TECHNICAL MEMORANDUM

Summary of Abandoned Mines as
Potential Bat Roosts at the
Proposed Tule Wind Project
San Diego, California

Submitted by:
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Introduction

Iberdrola is considering the development of a wind energy development in San Diego County, California (Figure 1). In the northwestern portion of the proposed project, several abandoned mines exist on State Lands Commission property (Figure 2). Iberdrola requested that Western EcoSystems Technology (WEST) investigate these mines for their potential as bat habitat.

Methods

WEST biologists surveyed the mines shafts externally, following protocols described in Sherwin et al. (2009). Externally, mines were examined for size and area of opening, internal condition, and depth. Where it was safe to do so, shafts were surveyed internally. One biologist remained outside the shaft while maintaining visual and vocal contact with the biologist inside. The interior of the shafts were examined for presence of bats, evidence of bat use (e.g., guano, urine staining, culled insect parts), and presence of cracks and crevices that might harbor roosting bats.

Results

The cluster of mine shafts in the southeastern section of the SLC Parcel (Figure 2) consists of 6 openings ranging from undercut schisms to straight tubular shafts. Most of the openings were of the latter type, and appeared to be have been produced as exploratory mining shafts.

Mine openings in the south section ranged from small, dirt-filled orifices to 4- by 6-ft rock openings. Two of the openings had partially back-filled openings that were approximately 2.5 ft high. Shafts were generally large enough to walk upright in, and tended to be approximately 6 ft high, 4 ft wide and approximately 30-100 ft deep.

None of the shafts showed any evidence of previous bat use. None of the shafts evidenced much potential for bat use. The back of the shafts were not deep enough to be out of the twilight zone (i.e., not completely dark), and were likely too shallow to provide suitable day-roosting roosting opportunities for bats.

Four of the six openings may be suitable for use as night-roosts (i.e., temporary resting structures), though if night-roosting occurs it apparently is not in high densities. To assess whether these structure attract or harbor large numbers of bats, one Anabat™ bat detector was placed down-slope of the majority of the openings during the period March 25 to April 7, 2010. A total of 8 bat passes were recorded during that period, 4 of which were likely produced by hoary bat (Lasiurus cinereus), a species that does not use subterranean roosts (Shump and Shump 1982). These results add support to the results of the visual surveys and suggest that bats do not use the structures.

In the northwestern portion of the SLC parcel, both vertical and horizontal shafts are present (Figure 2). Two vertical shafts and one horizontal shaft were investigated externally only. One of the vertical shafts had wood beams bracing the opening and was approximately 25 ft deep. It was partially caved-in or backfilled, and appeared to offer little potential as a bat roost. The other vertical shaft was surrounded by a fence, and the opening was covered with brush, provided no access for bats.

The horizontal shaft opening is approximately 3 ft by 6 ft. Wood beams support the opening, ceiling and walls. The shaft goes in approximately 75 ft, and then turns to the right. The opening and shaft appeared unstable, and no internal survey was attempted. Therefore, it is unclear how deep the shaft goes after the bend. Because the depth of the shaft was unknown, and the shaft otherwise appeared to have some potential as a bat roost, one Anabat bat detector was placed near the openings on April 8, 2010. The data are expected to be retrieved on April 22, 2010 and were not available at the time of this report. WEST intends to leave the Anabat detector near this location for longer-term monitoring during the 2010 survey season.

References

Sherwin, R.E., J.S. Altenbach, and D.L. Waldien. 2009. Managing abandoned mines for bats. Bat Conservation International, Austin, Texas.

Shump, K.A. and A.U. Shump. 1982. Lasiurus cinereus. Mammalian Species, 185:1-5.

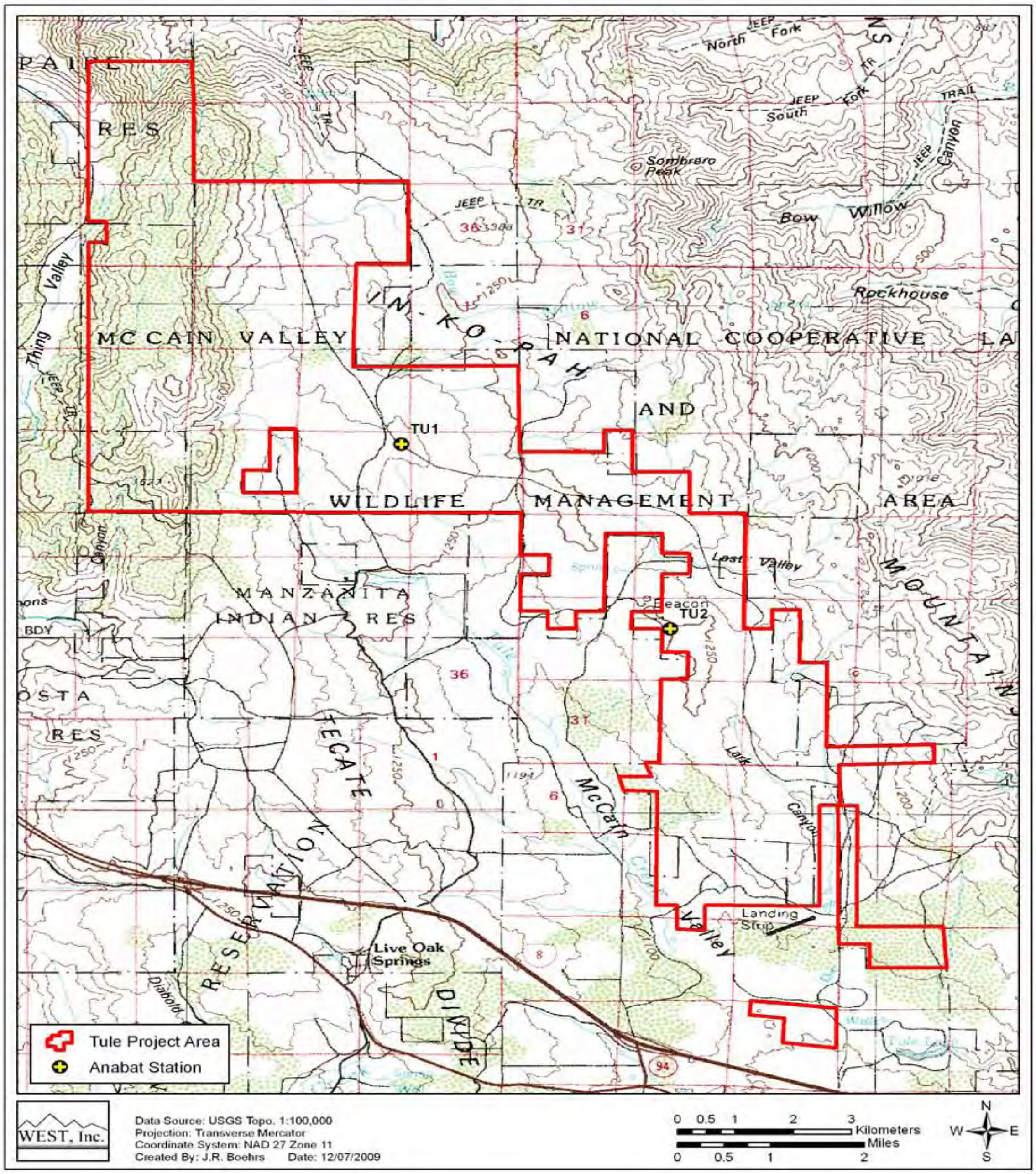

Figure 1. Study area map and Anabat sampling stations at the Tule Wind Resource Area.

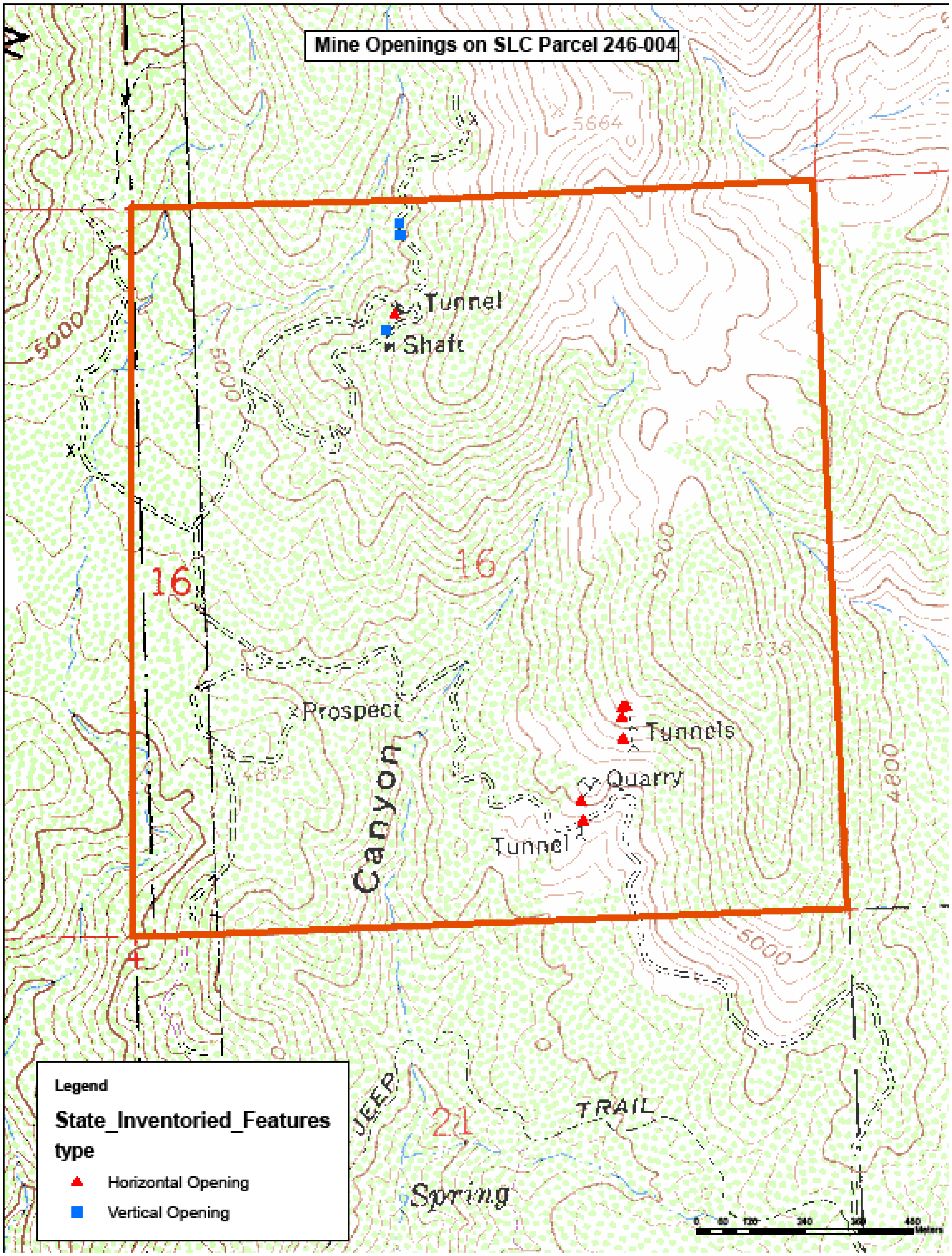

Figure 2. Location of abandoned mine openings on the State Lands Commission parcel in the proposed Tule Wind Project. This parcel is located in the northwest portion of the proposed project.

Bat Acoustic Studies for the Tule Wind Resource Area San Diego County, California

September 4th, 2008 – August 10th, 2009

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EXECUTIVE SUMMARY

Western EcoSystems Technology, Inc. initiated surveys in September 2008 designed to assess bat use within the proposed Tule Wind Resource Area, San Diego County, California. Acoustic surveys for bats using Anabat™ SD1 ultrasonic detectors at two fixed paired (ground and raised) stations were conducted from September 4, 2008 to August 10, 2009. The objective of the acoustic bat surveys was to estimate the seasonal and spatial use of the Tule Wind Resource Area by bats. A total of four Anabat units recorded 4,824 bat passes during 1,249 detector-nights. Averaging bat passes per detector-night across locations, a mean of 3.89 ± 0.36 bat passes per detector-night was recorded. The average pass rate for ground stations was 7.01 ± 0.61 bat passes per detector-night, and for raised stations was 0.77 ± 0.07 bat passes per detector-night.

The majority (71.1%) of the calls were greater than 40 kilohertz in frequency (e.g. *Myotis* species), 17.9% of the calls were less than 30 kilohertz in frequency (e.g., big brown bat, hoary bat, silver-haired bat), while 5.3% were by mid-frequency bat species (e.g. little brown bat). The remaining calls were by very low-frequency bat species (e.g. spotted bat). Activity levels for bat passes peaked in late June/early July.

The mean number of bat passes per detector-night was compared to existing data from six wind-energy facilities where both bat activity and mortality levels have been measured. The level of bat activity documented at the Tule Wind Resource Area was higher than that at wind-energy facilities in Minnesota and Wyoming, where reported bat mortalities were low, but was much lower than at facilities in the eastern US, where reported bat mortality has been highest. Assuming that a relationship between bat activity and bat mortality exists, and that it extends to the western US, relatively low levels of bat mortality would be expected to occur in the Tule Wind Resource Area, and they would most likely be highest during late June to mid-July.

Bat surveys could only be conducted at the 2 met towers that were erected at the beginning of the study. Given the size of the proposed area, results from these 2 locations may not adequately describe bat activity throughout the project area. We recommend a second season on acoustic monitoring at up to 6 additional met towers on site, and/or mobile ground-based stations. We further recommend that surveys be conducted between March 1 and November 15, as results of this study indicate that bat activity outside that period was very low.

Based solely on the bat call rates observed during this study along with fatality rates at wind-energy facilities in the western US, we expect that the potential risk to bats from turbine operations to be about the same as other western facilities. A post-construction monitoring program should be designed to accurately estimate the temporal pattern and level of bat fatalities.

STUDY PARTICIPANTS

Western EcoSystems Technology

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REPORT REFERENCE

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Iberdrola is proposing to develop a wind-energy facility in San Diego County, California. Iberdrola requested Western EcoSystems Technology, Inc. (WEST) to develop and implement a standardized protocol for baseline studies of bat use in the Tule Wind Resource Area (TWRA) for the purpose of estimating the impacts of the wind-energy facility on bats, and to assist with siting turbines to minimize impacts to bats. The protocol for this baseline study is similar to protocols used at other wind-energy facilities in the United States. The protocol has been developed based on WEST's experience studying wildlife and wind turbines at wind-energy facilities throughout the US and included passive acoustic sampling using Anabat™ bat detectors to quantify bat use in the TWRA.

The following is a report describing the results of the first year of Anabat surveys within the proposed TWRA. In addition to site-specific data, this report presents existing information and results of bat monitoring studies conducted at other wind-energy facilities. Where possible, comparisons with regional and local studies were made.

STUDY AREA

The proposed TWRA is in southeast San Diego County and includes Sections 5, 6, 7, & 8, Township 3N, Range 10E. It is approximately 4 miles (6 kilometers [km]) northwest of Live Oak Springs, California (Figure 1). The project area lies within the McCain Valley, and is flanked by the Laguna and In-Ko-Pah Mountains. Vegetation in the project is predominately chaparral-scrub. Elevation of the study area ranges from approximately 3300 to 4,400 feet (ft; 1000 to 1341 meters [m]) above sea level.

METHODS

Bat Acoustic Surveys

The objective of the bat use surveys was to estimate the seasonal and spatial use of the TWRA by bats. Bats were surveyed using Anabat™ SD1 bat detectors (Titley Scientific™, Australia). Bat detectors are a recommended method to index and compare habitat use by bats. The use of bat detectors for calculating an index to bat impacts is a primary bat risk assessment tool for baseline wind development surveys (Arnett 2007; Kunz et al. 2007*a*). Bat activity was surveyed using four detectors from September 4, 2008 to August 10, 2009. Detectors were placed near the ground at two fixed stations (Figure 1). At both of these stations, ground-based detectors were paired with detectors raised on meteorological towers to compare bat activity at different heights (ground versus raised) and monitor bat activity at heights within the eventual rotor-swept zone.

Anabat detectors record bat echolocation calls with a broadband microphone. The echolocation sounds are then translated into frequencies audible to humans by dividing the frequencies by a predetermined ratio. A division ratio of 16 was used for the study. Bat echolocation detectors also detect other ultrasonic sounds, such as those sounds made by insects, raindrops hitting vegetation, and other sources. A sensitivity level of six was used to reduce interference from these other sources of ultrasonic noise. Calls were recorded to a compact flash memory card with large storage capacity. The detection range of Anabat 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 2002), but is generally less than 98 ft (30 m) due to atmospheric absorption on echolocation pulses (Fenton 1991). To ensure similar detection ranges among detectors, microphone sensitivities were calibrated using a BatChirp (Tony Messina, Las Vegas, NV) ultrasonic emitter as described in Larson and Hayes (2000). All units were programmed to turn on each night approximately one half-hour before sunset and turn off approximately one half-hour after sunrise.

Anabat detectors were placed inside plastic weather-tight containers with a hole cut in the side of the container for the microphone to extend through. Microphones were encased in PVC tubing with drain holes that curved skyward at 45 degrees outside the container to minimize the potential for water damage due to rain. Containers were raised approximately 3.3 ft (1 m) off the ground to minimize echo interference and lift the unit above vegetation. Raised Anabat microphones were elevated 45 m (148 ft) on meteorological towers using a pulley system. Microphones were encased in a Bat-Hat weatherproof housing (EME Systems, Berkeley, California), and attached to a coaxial cable that transmitted ultrasonic sounds to an Anabat unit at the base of the tower.

Statistical Analysis

Bat Acoustic Surveys

We measured number of bat passes to index activity at this site (Hayes 1997). A pass was defined as a continuous series of two or more call notes produced by an individual bat with no pauses between call notes of more than one second (White and Gehrt 2001, Gannon et al. 2003). In this report, the terms bat pass and bat call are used interchangeably. The number of bat passes was determined by downloading the data files to a computer and tallying the number of echolocation passes recorded. Total number of passes was corrected for effort by dividing by the number of detector-nights.

For each station, bat calls were sorted into four groups, based on their minimum frequency, that correspond roughly to species groups of interest. For example, most species of *Myotis* bats echolocate at frequencies above 40 kilohertz (kHz), whereas species such as the western long-eared bat (*Myotis evotis*) and little brown bat (*Myotis lucifugus*) typically have echolocation calls that fall between 30 and 40 kHz. Species such as big brown (*Eptesicus fuscus*), silver-haired (*Lasionycteris noctivagans*), and hoary bat (*Lasiurus cinereus*), have echolocation that fall between 15 kHz and 30 kHz, and species such as the big free-tailed bat (*Nyctinomops macrotis*) and the spotted bat (*Euderma maculatum*) produce calls below 15 kHz. Therefore, we classified calls as high-frequency (HF; > 40 kHz), mid-frequency (MF; 30-40 kHz), low-frequency (LF; 15-30 kHz), and very low-frequency (VLF; <15 kHz). To establish which species may have produced calls in each category, a list of species expected to occur in the TWRA was compiled from range maps (Table 1; Harvey et al. 1999, BCI website). Data determined to be noise (produced by a source other than a bat) or call notes that did not meet the pre-specified criteria to be termed a pass were removed from the analysis.

The total number of bat passes per detector-night was used as an index for bat use in the TWRA. Bat pass data represented levels of bat activity rather than the numbers of individuals present, because individuals could not be differentiated by their calls. To assess potential for bat mortality, the mean number of bat passes per detector-night (averaged across ground-based monitoring stations) was compared to existing data from wind-energy facilities where both bat activity and mortality levels have been measured.

RESULTS

Bat Acoustic Surveys

Bat activity was monitored at four sampling locations on a total of 341 nights during the period September 4, 2008 to August 10, 2009. Anabat units were operable for 94.2% of the sampling period (Figure 2). Levels of wind and insect noise were relatively low through most of the study period, though wind-generated noise was relatively high at the elevated stations during some periods (Figure 3). Anabat units recorded 4,824 bat passes on 1,249 detector-nights (Table 2). Averaging bat passes per detector-night across locations, a mean of 3.89 ± 0.36 bat passes per detector-night was recorded. The average pass rate for ground stations was 7.01 ± 0.61 bat passes per detector-night, and for raised stations was 0.77 ± 0.07 bat passes per detector-night.

Spatial Variation

Bat activity was similar among the stations in the TWRA (Table 2; Figures 1, 4). Overall activity was slightly lower at stations TU2h and TU2g (0.74 and 6.38 bat passes per detector-night) compared to paired stations TU1h and TU1g (0.80 and 7.64, respectively). Comparing paired stations on just the nights that both ground and raised detectors were operating, nearly 90% of bat activity was recorded at the ground stations (Table 2; Figure 5).

Temporal Variation

The majority (75.7%) of bat activity occurred in two pulses during the survey period. During the minor pulse (21.5%), bat activity increased from late-February to a minor peak in activity in late April/ early May. Bat activity occurred at relatively low levels during the first half of June. An abrupt increase in activity on June 18 marks the beginning of the second, more intense pulse of bat activity in the TWRA that lasted through the end of the survey period and accounted for 54.2% of all bat activity. During the week of June 25 – July 1, over 10% of bat activity was recorded, which was the largest weekly concentration of overall bat activity detected during the survey period (Table 3, Figure 6). Weekly bat activity then declined steadily through the end of the survey period. Bat activity from September 4 – November 26, 2008 accounted for 22.3% of overall passes. Bat activity occurred at a lower baseline level over the winter months. The median number passes occurred during the week of June 11-17 (Table 3). No bat passes were recorded the week of January 1-7 and February 5-11.

We divided the survey into four seasonal periods: Fall 08 (September 4 – November 30, 2008),Winter 08/09 (December 1, 2008 – February 28, 2009), Spring 09 (March 1 – May 31, 2009), and Summer 09 (June 1 – August 10, 2009). Bat activity varied among seasons (Table 4; Figure 7). Overall activity was highest during Summer 09, averaging 9.72 bat passes per detector-night. Pass rates were relatively low during Winter 08/09 (0.33 bat passes per detector-night), with intermediate activity recorded during Fall 08 (3.25 bat passes per detector-night) and Spring 09 (2.86 bat passes per detector-night).

Temporal patterns between ground and raised stations were similar (Figure 8), and followed the overall trend. Ground stations recorded more activity than raised stations throughout the study period. The median number of passes for ground stations occurred approximately three months later than the median for raised stations.

Species Composition

Overall, passes by high-frequency bats (HF; 71.7% of all passes) outnumbered passes by mid-frequency bats (MF; 5.3%), low-frequency bats (LF; 17.9%) and very low-frequency bats (VLF; 5.1%; Table 2), and this pattern was consistent among ground stations (Table 2; Figure 2). Among raised stations, LF bats comprised 62.8% of passes, followed by VLF bats (21.8%), HF bats (13.8%), and MF bats (1.6%; Table 2; Figures 2, 5). Bat activity for HF and MF species both peaked during the week of June 25 – July 1, with 12.2% of HF bats and 15.1% of MF bats detected during this week. LF bat activity was highest during the week of April 30 – May 6, accounting for 11.0% of all LF bat passes. Peak VLF activity occurred during the week of September 18-24, 2008; just over 14% of VLF bat passes were recorded during this week (Table 3; Figure 6).

HF and MF bat activity suggested similar seasonal trends, with highest activity in the summer (8.25 and 0.54 bat passes per detector-night), followed by moderate levels of activity in fall (2.04 and 0.18) and spring (1.40 and 0.13), and low levels of activity in the winter (0.09 and 0.02 bat passes per detector-night, respectively; Table 4). Activity by LF was highest in spring (1.21 bat passes per detector-night) followed by summer (0.81), fall (0.57), and winter (0.16). VLF bats were most active during fall (0.47 bat passes per detector-night), followed by spring (0.12), summer (0.11), and winter (0.07). Activity by HF bat species was highest during all seasons except winter, when LF bat species accounted for the majority of activity.

DISCUSSION

Potential Impacts

Assessing the potential impacts of wind-energy development to bats at the TWRA is complicated by the current lack of understanding of why bats die at wind turbines (Kunz et al. 2007b, Baerwald et al. 2008), combined with the inherent difficulties of monitoring elusive, night-flying animals (O'Shea et al. 2003). In addition, because installed capacity for wind has increased rapidly in recent years, the availability of well-designed studies from existing projects lags development of proposed projects (Kunz et al. 2007b). To date, monitoring studies of wind-energy facilities suggest that:

a) bat fatalities show a rough correlation with bat activity (Table 4);

b) the majority of fatalities occur during the post-breeding or fall migration season (roughly August and September);

c) migratory tree-roosting species (eastern red, hoary, and silver-haired bats) comprise almost 75% of reported bat fatalities, and;

d) the highest reported fatalities occur at wind-energy facilities located along forested ridge tops in the eastern and northeastern US. However, recent studies in agricultural regions of Iowa and Alberta, Canada, report relatively high fatalities as well (Table 4).

Based on these patterns, current guidance to estimate potential mortality levels at a proposed wind-energy facility involves evaluation of the on-site bat acoustic data in terms of activity levels, seasonal variation, and species composition (Kunz et al. 2007*b*), as well as comparison to regional patterns.

Overall Activity

To date, six studies of wind-energy facilities have recorded both Anabat detections per night and bat mortality (Table 4), and these measured bat activity concurrently with fatality studies. While these studies show correlation between activity and fatalities, the expectation amongst the scientific and resource management communities is that a similar relationship holds for pre-construction activity and post-construction fatalities. The addition of data sets like this one will contribute to understanding of the relationship between bat activity near wind turbines and bat fatalities. To our knowledge, data for these studies were collected using Anabat detectors placed near the ground (i.e., none raised on met towers), and none of the detectors were located near features attractive to bats. Thus, this report relies on the mean activity rate for ground-based detectors placed near met towers to assess potential risk of bat fatality at the TWRA relative to the six studies with similar data.

Bat activity recorded by ground detectors within the TWRA (mean±SE = 7.01±0.61 bat passes per detector-night) was relatively high compared to that observed at facilities in Minnesota and Wyoming, where bat mortality was low, but was much lower than activity recorded at sites in West Virginia, Iowa, and Tennessee, where bat mortality rates were high (Table 3). Thus, based solely on the expected relationship between pre-construction bat activity and post-construction fatalities, bat mortality rates at the TWRA would be expected to be greater than the 2.4 bat fatalities/MW/year reported at Buffalo Ridge Minnesota, but much lower than the 31.5 fatalities/MW/year reported at Buffalo Mountain, Tennessee. However, we caution that the since the relationship between activity and fatality is based on projects in the midwest and eastern parts North America, it may not accurately predict the relationship in the American southwest, where species richness and abundance differ from other regions. In this case, fatalities from other wind-energy facilities in the same region may better predict fatality levels. We address regional fatality levels below.

Spatial Variation

The proposed wind-energy facility is not located near any large, known bat colonies or other features that are likely to attract large numbers of bats. Activity was evenly split between station TU1 and TU2. Bat activity was uniformly high among the ground stations. The raised units recorded about 10% of passes, suggesting generally lower bat activity at heights near the bottom of the proposed rotor swept area.

Temporal Variation

The number of bat calls detected per night at the TWRA was relatively high during late June and early July. This activity likely corresponds with the end of the reproductive season, when pups are being weaned and foraging rates are high. Spring and fall increases in activity likely represent normal seasonal movements of bats into and through the area. Fall activity may represent movement of migrating bats through the area, which may explain the greater number of LF and VLF bat passes at this time. After mid-November, activity was very low, indicating that most bats had either left the area for winter. Bats that remained in the study area appear to have curtailed their activity in response to seasonal changes in temperature, day length, etc.

Fatality studies of bats at wind projects in the US have shown a peak in mortality in August and September and generally lower mortality earlier in the summer (Johnson 2005; Arnett et al. 2008). While the survey effort varies among the different studies, the studies that combine Anabat surveys and fatality surveys show a general association between the timing of increased bat call rates and timing of mortality, with both call rates and mortality peaking during the fall. Based on the available data, it is expected that bat mortality at the TWRA will be highest in late June.

Species Composition

Of the 21 species of bat likely to occur in the TWRA, nine are known fatalities at wind-energy facilities (Table 1). Acoustic bat surveys were able to classify bat calls to frequency groups that correspond roughly with groups of relative risk. Approximately 71% of passes were by high-frequency bats, suggesting higher relative abundance of species such as *Myotis* species, canyon bats and western red bats.

At raised stations, LF passes outnumbered HF passes, which may reflect different foraging behaviors among species. Generally, LF species tend to forage in less cluttered conditions (e.g., at greater heights) than HF species due to their wing morphology and echolocation call structure (Norberg and Rayner 1987). To date, some LF species, (e.g., hoary, Mexican free-tailed and silver-haired bats) have been found as fatalities in higher proportions than other LF species (e.g., Arnett et al. 2008). Hoary bats in particular have comprised approximately 75% of fatalities recovered during studies at wind farms, though none of those studies were from the American southwest. Though relatively few studies are available from within the range of the Mexican free-tailed bat, they have comprised the majority of bat fatalities found during searches at a some sites (e.g., Piorkowski 2006, Tierney 2007), and as they are a swift, high flying species (Wilkins 1989), they may be at relatively high risk from encounters with turbine blades range-wide.

Bat activity at the two stations was highest during the summer (June – August), and the activity was predominately from HF species (Figure 6). Passes by MF species were also at their highest levels in early summer. Activity levels by LF species was similar across the fall, spring and summer, but were relatively more common in spring. Passes from VLF species were detected at low levels during the year, but were more common than LF species in late September and early October. Assuming that the activity levels reflect relative abundance of species groups, then MF and VLF species appear either to occur at relatively low levels during the year, or are transient in the project area and more common during particular seasons. Species in the HF and LF groups appear to be relatively abundant throughout the year (excepting winter), with LF species passes outnumbering HF passes in fall and spring, suggesting movement of these species through the area during those times.

Regional Fatality Studies

Bat mortality studies at wind-energy facilities across North America show a wide range of bat mortality rates, ranging from zero to 39.70 bat fatalities/MW/year (Table 4). In general, fatality rates have been highest in the Northeast and lowest in the Northwest, although a high degree of variation in fatality rates is present for most regions. To date, no fatality data have been made public for the Southwest or Southeast regions. Based solely on comparisons with other fatality surveys in the Western region, fatalities at the TWRA could range between 0.07 and 2.47 bat fatalities/MW/year, however there is much uncertainty surrounding that estimate. A post-construction fatality monitoring study should be designed to accurately estimate bat fatality rates.

REFERENCES

Arnett, E. 2007. Report from BWEC on Collaborative Work & Plans. Presentation at the NWCC Wildlife Workgroup Meeting, Boulder Colorado. November 14th, 2007. Conservation International. Information at www.nationwind.org.

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

Arnett, E.B., W.K. Brown, W.P. Erickson, J.K. Fieldler, B.L. Hamilton, T.H. Henry, A. Jain, G.D. Johnson, J. Kerns, R.R. Koford, C.P. Nicholson, T.J. O'Connell, M.D. Piorkowski, and R.D. 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., M.R. Schirmacher, M.M.P. Huso, and J.P. Hayes. 2009. Patterns of Bat Fatality at the Casselman Wind Project in South-Central Pennsylvania. Annual Report Prepared for the Bats and Wind Energy Cooperative (BWEC) and the Pennsylvania Game Commission. June 2009. http://www.batsandwind.org/pdf/2008%20Casselman%20Fatality%20Report.pdf

Baerwald, E.F. 2008. Variation in the Activity and Fatality of Migratory Bats at Wind Energy Facilities in Southern Alberta: Causes and Consequences. Thesis. University of Calgary, Calgary, Alberta, Canada.

Baerwald, E.F., G.H. D'Amours, B.J. Klug, and R.M.R. Barclay. 2008. Barotrauma is a significant cause of bat fatalities at wind turbines. Current Biology 18(16): R695-R696.

Bat Conservation International, Inc. (BCI). 2002. Bat Species: US Bats. Bat Conservation International, Inc., Austin, Texas. www.batcon.org.

Brown, W.K. and B.L. Hamilton. 2006. Monitoring of Bird and Bat Collisions with Wind Turbines at the Summerview Wind Power Project, Alberta: 2005-2006. Prepared for Vision Quest Windelectric, Calgary, Alberta by TEAM Ltd., Calgary, Alberta, and BLH Environmental Services, Pincher Creek, Alberta. September 2006. http://www.batsandwind.org/pdf/Brown2006.pdf

Burba, E.A., G.D. Schnell, and J.A. Grzybowski. 2008. Post-Construction Avian/Bat Fatality Study for the Blue Canyon II Wind Power Project, Oklahoma: Summary of Preliminary Findings for 2006-2007. Interim Report to Horizon Wind Energy. Sam Noble Oklahoma Museum of Natural History, University of Oklahoma, Norman, Oklahoma. August 2004.

Derby, C., A. Dahl, W. Erickson, K. Bay, and J. Hoban. 2007. Post-Construction Monitoring Report for Avian and Bat Mortality at the NPPD Ainsworth Wind Farm. Unpublished report prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, for the Nebraska Public Power District.

Erickson, W.P., G.D. Johnson, M.D. Strickland, and K. Kronner. 2000. Avian and Bat Mortality Associated with the Vansycle Wind Project, Umatilla County, Oregon: 1999 Study Year. Technical report prepared by WEST, Inc. for Umatilla County Department of Resource Services and Development, Pendleton, Oregon. 21pp.

Erickson, W.P., K. Kronner, and B. Gritski. 2003. Nine Canyon Wind Power Project Avian and Bat Monitoring Report. September 2002 - August 2003. Prepared for the Nine Canyon Technical Advisory Committee and Energy Northwest by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, and Northwest Wildlife Consultants (NWC), Pendleton, Oregon. October 2003. http://www.west-inc.com/reports/nine_canyon_monitoring_final.pdf

Erickson, W.P., J. Jeffrey, K. Kronner, and K. Bay. 2004. Stateline Wind Project Wildlife Monitoring Final Report: July 2001 - December 2003. Technical report for and peer-reviewed by FPL Energy, Stateline Technical Advisory Committee, and the Oregon Energy Facility Siting Council, by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, and Walla Walla, Washington, and Northwest Wildlife Consultants (NWC), Pendleton, Oregon. December 2004. http://www.west-inc.com

Erickson, W.P., J.D. Jeffrey, and V.K. Poulton. 2008. Puget Sound Energy, Wild Horse Wind Facility, Post-Construction Avian and Bat Monitoring. First Annual Report: January - December 2007. Prepared for Puget Sound Energy, Ellensburg, Washington, and the Wild Horse Wind Facility Technical Advisory Committee, Kittitas County, Washington. Prepared by Western EcoSystems Technology Inc. (WEST), Cheyenne, Wyoming. January 2008.

Fiedler, J.K. 2004. Assessment of Bat Mortality and Activity at Buffalo Mountain Windfarm, Eastern Tennessee. M.S. Thesis. University of Tennessee, Knoxville, Tennessee. August, 2004. http://www.tva.gov/environment/bmw_report/bat_mortality_bmw.pdf

Fiedler, J.K., T.H. Henry, C.P. Nicholson, and R.D. Tankersley. 2007. Results of Bat and Bird Mortality Monitoring at the Expanded Buffalo Mountain Windfarm, 2005. Tennessee Valley Authority, Knoxville, Tennessee. https://www.tva.gov/environment/bmw_report/results.pdf

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.

Harvey, M.J., J.S. Altenbach, and T.L. Best. 1999. Bats of the United States. Arkansas Game & Fish Commission and US Fish and Wildlife Service, Arkansas.

Hayes, J.P. 1997. Temporal Variation in Activity of Bats and the Design of Echolocation-Monitoring Studies. Journal of Mammalogy 78: 514-524.

Jain, A. 2005. Bird and Bat Behavior and Mortality at a Northern Iowa Windfarm. M.S. Thesis. Iowa State University, Ames, Iowa.

Jain, A., P. Kerlinger, R. Curry, and L. Slobodnik. 2007. Annual Report for the Maple Ridge Wind Power Project: Post-Construction Bird and Bat Fatality Study - 2006. Final Report. Prepared for PPM Energy and Horizon Energy and Technical Advisory Committee (TAC) for the Maple Ridge Project Study.

Jain, A., P. Kerlinger, R. Curry, and L. Slobodnik. 2008. Annual Report for the Maple Ridge Wind Power Project: Post-Construction Bird and Bat Fatality Study - 2007. Final report prepared for PPM Energy and Horizon Energy and Technical Advisory Committee (TAC) for the Maple Ridge Project Study.

Jain, A., P. Kerlinger, R. Curry, L. Slobodnik, A. Fuerst, and C. Hansen. 2009a. Annual Report for the Noble Ellenburg Windpark, LLC, Postconstruction Bird and Bat Fatality Study - 2008. Prepared for Noble Environmental Power, LLC by Curry and Kerlinger, LLC. April 13, 2009.

Jain, A., P. Kerlinger, R. Curry, L. Slobodnik, J. Histed, and J. Meacham. 2009b. Annual Report for the Noble Clinton Windpark, LLC, Postconstruction Bird and Bat Fatality Study - 2008. Prepared for Noble Environmental Power, LLC by Curry and Kerlinger, LLC. April 13, 2009.

Jain, A., P. Kerlinger, R. Curry, L. Slobodnik, and M. Lehman. 2009c. Maple Ridge Wind Power Avian and Bat Fatality Study Report - 2008. Annual Report for the Maple Ridge Wind Power Project, Post-construction Bird and Bat Fatality Study - 2008. Prepared for Iberdrola Renewables, Inc, Horizon Energy, and the Technical Advisory Committee (TAC) for the Maple Ridge Project Study. Prepared by Curry and Kerlinger, LLC. May 14, 2009.

Jain, A., P. Kerlinger, R. Curry, L. Slobodnik, J. Quant, and D. Pursell. 2009d. Annual Report for the Noble Bliss Windpark, LLC, Postconstruction Bird and Bat Fatality Study - 2008. Prepared for Noble Environmental Power, LLC by Curry and Kerlinger, LLC. April 13, 2009.

James, R.D. 2008. Erie Shores Wind Farm Port Burwell, Ontario: Fieldwork Report for 2006 and 2007 During the First Two Years of Operation. Report to Environment Canada, Ontario Ministry of Natural Resources, Erie Shores Wind Farm LP - McQuarrie North American and AIM PowerGen Corporation. January 2008.

Johnson, G.D. 2005. A Review of Bat Mortality at Wind-Energy Developments in the United States. Bat Research News 46(2): 45-49.

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: 1278-1288.

Johnson, G.D., W.P. Erickson, and J. White. 2003. Avian and Bat Mortality During the First Year of Operation at the Klondike Phase I Wind Project, Sherman County, Oregon. March 2003. Technical report prepared for Northwestern Wind Power, Goldendale, Washington, by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. http://www.west-inc.com

Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd, and D.A. Shepherd. 2000. Avian Monitoring Studies at the Buffalo Ridge Wind Resource Area, Minnesota: Results of a 4-Year Study. Final report prepared for Northern States Power Company, Minneapolis, Minnesota, by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. September 22, 2000. 212 pp. http://www.west-inc.com

Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd, D.A. Shepherd, and S.A. Sarappo. 2003. Mortality of Bats at a Large-Scale Wind Power Development at Buffalo Ridge, Minnesota. The American Midland Naturalist 150: 332-342.

Kerlinger, P. 2002. An Assessment of the Impacts of Green Mountain Power Corporation's Wind Power Facility on Breeding and Migrating Birds in Searsburg, Vermont: July 1996-July 1998. NREL/SR-500-28591. Prepared for Vermont Public Service, Montpelier, Vermont. US Department of Energy, National Renewable Energy Laboratory, Golden, Colorado. March 2002. 95 pp. http://www.nrel.gov/docs/fy02osti/28591.pdf

Kerlinger, P., R. Curry, L. Culp, A. Jain, C. Wilkerson, B. Fischer, and A. Hasch. 2006. Post-Construction Avian and Bat Fatality Monitoring for the High Winds Wind Power Project, Solano County, California: Two Year Report. Prepared for High Winds LLC, FPL Energy by Curry and Kerlinger, LLC. April 2006.

Kerlinger, P., R. Curry, A. Hasch, and J. Guarnaccia. 2007. Migratory Bird and Bat Monitoring Study at the Crescent Ridge Wind Power Project, Bureau County, Illinois: September 2005 - August 2006. Final draft prepared for Orrick Herrington and Sutcliffe, LLP. May 2007.

Kerns, J. and P. Kerlinger. 2004. A Study of Bird and Bat Collisions at the Mountaineer Wind Energy Facility, Tucker County, West Virginia: Annual Report for 2003. Prepared for FPL Energy and the Mountaineer Wind Energy Center Technical Review Committee. February 14, 2004. Technical report prepared by Curry and Kerlinger, LLC., for FPL Energy and Mountaineer Wind Energy Center Technical Review Committee. Curry and Kerlinger, LLC. 39 pp. http://www.wvhighlands.org/Birds/MountaineerFinalAvianRpt-%203-15-04PKJK.pdf

Kronner, K., B. Gritski, and S. Downes. 2008. Big Horn Wind Power Project Wildlife Fatality Monitoring Study: 2006?2007. Final report prepared for PPM Energy and the Big Horn Wind Project Technical Advisory Committee by Northwest Wildlife Consultants, Inc. (NWC), Mid-Columbia Field Office, Goldendale, Washington. June 1, 2008.

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, 71:2449-2486.

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 5:315-324.

Nicholson, C.P., J. R.D. Tankersley, J.K. Fiedler, and N.S. Nicholas. 2005. Assessment and Prediction of Bird and Bat Mortality at Wind Energy Facilities in the Southeastern United States. Final Report. Tennesee Valley Authority, Knoxville, Tennessee.

Norberg, U.M. and J.M.V. Rayner. 1987. Ecological Morphology and Flight in Bats (Mammalia: Chiroptera): Wing Adaptations, Flight Performance, Foraging Strategy and Echolocation. Philosophical Transactions of the Royal Society of London B 316:335-427.

Northwest Wildlife Consultants, Inc. (NWC) and Western EcoSystems Technology, Inc. (WEST). 2007. Avian and Bat Monitoring Report for the Klondike II Wind Power Project. Sherman County, Oregon. Prepared for PPM Energy, Portland, Oregon. Managed and conducted by NWC, Pendleton, Oregon. Analysis conducted by WEST, Cheyenne, Wyoming. July 17, 2007.

O'Shea, T.J., M.A. Bogan, and L.E. Ellison. 2003. Monitoring Trends in Bat Populations of the United States and Territories: Status of the Science and Recommendations for the Future. Wildlife Society Bulletin 31:16-29.

Piorkowski, M.D. 2006. Breeding Bird Habitat Use and Turbine Collisions of Birds and Bats Located at a Wind Farm in Oklahoma Mixed-Grass Prairie. M.S. Thesis. Oklahoma State University, Stillwater, Oklahoma. 112 pp. July 2006. http://www.batsandwind.org/pdf/Piorkowski_2006.pdf

Stantec Consulting Inc. (Stantec). 2008. 2007 Spring, Summer, and Fall Post-Construction Bird and Bat Mortality Study at the Mars Hill Wind Farm, Maine. Prepared for UPC Wind Management, LLC, Cumberland, Maine, by Stantec Consulting, formerly Woodlot Alternatives, Inc., Topsham, Maine. January, 2008.

Stantec Consulting Inc. (Stantec). 2009a. Post-Construction Monitoring at the Mars Hill Wind Farm, Maine - Year 2, 2008. Prepared for First Wind Management, LLC, Portland, Maine. Prepared by Stantec Consulting, Topsham, Maine. January 2009.

Tierney, R. 2007. Buffalo Gap I Wind Farm Avian Mortality Study: February 2006-January 2007. Final Survey Report. Prepared for AES SeaWest, Inc. TRC, Albuquerque, New Mexico.TRC Report No. 110766-C-01. May 2007.

TRC Environmental Corporation. 2008. Post-Construction Avian and Bat Fatality Monitoring and Grassland Bird Displacement Surveys at the Judith Gap Wind Energy Project, Wheatland County, Montana. Prepared for Judith Gap Energy, LLC, Chicago, Illinois. TRC Environmental Corporation, Laramie, Wyoming. TRC Project 51883-01 (112416). January 2008. http://www.newwest.net/pdfs/AvianBatFatalityMonitoring.pdf

URS, W.P. Erickson, and L. Sharp. 2005. Phase 1 and Phase 1A Avian Mortality Monitoring Report for 2004-2005 for the SMUD Solano Wind Project. Prepared for Sacramento Municipal Utility District (SMUD), Sacramento, California. Co-Authors: Wally Erickson, Western EcoSystems Technology, Inc. (WEST) and Lynn Sharp, Environmental Consultant. August 2005.

White, E.P. and S.D. Gehrt. 2001. Effects of Recording Media on Echolocation Data from Broadband Bat Detectors. Wildlife Society Bulletin 29: 974-978.

Wilkins, K. Tadarida brasiliensis. American Society of Mammalogists, Mammalian Species 331:1-10.

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, San Diego 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.

Young, D.P. Jr., J. Jeffrey, W.P. Erickson, K. Bay, and V.K. Poulton. 2006. Eurus Combine Hills Turbine Ranch. Phase 1 Post Construction Wildlife Monitoring First Annual Report. Technical report prepared for Eurus Energy America Corporation, San Diego, California, and the Combine Hills Technical Advisory Committee, Umatilla County, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, and Northwest Wildlife Consultants, Inc. (NWC), Pendleton, Oregon.

Young, D.P. Jr., W.P. Erickson, J. Jeffrey, and V.K. Poulton. 2007. Puget Sound Energy Hopkins Ridge Wind Project Phase 1 Post-Construction Avian and Bat Monitoring First Annual Report, January - December 2006. Technical report for Puget Sound Energy, Dayton, Washington and Hopkins Ridge Wind Project Technical Advisory Committee, Columbia County, Washington. Western EcoSystems Technology, Inc. (WEST) Cheyenne, Wyoming, and Walla Walla, Washington. 25 pp.

Young, D.P. Jr., W.P. Erickson, K. Bay, S. Nomani, and W. Tidhar. 2009. Mount Storm Wind Energy Facility, Phase 1 Post-Construction Avian and Bat Monitoring, July - October 2008. Prepared for NedPower Mount Storm, LLC, Houston, Texas, by Western EcoSystems Technology (WEST), Inc., Cheyenne, Wyoming.

Table 1. Bat species determined from range-maps (BCI website; Harvey et al. 1999) as likely to occur within the Tule Wind Resource Area, sorted by call frequency.

Common Name	Scientific Name
High-frequency (> 35 kHz)	
western red bat[1,3]	*Lasiurus blossevillii*
California leaf-nosed bat	*Macrotus californicus*
ghost-faced bat	*Mormoops megalophylla*
California bat	*Myotis californicus*
western small-footed bat	*Myotis ciliolabrum*
long-legged bat[3]	*Myotis volans*
Yuma bat	*Myotis yumanensis*
canyon bat[3]	*Parastrellus hesperus*
Mid-frequency (30-40 kHz)	
western yellow bat[3]	*Lasiurus xanthinus*
western long-eared bat	*Myotis evotis*
little brown bat[2,3]	*Myotis lucifugus*
Low-frequency (15-30 kHz)	
pallid bat	*Antrozous pallidus*
Townsend's big-eared bat	*Corynorhinus townsendii*
silver-haired bat[1,3]	*Lasionycteris noctivagans*
hoary bat[1,3]	*Lasiurus cinereus*
fringed bat	*Myotis thysanodes*
pocketed free-tailed bat	*Nyctinomops femorosaccus*
Brazilian free-tailed bat[3]	*Tadarida brasiliensis*
Very low-frequency (< 15 kHz)	
spotted bat[2]	*Euderma maculatum*
western mastiff bat	*Eumops perotis californicus*
big free-tailed bat[3]	*Nyctinomops macrotis*

1 = long-distance migrant;
2 = species distribution on edge or just outside project area;
3 = known casualty from wind turbines;
*= Federally listed species

Table 2. Results of acoustic bat surveys conducted at the Tule Wind Resource Area, September 4, 2008 – August 10, 2009.

Anabat Station	Location	# of HF Bat Passes	# of MF Bat Passes	# of LF Bat Passes	# of VLF Bat Passes	Total Bat Passes	Detector-Nights	Bat Passes/ Night
TU1g	ground	1,917	117	323	71	2,428	318	7.64±0.84
TU1h	raised	31	2	155	46	234	291	0.80±0.10
TU2g	ground	1,473	132	235	69	1,909	299	6.38±0.61
TU2h	raised	36	6	151	60	253	341	0.74±0.11
Total Ground		**3,390**	**249**	**558**	**140**	**4,337**	**617**	**7.01±0.61**
Total Raised		**67**	**8**	**306**	**106**	**487**	**632**	**0.77±0.07**
Grand Total		**3,457**	**257**	**864**	**246**	**4,824**	**1,249**	**3.89±0.36**

Table 3. Weekly bat activity and the contribution of each week (%) to total recorded activity for high-frequency (HF), mid-frequency (MF), low-frequency (LF), very low-frequency (VLF), and all bats within the Tule Wind Resource Area.

Week	HF Pass Rate	HF % Comp	MF Pass Rate	MF % Comp	LF Pass Rate	LF % Comp	VLF Pass Rate	VLF % Comp	All Bats Pass Rate	All Bats % Comp	Cumulative % Comp
09/04/08 to 09/10/08	3.62	2.7	0.33	3.5	0.38	1.1	0.24	2.5	4.57	2.5	2.5
09/11/08 to 09/17/08	3.48	2.6	0.19	2.0	1.48	4.5	0.57	6.1	5.71	3.1	5.6
09/18/08 to 09/24/08	2.86	2.2	0.21	2.2	0.75	2.3	1.32	14.1	5.14	2.8	8.4
09/25/08 to 10/01/08	5.75	4.3	0.29	3.0	0.50	1.5	1.11	11.8	7.64	4.1	12.5
10/02/08 to 10/08/08	1.89	1.4	0.21	2.2	0.61	1.8	0.50	5.3	3.21	1.7	14.3
10/09/08 to 10/15/08	0.62	0.5	0.19	2.0	0.33	1.0	0.10	1.0	1.24	0.7	14.9
10/16/08 to 10/22/08	1.54	1.2	0.21	2.2	1.18	3.6	0.14	1.5	3.07	1.7	16.6
10/23/08 to 10/29/08	2.46	1.9	0.21	2.2	1.57	4.7	1.00	10.7	5.25	2.8	19.4
10/30/08 to 11/05/08	0.54	0.4	0.07	0.7	0.14	0.4	0.21	2.3	0.96	0.5	19.9
11/06/08 to 11/12/08	0.21	0.2	0.04	0.4	0	0	0.21	2.3	0.46	0.2	20.2
11/13/08 to 11/19/08	2.68	2.0	0.25	2.6	0.14	0.4	0.11	1.1	3.18	1.7	21.9
11/20/08 to 11/26/08	0.39	0.3	0.04	0.4	0.18	0.5	0.25	2.7	0.86	0.5	22.4
11/27/08 to 12/03/08	0.11	<0.1	0.04	0.4	0	0	0.04	0.4	0.18	0.1	22.5
12/04/08 to 12/10/08	0.04	<0.1	0	0	0.07	0.2	0.04	0.4	0.14	<0.1	22.6
12/11/08 to 12/17/08	0.11	<0.1	0	0	0.04	0.1	0.04	0.4	0.18	0.1	22.7
12/18/08 to 12/24/08	0	0	0.04	0.4	0.18	0.5	0	0	0.21	0.1	22.8
12/25/08 to 12/31/08	0.07	<0.1	0.04	0.4	0	0	0.07	0.8	0.18	0.1	22.9
01/01/09 to 01/07/09	0	0	0	0	0	0	0	0	0	0	22.9
01/08/09 to 01/14/09	0.04	<0.1	0.04	0.4	0.14	0.4	0	0	0.21	0.1	23.0
01/15/09 to 01/21/09	0.11	<0.1	0.04	0.4	0.21	0.6	0.04	0.4	0.39	0.2	23.2
01/22/09 to 01/28/09	0	0	0	0	0.09	0.3	0.23	2.4	0.32	0.2	23.4
01/29/09 to 02/04/09	0	0	0	0	0.62	1.9	0.19	2.0	0.81	0.4	23.8
02/05/09 to 02/11/09	0	0	0	0	0	0	0	0	0	0	23.8
02/12/09 to 02/18/09	0	0	0	0	0.07	0.2	0	0	0.07	<0.1	23.9
02/19/09 to 02/25/09	0.55	0.4	0.05	0.5	0.55	1.7	0.20	2.1	1.35	0.7	24.6
02/26/09 to 03/04/09	0.67	0.5	0.04	0.4	0.25	0.8	0.08	0.9	1.04	0.6	25.1
03/05/09 to 03/11/09	0	0	0.04	0.4	0.29	0.9	0.07	0.8	0.39	0.2	25.4

Table 3. Weekly bat activity and the contribution of each week (%) to total recorded activity for high-frequency (HF), mid-frequency (MF), low-frequency (LF), very low-frequency (VLF), and all bats within the Tule Wind Resource Area.

Week	HF Pass Rate	HF % Comp	MF Pass Rate	MF % Comp	LF Pass Rate	LF % Comp	VLF Pass Rate	VLF % Comp	All Bats Pass Rate	All Bats % Comp	Cumulative % Comp
03/12/09 to 03/18/09	3.00	2.3	0	0	0.61	1.8	0.25	2.7	3.86	2.1	27.4
03/19/09 to 03/25/09	0.32	0.2	0	0	1.05	3.2	0.14	1.5	1.50	0.8	28.3
03/26/09 to 04/01/09	1.62	1.2	0.05	0.5	1.14	3.5	0.29	3.1	3.10	1.7	29.9
04/02/09 to 04/08/09	0.19	0.1	0.05	0.5	0.62	1.9	0	0	0.86	0.5	30.4
04/09/09 to 04/15/09	0.19	0.1	0	0	0.22	0.7	0.04	0.4	0.44	0.2	30.6
04/16/09 to 04/22/09	2.50	1.9	0.18	1.8	1.43	4.3	0.07	0.8	4.18	2.3	32.9
04/23/09 to 04/29/09	0.46	0.4	0.07	0.7	1.68	5.1	0.04	0.4	2.25	1.2	34.1
04/30/09 to 05/06/09	1.36	1.0	0.21	2.2	3.64	11.0	0.25	2.7	5.46	3.0	37.1
05/07/09 to 05/13/09	2.09	1.6	0.32	3.3	1.77	5.3	0.14	1.5	4.32	2.3	39.4
05/14/09 to 05/20/09	2.38	1.8	0.19	2.0	0.43	1.3	0	0	3.00	1.6	41.0
05/21/09 to 05/27/09	2.61	2.0	0.32	3.3	1.96	5.9	0.29	3.1	5.18	2.8	43.9
05/28/09 to 06/03/09	1.46	1.1	0.39	4.1	0.89	2.7	0	0	2.75	1.5	45.3
06/04/09 to 06/10/09	0.04	<0.1	0.04	0.4	0.11	0.3	0	0	0.18	0.1	45.4
06/11/09 to 06/17/09	0.29	0.2	0.07	0.7	0.25	0.8	0	0	0.61	0.3	45.8
06/18/09 to 06/24/09	8.43	6.4	0.25	2.6	1.54	4.6	0	0	10.21	5.5	51.3
06/25/09 to 07/01/09	16.18	12.2	1.46	15.1	2.29	6.9	0	0	19.93	10.8	62.1
07/02/09 to 07/08/09	8.29	6.3	0.82	8.5	1.00	3.0	0.11	1.1	10.21	5.5	67.6
07/09/09 to 07/15/09	15.11	11.4	0.86	8.9	1.00	3.0	0.18	1.9	17.14	9.3	76.9
07/16/09 to 07/22/09	6.90	5.2	0.29	3.0	0.38	1.1	0.10	1.0	7.67	4.2	81.1
07/23/09 to 07/29/09	6.29	4.8	0.64	6.7	0.82	2.5	0.39	4.2	8.14	4.4	85.5
07/30/09 to 08/05/09	12.86	9.7	0.61	6.3	0.32	1.0	0.29	3.1	14.07	7.6	93.1
08/06/09 to 08/10/09	12.15	9.2	0.30	3.1	0.20	0.6	0.05	0.5	12.70	6.9	100

Table 4. Seasonal passage rates by station, sorted by high-frequency (HF), mid-frequency (MF), low-frequency (LF) very low-frequency (VLF), and all bats (AB) within the Tule Wind Resource Area.

Station	Call	9/4/2008 to 11/30/2008	12/1/2008 to 2/28/2009	3/1/2009 to 5/31/2009	6/1/2009 to 8/10/2009	Totals
TU1g	VLF	0.53	0.11	0.14	0.08	**0.22**
TU1g	LF	0.66	0.33	2.41	0.73	**1.02**
TU1g	Mid	0.39	0.03	0.22	1.00	**0.37**
TU1g	HF	4.08	0.18	3.44	20.03	**6.03**
TU1g	AB	5.66	0.66	6.20	21.84	**7.64**
TU1h	VLF	0.44	0.02	0.03	0.08	**0.16**
TU1h	LF	0.71	0.11	0.77	0.48	**0.53**
TU1h	Mid	0	0	0	0.03	**0.01**
TU1h	HF	0.06	0	0.04	0.32	**0.11**
TU1h	AB	1.21	0.12	0.84	0.92	**0.80**
TU2g	VLF	0.39	0.10	0.23	0.18	**0.23**
TU2g	LF	0.54	0.11	1.16	1.14	**0.79**
TU2g	Mid	0.34	0.05	0.27	1.11	**0.44**
TU2g	HF	4.15	0.18	1.97	13.72	**4.93**
TU2g	AB	5.42	0.44	3.63	16.15	**6.38**
TU2h	VLF	0.50	0.04	0.07	0.08	**0.18**
TU2h	LF	0.36	0.06	0.58	0.86	**0.44**
TU2h	Mid	0.01	0	0	0.07	**0.02**
TU2h	HF	0.18	0	0.10	0.15	**0.11**
TU2h	AB	1.06	0.10	0.74	1.17	**0.74**
Total	**HF**	**2.04**	**0.09**	**1.40**	**8.27**	
Total	**MF**	**0.18**	**0.02**	**0.13**	**0.54**	
Total	**LF**	**0.57**	**0.16**	**1.21**	**0.81**	
Total	**VLF**	**0.47**	**0.07**	**0.12**	**0.11**	
Total	**AB**	**3.25**	**0.33**	**2.86**	**9.72**	

Table 5. Wind-energy facilities in North America, with both Anabat sampling data and mortality data for bat species, grouped by geographic region. To date, no results from southwestern or southeastern wind facilities have been made public. The activity level for this project is reported as the mean for ground-based units, and the overall mean including elevated stations in parentheses.

Geographic Region, Wind-Energy Facility	Activity (#/detector-night)	Mortality (bats/MW/year)	Number of Turbines	Total Site MW	References
Western					
Tule, CA	*7.0 (3.9)*				*This study*
Nine Canyon, WA		2.47	37	48	Erickson et al. 2003b
High Winds, CA		2.02	90	162	Kerlinger et al. 2006
Big Horn, WA		1.90	133	199.5	Kronner et al. 2008
Combine Hills, OR		1.88	41	41	Young et al. 2006
Stateline, WA/OR		1.70	454	300	Erickson et al. 2004
Vansycle, OR		1.12	38	24.9	Erickson et al. 2000
Klondike, OR		0.77	16	24	Johnson et al. 2003b
Hopkins Ridge, WA		0.63	83	150	Young et al. 2007
Klondike II, WA		0.41	50	75	NWC and WEST 2007
Wild Horse, WA		0.39	127	229	Erickson et al. 2008
SMUD, CA		0.07		15	Erickson et al. 2005
Midwest & Rocky Mountains					
Summerview, Alberta (2007/2008)		11.42	39	70.2	Baerwald 2008
Summerview, Alberta (2005/2006)		10.27	39	70.2	Brown and Hamilton 2006
Judith Gap, MT		8.93	90	135	TRC 2008
Crescent Ridge, IL		3.27	33	49.5	Kerlinger et al. 2007
Foote Creek Rim, WY (Phase I)	2.2	2.23	69	41.4	Young et al. 2003
NPPD Ainsworth, NE		1.16	36	59.4	Derby et al. 2007
Oklahoma Wind Energy Center, OK		0.53	68	102	Piorkowski 2006
Buffalo Gap, TX		0.10	67	134	Tierney 2007
Upper Midwest					
Top of Iowa, IA	34.9	10.27	89	80	Jain 2005
Buffalo Ridge, MN (Phase III)		2.72	138	103.5	Johnson et al. 2000
Buffalo Ridge, MN (Phase II)	2.1	2.37	143	107.25	Johnson et al. 2000
Buffalo Ridge, MN (Phase I)		0.76	73	25	Johnson et al. 2000

Table 5. Wind-energy facilities in North America, with both Anabat sampling data and mortality data for bat species, grouped by geographic region. To date, no results from southwestern or southeastern wind facilities have been made public. The activity level for this project is reported as the mean for ground-based units, and the overall mean including elevated stations in parentheses.

Geographic Region, Wind-Energy Facility	Activity (#/detector-night)	Mortality (bats/MW/year)	Number of Turbines	Total Site MW	References
Eastern					
Buffalo Mountain ,TN (Phase II)		39.70	18	29	Fiedler et al. 2007
Mountaineer, WV	38.3	31.69	44	66	Kerns and Kerlinger 2004
Buffalo Mountain TN (Phase I)	23.7	31.54	3	2	Nicholson et al. 2005
Casselman, PA		15.66	23	34.5	Arnett et al. 2009
Maple Ridge, NY 2006		15.00	195	321.75	Jain et al. 2007
Mount Storm, WV	35.2	12.21	82	164	Young et. al 2009
Meyersdale, PA		10.93	20	30	Arnett et al. 2005
Maple Ridge, NY 2007		9.42	195	321.75	Jain et al. 2008
Noble Ellensburg, NY		5.45	54	80	Jain et al. 2009
Noble Bliss, NY		5.05	67	100	Jain et al. 2009
Noble Clinton, NY		3.63	67	100.5	Jain et al. 2009
Mars Hill, ME 2007		2.91	28	42	Stantec 2008b
Erie Shores, Ont.		1.51	66	99	James 2008
Mars Hill, NY 2008		0.45	28	42	Stantec 2009
Searsburg, NY		0.00	11	7	Kerlinger 2002

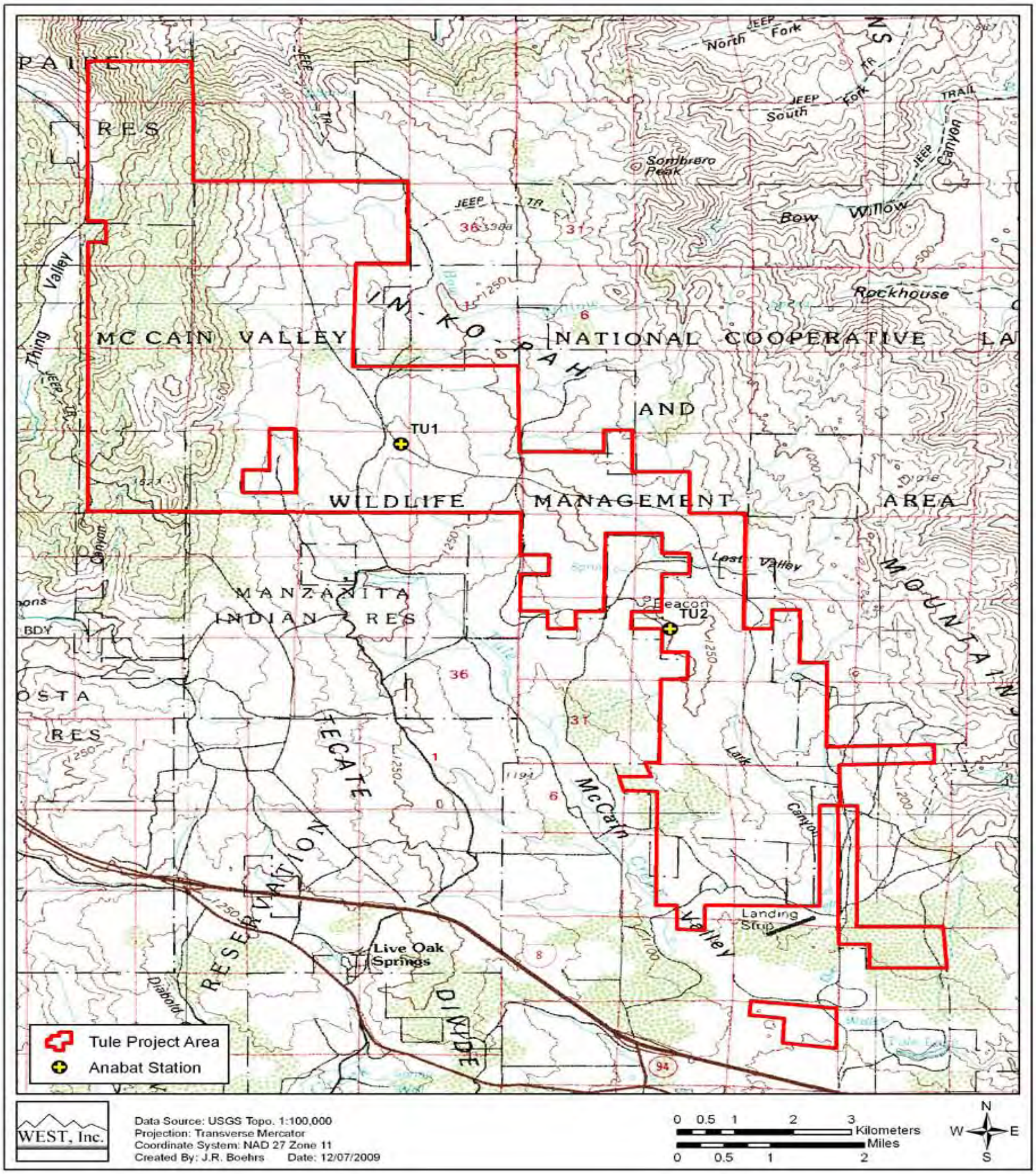

Figure 1. Study area map and Anabat sampling stations at the Tule Wind Resource Area.

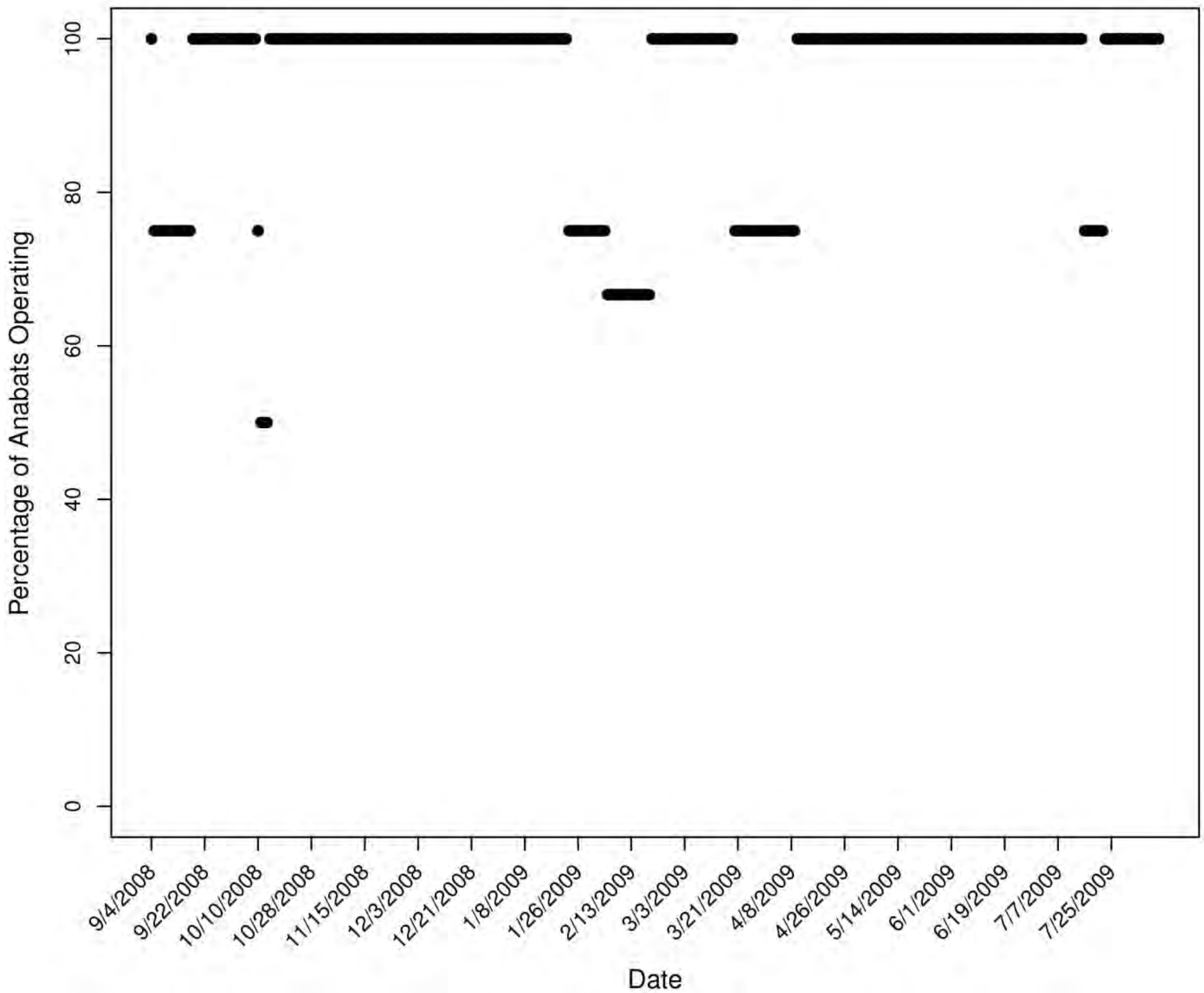

Figure 2. Percentage of Anabat detectors (n = 4) at the Tule Wind Resource Area operating during each night of the study period September 4, 2008 – August 10, 2009.

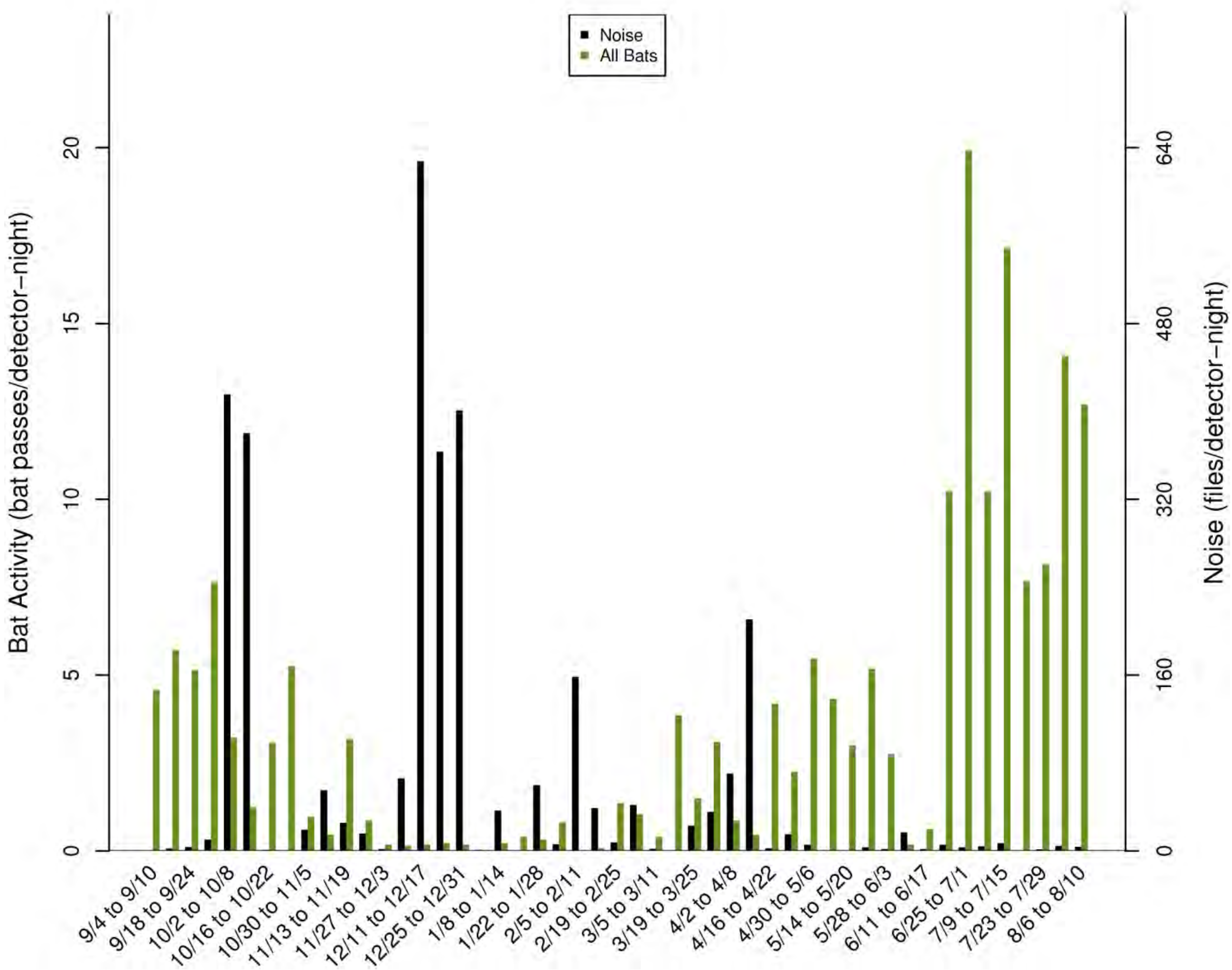

Figure 3. Number of bat passes and noise files detected per detector-night at the Tule Wind Resource Area for the study period September 4, 2008 – August 10, 2009, presented by week. Noise files are indicated on the second axis.

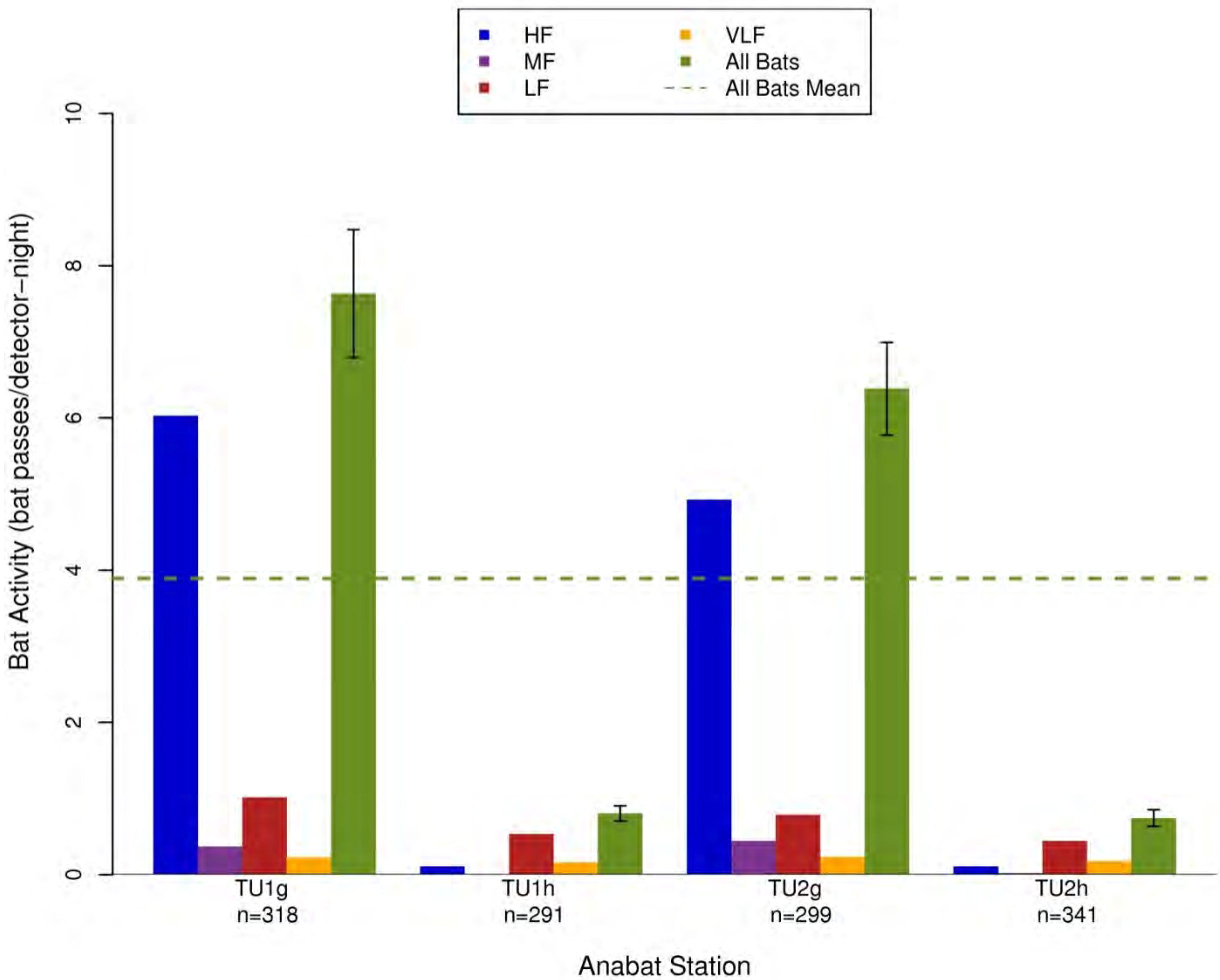

Figure 4. Number of bat passes per detector-night by Anabat location at the Tule Wind Resource Area for the study period September 4, 2008 – August 10, 2009.

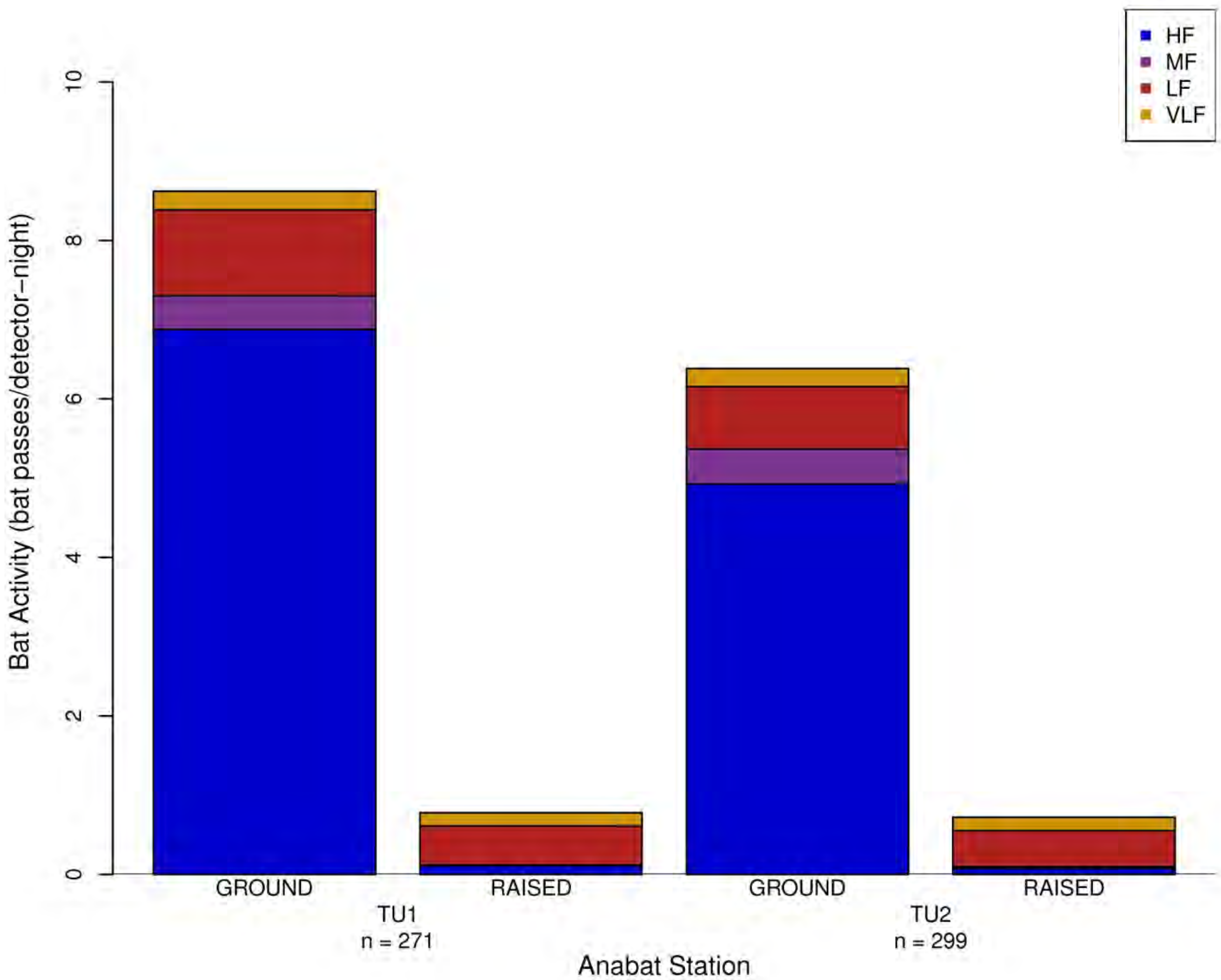

Figure 5. Number of high-frequency (HF), mid-frequency (MF), low-frequency (LF), and very low-frequency (VLF) bat passes per detector-night recorded at paired ground and high Anabat unit stations at the Tule Wind Resource Area for the study period September 4, 2008 – August 10, 2009.

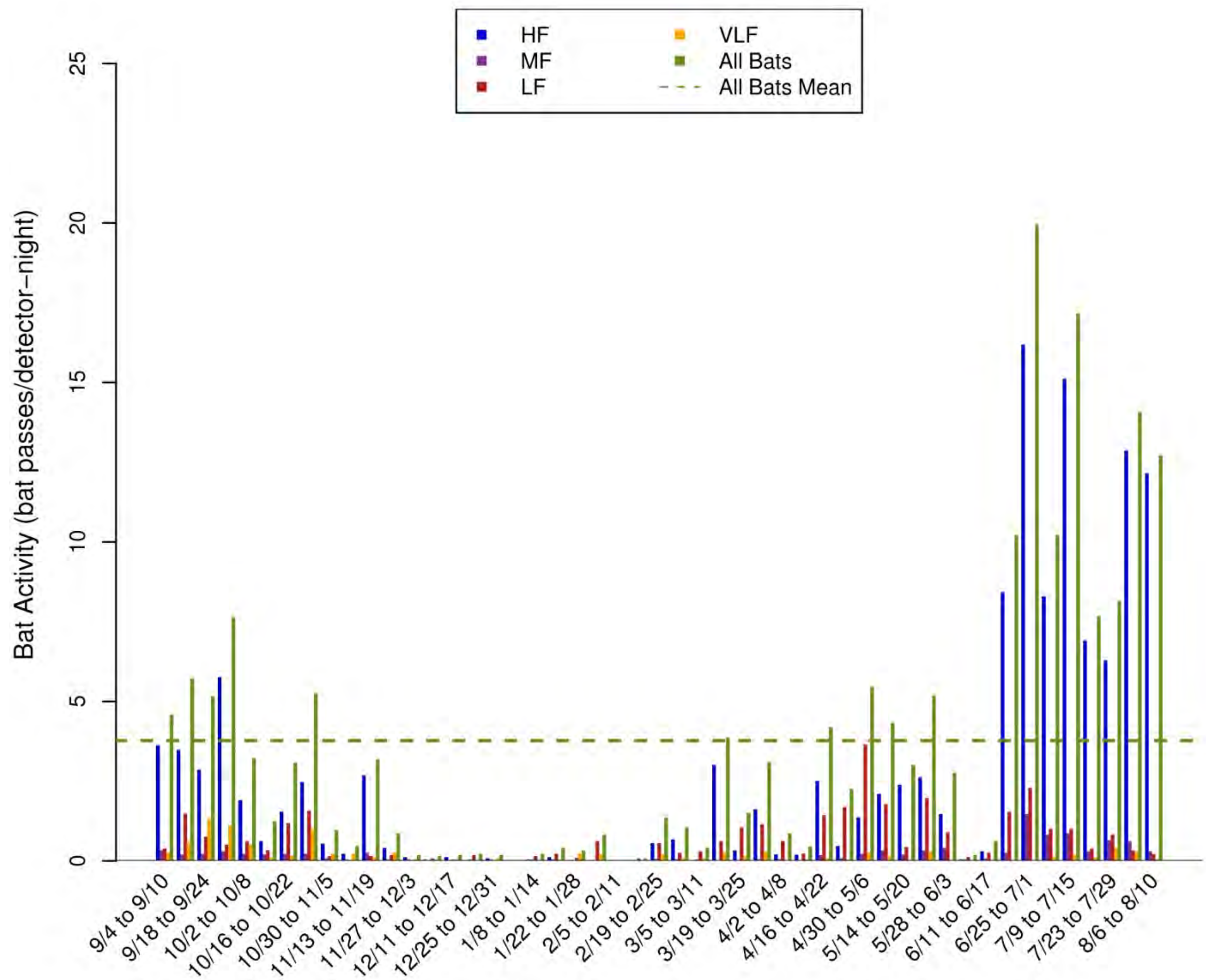

Figure 6. Weekly activity by high-frequency (HF), mid-frequency (MF), low-frequency (LF), and very low-frequency (VLF) bats at the Tule Wind Resource Area for the study period September 4, 2008 – August 10, 2009.

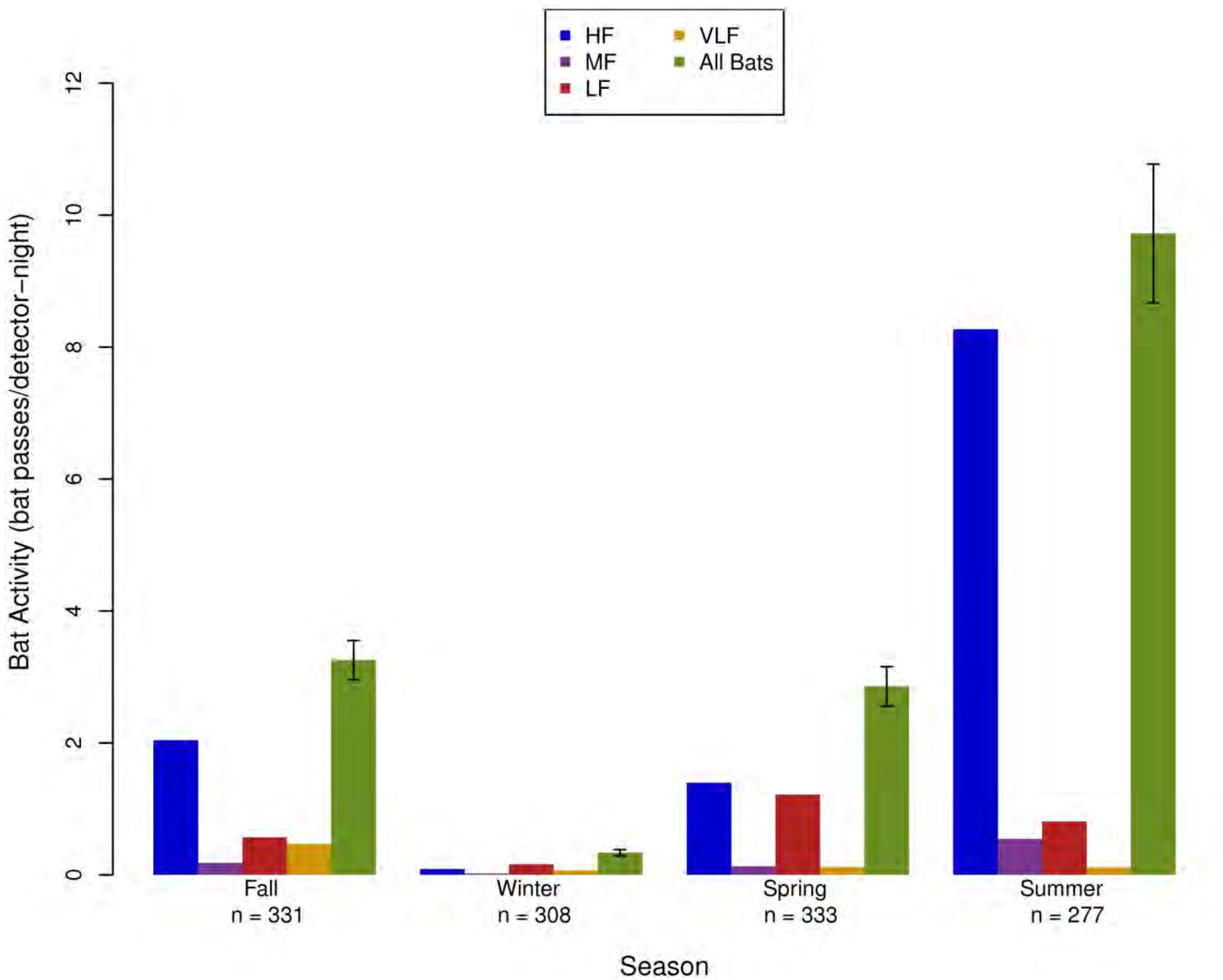

Figure 7. Seasonal bat passes by detector within the Tule Wind Resource Area.

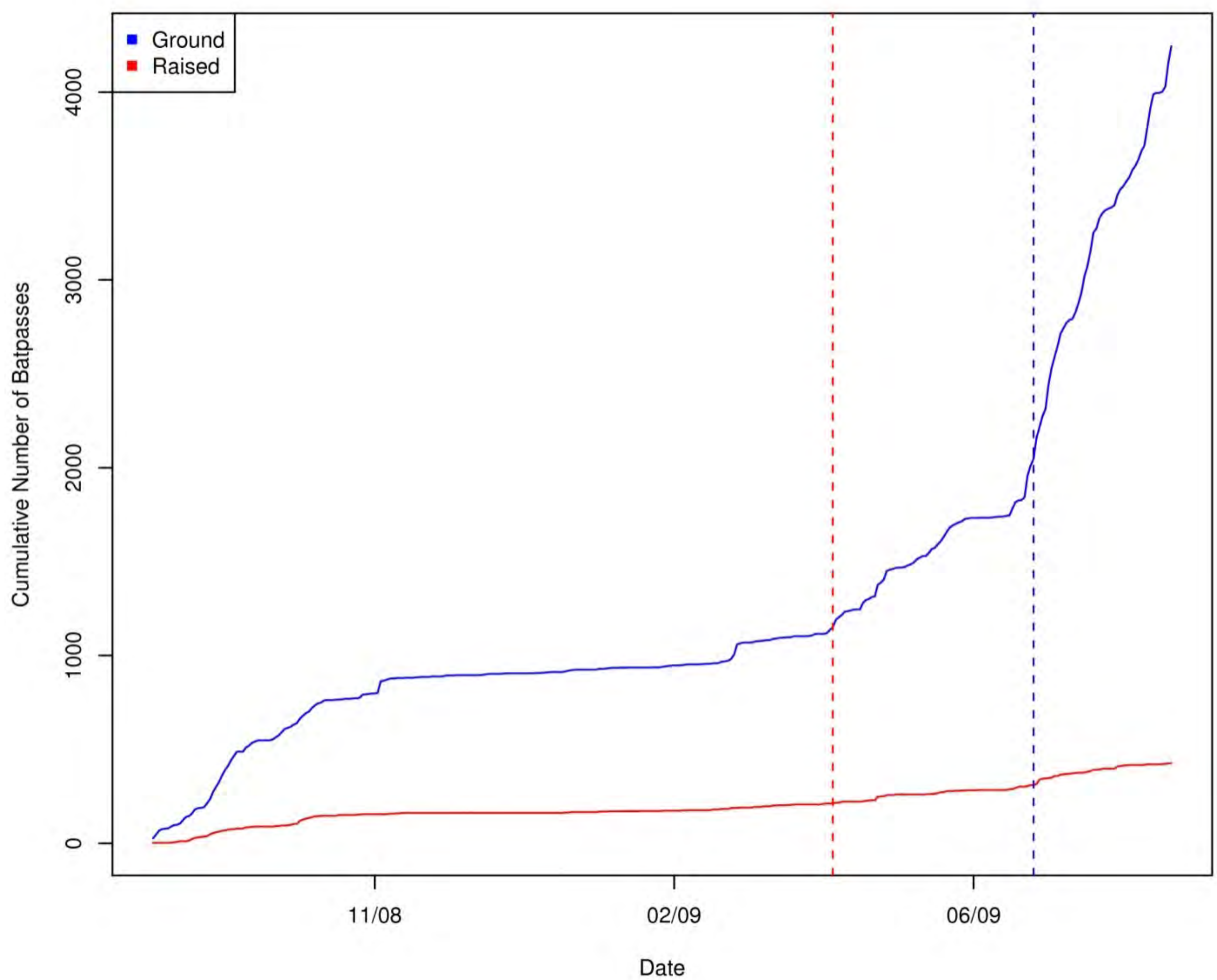

Figure 8. Empirical cumulative distribution of bat passes at ground and raised stations within the Tule Wind Resource Area, September 4, 2008 – August 10, 2009. Dashed vertical lines indicate the point at which 50% of the calls occurred, an indication of the median date of bat activity.