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Bat Species Distribution on the Oak Ridge Reservation

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October 2015

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Environmental Sciences Division

BAT SPECIES DISTRIBUTION ON THE OAK RIDGE RESERVATION

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LIST OF ACRONYMS

DOE	Department of Energy
ETTP	East Tennessee Technology Park
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
USFWS	US Fish and Wildlife Service
WMP	Wildlife Management Plan
WNS	White Nose Syndrome

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EXECUTIVE SUMMARY

This report summarizes results of a three-year acoustic survey of bat species on the US Department of Energy (DOE) Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee. The survey was implemented through the Oak Ridge National Laboratory (ORNL) Natural Resources Management Program and included researchers from the ORNL Environmental Sciences Division and ORNL Facilities and Operations Directorate, Tennessee Wildlife Resources Agency's ORR wildlife manager, a student from Tennessee Technological University, and a technician contracted through Excel Corp. One hundred and twenty-six sites were surveyed reservation-wide using Wildlife Acoustics SM2+ Acoustic Bat Detectors.

These surveys were conducted in an effort to determine species diversity and distribution of bat populations as part of the approved Wildlife Management Plan for the ORR, and results will be added to historical inventory records. This survey effort was initiated in part to meet requirements of the US Fish and Wildlife Service (USFWS), which requested owners of federal lands to implement its Range-wide Indiana Bat Summer Survey Guidelines. The Department of Energy's Oak Ridge Reservation consists of approximately 33,480 acres of land, including large forested areas, wetlands, stream and river watersheds and fields. There are also three major developed facilities with ancillary support areas, including power rights-of-way and substations, retention ponds and waste management facilities. The ORR is located within the species ranges of fourteen species of bats, among which are two species on the Federal Endangered Species list and one species newly listed as threatened. Survey sites were selected based on available suitable habitat. Acoustic surveys were conducted over several consecutive nights, and recorded data were analyzed using two different software packages, as recommended by the USFWS.

Calls from fourteen species of bats were recorded during 2013-15 summer surveys. Nine of these species have been confirmed through previous mist net captures. These are: big brown bat, eastern red bat, silver-haired bat, little brown bat, evening bat, tri-colored bat, gray bat (endangered), Indiana bat (endangered), and northern long-eared bat (threatened). One additional species, Seminole bat, has been captured by mist net, but its calls have not been definitively recorded on the ORR. Verification of the presence five additional species whose calls have been recorded will need to be done through mist net captures in the future. The species not yet verified via capture are: Townsend's big-eared bat, Rafinesque's big-eared bat, Brazilian free-tailed bat, hoary bat and eastern small-footed bat. It is important to note that the ORR is not within species range for Townsend's big-eared bat.

1. INTRODUCTION

The approved Wildlife Management Plan (WMP) for the US DOE ORR (Giffen et al. 2012) includes surveying wildlife species across the ORR to determine species diversity and population density. The results of these surveys are then used to manage habitats and resources in order to maintain the health and safety of wildlife, as well as people, on the ORR. In particular, preservation and protection of species which are endangered, threatened or in need of management and their habitats is an important aspect of the WMP (Webb 2000). Bat surveys on the ORR have been done sporadically, with records beginning in 1992 (Harvey 1992). For the most part, survey efforts were done to provide information on bat species presence relating to areas where disturbance of habitat was planned, such as construction of the Haul Road from East Tennessee Technology Park (ETTP) to the Bear Creek Environmental Management Waste Management Facility (EMWMF) (BHE Environmental, Inc. 2005), the remediation efforts on the K1009 ponds, and the K1007 P1 Pond (Harvey and Britzke 2004) and ORR Parcel ED-1 (BHE Environmental, Inc. 2008; Harvey 1997). Figure 1 shows the sampling locations by year for historical records from 1992 through 2012.

Beginning in 2006, bats overwintering in caves in the northeastern US were found dead in large numbers. Upon examination, these bats were found to have white, fuzzy growths on their noses, ears and wings, giving them a white appearance. The growth was later found to be *Pseudogymnoascus destructans*, a fungus inadvertently introduced to the US from caves in Europe (McCracken 2010). The fungal disease, White Nose Syndrome (WNS), has continued to spread to new areas, including Tennessee, causing the deaths of millions of bats. Among affected species, endangered Indiana bat populations have fallen drastically, and the USFWS requested that federal landowners conduct surveys of Indiana bats on their properties (USFWS 2009; USFWS 2012). The reasons for this are two-fold: establish summer movement and habitat use patterns of Indiana bats within the southern portions of their range, and provide data to be used in habitat management and Indiana bat recovery efforts (USFWS 2013).

Bats can be found in a variety of habitats across the landscape. Although some species roost in large cave colonies year-round, some species use caves only during winter months for hibernation. Several species roost singly or in small groups in caves, trees, shrubs, buildings, mines or under bridges for all or parts of the year. For example, gray bats are known to be cave dwelling bats which roost in large gatherings throughout the year, whereas eastern red bats generally roost singly or in small groups in trees the entire year, and they may burrow into leaf litter at the base of roost trees during particularly cold winter weather. Some bats may migrate hundreds of miles to reach foraging areas where insects are abundant, then return to hibernacula in the fall (Harvey et al. 1999).

Bats of east Tennessee generally are nocturnal, leaving their roosts at sunset to forage for insects during the night and return to their roosts before dawn. Traditionally, mist nets and harp traps have been used to capture bats as they emerge from roosts and as they forage nightly. However, these methods give a limited snapshot of total bats present, as some bat species are adept at net detection and avoidance, and some species travel and forage at greater altitude or in areas not conducive to mist netting. Acoustic detectors can be used to record bat calls over multiple nights, and software programs which compare unidentified recorded calls with libraries of known species' calls give a more complete record of bat species population diversity and density. Microphones can be raised to greater heights and be placed in a wide variety of locations, allowing for the potential to record more bat species. The AnaBat acoustic recorder was used for surveys on the ORR from 2003 through 2012. Call data was analyzed using AnaLook W software (Harvey and Brizke 2003; Harvey and Britzke 2004; Giffen and Evans 2011). Recent improvements in recording equipment and call analysis software have led to more acutely sensitive detection and more accurate call identification. In this report we present the results from acoustic surveys conducted at sites across the ORR during the 3-year term of this project. Historical records of bats are presented as well.

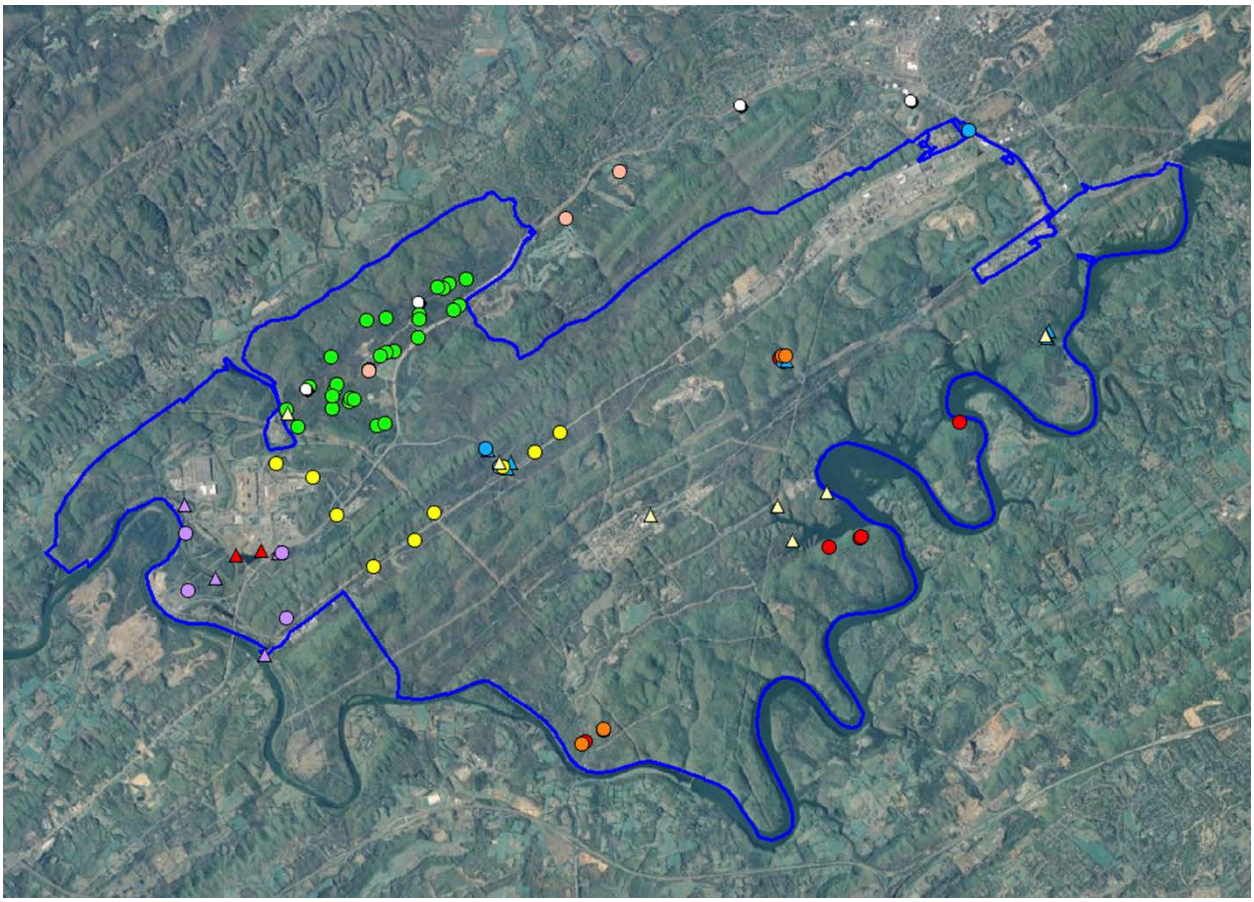

Figure 1. Historical bat monitoring sites on the Oak Ridge Reservation.

The map depicts the Oak Ridge Reservation and surrounding area with bat survey sites from 1992 to 2012 indicated as follows:

Symbol	Year	Survey type	Reference
○	1992	Mist net	Harvey 1992
●	1996	Mist net	Mitchell et al. 1996
●	1997	Mist net, cave census	Harvey 1997
●	2003	Mist net	Harvey and Britzke 2003
▲	2003	Acoustic (Anabat)	Harvey and Britzke 2003
▲	2004	Acoustic (Anabat)	Harvey and Britzke 2004
●	2005	Mist net	BHE Environmental, Inc. 2005
●	2006	Mist net	Giffen et al. 2006
●	2008	Mist net	BHE Environmental, Inc. 2008
▲	2008	Acoustic (Anabat)	BHE Environmental, Inc. 2008
●	2011	Mist net	Jackson 2011
▲	2011	Acoustic (Anabat)	Giffen et al. 2011
△	2012	Acoustic (Anabat)	Giffen and Evans 2012

2. MATERIALS AND METHODS

2.1 SURVEY SITE SELECTION

Previous studies on Indiana bats describe roosting and foraging habitat preferences. Aerial photographs of the ORR first were used to locate habitat similar to that described in the literature, then specific sites for deployment of bat call detectors were selected during site visits. The USFWS Indiana Bat Summer Survey Plan describes potential roosting habitat as trees with a minimum diameter at breast height (dbh) of 5 inches, either living or dead snags, with peeling bark and/or crevices (USFWS 2013). Roost trees generally are exposed to direct sunlight, south-facing along forest or wetland edges, or rise above the canopy; stands of several trees form maternity colonies, while single trees provide roosts for males or temporary roosts for females. Flight corridors go from roosts to foraging areas and are often along narrow roadways or streams. Interior forests, open fields and wetlands provide abundant insect forage (Callahan et al. 1997; Kurta et al. 2002).

Table 1 lists the sites selected for acoustic surveys during the three-year bat monitoring effort; GPS coordinates, deployment date and number of nights deployed are indicated. Figure 2 provides an overview of the ORR with the acoustic monitoring sites from 2013, 2014 and 2015 indicated on the map.

Table 1. Acoustic Monitoring Sites. Each location listed represents a multi-acre tract of the Oak Ridge Reservation. Site IDs are grouped together to provide survey information of each location. Deployment dates and number of nights deployed are indicated for each site. Acoustic recording began each night 30 minutes before dusk and ended 30 minutes after dawn. Please note that FBR-1 is the site used by Dr. Riley Bernard during her doctoral research at University of Tennessee, and it was monitored every night during the summers of 2013 (site number 6-13), 2014 (site number 66-14) and 2015 (site number 3-15).

Table 1A. Acoustic Monitoring Site—Summer 2013

Location	Site Number	Site ID	Latitude (N)	Longitude (W)	Altitude (ft.)	Date Deployed	Nights Deployed
Scarboro Creek	1-13	SCK-1	35.98285	-84.21676	859	5/28/2013	9
	2-13	SCK-2	35.98462	-84.21528	849	6/14/2013	4
Solway Bend	3-13	SOL-1	35.97668	-84.21829	780	6/24/2013	5
	4-13	SOL-2	35.98623	-84.19717	807	7/8/2013	4
	5-13	SOL-3	35.97767	-84.21356	830	6/28/2013	4
Freel's Bend Causeway	6-13	FBR-1	35.96150	-84.22437	825	5/24/2013	95
Freel's Bend	7-13	FBT-1	35.96241	-84.22880	829	6/28/2013	5
	8-13	FBL-1	35.94935	-84.21881	910	5/24/2013	18
	9-13	FBL-2	35.95244	-84.22489	849	6/14/2013	4
Gallaher Bend	10-13	GBR-1	35.95620	-84.25036	782	7/30/2013	4
	11-13	GBR-2	35.94768	-84.25106	810	7/30/2013	5
	12-13	GBR-3	35.93552	-84.24639	854	7/30/2013	5
McCoy Branch Creek	13-13	MCU-1	35.97117	-84.24962	882	7/17/2013	6
	14-13	MCL-1	35.96566	-84.25047	852	7/17/2013	6
	15-13	MCL-2	35.96332	-84.24928	811	9/16/2013	4
Melton Valley Road	16-13	MVR-1	35.93329	-84.28306	803	8/6/2013	3
ROW at Bearden Ck.Rd	17-13	PCK-1	35.92315	-84.28425	854	7/19/2013	4
Price Road	18-13	PRR-1	35.92297	-84.27050	1031	8/22/2013	5
	19-13	PRR-2	35.92383	-84.26015	1034	8/22/2013	5
Ponds at Bldg. 1504	20-13	POND-1	35.92209	-84.32178	829	7/23/2013	6
	21-13	POND-2	35.92214	-84.32111	782	7/23/2013	6
Y12 Storm damage area	22-13	Y12-1	35.97314	-84.28447	959	6/11/2013	2
	23-13	Y12-2	35.97491	-84.28514	1046	6/11/2013	2

Table 1A. (continued)

Location	Site Number	Site ID	Latitude (N)	Longitude (W)	Altitude (ft.)`	Date Deployed	Nights Deployed
	25-13	Y12-4	35.97621	-84.28638	1282	8/13/2013	3
	26-13	Y12-5	35.97619	-84.27852	1020	8/13/2013	3
	27-13	Y12-6	35.98198	-84.28351	922	8/13/2013	3
White Oak Creek	28-13	WOC-1	35.91666	-84.31617	824	7/30/2013	6
	29-13	WOC-2	35.91357	-84.31599	795	8/6/2013	3
	30-13	WOC-3	35.91281	-84.32175	869	8/23/2013	4
	31-13	WOC-4	35.91144	-84.31583	790	8/23/2013	4
ETTP P1 Pond	32-13	P1P-1	35.92485	-84.39650	769	9/11/2013	2
	33-13	P1P-2	35.92483	-84.39329	739	9/11/2013	2
	34-13	P1P-3	35.92437	-84.39760	739	9/13/2013	5
	35-13	P1P-4	35.92295	-84.39404	775	9/13/2013	5

Table 1B. Acoustic Monitoring Sites—Summer 2014

Location	Site Number	Site ID	Latitude (N)	Longitude (W)	Altitude (ft.)	Date Deployed	Nights Deployed
Jones Island Rd.	1-14	RC-1	35.90152	-84.35488	--	5/28/2014	4
	2-14	JI-1	35.90125	-84.35423	--	7/14/2014	4
	3-14	JI-2	35.90354	-84.34558	--	5/28/2014	4
	4-14	JI-3	35.90178	-84.33996	--	5/28/2014	4
	5-14	JIA-1	35.90064	-84.33293	806	6/23/2014	3
	6-14	ONZ-1	35.90898	-84.34558	778	7/14/2014	4
	7-14	FACE-1	35.90375	-84.33708	756	6/2/2014	3
	8-14	FACE-2	35.90391	-84.33627	744	6/2/2014	3
	9-14	FACE-3	35.90023	-84.33423	795	6/23/2014	3
	10-14	WOO-1	35.89845	-84.32833	788	6/23/2014	3
	11-14	WOO-2	35.89721	-84.33076	795	6/23/2014	3
Melton Branch /WBG	12-14	ME-1	35.91579	-84.30051	898	7/10/2014	4
	13-14	ME-2	35.91564	-84.30171	842	7/10/2014	4
	14-14	ME-3	35.91395	-84.30534	867	7/10/2014	4
	15-14	ME-4	35.91230	-84.31031	803	7/10/2014	4
	16-14	HFIR-1	35.91665	-84.30413	877	7/1/2014	6
	17-14	NRR-1	35.91556	-84.30874	824	7/1/2014	6
	18-14	NRR-2	35.91871	-84.30865	818	7/1/2014	6
	19-14	WOC-5	35.90912	-84.31810	826	7/1/2014	6
OST area	20-14	OST-1	35.92366	-84.36148	874	7/7/2014	3
	21-14	OST-2	35.92453	-84.36106	874	7/7/2014	3
	22-14	OST-3	35.92317	-84.36085	874	7/7/2014	3
	23-14	OST-4	35.92449	-84.35924	880	7/7/2014	3
West End Trail	24-14	WET-1	35.91994	-84.32778	926	7/24/2014	4
	25-14	WET-2	35.91761	-84.33055	864	7/24/2014	4
	26-14	WRSF-1	35.92161	-84.32415	838	7/14/2014	4
	27-14	PINE-1	35.89415	-84.32342	816	7/14/2014	4
Park City/Price Rds.	28-14	PCK-1	35.92296	-84.27288	961	7/18/2014	4
	29-14	PCK-2	35.91527	-84.26704	829	7/18/2014	4
	30-14	PCK-3	35.91393	-84.27093	864	7/18/2014	4
	31-14	PCK-4	35.92251	-84.32136	808	7/18/2014	4
Park City/Price Rds.	32-14	PRC-3	35.92100	-84.25746	856	8/15/2014	3
	33-14	PRC-4	35.92109	-84.25743	885	8/15/2014	3
	34-14	PRC-5	35.92758	-84.25835	885	8/15/2014	3

Table 1B. (continued)

Location	Site Number	Site ID	Latitude (N)	Longitude (W)	Altitude (ft.)	Date Deployed	Nights Deployed
SNS Area	36-14	SNS-1	35.94041	-84.30064	880	7/28/2014	4
	37-14	SNS-2	35.94432	-84.30339	970	7/28/2014	4
	38-14	SNS-3	35.95154	-84.29333	929	7/28/2014	4
	39-14	SNS-4	35.95108	-84.29786	1056	8/5/2014	3
	40-14	SNS-5	35.95471	-84.29776	1118	8/1/2014	3
	41-14	SNS-6	35.95368	-84.30317	1131	8/1/2014	3
	42-14	SNS-7	35.94702	-84.31037	987	8/1/2014	3
	43-14	SNS-8	35.94920	-84.30198	974	8/8/2014	3
	44-14	SNS-9	35.94800	-84.30454	985	8/8/2014	3
	45-14	SNS-10	35.94324	-84.30525	998	8/8/2014	3
Tower Shielding	46-14	CRC-1	35.89836	-84.31881	1133	8/4/2014	3
	47-14	TS-1	35.89983	-84.31787	1174	8/4/2014	3
	48-14	TS-2	35.89985	-84.31783	1184	8/4/2014	3
	49-14	TS-3	35.90998	-84.30240	1256	9/5/2014	4
	50-14	TS-4	35.90474	-84.29740	1302	9/5/2014	4
	51-14	TS-5	35.90335	-84.29214	1194	9/5/2014	4
	52-14	TS-6	35.89243	-84.29944	1064	9/5/2014	4
Walker Branch	53-14	WB-1	35.95653	-84.28914	1071	8/11/2014	4
	54-14	WB-2	35.95958	-84.28763	1174	8/11/2014	4
	55-14	WB-3	35.96298	-84.28452	1141	8/11/2014	4
	56-14	WB-4	35.96428	-84.28010	1154	8/11/2014	4
ORNL Cabin	57-14	NA14-1	35.93584	-84.27265	1207	8/8/2014	3
Bear Cr./Midway Rd.	58-14	BCK-1	35.93765	-84.33934	767	8/22/2014	3
	59-14	BCK-2	35.94556	-84.32546	826	8/22/2014	3
	60-14	BCK-3	35.95069	-84.32660	908	8/22/2014	3
	61-14	BCK-4	35.95755	-84.32274	1043	8/22/2014	3
	62-14	BCK-5	35.96235	-84.32998	944	8/25/2014	4
	63-14	BCK-6	35.96191	-84.31672	985	8/25/2014	4
	64-14	BCK-7	35.95076	-84.33592	946	8/25/2014	4
	65-14	BCK-8	35.94442	-84.34527	828	8/25/2014	4
Freel's Bend Causeway	66-14	FBR-1	35.96150	-84.22437	825	5/15/2014	122
Bldg. 1504	67-14	1504-1	35.92209	-84.32178	829	5/22/2014	2
	68-14	1504-2	35.92214	-84.32111	782	5/22/2014	2

Table 1C. Acoustic Monitoring Site—Summer 2015

Location	Site Number	Site ID	Latitude (N)	Longitude (W)	Altitude (ft.)	Date Deployed	Nights Deployed
Freel's Bend	1-15	C49	35.95750	-84.2275	826	6/12/2015	6
	2-15	FBL-3	35.95684	-84.2302	974	6/12/2015	6
Freel's Bend Causeway	3-15	FBR-1	35.98303	-84.2422	849	6/16/2015	86
Gallaher Bend	4-15	CPE	35.95829	-84.2323	749	6/16/2015	6
Price Rd.	5-15	C03	35.92402	-84.2705	830	6/24/2015	5
	6-15	C04	35.92728	-84.2632	825	6/25/2015	5
	7-15	C05	35.92702	-84.2649	961	6/24/2015	4
WOL Weir	8-15	HWY95-1	35.91144	-84.3160	821	6/30/2015	6
ETTP Beaver Ponds	9-15	K25-2	35.93400	-84.4121	847	7/1/2015	5
	10-15	K25-3	35.92637	-84.4053	815	7/1/2015	5
	11-15	K25-4	35.92558	-84.4004	760	7/1/2015	5
Black Oak Ridge CE	12-15	BORCE-1	35.95198	-84.3977	733	7/7/2015	6
	13-15	BORCE-2	35.94994	-84.4046	1374	7/7/2015	6
	14-15	BORCE-3	35.94288	-84.4232	1513	7/7/2015	6
	15-15	BORCE-4	35.92438	-84.4306	1353	7/7/2015	6

Table 1C. (continued)

Location	Site Number	Site ID	Latitude (N)	Longitude (W)	Altitude (ft.)	Date Deployed	Nights Deployed
Black Oak Ridge CE	16-15	BORCE-5	35.94335	-84.4180	1066	7/14/2015	7
	17-15	BORCE-6	35.95070	-84.5070	1028	7/14/2015	7
Bear Creek Rd. West	18-15	BP-1	35.90846	-84.3897	754	7/14/2015	7
	19-15	BP-2	35.91604	-84.4066	774	7/14/2015	7
DOSAR Rd.	20-15	DOS-1	35.94184	-84.3868	808	7/20/2015	8
Bearden Ck. Rd.	21-15	BCR-1	35.92505	-84.2811	820	7/20/2015	8
	22-15	BCR-2	35.92929	-84.2842	829	7/20/2015	8
Quarry near Blair Rd.	23-15	QAR	35.94181	-84.3867	808	7/20/2015	8

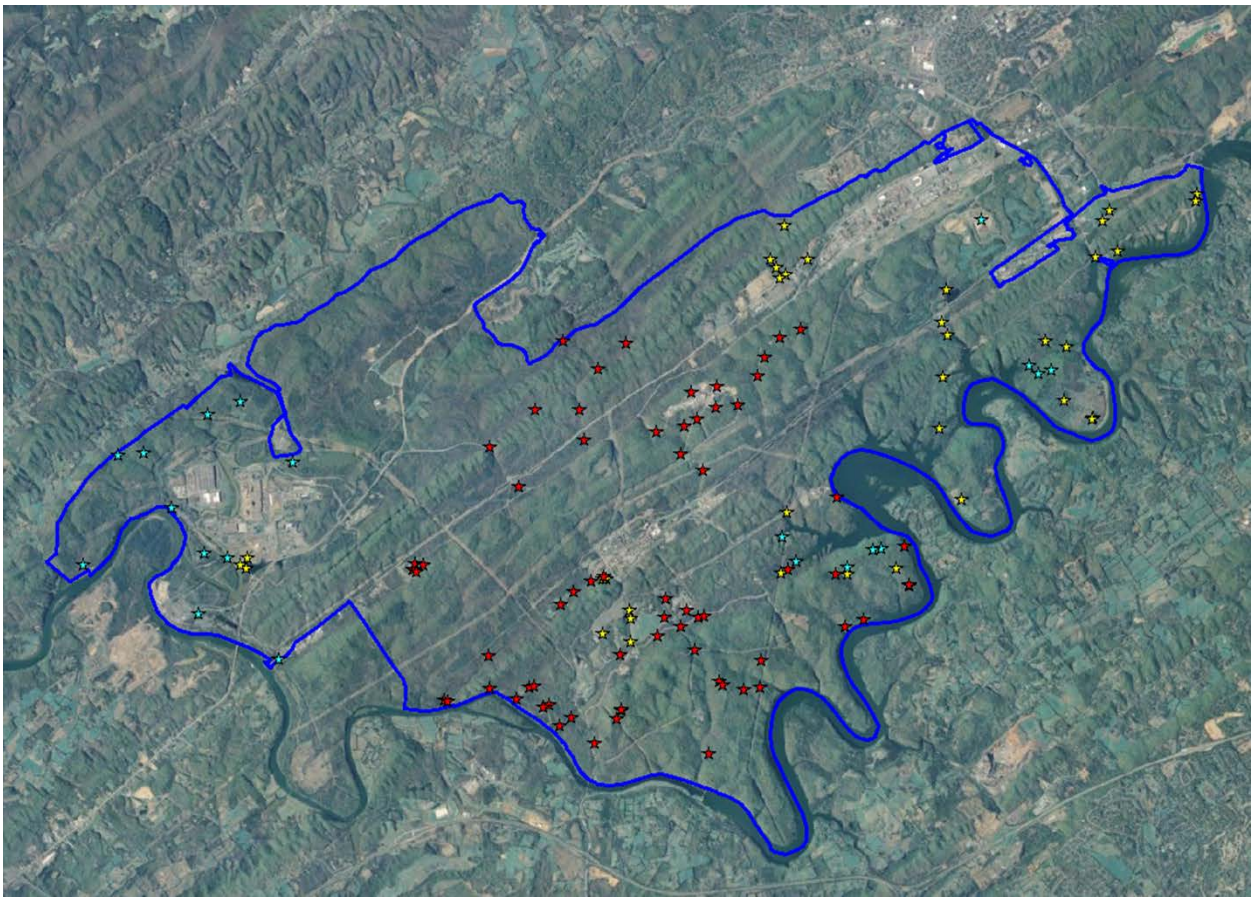

Figure 2. Bat survey sites on the Oak Ridge Reservation. Yellow stars indicate sites monitored in 2013, red stars indicate sites monitored in 2014 and blue stars indicate sites monitored in 2015.

2.2 ULTRASONIC ACOUSTIC ANALYSIS

The acoustic detector used for recording ultrasonic bat calls was Wildlife Acoustics SM2Bat+ Ultrasonic Bat Song Detector with an SMX Ultrasonic Microphone attached to an approximately 1.5 meter pole, collectively referred to as SM2 (Wildlife Acoustics, Inc.). When deployed, the SM2 was attached to a tree, telephone pole or other structure, and the microphone was raised to a height of approximately 3 meters. SM2s were set up to record nightly, beginning 30 minutes prior to sunset and ending 30 minutes after sunrise. Other sounds within the specified frequency range were recorded; these may include insect prey ultrasonic sounds, some of which may be used to jam bat foraging calls, and other non-bat-call noise.

Kaleidoscope Pro Software, Version 1 (Wildlife Acoustics) was used to analyze data from all monitoring sites (Lausen 2015). Data were analyzed as WAV files, which display full spectrum details of each call, including the frequency sweep of each portion of the call, as well as the amplitude, or loudness, of each sweep and the time between each call sweep. Kaleidoscope software compared each call file to a library of known calls for each species. Using these comparisons, data were sorted into categories: noise (NOISE); bat call of indeterminate species (NO ID), and bat call of specific species. Certainty of call identification accuracy was determined along with the number of calls recorded for each bat species. Sonabat 2 Software (Bat Conservation and Management, Inc.) was also used to identify calls; this software indicates probability of call identification accuracy. Table 2 lists each bat species found in Tennessee by scientific and common name as well as a standard 4-letter code used to refer to each species.

Table 2. Bat Species Found in Tennessee.

Species Code	Species	Common Name
CORA	*Corynorhinus rafinesquii*	Rafinesque's Big-eared Bat
COTO	*Corynorhinus townsendii*	Townsend's Big-eared Bat—endangered
EPFU	*Eptesicus fuscus*	Big brown Bat
LABO	*Lasiurus borealis*	Eastern Red Bat
LACI	*Lasiurus cinereus*	Hoary Bat
LANO	*Lasionycteris noctivagans*	Silver-haired Bat
LASE	*Lasiurus seminolus*	Seminole Bat
MYAS	*Myotis austroriparius*	Southeastern Bat
MYGR	*Myotis grisescens*	Gray Bat—endangered
MYLE	*Myotis leibii*	Eastern Small-footed Bat
MYLU	*Myotis lucifugus*	Little Brown Bat
MYSE	*Myotis septentrionalis*	Northern Long-eared Bat—threatened
MYSO	*Myotis sodalis*	Indiana Bat—endangered
NYHU	*Nycticeius humeralis*	Evening Bat
PESU	*Perimyotis subflavus*	Tri-colored Bat (formerly Eastern Pipistrelle)
TABR	*Tadarida brasiliensis*	Brazilian Free-tailed Bat

3. RESULTS

During this three-year study, one hundred and twenty-six sites were selected across the ORR to be monitored for bat ultrasonic calls, and each site was monitored a minimum of 2 consecutive nights. Thirty-five sites were surveyed from May 24th through October 1st, 2013, sixty-eight sites were surveyed from May 28th through September 10th, 2014, and twenty-three sites were surveyed from June 12th through September 8th, 2015. Table 3 presents the number of calls identified to species at each site using Kaleidoscope software. Species recorded were big brown bat, eastern red bat, hoary bat, silver-haired bat, gray bat, eastern small-footed bat, little brown bat, northern long-eared bat, Indiana bat, evening bat, tri-colored bat and Townsend's big-eared bat. Two additional bat species were detected using Sonabat 2 software: Rafinesque's big-eared bat and Brazilian free-tailed bat. It is important to note that number of calls does not equate with number of bats, as each bat makes multiple calls while foraging and may pass through the same area several times, thus the number of bats per species recorded at each site cannot be quantified. Surveys at several of the sites did not result in any identified bat calls.

Table 3. Results of Acoustic Monitoring. Number of calls recorded per Site Number by Bat Species: Ultrasonic bat calls identified to species. Each site surveyed lists the number of calls recorded per species identified using Kaleidoscope software. Results for CORA and TABR are from Sonabat software. Results from Freel's Bend Causeway were provided by Dr. Riley Bernard, University of Tennessee, Knoxville, TN. (2013, 2014, 2015).

Table 3A. Results for summer 2013.

Site ID	COTO CORA	EPFU	LABO	LACI	LANO	MYGR	MYLE	MYLU	MYSE	MYSO	NYHU	PESU	TABR
1-13	-	-	8	-	2	49	-	3	5	2	4	79	1
2-13	-	17	-	-	1	7	-	-	25	2	-	2	-
3-13	-	-	-	-	-	1	-	2	-	-	-	1	-
4-13	-	-	1	-	-	1	-	1	-	-	-	1	-
5-13	-	-	-	-	-	1	1	1	2	-	-	-	-
6-13	135	693	2843	175	131	5599	101	1283	25	249	670	14071	-
7-13	-	5	353	-	-	1	-	3	47	-	58	5757	-
8-13	-	20	51	-	11	15	-	1	2	-	-	699	1
9-13	-	-	1	-	-	-	-	-	3	-	4	-	2
10-13	-	-	-	-	-	-	-	-	1	-	-	1	-
11-13	2	17	3	-	3	9	-	3	2	3	-	63	2
12-13	-	1	45	-	45	187	5	66	55	-	-	215	1
13-13	-	-	-	-	-	-	-	-	-	-	-	1	-
14-13	-	1	7	-	-	-	-	2	5	-	1	4	-
15-13	-	-	-	-	-	-	-	-	-	-	-	-	-
16-13	-	-	75	1	-	126	1	3	3	-	4	612	1
17-13	-	1	-	-	-	1	3	-	-	-	-	-	-
18-13	-	1	5	-	-	35	1	24	71	4	-	12	-
19-13	-	15	5	-	1	2	-	-	-	-	12	3	-
20-13	-	-	20	-	1	1	-	2	5	1	3	41	-
21-13	-	-	26	-	-	4	-	-	23	-	3	47	-
22-13	-	-	-	-	-	1	1	4	2	-	-	-	-
23-13	-	-	-	-	-	-	-	-	1	-	-	-	-
24-13	-	-	-	-	-	-	-	-	1	-	-	-	-
25-13	-	-	-	-	-	-	-	-	-	-	-	2	-
26-13	-	22	8	-	-	-	1	6	7	-	-	6	-
27-13	-	3	2	-	-	-	-	-	-	-	-	2	-
28-13	-	2	9	-	-	9	1	1	4	-	1	55	-
29-13	-	-	116	1	-	1837	-	1	1	-	1	2040	-

Table 3A. (continued)													
Site ID	**COTO CORA**	**EPFU**	**LABO**	**LACI**	**LANO**	**MYGR**	**MYLE**	**MYLU**	**MYSE**	**MYSO**	**NYHU**	**PESU**	**TABR**
30-13	-	-	2	-	-	-	-	-	-	-	-	2	-
31-13	-	2	23	1	-	20	-	20	35	1	4	58	-
32-13	-	-	-	-	-	-	-	-	-	-	-	-	-
33-13	-	-	-	-	-	-	-	-	-	-	-	-	-
34-13	-	-	-	-	-	2	-	-	1	-	-	3	-
35-13	-	-	4	-	1	-	-	1	-	-	-	7	-

Table 3B. Results from summer 2014.													
Site ID	**COTO/ CORA**	**EPFU**	**LABO**	**LACI**	**LANO**	**MYGR**	**MYLE**	**MYLU**	**MYSE**	**MYSO**	**NYHU**	**PESU**	**TABR**
1-14	-	-	-	-	-	-	-	-	1	3	-	5	-
2-14	-	2	-	-	5	-	-	1	2	-	1	-	-
3-14	-	12	12	-	1	24	-	9	56	3	15	125	-
4-14	-	-	48	1	2	6	1	10	14	-	1	19	-
5-14	6	144	4	-	33	-	-	1	4	-	-	2	-
6-14	1	371	4	1	1	2	1	7	17	1	-	5	-
7-14	-	56	2	1	3	-	-	3	16	-	-	-	-
8-14	-	17	2	-	-	-	-	-	2	-	3	1	-
9-14	-	11	3	-	6	-	-	-	1	-	-	-	-
10-14	-	3	1	-	3	4	-	1	-	1	-	1	-
11-14	-	20	1	-	5	3	-	6	2	3	-	18	-
12-14	-	4	-	1	-	2	-	1	1	1	-	7	-
13-14	-	6	-	1	-	2	-	-	2	-	1	3	-
14-14	-	-	-	-	-	-	2	-	-	-	-	-	-
15-14	-	2	2	-	-	-	-	-	3	1	-	-	-
16-14	-	4	-	-	1	-	-	2	23	-	2	1	-
17-14	3	37	1	-	1	2	-	1	-	-	-	101	-
18-14	-	1	7	1	1	-	-	1	32	-	10	-	-
19-14	-	-	1	-	-	1	-	-	-	-	-	2	-
20-14	-	-	-	-	-	-	-	-	-	-	-	-	-
21-14	-	-	-	-	1	-	-	-	-	-	-	-	-
22-14	10	123	1	-	4	3	-	-	4	-	-	5	1
23-14	1	59	-	-	2	1	-	-	4	-	-	-	-
24-14	-	-	-	-	-	-	-	-	-	-	-	-	-
25-14	-	1	4	-	-	4	-	2	3	1	4	6	-
26-14	-	4	1	-	1	-	-	-	-	-	1	-	-
27-14	-	25	1	-	2	-	-	-	-	-	-	-	1
28-14	-	-	-	-	-	-	-	-	-	-	-	-	-
29-14	-	2	1	-	-	1	-	1	1	-	-	-	1
30-14	1	75	8	-	1	3	-	2	16	-	-	5	-
31-14	3	6	1	-	2	1	-	-	13	-	-	2	-
32-14	-	-	1	-	-	-	-	-	2	-	-	-	-
33-14	-	-	4	-	-	-	-	1	-	-	-	-	-
34-14	-	9	43	-	3	35	-	63	23	1	12	-	-
35-14	-	-	2	-	-	-	1	1	3	-	-	1	-
36-14	-	-	4	1	2	-	-	-	-	-	-	-	-
37-14	-	2	11	-	13	1	1	3	22	-	-	1	-
38-14	1	-	1	-	-	-	-	-	-	-	-	1	-
39-14	-	-	3	-	-	-	-	-	1	-	8	1	-

Table 3B. (continued)													
Site ID	**COTO/ CORA**	**EPFU**	**LABO**	**LACI**	**LANO**	**MYGR**	**MYLE**	**MYLU**	**MYSE**	**MYSO**	**NYHU**	**PESU**	**TABR**
40-14	-	-	-	-	-	-	-	-	-	-	1	3	-
41-14	-	1	-	2	-	-	-	-	1	-	4	5	-
42-14	-	-	10	-	-	3	-	-	-	-	6	5	-
43-14	-	-	1	-	-	-	-	-	-	-	-	3	-
44-14	-	1	26	-	-	400	1	3	1	-	6	118	-
45-14	-	-	2	-	-	-	-	-	-	-	-	-	-
46-14	-	-	6	-	-	6	3	23	18	-	-	28	-
47-14	-	-	3	-	-	5	-	-	-	-	-	12	2
48-14	1	51	15	-	-	11	-	22	13	2	2	55	-
49-14	-	-	1	-	-	-	-	-	1	-	-	1	-
50-14	-	6	51	-	1	25	-	4	5	-	-	23	-
51-14	-	-	28	-	-	31	-	3	1	-	-	149	-
52-14	-	-	-	-	-	16	-	58	62	1	-	-	-
53-14	-	3	3	-	-	-	-	-	5	-	-	5	-
54-14	-	-	-	-	-	-	-	-	1	-	-	-	-
55-14	-	17	-	-	-	1	-	-	2	-	-	7	-
56-14	-	1	4	-	-	4	-	2	3	1	4	6	-
57-14	-	1	9	-	-	4	-	4	4	-	1	5	-
58-14	-	-	-	-	1	-	-	-	-	-	-	-	-
59-14	-	1	-	2	-	-	-	1	-	-	-	1	-
60-14	-	7	5	-	-	13	-	2	5	-	-	51	-
61-14	-	1	-	-	-	-	1	-	3	-	-	20	-
62-14	-	34	6	-	-	13	-	4	1	-	1	7	-
63-14	-	-	3	-	-	-	-	-	5	-	-	-	-
64-14	-	-	-	-	-	-	-	-	1	-	2	-	-
65-14	2	31	2	-	10	6	2	12	4	1	8	23	-
66-14	120	452	1124	140	79	3603	98	193	22	71	128	2119	-
67-14	-	-	-	-	-	-	-	-	-	-	-	-	-
68-14	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3C. Results from summer 2015													
Site ID	**COTO/ CORA**	**EPFU**	**LABO**	**LACI**	**LANO**	**MYGR**	**MYLE**	**MYLU**	**MYSE**	**MYSO**	**NYHU**	**PESU**	**TABR**
1-15	-	**1**	**2**	-	-	-	**1**	**2**	**3**	-	-	**2**	-
2-15	-	-	-	-	-	-	-	**11**	**15**	-	-	**9**	-
3-15	-	**3**	**9**	-	**2**	**47**	-	**41**	**32**	**1**	-	**3**	-
4-15	-	-	**1**	**1**	**1**	**2**	-	-	**1**	-	-	**2**	-
5-15	-	-	-	-	-	-	**1**	**1**	**4**	-	-	-	**1**
6-15	-	**6**	-	-	-	**6**	-	**4**	**6**	-	-	**1**	**1**
7-15	-	**3**	**3**	-	**3**	**20**	-	**29**	**11**	-	-	-	-
8-15	-	**1**	**7**	-	-	**19**	-	**5**	**9**	-	-	-	-
9-15	**1**	**4**	-	-	**2**	**1**	-	**1**	-	-	-	**2**	-
10-15	-	**7**	**9**	**1**	**10**	-	-	**1**	-	-	**15**	-	**3**
11-15	**1**	**14**	**1**	-	**3**	**2**	-	**2**	**3**	-	**4**	**1**	-
12-15	-	**4**	**5**	-	**2**	**1**	-	**3**	**6**	-	**6**	**3**	-
13-15	**2**	**5**	**30**	-	-	**1**	-	**4**	**60**	**5**	**22**	**7**	**1**
14-15	**8**	**101**	**4**	-	**9**	**5**	-	**9**	**19**	**2**	**1**	**24**	-
15-15	-	**11**	**3**	**2**	-	-	-	**2**	**7**	-	-	-	-
16-15	-	-	-	-	-	-	-	-	-	-	-	-	-
17-15	-	-	**4**	**1**	-	-	-	**24**	**16**	**8**	**5**	-	-
18-15	-	-	**4**	**1**	-	**3**	-	-	**1**	-	**4**	**4**	-
19-15	-	-	-	-	-	-	-	-	-	-	-	-	-
20-15	-	-	-	-	-	-	-	-	-	-	-	-	-
21-15	-	-	-	-	-	**1**	-	-	-	-	-	-	-
22-15	-	-	-	-	-	-	-	-	-	-	**1**	**2**	-
23-15	-	-	-	**1**	-	-	-	-	-	-	**1**	-	-

4. DISCUSSION

One focus of this study has been to establish the presence of the endangered Indiana bat on the ORR during summer months. As reported previously, one Indiana bat was captured during mist-netting on June 23, 2013, and species identification was verified by Dr. Riley Bernard, (Ecology and Evolutionary Biology Department, University of Tennessee, Knoxville). Using Kaleidoscope software, Indiana bat ultrasonic calls were identified at 7 of 35 sites monitored during the summer of 2013, at 14 of 68 sites monitored during the summer of 2014, and at 4 of 23 sites monitored during the summer of 2015.

In summary, fourteen species of bats were detected acoustically on the ORR. Identification of ultrasonic bat calls to species using comparisons with libraries of known bat calls is complex. Software-based species decisions on unknown calls should be considered suggested classifications only (Lausen 2015). Bats may vary their calls to cover different situations, such as foraging in open fields, avoiding obstacles while flying through a forest, etc. Additionally, loudness of call, multiple concurrent bat calls, echos reflected off water, position of microphone in relation to the calling bat and other situations can result in an inability of software to accurately categorize each unknown call. Some bat species have overlapping acoustic characteristics as well. Species such as little brown bat and Indiana bat have very similar calls. All of these factors can contribute to call misidentification or rejection from identification altogether (Agranat 2012; Allen et al. 2015). Both software systems we used can identify most bat species found on the ORR; however, Kaleidoscope software version 1 could identify Townsend's big-eared bat calls but not Rafinesque's big eared bat calls, and Sonabat 2 software version could identify Rafinesque's big-eared bat calls but not Townsend's big-eared bat calls. Both software systems could identify Brazilian free-tailed bat calls, but only Sonabat 2 positively identified Brazilian free-tailed bat calls on the ORR. Neither software included Seminole bat identification capabilities, yet that species has been captured on the ORR in the past, and the ORR is within the extended range of the Seminole bat.

Bat captures are used to confirm bat species presence, and mist net surveys are included in Phase II of the USFWS Range-wide Indiana Bat Summer Survey Guidelines. Once species presence is confirmed by physical capture, acoustic analysis can be used more confidently to establish which bat species are present within a given area. Knowledge of the physical characteristics of an area along with literature reviews of habitat specificity for each species can suggest which species may be present within an area. Historical records of bat mist netting on the ORR have confirmed the presence of ten bat species: big brown bat, eastern red bat, silvered-haired bat, gray bat, little brown bat, northern long-eared bat, Indiana bat, evening bat, tri-colored bat and Seminole bat. Several bat species have been identified acoustically, but have not been captured. These are Rafinesque's big-eared bat, Townsend's big-eared bat, Brazilian free-tailed bat, hoary bat and eastern small-footed bat. The species ranges of Rafinesque's big-eared bat, hoary bat, eastern small-footed bat, and Brazilian free-tailed bat include the ORR, whereas Townsend's big-eared bat's known range does not include the ORR. The southeastern bat, *Myotis austroriparius*, whose range includes some counties in southern Tennessee, has not been trapped or recorded acoustically on the ORR. Table 4 summarizes bat species found on the ORR, either through mist net captures or acoustic call identification from 1992 through 2015.

Table 4. Bat Surveys on the Oak Ridge Reservation and Surrounding Area: 1992 through 2015 results.

Year	Method	COTO	CORA	EPFU	LABO	LACI	LANO	LASE	MYGR	MYLE	MYLU	MYSE	MYSO	NYHU	PESU	TABR
1992	net			x	x		x								x	
1996	net								x						x	
1997	net			x	x		x					x		x	x	
2003	net			x	x										x	
2003	acoustic			x	x				x						x	
2004	acoustic			x	x				x						x	
2005	net			x	x										x	
2006	net			x				x	x		x	x			x	
2008	net			x	x									x	x	
2011	net			x	x				x		x	x		x	x	
2011	acoustic			x			x		x					x	x	
2012	acoustic					x			x						x	
2013	net				x				x		x	x	x	x	x	
2013	acoustic	x	x	x	x	x	x		x	x	x	x	x	x	x	x
2014	acoustic	x	x	x	x	x	x		x	x	x	x	x	x	x	x
2015	acoustic	x	x	x	x	x	x		x	x	x	x	x	x	x	x

5. CONCLUSIONS

Acoustic surveys provide a good baseline for monitoring the presence of bat species populations in a given area. However, software used to identify bats to species base identification verification on species-specific libraries of calls unique to each software provider and even to each version of the software leading to possible questions concerning species identification accuracy in some cases. This is complicated by similarity in calls between certain species and variation in calls within species based on bat flight behavior, physical variations in habitat and positioning of the acoustic device in relation to the bat flight patterns. Therefore, bat capture through mist netting, other trapping methods or cave census ultimately should be the measure for confirmation of bat species presence in an area. Through both acoustic surveys and mist netting, the Oak Ridge Reservation has proven to be home to both endangered Indiana bats and gray bats, as well as the threatened northern long-eared bat. Seven additional species have been mist netted and recorded on the ORR. Bats identified acoustically, but as yet not had their presence confirmed through capture are the endangered Townsend's big-eared bat, Rafinesque's big-eared bat, eastern small-footed bat, Brazilian free-tailed bat and hoary bat. These data point to the need for future mist netting events to confirm the presence of all species of bats thus far recorded acoustically on the ORR. Further surveys will add to information on bat diversity and population locations across the ORR, and acoustic surveys at cave entrances need to be done in order to investigate the potential for hibernacula of endangered bats.

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