# RANGEWIDE INDIANA BAT SUMMER SURVEY GUIDANCE
# DRAFT- February 3, 2012

The following strategy is designed to provide standardized protocols to determine whether Indiana bats (*Myotis sodalis*) are present or likely absent at a given site during the summer (May 15[1] to August 15). This guidance is based on our current understanding of Indiana bat life history and their habitat. The following phased approach, which includes acoustic, mist net, radio-tracking, and emergence surveys, once finalized, will supersede the 2007 Indiana Bat Mist-Netting Guidelines. Future changes to this guidance are likely and will be posted on the U.S. Fish and Wildlife Service's (USFWS) Indiana bat website (http://www.fws.gov/midwest/Endangered/mammals/inba/index.html). Please check this website to ensure that you are using the most current version of the guidelines. **Note:** following this guidance will meet USFWS requirements; however, surveyors also need to ensure they meet all applicable State permitting and reporting requirements. Also, the use of TRADE, FIRM, OR CORPORATION NAMES in this document is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Interior of any product or service to the exclusion of others that may be suitable.

## RATIONALE/GENERAL STANDARDS

Historically, surveys to determine the presence or probable absence of Indiana bats in summer habitats have focused on mist-netting techniques. In addition to providing researchers and managers with comparable data sets to estimate changes in spatial distribution over time, other benefits of mist-netting include the collection of demographic data and the possibility of transmitter attachment. However, there are several limitations that serve to reduce the effectiveness of mist-netting for the documentation of Indiana bats at a particular site.

First, mist nets cannot be deployed in all habitats used by Indiana bats, thereby leaving some sites under-sampled. Additionally, some bats avoid capture in mist nets. It is well documented that Indiana bats, even when we know they are present, can be difficult to capture using currently accepted mist-netting survey protocols. In response to this limitation, studies have been conducted to investigate the effectiveness of mist-netting to determine Indiana bat presence (Robbins et al. 2008) and several other studies have been conducted to directly compare mist-netting and acoustical monitoring (Kunz and Brock 1975, Kuenzi and Morrison 1998, Murray et al. 1999, O'Farrell and Gannon 1999, Flaquer et al. 2007). Murray et al. (1999) deployed mist nets and acoustical monitoring equipment at the same locations on the same nights and found that ultrasonic detectors consistently detected bat species that mist-netting missed, including Indiana bats. Additionally, white-nose syndrome (WNS) has served to dramatically reduce bat densities, thereby reducing the effectiveness of mist-netting to capture bats. Finally, capturing bats increases the possibility of spreading the fungus that causes WNS. Thus, with all of these

[1] Due to concerns with transmission of white-nose syndrome, some USFWS FO(s) and State Natural Resource Agency(s) have delayed the start of the Indiana bat summer field survey season/mist-netting until June 1st. Researchers/applicants should always coordinate with your local USFWS FO(s)/ State Natural Resource Agency(s) before beginning surveys.

limitations on mist-netting, another technique is needed to more effectively survey for bats under these circumstances.

Ultrasonic detectors allow researchers to eavesdrop on the echolocation calls produced by bats as they forage and navigate in their surroundings without disturbing them. While ultrasonic detectors have been around for decades, recent advances in the equipment and quantitative analysis now allows for quantitative analysis of echolocation call data (Britzke et al 2011). With these advancements and since many bat echolocation characteristics are species-specific, bat detectors are now more efficient at documenting individual species presence than the time-consuming and labor-intensive traditional capture techniques such as mist-netting (Murray et al. 1999). Thus, the USFWS' decision to use ultrasonic detectors to determine presence or probable absence of Indiana bats and to focus subsequent survey efforts is a logical use of this technology in the current environment.

The following field survey guidelines were designed in an attempt to determine presence or probable absence of Indiana bats in an area of interest, but are not intended to be rigorous enough to provide sufficient data to fully determine population size or structure. Following these guidelines will help: 1) standardize survey procedures rangewide; 2) maximize the potential for detection/capture of Indiana bats at a minimum acceptable level of effort; and 3) ensure that survey results are sufficient to be accepted by the USFWS for regulatory purposes. Although acoustic detections and/or capture of Indiana bats confirm their presence, failure to acoustically detect or catch them does not absolutely confirm their absence.

Indiana bat surveys for some proposed projects will require modification (or clarification) of these guidelines. These situations must be resolved through coordination with the USFWS Ecological Services Field Office (USFWS FO) responsible for the state in which your project occurs. Consultation with the USFWS FO is always recommended and may be required by your federal permit. Implementing these survey guidelines without prior coordination with the USFWS FO may result in invalid or unacceptable conclusions for regulatory purposes. An online directory of USFWS FO(s) is available at http://www.fws.gov/offices/directory/listofficemap.html. Unless otherwise agreed to by the USFWS, negative acoustic survey results obtained using these protocols are valid for a minimum of two years[2] from the completion of the acoustic survey.

Both acoustic and mist-net surveys should be conducted in the best suitable habitat possible for each survey type to increase the likelihood of detecting/capturing Indiana bats. In some cases, the most suitable habitat for effectively conducting surveys may occur outside a project site boundary and may be sampled. However, if proposed sample sites are more than 1,000 feet from the project site boundary, then the USFWS FO should be consulted. All efforts should be made to coordinate with adjacent landowners to obtain appropriate authorizations and to ensure the best possible sites are surveyed.

[2] The minimum timeframe may be extended to five years when we believe it is highly unlikely that colonization of the habitat can occur within five years (e.g., if the unoccupied habitat is isolated from occupied habitat).

There are four phases of surveys, each dependent upon positive results of the prior phase (see Figures 1 and 2):

- Phase 1- Habitat Assessments;
- Phase 2- Acoustic Surveys;
- Phase 3- Mist-net Surveys; and
- Phase 4- Radio-tracking and Emergence Surveys.

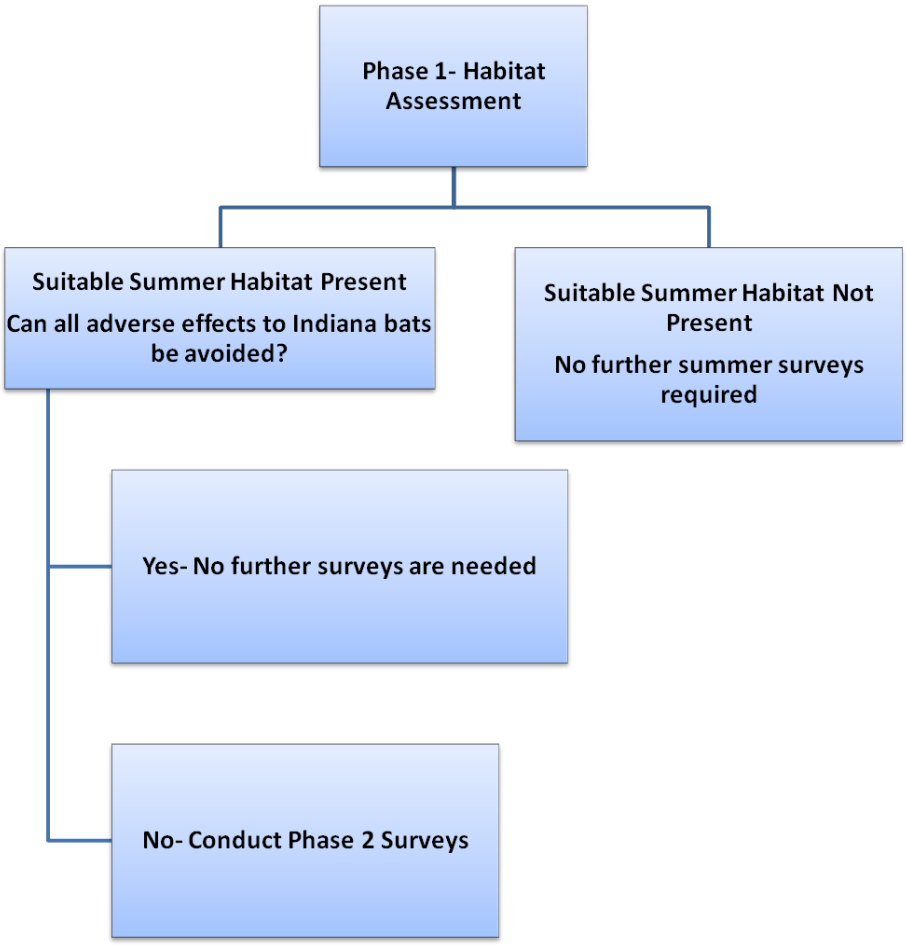



**Figure 1.** Indiana Bat Survey Guidance Decision Tree for Phase 1.

PHASE 1 - HABITAT ASSESSMENTS

The first step in determining whether Indiana bats may be present at a given site is to assess whether there is any suitable Indiana bat summer habitat. Habitat assessments can be completed any time of the year and ideally would be submitted to the USFWS FO(s) for review and approval well in advance of the summer survey period. Habitat assessments should be conducted for projects that have the potential to impact Indiana bats within areas identified by the USFWS as being within the range of the Indiana bat

(http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A000). Given that information can rapidly change, please coordinate with your local USFWS FO(s) to verify the location information and determine what level of coordination will be required prior to conducting any field work. **Please note that recommendations may be modified in areas that are already known to be occupied by Indiana bats during part of the year (i.e., spring staging, summer, fall swarming, and/or winter**).

Suitable summer habitat includes roosting, foraging, and commuting areas. Suitable summer roosting habitat is characterized by the presence of exfoliating bark, cracks, or crevices in trees (alive or dying) or snags that are > 3[3] inches diameter-at-breast height (dbh). Foraging habitat consists of forested patches, wooded riparian corridors, and natural vegetation adjacent to these habitats. Commuting habitat includes wooded tracts, tree-lines, wooded hedgerows, streams or other such pathways that are within or connected to roosting or foraging areas.

A habitat assessment report and project description must be provided to the USFWS FO(s) to determine whether additional survey phases are necessary. If the USFWS FO(s) concurs that there is no suitable Indiana bat *summer* habitat present in the project area or impacts are unlikely from the proposed project, no further *summer* surveys for Indiana bats are necessary. Project modifications (e.g., inclusion of adequate avoidance and minimization measures) may be possible at this phase in consultation with the USFWS FO(s) so that no additional surveys are needed. However, further coordination with the USFWS FO(s) may be necessary if known or potential migrating, swarming, or hibernating habitat is present in the project area. If suitable Indiana bat summer habitat is present, submit the habitat assessment report and draft study plan for conducting an acoustic survey to the USFWS FO(s) for review and concurrence. To ensure USFWS FO(s) acceptance of results, the habitat assessment and/or draft study plan for an acoustic survey should be submitted for pre-approval. Habitat assessment protocols are contained in Appendix A.

[3] While any tree greater than 3" dbh has the potential to be Indiana bat summer roosting habitat, we would not define solid stands of 3" dbh and smaller trees as suitable roosting habitat. While trees as small as 2.5" dbh can be used by males, suitable roosting habitat would generally consist of forest patches with larger trees also present.

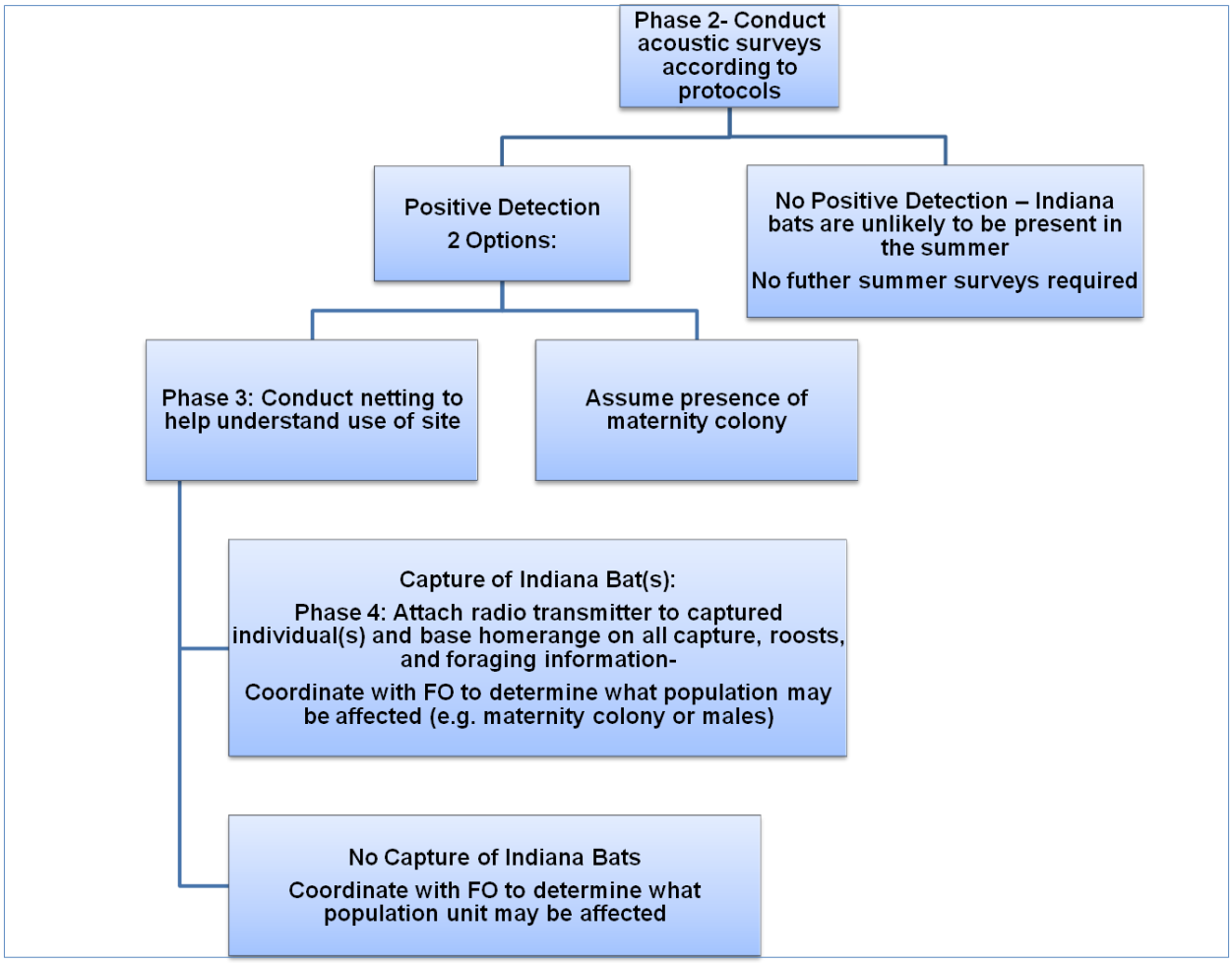



**Figure 2.** Indiana Bat Survey Guidance Decision Tree Phase 2-4.

PHASE 2 - ACOUSTIC SURVEYS

Acoustic surveys can be completed between May 15th and August 15th to determine whether Indiana bats may be present on-site following the methods described in Appendix B. If the acoustic surveys do not indicate that Indiana bats are present, no further summer surveys are needed. Submit negative results of the surveys to the local USFWS FO(s) for their review and concurrence.

If the acoustic surveys indicate that Indiana bats are present, then there are two options: (1) conduct no additional field surveys and assume presence of one or more maternity colony(ies) based upon distribution of detections, or (2) conduct mist-netting to better define use of site by Indiana bats. It is advantageous for surveyors to capture, track, and count Indiana bats initially detected with acoustics. The resulting information collected from radio-tagged bats greatly improves the USFWS's understanding about the type and level of bat presence (i.e., maternity or non-maternity) and their use of an area (e.g., focal roost sites) which facilitates the design of appropriate conservation measures and ultimate analysis of project effects on the species. For example, evidence suggesting that maternity roosts are located off-site will typically benefit a

project proponent. If mist-netting is not conducted and no additional site-specific data are generated, then the USFWS FO(s) will have to assume a reasonable worst-case scenario [e.g., presence of a maternity colony(ies) roosting within suitable habitat within the middle of the project area boundary], and therefore will require the most conservative measures for the protection of the species.

Results of positive acoustic surveys should be submitted to the local USFWS FO(s) for their review and concurrence within 10 days of survey completion (or other agreed upon date). If the acoustic survey results indicate that Indiana bats are present, and the project proponent wishes to conduct mist-netting to better determine the use of site by Indiana bats, then we recommend that the project proponent prepare and submit a draft Phase 3/4 study plan to their local USFWS FO concurrent with their acoustic survey report.

Note: If the project proponent wishes to complete all survey phases in the same summer season, then acoustic surveys must be completed and the draft mist-netting/radio-tracking/emergence survey study plan must be submitted to the USFWS FO(s) early enough so that mist-netting can be completed by July 31st. Radio-tracking of captured Indiana bats and emergence surveys may continue into August.

## PHASE 3- MIST-NETTING AND PHASE 4- RADIO-TRACKING/ EMERGENCE SURVEYS

Mist-netting surveys should be completed between May 15th and July 31st in project areas that previously have been confirmed as Indiana bat habitat by means of acoustical surveys. Mist-net surveys are designed to capture Indiana bats so that their gender, age, and reproductive condition can be determined. Additionally, captured bats may be banded (not required; contact your state natural resource permitting agency for banding recommendations) and have radio transmitters attached (as required). Mist-netting protocols are contained in Appendix C.

If an Indiana bat(s) is captured during mist-netting surveys, guidance on radio-tracking protocols and emergence survey requirements provided in Appendix D and E, respectively, must be followed. Radio-tracking and emergence surveys can provide vital data regarding roosting habitat and colony size.

If Indiana bats are <u>not</u> captured during mist-netting, coordinate with the local USFWS FO to determine which type of Indiana bat population (e.g., maternity colony or males) is likely to use the project site. If the assumption is a maternity colony, buffer positive acoustic survey sites by an assumed 5-mile radius home range. If positive acoustic results are obtained at sites located >5 miles apart, then multiple maternity colonies generally will be assumed present but other factors will also be considered (e.g., spatial distribution of positive acoustic sites in conjunction to available summer habitat). Submit the results of all field work conducted for a project to the local USFWS FO(s) for their review. The USFWS FO(s) will use this information in our analysis of effects (e.g., analysis of habitat quality, juxtaposition).

REFERENCES

Britzke, E.B., J.E. Duchamp, K.L. Murray, and L.W. Robbins. 2011. Acoustic Identification of Bats in the Eastern United States: A Comparison of Parametric and Nonparametric methods. Journal of Wildlife Management 75(3): 660-667.

Flaquer, C., I. Torre, and A. Arrizabalaga. 2007. Comparison of sampling methods for inventory of bat communities. Journal of Mammalogy 88:526-563.

Kuenzi, A.J., and M.L. Morrison. 1998. Detection of bats by mist-nets and ultrasonic sensors. Wildlife Society Bulletin 26(2):307-311.

Kunz, T. H., and C. E. Brock. 1975. A comparison of mist nets and ultrasonic detectors for monitoring flight activity of bats. Journal of Mammalogy 56:907-911.

Murray, K.L., E.R. Britzke, B. Hadley, and L.W. Robbins. 1999. Surveying bat communities: a comparison between mist nets and the Anabat II bat detector system. Acta Chiropterologica 1(1):105-111.

O'Farrell, M.J., and W.L. Gannon. 1999. A comparison of acoustic versus capture techniques for the inventory of bats. Journal of Mammalogy 80(1):24-30.

Robbins, L.W., K.L. Murray, and P.M. McKenzie. 2008. Evaluating the effectiveness of the standard mist-netting protocol for the endangered Indiana bat (*Myotis sodalis*). Northeastern Naturalist 15:275-282.

# APPENDIX A
# PHASE 1 HABITAT ASSESSMENTS

The information below is provided to assist applicants, consultants, and/or project proponents (hereinafter termed the "applicant") in establishing whether summer surveys for Indiana bats should be conducted. Acoustic and mist-netting survey results and the results of any subsequent radio-tracking/telemetry and emergence surveys (if applicable) will be used to complete a project-specific analysis to determine if proposed activities are likely to adversely affect Indiana bats and/or their habitat. The applicant is responsible for developing and providing sufficient information as to whether potentially suitable summer Indiana bat habitat exists within a proposed project area. **Habitat assessments for Indiana bats can be completed any time of year, are encouraged to be submitted prior to the summer survey season, and are required to be submitted to the USFWS FO(s).**

## PERSONNEL

While no formal training is required for conducting habitat assessments, we prefer they be completed by individuals with a natural resource degree or adequate work experience. Full names of individuals completing the habitat assessment and their relevant titles/qualifications must be provided with the habitat assessment report.

## INFORMATION TO DETERMINE IF POTENTIALLY SUITABLE SUMMER HABITAT IS PRESENT

Suitable summer habitat for Indiana bats consists of the variety of forested/wooded habitats where they roost, forage, and travel as well as surrounding non-forested habitats (e.g., agricultural fields, emergent wetlands, old fields, pasture). This includes forests and woodlots containing potential roosts (i.e., trees and/or snags > 3[4]" dbh that have exfoliating bark/cracks/crevices/hollows), as well as linear features such as fencerows, riparian forests, and other wooded corridors. These wooded areas may be dense or loose aggregates of trees with variable amounts of canopy closure. Individual trees may be considered suitable habitat when they exhibit the characteristics of a potential roost tree and are located within 1,000 feet of other suitable habitat.

## SUBMISSION OF PHASE 1 HABITAT ASSESSMENT RESULTS

A habitat assessment report must be submitted to the appropriate USFWS FO(s) along with a draft study plan for the acoustic survey (if completed). Each report must include the following:

1. Full names of individuals completing the habitat assessment, their relevant titles/qualifications, and when the assessment was conducted.

[4] While any tree greater than 3" dbh has the potential to be Indiana bat summer roosting habitat, we would not define solid stands of 3" dbh and smaller trees as suitable roosting habitat. While trees as small as 2.5" dbh can be used by males, suitable roosting habitat would generally consist of forest patches with larger trees also present.

2. A map and latitude/longitude or UTM clearly identifying the project location and boundaries.
3. A detailed project description.
4. Documentation of any known occupied spring staging, summer, fall swarming, and/or winter habitat for Indiana bats within the project area.
5. A description of methods used during the habitat assessment.
6. A completed Indiana Bat Habitat Assessment Worksheet (see attached below).
7. A map identifying the location of any exposed bedrock that supports caves, crevices, fissures, or sinkholes, or abandoned mines of any kind, and representative photographs of these areas.
8. Any other information requested by the USFWS FO(s) in the state you are working.
9. If a Phase 1 habitat assessment confirmed the presence of suitable Indiana bat habitat and an acoustic survey is planned, then a draft study plan for a Phase 2 acoustic survey should be submitted to the USFWS FO(s) for review and approval. Phase 2 study plans should include a map/aerial photo identifying the proposed project area boundaries, suitable bat habitats and acreages within the project area, and the proposed number of acoustical monitoring sites (see Appendix B for level of effort) and their tentative locations.
10. Some federal permit holders are required to request and receive written authorization from their local USFWS FO(s). These requests should be submitted in conjunction with the draft study plan for acoustic surveys and at least 15 days prior to initiation of proposed work.

# APPENDIX A
# PHASE 1 HABITAT ASSESSMENTS

## INDIANA BAT HABITAT ASSESSMENT DATASHEET

Project Name:_____ Date:_____

Township/Range/Section:_____

Latitude/Longitude:_____ Surveyor:_____

**Brief Project Description**

| |
|---|
| |

**Project Area**

| | Total Acres | Forest Acres | | Open Acres | |
|---|---|---|---|---|---|
| | | % of site | % w/in 1 mile | % of site | % w/in 1 mile |
| **Project** | | | | | |

| | Completely cleared | Partially cleared (with leave trees) | Reserve acres-no clearing |
|---|---|---|---|
| **Tree Removal (ac)** | | | |

**Landscape within 3 mile radius**

| |
|---|
| **Flight corridors to other forested areas?** |
| **Describe Adjacent Properties (e.g. forested, grassland, commercial or residencial development, water sources)** |

**Proximity to Public Land**

| |
|---|
| **What is the distance (mi.) from the project area to public lands (i.e., national or state forests, national or state parks, conservation areas, wildlife management areas)?** |

# APPENDIX A
# PHASE 1 HABITAT ASSESSMENTS

Use additional sheets to assess habitat at multiple sites in a project area

*Include a map depicting locations of sample sites if assessing habitat at multiple sites in a project area*
*A single description can be used for multiple sample sites if habitat is the same*

| **Sample Site Description** |
|---|
| Sample Site No.(s): _____ |

| **Water Resources at Sample Site** | | | | |
|---|---|---|---|---|
| **Stream Type (# and length)** | Ephemeral | Intermittent | Perennial | Describe existing condition of water sources: |
| | | | | |
| **Pools/Ponds (# and size)** | | Open and accessible to bats? | | |
| | | | | |
| **Wetlands (approx. ac.)** | Permanent | Seasonal | | |
| | | | | |

| **Forest Resources at Sample Site** | | | | |
|---|---|---|---|---|
| **Closure/Density** | Canopy | Midstory | Understory | 1=1-10%, 2=11-20%, 3=21-40%, 4=41-60%, 5=61-80%, 6=81=100% |
| | | | | |
| **Dominant Species** | | | | |
| **% Trees w/ Exfoliating Bark** | | | | |
| **Size Composition of Live Trees (%)** | Small (4-8 in) | Med (9-15 in) | Large (>15 in) | |
| | | | | |
| **No. of Suitable Snags** | | | | |

Standing dead trees with exfoliating bark, cracks, crevices, or hollows. Snags without these characteristics are not considered suitable.

**IS THE HABITAT SUITABLE FOR INDIANA BATS?** _____

IF SUITABLE: HIGH MODERATE LOW

| **Additional Comments:** |
|---|
| |

**Attach aerial photo of project site with all forested areas labeled and a general description of the habitat**

**Photographic Documentation:** habitat shots at edge and interior from multiple locations; understory/midstory/canopy; examples of potential suitable snags and live trees; water sources

APPENDIX B
PHASE 2 ACOUSTIC SURVEYS

## SUMMER ACOUSTIC SURVEY SEASON: May 15 – August 15

May 15-August 15 are acceptable limits for documenting the presence of summer populations of Indiana bats, especially maternity colonies. Outside of May 15-August 15, acoustic data cannot be used to conclusively document summer presence or probable absence.

## PERSONNEL

Individuals must have a working knowledge of the acoustic equipment, analysis tools and the Indiana bat. Individuals must identify each detector placement site and establish those sites in the areas that are most suitable for detecting Indiana bat calls.

## DETECTOR AND MICROPHONE REQUIRED CHARACTERISTICS

There are four major classes of ultrasonic detectors: heterodyne, time-expansion, frequency-division, and direct-recording. Heterodyne detectors are not suitable for this protocol because they only sample a small part of the frequency range used by bats. The reduced duty cycle offered by time-expansion detectors (the detector does not record while a call is being "processed") means these detectors are also not suitable for this protocol because the results cannot be acceptably compared to detector types that record 100% of the time. Frequency-division and direct-recording units are broadband detectors that sample 100% of the time and are suitable for this protocol.

Another important factor in the selection of appropriate ultrasonic detectors is the directionality of the microphone. Some units utilize omnidirectional microphones (e.g., Wildlife Acoustics and Batcorder) while most are strongly directional (e.g., AnaBat, Binary Acoustic, Pettersson, and Avisoft). Our conclusion is that it would be difficult to develop a protocol simultaneously suitable for both directional and omnidirectional detectors. **While both types of microphones have their uses, directional microphones allow greater flexibility in sampling a wider variety of habitats and are required for acoustic surveys at this time.**

## DEPLOYMENT OF ULTRASONIC DETECTORS

### Verification of Proper Functioning

As is the case with any electronic field-sampling equipment, verification that acoustic detectors are functioning properly is important to ensure high-quality bat calls are being recorded. It is common practice for electronic field equipment to undergo an annual verification process, with perhaps variable interval testing depending on demonstrated reliability (or lack of it). Therefore, it is highly recommended that surveyors ensure acoustic detectors are functioning properly. This includes a periodic verification of performance to factory specifications. This service is currently offered or is in development by several manufacturers. It may be possible that

independent service bureaus would be willing to perform this service, providing that a standard test/adjustment procedure can be developed.

It is also recommended that individuals ensure equipment is working after setup in the field. If timers are used, they should be adjusted so that the deployment of detectors is completed after the start time and pick-up is completed before the end time (i.e., the detector is on while surveyor is present at each site). Doing this also allows the surveyor to test proper equipment functioning at the site by rubbing their fingers in front of the microphone or using a commercially available tester. Testing shall be completed at the beginning and end of the sampling period to ensure that the equipment was functioning properly. Abnormal results (e.g., no files, file stopped early in the night, etc.) will require re-sampling if the setup and tear-down test files cannot be produced.

Suitability of the selected acoustic survey sites will also be assessed in the data-analysis stage. Suitable setup of the equipment should result in high-quality calls that are adequate for identification. Thus, at least 10 recorded bat calls (i.e., 3 high-quality pulses in a file) and a minimum of 40% of all recorded bat calls must be identified to species for the setup/site to be deemed suitable. Nights of sampling at individual sites that do not meet these minimum requirements will need to be re-sampled. Modifications of the equipment (employing modified weatherproofing or orientation) at the same location may improve quantity and quality of calls recorded. If modifications of the equipment do not improve call identification, then the detectors will need to be moved to a new location.

Weatherproofing

Recording of high-quality bat calls is critical to their proper analysis. Most bat detectors are not weatherproof when delivered from the factory. **Recording without weatherproofing is preferred as all weatherproofing systems result in some signal degradation.** However, it is common to employ weatherproofing methods when leaving bat detectors in the field for extended, unattended monitoring. These methods have the potential to affect the ability to detect bats. There are two popular types of weatherproofing options. Both rely on reflective surfaces to guide sounds to the microphone.

If the situation requires the use of weatherproofing the currently accepted option is the use of a polyvinyl chloride (PVC) tube, generally in the form of a 45-degree elbow the same diameter as the microphone. The microphone is pointed into one end of the elbow and the open end of the elbow points in the direction to be monitored (generally 45 degrees to horizontal). The elbow is attached to a weatherproof box that houses the main portion of the detector. The use of the PVC elbow results in performance similar to unprotected units (Britzke et al. 2010). The PVC elbow-weatherproofing option allows for suitable call quality and, therefore, is an approved method for weatherproofing detectors (see O'Farrell 1998; Britzke et al. 2010 for examples of this setup).

Other available weatherproofing, including the use of the flat reflector, are currently not accepted. Research has shown that the flat reflector results in a modified detection cone and reduced call quality, perhaps because the size of the reflector is too small for optimal performance (Britzke et al. 2010). Other weatherproofing (or modifications of flat reflectors)

may become available and approved by the Service provided they show that call quality and the number of calls recorded are consistent with no weatherproofing.

Orientation

Ultrasonic detectors can be deployed in a vast variety of orientations depending on the recording situation; however the orientation of the detector and relative position of the microphone may have a significant impact on the quality of recordings obtained (O'Farrell 1998). When deciding the orientation of the detector, the user should always keep in mind that the detection cone extends out from the unit. Horizontal orientations are not appropriate as they waste roughly ½ of the detection zone that is pointed to the ground. This serves to reduce call quality and detection (Britzke et al. 2010). In some circumstances, such as forest openings, it might be desirable to deploy the detector in a vertical fashion. This works well but does preclude the use of weatherproofing for protection of the microphone since all currently approved weatherproofing systems result in a 45 degree orientation. A 45 degree orientation minimizes the amount of the detection cone lost by sampling the ground, while maintaining the ability to use weatherproofing, if needed.

The relative position of the microphone to the bats is also an important factor in call quality. If a microphone is above the bats (e.g., on a stream bank) call quality will be reduced. Thus it is important to deploy the detector at or below the lowest expected flight height of the bats but above ground vegetation. Based on this information, an orientation of 45 degrees or higher is required for recording calls for presence/absence surveys. Once acoustic sites are identified, photographs documenting the orientation, detection cone (i.e., what the detector is "sampling"), and relative position of the microphone should be taken for later submittal to the USFWS FO(s) as part of the acoustic survey report.

## SAMPLING PROTOCOL

Detector Placement

Detectors must be properly placed at suitable monitoring sites, because such placement is critical to the successful isolation of bat calls for later analysis. The following locations are likely to be suitable sites for detectors, including, but not limited to: (a) forest-canopy openings that are no more than 50 meters wide; (b) water sources; (c) wooded fence lines that are adjacent to large openings or connect two larger blocks of suitable habitat; (d) blocks of recently logged forest where some potential roost trees remain; and (e) road and/or stream corridors with open tree canopies or canopy height of more than 10 meters (Britzke et al. 2010). If detectors are placed in unsuitable locations (e.g., cluttered sites with vegetation within 10 meters of the microphone), effective data analysis may be impossible, and the results of the sampling effort may be invalid.

Detectors should be deployed in areas without, or with minimal, vegetation within 10 meters in front of the microphone. If necessary, surveyors can remove small amounts of vegetation (e.g., small limbs, saplings) from the estimated detection cone at a site, much like what has been done while setting up mist nets. Deployment of detectors in closed-canopy locations that typically are

good for mist-netting are acceptable as long as the area sampled below the canopy does not restrict the ability of the equipment's detection cone to record high-quality calls.

Detectors also allow sampling of habitats that cannot be effectively sampled with mist nets (e.g., forest edges, large streams, large ponds, etc). Surveyors should distribute acoustic sites throughout the project area or adjacent habitats. In most cases, detector sites should be at least at least 200 meters apart. If closer spacing was determined to be necessary or beneficial (e.g., multiple suitable acoustic sites and habitats immediately adjacent to each other), sufficient justification must be provided by the surveyor within the acoustic survey report submitted to USFWS FO(s).

NOTE: Deployment of acoustic detectors immediately adjacent to known or suitable roost trees in hopes of recording the bats emerging from these trees is not appropriate for this protocol. Call characteristics of bats emerging from a roost tree, building, or bat house are not typical search-phase calls and thus cannot be reliably used to determine species identification at this time. If the surveyor discovers a potential roost and wishes to document bat use, please refer to Appendix E for guidance on conducting emergence surveys and contact the USFWS FO(s).

Weather Conditions

Severe weather adversely affects the activity levels of bats. If any of the following weather conditions exist at the project site during acoustical sampling, the time and duration of such conditions must be noted, and the acoustical sampling effort must be repeated for that night: (a) temperatures fall below 10°C (50°F); (b) precipitation, including rain and/or fog, that exceeds 30 minutes or continues intermittently during the survey period; and (c) sustained wind speeds greater than 4 meters/second (9 miles/hour).

Minimum Level of Effort

The number of acoustical sampling sites required for a project will be dependent upon the overall acreage of suitable habitat proposed to be impacted by the action. To determine the acoustic sampling effort, quantify the amount of suitable habitat within the project area. All projects will require (1) a minimum of 2 sites, (2) the deployment of 1 detector per site, and (3) all sampling to be conducted for 2 suitable nights. The acoustical sampling period must begin before sunset[5] and continue throughout the entire night (e.g., until after sunrise) on each site night of sampling.

- For non-linear projects: One site per 30 acres of suitable habitat
- For linear projects: One site for each kilometer of the project corridor that contains suitable habitat.

[5] Sunset tables for the location of survey can be found at: http://www.usno.navy.mil/USNO/astronomical-applications/data-services/rs-one-year-us

# APPENDIX B
# PHASE 2 ACOUSTIC SURVEYS

## ANALYSIS OF RECORDED ECHOLOCATION CALLS

Previous research has shown the ability to accurately identify bats by their echolocation, including the Indiana bat (Britzke et al. 2011). As there are numerous potential analysis programs, the purpose of this section is not to provide step-by-step analysis program-specific instructions, but rather to provide an understanding of the minimum requirements for what is expected if the results from the acoustic surveys are to be accepted as valid.

1. Any call identification analysis program should be based on a large call library.
2. The entire analysis process should be quantitative (preferably automated) to ensure repeated consistency in analysis.
3. The process should include filtering to remove extraneous noise and no-bat files.
4. The process should include an "unknown" category for classifying calls that are not characteristic of species in the call library to ensure that such calls are not forced to species identification.
5. Accuracy rates of the program should be derived through cross-validation, published in a peer-reviewed journal, and should be comparable to other methods.
6. As species identifications are never perfect, all analysis programs should utilize the maximum likelihood to determine species presence at the site (Britzke et al., 2002), rather than relying on a single sequence.
7. Results should include file level summaries (# of pulses, species IDs), site/night analyses (# of files, # IDs for each species), and the maximum likelihood results.

Once completed with the analysis, all of the raw files as well as the output files should be retained for 7 years. These files may be requested by state or federal agencies. Failure to retain these files may result in the requirement for additional sampling.

### *Interpretation of Acoustic Analysis Results*

If the results of the acoustic analysis results in the identification of Indiana bat calls with high levels of certainty (i.e., a maximum likelihood result of $P < 0.05$), then the project proponent may either mist net in an attempt to capture recorded bats or assume presence of a maternity colony. Additional survey work should follow the mist-netting guidance found in Appendix C. While mist-netting is encouraged immediately after acoustic surveys are completed, additional survey work to capture and radio track Indiana bats can occur at anytime within the mist-netting survey window. Additionally, if the data analysis of collected calls results in the identification of other federally endangered bat species (e.g., gray bats, Virginia big-eared bats, and/or Ozark big-eared bats), then the USFWS FO(s) in the state(s) where calls were detected should be notified immediately to determine if any additional survey effort for those species is necessary.

## SUBMISSION OF ACOUSTIC SURVEY RESULTS

A complete acoustic survey report documenting the presence of Indiana bats must be submitted to the appropriate USFWS FO within 10 days of completion of acoustic data collection. If acoustic surveys do not indicate the presence of Indiana bats, no further sampling is needed.

## APPENDIX B
## PHASE 2 ACOUSTIC SURVEYS

You must still submit the complete survey report with negative results to the local USFWS FO(s) for their review and concurrence, but negative findings may be submitted at any time. Each acoustic survey report must include the following:

1. Copy of habitat assessment and acoustic survey study plan report (if not previously provided).
2. Explanation of any modifications from study plan (e.g., site locations being moved).
3. Description of acoustical monitoring sites, survey dates, duration of survey, and weather conditions.
4. Map identifying acoustical monitoring locations including GPS coordinates.
5. Full names of all personnel present during acoustic surveys including those that selected acoustic sites and deployed detectors, including copies of State and Federal permits.
6. Table with information on acoustical monitoring and resulting data including but not limited to: acoustic detector brand(s) used, use of weatherproofing, acoustical monitoring equipment settings (e.g., sensitivity, audio and data division ratios), deployment data (i.e., deployment site, habitat, date, time started, time stopped, orientation), and summary of output results from Excel spreadsheet by site.
7. Photographs of each acoustic site documenting the orientation and detection cone (i.e., what the detector sampled).
8. Any other information requested by the USFWS FO(s) in the state you are working.
9. If acoustic survey resulted in the documentation of Indiana bats and project proponent has elected to continue with mist-netting surveys, then provide a draft Phase 3 & 4 mist-netting, radio-tracking and emergence survey study plan for USFWS FO(s).

## REFERENCES


Britzke, E.R., K.L. Murray, J.S. Heywood, and L.W. Robbins. 2002. Acoustic identification. Pages 221-225 *In* A. Kurta, and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species, Bat Conservation International, Inc., Austin, Texas.

Britzke, E.R, B.A. Slack, M.P. Armstrong, and S.C. Loeb. 2010. Effects of orientation and weatherproofing on the detection of bat echolocation calls. Journal of Fish and Wildlife Management 1(2):136-141.

Britzke, E.B., J.E. Duchamp, K.L. Murray, and L.W. Robbins. 2011. Acoustic Identification of Bats in the Eastern United States: A Comparison of Parametric and Nonparametric methods. Journal of Wildlife Management 75(3): 660-667.

Kiser, J.D. and J.R. MacGregor. 2005. Indiana bat (*Myotis sodalis*) mist net surveys for coal mining activities. Pp. 169-172 *in* K.C. Vories and A. Harrington (eds.), The Proceedings of the Indiana bat and coal mining: a technical interactive forum Office of Surface Mining, U.S. Department of the Interior, Alton, IL. Available at: http://www.mcrcc.osmre.gov/MCR/Resources/bats/pdf/Indiana_Bat_and_Coal_Mining.pdf. (Accessed October 06, 2011).

O'Farrell, M. J. 1998. A passive monitoring system for Anabat II using a laptop computer. Bat Research News 39:147-150.

APPENDIX C
PHASE 3 MIST-NETTING SURVEYS

NETTING SEASON: May 15 – July 31

May 15 – July 31 are acceptable limits for capturing summer populations of Indiana bats, especially maternity colonies. Capture of reproductive adult females (i.e., pregnant, lactating, or post-lactating) and/or young of the year during May 15 – July 31 confirms the presence of a maternity colony in the area. Since adult males and non-reproductive females have commonly been found summering with maternity colonies, radio-tracking results will be relied upon to determine the presence and or absence of a maternity colony in the area.

PERSONNEL

A qualified biologist(s)[6] must (1) select/approve mist net locations in areas that are most suitable for capturing Indiana bats, 2) be physically present at each mist net location throughout the survey period, and 3) determine all bat species identifications.

EQUIPMENT

Mist nets to be used for Indiana bat surveys should be the finest, lowest visibility mesh commercially available. Currently, the finest net on the market is 75 denier, 2 ply, denoted 75/2 (Arndt and Schaetz 2009), however, the 50 denier nets are still acceptable for use. The finest mesh size available is approximately 38 millimeter (~1 1/2 inch).

No specific hardware is required. There are many suitable systems of ropes and/or poles to hold nets. The system of Gardner et al. (1989) has been widely used. See NET PLACEMENT for minimum net heights, habitats, and other netting requirements that affect the choice of hardware.

To minimize potential for disease transmission, any equipment that comes in contact with bats should be kept clean and disinfected, following approved protocols; this is particularly a concern relative to white-nose syndrome (WNS). Disinfection of equipment used in WNS-affected areas is required; protocols are posted at http://www.whitenosesyndrome.org/ Federal and State permits may also have specific equipment restrictions and disinfection requirements. The disinfection protocols were developed for addressing concerns about WNS. However, these protocols are generally good practices to avoid disease transmission and risk of exposure to other bats, and we recommend disinfection of equipment for all bat studies to minimize potential disease-related impacts to wildlife and people, even in areas where WNS is not known to occur.

[6] A qualified biologist is an individual that holds a USFWS Recovery Permit (Federal Fish and Wildlife Permit) for federally listed bats in the state/region which they are surveying and/or has been authorized by the appropriate State Agency to survey for Indiana bats. Several USFWS offices maintain lists of qualified bat surveyors and if working in one of those states, the individual will either need to be on that list or submit qualifications or receive USFWS approval prior to conducting any field work.

# APPENDIX C
# PHASE 3 MIST-NETTING SURVEYS

## NET PLACEMENT

Potential travel corridors (e.g., streams, logging trails) typically are the most effective places to net (although other sites may also be productive; see Carroll et al. 2002). Place nets approximately perpendicular across the corridor. Nets should fill the corridor from side to side and from stream (or ground) level up to the overhanging canopy. Nets of varying widths and heights may be used as the situation dictates. If netting over water, ensure there is enough space between the net and the water so that the bat will not get wet upon capture.

Occasionally it may be necessary or desirable to net where there is no good corridor. Take caution while attempting to place nets in the canopy. The typical equipment described in the section above may be inadequate for these situations, requiring innovation on the part of the researchers (see Humphrey et al. 1968). Always exercise safety precautions when placing nets making sure poles and nets are clear of overhead wires. See Kiser and MacGregor (2005) for additional discussion of net placement.

## SUGGESTED MINIMUM MIST-NETTING EFFORT

An effective mist-netting effort should be used at locations best suited for capturing Indiana bats. Mist net locations should be within the general vicinity of positive acoustic detection sites for Indiana bats and suitable habitat. Mist-netting is a focused effort to capture Indiana bats detected during the Phase 2 Acoustic Surveys and to better understand their use of a project area. Results from the acoustic survey should be used to identify potential netting locations, especially if netting occurs shortly after collection of acoustic data.

In order to determine the mist-netting effort for each individual project (Linear or non-linear) complete the following (also see Figures 1 and 2 for examples of small and large projects, respectively):

1. For projects with 1 positive acoustic site for Indiana bats, place a 1-mile radius buffer circle around the positive site, then continue to Step 3.a.
2. For projects with multiple positive acoustic sites documenting Indiana bats:
    a. Identify the 2 positive acoustic sites that are in the closest proximity to each other.
    b. If those sites are within 1-mile of each other, then identify the midpoint of the line connecting the 2 sites. Place a 1-mile radius buffer circle around the midpoint and identify the total number of positive acoustic sites within that buffer circle, then proceed to Step 3.a. Once positive acoustic sites are included within a buffer circle, they will not be considered during the creation of any remaining buffer circles.
    c. If the sites are greater than 1-mile from each other, place a 1-mile radius buffer circle around each positive site, then proceed to Step 3.a.
    d. Continue this process until all sites are placed in a sampling circle.

3. For each buffer circle identified, mist-netting should be conducted using the following schedule (overlapping circles does not affect the minimum number of net nights recommended):
    a. 1 positive acoustic site within a circle = 10 net nights
    b. 2 positive acoustic sites within a circle = 14 net nights
    c. 3 positive acoustic sites within a circle = 18 net nights
    d. 4+ positive acoustic sites within a circle = 20 net nights

A "net night" is defined as 1 location being surveyed using 1 mist net set for a single night. Although no minimum spacing between mist nets is being specified, surveyors should distribute their net locations within suitable habitat. Net locations can be repeatedly sampled throughout the project; but, generally no more than two nights at a single net location. In addition, changing locations within a site may improve capture success (see Robbins et al. 2008, Winhold and Kurta 2008). The survey period should begin at sunset[7] and continue for at least 6 hours (longer survey periods may also improve success).

The USFWS Field Office responsible for the state in which your project occurs should be consulted during survey design to resolve issues related to mist-netting for specific projects.

[7] Sunset tables for the location of survey can be found at: http://www.usno.navy.mil/USNO/astronomical-applications/data-services/rs-one-year-us

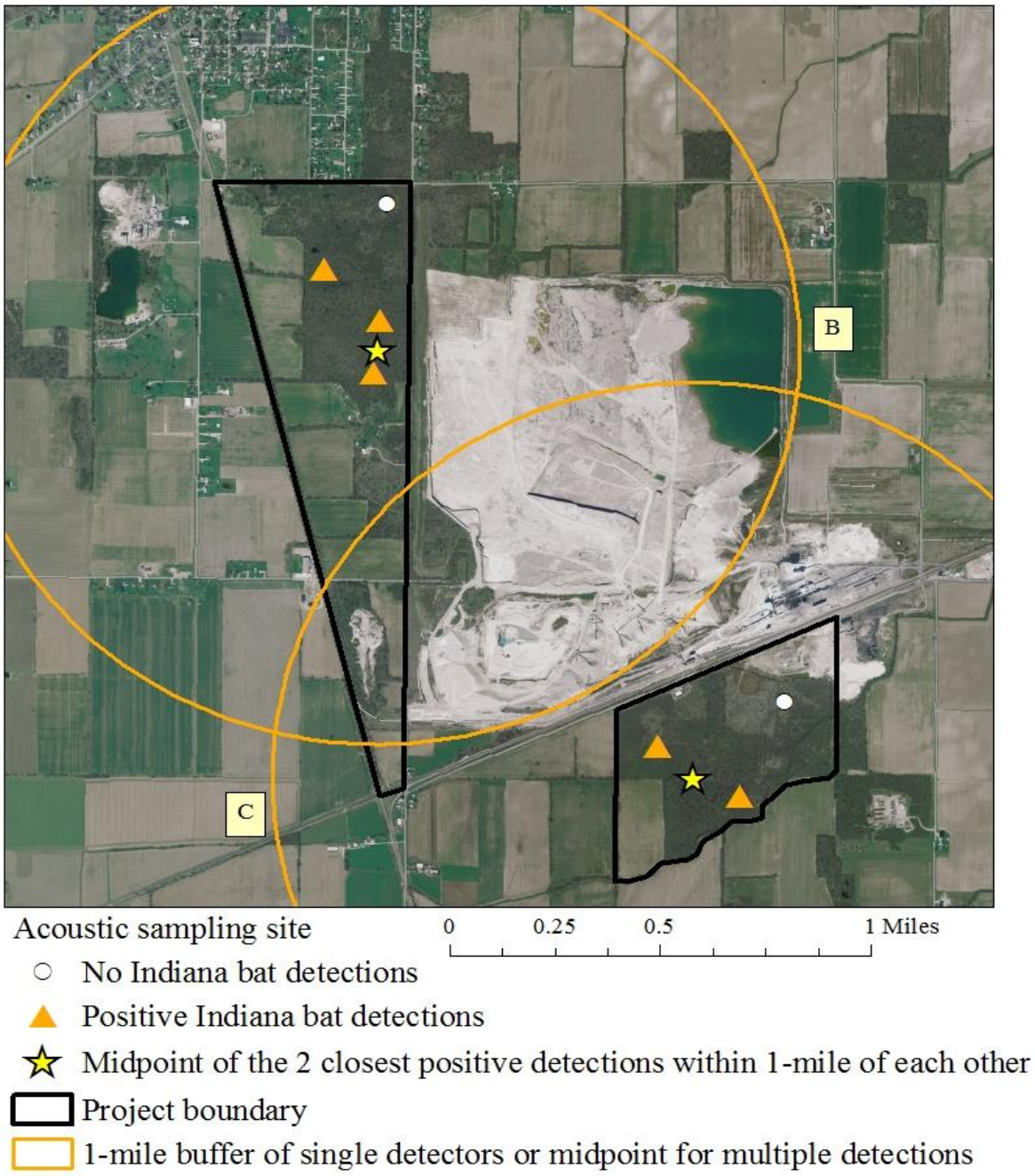



**Figure 1.** An example of a small project area depicting positive and negative results at Phase 2 acoustic survey sites and 1-mile buffers used for establishing an appropriate number of Phase 3 mist net locations. [According to this mist-netting survey protocol, a minimum of 32 net nights would be sampled in this example.]

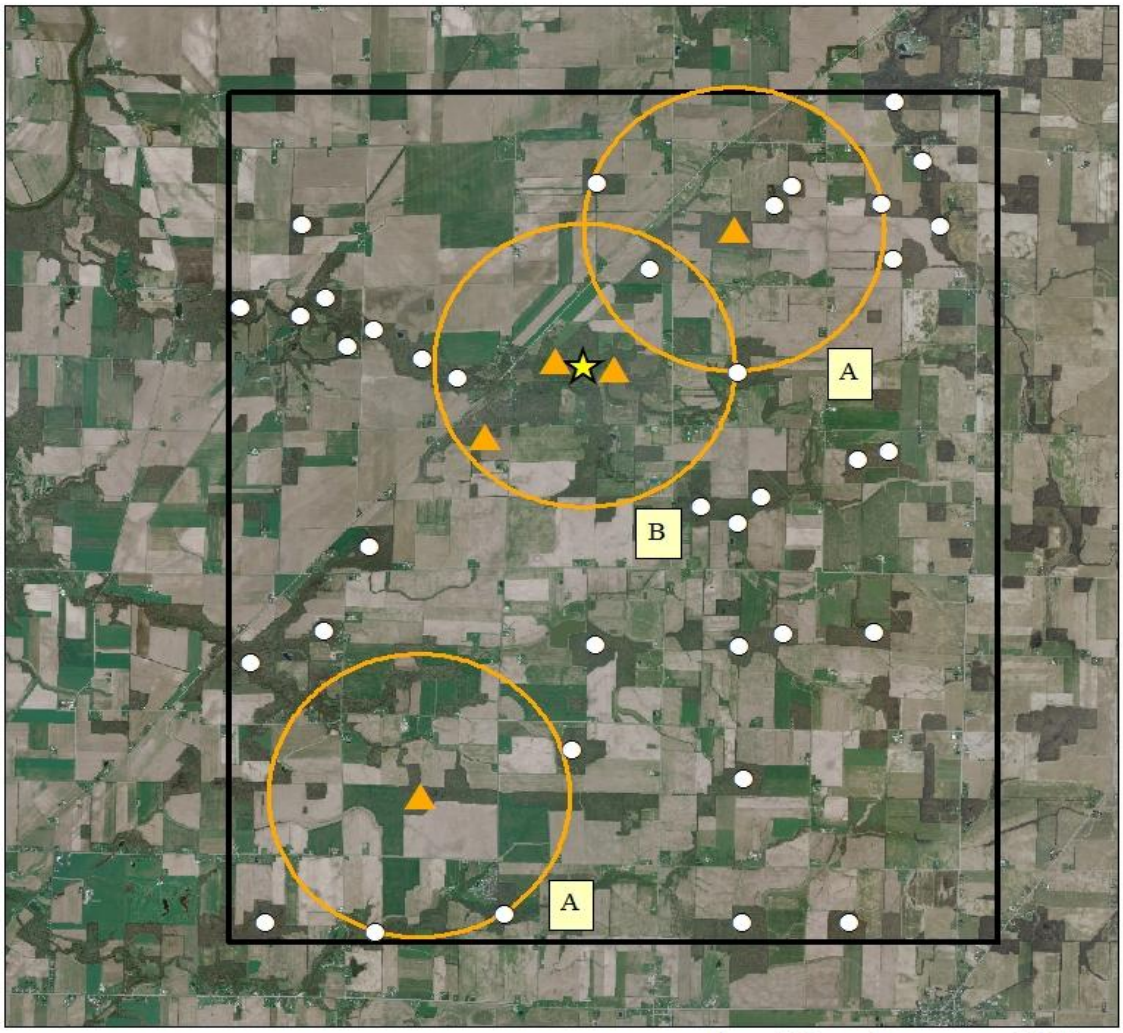



**Figure 2.** An example of a large project area depicting positive and negative results at Phase 2 acoustic survey sites and 1-mile buffers used for establishing an appropriate number of Phase 3 mist net locations. [According to this mist-netting survey protocol, a minimum of 38 net nights would be sampled in this example.]

# APPENDIX C
# PHASE 3 MIST-NETTING SURVEYS

## CHECKING NETS

Each net should be checked approximately every 10 minutes, never exceeding 15 minutes (Gannon et al. 2007). Some researchers prefer continuous monitoring (with or without a bat detector); care must be taken to avoid noise and movement near the nets if this technique is used. When monitoring the net continuously with a bat detector, bats can be detected immediately when they are captured. Prompt removal from the net decreases stress on the bat and potential for the bat to escape (MacCarthy et al. 2006). Monitoring the net with a bat detector also allows the researcher to assess the effectiveness of their net placement (i.e., if bats are active near the nets but avoiding capture); this may allow for adjustments that will increase netting success on subsequent nights. There should be no disturbance near the nets, other than to check nets and remove bats. Researchers should be prepared to cut the net if a bat is severely entangled (CCAC 2003; Kunz et al. 2009).

Capture and handling are stressful for bats. Emphasis should be on minimizing handling and holding bats for as short a time as possible to achieve research objectives. Indiana bats should not be held for more than 30 minutes after capture. Federal and state permits usually specify maximum holding times (e.g., Recovery Permits issued by Regions 3 and 4 of the USFWS specify a maximum holding time of 30 minutes for most projects). See Kunz and Kurta (1988) for general recommendations for holding bats.

## WEATHER AND LIGHT CONDITIONS

Severe weather adversely affects capture of bats. Negative results combined with any of the following weather conditions throughout all or most of a sampling period is likely to need additional netting effort: (a) temperatures that fall below 10°C (50°F); (b) precipitation, including rain and/or fog, that exceeds 30 minutes or continues intermittently during the survey period; and (c) sustained wind speeds greater than 4 meters/second (9 miles/hour). Further, consider human safety when netting during adverse weather.

It is typically best to set nets under the canopy where they are out of moonlight, particularly when the moon is ½-full or greater. Areas illuminated by artificial light sources should also be avoided.

## DOCUMENTATION OF *MYOTIS SODALIS* CAPTURES

If an Indiana bat(s) is captured during mist-netting, guidance on radio-tracking and emergence survey requirements, as provided in Appendix D and E, respectively, must be followed. In addition, you must notify the appropriate USFWS FO(s) of the capture, in writing, within 48 hours of an Indiana bat capture (including the sex and reproductive condition of the bat and GPS coordinates of the capture site).

# APPENDIX C
# PHASE 3 MIST-NETTING SURVEYS

Several species of bats from the genus *Myotis* share common features which can make identification difficult; the Indiana bat and the little brown bat (*Myotis lucifugus)* can be particularly difficult to distinguish. Photo documentation of all bats captured and identified as Indiana bats and the first 10 little brown bats per site are required to verify the identification that was made in the field. Remember, close-up, in-focus, photos of a bat's head, calcar, tragus, feet, toe hairs, etc. are often diagnostic.

If a bat is captured during mist-netting that cannot be readily identified to the species level, species can be verified through fecal DNA analysis. Collect one or more fecal pellets (i.e., guano) from the bat in question by placing it temporarily in a holding bag (no more than 15 minutes is recommended). The pellet (or pellets) collected should be placed in a 1.5 milliliter vial with silica gel desiccant; pellets from each individual bat should be stored in separate vials. Samples should be stored out of direct light. Samples should be shipped to Dr. Jan Zinck, Department of Biology, Portland State University, 630 SW Mill St., Portland, Oregon, 97201 for subsequent fecal DNA analysis to assign or confirm the specimens' identification to the species level. The current cost for sequencing is approximately $50 per individual pellet of guano. Contact Dr. Zinck (e-mail: zinckj@pdx.edu) prior to shipping samples. To our knowledge, this is the only lab that currently provides this service. Any additional information (or additional sources) on this technique will be posted when available on the Indiana bat webpage on the USFWS Region 3 website (http://www.fws.gov/midwest/Endangered/mammals/inba/index.html).

## SUBMISSION OF MIST-NETTING SURVEY RESULTS

A Phase 3 mist-netting survey report must be submitted to the appropriate USFWS FO(s) for review and approval. If the surveyor captures Indiana bats, this report should also include the data submission requirements of the subsequent radio-tracking and emergence count efforts. Each mist-netting survey report must include the following:

1. Copy of Phase 1 habitat assessment, Phase 2 acoustic survey report and Phase 3 and 4 mist-netting/radio-tracking/emergence count survey study plan (if not previously provided).
2. Description and justification of any modifications from the Phase 3 and 4 mist-netting/radio-tracking/emergence count study plan (e.g., net locations being moved).
3. Description of net locations (including a diagram of each netting location), net set-up (include net height), survey dates, duration of survey, and weather conditions.
4. Map identifying netting locations and information regarding net sets, including lat/long or UTM, individual net placement, and net spacing (i.e., include mist-netting equipment in photographs of net locations).
5. Full Names of survey personnel present at each mist net location during the surveys, including the federally permitted/qualified biologist present at each mist

net location. Also, full name of person who identified bats each night at each location (indicate on field data sheet).

6. Copies of all original mist-netting datasheets (see example datasheet below) and a summary table with information on all bats captured during the survey including, but not limited to: capture site, height of capture in net, date of capture, time of capture, sex, reproductive condition, age, weight, right forearm measurement, band number and type (if applicable), and Reichard's wing damage index score (available at: http://www.fws.gov/northeast/PDF/Reichard_Scarring%20index%20bat%20wings.pdf).
7. Photographs of all netting locations, as well as **all** Indiana bats and the first 10 little brown bats captured from each project, so that the placement of netting equipment and identification of species can be verified. Photographs of bats should include all distinguishing characteristics that resulted in the identification of the bat to species level.
8. Results of any fecal DNA analyses conducted.
9. Any other information requested by the USFWS FO(s) in the state you are working
10. Submission of a copy of the site-specific authorization (if necessary).

REFERENCES

Arndt, R. J. and B. A. Schaetz. 2009. A tale of two deniers: nylon versus polyester mist nets. Bat Research News 50(3):57.

Carroll, S.K., T.C. Carter, and G.A. Feldhamer. 2002. Placement of nets for bats: effects on perceived fauna. Southeastern Naturalist 1:193-198.

Canadian Council on Animal Care (CCAC). 2003. CCAC species-specific recommendations on bats. 9pp. Available at: http://www.ccac.ca/en/CCAC_Programs/Guidelines_Policies/GDLINES/BatsFinal20May03.htm (Accessed October 30, 2008).

Ford, W.M., M.A. Menzel, J.L. Rodrigue, J.M. Menzel and J.B. Johnson. 2005. Relating bat species presence to simple habitat measures in a central Appalachian forest. Biological Conservation 126:528-539. Available at: www.sciencedirect.com. (Accessed June 25, 2008).

Gannon, W.L., R.S. Sikes, and the Animal Care and Use Committee of the American Society of Mammologists. 2007. Guidelines of the American Society of Mammologists for the use of wild mammals in research. Journal of Mammalogy 88:809-823.

APPENDIX C
PHASE 3 MIST-NETTING SURVEYS

Gardner, J. E., J. D. Garner, and J. E. Hofmann. 1989. A portable mist-netting system for capturing bats with emphasis on *Myotis sodalis* (Indiana bat). Bat Research News 30:1-8.

Humphrey, P.S., Bridge, D. and T.E. Lovejoy. 1968. A technique for mist-netting in the forest canopy. Bird-Banding 39(1): 43-50.

Kiser, J.D. and J.R. MacGregor. 2005. Indiana bat (*Myotis sodalis*) mist net surveys for coal mining activities. Pp. 169-172 *in* K.C. Vories and A. Harrington (eds.), The Proceedings of the Indiana bat and coal mining: a technical interactive forum Office of Surface Mining, U.S. Department of the Interior, Alton, IL. Available at: http://www.mcrcc.osmre.gov/MCR/Resources/bats/pdf/Indiana_Bat_and_Coal_Mining.pdf. (Accessed October 06, 2011).

Kunz, T.H. and A. Kurta. 1988. Capture methods and holding devices. Pp. 1-29 in T.H. Kunz (ed.), Ecological and behavioral methods for the study of bats. Smithsonian Institution Press, Washington, D.C.

Kunz, T.H., R. Hodgkison, and C.D. Weise. 2009. Methods of capturing and handling bats. Pp. 3-35 in T.H. Kunz and S. Parsons (eds.), Ecological and behavioral methods for the study of bats, second edition. The Johns Hopkins University Press, Baltimore, Maryland.

MacCarthy, K.A., T.C. Carter, B.J. Steffen, and G.A. Feldhamer. 2006. Efficacy of the mist-net protocol for Indiana bats: A video analysis. Northeastern Naturalist 13:25-28.

Murray K., E. Britzke, B. Hadley, and L. Robbins. 1999. Surveying bat communities: a comparison between mist nets and the Anabat II bat detector system. Acta Chiropterologica 1(1):105-12.

Murray, K.L., J.G. Boyle, J.C. Timpone, M.N. Miller, and L.W. Robbins. 2003. A test of the sampling protocol for Indiana bats. Bat Research News 44(1):25.

O'Farrell, M.J. and W.L. Gannon. 1999. A comparison of acoustic versus capture techniques for the inventory of bats. Journal of Mammalogy 80(1):24-30.

Robbins, L.W., K.L. Murray, and P.M. McKenzie. 2008. Evaluating the effectiveness of the standard mist-netting protocol for the endangered Indiana bat (*Myotis sodalis*). Northeastern Naturalist 15:275-282.

Slack, B.A., M.P. Armstrong, and E.R. Britzke. 2008. Indiana bat (*Myotis sodalis*) acoustical survey guidance for the Commonwealth of Kentucky. Page 27 *in* Abstracts of the Joint meeting of the Southeastern Bat Diversity Network, Northeast Bat Working Group, and Colloquium on Conservation of Mammals in the Southeastern United States, Blacksburg, VA, February 20-22, 2008.

# APPENDIX C
# PHASE 3 MIST-NETTING SURVEYS

Winhold, L. and A. Kurta. 2008. Netting surveys for bats in the Northeast: differences associated with habitat, duration of netting, and use of consecutive nights. Northeastern Naturalist 15:263-274.

APPENDIX C
PHASE 3 MIST-NETTING SURVEYS

## Sample Data Sheets for Indiana Bat Surveys

| Site No. | | | Project/Firm: | | | | | | | | Date: |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Location: | | | | | | | | | | | |
| County: | | | State: KY | Quad: | | | | | | | Quadrant: |
| Lat/Long (DMS): | N | | W | | Zone: | | | | | | Surveyors: |

| # | Time | Species | Age | Sex | Repro. Cond.* | RFA (mm) | Mass (g) | Net/ Ht | Guano/ Hair | Wing Score | Band # Type |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | |
| 2 | | | | | | | | | | | |
| 3 | | | | | | | | | | | |
| 4 | | | | | | | | | | | |
| 5 | | | | | | | | | | | |
| 6 | | | | | | | | | | | |
| 7 | | | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |
| 10 | | | | | | | | | | | |
| 11 | | | | | | | | | | | |
| 12 | | | | | | | | | | | |
| 13 | | | | | | | | | | | |
| 14 | | | | | | | | | | | |
| 15 | | | | | | | | | | | |
| 16 | | | | | | | | | | | |
| 17 | | | | | | | | | | | |
| 18 | | | | | | | | | | | |
| 19 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 21 | | | | | | | | | | | |
| 22 | | | | | | | | | | | |
| 23 | | | | | | | | | | | |
| 24 | | | | | | | | | | | |
| 25 | | | | | | | | | | | |
| 26 | | | | | | | | | | | |
| 27 | | | | | | | | | | | |
| 28 | | | | | | | | | | | |
| 29 | | | | | | | | | | | |
| 30 | | | | | | | | | | | |

| Moon Phase: | | % |
|---|---|---|
| | Rise | Set |
| Moon: | | |
| Sun: | | |

| Time | Temp | Sky | Wind | # Bats |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| Avg | | | | |

| Sky Code | |
|---|---|
| 0 | Clear |
| 1 | Few Clouds |
| 2 | Partly Cloudy |
| 3 | Cloudy or overcast |
| 4 | Smoke or fog |
| 5 | Drizzle or light rain |
| 6 | Thunderstorm |

| Beauford Wind Code | |
|---|---|
| 0 | Calm (0 mph) |
| 1 | Light wind (1-3 mph) |
| 2 | Light breeze (4-7 mph) |
| 3 | Gentle breeze (8-12 mph) |
| 4 | Moderate breeze (13-18 mph) |

*Repro. Cond (Reproductive Condition): (P) pregnant; (L) lactating; (PL) post-lactating; (NR) non-reproductive, (TD) testes descended

| Net Site Diagram | Dominant Vegetation |
|---|---|

**Sample Data Sheets for Indiana Bat Surveys**

| | |
|---|---|
| | 1 |
| | 2 |
| | 3 |
| | 4 |
| | 5 |

| Net Site(s) by Habitat | | | | |
|---|---|---|---|---|
| Habitat | A | B | C | |
| River | | | | |
| Stream | | | | |
| Pond | | | | |
| Road Rut | | | | |
| Corridor | | | | |
| Cave/mine | | | | |
| | | | | |
| Total | | | | |

| No. of Poles X Net length | | | | |
|---|---|---|---|---|
| A | = | | X | |
| B | = | | X | |
| C | = | | X | |
| D | = | | X | |

| Other Species: |
|---|
| |

| Comments: |
|---|
| |
| |
| |

APPENDIX D
PHASE 4 RADIO-TRACKING

PERSONNEL

A qualified biologist[8] that is experienced in handling Indiana bats and attaching radio transmitters must attach radio transmitters to Indiana bats as further explained in the guidance below.

METHODS

If one or more Indiana bats are captured during survey efforts, the following radio-tracking protocols will apply:

1. Radio transmitters shall be attached to all[9] female, juvenile, and adult male[10] ($\geq$ 6.0 grams) Indiana bats captured at each site. Since the maximum holding times for Indiana bats is 30 minutes, surveyors should be prepared to place transmitters on bats when they are captured to minimize holding times. Surveyors should carry a minimum of 5 transmitters with them for each mist net survey unless the size of the project area could encompass more than one maternity colony home range (i.e., 5 mile buffered area from center of project). These large projects would require surveyors to have a minimum of 5 transmitters per potential colony.

2. The radio transmitter, adhesive, and any other markings ideally should weigh less than 5% of pre-attachment body weight but must not weigh more than 10% of a bat's total body weight (Kurta and Murray 2002). In all cases, the lightest transmitters capable of the required task should be used, particularly with pregnant females and volant juveniles. Radio telemetry equipment (e.g., receivers, antennas, and transmitters) and frequencies should be coordinated with the appropriate state natural resource agency and USFWS FO(s).

3. The qualified biologist or technician should track all radio-tagged bats captured to diurnal roosts for at least 7 days and must conduct a minimum of 2 evening emergence counts at each identified roost tree (See Appendix F for Emergence Survey Protocols). However, biologists are encouraged to continue radio-tracking efforts voluntarily until the transmitter fails, fall off, or cannot be located. Biologists should contact the USFWS FO(s) immediately once they suspect a transmitter(s) has failed or fallen off before the 7 day tracking period ends. In all cases, landowner(s) should be contacted and grant access to roost trees prior to conducting these activities. If access is denied, roost tree locations

[8] A qualified biologist is an individual that holds a USFWS Recovery Permit (Federal Fish and Wildlife Permit) for federally listed bats in the state/region which they are surveying and/or has been authorized by the appropriate State Agency to survey for Indiana bats. Several USFWS offices maintain lists of qualified bat surveyors and if working in one of those states, the individual will either need to be on that list or submit qualifications or receive USFWS approval prior to conducting any field work.
[9] Surveyors should coordinate with USFWS FO(s) regarding recommendations for distribution of transmitters (e.g., prioritization of animals, maximum number per site, etc.) and whether foraging data would be beneficial to collect.
[10] Please consult with the USFWS FO in the state in which mist-netting will occur prior to completing those surveys to determine if tracking of adult males is necessary and if so project-specific protocol.

(i.e., coordinates) should be determined using triangulation. Surveyors conducting radio tracking work should never trespass.

4. Daily radio telemetry searches for roost trees must be conducted during daylight hours and must be conducted until the bat(s) is located or for a minimum of 4 hours of ground or 1 hour of aerial-searching effort per tagged bat per day for 7 days. Once a signal is detected, tracking should continue until the roost is located. At a minimum, qualified biologists must document all ground and aerial-searching effort for submittal with the survey report. For each roost tree identified during tracking, the surveyor should complete a "USFWS Indiana Bat Roost Tree Datasheet" (Appendix D).

5. To minimize potential for disease transmission, any equipment that comes in contact with bats should be kept clean and disinfected, following approved protocols; this is particularly a concern relative to white-nose syndrome (WNS). Disinfection of equipment used in WNS-affected areas is required; protocols are posted at http://www.whitenosesyndrome.org/ Federal and State permits may also have specific equipment restrictions and disinfection requirements. The disinfection protocols were developed for addressing concerns about WNS. However, these protocols are generally good practices to avoid disease transmission and risk of exposure to other bats, and we recommend disinfection of equipment for all bat studies to minimize potential disease-related impacts to wildlife and people, even in areas where WNS is not known to occur.

## SUBMISSION OF RADIO-TRACKING RESULTS

Radio-tracking results should be included with the Phase 3 mist-netting survey report and must be submitted to the appropriate USFWS FO(s) for review and approval. Each survey report must include the following information related to radio-tracking efforts:

1. Copy of Phase 1 habitat assessment, Phase 2 acoustic survey report, and Phase 3 and 4 mist-netting/radio-tracking/emergence count survey study plan (if not previously provided).
2. Description and justification of any modifications from the Phase 3 and 4 mist-netting/radio-tracking/emergence count study plan (e.g., number of transmitters used, frequency of transmitters changed).
3. Map and narrative detailing all ground and aerial searching effort.
4. Map summarizing all Indiana bat data collected from summer surveys for the proposed project (e.g., project area boundary and results from the site habitat assessment, acoustic survey, mist net survey, radio-tracking, and emergence surveys).
5. Full Names of personnel conducting radio-tracking efforts and that attached transmitters to Indiana bats.
6. Photographs of all roost trees identified during radio-tracking.
7. Copies of all original USFWS Indiana Bat Roost Tree datasheets.

8. Any other information requested by the USFWS FO(s) in the state you are working.
9. Submission of a copy of the pre-approved site-specific authorization (if necessary).

REFERENCES

Cline, S.P., Berg, A.B., Wight, H.M., 1980. Snag characteristics and dynamics in Douglas-fir forests, western Oregon. Journal of Wildlife Management 4:773–786.

Higgens, K.F., J.L. Oldemeyer, K.J. Jenkins, C.K. Clambey and R.F. Harlow. 1994. Vegetation sampling and measurement. Pages 567-591 *in:* T.A. Bookhout (ed.). Research and management techniques for wildlife and habitats, 5th edition. The Wildlife Society, Bethesda, MD. 740 p.

Johnson, J.B., J.W. Edwards, W.M. Ford and J.E. Gates. 2009. Northern myotis (*Myotis septentrionalis*) roost tree selection in a central Appalachian Mountains hardwood forest subjected to prescribed fire. Forest Ecology and Management 258:233-242.

Johnson, J.B., W.M. Ford, J.W. Edwards, J.L. Rodriguez and C.L. Johnson. 2010. Indiana bat day-roosts in burned areas in the central Appalachians. Journal of Fish and Wildlife Management 1:111-121.

Kurta, A., and S. Murray. 2002. Philopatry and migration of banded Indiana Bats (*Myotis sodalis*) and effects of radio transmitters. Journal of Mammalogy 83:585-589.

Maser, C., Anderson, R.G., Cromack, K., Jr., Williams, J.T., Martin, R.E., 1979. Dead and down woody material. Pages 78-90 *in*: J. W. Thomas (Ed.). Wildlife habitat in managed forests – the Blue Mountains of Oregon and Washington. USDA Forest Service Agriculture Handbook 553.

Nyland, R.D., 1996. Silviculture: concepts and applications. McGraw-Hill, New York, NY, 633 pp.

Owen, S.F., Menzel, M.A., Ford, W.M., Edwards, J.W., Chapman, B.R., Miller, K.V., Wood, P.B., 2002. Roost tree selection by maternal colonies of northern long-eared myotis in an intensively managed forest. USDA Forest Service, General Technical Report NE-292, Northeastern Research Station, Newtown Square, PA, 6 pp.

APPENDIX D
PHASE 4 RADIO-TRACKING

# USFWS INDIANA BAT ROOST TREE DATASHEET

**Biologists (Full Name):_____ Date:_____**

**UTM: Zone_____ Easting _____ Northing_____ *OR***

**LAT_____ LONG_____**

**Property Owner:_____ ___ Phone#_____**

**State_____ County_____ Site #_____**

**Roost #_____ Roost Name:_____**

***Roost Tree Data***

**Species: _____ Live __ Snag __ Other __**

**(if other explain) _____**

**DBH (note inches or cm)_____ Total Height (ft. or m)_____**

**Height of roost area (if known)_____Dist. from capture site_____**

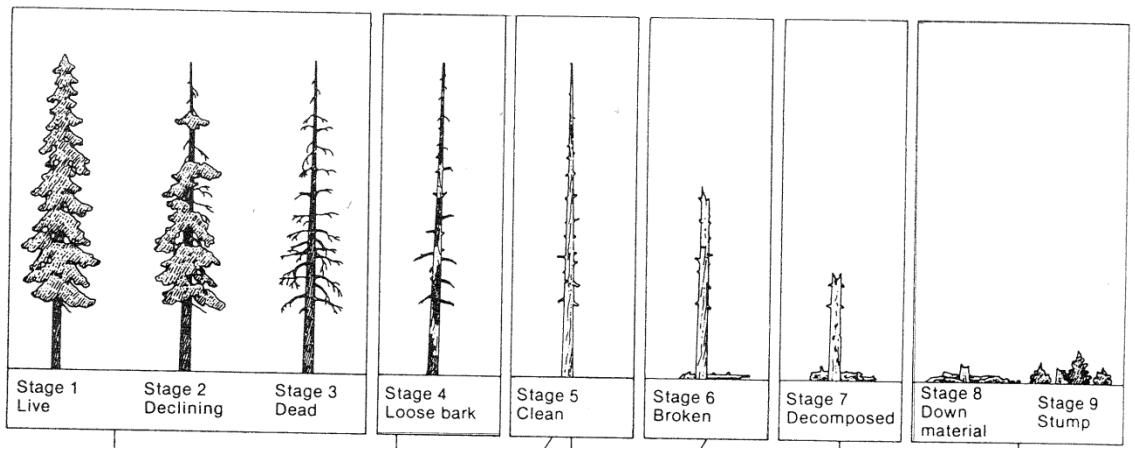
**Roost position aspect (deg)_____**

**Exfoliating bark on bole (%)_____ Describe: sloughing __ platy__ tight__**

**Cavities present? ____ If so, describe:_____**

---

**Roost Decay State: 1 2 3 4 5 6 7 8 9 Other**




**Roost tree or snag canopy position: Dominant __ Co-Dominant __ Suppressed __**

APPENDIX D
PHASE 4 RADIO-TRACKING

***Surrounding Habitat Condition***

**Canopy closure at roost (%) _____**

**Approximate woodlot size (acres)_____ Distance to non-forest (m)_____**

**Describe forest/woodlot current condition (mature, partially cut-over, burned, insect damage, etc.)**
**_____**

**_____**

**_____**
**_____**
**_____**
**_____**

**Additional Comments_____**

**_____**
**_____**
**_____**
**_____**
**_____**
**_____**
**_____**
**_____**
**_____**
**_____**
**_____**

## PERSONNEL

A qualified biologist[11] that is experienced in conducting emergence surveys for Indiana bats and identifying and handling Indiana bats must be present and actively involved in all emergence surveys for Indiana bats as further explained in the guidance below.

## EMERGENCE SURVEYS FOR KNOWN INDIANA BAT ROOSTS

The following protocols apply to all emergence survey efforts:

1. Bat emergence surveys should begin ½ hour before sunset[12] and continue until at least 1 hour after sunset or until it is otherwise too dark to see emerging bats. The surveyor(s) should be positioned so that emerging bats will be silhouetted against the sky as they exit the roost. There should be at least one surveyor per roost tree. Surveyors must be close enough to the roost tree to observe all exiting bats, but not close enough to influence emergence. That is, do not stand directly beneath the roost, do not make noise or carry on a conversation, and minimize use of lights (use a small flashlight or similar to record data if necessary). Do not shine a light on the roost tree as this may prevent or delay bats from emerging. Use of an infra-red/night vision or thermal-imaging video camera or spotting scope is encouraged, but not required. Likewise, use of an ultrasonic bat detector may aid in identifying the exact timing of bats emerging and therefore is strongly recommended. If multiple roost trees are known within a colony then simultaneous emergence surveys are encouraged to estimate population size. [Note: If a roost tree cannot be adequately silhouetted, then the local USFWS FO(s) should be contacted to discuss alternative survey methods].

2. Bat activity is affected by weather. Therefore emergence surveys should not be conducted when the following conditions exist: (a) temperatures that fall below 10°C (50°F); (b) precipitation, including rain and/or fog, that exceeds 30 minutes or continues intermittently during the survey period; and (c) sustained wind speeds greater than 4 meters/second (9 miles/hour).

3. Surveyors should use the attached "Bat Emergence Survey Datasheet".

4. Surveyors should also complete an "Indiana Bat Roost Tree Datasheet" for each roost tree known to be used by one or more Indiana bats (Appendix D).

[11] A qualified biologist is an individual that holds a USFWS Recovery Permit (Federal Fish and Wildlife Permit) for federally listed bats in the state which they are surveying and/or has been authorized by the appropriate State Agency to survey for Indiana bats. Several USFWS offices maintain lists of qualified bat surveyors and if working in one of those states, the individual will either need to be on that list or submit qualifications or receive USFWS approval prior to conducting any field work.

[12] Sunset tables for the location of survey can be found at: http://www.usno.navy.mil/USNO/astronomical-applications/data-services/rs-one-year-us

5. Completed datasheets should be maintained in project files and included in reports prepared for the USFWS.

## EMERGENCE SURVEYS FOR POTENTIAL INDIANA BAT ROOSTS

In some limited cases (e.g., hazard trees), surveyors may have the option of conducting emergence surveys of individual potential Indiana bat roosts to determine use. The following protocol applies to these surveys:

1. Consult with your local USFWS FO(s) to determine whether a tree(s) that you need to fell/clear may be potential roosting habitat for Indiana bats and whether conducting an emergence survey is an appropriate means of avoiding take of roosting Indiana bats. In general, the USFWS only approves of conducting emergence surveys as a means of avoiding direct take of bats for projects only affecting a very small number of potential roost trees (e.g., ≤ 10). An online directory of USFWS Offices is available at http://www.fws.gov/offices/directory/listofficemap.html.

2. If the USFWS FO(s) approves/concurs with Step 1, then follow the emergence guidelines above to determine if any bats are roosting in the tree(s).

3. At the conclusion of the emergence survey…

    a. If **no** bats were observed emerging from the potential roost tree(s), then it should be felled immediately. If safety concerns dictate that a tree cannot be felled immediately (i.e., in the dark), then the tree(s) should be felled as soon as possible after sunrise on the following day. If a tree is not felled during the daytime immediately following an emergence survey, then the survey has to be repeated, because bats may switch roosts on a nightly basis. Immediately after the tree is felled and provided there is adequate daylight, an inspection of the downed tree must be completed to ensure that no bats were present, injured, or killed. The USFWS FO(s) should be contacted the next working day for further guidance if bats are discovered during this inspection.

    b. If **1 or more** bats (regardless of species, as species identification cannot reliably be made during visual emergence counts) are observed/detected emerging from the tree, then the tree should **not** be felled and the USFWS FO(s) should be contacted the next working day for further guidance.

## SUBMISSION OF EMERGENCE SURVEY RESULTS

Emergence survey results should be included with the mist-netting survey report, unless the survey was completed as an evaluation of potential roosts, and must be submitted to the

appropriate USFWS FO(s) for review. Each survey report must include the following information related to emergence survey efforts:

1. Copy of Phase 1 habitat assessment, Phase 2 acoustic survey report, and Phase 3 and 4 mist-netting/radio-tracking/emergence count survey study plans (if not previously provided).
2. Explanation of any modifications from the Phase 3 and 4 mist-netting/radio-tracking/ emergence count study plan (e.g., number of potential roost trees surveyed).
3. Map identifying location of roost tree(s) identified during radio-tracking and/or emergence surveys for Indiana bat(s) including lat/long coordinates of tree(s).
4. Full names of personnel present during emergence survey efforts and that conducted emergence surveys of roosts.
5. Photographs of each identified roost.
6. Copies of all "Emergence Survey" and "Indiana bat Roost Tree" datasheets.
7. Any other information requested by the USFWS FO(s) in the state you are working.
8. Submission of a copy of the pre-approved site-specific authorization (if necessary).

# USFWS BAT EMERGENCE SURVEY DATASHEET

**Date: _____ Surveyor(s) Full Name:_____**

**State: _____ County: _____ Project Name: _____**

**Site Name/#: _____ Roost Name/# and/or Bat #:_____**

**Lat/Long of Roost Tree: _____**

**Description of Roost/Habitat Feature being Surveyed: _____**

**_____**

**Bat Species Known to be using this Roost/Feature (if not known, leave blank):**

**_____**

**Other Suspected Bat Species (explain): _____**

**Weather Conditions during Survey (temperature, precipitation, wind speed):**

**_____**

**Survey Start Time: _____ Time of Sunset: _____ Survey End Time: _____**

**NOTE:** Emergence surveys should begin ½ hour before sunset and continue for a minimum of one hour or until it is otherwise too dark to see emerging bats. The surveyor(s) should position him or herself so that emerging bats will be silhouetted against the sky as they exit the roost. Tallies of emerging bats should be made at approximately 2-minute intervals. Please ensure that you are close enough to the roost tree to observe all exiting/returning bats, but not close enough to influence emergence (i.e., do not stand directly beneath the roost and do not make unnecessary noise and/or conversation, and minimize use of lights (it's okay to use a small flashlight to record data if necessary). Do not shine a light on the roost tree/crevice/cave/mine entrance itself as this may prevent or delay bats from emerging. If available, use of an infra-red/night vision or thermal-imaging video camera or spotting scope and an ultrasonic bat detector is strongly recommended, but not required.

| Time | Number of Bats Leaving Roost* | Comments / Notes |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

**Site Name/#: _____ Roost Name/#: _____**

| Time | Number of Bats Leaving Roost* | Comments / Notes |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| **Total Number of Bats Observed Emerging from the Roost/Feature During the Survey:** | | |

* If any bats return to the roost during the survey, then they should be subtracted from the tally.

**Describe Emergence**: Did bats emerge simultaneously, fly off in the same direction, loiter, circle, disperse, etc. If a radio-tagged bat was roosting in the tree, at what time did it emerge?

_____

_____