STATE OF CONNECTICUT
CONNECTICUT SITING COUNCIL

PETETION OF BNE ENERGY, INC. FOR A DECLARATORY RULING THAT NO CERTIFICATE OF ENVIRONMENTAL COMPATIBILITY AND PUBLIC NEED IS REQUIRED FOR THE CONSTRUCTION, MAINTENANCE, AND OPERATION OF A 4.8 MW WIND RENEWABLE GENERATING FACILITY LOCATED ON FLAGG HILL ROAD, COLEBROOK, CONNECTICUT

March 15, 2011

PRE-FILED TESTIMONY OF DAVID TIDHAR

Q1. Mr. Tidhar, please state your name and position.

A. David Tidhar and I am a Project Manager and Research Biologist at Western EcoSystems Technology, Inc. ("West"). West's corporate office is located in Cheyenne Wyoming and West maintains a regional branch office in Waterbury, Vermont, of which I serve as the Branch Manager.

Q2. Please state your qualifications.

A. I have a Master's degree in Ecology (with Distinction) from the University of Aberdeen, Scotland (2000), and a Bachelor of Arts degree (with Honors) from the University of Montana (1997). My background includes over 13 years of professional experience in the field of wildlife biology and ecology, including six years of environmental consulting. I have been Project Manager for more than 4 years where I have led environmental site assessments and field investigations for proposed and existing commercial wind-energy projects. My responsibilities include study design, study implementation, field studies and surveys including for threatened and endangered species, managing personnel, managing budgets, client communications, agency communications, attendance of meetings and authoring reports and white papers. I have additional experience completing wildlife surveys for state and federal agencies, a conservation organization and universities. A copy of my resume is attached hereto as Exhibit 1.

Q3. Please describe your involvement in this matter.

A. West was retained in June 2010 to conduct the bat acoustic study and breeding bird study for the Colebrook South phase of BNE Energy Inc.'s ("BNE") Wind Colebrook project (the "Site"). West's preliminary bat acoustic study report is contained in BNE's petition and consists of an analysis results of the summer 2010 acoustic bat survey. West's breeding bird survey was completed in June and July of 2010 and is located at Exhibit M of BNE's petition. Due to the fact that West was continuing to collect data concerning bat activity on the Site, Exhibit L to the petition is a preliminary report. Our final bat acoustic report is attached hereto as Exhibit 2. This report contains results from the entire monitoring period (June – October 2010).

Q4. Please describe aspects of Wind Colebrook that will serve to avoid and/or minimize impacts to bat populations.

A. West conducted both the breeding bird survey and bat acoustic studies in accordance with the United States Fish and Wildlife draft wind turbine guidelines, tiers one through three recommended assessments. The results of these surveys were considered in regards to project planning.

One of the key factors in minimizing impacts to bat populations is to avoid locating wind facilities near high-value bat habitat such as forested wetlands. The three proposed turbine locations on the Site do not directly impact high value bat habitat such as forested wetlands.

In addition, not only does the siting of the proposed turbines avoid high value bat habitat, but additional design features of Wind Colebrook help to further minimize potential impacts to bats. West has worked closely with VHB and other members of the BNE team to implement design features to minimize such impacts. These include not creating or locating the turbines near permanent standing water, and minimization of clearance areas for roads, turbines and infrastructures. Just over 14.05 acres of permanent impacts to deciduous forest will result from construction at the Site.

Q5. Will the Site have undue impacts to bat populations in the Colebrook area?

A. No. Given the discussion above and the data collected, the Site is not anticipated to impact bat populations. While wind projects do result in collision-induced mortality of bats, these impacts have not been shown to result in population-level effects. At operating commercial wind-energy facilities located within the region within similar forest-dominated landscapes (e.g., Noble Ellenberg NY, Noble Clinton NY, Maple Ridge NY, Lempster NH, Stetson Mountain ME and Mars Hill ME), bat fatality patterns have been low to moderate relative to the range of fatalities observed during formal post-construction monitoring projects. If patterns observed in regional studies are consistent, fatality rates for bats at the Site would be expected to be moderate. The vast majority of formal post-construction mortality studies conducted in the Unites States have been completed at facilities with substantially larger numbers of turbines and MW capacity than what have been proposed for the Site. For example, 76 studies evaluated in the final bat acoustic report had an average of 53.8 turbines (range: 3-195). The impact to bats from small wind facilities such as the Site may be lower in terms of the number of bats killed per year compared to these facilities, given that only 3 turbines are proposed for the Site.

Q6. <u>Will the Site have undue impacts to breeding bird populations in the Colebrook area?</u>

A. No. While wind projects do result in collision-induced mortality of birds, these impacts have not been shown to result in population-level effects. The breeding birds identified at the Site were largely regionally common species and no high value bird habitats are being directly impacted by the Site. No state or federally listed threatened or endangered species were identified during the 2010 breeding bird survey. As mentioned above for bats, habitats which may be less common than the dominant deciduous forest of the Site, such as forested wetlands, are being avoided by project development. There is a current lack of information on the indirect impacts of wind energy facilities on forested bird communities. It is thought that indirect impacts of wind energy developments are low compared to other, alternative, forms of development within forested landscapes. For example, a housing development within the project area boundaries of the Site would result in far greater loss of forested habitats and increased fragmentation compared with the proposed wind project, which is resulting in a total of 14.05 acres of permanent impacts within deciduous forestlands. Wind turbine pads, access roads and other infrastructure have been minimized in size through project planning, reducing the overall impact areas of development areas on bird habitats.

Date: March 15, 2011

David Tidhar

ACTIVE/72955.2/BHEIPLE/2408137v1

EXHIBIT 1

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EDUCATION

M.S.
University of Aberdeen
Aberdeen, Scotland
2000
Ecology, with Distinction

B.A.
University of Montana
Missoula, Montana
1997
Political Science/History, with honors

University of Edinburgh
Edinburgh, Scotland
1992-1996
Non-graduating International Student

SCIENTIFIC ORGANIZATION MEMBERSHIPS

The Wildlife Society

Hawk Migration Society of North America

David Tidhar, *Research Biologist/Project Manager*

PROFESSIONAL EXPERIENCE

2007-Present	*Research Biologist/Project Manager,* Western EcoSystems Technology, Inc., Waterbury, Vermont
2006-2007	*Visiting Professional Researcher,* College of William and Mary, Williamsburg, Virginia
2005	*Northern Goshawk Surveyor*, Idaho Fish and Game Department, Lewiston, Idaho
2004	*Wildlife Biologist*, Colorado Plateau Research Station, Flagstaff, Arizona
2003-2004	*Red Deer Research Assistant*, The Macaulay Institute, Scotland
2003, 1998	*Conservation Scientist & Hawk Mitigation Observer*, HawkWatch International, Salt Lake City, Utah
2000-2003	*Wildlife Biologist and Field Supervisor*, University of Aberdeen, Scotland

SPECIALTY AREAS

Project Management of environmental surveys related to commercial wind power projects including agency and client communication, project/study plan development and implementation, supervision/coordination of field staff, data and budget management, and report writing.

Coordination and conduct of wildlife and environmental surveys and monitoring related to the impact of human activities on wildlife and wildlife habitat. Survey design and implementation including pre- and post-construction surveys for threatened and endangered species; habitat evaluation; bio-monitoring; and biological impact assessments.

Preparation of scientific reports, presentations and documents including Avian and Bat Protection Plans, Incidental Take Permit Applications (e.g. New York State Article 11), and Biological Assessments and Biological Evaluations.

Recommendation and implementation of mitigation measures.

Experience in the development and implementation of scientific protocols (e.g. indirect inventory and monitoring tools for small mammals; threatened, endangered or rare species; and relative abundance surveys for raptors).

Received formal training and approval/certification for threatened, endangered, rare or sensitive species including: northern goshawk, pygmy rabbits & black-footed ferrets, and southern leopard frog.

SELECTED PROFESSIONAL PUBLICATIONS

Tidhar, D., W. L. Tidhar, C. Derby, K. Taylor, and T. Rintz. (in prep). Pygmy Rabbit Habitat Use and Distribution in Western and Central Wyoming.

Tidhar, D. and A. Sibbald (in prep). The Effect of Human Disturbance on Red Deer Behavior in Scotland.

Peacock, W. L., **D. Tidhar,** and J. R. Speakman. (in prep). The Effect of Predation Risk on Body Mass and Faecal Corticosterone Levels in the Field Vole: A Field Study.

Bierman, S. M., J. P. Fairbairn, S. J. Petty, D. A. Elston, **D. Tidhar,** and X. Lambin. 2006. Changes Over Time in the Spatiotemporal Dynamics of Cyclic Populations of Field Voles (*Microtus agrestis* L.) *The American Naturalist,* Vol. 167(4).

Tidhar, D., Gruver, J. and Courage, Z.. 2010. Middlebury Airport Vermont Bat Acoustic Survey Report. Technical report prepared for URS Corporation by Western EcoSystems Technology, Inc.

Derby, C., **Tidhar, D.,** Tidhar, W. L., Rintz, T., Taylor, K., Dahl, A. L. 2006. Overland Pass Pipeline Project: 2006 Pygmy Rabbit Presence-Absence Survey. Technical report prepared for NRG, Willbros Engineers, Inc., and Overland Pass Pipeline by Western EcoSystems Technology, Inc.

Derby C., **D. Tidhar,** and W. Erickson. 2005. Bird and Bat Fatality Monitoring of Six Un-guyed, Un-lit Cellular Telecommunications Towers with the Coconino and Prescott National Forests, Arizona: 2005 Season Results. Technical report prepared for American Tower corporation by Western EcoSystems Technology, Inc.

Lambin, X. L., J. P. Gairbairn, I. Graham, and **D. Tidhar.** 2003. Multi-Annual Population Cycles in Field Vole Populations: An Experimental Refutation of the Specialist Predation Hypothesis. 2nd International Conference on Rodent Biology & Management.

EXHIBIT 2

Bat Acoustic Studies for the Colebrook Wind Resource Area Litchfield County, Connecticut

Final Report

June 25 – November 1, 2010

Prepared for:

BNE Energy, Inc.

Town Center, Suite 200
29 South Main Street
West Hartford, Connecticut 06107

Prepared by:

David Tidhar and Jeff Gruver

Western EcoSystems Technology, Inc.
26 North Main St.
Waterbury, Vermont 05676

NATURAL RESOURCES ◆ SCIENTIFIC SOLUTIONS

March 14, 2011

EXECUTIVE SUMMARY

Western EcoSystems Technology, Inc. initiated bat acoustic surveys in June 2010 on behalf of BNE Energy Inc. The purpose of the study was to characterize seasonal and spatial activity by bats during the summer maternity and fall migration seasons, and provide species identification of calls recorded to document presence of bat species within the proposed Colebrook Wind Resource Area (CWRA) in Litchfield County, Connecticut. Surveys were conducted using Anabat^{TM} SD1, Anabat^{TM} SD2, and Wildlife Acoustic™ SM2Bat Unit ultrasonic detectors during the summer and fall of 2010.

The CWRA is being permitted in two phases as Colebrook North and Colebrook South. The phases are located adjacent to one another. This report addresses only surveys conducted at Colebrook South, but due to similar habitat, land use, and land cover between the two phases, results of acoustic bat surveys for Colebrook South are likely indicative of species composition and relative abundance for Colebrook North.

The objective of the acoustic bat surveys was to characterize seasonal and spatial activity by bats within the CWRA during the maternity and migratory seasons. Bat activity was monitored using Anabats at two fixed stations from June 25 to November 1, 2010. A single SM2Bat Unit was deployed at the site for 43 nights during this period, 7 of which occurred within the estimated maternity season (June 25 – August 15) and 36 of which occurred within the estimated fall migration season (August 16 – November 1). The SM2Bat was used primarily to identify the bat species using the study area, and secondarily to provide an estimate of relative bat activity. The secondary purpose was necessitated due to malfunction by one of the Anabat detectors, which was removed from the analysis.

Bat activity monitored was monitored at CWRA by an Anabat detector at one station on a total of 102 nights from June 25 to November 1, 2010. Activity during this period was estimated by to be 39.34±5.49 bat passes per detector-night, a value just outside the range of activity recorded at five eastern wind facilities where pre- and post-construction data are available (range: 0.3-38.3; mean: 19.58). Bat activity also was monitored by a SM2Bat full-spectrum detector. A total of 575 zero-crossing files recorded by the SM2Bat unit on 30 detector-nights contained a bat pass, yielding a mean of 19.17±7.73 passes per detector-night.

Overall, passes by mid-frequency bats (79.6% of all passes) outnumbered passes by low-frequency bats (15.5%) and high-frequency bats (4.9%). Species identification was attempted for hoary bat and eastern red bat. Hoary bat passes comprised 0.10% of overall activity (four passes); eastern red bats comprised 0.12% of overall activity (five passes). However, given the conservative approach used for species identification, it is likely that more hoary and eastern red bat calls were recorded than were positively identified. Based on zero-crossing data from the SM2Bat, passes by LF bats (74.1% of all passes) outnumbered passes by MF bats (15.7%) and HF bats (10.3%). However, data from the SM2Bat reflect mostly migration season trends.

Bat activity levels peaked in mid-July and again in late September. During the maternity season, high-frequency bat activity peaked during the period July 11 – 17, mid-frequency activity peaked July 14 – 20, and low-frequency activity peaked August 7 – August 13, 2010. The mid-summer peak in high- and mid-frequency bat activity likely corresponds to the time when pups are being weaned and have joined the adult population in foraging. During migration, high-frequency bat activity peaked between August 22 and August 30, mid-frequency activity peaked September 24 – September 30, and low-frequency activity peaked August 25 – August 31, 2010. The increase in activity in late-August/early September may represent movement of migrating bats through the area, which may also explain the greater number of low-frequency bat passes during this period, as two of the three northern migratory species – hoary and silver-haired bats – produce low-frequency echolocation calls. Migratory activity by these species may also explain the relatively late peak for low-frequency activity during the summer season.

A total of 11,770 full-spectrum files were recorded by the SM2Bat detector, 3,307 of which contained bat calls (28.1%). Of those files with bat calls, 441 files (13.3%) were classified to frequency group and species identification. Six bat species were identified at CWRA: big-brown bat, eastern red bat, hoary bat, silver-haired bat, little brown bat, and tri-colored bat. The proportion of nights each species was identified differed seasonally, through surveys during the maternity season were restricted to the late part of the season, and likely overlapped with early migration. Of the 6 species identified acoustically at CWRA, only little brown bat was not identified during the maternity season. Big brown, hoary and silver-haired bats were recorded 6 nights each, an deastern red and tri-colored bats were recorded 4 and 3 nights, respectively, On 23 nights during the fall migration (August 16-November 1), silver-haired bats were detected on 10 nights, while eastern red, hoary and little brown bats were identified on 1 night each. Big brown and tri-colored bats were not identified during the migration season.

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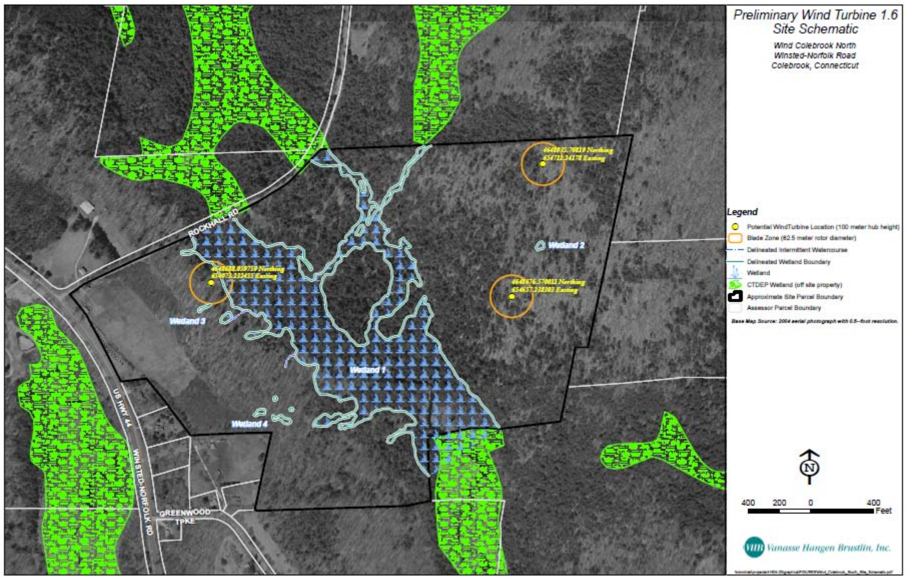
INTRODUCTION

BNE Energy, Inc (BNE) is proposing to develop the Colebrook Wind project in Litchfield County, Connecticut. The proposed CWRA is located near the town of Colebrook, Connecticut, in northeastern Litchfield County (VHB 2010a; Figure 1). The Colebrook Wind project is being permitted in two phases as Colebrook North and Colebrook South. The phases are located adjacent to one another and have similar vegetation composition and physiographic characteristics. Three GE wind turbine generators are proposed for each phase. In June 2010, BNE contracted Western EcoSystems Technology, Inc. (WEST) to develop and implement a standardized protocol for a baseline study of bat activity within the Colebrook South component of the Colebrook Wind project, herein referred to as the Colebrook Wind Resource Area (CWRA). The protocol is based on WEST's experience studying wildlife and wind turbines at wind energy facilities throughout the US and is similar to protocols used at numerous wind energy facilities.

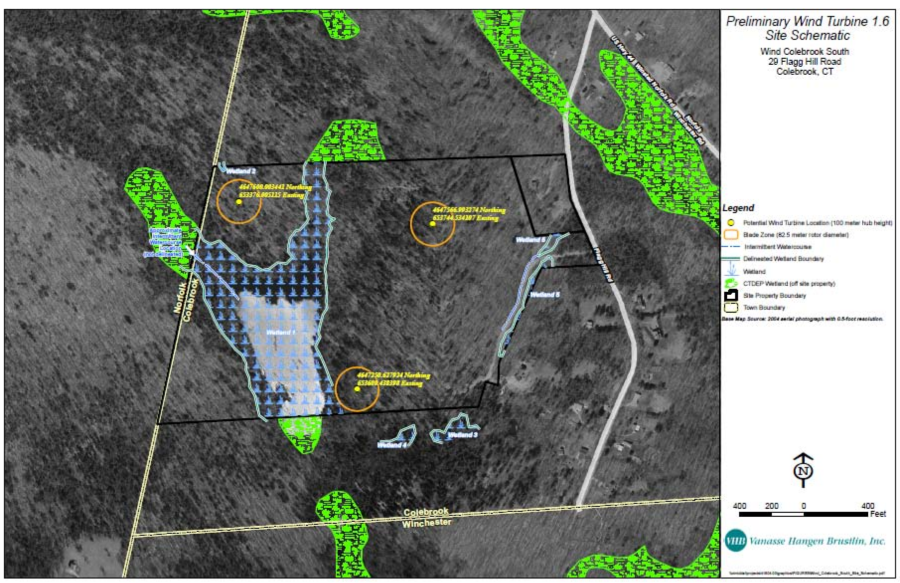
The purpose of the study was to characterize seasonal and spatial activity by bats within the CWRA during the summer maternity and fall migration seasons and provide species identification of calls recorded to document presence of bat species within CWRA. The study was completed using passive acoustic sampling, using Tetley Anabat™ and Widllife Acoustics SM2Bat™ ultrasonic bat detectors. The following report describes the results of acoustic bat surveys conducted during the summer and fall of 2010 in the CWRA. Breeding bird surveys were also completed during the summer of 2010 at the CWRA, the results of which are presented in a separate report.

STUDY AREA

The CWRA lies within the Northwest Highlands region (Bell 1985), characterized by hard, metamorphic bedrock that has shaped the landscape into high, steeply sided plateaus, broad valleys, and rolling foothills. The Appalachian Mountains extend through Connecticut west of the study area. The CWRA is situated primarily along the top and side slopes of an unnamed hill capped with glacial till. It also includes a small part of the eastern slope of Flagg Hill, as well as a valley between these two hills. The CWRA is approximately 80 acres (0.13 square miles [mi^2]) in size and elevation ranges from approximately 433 to 457 meters (m; 1,420 to 1,500 feet [ft]) above sea level. The region is primarily deciduous and coniferous forest, with pockets of residential development and agriculture. The majority of the study area is covered by secondary-growth upland forest, but also includes forested wetland. The forested portion of the CWRA is dominated by deciduous pole timber. The upland forest understory is relatively open, but, where vegetated, is dominated by mountain laurel (*Kalmia angustifolia*). Saplings and shrubs of American beech (*Fagus grandifolia*) and blackberry (*Rubus sp.)* species occur as well. Rotting logs, old forest tracks, woody debris, and slash are abundant throughout the CWRA (VHB 2010a). Two intermittent watercourses also occur on-site. The city of Winsted is located less than eight km (five mi) to the southeast. Residential development occurs to the east of the CWRA, on both sides of Flagg Hill Road.



North Colebrook



South Colebrook

Figure 1. Maps of the Colebrook Wind project.

METHODS

Bat Acoustic Surveys

The objective of the bat activity surveys was to characterize seasonal and spatial bat activity within the CWRA during the majority of the summer maternity and fall migration seasons using ultrasonic detectors. The use of such 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). Bat activity was surveyed within CWRA using ultrasonic detectors from June 25 to November 1, 2010, a period encompassing both the estimated summer maternity season and fall migration season at this site. From June 25 to August 10, bat activity was surveyed using two Anabat™ SD1 bat detectors (Titley Scientific™, Australia). On August 11, Anabat SD1 detectors were exchanged for newer model Anabat SD2 detectors (Titley Scientific™, Australia), which were used for the remainder of the study period. To provide a better understanding and identification of the species composition within the project area, bat activity at the CWRA was also surveyed using a single SM2Bat Unit (Wildlife Acoustics™, Inc., Concord, Massachusetts), utilizing full-spectrum recording technology, compatible with zero crossing analysis on a variable one to two week schedule throughout the study period. This unit was initially deployed at CWRA on August 4, 2010.

The two Anabat detectors were placed near the ground at two fixed stations (CA1 and CA2). The SM2Bat unit was placed near the ground at a third location (CS1; Figure 2). Station CA1 was located along an abandoned forest track in deciduous forest at one of the proposed turbine locations near the center of the CWRA (Appendix A). A narrow woodland shelterbelt was located between station CA1 and a forest clearing in which the meteorological (met) tower was located. Station CA2 was located along an abandoned forest track at a proposed turbine location in the northwest corner of the CWRA, also in deciduous forest (Appendix B). The SM2Bat unit was placed at the edge of a beaver pond and wetland complex between the two Anabat stations. Open water is considered a feature attractive to bats for foraging, and placement of the SM2Bat unit at this location increased potential for recording bat species that may occur in the project area. Anabat detectors were placed inside plastic weather-tight containers with an opening in the side through which the microphone extended. To minimize potential for water damage due to rain, holes were drilled in the PVC. Detectors protected in this manner have been found to detect similar numbers of bat calls as detectors exposed to the environment (Britzke et al. 2010). The SM2Bat Unit (PS1) is a self contained weatherproof unit requiring no additional weatherproofing containers or retrofit of microphones. All units were raised approximately two m (6.6 ft) off the ground to minimize echo interference and lift the unit above ground vegetation.

Anabat detectors record bat echolocation calls with a broadband microphone. Calls were recorded to a compact high-capacity flash memory card; data were subsequently transferred onto a computer for analysis. The echolocation sounds were then translated into frequencies audible to humans by dividing the frequencies by a predetermined ratio. A division ratio of 16 was used for this study. Bat echolocation detectors also detect other ultrasonic sounds, such as those sounds made by insects, raindrops hitting vegetation, and other sources. Depending on the environment in which the unit was placed, a sensitivity level of 5.5 or six was used to reduce interference from these other sources of ultrasonic noise. 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 30 m (98 ft) due to atmospheric absorption of echolocation pulses (Fenton 1991). To ensure similar detection ranges among anabat units, microphone sensitivities were calibrated using a BatChirp ultrasonic emitter (Tony Messina, Las Vegas, Nevada) as described in Larson and Hayes (2000). All units were programmed to turn on each night approximately 30 minutes before sunset and turn off approximately 30 minutes after sunrise.

An additional objective of the survey was to identify the bat species using the study area and to estimate the relative levels of activity by different species within the site. To address this objective, a SM2Bat Unit (Wildlife Acoustics™, Inc., Concord, Massachusetts) was deployed at the site (Appendix C). The SM2Bat Unit is a full-spectrum bat detector, which records complete acoustic waveforms by sampling sound waves at 192 kHz. This high sampling rate enables the detector to record sound amplitude data at all frequencies up to 96 kHz and to make high resolution recordings (Wildlife Acoustics, 2010). In contrast, the zero-crossing meter in the Anabat SD1 or SD2 detector records the frequency of only the highest amplitude sound and samples at a lower rate (e.g., 1/16th of the sound frequency) which produces lower resolution recordings. The higher quality recordings produced by the SM2 detector provides more detailed information in which to make bat species identification at the cost of higher data storage requirements and slower data analysis. Calls were recorded to high-capacity SDHC memory cards, and subsequently transferred onto a computer for analysis in the SonoBat™, program, discussed under the statistical analysis section below (SonoBat™; Arcata, California).

As noted above, echolocation detectors, including the SM2Bat Unit, also detect other ultrasonic sounds. To reduce this type of interference during recording, frequencies below 16kHz (below the range of bat echolocation in the Northeast) were filtered out using a high-pass filter. In addition, an adaptive trigger level of 12 signal to noise ratio (SNR; adaptive +12dB) was used, which specified that incoming signals (presumably bat calls) exceed the average background spectrum within the frequency band by 12 dB. The adaptive trigger levels range from +1 and +88 dB SNR, where a higher value is less sensitive than a lower value between. The trigger window was set to 1 second. After initial deployment and continued discussion with Wildlife Acoustics and professional bat biologists, the settings were adjusted for the remainder of the study period, as follows: high pass filter of 16, adaptive trigger level of 15 dB SNR, and a trigger window of 5 seconds. This means that the SM2Bat Unit measured the rolling-average power spectrum in the appropriate frequency band (above 16kHz) for the length of the trigger window setting (5.0 seconds), and if a signal exceeding this threshold by 15dB was detected, the bat call or other ultrasonic noise signal was recorded until no trigger was detected for a full second.

The detection range of Anabat detectors and SM2Bat Units depend on a number of factors, such as echolocation call characteristics, microphone sensitivity, habitat, the orientation of the bat, and atmospheric conditions (Limpens and McCracken 2004; Ian Agranat, President & CEO Wildlife Acoustics, pers. comm. 2010). The detection range of Anabat detectors is generally less than 30 m (98 ft) due to atmospheric absorption of echolocation pulses (Fenton 1991). The SM2Bat equipment manufacturer, Wildlife Acoustics, claims a detection distance of 100-300 feet (30-100 meters), though given the physics of sound transmission in air, the range of song meter is likely to be similar to that of an Anabat detector (approximately 100 ft [30-m]), and will be subject to all the same sources of variance, including air temperature, relative humidity, and proximity and orientation of the bat relative to the detector. The nature of sound wave propagation produced by a variable source (moving bats) through a variable medium (air) means that detection distances are subject to a lot of variation. The frequency range of a bat can also affect detection distances.

The SM2Bat unit was programmed to turn on each night at sunset and turn off at sunrise based on an internal solar tracking feature programmed with the specific coordinates and time zone for Colebrook, CT.

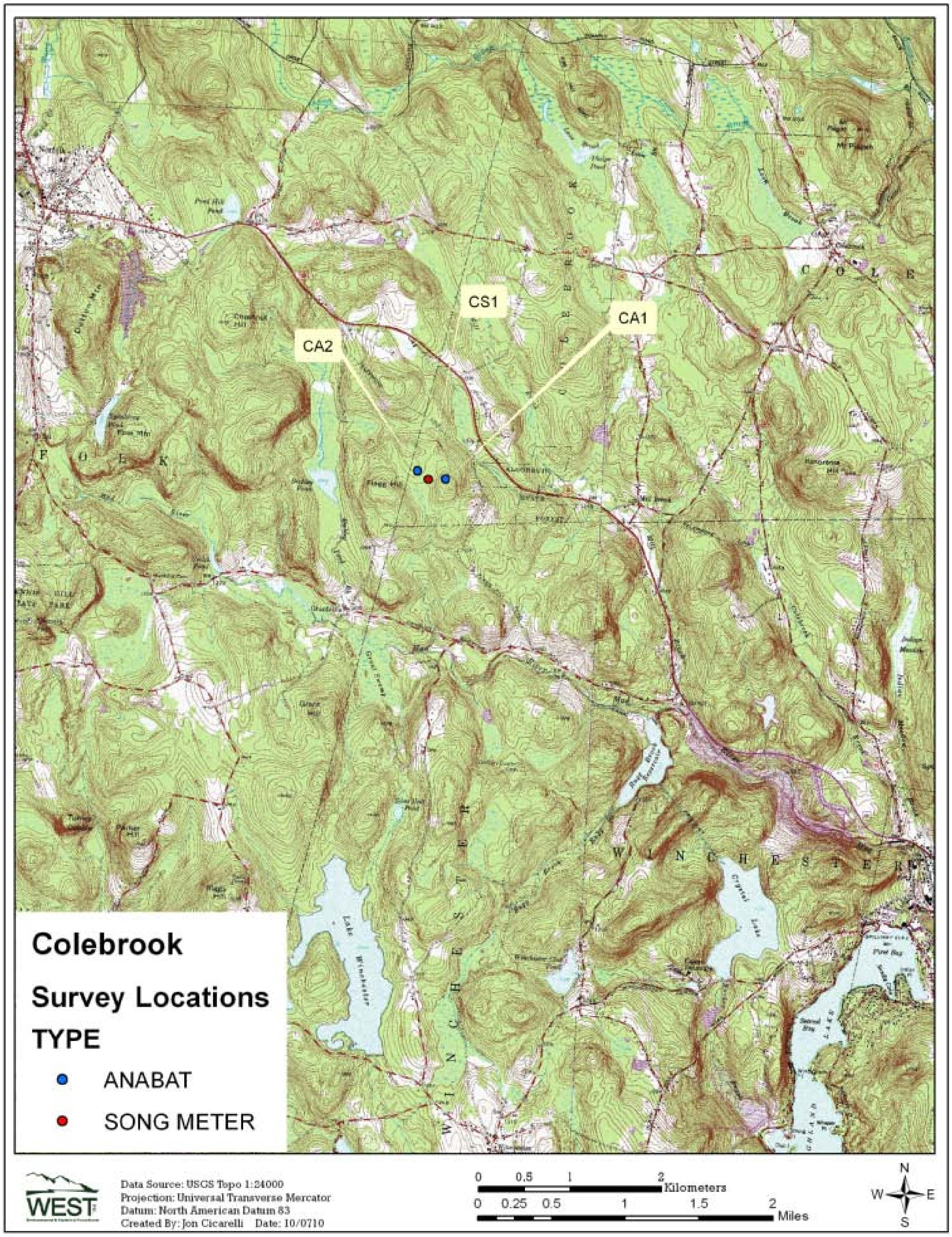


Figure 2. Study area map and acoustic bat sampling stations at the CWRA.

Statistical Analysis

Anabat Units

The units of bat activity used for analysis were number of bat passes (Hayes 1997). A bat 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. Data files recorded by Anabat units were analyzed using AnalookW v3.5r (©2008, Chris Corben) and Analook DOS v4.9j (©2004, Chris Corben) software. The Analook software displays bat calls (and extraneous noise) as a series of pixels on a time over frequency display. Analook provides a framework to build filters that constrain the values of certain call parameters. Pixels that fall outside the specified range of the filter parameters are ignored (e.g. pixels not following a smooth line, pixels below or above a specified frequency, etc.). In addition, a series of filters, developed by WEST, was used to quickly and effectively separate out files that contained only noise, and to sort remaining files containing bat calls into frequency groups. Filtered files were visually examined by an analyst to ensure accuracy. Data determined to be noise (produced by a source other than a bat) and call notes that did not meet the pre-specified criteria to be termed a pass were removed. The total number of bat calls was then corrected for effort by dividing the number of calls by the number of detector-nights, where a detector-night was defined as one detector collecting data for one night.

While some bat species produce a call that has a distinctive sonogram (i.e., the shape on a frequency-time graph), there is much overlap and variation among some species. For this reason, a conservative approach to species identification was used. For each Anabat station, bat passes were sorted into three groups, based on their minimum frequency, that correspond roughly to species groups of interest. For example, the species of *Myotis* bats in Connecticut generally have echolocation with minimum frequencies near 40 kilohertz (kHz), whereas species such as the eastern red bat (*Lasiurus borealis*) typically have echolocation calls that fall between 30 and 40 kHz, and species such as big brown (*Eptesicus fuscus*), silver-haired (*Lasionycteris noctivagans*), and hoary bat (*Lasiurus cinereus*), have echolocation frequencies that fall at or below 25 kHz. Therefore, passes were classified as high-frequency (HF; more than 40 kHz), mid-frequency (MF; 30 to 40 kHz), or low-frequency (LF; less than 30 kHz). To establish which species may have produced passes in each category, a list of species expected to occur in the study area was compiled from range maps (Table 1; Harvey et al. 1999, CDEF 1999).

Table 1. Bat species with the potential to occur within the CWRA. Data from Harvey et al. (1999) and the Connecticut Department of Environmental Protection (CDEP 1999).

Common Name	Scientific Name
High-Frequency (> 40 kHz)	
northern long-eared bat[2]	*Myotis septentrionalis*
Indiana bat[2]	*Myotis sodalis*
tri-colored bat[2]	*Perimyotis subflavus*
Mid-Frequency (30-40 kHz)	
eastern red bat[1,2]	*Lasiurus borealis*
little brown bat[2]	*Myotis lucifugus*
Low-Frequency (< 30 kHz)	
big brown bat[2]	*Eptesicus fuscus*
silver-haired bat[1,2]	*Lasionycteris noctivagans*
hoary bat[1,2]	*Lasiurus cinereus*

[1]long-distance migrant; [2]species known to have been killed at wind energy facilities

Within these categories, distinctive passes made by two *Lasiurus* species, hoary bat and eastern red bat, were identified. Echolocation calls that had a distinct U-shape and that exhibited variability in the minimum frequency across the call sequence were identified as belonging to the *Lasiurus* genus (C. Corben, pers comm.). Hoary and eastern red bats were distinguished based on minimum frequency. Hoary bats typically produce calls with minimum frequencies between 18 and 24 kHz, whereas eastern red bats typically emit calls with minimum frequencies between 30 and 43 kHz (J. Szewczak, pers comm.). Only sequences containing three or more calls were used for species identification. These are conservative standards. Given the high intra-specific variability of *Lasiurus* calls and the number of call files that were too fragmented for proper identification, it is likely that more hoary and eastern red bat calls were recorded than were positively identified.

SM2Bat Unit

The SM2Bat unit is a full-spectrum recorder and differs from Anabat by preserving the amplitude and harmonic details of the original signal (Wildlife Acoustics, 2010b). Full-spectrum recording provides a data-rich output, which can be analyzed by software programs designed to process at a higher resolution. This provides potential for increased ability to accurately identify call to species. Echolocation calls were recorded to SDHC memory cards and subsequently transferred to a computer for analysis in Sonobat 3.02 (Sonobat, Arcata, California). Sonobat uses a proprietary algorithm to analyze 76 call parameters with a hierarchical discriminant function developed from a library of 10,000 known bat passes, and assigns a bat species and probability to each pass. However, as with Anabat some bat passes cannot be identified with certainty, either because the pass consists of only call fragments or because different bat species produce similar calls with overlapping characteristics that often cannot be distinguished. For analysis, Sonobat was instructed to report positive identification of bat species only if call quality was ≥80% and if discriminant probability was ≥90%. Therefore, only a small portion of recorded calls were identified to species. The Sonobat output was used to generate a list of species that appear to be present on site and to estimate the relative share of identifiable bat calls generated by each species by number of detector nights a species' call was identified.

The data collected by the SM2Bat unit and the discriminant analysis conducted were to determine presence/absence of species within CWRA, rather than to estimate levels of bat activity. Presence and absence is presented as the number and proportion of nights that at least one call from a species was detected and identified.

RESULTS

Anabat Acoustic Surveys

Bat activity was monitored within the CWRA using Anabat SD1 and SD2 units at two sampling locations. However, due to concerns that data collected by the CA2 detector were compromised by electronic or mechanical problems, data from the detector were removed from the final analysis and results. Therefore, bat activity was only assessed from the CA1 station on a total of 102 nights during the period June 25 to November 1, 2010. Data collected by the SM2BAT detector was analyzed using Zero-Crossing Analysis in an attempt to expand the scope of bat activity analysis (see below).

Station CA1 recorded data for the entire nightly survey period (from 1700 to 0900 EDT) during 80.3% of the sampling period. Equipment failure compromised data collection from September 26 through October 19, 2010 (Figure 3). The number of noise files in a given week ranged from 1.50 to 179.60 files. With the exception of one week during the study, the number of noise files was less than the number of bat passes recorded and was unlikely to have interfered with overall data collection (Figure 4). The highest level of noise was recorded during the week of August 20-28, 2010 (Figure 4).

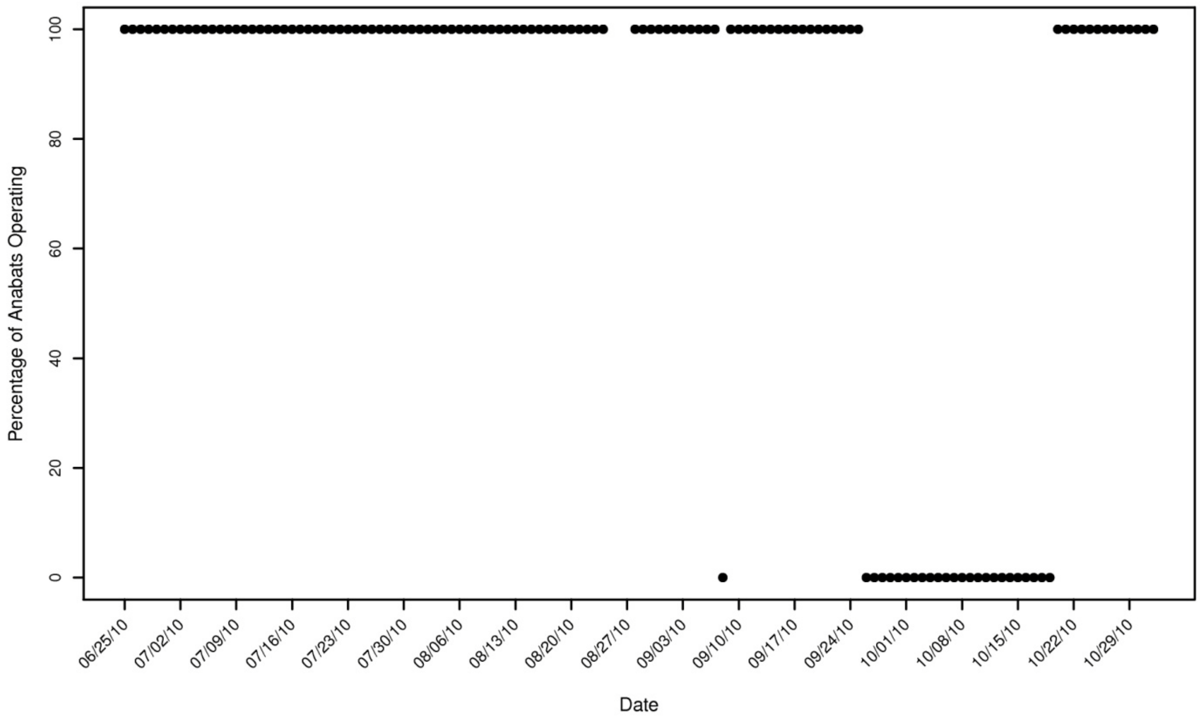


Figure 3. Proportion of Anabat detectors (n = 1) operating during each night of the study within the CWRA, June 25 – November 1, 2010.

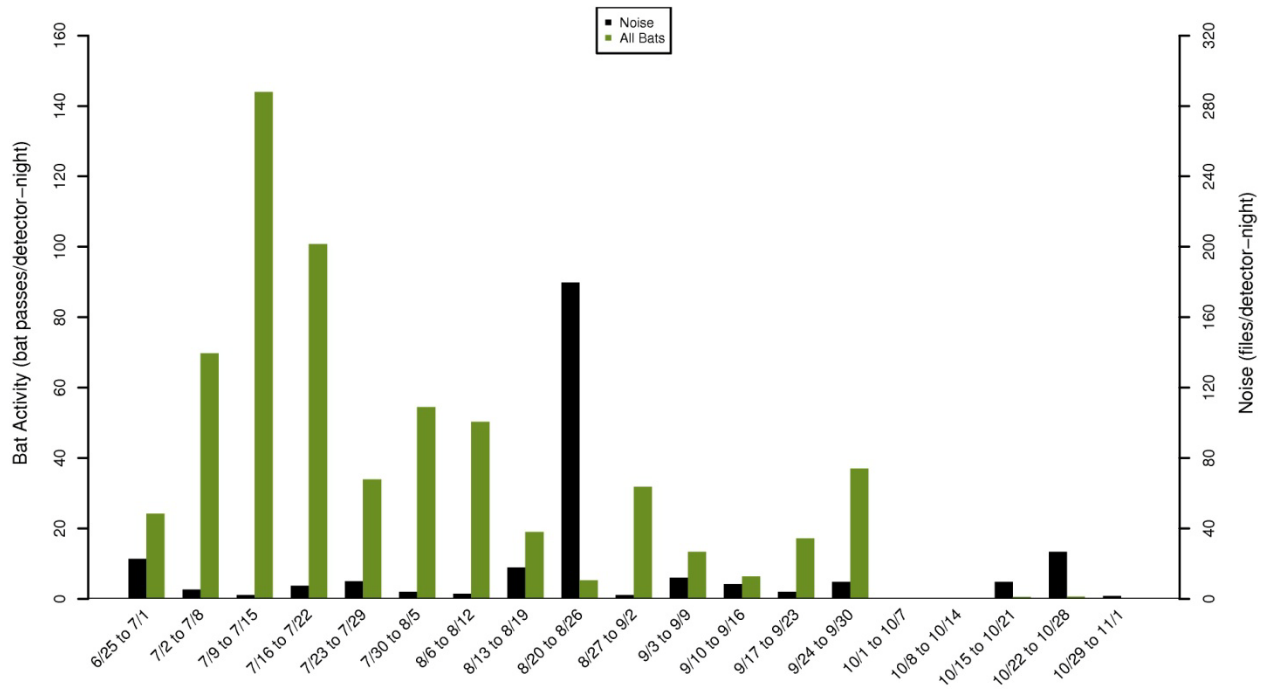


Figure 4. Bat activity and noise files recorded per detector-night within the CWRA; June 25 – November 1, 2010, presented weekly.

In total, 4,013 bat passes were recorded at station CA1 on 102 detector nights, yielding a mean of 39.34 passes/detector-night (Table 2). Overall, passes by MF bats (79.6% of all passes) outnumbered passes by LF bats (15.5%) and HF bats (4.9%; Table 2; Figure 5). Mid-frequency passes averaged 31.32 per detector-night compared to 6.10 and 1.92 bat passes per detector-night by LF and HF species, respectively.

Table 2. Results of Anabat detector acoustic bat surveys conducted at the CWRA, June 25 – November 1, 2010, separated by call frequency (high-frequency [HF], mid-frequency [MF], and low-frequency [LF]).

Station	HF-Calls	MF-Calls	LF-Calls	Eastern Red Bat Calls[a]	Hoary Bat Calls[b]	Total Bat Passes	Detector-Nights	Bat Passes / Detector-Night[*]
CA1	196	3,195	622	5	4	4,013	102	39.34±5.49
Total	**196**	**3,195**	**622**	**5**	**4**	**4,013**	**102**	**39.34±5.49**

[a]Passes by eastern red bats are included in mid-frequency (MF) numbers; [b]Passes by hoary bats included in low-frequency (LF) numbers. [*]± bootstrapped standard error.

The study was divided into two seasonal survey periods: summer and fall. Summer corresponded with the estimated maternity season, June 25 – August 15, 2010. The fall season was based on the migration period for bats in the northeast US, August 16 – November 1, 2010. Bat activity varied between and within seasons (Table 3; Figure 6). Overall bat activity was substantially higher during the estimated summer maternity season, averaging 65.58 bat passes per detector-night compared to bat activity during the fall migratory season, which averaged 12.06 bat passes per detector-night (Table 3 and Figure 6).

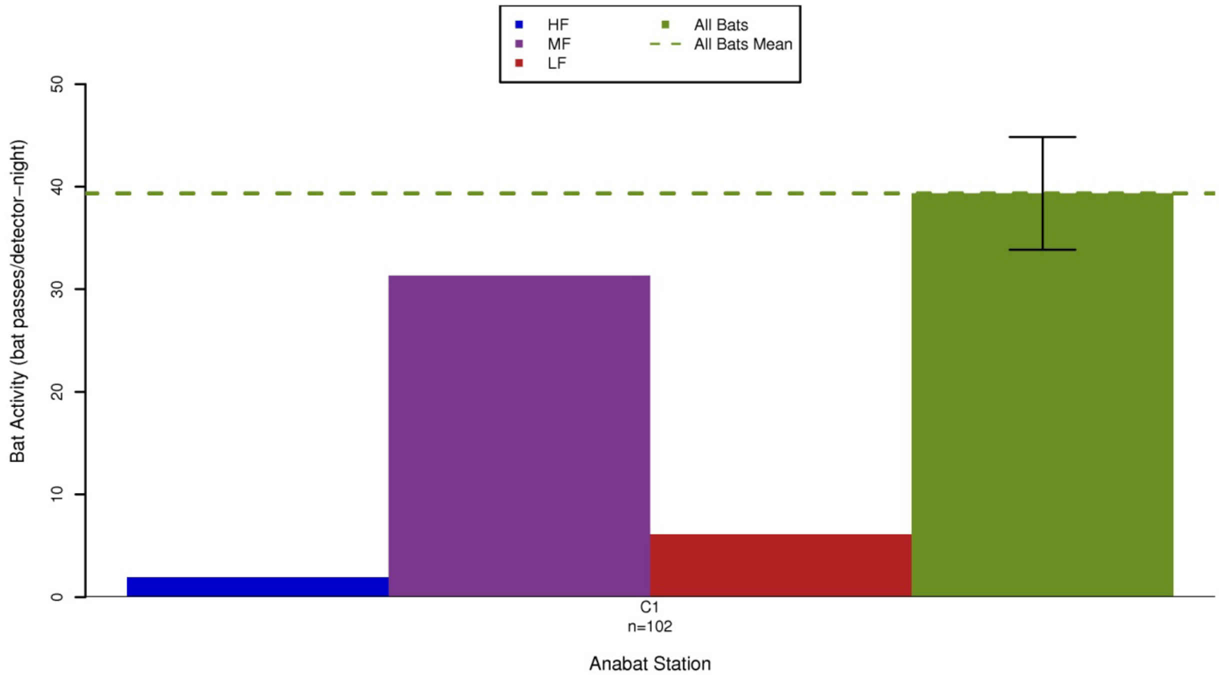


Figure 5. Bat activity (bat passes/detector-night) by frequency group recorded at Anabat station CA1 within the CWRA, June 25 – November 1, 2010. Error bars represent standard errors.

Activity by mid- and low-frequency species was greater during the summer maternity season than during fall migration (Table 3; Figure 6). Activity by high-frequency (HF) bats averaged 1.85 bat passes per detector-night during the maternity season and 2.0 bat passes per detector-night during migration. Low-frequency (LF) species activity averaged 7.81 bat passes per detector-night during the maternity season and 4.32 bat passes per detector-night during migration. Activity by mid-frequency (MF) species averaged 55.92 bat passes per detector-night during summer and decreased to 5.74 passes per detector-night during migration.

Table 3 Mean nightly pass rates by pass type, station, and season. Pass types are high-frequency (HF), mid-frequency (MF), low-frequency (LF), and all bats (AB) within the CWRA, June 25 - November 1, 2010.

Station	Pass type	Summer Maternity 6/25/2010 to 08/15/2010	Fall Migration 816/2010 to 11/01/2010
CA1	LF	7.81	4.32
CA1	MF	55.92	5.74
CA1	HF	1.85	2
CA1	AB	65.58	12.06
Total	**LF**	**7.81±1.04**	**4.32±0.70**
Total	**Mid**	**55.92±8.43**	**5.74±1.82**
Total	**HF**	**1.85±0.71**	**2.00±0.44**
Total	**AB**	**65.58±8.84**	**12.06±2.34**

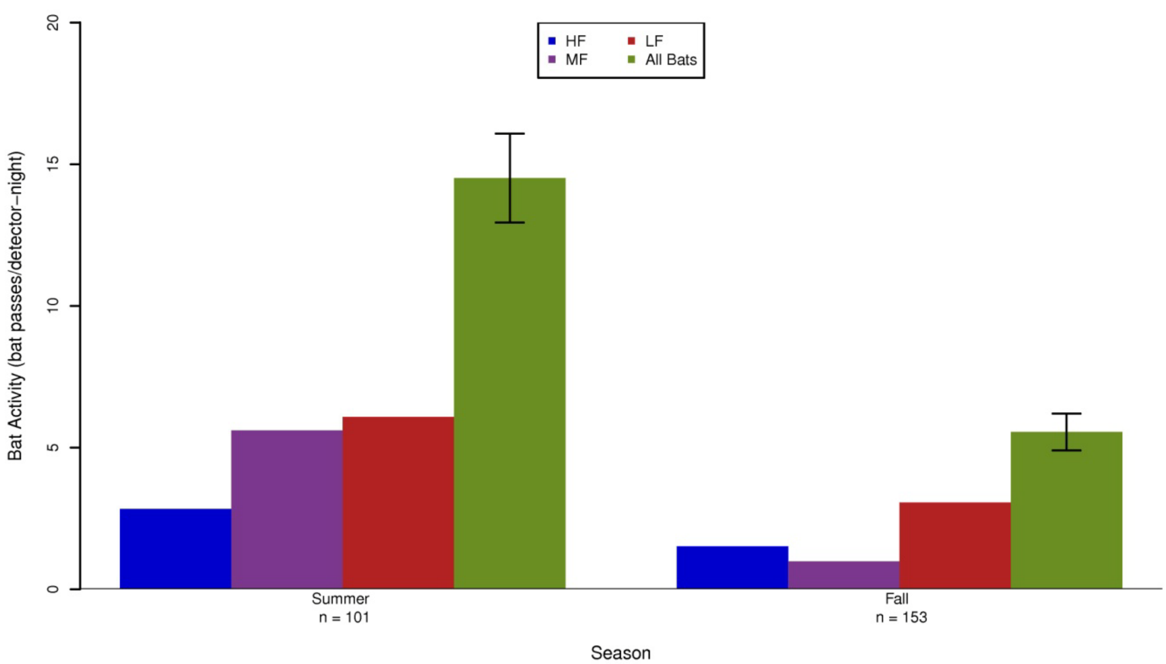


Figure 6. Seasonal bat activity in the CWRA; Summer Maternity (June 25- August 15, 2010) and Fall Migration (August 16-November 1, 2010). The bootstrapped standard errors are represented in the 'All Bats' columns.

The period of highest bat activity within the study area was estimated by taking the maximum average bat activity rate for any seven day period, not restricted to a particular starting date. If two or more consecutive seven day periods had this maximum rate, the start date and end date for peak activity was determined to be the start date of the first seven day period through the end date of the last seven day period. Peak bat activity was estimated for the maternity season, the fall migration season and for the entire study period (Table 4; Figure 7).

Bat activity for all groups was highest between July 14 and July 20, 2010. This pattern was similar for high- and mid-frequency groups throughout the entire study period, and during the maternity season. Activity by HF bats peaked from July 11-17 and MF activity peaked from July 14-20. Both overall and maternity season activity for LF bats occurred later in the summer, August 10-16, and is more indicative of the onset of migratory activity for this site than the timing of maternity activity. During fall migration, peak activity for all frequency groups and MF bats occurred from September 24 to September 30. Peak activity for HF and LF species peaked a month earlier, August 22- August 30, 2010 and August 25-August 31, respectively (Table 4; Figure 7).

Table 4. Highest activity rates in a seven day period, unconstrained by calendar week, sorted by call frequency (high frequency [HF], mid frequency [MF], and low frequency [LF]) and by identified species (hoary and eastern red bat) for the overall study period, summer maternity season, and the fall migration period, June 25-November 1, 2010.

Period of Interest	Seven Day Period of Highest Activity Rate	Mean activity rate within seven day period described as bat passes/detector night
All Bats		
Overall	07/14/10 to 07/20/10	158.57
Summer Maternity	07/14/10 to 07/20/10	158.57
Fall Migration	09/24/10 to 09/30/10	37.00
HF Bats		
Overall	07/11/10 to 07/17/10	7.86
Summer Maternity	07/11/10 to 07/17/10	7.86
Fall Migration	08/22/10 to 08/30/10	4.25
MF Bats		
Overall	07/14/10 to 07/20/10	143.29
Summer Maternity	07/14/10 to 07/20/10	143.29
Fall Migration	09/24/10 to 09/30/10	32.50
LF Bats		
Overall	08/10/10 to 08/16/10	14.86
Summer Maternity	08/07/10 to 08/13/10	14.57
Fall Migration	08/25/10 to 08/31/10	12.25
Hoary Bats		
Overall	09/02/10 to 09/13/10	0.33
Summer Maternity	07/14/10 to 07/27/10	0.14
Fall Migration	09/02/10 to 09/13/10	0.33
Eastern Red Bats		
Overall	08/11/10 to 08/17/10	0.57
Summer Maternity	08/06/10 to 08/16/10	0.43
Fall Migration	08/22/10 to 09/01/10	0.25

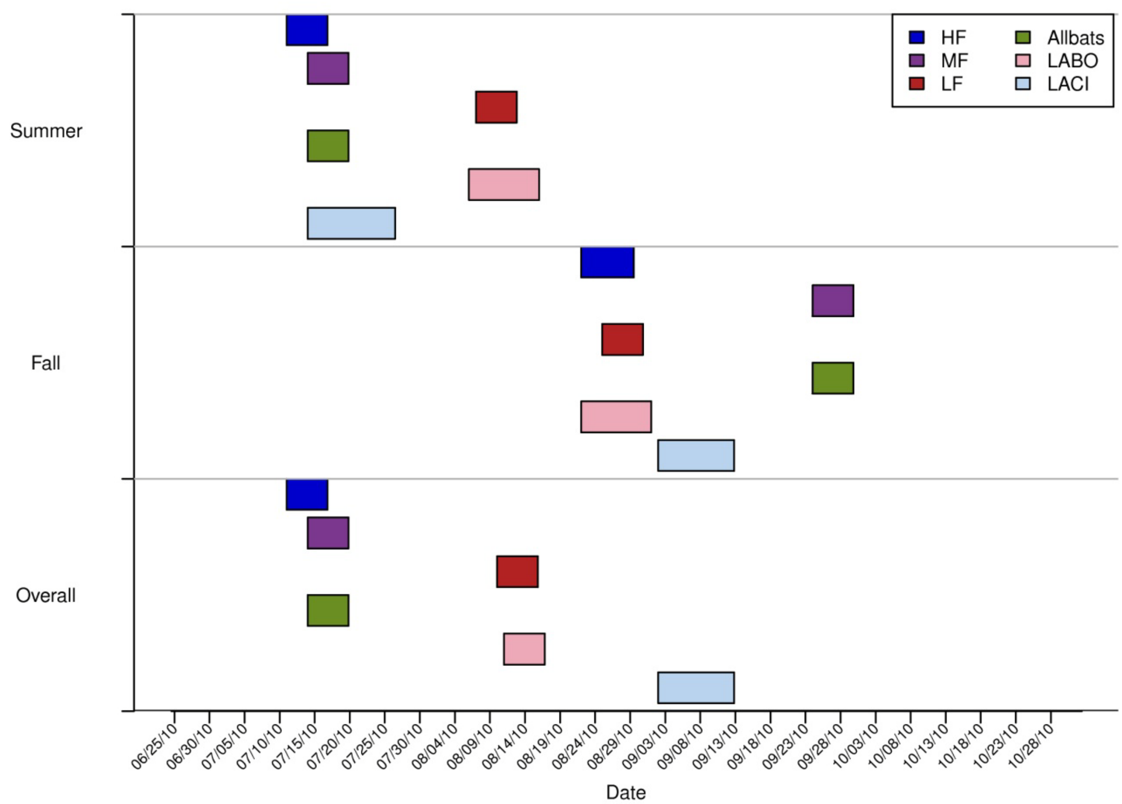


Figure 7. Highest activity rates recorded within a seven night period, sorted by call frequency (high frequency [HF], mid frequency [MF], low frequency [LF]), by season and overall for the CWRA, June 25-November 1, 2010.

Overall bat activity followed a positive skew distribution from the start of the study through the last week of August, and this pattern was largely driven by MF passes (Figure 5). After late August, bat activity was lower, with activity spikes during the weeks of August 27 and September 24. Whereas bat activity at CWRA was dominated by MF bat passes in July and the first half of August, the relative contribution of MF bats declined markedly by mid-August, and with the exception of a late September influx, was approximately on par with activity by HF and MF species in late summer and early fall (Figure 5).

The number of passes attributable to eastern red and hoary bats during the 2010 maternity season was low (nine passes for the two species combined; Table 2). Passes identified as hoary bats (four passes) comprised only 0.10% of total passes detected and only 0.64% of all LF passes. The majority of recognizable hoary bat activity occurred during the first week of September (0.33%; Figure10), which corresponds to the peak activity level for this species during fall migration. During the maternity season, peak activity extended over a 14 day period, July 14-July 27, 2010, with a mean of 0.14 bat passes/detector-night (Table 4). No hoary bats were detected after September 10, 2010 (Figure10).

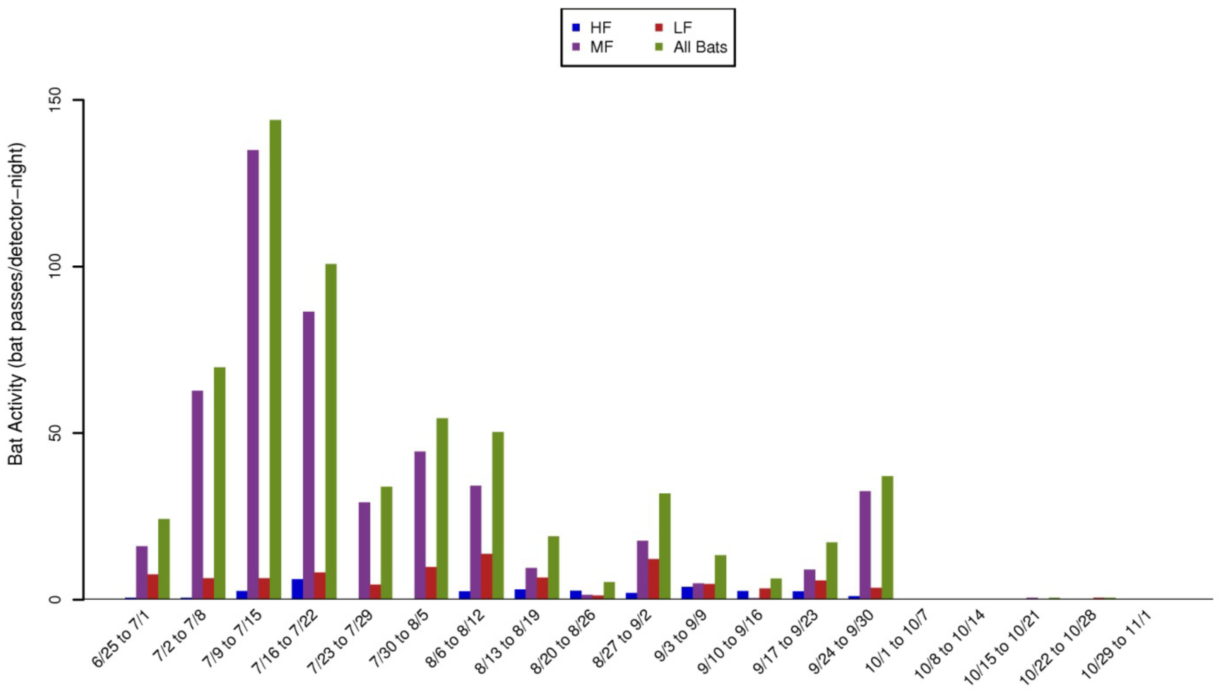


Figure 8. Weekly activity of high-frequency (HF), mid-frequency (MF), and low-frequency (LF) bats within the CWRA, June 25 – November 1, 2010.

Passes recognizable as eastern red bats accounted for only 0.12% of all passes and only 0.16% of all MF calls (Table 2). The majority of recognizable eastern red bat activity occurred during the first two weeks of August (0.57%, Figure10), with peak activity occurring from August 11-August 17. Activity by eastern red bats was concentrated from August 6-August 16 during summer and August 22-September 1 during fall (Table 4). No eastern red bats were detected after September 2, 2010 (Figure10).

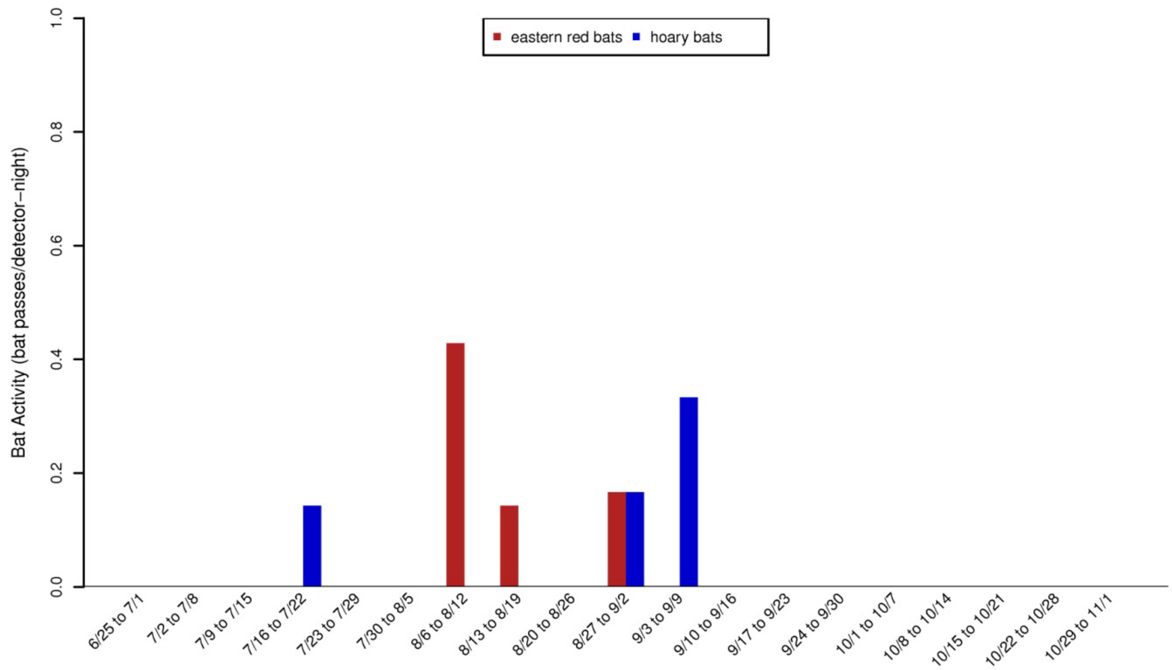


Figure 10. Weekly activity by hoary and eastern red bats recorded within the CWRA, June 25 – November 1, 2010.

SM2BAT Acoustic Surveys with Zero-Crossing Analysis

In addition to recording echolocation calls in full-spectrum, the SM2Bat has a zero-crossing function that can convert the data to an Anabat-compatible (i.e., zero-crossing) format. For the purposes of estimating general bat activity in CWRA, SM2Bat data recorded during this study were converted to Anabat files, and treated in the same manner as data collected by the Anabat unit (See Methods above). However, the conversion of SM2Bat data to zero-crossing data is not without loss, so no comparison of activity measured by the SM2Bat is made between the Anabat or with other wind facilities. In addition, due to the limited data collected by the SM2Bat during the maternity and migratory seasons, no analysis was conducted to compare temporal distribution of bat activity during these seasons.

Bat echolocation was sampled by an SM2BAT unit (CS1) in the CWRA at one sampling location between August 4 and November 1, 2010 (Figure 2). The SM2Bat unit recorded data from sunset to sunrise on the nights it was deployed and active. In total the unit collected data on 30 of 43 detector nights (Figure 11). The loss of battery power and mechanical or electronic problems interrupted data collection on portions of weeks October 6-12 and October 20-27.

The number of noise files on a given night ranged from zero to 7,183 files, with peak noise recorded on the night of August 8, 2010 (Figure 12). Noise interference was most likely largely the result of rasping insects (eg, katydids) that are highly active at this time of year (Elliott and Hershberger 2007). During the first deployment period, August 4-August 10, the number of noise files was large relative to the number of bat calls. During the second deployment (August 18-24), noise files again exceeded bat calls recorded but at a substantially smaller ratio, and during the third deployment (September 8-21), bat calls often exceeded noise files on a nightly basis. The loss of battery power and mechanical or electronic problems interrupted data collection on portions of weeks October 6-12 and October 20-27. Data collection only occurred on a single night during the fourth deployment (October 6-12) and on only three nights during the final deployment (October 20-27).

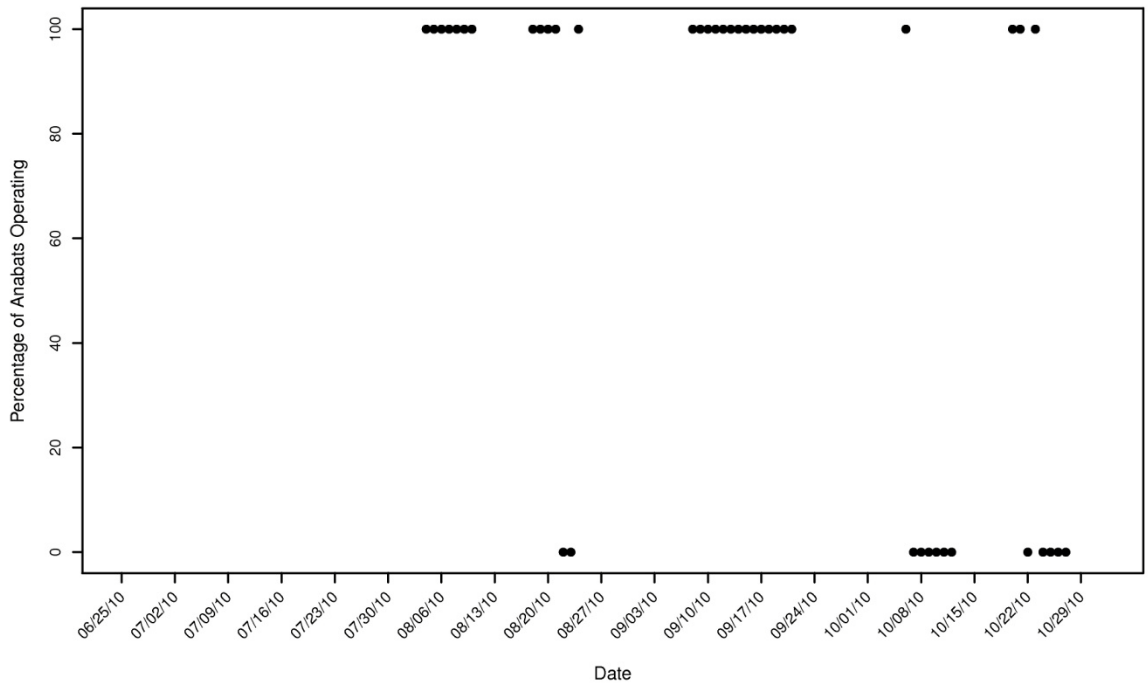


Figure 11. Proportion of SM2Bat detectors (n = 1) operating during each night of the study period for which it was deployed within the CWRA, August 4 – November 1, 2010.

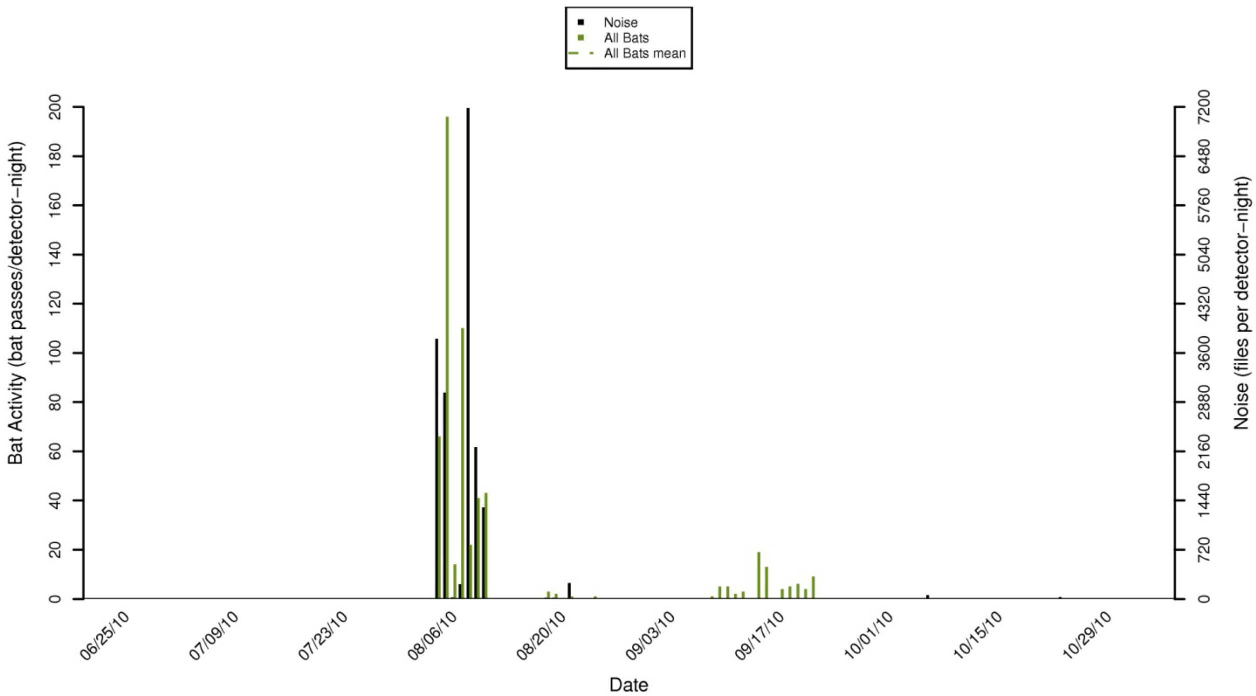


Figure 12. Bat activity and noise files recorded by the SM2Bat unit (CS1) per detector-night within the CWRA, August 4 – November 1, 2010, presented nightly.

A total of 575 bat passes were recorded at CS1 on 30 detector nights, yielding a mean of 19.17 passes per detector-night (Table 5). Overall, passes by LF bats (74.1% of all passes) outnumbered passes by MF bats (15.7%) and HF bats (10.3%; Table 5; Figure 13). Low-frequency species had a mean of 14.20 passes per detector night compared to 3.00 and 1.97 bat passes per detector night by MF and HF species, respectively.

Table 5. Results of SM2Bat detector acoustic bat surveys conducted at the CWRA, August 4 – November 1, 2010, separated by call frequency (high-frequency [HF], mid-frequency [MF], and low-frequency [LF]).

Station	HF-Calls	MF-Calls	LF-Calls	Eastern Red Bat Calls[a]	Hoary Bat Calls[b]	Total Bat Passes	Detector-Nights	Bat Passes / Detector-Night[*]
CS1	59	90	426	1	0	575	30	19.17±7.73
Total	**59**	**90**	**426**	**1**	**0**	**575**	**30**	**19.17±7.73**

[a]Passes by eastern red bats are included in mid-frequency (MF) numbers; [b]Passes by hoary bats included in low-frequency (LF) numbers. [*]± bootstrapped standard error.

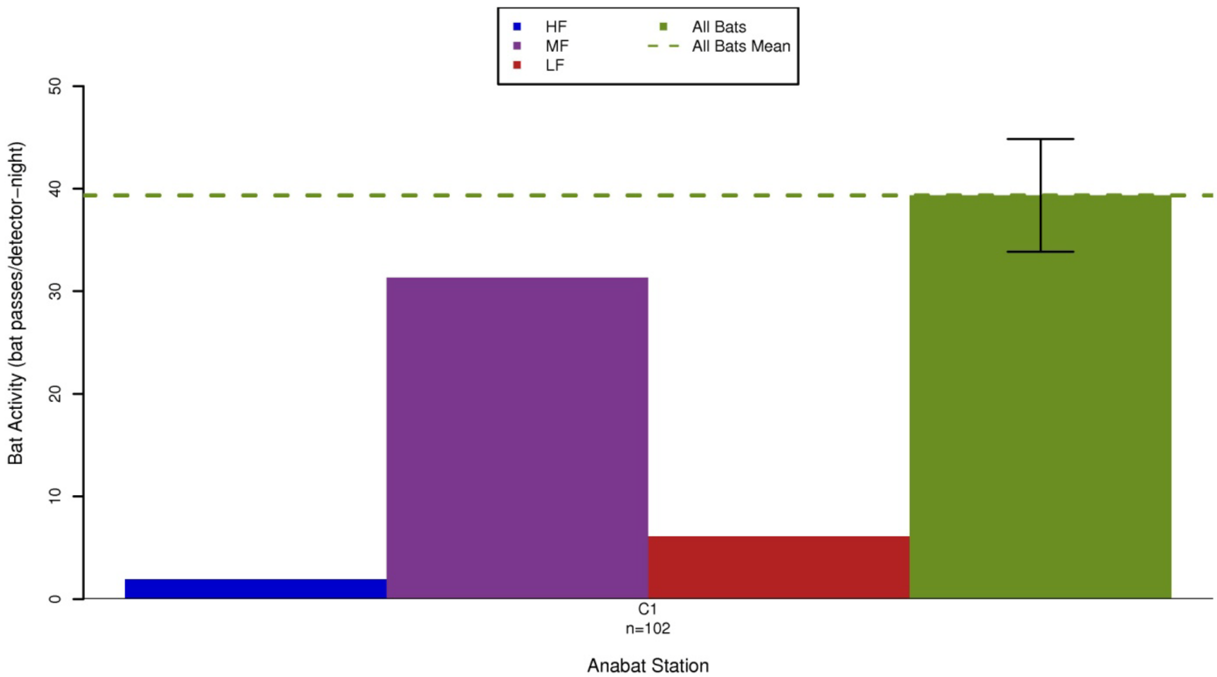


Figure 13. Bat activity (bat passes/detector-night) by frequency group recorded at SM2Bat station CS1 in the CWRA from August 4 – November 1, 2010. Error bars represent standard errors.

The SM2Bat sampling protocol was not designed to evaluate temporal trends or patterns. In general, bat activity was highest the first week of August and lower later in the season (Figure 14). Comparing rates on a nightly basis, bat activity was markedly higher during the first deployment of the SM2Bat (i.e., early August) than during any other deployment period (Figure 15). The peak nightly activity level for the entire survey period, 196 bat passes, was recorded on August 5, 2010.

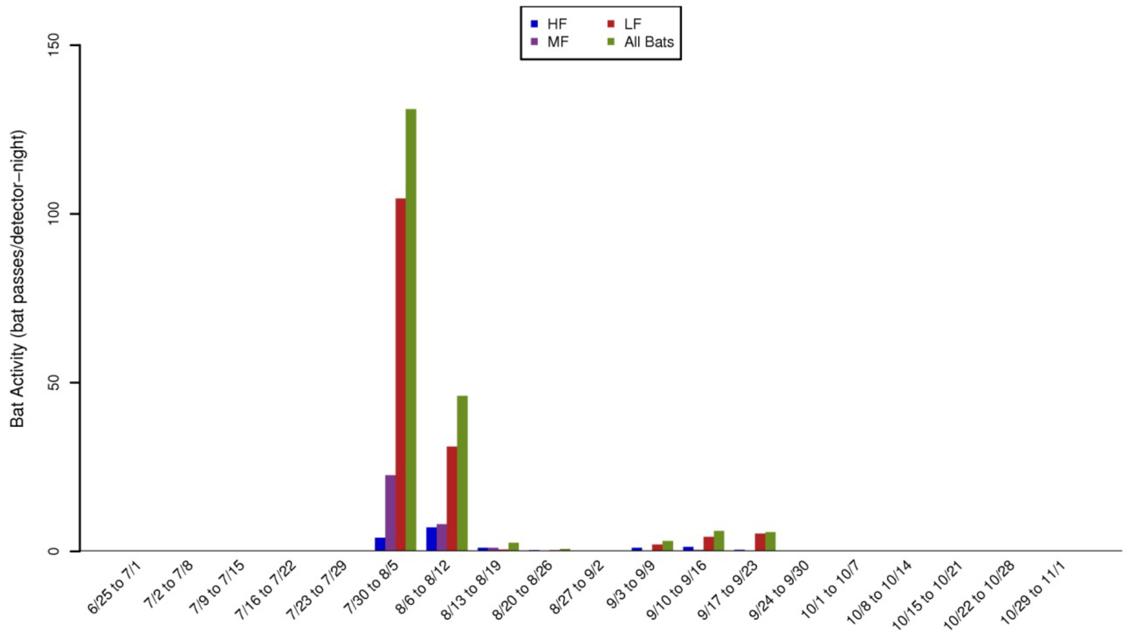


Figure 14. Weekly activity of high-frequency (HF), mid-frequency (MF), and low-frequency (LF) bats within the CWRA, June 25 – November 1, 2010, measured by SM2Bat.

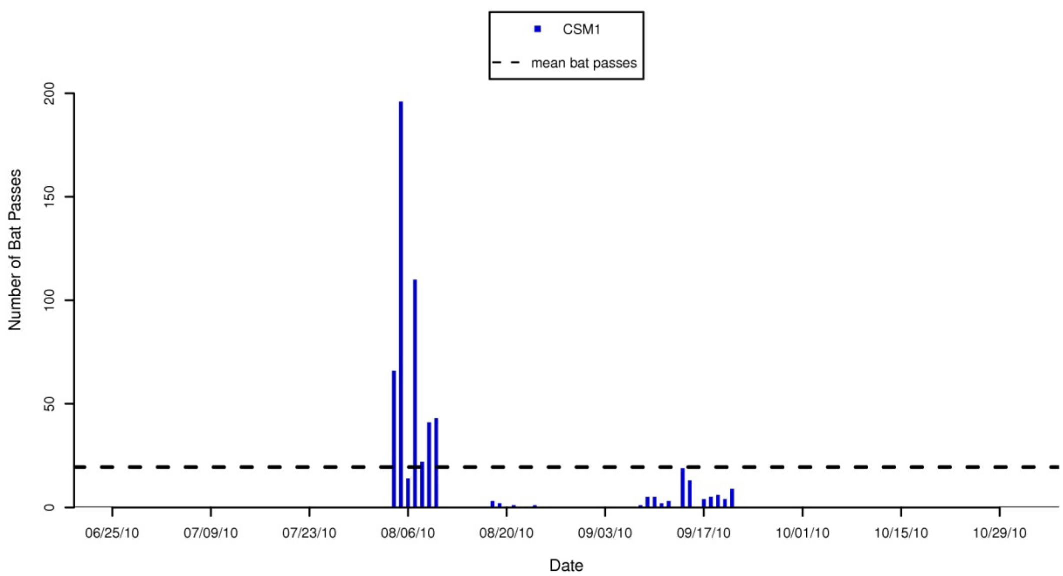


Figure 15. Nightly bat activity measured by SM2Bat within the CWRA, during five sampling periods, August 4-10, August 18-24, September 8-21, October 6-12, and October 20-27, 2010.

SM2BAT Acoustic Surveys with SonoBat™ Analysis

As with the Anabat data, the full-spectrum study period was divided into two biologically relevant seasons: maternity season (August 4-August 15) and migration season (August 16-November 1, 2010). There were a total of 7 detector nights during the maternity season and 23 detector nights during the migratory season in which data was collected and species identified. Of the 11,770 total files collected, 3,307 contained bat calls (28.1%). Of these 3,307 files, 441 files (13.3%) were classified to frequency group and species. Based on these results, six species were confirmed to have been present in the CWRA area during the 2010 study (Table 6). Of the calls classified to species, silver-haired bat was detected on 16 detector nights (53.3%), followed by hoary bat (seven detector nights; 23.3%), big brown bat (six detector nights; 20.0%) and eastern red bat (five detector nights; 16.7%). Tri-colored bat (*Perimyotis subflavus*) and little brown bat (*Myotis lucifugus*) were identified on three (10.0%) and one detector nights (3.3%), respectively (Table 6).

Table 6. Bat species identified during the SM2Bat detector acoustic monitoring survey at the CWRA by number of detector nights (n) and percentage of detector nights each species was identified.

Species		Study Period (n=30) August 4-Nov 1, 2010	
Common Name	**Scientific Name**	**Detector Nights**	**Percentage of Nights**
Silver-haired bat	*Lasionycteris noctivagans*	16	53.3
Hoary bat	*Lasiurus cinereus*	7	23.3
Big brown bat	*Eptesicus fuscus*	6	20.0
Eastern red bat	*Lasiurus borealis*	5	16.7
Tri-colored bat*	*Perimyotis subflavus*	3	10.0
Little brown bat	*Myotis lucifugus*	1	3.3

*formerly known as eastern pipistrelle

The proportion of nights each species was identified differed seasonally (Table 7; Figure 16). Of the seven nights data was collected during the maternity season, silver-haired bat, big brown bat, and hoary bat were identified on six nights (85.7%), followed by eastern red bat (four nights; 57.1%) and tri-colored bat (three nights; 42.9%). Little brown bat was not identified during the maternity season (Table 7). Silver-haired bat was identified on ten of the 23 nights (43.5 %) sampling occurred during the migration season, while hoary bat, little brown bat, and eastern red bat were each recorded on a single night (4.3%). Big brown bat and tri-colored bats were not identified during the migratory season.

Table 7. The number of detector nights (n) and percentage of detector nights with bat species identified during the maternity and migratory seasons at the CWRA.

	Maternity Season (n=7) August 4-August 15, 2010		Migration Season (n=23) August 16-November 1, 2010	
Species	**Detector Nights**	**% of Nights**	**Detector Nights**	**% of Nights**
Big brown bat	6	85.7	0	0
Eastern red bat	4	57.1	1	4.3
Hoary bat	6	85.7	1	4.3
Silver-haired bat	6	85.7	10	43.5
Little brown bat	0	0	1	4.3
Tri-colored bat	3	42.9	0	0

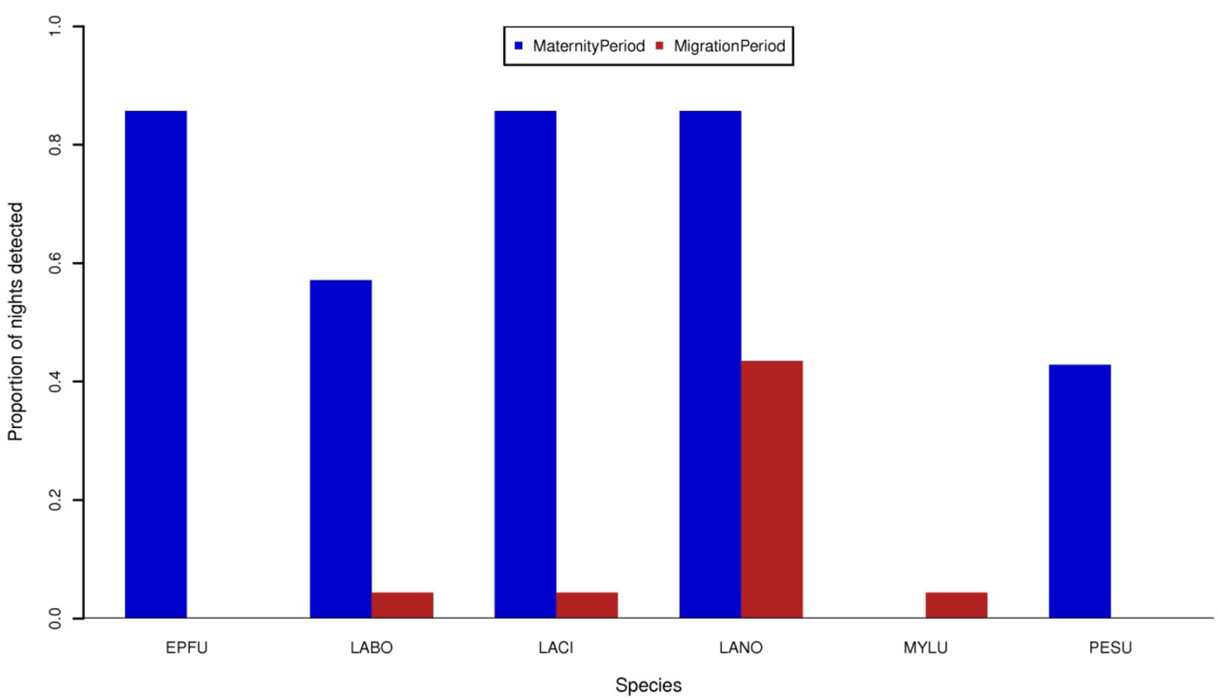


Figure 16. Proportion of detector nights that each species was recorded and identified by at least one bat call, presented by maternity and migratory seasons within the CWRA during the study period, August 4 – November 1, 2010.

*EPFU=big brown bat; LABO=eastern red bat; LACI=hoary bat; LANO=silver-haired bat; MYLU=little brown bat and PESU=tri-colored bat (formerly known as eastern pipistrelle).

The three most commonly identified species (big brown, silver-haired, and hoary bats) all produce low-frequency echolocation calls (Table 1). The eastern red bat, little brown bat, and tri-colored bat are grouped in the mid to high frequency class, producing calls above 30 kHz. These HF/MF species were consistently identified on fewer detector-nights proportionally than LF species. Therefore, when divided by frequency group across the entire study period and by season, low frequency species were identified on more detector-nights than high/mid-frequency species (Table 8). During the maternity season, high/mid-frequency species were detected on six nights (85.7%); low-frequency species were detected on 100% of the seven detector-nights. During migration, low-frequency species were recorded on 10 detector-nights (43.5%) and high/mid-frequency species were identified on only two nights (8.7%). Across the entire study period, high/mid-frequency species were identified on eight of the 30 detector-nights (26.7%) compared to low-frequency species which were identified on 17 nights (56.7%; Table 8).

Table 8. The number of detector nights (n) and percentage of detector nights with high/mid-frequency and low-frequency bat species groups identified during maternity and migratory seasons at the CWRA, August 4-November 1, 2010.

	Maternity Season (n=7) August 4-August 15, 2010		Migration Season (n=23) August 16-November 1, 2010		Total: Study Period (n=30) August 4-November 1, 2010	
Frequency Class	**Detector nights**	**%**	**Detector nights**	**%**	**Detector nights**	**%**
High/Mid-Frequency	6	85.7	2	8.7	8	26.7
Low Frequency	7	100	10	43.5	17	56.7

DISCUSSION

This report reviewed results from the period June 25 – November 1, 2010, a period encapsulating the majority of the summer bat maternity and fall bat migratory season in central Connecticut. Two Anabat detectors (CA1 and CA2) were used as part of the acoustic monitoring study, however, electronic or mechanical problems with the Anabat detector located at the CA2 station led to removal of those data from the analysis[1]. Based on bat activity monitored by the Anabat detector at station CA1 from June 25 to November 1, 2010, bat activity averaged 39.3 passes per detector-night, and was highest during July.

Eight species of bats have the potential to occur within the CWRA (Table 1), all of which have been recorded as casualties at wind energy facilities. The project contains forestlands and some forested wetlands which likely support tree-roosting bat species of the region. These habitat types are not unique to the site; nor do they occur in greater abundance or quality relative to the surrounding region, based on landcover imagery and the results of the VHB habitat analysis.

Bat echolocation calls recorded by Anabat detectors were classified to frequency groups (Table 1). Overall, passes by mid-frequency passes (79.6% of all passes) outnumbered low- and high-frequency passes (15.5% and 4.9%, respectively). This suggests a higher relative abundance of MF species (little brown and eastern red bats) compared to LF or HF species.

[1]Inspection of the detector and determination of the malfunction(s) will be performed by the manufacturer (Titley Electronics), which is located in Australia.

Temporal patterns of bat activity by frequency class varied during the study period. The period of largest discrepancy in activity between passes in the mid-frequency class and those in the low- and high-frequency classes was in late-June, July and the first two weeks of August. A full-spectrum SM2Bat detector was deployed beginning August 4, and therefore began recording data after the period when the most MF passes were recorded by the Anabat. However, the general shape and frequency range of many of the MF passes suggest that they may have been non-typical calls produced by big-brown bat, which may produce higher-frequency calls near roosts and/or while echolocating in the presence of acoustic clutter (Surlykke and Moss 2000). It is possible that the forest and shelter-belt surrounding CA1 may have influenced echolocation call structure such that the typically LF producing big brown bat was elevated into the mid-frequency range. While presence of one or more roosts near Station CA1 is unknown, the rather abrupt decrease in MF passes in mid-August and the absence of big brown bat passes during the fall migration season (as reflected in the full-spectrum analysis results) suggests that a maternity colony may have been located nearby, and that it had dispersed by approximately mid-August.

Eastern red bat is a long-distance migratory tree roosting bat and is one of the three species found most often as casualties at wind-energy facilities (Kunz et al. 2007b). Surprisingly very few (less than 1 %) MF-bat calls recorded were identified as being produced from eastern red bats, although due to the conservative approach for determine species it is likely that not all eastern red bat (or hoary bat) calls were identified as such.

Based on the information available concerning the ecology and habitat use of bat species in New England (DeGraaf and Yamasaki 2001), the majority of HF-bats recorded at may have been northern long-eared bat, a species with the anatomy and ability to forage within forested areas (Lacki et al. 2007). Although this was not supported by the results of the analysis of full-spectrum data, which did not identify any northern long-eared bats, the low-intensity echolocation used by this species may make it more difficult to detect acoustically (Broders et al. 2004). Some of the calls within the HF group may also have been produced by little brown bats or tri-colored (DeGraaf and Yamasaki 2001), both of which were identified during the full-spectrum analysis, but did not seem to be common, at least in late summer and fall.

LF-bats with the potential to occur within the study area include hoary, silver-haired, and big-brown bat. This group of bats tends to be larger in size, with wing shape and echolocation style that is adapted for generally open-air foraging (Norberg and Rayner 1987, Lacki et al. 2007). Hoary bats comprised only 0.10% of all LF passes with only four calls identified. The small number of recognizable hoary bat calls recorded within the study area may be due to the conservative approach taken to determine species identification. Little is known about summer populations of silver-haired bats in Connecticut, but, like big brown bats, use forest clear-cuts and other less acoustically cluttered areas. Both are likely to forage along forest edges, with silver-haired bats using air-space closer to the ground than big brown bats (DeGraaf and Yamasaki 2001). Similar studies at other proposed wind-energy facilities have shown a higher number of LF-bat calls recorded at elevated units and higher numbers of HF-bat calls recorded at ground-based units (Collins and Jones, 2009).

The overall number of bat calls detected per night at the CWRA was highest during mid-July and likely corresponds to the time when pups are being weaned and have joined the adult population in foraging. During lactation, energy requirements are at their highest for female bats and as such foraging is increased (Kurta et al. 1989, Lacki et al. 2007). In addition, juvenile bats begin to fly prior to weaning increasing the number of calls recorded. In New England, young of hoary, silver-haired, and big brown bats are typically born in late-May-early June, June-July, and June, respectively and it is likely that weaning occurs at approximately 5-6 weeks (DeGraff and Yamasaki 2001; Barclay and Harder 2005). However, the timing of reproductive events may vary by several weeks in any given year or among individuals that comprise a maternity colony, depending on a number of external factors (eg, temperature (Wilde et al. 1999) and precipitation (Grindal et al. 1992). Calls recorded from the last week of August are likely to represent migrating bats traveling through the area.

The results from the full spectrum analysis of data indicate the presence of six species of bat within the CWRA during the study period: big brown bat, eastern red bat, hoary bat, silver-haired bat, little brown bat and tri-colored bat. The only species with potential to occur that were not identified by call were the Indiana and northern long-eared bats. Station CS1 unit was located along an abandoned forest track at a proposed turbine location within deciduous forest in the northwest corner of the CWRA (Appendix B). The SM2Bat unit was placed along the edge of a beaver pond and wetland complex between the two Anabat stations. Open water is considered a feature attractive for bats for foraging, and placement of the SM2Bat unit at this location was intended to maximize the potential to record and identify the species of bats that occur in the project area.

Not all species identified were detected in both the maternity and migratory seasons. The SM2Bat unit could not be deployed until the beginning of August, so species composition during the maternity season assessed by the SM2Bat may not be fully representative. The pattern of detection indicates that some species (e.g., big brown bat) are likely residents within the project area, whereas other species (e.g., silver-haired bat) primarily pass through during transit between summer and winter territories. Species composition during the first week of August is likely to have reflected both resident species and migratory species engaged in early migratory movement within the area. Results from the Anabat analysis of calls to species (i.e.,hoary and eastern red bat) suggest that SM2BAT captured the peak of eastern red bat maternity activity but missed the hoary bat peak of activity during the maternity season. A conservative approach to species identification is taken during the analysis of data files. For analysis, Sonobat was reported identification to species if call quality was ≥80% and if discriminant probability was ≥90%. Therefore, only a portion of recorded calls were identified to species. Bat passes that were not identified with certainty by Sonobat, included those that contained primarily fragmented calls and those produced by bat species that have inherently similar echolocation with overlapping call characteristics. Two such species, northern long-eared bat and Indiana bat, were not identified during the full-spectrum analysis. However, the absence of calls identified to these species does not provide definitive proof of species absence.

Potential Impacts

Assessing the potential impacts of wind energy development to bats is confounded due the proximate and ultimate causes of bat fatalities at turbines being poorly understood (Kunz et al. 2007b, Baerwald et al. 2008, Cryan 2008, Cryan and Barclay 2009). In addition, the monitoring of elusive, night-flying animals is inherently difficult (O'Shea et al. 2003) and although installed wind energy capacity has increased rapidly in recent years, the availability of results from well-designed studies from these projects has lagged (Kunz et al. 2007b).

Nonetheless, monitoring studies at constructed wind energy facilities suggest that:

a) bat mortality shows 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 casualties, and;
d) some of the highest reported fatalities occur at wind energy facilities located along forested ridge tops in the eastern and northeastern US .

Based on these patterns, current guidance on estimating potential mortality levels of a proposed wind energy development involves the evaluation of on-site bat acoustic data including activity levels, seasonal variation, and species composition (Kunz et al. 2007b), as well as comparing overall results with regional data. There are few instances where both bat activity and bat mortality have been recorded at wind energy facilities and where results are comparable. For this reason, a definitive relationship between pre-construction bat activity and post-construction bat mortality has not been established empirically. From the data available, there appears to be a positive correlation between the two variables and there is the expectation amongst the scientific and resource management communities that when more data become available this relationship will hold (Kunz et al. 2007a). Datasets such as that provided by the current study will further contribute to our understanding of this relationship. Table 4 summarizes the results of publically-available activity and fatality data from wind energy facilities in the eastern US and Canada. To our knowledge, activity data for studies listed in Table 4 were collected using ground-based Anabat detectors.

Table 9. Summary of publically available bat activity and bat fatality data from wind energy facilities in eastern North America.

Wind Energy Facility	Bat Activity Estimate[A]	Fatality Estimate[B]	No. of Turbines	Total MW
Colebrook, CT	*39.34*	*n/a*	*6*	*9.6*
Buffalo Mountain, TN (2006)		39.70	18	29
Mountaineer, WV	38.3	31.69	44	66
Buffalo Mountain, TN (2000-2003)	23.7	31.54	3	2
Meyersdale, PA		18.00	20	30
Cohocton/Dutch Hill, NY		16.02	50	125
Casselman, PA		15.66	23	34.5
Maple Ridge, NY (2006)		15.00	120	198
Noble Bliss, NY (2008)		14.66	67	100
Mount Storm, WV (2008)	35.2	12.11	82	164
Maple Ridge, NY (2007)		9.42	195	321.75
Noble Clinton, NY (2009)		6.48	67	100
Wolfe Island, Ont.		6.42	86	197.8
Noble Bliss, NY (2009)		5.50	67	100
Noble Ellenburg, NY (2008)		5.45	54	80
Noble Ellenburg, NY (2009)		5.34	54	80
Ripley, Ont.		4.67	38	76
Noble Clinton, NY (2008)		3.63	67	100
Lempster, NH (2009)	0.4	3.08	12	24
Mars Hill, ME (2007)		2.91	28	42
Stetson Mountain, ME	0.30	1.40	38	57
Munnsville, NY		0.46	23	34.5
Mars Hill, ME (2008)		0.45	28	42

A=bat passes per detector night
B=number of bat fatalities/MW/study period
C=averaged across phases and/or study years, and may not be directly related to mortality estimates
D=bat activity not measured concurrently with bat mortality studies
Data from the following sources:

Facility	Use Estimate	Mortality Estimate	Facility	Use Estimate	Mortality Estimate
Buffalo Mountain, TN (2006)		Fiedler et al. 2007			
Mount Storm, WV (2008)	Young et. al 2009	Young et. al 2009	Lempster, NH	Stantec 2006	Tidhar et al 2010
Cohocton/Dutch Hill, NY		Stantec 2010	Noble Ellenburg, NY (2009)		Jain et. al 2010
Munnsville, NY		Stantec 2009	Ripley, Ont.		Stantec 2009
Buffalo Ridge, MN (Phases II&III; 2001)	Johnson et al. 2004	Johnson et al. 2004	Wolfe Island, Ont.		Stantec 2010
Biglow Canyon I, OR (2009)		Enk et al. 2010	Mars Hill (2008)		Stantec 2009

Fatality estimates from post-construction monitoring at wind energy facilities in eastern North America range from 0.45 to 39.7 bats/MW/year (Table 4). Bat activity between June 25 – November 1 within the CWRA averaged 39.34±5.49 passes per detector-night, a value slightly higher than the range of the five facilities in the eastern US where pre- and post-construction data are available (range: 0.3-38.3; mean: 19.58).

However, bat activity during the fall migration period was lower (12.06±2.34) than the maximum seasonal estimates recorded at other facilities where pre- and post-construction data are available. In the context of pre-construction studies at proposed wind projects, the period of greatest risk to bats occurs at the blurry interface between the end of the maternity season and beginning of migration season. Overall bat activity was highest between July 14 and July 20, 2010 at the CWRA, whereas post-construction monitoring at wind energy facilities throughout North America show the highest number of bat casualties during fall migration (approximately mid-August through mid-September) with lower numbers in general in the summer and spring (Johnson 2005; Arnett et al. 2008). Peak bat activity bouts during the fall migration period were in late August through September, and it is expected that most bat fatalities at CWRA will occur during this period. The seasonal fall migration period activity estimate for the CWRA suggests the site is not located in an area which experiences high bat migration activity. There appears to be some latitudinal variation in the eastern US, such that higher numbers of fatalities are estimated for more southerly sites compared to those further north. This requires more data but may possibly reflect the migratory patterns of bats on a broad-scale in this region. For facilities within the region located in similar forest-dominated landscapes (e.g., Noble Ellenberg NY, Noble Clinton NY, Maple Ridge NY, Lempster NH, Stetson Mountain ME and Mars Hill ME) bat fatality have been low to moderate (Table 4). If patterns observed in regional studies are consistent, fatality rates for bats at the CWRA may be moderate.

The vast majority of formal post-construction mortality studies conducted in the Unites States have been completed at facilities with substantially larger numbers of turbines and MW capacity than what have been proposed for the CWRA. For example, studies included in Table 4 have an average 53.8 turbines (range: 3-195). The impact to bats from small wind facilities such as the CWRA may be lower in terms of the number of bats killed per year compared to these facilities, given that 6 turbines are proposed for the site.

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Appendix A. Photographs of Anabat Station CA1 Placement and Surrounding Habitat within the Colebrook Wind Resource Area for the Period of June 25 – November 1, 2010.

Appendix A. Photographs of Anabat station CA1 placement and surrounding habitat within the Colebrook Wind Resource Area for the period of June 25 – November1, 2010.

Pictures taken in clockwise direction with the top picture at the front of the station.

Appendix B. Photographs of Anabat Station CA2 Placement and Surrounding Habitat within the Colebrook Wind Resource Area for the Period of June 25 – November 1, 2010.

Appendix B. Photographs of Anabat station CA2 placement and surrounding habitat within the Colebrook Wind Resource Area for the period of June 25 – November 1, 2010.

Pictures taken in clockwise direction with the top picture at the front of the station.

Appendix C. Photographs of Anabat Station CS1 Placement and Surrounding Habitat within the Colebrook Wind Resource Area for the Period of August 4 – November 1, 2010.

Appendix C. Photographs of SM2Bat station CS1 placement and surrounding habitat within the Colebrook Wind Resource Area for the period of August 4 – November 1, 2010.

Pictures taken in clockwise direction with the top picture at the front of the station.