bats and Wind Energy: Impacts, Mitigation, and Tradeoffs. AWWI, Washington, D. C. November 15, 2018. Available online: https://awwi.org/wp-content/upoads/ 2018/11/AWWI-Bats-and-Wind-Energy-White-Paper-FINAL.pdf

AnaLook. 2004. Bat call analysis program. © 2004, C. Corben.

Arnett, E. B., W. P. Erickson, J. Kerns, and J. Horn. 2005. Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines. Prepared for the Bats and Wind Energy Cooperative. March 2005.

Arnett, E. B., K. Brown, W. P. Erickson, J. Fiedler, B. L. Hamilton, T. H. Henry, A. Jain, G. D. Johnson, J. Kerns, R. R. Koford, C. P. Nicholson, T. O'Connell, M. Piorkowski, and R. Tankersley, Jr. 2008. Patterns of Bat Fatalities at Wind Energy Facilities in North America. Journal of Wildlife Management 72(1): 61-78.

Arnett, E. B. and E. F. Baerwald. 2013. Chapter 21. Impacts of Wind Energy Development on Bats: Implications for Conservation. Pp. 435-456. *In*: R. A. Adams and S. C. Pederson, eds. Bat Ecology, Evolution and Conservation. Springer Science Press, New York.

BioResource Consultants, Inc. (BRC). 2012. Avian Mortality Monitoring Report, Pine Tree Wind Farm, Kern County, California. Prepared for the City of Los Angeles Department of Water and Power. Report prepared by BioResource Consultants, Inc., Ojai, California. March 26, 2012.

Bishop-Boros, L. 2014. The Influence of Weather and Geographic Location on Reproduction and Nightly Activity of Bats in Missouri. Missouri State University. Master of Science.

Boyles, J. G. and C. K. R. Willis. 2010. Could Localized Warm Areas inside Cold Caves Reduce Mortality of Hibernating Bats Affected by White-Nose Syndrome? Frontiers in Ecology and the Environment 8(2): 92-98.

Brooks, R. T. and W. M. Ford. 2005. Bat Activity in a Forest Landscape of Central Massachusetts. Northeastern Naturalist 12(4): 447-462. Caceres, M. C., and R. M. R. Barclay. 2000. Myotis septentrionalis. Mammalian Species 634:1-4.

Collins, J. and G. Jones. 2009. Differences in Bat Activity in Relation to Bat Detector Height: Implications for Bat Surveys at Proposed Wind Farms. Acta Chiropterologica 11(2): 343-350. doi: 10.3161/150811009X485576.

Cryan, P. M. 2008. Mating Behavior as a Possible Cause of Bat Fatalities at Wind Turbines. Journal of Wildlife Management 72(3): 845-849. doi: 10.2193/2007-371.

Endangered Species Act (ESA). 1973. 16 United States Code (USC) §§ 1531-1544, Public Law (PL) 93-205, December 28, 1973, as amended, PL 100-478 [16 USC 1531 et seq.]; 50 Code of Federal Regulations (CFR) 402.

ESRI. 2019. World Imagery and Aerial Photos. (World Topo). ArcGIS Resource Center. Environmental Systems Research Institute (ESRI), producers of ArcGIS software. Redlands, California. Information online: http://www.arcgis.com/home/webmap/viewer.html?useExisting=1

Fenton, M. B. 1980. Adaptiveness and Ecology of Echolocation in Terrestrial (Aerial) Systems. Pp. 427-446. *In*: R. G. Busnel and J. F. Fish, eds. Animal Sonar Systems. Plenum Press, New York.

Frick, W. F., J. F. Pollock, A. C. Hicks, K. E. Langwig, D. S. Reynolds, G. G. Turner, C. M. Butchkoski, and T. H. Kunz. 2010a. An Emerging Disease Causes Regional Population Collapse of a Common North American Bat Species. Science 329(5992): 679-682.

Frick, W. F., D. S. Reynolds, and T. H. Kunz. 2010b. Influence of Climate and Reproductive Timing on Demography of Little Brown Myotis Myotis lucifugus. Journal of Animal Ecology 79: 128-136. doi: 10.1111/j.1365-2656.2009.01615.x.

Gannon, W. L., R. E. Sherwin, and S. Haymond. 2003. On the Importance of Articulating Assumptions When Conducting Acoustic Studies of Habitat Use by Bats. Wildlife Society Bulletin 31: 45-61.

Grindal, S. D., J. L. Morissette, and R. M. Brigham. 1999. Concentration of Bat Activity in Riparian Habitats over an Elevational Gradient. Canadian Journal of Zoology 77(6): 972-977. doi: 10.1139/cjz-77-6-972.

Gruver, J. 2002. Assessment of Bat Community Structure and Roosting Habitat Preferences for the Hoary Bat (*Lasiurus cinereus*) near Foote Creek Rim, Wyoming. Thesis. University of Wyoming, Laramie, Wyoming.

Hein, C. D., J. Gruver, and E. B. Arnett. 2013. Relating Pre-Construction Bat Activity and Post-Construction Bat Fatality to Predict Risk at Wind Energy Facilities: A Synthesis. A report submitted to the National Renewable Energy Laboratory (NREL), Golden Colorado. Bat Conservation International (BCI), Austin, Texas. March 2013. Available online: http://batsandwind.org/pdf/Pre-%20Post-construction%20Synthesis_FINAL%20REPORT.pdf

Heffernan, L. 2016. Map of White-Nose Syndrome (WNS) Occurrence by County/District. Pennsylvania Game Commission. August 2, 2016. Available online: https://www.whitenosesyndrome.org/mmedia-education/august-2-2016

Hester, S. G. and M. B. Grenier. 2005. A Conservation Plan for Bats in Wyoming. Wyoming Game and Fish Department, Nongame Program, Lander, Wyoming.

International Union for Conservation of Nature (IUCN). 2017. IUCN Red List of Threatened Species: Bat Species. Version 2017-3. Accessed April 2018. Information online: www.iucnredlist.org

Jain, A. 2005. Bird and Bat Behavior and Mortality at a Northern Iowa Windfarm. Thesis. Iowa State University, Ames, Iowa. Available online: http://batsandwind.org/pdf/Jain_2005.pdf

Johnson, G. D., M. K. Perlik, W. P. Erickson, and M. D. Strickland. 2004. Bat Activity, Composition and Collision Mortality at a Large Wind Plant in Minnesota. Wildlife Society Bulletin 32(4): 1278-1288.

Koford, R., A. Jain, G. Zenner, and A. Hancock. 2005. Avian Mortality Associated with the Top of Iowa Wind Farm. Progress Report, Calendar Year 2004. February 2005. Iowa Cooperative Fish and Wildlife Research Unit, Iowa State University, Ames, Iowa. 12 pp.

Kunz, T. H., E. B. Arnett, B. M. Cooper, W. P. Erickson, R. P. Larkin, T. Mabee, M. L. Morrison, M. D. Strickland, and J. M. Szewczak. 2007a. Assessing Impacts of Wind-Energy Development on Nocturnally Active Birds and Bats: A Guidance Document. Journal of Wildlife Management 71(8): 2449-2486. doi: 10.2193/2007-270.

Kunz, T. H., E. B. Arnett, W. P. Erickson, A. R. Hoar, G. D. Johnson, R. P. Larkin, M. D. Strickland, R. W. Thresher, and M. D. Tuttle. 2007b. Ecological Impacts of Wind Energy Development on Bats: Questions, Research Needs, and Hypotheses. Frontiers in Ecology and the Environment 5(6): 315-324.

Lučan, R. K., M. Weiser, and V. Hanák. 2013. Contrasting Effects of Climate Change on the Timing of Reproduction and Reproductive Success of a Temperate Insectivorous Bat. Journal of Zoology 290(151-159): doi: 10.1111/jzo.12021.

Minnis, A. M. and D. L. Lindner. 2013. Phylogenetic Evaluation of *Geomyces* and Allies Reveals No Close Relatives of *Pseudogymnoascus destructans*, Comb. Nov., in Bat Hibernacula of Eastern North America. Fungal Biology 117: 638-649.

Müeller, J., R. Brandl, J. Buchner, H. Pretzsch, S. Seifert, C. Strätz, M. Veith, and B. Fenton. 2013. From Ground to above Canopy - Bat Activity in Mature Forests Is Driven by Vegetation Density and Height. Forest Ecology and Management 306: 179-184.

Multi-Resolution Land Characteristics (MRLC). 2019. National Land Cover Database (NLCD) 2016. Multi-Resolution Land Characteristics (MRLC) Consortium. US Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center, MRLC Project, Sioux Falls, South Dakota. May 10, 2019. Information online: https://www.mrlc.gov/data

Murray, K. L., E. R. Britzke, and L. W. Robbins. 2001. Variation in the Search-Phase Calls of Bats. Journal of Mammalogy 82(3): 728-737. doi: 10.1644/1545-1542(2001)082<0728:VISPCO>2.0.CO;2.

National Park Service (NPS). 2019. Bat Fungus Potentially Detected at Grand Canyon. News Release. Grand Canyon National Park, Arizona. December 4, 2019. Accessed December 2019. Available online: https://www.nps.gov/grca/learn/news/bat-fungus-potentially-detected-at-grand-canyon-20191204.htm

New Mexico Game and Fish Department (NMGFD). 2019. Early Detection of *P. destructans* in New Mexico. Final Report March 1, 2018 through June, 2019. Investigators J. Hataway and D. Northup, University of New Mexico. NMGFD, Santa Fe, New Mexico. July 12, 2019. Available online: http://www.wildlife.state.nm.us/download/conservation/share-with-wildlife/reports/2018/Early-detection-of-Pd-in-New-Mexico-_-Jenny-Hathaway.pdf

North American Datum (NAD). 1983. NAD83 Geodetic Datum.

O'Farrell, M. J., B. W. Miller, and W. L. Gannon. 1999. Qualitative Identification of Free-Flying Bats Using the Anabat Detector. Journal of Mammalogy 80: 11-23.

Poulton, V. and W. P. Erickson. 2010. Post-Construction Bat and Bird Fatality Study, Judith Gap Wind Farm, Wheatland County, Montana. Final Report: Results from June-October 2009 Study and Comparison with 2006-2007 Study. Prepared for Judith Gap Energy, LLC. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. March 2010.

Racey, P. A. 1973. The Onset of Hibernation in Pipistrelle Bats, *Pipistrellus pipistrellus*. Journal of Zoology 171(4): 465-467. doi: 10.1111/j.1469-7998.1973.tb02225.x.

Racey, P.A. and J.R. Speakman. 1987. The Energy Costs of Pregnancy and Lactation in Heterothermic Bats. Symposium of the of Zoological Society of London. 57: 107-125.

Racey, P. A. and S. M. Swift. 1981. Variations in Gestation Length in a Colony of Pipistrelle Bats (*Pipistrellus pipistrellus*) from Year to Year. Journal of Reproduction and Fertility 61: 123-129.

Racey, P. A. 1998. The Importance of the Riparian Environment as a Habitat for British Bats. Behaviour and Ecology of Riparian Mammals: 69-91.

Reeder, D. M., C. L. Frank, G. G. Turner, A. Kurta, E. R. Britzke, S. R. Darling, C. W. Stihler, A. C. Hicks, C. U. Meteyer, R. Jacob, L. A. Grieneisen, S. A. Brownlee, M. E. Vodzak, L. K. Muller, and D. S. Blehert. 2012. Frequent Arousal from Hibernation Linked to Severity of Infection and Mortality in Bats with White-Nose Syndrome. PLoS ONE 7(6): e38920. doi: 38910.31371/journal.pone.0038920. Reeves, J. 2017. Northern Long-Eared Bat (*Myotis septentrionalis*). PowerPoint. Presented to the Society of American Foresters. Wyoming Ecological Services, US Fish and Wildlife Service Region 6 (Mountain-Prairie Region), Cheyenne, Wyoming. March 10, 2017. 50 slides. Available online: https://www.fws.gov/wyominges/PDFs/Species_Listed/NLEB_20170310_JReeves_PresToSocietyAmerForesters.pdf

Rintz, T. and K. Bay. 2012. Year 1 Post-Construction Monitoring for the Top of the World Windpower Project, Converse County, Wyoming. Final Report: November 2010 - November 2011. Prepared for Top of the World Windpower, LLC/Duke Energy Generation Services, Glenrock, Wyoming. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. March 12, 2012.

Rintz, T. and K. Bay. 2013. Year 2 Post-Construction Monitoring for the Top of the World Windpower Project, Converse County, Wyoming. Final Report: November 2011 - November 2012. Prepared for Top of the World Windpower LLC/Duke Energy Generation Services, Glenrock, Wyoming. Prepared by Western EcoSystems Technology, Inc. (WEST), Laramie, Wyoming. February 25, 2013.

Rintz, T. and K. Bay. 2014. Year 3 Post-Construction Monitoring for the Top of the World Windpower Project, Converse County, Wyoming. Final Report: December 2012 - November 2013. Prepared for Top of the World Windpower, LLC/Duke Energy Generation Services, Glenrock, Wyoming. Prepared by Western EcoSystems Technology, Inc. (WEST), Laramie, Wyoming. April 10, 2014.

Roemer, C., T. Disca, A. Coulon, and Y. Bas. 2017. Bat Flight Height Monitored from Wind Masts Predicts Mortality Risk at Wind Farms. Biological Conservation 215: 116-122.

Solick, D. I., C. Nations, and J. C. Gruver. 2011. Activity Rates and Call Quality by Full-Spectrum Bat Detectors. Presented at the 41st Annual Symposium of the North American Society for Bat Research, October 26-29, 2011, Toronto, Ontario.

Solick, D. I., S. Howlin, and L. Bishop-Boros. 2019. Does Bat Activity Predict Bat Fatality at Wind-Energy Facilities? Presented at the Western Bat Working Group, Tulsa, Oklahoma. April 22-25.

Stantec Consulting, Inc. (Stantec). 2011. Post-Construction Monitoring 2010 Final Annual Report – Year 1, Milford Wind Corridor Phase I, Milford, Utah. Prepared for First Wind Management, LLC, Portland, Maine. Prepared by Stantec, Topsham, Maine. August 2011.

Stantec Consulting, Inc. (Stantec). 2012. Post-Construction Monitoring 2011 - 2012, Milford Wind Corridor Phase I and II, Milford, Utah. Prepared for First Wind Management, LLC, Portland, Maine. Prepared by Stantec, Topsham, Maine. May 2012.

SWCA Environmental Consultants (SWCA). 2015. Post-Construction Avian and Bat Fatality at the Horse Butte Wind Facility, Years 1–3. Prepared for Horse Butte Wind I, LLC, New York, New York. Prepared by SWCA, Salt Lake City, Utah. November 2015.

Taylor, K., D. Solick, and K. Bay. 2010. Bat Acoustical Studies for the Hermosa West Wind Resource Area, Albany County, Wyoming. Final Report: July 2009 - November 2009. Prepared for Shell WindEnergy, Inc., Houston, Texas. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. July 9, 2010. Available online: https://tethys.pnnl.gov/publications/hermosa-west-wind-energy-project-draft-eis-appendix-f-bat-acoustical-studies

Thompson, M., J. A. Beston, M. Etterson, J. E. Diffendorfer, and S. R. Loss. 2017. Factors Associated with Bat Mortality at Wind Energy Facilities in the United States. Biological Conservation 215: 241-245. doi: 10.1016/j.biocon.2017.09.014.

US Fish and Wildlife Service (USFWS). 2012a. Land-Based Wind Energy Guidelines. March 23, 2012. 82 pp. Available online: http://www.fws.gov/cno/pdf/Energy/2012_Wind_Energy_Guidelines_final.pdf

US Fish and Wildlife Service (USFWS). 2012b. North American Bat Death Toll Exceeds 5.5 Million from White-Nose Syndrome. USFWS News Release, USFWS Office of Communications, Arlington, Virginia. January 17, 2012. Available online: https://www.batcon.org/pdfs/USFWS_WNS_Mortality_2012_NR_FINAL.pdf

US Fish and Wildlife Service (USFWS). 2013. Acoustic Bat Identification Software Testing Criteria – Draft January 2013. Available online: https://www.fws.gov/midwest/endangered/mammals/inba/surveys/pdf/AcousticPrgrmDrftTestCriteria3Jan13.pdf

US Fish and Wildlife Service (USFWS). 2015. Endangered and Threatened Wildlife and Plants; Threatened Species Status for the Northern Long-Eared Bat with 4(d) Rule; Final Rule and Interim Rule. Department of the Interior, Fish and Wildlife Service, 50 CFR Part 17. 80 Federal Register (FR) 63: 17974-18033. April 2, 2015.

US Fish and Wildlife Service (USFWS). 2016. Endangered and Threatened Wildlife and Plants; 4(d) Rule for the Northern Long-Eared Bat; Final Rule. 50 CFR Part 17. Department of the Interior Fish and Wildlife Service. 81 Federal Register (FR) 9: 1900-1922. January 14, 2016.

US Fish and Wildlife Service (USFWS). 2019. Northern Long-Eared Bat (*Myotis septentrionalis*). USFWS Wyoming Ecological Services - Species. Mountain-Prairie Region. Page last updated July 8, 2019. Available online: https://www.fws.gov/wyominges/Species/NLEBat.php

US Geological Survey (USGS). 2010. White-Nose Syndrome Threatens the Survival of Hibernating Bats in North America. USGS Fort Collins Science Center.

USA Topo. 2019. USA Topo Maps. US Geological Survey (USGS) topographical maps for the United States. ArcGIS. Environmental Systems Research Institute (ESRI), producers of ArcGIS software. Redlands, California.

Warnecke, L., J. M. Turner, T. K. Bollinger, J. M. Lorch, V. Misra, P. M. Cryan, G. Wibbelt, D. S. Blehert, and C. K. R. Willis. 2012. Inoculation of Bats with European *Geomyces destructans* Supports the Novel Pathogen Hypothesis for the Origin of White-Nose Syndrome. Proceedings of the National Academy of Sciences 109(18): 6999-7003.

Weather Underground. 2019. Laramie, WY Weather History. Laramie Regional Airport Station, October 2019. The Weather Company, an IBM business, Brookhaven, Georgia. Accessed December 2019. Information online: https://www.wunderground.com/history/monthly/KLAR/date/2019-10

Western Area Power Administration (WAPA). 2012. Draft Environmental Impact Statement: Hermosa West Wind Energy Project. DOE/EIS-0438. US Department of Energy–Western Area Power Administration. September 2012. Available online: https://www.energy.gov/nepa/downloads/eis-0438-draft-environmental-impact-statement

Western Bat Working Group (WBWG) Minutes. 2019. WBWG Monthly Conference Call: November 12th, 2019. WBWG, Rapid City, South Dakota.

Western EcoSystems Technology, Inc. (WEST). 2019. Regional Summaries of Wildlife Fatalities at Wind Facilities in the United States. 2019 Report from the Renew Database. Published by WEST, Inc., Cheyenne, Wyoming. December 31, 2019.

Wildlife Acoustics, Inc. 2019. Kaleidoscope Pro® Version 5.1.0. (Acoustic analysis computer software). Wildlife Acoustics, Maynard, Massachusetts. Information online: www.wildlifeacoustics.com

White-Nose Syndrome Response Team. 2019. White-Nose Syndrome Occurrence Map by Year - 2019. Where is WNS now? US Fish and Wildlife Service (USFWS). Updated August 30, 2019. Accessed December 2019. Available online: https://www.whitenosesyndrome.org/where-is-wns

Wyoming Bat Working Group (WYBWG). 2019. Meeting Notes. WBWG Annual Meeting, Tongue River Ranger District Office, US Forest Service, Sheridan, Wyoming. November 19, 2019.

Wyoming Game and Fish Department (WGFD). 2017. Wyoming State Wildlife Action Plan. Available online: https://wgfd.wyo.gov/Habitat/Habitat-Plans/Wyoming-State-Wildlife-Action-Plan

Wyoming Game and Fish Department (WGFD). 2018. Fungus That Causes White-Nose Syndrome in Bats Detected in Wyoming for First Time. Press Release. June 1, 2018. WGFD, Cheyenne, Wyoming. Available online: https://wgfd.wyo.gov/News/Fungus-that-causes-white-nose-syndrome-in-bats-det

Wyoming Game and Fish Department (WGFD). 2019a. Letter: General Survey Recommendations. Prepared for Tetra Tech, Portland, Oregon. Prepared by WGFD, Cheyenne, Wyoming. April 12, 2019.

Wyoming Game and Fish Department (WGFD). 2019b. Rail Tie Wind Project, Wyoming Game and Fish Department Introductory Meeting, Cheyenne, WY. Prepared by WGFD, Cheyenne, Wyoming. July 31, 2019.

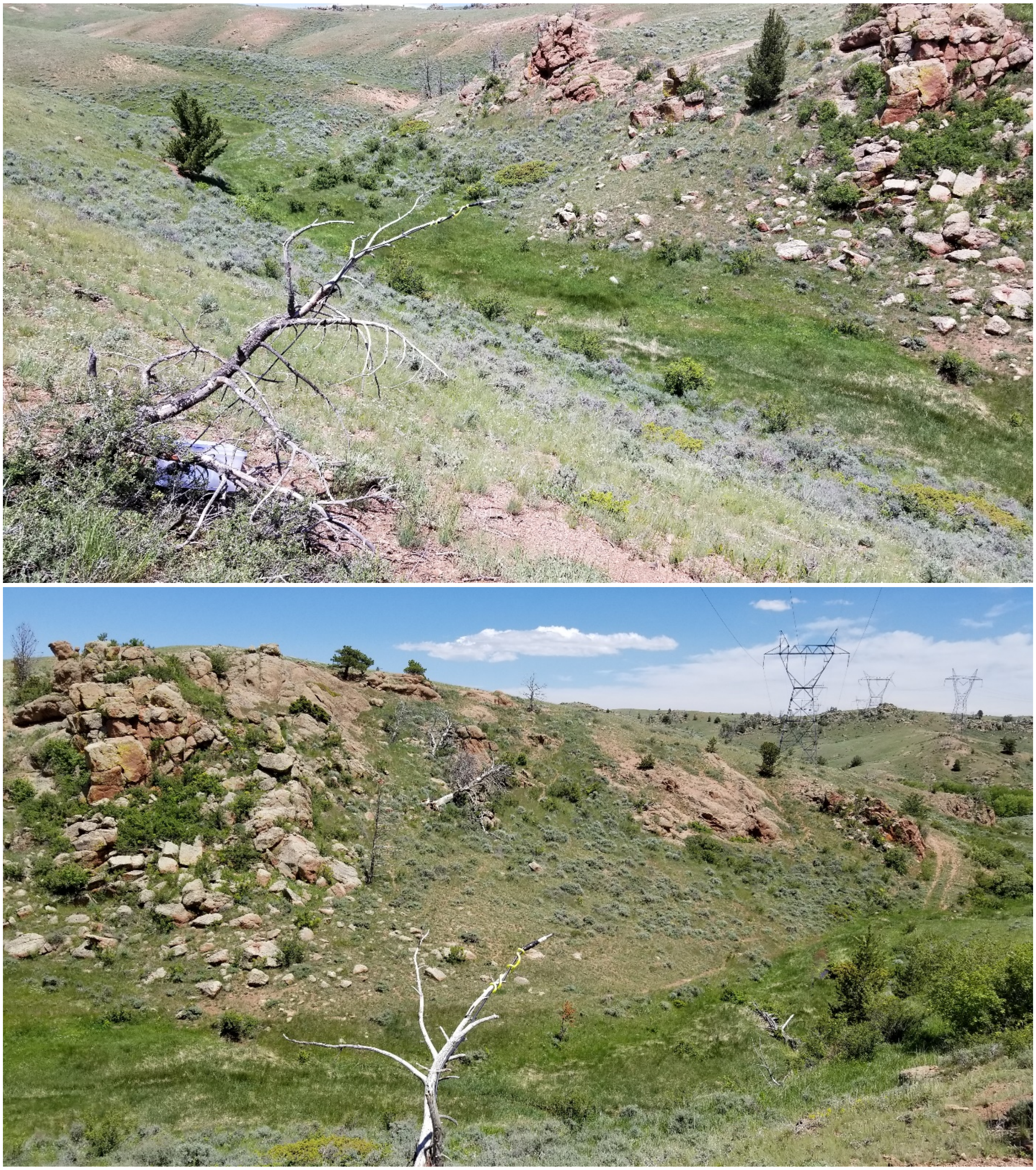
Yang, L., S. Jin, P. Danielson, C. Homer, L. Gass, S. M. Bender, A. Case, C. Costello, J. Dewitz, J. Fry, M. Funk, B. Granneman, G. C. Liknes, M. Rigge, and G. Xian. 2018. A New Generation of the United States National Land Cover Database: Requirements, Research Priorities, Design, and Implementation Strategies. ISPRS Journal of Photogrammetry and Remote Sensing 146: 108-123. doi: 10.1016/j.isprsjprs.2018.09.006.

Yates, M. and R. M. Muzika. 2006. Effect of Forest Structure and Fragmentation on Site Occupancy of Bat Species in Missouri Ozark Forests. Journal of Wildlife Management 70: 1238-1248.

Young, D. P., Jr., W. P. Erickson, R. E. Good, M. D. Strickland, and G. D. Johnson. 2003. Avian and Bat Mortality Associated with the Initial Phase of the Foote Creek Rim Windpower Project, Carbon County, Wyoming, Final Report, November 1998 - June 2002. Prepared for Pacificorp, Inc. Portland, Oregon, SeaWest Windpower Inc. San Diego, California, and Bureau of Land Management, Rawlins District Office, Rawlins, Wyoming. January 10, 2003. Available online: http://west-inc.com/reports/fcr_final_mortality.pdf

Appendix A: Site Photos for Rail Tie Bat Acoustic Surveys

Appendix A1. Photo of the Northeastern site for North American Bat Surveys.

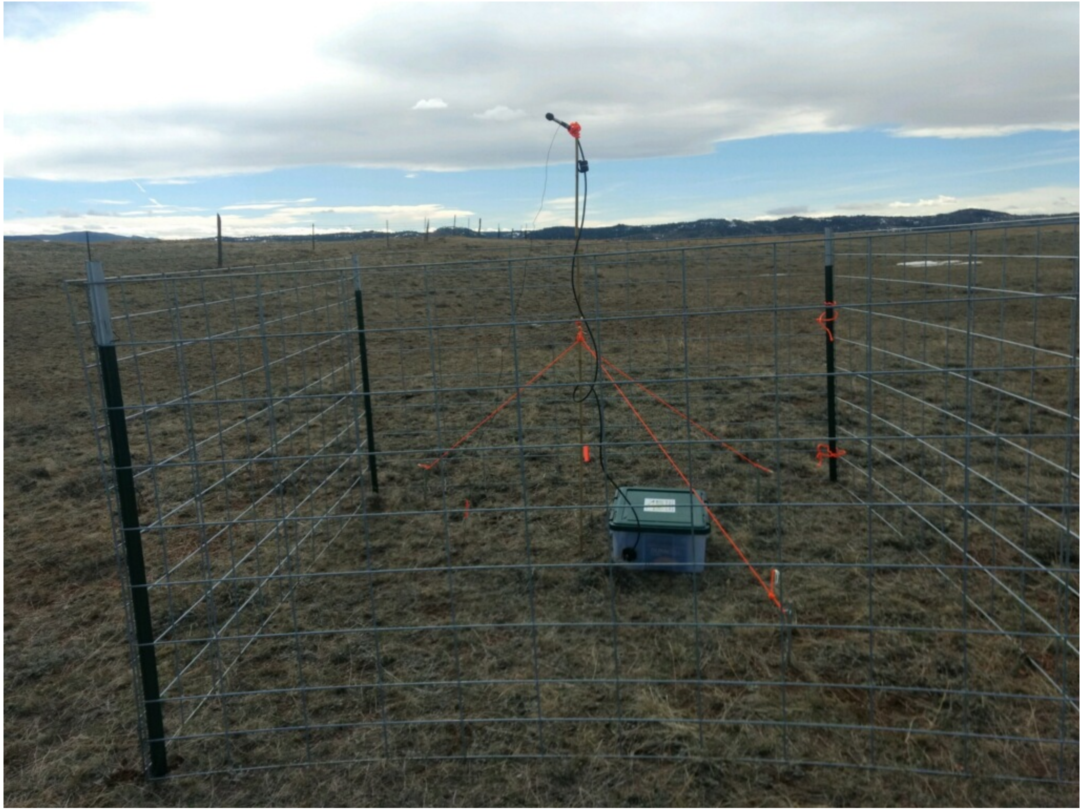


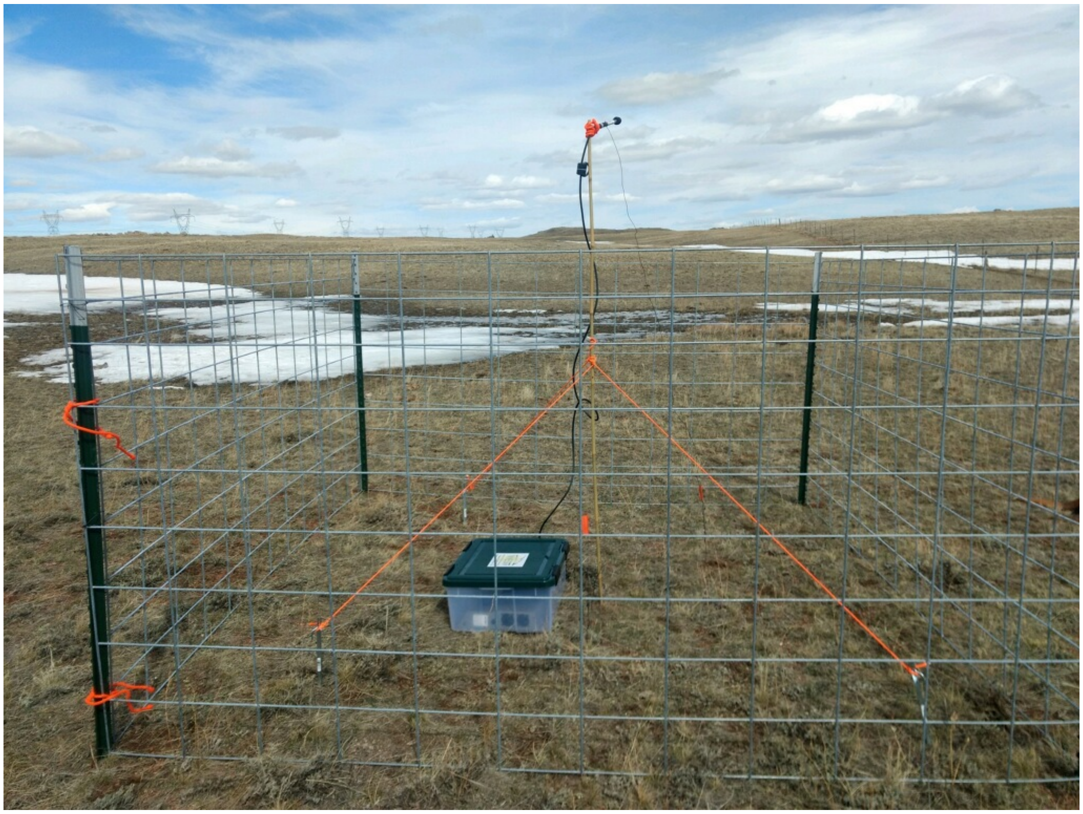
Appendix A2. Photo of the Northwestern site for North American Bat Surveys.

Appendix A3. Photo of the Southeastern site for North American Bat Surveys.

Appendix A4. Photo of the Southwestern site for North American Bat Surveys.

Appendix A5. Photo of RT1g for the Bat Activity Surveys.





Appendix A6. Photo of RT2g for Bat Activity Surveys.