Notes

Effectiveness of Acoustic Lures for Increasing Indiana Bat Captures in Mist-Nets

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Abstract

As bat (Chiroptera) populations continue to decline in the eastern United States due to threats such as white-nose syndrome and interactions with wind facilities, capturing already rare species such as the federally endangered Indiana bat *Myotis sodalis* to assess health and demographics has become increasingly difficult. Mist-nets are a standard method for capturing and studying bats, but bats have the ability to escape from or avoid mist-nets. Past research has shown that the use of acoustic lures may increase mist-net capture success. Using prerecorded Indiana bat social calls, we tested the effectiveness of acoustic lures on capture rates across 24 nights at 37 sites in summers 2013 and 2014 in north-central Kentucky. Each site consisted of two nets (treatment and control) placed >35 m apart: we placed an acoustic lure set 1 m in front of the treatment net, whereas the control net received no lure. At the species level, we recorded significantly more captures in treatment nets ($n = 262$) than in control nets [$n = 128$; $t(36) = 5.08$, $P < 0.001$]. However, although we found a trend toward higher Indiana bat captures, the only species' with significant positive responses were evening bats *Nycticeius humeralis* [$t(15) = 6.25$, $P < 0.001$] and eastern red bats *Lasiurus borealis* [$t(36) = 3.60$, $P < 0.001$]. Further study is required to determine whether modifications to lure settings or call types result in increased Indiana bat captures.

Keywords: acoustic lure; bats; capture techniques; Chiroptera; Indiana bat; *Myotis sodalis*

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Introduction

Bat populations are declining in the eastern United States due to threats such as white-nose syndrome (Frick et al. 2010; Thogmartin et al. 2013) and negative interactions with wind facilities such as collisions and barotrauma (Arnett et al. 2008; Baerwald and Barclay 2011; Erickson et al. 2016). As a result, documenting species presence or probable absence is increasingly important, especially for federally endangered species pursuant to the US Endangered Species Act (ESA 1973, as amended) such as the Indiana bat *Myotis sodalis*. Mist-nets are a commonly used tool, but studies show that bats are often able to elude capture in mist-nets (Kunz et al. 1996; Waldien and Hayes 1999; Hill and Greenaway 2005, 2008). As a result, several studies recommend the use of acoustic bat detectors to supplement mist-netting efforts (Fenton et al. 1987; Kuenzi and Morrison 1998; O'Farrell and Gannon 1999; Murray et al. 1999; Flaquer et al. 2007). However, call sequences from many bats, particularly members of the genus *Myotis*, are difficult to detect and identify acoustically, especially when collected in cluttered environments such as interior forests (Schnitzler and Kalko 2001; Hill and Greenaway 2005). Furthermore, acoustic documentation may not be sufficient; many studies require the capture of individuals to record biometric data or to fit captured bats with identifying bands or radio transmitters.

Acoustic lures have been used to increase capture rates for taxa such as birds (Sydeman et al. 1998; Schaub et al. 1999), and there is growing literature on their use for bats (Gillam 2007; Lintott et al. 2014; Quackenbush et al. 2016; Braun de Torrez et al. 2017). Hill and Greenaway (2005, 2008) reported that even in areas where Bechstein's bat *Myotis bechsteinii* is known to occur in large numbers, individuals are rarely captured in nets. However, the authors were able to increase capture rates for this species by using ultrasonic playback of synthesized Bechstein's bat calls. Loeb and Britzke (2010) tested the response of Rafinesque's big-eared bat *Corynorhinus rafinesquii* to recorded social calls (Wilkinson 1995) of conspecifics and examined whether these recordings increase capture success at nearby mist-nets. Although their study suggests that Rafinesque's big-eared bat may not be attracted to, but rather repulsed by, conspecific calls, they did find that the capture rate of other bat species increased. Recently, Braun de Torrez et al. (2017) found that Florida bonneted bats *Eumops floridanus* responded positively to acoustic lures, and Quackenbush et al. (2016) developed models that suggest the use of an acoustic lure increased captures of *Myotis* species. Results from these studies show that it is possible to increase capture rates through the use of acoustic lures.

We sought to build on past research by specifically testing the ability of Indiana bat calls to increase conspecific captures in mist-nets. We placed acoustic lures at mist-net sets throughout Fort Knox, Kentucky, and hypothesized that broadcasting an Indiana bat roost call through an acoustic lure would increase captures of this species. We further hypothesized that playback of an Indiana bat distress call would increase captures across all species (Russ et al. 1998, 2004). We tested these hypotheses in field trials during summers 2013 and 2014.

Study Site

Field tests took place at Fort Knox, Kentucky, a military installation that spans portions of Meade, Bullitt, and Hardin counties and is divided across the level IV subdivisions of Mitchell Plain and Knobs-Norman Upland within the Interior Low Plateaus physiographic region (Woods et al. 2002). The area is characterized by rolling hills, flat wide bottomlands, entrenched streams, plentiful sinkholes, springs, wetlands, and underground drainage due to extensive karst topography. All of Fort Knox lies within the mesophytic forest region as described by Dyer (2006) and is adjacent the Beech-Maple-Basswood region. The mesophytic forest region is a combination of three regions described by Braun (1950): mixed mesophytic, western mesophytic, and oak-chestnut. The study site falls within the known range of 13 bat species.

Methods

We recorded two social call files at a known Indiana bat maternity colony at Fort Knox for use in this study. We collected full-spectrum, ultrasonic recordings using D240X ultrasound detectors (Pettersson Elektronik, Uppsala, Sweden). We examined calls visually using SonoBat software for bat call analysis (SonoBat, Arcata, CA). Bat communication can include a broad range of call types and behavioral responses (Fenton and Bell 1979; Fenton and Barclay 1980; Russ et al. 1998; Fenton 2003); due to our known collection method, we refer to our recordings as a roost call and a distress call. We acquired the roost call recording by placing the detector and a Zoom H2 sound recorder (Samson Technologies, Hauppauge, NY) on a pole approximately 2 m beneath the roost. We collected calls as bats exited the roost on the evening of 7 May 2012. We collected the distress call from an Indiana bat in-hand during processing on 18 May 2012. We identified the roost call by the long, low-frequency sweeps found in pulses 6–11 of the call sequence (Russ et al. 1998; Pfalzer and Kusch 2003) (Figure 1); we defined the distress call by the high amplitude of the call sequence, combined with the large frequency spread dropping close to 25 kHz (Russ et al. 1998) (Figure 2).

Recorded calls were broadcast through AT100 ultrasonic wide-bandwidth transmitters (Binary Acoustic Technology, Tucson, AZ) that had been modified with a conical diffuser and power boost unit. These modifications provide a 360° broadcast field, eliminating the need to rotate the transmitters during trials (Hill and Greenaway 2005; Loeb and Britzke 2010), while maintaining a 100-dB sound pressure level at 1 m (M. Jensen, Binary Acoustic Technology, personal communication). We used the GTools software program PLAY'R (Binary Acoustic Technology) to play back the prerecorded calls. Based on amplitude levels used in other studies (Lawrence and Simmons 1981; Gillam 2007), we set the volume levels in PLAY'R for each call to average 100 dB during playback. We then tested the range of the AT100 transmitter using these settings and our collected calls with an AnaBat SD2 bat detector (Titley Electronics Pty. Ltd., Ballina, NSW, Australia) and found broadcast distances up to 35 m in an open, uncluttered environment.

A power test using preliminary lure response data indicated that we required approximately 23 ($n = 22.7$) sample sites to capture experimental variation (Champley 2016). Therefore, we sampled 37 sites in an effort to detect significant differences. Each site was a minimum of 200 m apart when sampled on the same evening to maintain independence. The study took place over 24 calendar nights during summers 2013 (June and August) and 2014 (July and August). Each sample event started at sunset and lasted for 5 h. We only conducted a sample event in favorable weather as dictated by survey guidelines for Indiana bats (U.S. Fish and Wildlife Service [USFWS] 2013). We captured bats under USFWS permit TE94849B-0 and following the American Society of Mammalogists guidelines for the safe/proper handling of wild animals (Sikes et al. 2011).

At each site, we filled corridors side to side with two, 5.2-m-high mist-nets positioned to maximize bat captures (i.e., over road ruts or near canopy closures). Based on our broadcast range tests, we spaced nets within a site more than 55 m apart to ensure independence. We

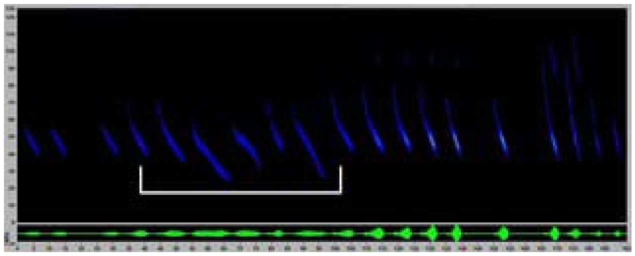

Figure 1. Indiana bat *Myotis sodalis* roost call sonogram recorded from bats exiting a maternity roost on 7 May 2012 in Fort Knox, Kentucky, and used for playbacks.

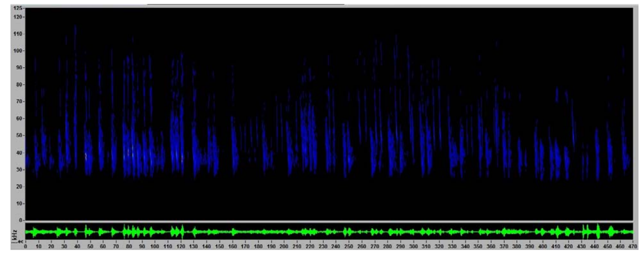

Figure 2. Indiana bat *Myotis sodalis* distress call sonogram recorded from a bat in-hand during field surveys on 18 May 2012 in Fort Knox, Kentucky, and used for playbacks.

set an acoustic lure 1 m in front of a treatment net on a 1-m-high tripod, whereas the control net received no lure. To limit the influence of microsite habitat advantages from one net to the other, we randomly assigned a lure to either net A or net B at each site by way of coin toss. We also used a coin toss to determine which of the two call types would be used at that net. Because we did not sample both call types at a net, direct comparisons at a single net based on call type were not possible with these data. To determine whether each call type produced varied results in general, we tested differences in capture distributions between roost and distress calls by using a chi-squared test and found no significant difference ($\chi^2 = 2.23$, $df = 1$, $P = 0.14$) when we expected equal capture probabilities. Consequently, we combined our call types for subsequent analysis.

We compared counts of bat captures in control versus treatment nets by using a series of zero-inflated generalized linear models for a Poisson distribution in the R software environment (R Core Team 2017) using package "pscl" (Jackman 2017). We determined model selection and weighting by using a small-sample corrected Akaike Information Criterion (AICc), calculated in the "AICcmodavg" package in the R environment (Mazerolle 2017). We calculated weights for AICc scores using the "MuMIn" package (Barton 2018). These models compared the influence of lure and sex on capture rates for overall bat captures and by species. We captured nine species and we modeled all species with more than 10 captures, resulting in species-specific exclusions of little brown bats *Myotis lucifugus*, hoary bats *Lasiurus cinereus*, and gray bats *Myotis grisescens*. We further modeled capture heights by lure or nonlure by using a generalized linear model for binomial distributions in R base package. Finally, we descriptively evaluated the number of species-specific captures by site and net (treatment or control) to ensure that if we captured more individuals in a specific net type, it was not the consequence of one site. This process is clarified in the Results and presented in Figure 3. Means are reported as $\pm$SE and tests were significant at $\alpha = 0.05$, unless otherwise noted.

Results

In total, we captured 390 individual bats of nine species during the study (see *Supplemental Material,* Data S1). We found no significant difference in Indiana bat captures during playback of either the Indiana bat roost call or distress call. However, when we combined all species captures, treatment nets, playing either call type, yielded significantly more captures ($n = 262$) than control nets [$n = 128$; $t(36) = 5.08$, $P < 0.001$; Table 1]. Bat species with high capture rates at treatment nets were also commonly captured across sites (Figure 3). We consistently observed higher treatment-net captures across sites than control-net captures, indicating that increases in capture rates were a universal phenomenon (Figure 3). We compared counts of individual species captures across treatment and control sites. On average, we captured 10.9 $\pm$ 0.5 bats per night at treatment nets and 5.3 $\pm$ 0.4 bats per night at control nets. Overall, we captured more males than females [$t(36) = 2.86$, $P = 0.004$]. Differences in average capture height were not significant between treatment and control nets [2.0 and 2.2 m respectively; $t(192) = 1.25$, $P = 0.22$]. Zero-inflated generalized linear models consisted of models exploring the influence of lure, sex, and an interaction between lure and sex. Models including bat lure and sex consistently produced the lowest AICc scores, but not an interaction (Table 2). Big brown bats *Eptesicus fuscus*, northern long-eared bats *Myotis septentrionalis*, evening bats *Nycticeius humeralis*, and Indiana bat captures were best modeled using only lures (Table 2). The model with the lowest AICc score was run for all bat species combined and each bat species individually (Table 3). We observed significant differences in capture rates for treatment nets when we combined all bat captures and for eastern red bats *Lasiurus borealis* and evening bats specifically (Table 3).

In addition to Indiana bats, captures also included the federally endangered gray bat (USFWS 1976) and the threatened northern long-eared bat (USFWS 2016), but there was no significant difference between the captures of these species in treatment nets versus control nets (Table 1). Of the nine species caught, only two species had significant positive responses to lures: evening bats and eastern red bats. Evening bats made up only 5% of total captures, but we caught 18 individuals of this species in treatment nets, whereas only one was caught in a control net (Table 1). These captures in treatment nets were distributed across multiple sites (Figure 3). Eastern red bats comprised 49% of captures, with 124 captured in treatment nets compared to 57 captured in control nets (Table 1). When we removed this species,

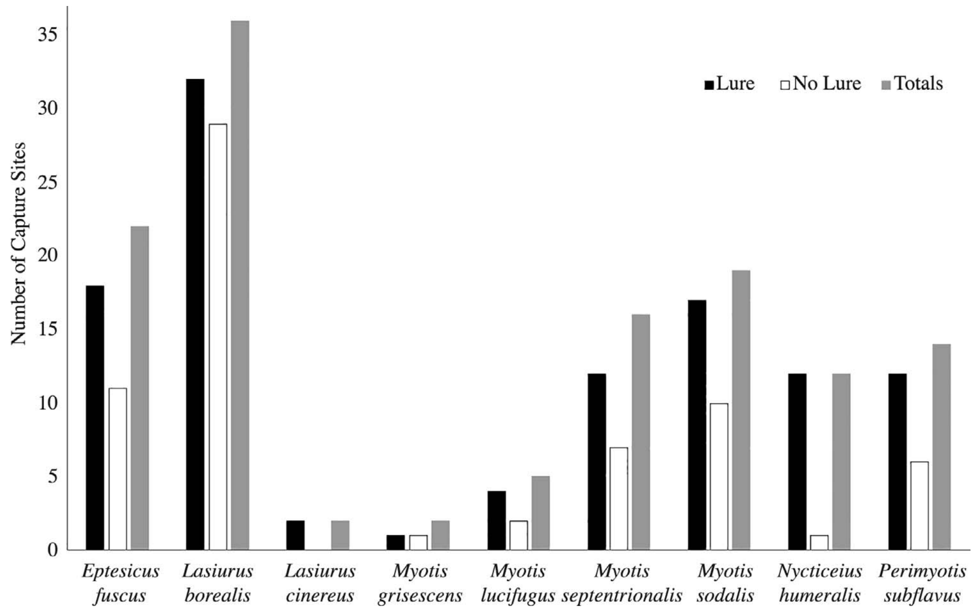

Figure 3. Number of sites at which we captured species in mist-nets across 37 sites at Fort Knox, Kentucky, in summers 2013 and 2014. Total = the number of sites where the species was caught. Lure = the number of sites the species was caught using an acoustic lure. No lure = the number of sites the species was caught without acoustic lures.

overall bat captures for the remaining species were still significantly higher in treatment nets compared to control nets.

Discussion

We hypothesized that broadcasting Indiana bat roost calls through an acoustic lure would increase capture success of this species. We further hypothesized that playback of a distress call would increase captures across all species (Russ et al. 1998, 2004). However, we found no difference between the call type and the number of captures for conspecifics or heterospecifics. This suggests that our particular roost call did not have characteristics that Indiana bats find attractive and that further study is needed to determine whether such a call type exists.

Although we found no significant difference in capture rates for Indiana bats, we did observe increased capture rate trends when an acoustic lure was present (Table 1). Our results support past studies that have shown an increased number of captures with the use of lures during bat mist-netting studies (Hill and Greenaway 2005, 2008; Loeb and Britzke 2010; Lintott et al. 2014; Braun de Torrez et al. 2017). Our results differ from those of Quackenbush et al. (2016), who found the use of a lure increased capture rates for *Myotis* species while decreasing rates in big brown bats and had no effect on eastern red bat capture rates. Quackenbush et al. (2016) suggested that the lack of impact on *Lasiurus* species may be tied to their solitary nature. By contrast, our results align more closely with those of Loeb and Britzke (2010), who found that big brown bats and eastern red bats were the most common species captured overall and had slightly higher captures at lure nets. Although we recognize that eastern red bats are likely the most common species in the Fort Knox study area, when we removed these bats from the analyses, the overall

Table 1. Species-specific bat captures at 37 sites on Fort Knox, Kentucky, in treatment nets (with lure) and control nets (no lure) sampled in summers 2013 and 2014.

Species	Scientific name	Treatment	Control	*t*-value	*P*
Big brown bat	*Eptesicus fuscus*	43	24	1.64	0.10
Eastern red bat	*Lasiurus borealis*	124	57	3.60	<0.001
Hoary bat	*Lasiurus cinereus*	2	0	NA	NA
Gray bat	*Myotis grisescens*	1	1	NA	NA
Little brown bat	*Myotis lucifugus*	4	3	0.33	0.74
Northern long-eared bat	*Myotis septentrionalis*	16	8	1.74	0.08
Indiana bat	*Myotis sodalis*	37	25	1.58	0.13
Evening bat	*Nycticeius humeralis*	18	1	6.25	<0.001
Tricolored bat	*Perimyotis subflavus*	17	9	1.68	0.09
Total without eastern red bats		138	71	2.61	0.003
Grand total		262	128	5.08	<0.001

NA = insufficient captures for comparisons.

Table 2. Zero-inflated generalized linear model outputs for bat captures, both combined and by species, on Fort Knox, Kentucky, sampled in summers 2013 and 2014. The model with the lowest small-sample corrected Akaike's Information Criteria (AICc) is listed first and bolded.

Species	Model	AICc	ΔAICc	w_i
All bats	**Lure+Sex**	**3626**	0	0.66
	Lure+Sex+Lure:Sex	3628	1.6	0.3
	Lure	3631	5.2	0.05
All bats except eastern red bat	**Lure+Sex**	**2238**	0	0.52
	Lure+Sex+Lure:Sex	2239	0.5	0.4
	Lure	2242	3.8	0.08
Big brown bat	**Lure**	**608**	0	0.97
Eptesicus fuscus	Lure+Sex+Lure:Sex	616.1	8.1	0.02
	Lure+Sex	616.3	8.3	0.02
Eastern red bat	**Lure+Sex**	**1216**	0	0.59
Lasiurus borealis	Lure+Sex+Lure:Sex	1218	2	0.22
	Lure	1218	2.2	0.2
Hoary bat *Lasiurus cinereus*	Too few captures			
Gray bat *Myotis grisescens*	Too few captures			
Little brown bat *Myotis lucifugus*	Too few captures			
Northern long-eared bat	**Lure**	**284.8**	0	0.65
	Lure+Sex	286.8	2	0.24
Myotis septentrionalis	Lure+Sex+Lure:Sex	288.2	3.4	0.11
Indiana bat	**Lure**	**535**	0	0.66
Myotis sodalis	Lure+Sex	537	2	0.24
	Lure+Sex+Lure:Sex	538.8	3.8	0.1
Evening bat	**Lure+Sex**	**206.1**	0	0.67
Nycticeius humeralis	Lure+Sex+Lure:Sex	207.7	1.6	0.3
	Lure	211.9	5.8	0.04
Tricolored bat	**Lure**	**305.4**	0	0.53
Perimyotis subflavus	Lure+Sex	306.3	0.9	0.34
	Lure+Sex+Lure:Sex	308.1	2.7	0.14

w_i = relative likelihood of a model (compared with other tested models).

capture rates were still significantly higher in lure nets for all other species.

Although Loeb and Britzke (2010) found that conspecifics associated with the broadcasted call were repelled by their lures, our study indicated a trend toward increased capture rates, even for conspecifics. We agree with their suggestion that the higher capture rates they observed may be due to species' reliance on ephemeral insect swarms, and that an acoustic lure, regardless of which species call is broadcast, may indicate food availability (Loeb and Britzke 2010). Because acoustic lures do not broadcast over a long distance, they likely only help increase capture success of bats already in the vicinity of the net site, as suggested by Loeb and Britzke (2010).

The inherent variability of mist-net studies makes comparisons between capture results difficult. Many factors at the site level (e.g., canopy cover, vegetative clutter, presence of water) and landscape level (e.g., distance to water, distance to roosts, distance to open fields) can influence capture success (Brigham et al. 1997; Yates and Muzika 2006; Duff and Morrell 2007) as can Julian day (Quackenbush et al. 2016). We limited the influence of these variables by sampling more sites than any previously published study and more than the minimum necessary indicated in a power test.

Comparisons between acoustic lure studies are also complicated by study design variations. This is especially true when considering the types of prerecorded calls used. All lure studies cited (Hill and Greenaway 2005, 2008; Loeb and Britzke 2010; Lintott et al. 2014; Quackenbush et al. 2016; Braun de Torrez et al. 2017) used a variety of call types, species, and methods. Although our data showed no difference in capture rates between lures playing an Indiana bat roost call or a

Table 3. Model outputs using the most parsimonious of a series of zero-inflated generalized linear models to test the effectiveness of acoustic lures to increase bat captures at Ft. Knox, Kentucky, sampled in summers 2013 and 2014.

Species	Covariate	Beta	SE	*P*
All bats	Intercept	−0.6		
	Lure	0.6	0.13	<0.001***
	Sex	−0.3	0.13	0.007**
All bats except eastern red bat	Intercept	−1		
	Lure	0.53	0.17	0.003**
	Sex	−0.4	0.17	0.02*
Big brown bat *Eptesicus fuscus*	Intercept	−4.3		
	Lure	0.58	0.25	0.2
Eastern red bat *Lasiurus borealis*	Intercept	−0.3		
	Lure	0.79	0.2	<0.001***
	Sex	−0.4	0.18	0.04*
Northern long-eared bat *Myotis septentrionalis*	Intercept	−2.2		
	Lure	0.71	0.46	0.13
Indiana bat *Myotis sodalis*	Intercept	−0.1		
	Lure	0.03	0.34	0.93
Evening bat *Nycticeius humeralis*	Intercept	−3.7		
	Lure	2.9	1.05	0.006**
	Sex	−1.7	0.67	0.011*
Tricolored bat *Perimyotis subflavus*	Intercept	−2.3		
	Lure	0.65	0.44	0.14

*Significant at the $\alpha = 0.05$ level.
**Significant at the $\alpha = 0.01$ level.
***Significant at the $\alpha = 0.001$ level.

distress call, we only tested one example of each of these call types. Given the variety of calls this species produces, further research is needed to determine whether other call types produce similar results.

Our results support the use of acoustic lures as a tool to increase overall bat captures and, possibly, to increase captures of less common species. We are confident that acoustic lures will play an increasingly important role in bat research and may be used to supplement existing survey efforts in industry-based baseline wildlife surveys. Finding the most effective ways to use this new tool is essential for success.

Supplemental Material

Please note: The *Journal of Fish and Wildlife Management* is not responsible for the content or functionality of any supplemental material. Queries should be directed to the corresponding author for the article.

Data S1. Raw bat capture data from acoustic lure trials in summers 2013 and 2014 at Fort Knox, Kentucky.

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References

Arnett EB, Brown WK, Erickson WP, Fiedler JK, Hamilton BL, Henry TH, Jain A, Johnson GD, Kern J, Koford RR, Nicholson CP, O'Connell TJ, Piorkowski MD, Tankersley RD Jr. 2008. Patterns of bat fatalities at wind energy facilities in North America. Journal of Wildlife Management 72:61–78.

Baerwald EF, Barclay RMR. 2011. Patterns of activity and fatality of migratory bats at a wind energy facility in Alberta, Canada. Journal of Wildlife Management 75:1103–1114.

Barton K. 2018. MuMIn: multi-model inference. R package version 1.40.4. Available: https://CRAN.R-project.org/package=MuMIn (September 2018). Archived by WebCite: http://www.webcitation.org/75IdEwQul.

Braun de Torrez EC, Samoray ST, Silas KA, Wallrichs MA, Gumbert MW, Ober HK, McCleery RA. 2017. Acoustic lure allows for capture of a high-flying, endangered bat. Wildlife Society Bulletin 41:322–328.

Braun EL. 1950. Deciduous forests of eastern North America. Philadelphia: Blakiston.

Brigham RM, Grindal SD, Firman MC, Morissette JL. 1997. The influence of structural clutter on activity patterns of insectivorous bats. Canadian Journal of Zoology 75:131–136.

Champley S. 2016. pwr: basic functions for power analysis. R package version 1.2-0. Available: https://CRAN.R-project.org/package=pwr (June 2018). Archived by WebCite: http://www.webcitation.org/75IdOgtDT.

Duff AA, Morrell TE. 2007. Predictive occurrence models for bat species in California. Journal of Wildlife Management 71:693–700.

Dyer JM. 2006. Revisiting the deciduous forests of Eastern North America. BioScience 56:341–352.

Erickson RA, Thogmartin WE, Diffendorfer JE, Russell RE, Szymanski JA. 2016. Effects of wind energy generation and white-nose syndrome on the viability of the Indiana bat. PeerJ 4:e2830. https://doi.org/10.7717/peerj.2830.

[ESA] Endangered Species Act of 1973, as amended, Pub. L. No. 93-205, 87 Stat. 884 (Dec. 28, 1973). Available: http://www.fws.gov/endangered/esa-library/pdf/ESAall.pdf (January 2019). Archived by WebCite: http://www.webcitation.org/75IdbaBJ6.

Fenton MB. 2003. Eavesdropping on the echolocation and social calls of bats. Mammal Review 33:193–204.

Fenton MB, Bell GP. 1979. Echolocation and feeding behaviour in four species of *Myotis* (Chiroptera). Canadian Journal of Zoology 57:1271–1277.

Fenton MB, Barclay RMR. 1980. *Myotis lucifugus*. Mammalian Species 142:1–8.

Fenton MB, Tennant DC, Wyszecki J. 1987. Using echolocation calls to measure the distribution of bats: the case of *Euderma maculatum*. Journal of Mammalogy 68:142–144.

Flaquer C, Torre I, Arrizabalga A. 2007. Comparison of sampling methods for inventory of bat communities. Journal of Mammalogy 88:526–533.

Frick WF, Pollock JF, Hicks AC, Langwig KE, Reynolds DS, Turner GG, Butchkoski CM, Kunz TH. 2010. An emerging disease causes regional population collapse of a common North American bat species. Science 329:679–682.

Gillam EH. 2007. Eavesdropping by bats on the feeding buzzes of conspecifics. Canadian Journal of Zoology 85:795–801.

Hill DA, Greenaway F. 2005. Effectiveness of an acoustic lure for surveying bats in British woodlands. Mammal Review 35:116–122.

Hill DA, Greenaway F. 2008. Conservation of bats in British woodlands. British Wildlife February 2008:161–169.

Jackman S. 2017. Pscl: classes and methods for R developed in the Political Science Computational Laboratory. Sydney, NSW, Australia: U.S. Studies Centre, University of Sydney. R package version 1.5.2. Available: https://github.com/atahk/pscl (August

2018). Archived by WebCite: http://www.webcitation.org/75IdhbbN9.

Kuenzi AJ, Morrison ML. 1998. Detection of bats by mist-net and ultrasonic sensors. Wildlife Society Bulletin 26:307–311.

Kunz, TH, Tidemann CR, Richards GC. 1996. Capturing mammals: small volant mammals. Pages 122–146 in Wilson DE, Cole FR, Nichols JD, Rudran R, Foster MS, editors. Measuring and monitoring biological diversity: standard methods for mammals. Washington, D.C.: Smithsonian Institution Press.

Lawrence BD, Simmons JA. 1981. Measurements of atmospheric attenuation at ultrasonic frequencies and the significance for echolocation by bats. Journal of the Acoustical Society of America 71:583–590.

Lintott PR, Fuentes-Montemayor E, Goulson D, Park KJ. 2014. Testing the effectiveness of surveying techniques in determining bat community composition within woodland. Wildlife Research 40:675–684.

Loeb SC, Britzke ER. 2010. Intra-and interspecific responses to Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) social calls. Acta Chiropterologica 12:329–336.

Mazerolle MJ. 2017. AICcmodavg: model selection and multimodel inference based on (Q)AIC(c). R package version 2.1-1. Available: https://cran.r-project.org/package=AICcmodavg (September 2018). Archived by WebCite: http://www.webcitation.org/75IdoarhQ.

Murray KL, Britzke ER, Hadley BM, Robbins LW. 1999. Surveying bat communities: a comparison between mist nets and the Anabat II bat detector system. Acta Chiropterologica 1:105–112.

O'Farrell MJ, Gannon WL. 1999. A comparison of acoustic versus capture techniques for the inventory of bats. Journal of Mammalogy 80:233–243.

Pfalzer G, Kusch J. 2003. Structure and variability of bat social calls: implications for specificity and individual recognition. Journal of the Zoological Society of London 261:21–33.

Quackenbush H, D'Acunto LE, Flaherty EA, Zollner PA. 2016. Testing the efficacy of an acoustic lure on bat mist-netting success in North American central hardwood forests. Journal of Mammalogy 97:1617–1622.

R Core Team. 2017. R: A language and environment for statistical computing. Vienna: R Foundation for Statistical Computing. Available: https://www.R-project.org/ (September 2018). Archived by WebCite: http://www.webcitation.org/75IdsBZmA.

Russ JM, Racey PA, Jones G. 1998. Intraspecific responses to distress calls of the pipistrelle bat, *Pipistrellus pipistrellus*. Animal Behaviour 55:705–713.

Russ JM, Jones G, Mackie IJ, Racey PA. 2004. Interspecific responses to distress calls in bats (Chiroptera: Vespertilionidae): a function for convergence in call design? Animal Behaviour 67:1005–1014.

Schaub M, Schwilch R, Jenni L. 1999. Does tape-luring of migrating Eurasian reed-warblers increase number of recruits or capture probability? Auk 116:1047–1053.

Schnitzler H, Kalko EKV. 2001. Echolocation by insect-eating bats. Bioscience 51:557–569.

Sikes, RS, Gannon WL, The Animal Care and Use Committee of the American Society of Mammalogists. 2011. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. Journal of Mammalogy 92:235–253.

Sydeman WJ, Nur N, McLaren EB, McChesney GJ. 1998. Status and trends of the ashy storm-petrel on southeast Farallon island, California, based upon capture-recapture analyses. Condor 100:438–447.

Thogmartin WE, Sanders-Reed CA, Szymanski JA, McKann PC, Pruitt L, King RA, Runge MC, Russell RE. 2013. White-nose syndrome is likely to extirpate the endangered Indiana bat over large parts of its range. Biological Conservation 160:162–172.

[USFWS] U.S. Fish and Wildlife Service. 1976. Determination that two species of butterflies are threatened species and two species of mammals are endangered species (Schaus swallowtail; Bahama swallowtail; Mexican wolf, *Canis lupus baileyi*; gray bat, *Myotis grisescens*). 41 FR 17742 17747, 28 April 1976.

[USFWS] U.S. Fish and Wildlife Service. 2013. 2013 Revised range-wide Indiana bat summer survey guidelines, May 2013.

[USFWS] U.S. Fish and Wildlife Service. 2016. Endangered and threatened wildlife and plants; 4(d) Rule for the northern long-eared bat. Final rule. 81 FR 1900 50 CFR 17, 14 January 2016.

Waldien DL, Hayes JP. 1999. A technique to capture bats using hand-held mist nets. Wildlife Society Bulletin 27:197–200.

Wilkinson GS. 1995. Information transfer in bats. Zoological Society of London 67:345–360.

Woods AJ, Omernik JM, Martin WH, Pond GJ, Andrews WM, Call SM, Comstock JA, Taylor DD. 2002. Ecoregions of Kentucky (color poster with map, descriptive text, summary tables, and photographs; map scale: 1:1, 000,000). Reston, Virginia: U.S. Geological Survey.

Yates MD, Muzika RM. 2006. Effect of forest structure and fragmentation on site occupancy of bat species in Missouri Ozark forests. Journal of Wildlife Management 70:1238–1248.