Bat Mist Netting and Acoustic Surveys
Beech Ridge Wind Energy Project
Greenbrier and Nicholas Counties, West Virginia

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1.0 Introduction and Background Information

Currently, Beech Ridge Energy, LLC (BRE) is working collaboratively with the U.S. Fish and Wildlife Service (USFWS) to develop an application for an Incidental Take Permit (ITP) pursuant to Section 10 of the Endangered Species Act (ESA) that would cover BRE's Beech Ridge Wind Energy Project (Project), located in Greenbrier and Nicholas Counties, West Virginia. Integral to the application, BRE is developing a habitat conservation plan (HCP) in accordance with applicable guidance and regulations (USFWS and NMFS 1996, USFWS and NOAA 2000). The proposed covered activities in the HCP include operation, maintenance, and decommissioning of the existing 67 turbines and associated infrastructure and construction, operation, maintenance, and decommissioning of up to 33 additional turbines and associated infrastructure at the Project.

The USFWS requested that BRE conduct additional surveys for bats at the Project site in order to compare data from previous site study results, and to provide additional information for the HCP including bat use and occurrence at the Project site during the summer and fall seasons. BRE developed a scope of work for the studies with input from USFWS (Carter 2010) and West Virginia Department of Natural Resources (WVDNR) (Stihler 2010 pers. comm.) to address the request and to insure the HCP and ITP are based upon the best available scientific information as required by the ESA.

BRE conducted mist-net surveys for bats at 15 net sites within the then proposed Project site from July 22-26, 2005. The surveys resulted in the capture of 78 bats of six species (see BHE 2005). BRE also conducted mist net surveys for bats at 12 net sites along the proposed 14.5 mile transmission line right-of-way, including six locations within one mile of proposed turbine sites, from June 12-22, 2006. The surveys resulted in the capture of 42 bats of five species (see BHE 2006). No Indiana bats (*Myotis sodalis*) or Virginia big-eared bats (*Corynorhinus townsendii virginianus*) were captured during either survey.

The primary objective for the current study was to provide additional information about bat species composition, occurrence, and activity at the Project site during the summer and fall seasons (WEST 2010). The purpose of netting during the summer and fall was to provide data on presence/probable absence of Indiana bats and Virginia big-eared bats during the summer maternity season and during the fall migration and swarming period (Carter 2010). The primary objective for acoustic surveys was to assess temporal patterns in bat activity in the project area. A secondary objective of the acoustic survey was to screen the data for the potential presence of Indiana bat and provide more general results

for other bat species that occur at the site.

2.0 Methods

The 2010 summer and fall field surveys consisted of mist-netting surveys for bats within the existing project area and the area proposed for the 33-turbine expansion and acoustic surveys for bats using AnaBat acoustic bat detectors within the existing project area and near mist-net sites.

2.1 Mist-Net Survey

The mist-net survey effort was determined in consultation with the USFWS (Carter 2010). The USFWS guidelines recommend that two net sites be surveyed for every square-kilometer (247 acres [100 hectares, ha); one net site per 123 acres [50 ha]) of habitat impact for determining presence or probable absence of Indiana bats[1]. The Project has been reduced in size since the 2005 and 2006 site surveys from 123 turbines to a 100-turbine project. The total disturbance for the Project facilities once complete (all 100 turbines), including both temporary and life-of-project disturbance, will be approximately 356 acres[2] (144 ha). The level of mist-netting survey effort recommended by the USFWS guidelines for the size of this Project is four total net sites. In order to meet the survey objectives and to assess the presence/probable absence of Indiana bats and Virginia big-eared bats at the Project site, it was determined that eight net sites would be established over the existing Project area, and that an additional six net sites be established over the area proposed for the additional 33 turbines (14 total net sites). This level of survey effort is more than three times the effort recommended by the USFWS guidelines for a 356-acre (144-ha) project and was determined to be sufficient to provide coverage given the number of acres and linear extent of the project (Carter 2010). This survey effort is consistent with previous studies at the Project and, similar to the previous studies, was

[1] The USFWS mist-netting guideline recommendations state that nets should be set near "[s]treams and other linear corridors - one net site per kilometer of stream or corridor; non-corridor study areas – two net sites per square kilometer of habitat (USFWS 2007)." The Project does not clearly fit into either method of determining mist-netting effort. The Project area is not a linear corridor but a discontinuous series of small turbine strings constructed in an area where there are multiple ridgelines (see Figure 1). The Project is constructed on top of ridges where there are no streams. Total linear distance of new disturbance was not easily calculated because portions of the project were constructed adjacent to existing roads that support the current land use and the turbine strings are not one continuous row. Turbines were constructed in smaller cleared areas adjacent to existing roads. Given uncertainties regarding the appropriate level of survey effort, the proposed survey effort was vetted with the USFWS and increased beyond that recommended by the USFWS guidelines (2007) based on total disturbance to insure that adequate coverage was achieved and equivalent to the previous studies in 2005 and 2006 despite the reduction in the overall project size.

[2] Note: the estimated amount of temporary disturbance has since been revised to 343 acres (139 ha), but this did not affect the methods used in this study.

determined in consultation with USFWS and WVDNR.

The mist-net survey for bats was conducted using methods described in the USFWS Indiana Bat Mist-netting Guidelines (USFWS 2007). The survey was conducted by a permitted biologist for Indiana bat capture surveys and with a valid West Virginia State scientific collecting permit. All permit conditions were followed including the most current white-nose syndrome (WNS) decontamination procedures.
Net site locations were determined in the field by qualified biologists with extensive experience netting for bats and permitted for Indiana bat capture. Net sites were established throughout the existing Project and in areas of proposed construction (Figure 1). Mist-net site selection focused on the wooded habitat and ecotones associated with the forested areas, as well as water sources where available. Specific net sites were selected based on the suitability for netting, habitat characteristics, distribution across the project area, topography, and the ability to funnel or direct bats to the selected netting locations.

Each net site had a minimum of two separate net sets and was erected approximately one-half hour prior to sunset. Net sets consisted of single nets 8.5 feet (~2.6 m) to triple-high nets 25.5 feet (~7.8 m) ranging from 18 to 60 feet (~6 to 18 m) in length and depended on the net site characteristics (e.g., canopy height). Individual net sets were placed in three basic configurations: blocking trails/roads/flyways, over water, or jutting from the edge of a block of forest into an open area. Trail and flyway net sets were placed to give optimum coverage in the selected flyway. The ends of the nets were set back into the woods, making it difficult for bats to fly around the nets. Triple-high net sets were used to reach as high into the canopy as possible. Net sets over water were set to catch bats either coming in for a drink or foraging over the water. Nets over water were placed in V, N, or W shapes to obstruct bats' access to the water.

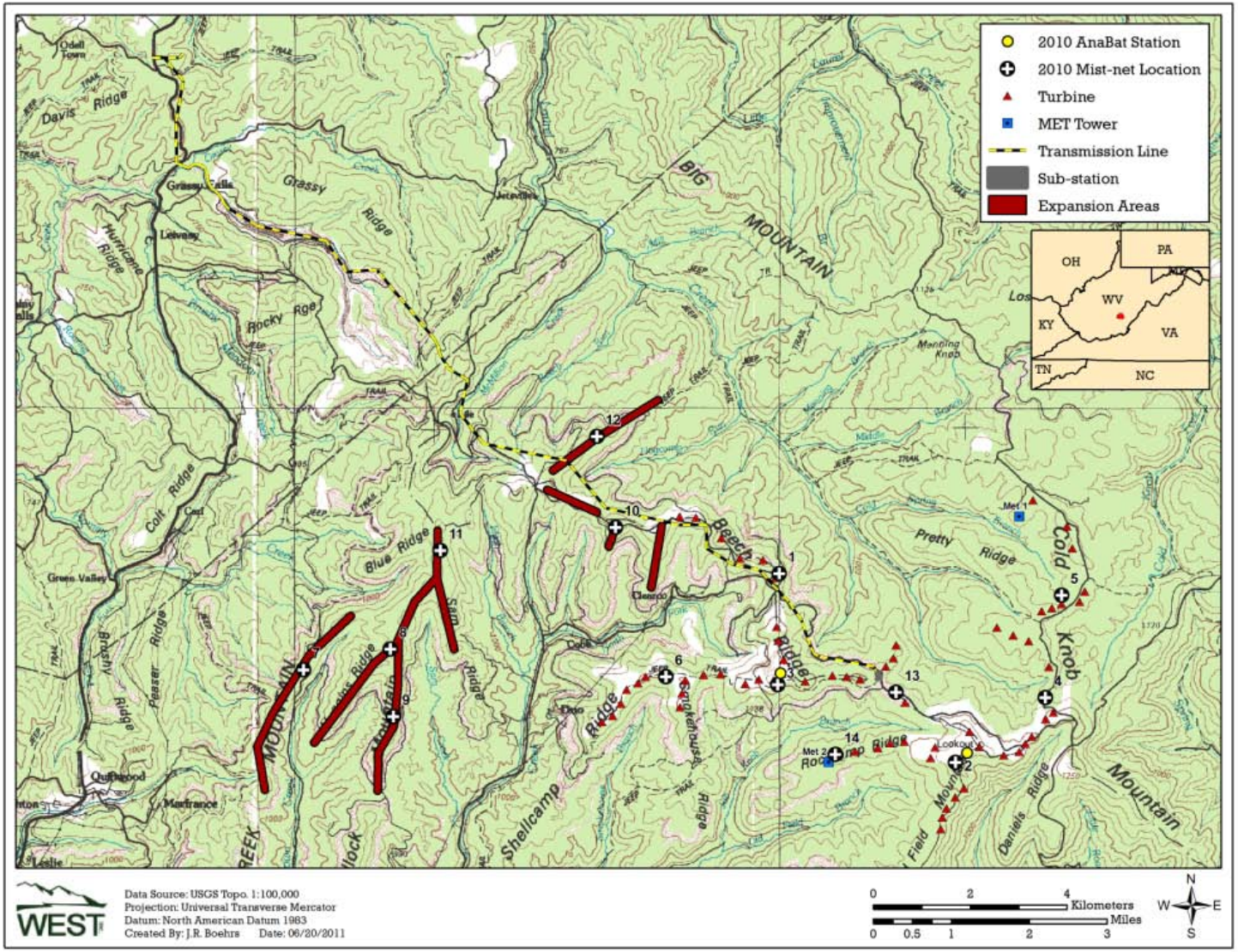


Figure 1. Mist-net and AnaBat survey locations within the Beech Ridge wind energy project and proposed expansion area.

Each net site was surveyed for two consecutive nights, unless interrupted by weather events, in which case the site was surveyed for a third night. Nets were monitored approximately every 15 minutes for at least five hours after sunset, weather permitting, as described in the guidelines, and captured bats were removed and processed as soon as they were detected. Data recorded included, net of capture, height of capture, time of capture, species, age, sex, reproductive condition, weight, forearm length, and wing damage index. Efforts were made to conduct the netting survey on nights with no precipitation, warm temperatures, and low winds according to conditions defined in the guidelines. Most nets were set under canopy cover or there was cloud cover which minimized potential effects on capture rate due to moon light.

2.2 AnaBat Acoustic Survey

A passive acoustic survey using AnaBat SD1 acoustic detectors (Titley Electronics Pty Ltd., NSW, Australia) at two turbines (Figure 1) was conducted from mid-July through mid-November. The methods used were based on recommendations for study of wind project sites (Anderson et al. 1999, Arnett et al. 2006, Kunz et al. 2007) and followed the most effective known measures for orienting and weatherproofing the AnaBat recommended in Britzke et al. 2010.

AnaBat detectors record bat echolocation calls with a broadband microphone. Calls are recorded to a compact flash memory card with large storage capacity. The 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 and insure optimal detection of bat calls. This method of orienting and weatherproofing AnaBat detectors has been shown to provide greater rates of detection and highest call quality compared to other measures (Britzke et al. 2010).

Four AnaBat units were deployed at two turbines, one in the eastern half and one in the western half of the Project (Figure 1). At each turbine, one AnaBat was deployed at ground level, near the base of the turbine, and the second AnaBat was mounted on top of the turbine nacelle, approximately 262 feet (80 m) above ground level (agl). The ground-based unit containers were raised approximately 3 feet (1 m) off the ground to lift the unit above ground vegetation and minimize potential echo interference.

The AnaBat units were programmed to run continuously each night beginning a minimum of one hour before sunset and ending a minimum of one hour after sunrise.

Data stored on the compact flash cards were downloaded approximately every two weeks and checked to insure the AnaBat units were functioning properly.

In addition to the four AnaBat detectors at turbines, two additional AnaBat detectors were used to investigate bat activity near mist-net sites by deploying the units at ground level within approximately 164 (50 m) of a mist-net site on each night of netting. The detectors were operated during the mist-net survey effort, from approximately sunset to the end of the netting survey period, and remained fixed (i.e., the AnaBat detector was not moved) for the sampling period each night.

The AnaBat data were analyzed to investigate temporal changes in bat activity within the Project. The unit of activity for the acoustic analysis was the number of bat passes (Hayes 1997). The total number of bat passes per detector-night was used as an index of bat activity in the Project. Bat pass data represented levels of bat activity rather than the numbers of individuals present because individuals cannot be differentiated by calls. A pass, or bat call, 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). The number of bat passes was determined by downloading the data files to a computer and tallying the number of echolocation passes recorded using AnalookW 3.8.13 (Corben 2010). Total number of passes was standardized for effort by dividing by the number of nights the detector was operating (detector-night). Bat calls were classified as either high-frequency calls (> 40 kHz), mid-frequency (30-40 kHz), or low-frequency calls (< 30 kHz) by using the minimum frequency for any give call as displayed by the Analook software. High frequency calls are generally made by small bats (e.g. *Myotis* sp.) while lower frequency calls are generally made by larger bats [e.g. silver-haired bat (*Lasionycteris noctivagans*), big brown bat (*Eptesicus fuscus*), hoary bat (*Lasiurus cinereus*)]. 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 bat pass were removed from the data prior to analysis.

2.2.1 Quantitative Analysis of Echolocation Data

Echolocation call sequences were subjected to quantitative analysis in two ways. Calls sequences were examined with a discriminant function analysis (DFA) intended to classify echolocation call sequences to species. Based on a library of known calls[3] (Table 1), WEST developed a discriminant function (DF) model that used values from 11 parameters of echolocation call sequences (Table 2). Developing a DF model

[3] Call library provided by Dr. Lynn Robbins, and collected by him and students, including Eric Britzke, between 1997 and 2008.

involves statistically determining functions that maximally separate (i.e., discriminate) two or more groups based on a set of variables that are measured on individuals in the groups. Each function is constructed as a linear combination of the measured variables, and each is designed to be uncorrelated with the other functions. Once the model is developed, parameters from unknown echolocation calls are submitted to the model, which probabilistically determines the species match that is most likely, subject to the species being in the model. Species were excluded if they are not known to occur in the area (Table 1). The DFA produces a posterior discriminant probability (PDP), or the probability that an unknown call sequence was correctly classified, subject to the constraints of model error. To improve prediction accuracy during the analysis it was specified that a PDP of 0.99 or better was required to make a species identification. Echolocation sequences that had PDPs < 0.99 were classified as "Other". To increase prediction accuracy, we used a filter[4] to remove low quality and incomplete calls and to specify a minimum number of calls (or pulses) per sequence. After applying this filter, 1,481 call sequences were available to be used in the DFA.

As a group, bats in the genus *Myotis* can be difficult to differentiate based on echolocation calls. For example, calls of the Indiana bat and the more common little brown bat and northern Myotis can be especially difficult to differentiate. Because of similarity of echolocation between Indiana and the more common Myotis bats, these species tend to have higher rates of misclassification as one another during modeling attempts (Britzke et al. 2002, Britzke et al. 2011). Because of the ambiguity associated with Indiana bat echolocation calls, a second quantitative screening tool was used to provide increased confidence in classifications. The second method involved using a filter in the software used to view and label AnaBat echolocation call data (Analook v4.9j; Corben 2010). The filter[5] itself was developed by Dr. Eric Britzke for the USFWS and Kentucky Department of Fish and Wildlife Services (KDFWS). This "Britzke" filter is not intended to provide independent evidence of presence, but rather is used to guide decisions on where to conduct mist-net surveys and the need for additional mist-net surveys at a site (USFWS & KDFWR 2007). However, using this second quantitative screen provides additional support for Indiana bat classifications when both screens identify the same call in an echolocation file as consistent with Indiana bat echolocation characteristics. A third screen used to provide added confidence was to qualitatively review the data, and this approach is outlined below in Section 2.2.1.

[4] Based on the noise filter described in USFWS & KDFWR (2007), but requiring at least 5 pulses with bandwidth of 10 kHz or greater.
[5] Filter parameters and protocol available in USFWS & KDFWR (2007).

For other species, DFA results were used to determine the proportion of nights at each AnaBat detector that a species was detected at least once. This was done because the number of echolocation passes does not provide an index to the number of individuals present, only the amount of activity or use of the area by bats.

Table 1. Summary of bat call data used to develop the DF model

Species		Number of Files	Mean Number Calls per File	Within Range?	In DF Model?
Big brown bat	*Eptesicus fuscus*	110	33.2	Y	Y
Eastern red bat	*Lasiurus borealis*	46	34.7	Y	Y
Hoary bat	*Lasiurus cinereus*	32	22.8	Y	Y
Silver-haired bat	*Lasionycteris noctivagans*	34	23.2	Y	Y
Gray bat	*Myotis grisescens*	62	57.9	N	N
Eastern small-footed bat[1]	*Myotis leibii*	12	37.5	Y	Y
Little brown bat	*Myotis lucifugus*	68	38.3	Y	Y
Northern long-eared bat	*Myotis septentrionalis*	50	36.9	Y	Y
Indiana bat	*Myotis sodalis*	93	37.6	Y	Y
Evening bat [1]	*Nycticeius humeralis*	15	26.0	N	N
Tri-colored bat	*Perimyotis subflavus*	118	27.9	Y	Y

[1] Low number of reference files (N <15) suggests that results for this species are subject to a high degree of uncertainty; however, all the results should be interpreted with caution (see Section 4.2).

Table 2. Description of call parameters extracted in Analook and used in the DF model.

Parameter	Description	Units
Dur	Pulse duration	Milliseconds (ms)
Fc	Characteristic frequency	kilohertz (kHz)
Fk	Frequency at knee (inflection point)	kHz
Fmax	Maximum frequency of pulse	kHz
Fmean	Mean frequency of pulse	kHz
Fmin	Minimum frequency of the pulse	kHz
varFmin	Variance in mean Fmin	kHz
S1	Initial slope of pulse	Octaves per second (OPS)
Sc	Characteristic slope of the pulse	OPS
Tk	Time to knee	ms

2.2.1 Qualitative Analysis of Echolocation Data (for Indiana bat Calls)

In addition to the Britzke filter and DFA analyses, all 12,431 calls recorded during 2010 were examined qualitatively by WEST's Indiana bat biologist, Dr. Kevin Murray, who

scanned the sequences for calls with visual characteristics (e.g., duration, slope, general appearance) consistent with Indiana bat. Those sequences that Dr. Murray deemed to have met the criteria and thus may have been produced by Indiana bat were noted. Qualitative analysis also included Dr. Murray's review of call sequences that were identified by one or both of the quantitative screens as Indiana bat calls. This was done to minimize false positives that arise from instances in which the quantitative screens select certain pulses as potential Indiana bats in sequences that are either inconsistent with known Indiana bat calls or were clearly produced by a different species. Review and vetting of the output from predictive models is strongly recommended by those whose models attempt to probabilistically determine bat species identification (e.g., Joe Sczewczak, Humboldt State University, pers. comm).

3.0 Results

3.1 Mist-Net Survey

The summer mist-net survey was conducted between July 27 and August 9, 2010 (Sanders Environmental 2010a). Precipitation events on the night of July 31 interrupted either the first or second night of netting at three sites. These three sites were netted for a third night to insure that the minimum survey time (5 hours per night) was achieved (see Sanders Environmental 2010a for details on netting time per site). No netting occurred on the nights of August 4 and 5 due to rain.

Two-hundred and nine bats of seven species were captured (Table 3). No Indiana bats or Virginia big-eared bats were captured during the summer survey. Over all net sites, all nights, and all species, on average approximately 15 bats were captured per net site (Table 3).

The most common species in terms of numbers and distribution during the summer was red bat (*Lasiurus borealis*) which comprised more than 35% of all bats captured (Table 3). Seventy-four red bats were captured and this species was caught at 13 of the 14 net sites (~93%). On average 5.3 red bats were captured per night during the summer netting. The most common *Myotis* captured during the summer was little brown bat (*Myotis lucifugus*), which comprised slightly more than 24% of all bats captured (Table 3). Fifty-one little brown bats were captured at 12 of 14 net sites (~86%).

Table 3. Summary of bat captures during the summer mist-net survey

Site	Little brown bat	Northern long-eared bat	Eastern small-footed bat	Big brown bat	Tri-colored bat	Red bat	Hoary bat	Total
1	1	7	2			5		15
2	4	1	2	1	2	4		14
3		6				1		7
4	11	2	1	3		6		23
5	4				4	4		12
6		2				2		4
7	7	5	4	3	1	18		38
8	4	2		4				10
9	1	5		1	2	1		10
10	2	1						11
11	10	5	2	2	4	17		40
12	4	1	1	6		4	1	17
13	2					3		5
14	1				1	1		3
Total	51	37	12	20	14	74	1	209
Percent of total	24.4%	17.7%	5.7%	9.6%	6.7%	35.4%	0.5%	
Average per site	3.6	2.6	0.9	1.4	1.0	5.3	0.1	14.9

The fall mist-net survey was conducted between September 13 and September 24, 2010 (Sanders Environmental 2010b). No netting was interrupted due to precipitation during the fall study period. One-hundred and fifteen bats of eight species were captured (Table 4). No Indiana or Virginia big-eared bats were captured during the fall survey. Over all net sites, all nights, and all species, on average approximately 8 bats were captured per net site (Table 4).

Table 4. Summary of bat captures during the fall mist-net survey

Site	Little brown bat	Northern long-eared bat	Eastern small-footed bat	Big brown bat	Tri-colored bat	Red bat	Hoary bat	Silver-haired bat	Total
1		6				7			14
2						1			1
3		2				3			5
4	4		5		1	5		1	16
5	2	2				11			15
6	2					1			3
7	3			1		2			6
8		1				2			3
9									0
10	1	1				2			4
11		3	3		1	5			12
12		1				3			4
13	2	6	3		2	11	2	6	32
14				1					1
Total	14	22	11	2	4	53	3	7	116
Percent of total	12.1%	19.0%	9.5%	1.7%	3.4%	45.7%	2.6%	6.0%	
Average per site	1.0	1.6	0.8	0.1	0.3	3.8	0.2	0.5	8.3

The most common species in terms of numbers and distribution was red bat which comprised more than 45% of all bats captured (Table 4). Fifty-three red bats were captured and this species was caught at 12 of the 14 net sites (~86%). On average 3.8 red bats were captured per night during the fall netting. The most common *Myotis* captured during the fall was northern long-eared bat (*Myotis septentrionalis*), which comprised 19% of all bats captured. Twenty-two northern long-eared bats were captured at 8 of 14 net sites (~57%).

During the summer netting, 65% of the bats captured were adults (26% females and 39% males), 28% were juveniles and for 7% age and sex were not determined (Table 5; Sanders Environmental 2010a). Signs of reproduction were noted in adult females of five species: northern long-eared bat, little brown bat, eastern small-footed bat (*Myotis leibeii*), red bat, and big brown bat (Sanders Environmental 2010a). Juveniles were captured of six species: northern long-eared bat, little brown bat, eastern small-footed bat, red bat, tri-colored bat (*Perimyotis subflavus*), and big brown bat (Table 5).

Table 5. Composition of bat species captured during the summer mist-net survey

Species	Juvenile	Adult Male	Adult Female	ND	Total
Little brown bat	12	29	8	2	51
Northern long-eared bat	19	15	3	0	37
Eastern small-footed bat	1	3	8	0	12
Red bat	17	23	23	11	74
Hoary bat	0	1	0	0	1
Tri-colored bat	5	7	1	1	14
Big brown bat	5	4	11	0	20
Total	59	82	54	14	209
Percent of Total	28%	39%	26%	7%	

ND = not determined

During the fall netting, 36% of the bats captured were adults (9% females and 27% males), 58% were juveniles, and for 6% age and sex were not determined (Table 6; Sanders Environmental 2010b). Juveniles were captured of all eight species captured: northern long-eared bat, little brown bat, eastern small-footed bat, red bat, tri-colored bat, big brown bat, hoary bat, and silver-haired bat (Table 6).

Table 6. Composition of bat species captured during the fall mist-net survey

Species	Juvenile	Adult Male	Adult Female	ND	Total
Little brown bat	8	4	2	0	14
Northern long-eared bat	14	4	2	1	21
Eastern small-footed bat	4	1	6	0	11
Red bat	30	18	0	6	53
Hoary bat	1	2	0	0	3
Tri-colored bat	3	0	1	0	4
Big brown bat	1	1	0	0	2
Silver-haired bat	6	1	0	0	7
Total	67	31	11	7	116
Percent of Total	58%	27%	9%	6%	

ND = not determined

3.2 AnaBat Acoustic Survey

Acoustic monitoring occurred from July 21 to November 15, 2010 for a total of 433 detector-nights over all four AnaBat detectors. During the study period the AnaBat detectors operated 91.7% of the time (433 out of 472 possible detector-nights). The nacelle-based units operated 100% of the nights and the ground-based units operated 83.5% of the nights. The primary reason for missed sampling nights at the ground-based units was due to disturbance of the detectors by black bear(s). A secondary reason for missed sampling nights at the ground-based units was power malfunction that was suspected to have been caused by damage to the equipment from bears. The overall quality of the data as measured by the proportion of bat calls to noise files was good indicating that the AnaBat detectors operated effectively and with little interference. For the four AnaBat detectors between 74% and 89% of the files recorded were bat calls (Table 7).

Table 7. Proportion of bat call files to all files recorded for the fixed AnaBat detectors.

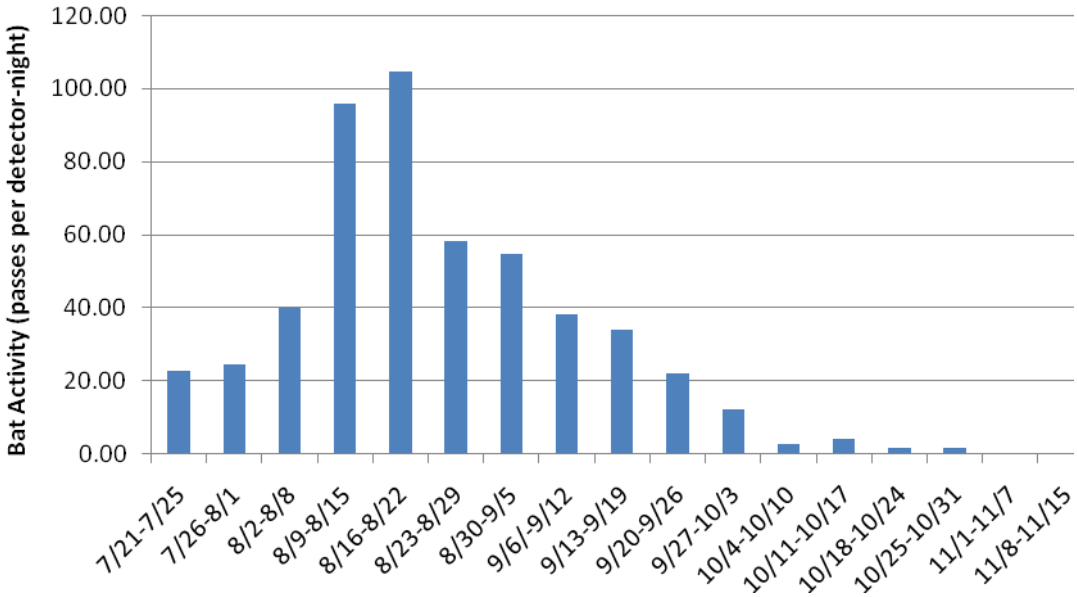
Location	Number of files recorded	Number of bat call files	Proportion
A17g	8762	7675	0.88
A17h	1138	1015	0.89
G5g	5861	4670	0.80
G5h	1294	963	0.74
	17055	14323	0.83

g = mounted near the ground, h = mounted on the nacelle

For all detectors, the mean bat activity for the period was 33.08 bat passes per detector-night. On a weekly basis, the high was approximately 104.64 passes per detector-night during week of August 16, and a low of 0.04 passes per detector-night during week of November 1 (Figure 2). The highest overall activity occurred on August 16 (203.75 passes), and the three highest nights occurred between August 16 and August 22 (Figure 3; Appendix A).

The ground-based AnaBat at each turbine recorded between 5 and 10 times more bat passes than the AnaBat on the turbine nacelle (Figure 4). When divided by echolocation type, high-frequency calls were the most abundant call type at ground level AnaBats and low-frequency calls were most abundant at the nacelle level AnaBats (Figure 5).

Figure 2. Weekly bat activity over all AnaBat detectors.



Week	LF	MF	HF	All Bats
7/21-7/25	5.79	7.46	9.38	22.63
7/26-8/1	3.43	5.68	15.29	24.39
8/2-8/8	12.00	13.04	14.96	40.00
8/9-8/15	22.04	36.43	37.29	95.75
8/16-8/22	15.25	36.00	53.39	104.64
8/23-8/29	16.93	24.21	17.04	58.18
8/30-9/5	16.21	19.82	18.86	54.89
9/6/-9/12	10.61	9.71	17.75	38.07
9/13-9/19	15.71	8.18	10.18	34.07
9/20-9/26	10.07	5.89	6.11	22.07
9/27-10/3	4.43	4.82	3.11	12.36
10/4-10/10	1.41	0.82	0.50	2.73
10/11-10/17	1.05	1.86	1.14	4.05
10/18-10/24	0.52	0.24	0.76	1.52
10/25-10/31	0.19	0.57	0.71	1.48
11/1-11/7	0.00	0.04	0.00	0.04
11/8-11/15	0.00	0.14	0.19	0.33
Totals	**8.67**	**11.18**	**13.22**	**33.08**

Figure 3. Nightly bat activity over all AnaBat detectors.

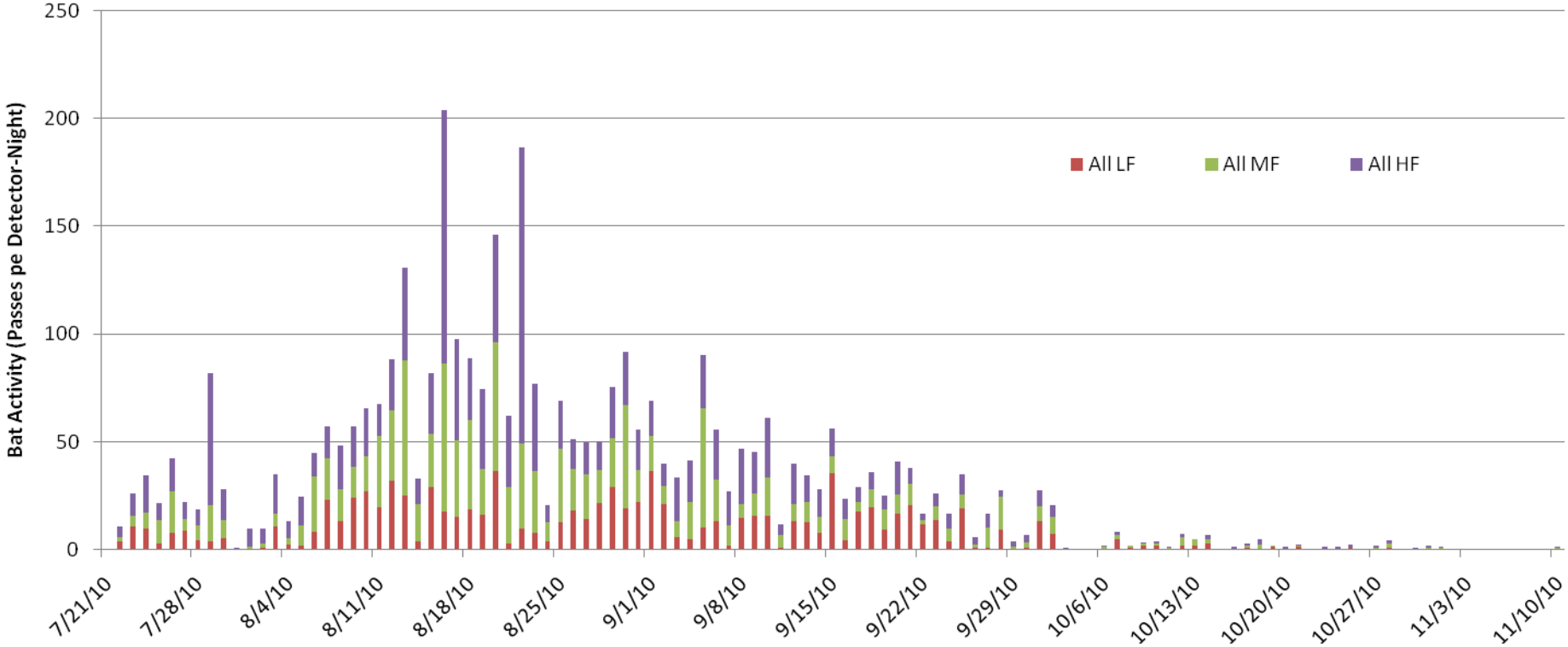
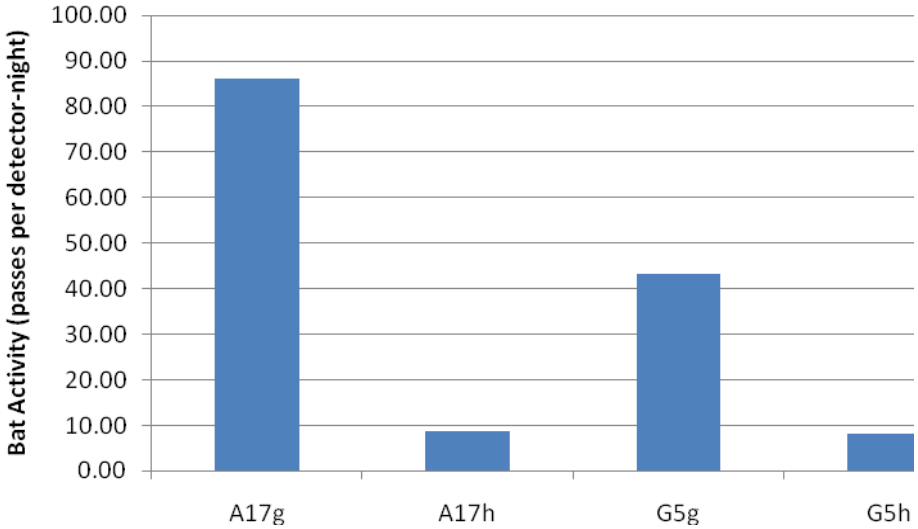
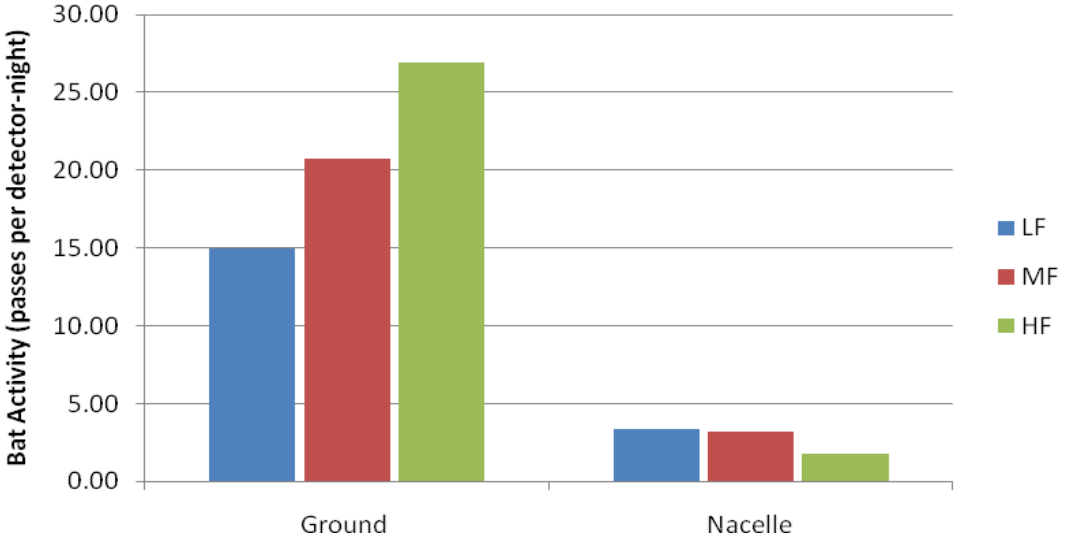


Figure 4. Bat activity at ground versus nacelle AnaBat detectors (A17 and G5 are turbine numbers, g = ground, h = nacelle



Station			
A17g	A17h	G5g	G5h
86.24	8.60	43.24	8.16

Figure 5. Bat activity by echolocation type at ground versus nacelle AnaBat detectors.



Two additional AnaBat detectors were used to investigate bat activity near mist-net sites. The number of sites netted per night during the summer period ranged from 1-4 and during the fall period ranged from 2-3. During the summer netting period, there was a distinctive pattern in bat activity with increasing activity through approximately 11:00 PM followed by a decrease in activity to the end of the netting period which usually occurred around 1:00 or 2:00 AM (Figure 6). The majority of bat passes recorded during the summer netting period were high frequency calls (Table 8), which is consistent with the results from the ground level detectors at turbines. During the fall netting period, bat activity was highest during the first two hours of netting and dropped off after approximately 9:00 PM. The majority of bat passes recorded during the fall netting period were high-frequency calls; however, the relative percentage of high frequency calls was lower during the fall netting period compared with summer (Table 8).

Figure 6. Bat passes per detector-hour recorded near net sites during the summer netting period.

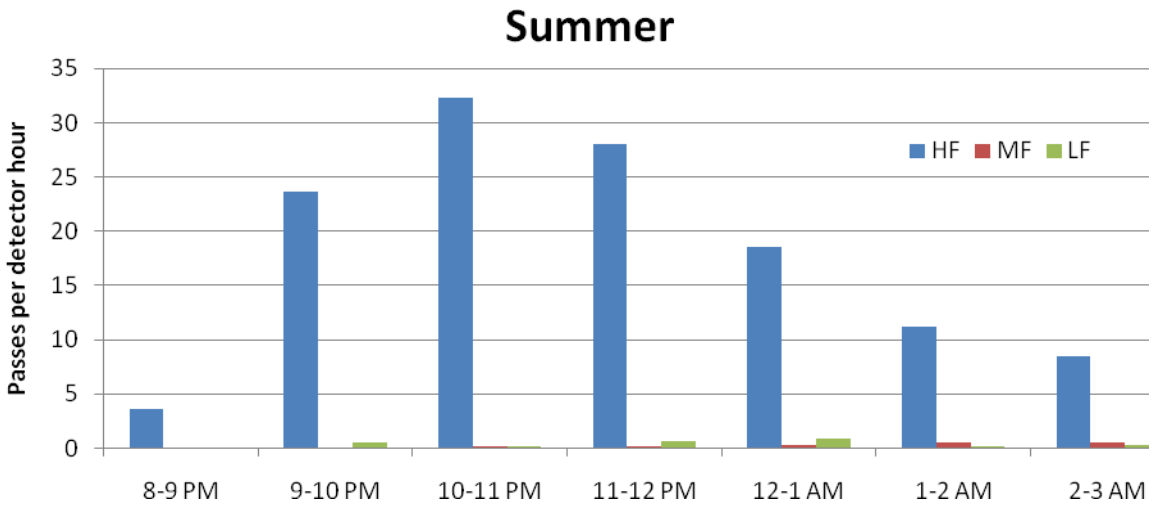
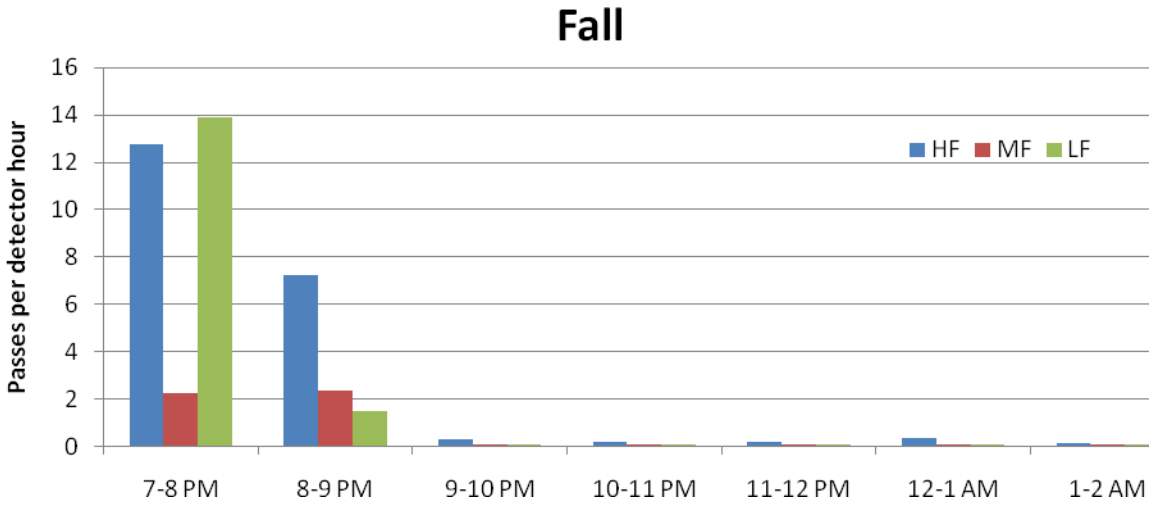


Table 8. Summary of bat passes recorded by survey night during the summer and fall mist-net surveys

Survey Night	HF	MF	LF	Total
7/28/10	57	0	3	60
7/29/10	900	4	0	904
7/30/10	203	12	16	231
8/1/10	37	0	0	37
8/2/10	25	0	5	30
8/3/10	64	1	6	71
8/7/10	210	1	0	211
8/8/10	45	0	0	45
8/9/10	44	1	3	48
Total	1585	19	33	1637
Percent of Total	97%	2%	1%	
9/13/10	59	10	6	75
9/14/10	93	0	0	93
9/15/10	582	91	69	742
9/18/10	32	1	4	37
9/19/10	33	5	1	39
9/20/10	31	0	4	35
9/21/10	141	50	42	233
9/22/10	9	0	4	13
9/23/10	16	9	33	58
9/24/10	6	0	1	7
Total	1002	166	164	1332
Percent of Total	75%	12.5%	12.5%	
Grand Total	2587	185	197	2969

Figure 7. Bat passes per detector-hour recorded near net sites during the fall netting period.



3.2.1 Quantitative Analysis of Echolocation Data

12,431 call sequences recorded at the turbines and during mist-netting AnaBat surveys were examined for potential Indiana bat calls. Of the 12,431 files, eight (0.006%) were identified as potential Indiana bat calls by the Britzke Filter. Of the 12,431 files, 1,481 call sequences were of sufficient quality to be used in the DFA (see Section 2.2.1), of which 111 (7.5%) were considered by the model to fit best as Indiana bat calls. Of these totals, three files were considered by both quantitative screens as potential Indiana bat calls (Table 9).

Table 9. Summary of echolocation files identified by 2 or more screening tools**.**

			Screening Tool		
Station	**File**	**Survey Night**	**Britzke Filter**	**DFA**	**Dr. Kevin Murray**
3559	K7282137.28#	7/28/2010		x	x
3559	K7290021.10#	7/28/2010	x		x
3559	K7292225.33#	7/29/2010	x	x	
3559	K7302217.27#	7/30/2010	x	x	x
4141	K7292145.36#	7/29/2010	x	x	
A17g	K7282143.23#	7/28/2010	x		x
A17g	K8052321.16#	8/5/2010	x		x

Based on results of the DFA, potential calls from big brown and eastern red bats were most frequently detected during the survey period, followed by tri-colored bats and the *Myotis* species (Table 10). Calls from nearly all the species were more frequently detected at ground-based detectors. Potential calls for silver-haired bat were identified at one nacelle station only.

Table 10. Percentage of survey nights by location that possible calls of each species were detected at least once, determined by the DFA.

Location	Big brown bat	Red bat	Silver-haired bat	Northern long-eared bat	Little brown bat	Eastern small-footed bat	Tri-colored bat
3559	7.1%	21.4%	0.0%	35.7%	28.6%	35.7%	28.6%
4141	7.1%	0.0%	0.0%	28.6%	7.1%	35.7%	0.0%
A17g	16.1%	19.5%	0.0%	13.6%	15.3%	9.3%	17.8%
A17h	8.5%	5.1%	0.8%	8.5%	0.0%	9.3%	2.5%
G5g	18.6%	14.4%	0.0%	4.2%	13.6%	2.5%	18.6%
G5h	5.1%	7.6%	0.0%	7.6%	0.0%	0.8%	2.5%
Totals	50.0%	49.2%	0.8%	41.5%	33.1%	30.5%	44.9%

3.2.2 Qualitative Analysis of Echolocation Data

Of the 12,431 call files, Dr. Murray identified a total of eight call files as potential Indiana bats: five files from mist-net site 3559 (k7282137.28#, k7282218.02#, k7290021.10#, k7300055.39#, and k7302217.27#); two files from turbine site A17g (k7282143.23# and k8052321.16#); one file from mist-net site 4141 (k7310009.18#); and 0 files from turbine sites A17h, G5g, and G5h.

Dr. Murray further re-examined the 111 call files identified by the DF model as *Myotis sodalis* and concurred with the call identifications of three of the 111 call files (i.e., he identified as potential *M. sodalis* three of the call files identified by the DF as *M. sodalis*). The rest of the calls were identified by him as other species (either *M. lucifugus* or *L. borealis*) or were not classified to species in cases where call structure did not show characteristics clearly consistent with a particular species. The three call files were k7282137.28# and k7302217.27# from mist-net site 3559 and k8052321.16# from turbine site A17g. Dr. Murray identified 3 of the 8 calls that the Britzke Filter identified as

potential Indiana bat calls. The three call files were k7290021.10# and 7302217.27# from mist-net site 3559 and k7282143.23# from turbine site A17g (Table 9).

4.0 Discussion

4.1 Mist-Net Survey

The primary objectives of the study were to provide additional information about bat species composition and occurrence at the Project site during the summer and fall seasons (WEST 2010). The purpose of netting during the summer and fall was to provide data on presence/probable absence of Indiana bats throughout the Project during the summer maternity season and fall migration and swarming period (Carter 2010).

During the 2005-2006 pre-construction development period, BRE conducted mist-netting surveys of the project site and transmission line (see BHE 2005, 2006). Results of the 2010 mist-netting survey were similar to the 2005-2006 surveys in terms of species composition, with the exception that eastern small-footed myotis and silver-haired bats were captured in 2010. No Indiana bats or Virginia big-eared bats have been captured during either study period at the Project.

More bats were captured during the 2010 surveys than in 2005-2006; however, the level of netting effort was similar for both periods: 15 sites in 2005 resulting in 80 bats captured, 12 sites in 2006 resulting in 42 bats captured, and 14 sites in 2010 resulting in 209 summer captures and 116 fall captures. The number of bats captured over the different study periods could be influenced by a number of factors including nightly weather conditions, time of year, population status, mist-net site conditions, bat behavior, and experience of the field biologists. For example, the surveys in 2005-2006 were conducted slightly earlier in the summer, June 12-22 and July 22-26, when there may have been fewer volant juvenile bats. During the 2010 surveys 28% and 58% of the bats captured were juveniles over the summer and fall netting periods, respectively. In contrast during the 2005-2006 surveys, 16% of the bats captured in July were juveniles (BHE 2005) and 35% of the bats captured in June were juveniles (BHE 2006).

It is also possible that the number of bats in the project area has increased since 2005; however, due to the numerous factors influencing mist-netting surveys it is difficult to use mist-netting data to assess population sizes. The 2010 surveys do, however, corroborate the 2005-2006 results (BHE 2005, 2006) that suggested that no Indiana bats or Virginia big-eared bats occur on the site during the summer maternity period. Based on these results it is considered a low likelihood of an Indiana bat or Virginia big-

eared bat maternity area being on or within 2.5 miles of the areas surveyed (L. Hill, USFWS, pers. comm.).

No Indiana bats were captured out of 116 total bat captures during the fall survey. Based on available data from cave counts (USFWS 2007) the number of Indiana bats moving through area is likely low. For example the nearest known Indiana bat hibernacula, Snedegar Cave and Martha Cave, have extant wintering populations with estimates of between 110 and 304 and 145 to 285 (since 1993), respectively. Snedegar Cave is approximately 9.2 mi (14.7 km) and Martha Cave is approximately 12.6 mi (20.2 km) from the eastern edge of the Project area (BHE 2006a). The lack of Indiana bat captures during the fall likely indicates a low level of movement through the project area and little roosting on the site during the fall season.

The lack of Virginia big-eared bat captures during summer and fall surveys supports the general knowledge that this species is generally sedentary and supports other data on the known distribution of the species and lack of known occurrences in the proximity of the project area. In West Virginia, the greatest movement recorded between summer and winter roosts was 19.8 mi (31.9 km; C. Stihler unpublished data in Piaggio et al. 2009). The Project is more than 30 miles (x km) from the nearest known Virginia big-eared bat cave.

4.2 AnaBat Acoustic Survey

The primary objective of the acoustic sampling was to investigate temporal patterns of bat activity within the Project to help support the HCP. In general, bat activity increased from late July to mid- to late-August and then began to taper off. This is likely an indication that bats are moving through the Project during August and September and corresponds with the period of time when most impacts to bats from wind turbines occur (see Johnson 2005, Arnett et al. 2008).

A secondary objective of the AnaBat survey, as requested by USFWS, was to screen the bat calls for species identification to the extent possible. The initial analysis for species identification was identifying echolocation call sequences that had characteristics consistent with echolocation produced by Indiana bat. A secondary analysis was to screen the acoustic data for all species potentially occurring in the project area.

Unequivocal identification of bat call sequences to species is confounded by intrinsic plasticity of bat echolocation (Barclay 1999) that results from individual and behavioral variability (Faure and Barclay 1994), as well as variability introduced by habitat differences (Broders et al. 2004) and the presence of conspecifics (i.e., other individuals of the same species) (Obrist 1995). The effects of this variability on accurate species identification are exacerbated for species whose echolocation structure is inherently similar, as with many species in the genus *Myotis*. Therefore, a multi-level strategy was used to identify potential Indiana bat echolocation calls. The approach consisted of two quantitative screens and one qualitative screen. Quantitative screens included a call analysis filter and a multivariate statistical model developed from a set of known calls, as described above. In addition, calls were examined qualitatively by WEST's Indiana bat biologist, Dr. Kevin Murray. In an effort to maintain a conservative approach in the analysis, echolocation sequences that were identified by two or more of the screens were considered to have likely come from an Indiana bat.

In an effort to increase prediction accuracy for the DFA analysis, a filter was used to remove low quality and incomplete calls that could introduce variability. The filter eliminated calls with fewer than five pulses and resulted in approximately 88% of the calls being dropped from suitability for analysis using the DFA. This process likely introduced a bias against short duration calls in favor of longer duration calls. For example, hoary bat is known to occur in the region and was captured during the mist-net survey, yet no calls were identified by the DFA as potential hoary bat calls. However, a qualitative analysis of the acoustic data suggests that hoary bats were present on up to 58% of the nights, yet were recorded primarily by short duration calls. This also reflects that, as with any model, the DFA is not 100% accurate and results should be viewed as potential calls for any given species.

Results of the 2010 acoustic data analysis suggest that Indiana bats were potentially recorded onsite in very low numbers from late July to early August which coincides with the beginning of the fall migration period for Indiana Bats. Of the 12,431 files examined for characteristics of Indiana bat calls, six were identified by two screening tools, and one was identified by all three screening tools (Table 9) as potentially coming from Indiana bats. Three of the files were recorded on the same night (7/28/10), and of those, two were from the same mist-net site (3559). The only file to have been considered by all three screening tools to be consistent with Indiana bat echolocation was also recorded at mist-net site 3559 on the night of July 29, 2010.

USFWS & KDFWR (2007) suggest that at least two potential Indiana bat call files per night are needed to conclude that the species is present. During the study period, this occurred only on the night of July 28 at station 3559.

Given the very low number of recorded calls that were potentially Indiana bat relative to the overall number of recorded calls (6 out of 12,431 or 0.04%), and the fact that acoustic analyses do not provide 100% positive identifications, it is possible that no Indiana bats were in fact recorded during the acoustic survey (i.e., detections were false positives). Furthermore, none of the potential Indiana bat calls (selected by two or more screens) were recorded at the two detectors mounted on turbine nacelles; all were recorded at ground level where fatalities with operating rotors would not occur.

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Appendix A. Nightly Mean Bat Passes by Echolocation Type.

Night	All LF	All MF	All HF	All Bats
7/21/10	0.00	0.00	0.00	0.00
7/22/10	4.00	1.75	5.00	10.75
7/23/10	10.75	5.00	10.50	26.25
7/24/10	9.50	7.75	17.25	34.50
7/25/10	2.75	10.75	8.25	21.75
7/26/10	7.75	19.50	15.25	42.50
7/27/10	8.75	5.50	8.00	22.25
7/28/10	4.25	6.75	7.50	18.50
7/29/10	3.75	16.75	61.50	82.00
7/30/10	5.50	8.00	14.75	28.25
7/31/10	0.25	0.00	0.25	0.50
8/1/10	0.50	1.00	8.00	9.50
8/2/10	1.00	1.75	7.00	9.75
8/3/10	10.75	5.75	18.25	34.75
8/4/10	2.25	3.00	8.00	13.25
8/5/10	2.00	9.00	13.75	24.75
8/6/10	8.50	25.25	11.00	44.75
8/7/10	23.25	19.00	15.00	57.25
8/8/10	13.25	14.75	20.25	48.25
8/9/10	24.00	14.50	18.50	57.00
8/10/10	27.00	16.25	22.25	65.50
8/11/10	19.50	33.25	14.75	67.50
8/12/10	31.75	32.75	23.75	88.25
8/13/10	25.25	62.50	43.00	130.75
8/14/10	4.00	17.25	11.50	32.75
8/15/10	29.00	24.50	28.25	81.75
8/16/10	17.75	68.50	117.50	203.75
8/17/10	15.00	35.50	47.00	97.50
8/18/10	18.75	41.50	28.50	88.75
8/19/10	16.25	21.25	37.00	74.50
8/20/10	36.25	59.75	50.25	146.25
8/21/10	2.75	26.25	33.00	62.00
8/22/10	9.75	39.50	137.25	186.50
8/23/10	8.00	28.25	40.75	77.00
8/24/10	4.00	8.75	8.00	20.75
8/25/10	12.75	34.25	21.75	68.75

Night	All LF	All MF	All HF	All Bats
8/26/10	18.25	19.25	13.75	51.25
8/27/10	14.00	21.00	14.50	49.50
8/28/10	21.75	15.25	13.00	50.00
8/29/10	28.75	22.75	24.00	75.50
8/30/10	19.00	48.25	24.25	91.50
8/31/10	22.00	15.00	18.50	55.50
9/1/10	36.25	16.25	16.25	68.75
9/2/10	21.00	8.50	10.50	40.00
9/3/10	6.00	7.25	20.00	33.25
9/4/10	4.75	17.25	19.25	41.25
9/5/10	10.25	55.50	24.25	90.00
9/6/10	13.25	19.00	23.25	55.50
9/7/10	2.00	9.25	15.75	27.00
9/8/10	14.50	6.75	25.50	46.75
9/9/10	15.50	10.50	19.50	45.50
9/10/10	15.50	18.00	27.50	61.00
9/11/10	1.00	6.00	4.75	11.75
9/12/10	13.25	8.00	18.75	40.00
9/13/10	12.50	9.50	12.50	34.50
9/14/10	7.75	7.50	12.75	28.00
9/15/10	35.50	8.00	12.75	56.25
9/16/10	4.25	9.75	9.75	23.75
9/17/10	17.50	4.75	6.50	28.75
9/18/10	19.50	8.50	7.75	35.75
9/19/10	9.00	9.75	6.50	25.25
9/20/10	16.50	9.00	15.25	40.75
9/21/10	20.75	9.50	7.50	37.75
9/22/10	11.50	2.00	3.25	16.75
9/23/10	13.75	6.25	6.25	26.25
9/24/10	3.75	6.00	6.75	16.50
9/25/10	19.00	6.75	9.00	34.75
9/26/10	1.00	1.25	3.50	5.75
9/27/10	0.75	9.50	6.50	16.75
9/28/10	9.25	15.25	3.00	27.50
9/29/10	0.00	1.25	2.50	3.75
9/30/10	1.00	2.50	3.25	6.75
10/1/10	13.25	7.00	7.25	27.50
10/2/10	7.25	7.75	5.50	20.50
10/3/10	0.25	0.00	0.25	0.50

Night	All LF	All MF	All HF	All Bats
10/4/10	0.00	0.00	0.00	0.00
10/5/10	0.00	0.00	0.00	0.00
10/6/10	0.33	1.00	0.67	2.00
10/7/10	5.00	1.67	1.67	8.33
10/8/10	0.67	1.00	0.00	1.67
10/9/10	2.00	1.00	0.33	3.33
10/10/10	2.00	1.00	0.67	3.67
10/11/10	0.33	0.33	0.33	1.00
10/12/10	1.67	4.33	1.33	7.33
10/13/10	1.67	3.00	0.00	4.67
10/14/10	3.00	2.00	2.00	7.00
10/15/10	0.00	0.00	0.00	0.00
10/16/10	0.00	0.33	1.00	1.33
10/17/10	0.67	1.33	1.00	3.00
10/18/10	0.33	2.00	2.67	5.00
10/19/10	1.33	0.67	0.00	2.00
10/20/10	0.00	0.33	1.00	1.33
10/21/10	1.33	0.33	0.67	2.33
10/22/10	0.00	0.00	0.00	0.00
10/23/10	0.00	0.33	1.00	1.33
10/24/10	0.00	0.00	1.33	1.33
10/25/10	1.00	0.00	1.33	2.33
10/26/10	0.00	0.33	0.00	0.33
10/27/10	0.33	0.33	1.33	2.00
10/28/10	0.67	2.00	1.67	4.33
10/29/10	0.00	0.00	0.00	0.00
10/30/10	0.00	0.00	1.00	1.00
10/31/10	0.00	1.00	0.67	1.67
11/1/10	0.33	0.33	0.33	1.00
11/2/10	0.00	0.00	0.00	0.00
11/3/10	0.00	0.00	0.00	0.00
11/4/10	0.00	0.00	0.00	0.00
11/5/10	0.00	0.00	0.00	0.00
11/6/10	0.00	0.00	0.00	0.00
11/7/10	0.00	0.00	0.00	0.00
11/8/10	0.00	0.33	0.00	0.33
11/9/10	0.00	0.00	0.33	0.33
11/10/10	0.00	0.67	0.67	1.33
11/11/10	0.00	0.00	0.00	0.00

Night	All LF	All MF	All HF	All Bats
11/12/10	0.00	0.00	0.00	0.00
11/13/10	0.00	0.33	0.33	0.67
11/14/10	0.00	0.00	0.00	0.00
11/15/10	0.00	0.00	0.00	0.00
Totals	**8.67**	**11.18**	**13.22**	**33.08**