DRAFT REPORT

I-69 MIST NETTING SURVEY FOR THE INDIANA BAT (*MYOTIS SODALIS*) 2012 – SECTION 5 BLOOMINGTON TO MARTINSVILLE

18 June 2012

Prepared for:

Bernardin, Lochmueller, and Associates
6200 Vogel Rd.
Evansville, IN 47715

Indiana Department of Transportation
100 N. Senate Avenue
Indianapolis, IN 46204

Prepared by:
Valerie Clarkston, Dale W. Sparks, Ph. D., and Virgil Brack, Jr. Ph.D.

Environmental Solutions & Innovations, Inc.

4525 Este Ave
Cincinnati, Ohio 45232
Phone: (513) 451-1777
Fax: (513) 451-3321

1153 W. Fayette St., Suite 1-C
Syracuse, New York 13204
Phone: (315) 314-7309
Fax: (315) 314-7546

Table of contents

1.0 INTRODUCTION.....1

2.0 STUDY AREA.....2

2.1 Location –.....2

2.2 Physiography –.....2

2.3 Previous Studies –.....3

2.3.1 Entire I-69 Corridor – 3

2.3.2 Section 5 –2004 Sampling.....3

2.4 Indiana Bat – 4

2.4.1 Status –.....4

2.4.2 Regional Occurrence – 4

2.4.3 Ecology – 5

2.5 Evening Bat –.....13

2.5.1 Status and Distribution – 13

2.5.2 Regional Occurrence – 13

2.5.3 Ecology – 14

3.0 METHODS 15

3.1 Mist Net Survey –.....15

3.1.1 Site Selection –.....15

3.1.2 Mist Netting –.....15

3.1.3 Bat Capture –.....15

3.1.4 Net Site Habitat Assessment – 16

3.1.5 Weather –.....17

3.2 Radio-telemetry – 17

3.2.1 Transmitter Application –.....17

3.2.2 Bat Tracking – 17

4.0 RESULTS 17

4.1 Bat Captures –.....17

4.2 Indiana Bat Captures and Radio-telemetry – 18

4.2.1 Indiana Bat 824 – 18

4.2.2 Indiana Bat 869 – 18

4.2.3 Indiana Bat 782 – 18

4.2.4 Indiana Bat 768 – 19

4.2.5 Indiana Bat 927 – 19

4.3 Evening Bat Captures –.....20

4.4 Net Site Habitat Assessment – 20

5.0 DISCUSSION 25

5.1 Bat Captures –.....25

5.2 Indiana Bats –.....25

5.3 Evening Bats – 26

6.0 ACKNOWLEDGEMENTS 26

7.0 LITERATURE CITED 27

APPENDIX A. QUALIFIED SURVEYORS

APPENDIX B. FIGURES

APPENDIX C. TABLES

APPENDIX D. REPRESENTATIVE PHOTOGRAPHS

APPENDIX E. COMPLETED MIST NET DATA SHEETS

APPENDIX F. COMPLETED TELEMETRY DATA SHEETS

I-69 MIST NETTING SURVEY
FOR THE INDIANA BAT (*MYOTIS SODALIS*)
2012 – SECTION 5 BLOOMINGTON TO MARTINSVILLE

Valerie Clarkston, Dale W. Sparks, Ph.D., and Virgil Brack, Jr. Ph.D.
Environmental Solutions & Innovations, Inc., 4525 Este Ave, Cincinnati, OH 45232

Abstract

In 2004 the entire proposed route of I-69 from Evansville to Indianapolis, Indiana was sampled to determine the presence/probable absence of the federally endangered Indiana bat (*Myotis sodalis*). The route was broken into 6 sections with Section 5 following the route of State Road 37 (SR-37) between the cities of Bloomington and Martinsville, Indiana. The initial survey effort in Section 5 yielded a total of five Indiana bats. The amount of time that an Indiana bat presence/probable absence survey is considered valid varies typically between three and five years. As such, the U.S. Fish and Wildlife Service requested that Section 5 be resurveyed prior to the finalization of an Environmental Impact Statement which is scheduled to occur in summer 2012. Environmental Solutions & Innovations, Inc. (ESI) completed this study between 15 and 30 May 2012. As in 2004, the primary objective of this study was to mist net and radio-track Indiana bats. Another objective was to note other bats, especially the presence of the state-endangered evening bat (*Nycticeius humeralis*). Three hundred thirty-four bats representing nine species including: 119 eastern red bats (*Lasiurus borealis*), 78 big brown bats (*Eptesicus fuscus*), 44 eastern pipistrelles (*Perimyotis subflavus*), 36 northern bats (*Myotis septentrionalis*), 28 little brown bats (*Myotis lucifugus*), 12 Indiana bats (*Myotis sodalis*), 7 hoary bats (*Lasiurus cinereus*), 7 silver-haired bats (*Lasionycteris noctivagans*), and 3 evening bats (*Nycticeius humeralis*). Transmitters were attached to five Indiana bats, and all were tracked to at least one specific roost. The first two Indiana bats of the season were captured at site 2. Both bats were adult males and used a total of 3 roost trees in and adjacent to Leonard Springs Park. A third adult male was captured at site 14A and tracked to a batbox near a residence on Dittemore Road. Two pregnant females were captured and successfully tracked to a total of three roosts. The first pregnant female was captured at site 24 and tracked to two roosts located south and west of Martinsville. One of these roosts was located in a large cottonwood (*Populus deltoides*) on the White River and the second was a dead American Elm (*Ulmus americana*) along Lamb's Creek. The second pregnant female was tracked to a single roost which was also a large cottonwood located along the White River. All three roosts used by pregnant females are consistent with primary roosts.

Key Words – Indiana bat, *Myotis sodalis*, Indiana, mist netting, radio-telemetry

1.0 INTRODUCTION

The federal Endangered Species Act (ESA) [16 U.S.C. 1531 *et seq*.] became law in 1973 and provides for the listing, conservation, and recovery of endangered and threatened species of plants and wildlife. Under ESA, the U.S. Fish and Wildlife Service (USFWS) strives to protect and monitor the numbers and populations of listed species. Many states enacted similar laws.

Section 7(a)(2) of the Act states that each federal agency shall insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in destruction or adverse modification of designated critical habitat. Federal actions include (1) expenditure of federal funds for roads, buildings, or other construction projects, and (2) approval of a permit or license, and the activities resulting from such permit or license. This is true regardless of whether involvement is apparent, such as issuance of a federal permit, or less direct, such as federal oversight of a state-operated program.

Section 9 of the Act prohibits take of listed species. Take is defined by the Act as "*to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect*". The definition of harm includes adverse habitat modification. Actions of federal agencies that do not result in jeopardy or adverse modification, but that could result in a take, must be addressed under Section 7.

Several conservation measures were jointly developed by the Federal Highway Administration (FHWA), the Indiana Department of Transportation (INDOT) and the USFWS for the Tier 1 Biological Assessment (BA) and the subsequent Tier 1 BA Addendum (dated 28 February 2006) as part of the construction of the I-69 corridor project from Evansville to Indianapolis, Indiana. These measures were specifically designed to avoid and minimize impacts of the proposed action on Indiana bats (*Myotis sodalis*) and bald eagles (*Haliaeetus leucocephalus*) and to further their recovery. These conservation measures are included in the I-69 Tier 1 Revised Programmatic Biological Opinion (BO) (dated 24 August 2006) and required under the terms of the Section 7 consultation.

During the summer of 2004, 13 Indiana bat maternity colonies were discovered within the I-69 Summer Action Area (SAA). The SAA encompasses a 5-mile band (2.5 miles on both sides of the centerline) of the preferred alternative that runs the length of the entire I-69 corridor. Additional mist netting and radio-tracking were conducted during 2005 in an attempt to locate additional primary roost trees for each of the 13 Indiana bat maternity colonies; however, none were found. In 2010, an additional fourteenth colony was identified in Section 4.

Per the Revised Programmatic BO, one commitment requires pre- and post-construction summer bat surveys to be conducted at 50 mist netting sites. These surveys are focused at each of the 14 known maternity colonies.

Through prior coordination between the USFWS, INDOT and FHWA, and as a stipulation of the I-69 Tier 1 BO it was determined that summer bat surveys should be conducted at pre-construction, during construction and for five years post-construction. Pre-construction surveys are

to be conducted within the summer bat mist netting season immediately prior to the start of construction activities (including tree clearing) for any given construction contract. Surveys during construction are to be conducted each year up to the year that the highway is open to traffic. The first of the five post-construction surveys are to begin the summer following completion of the Section when the highway is open to traffic. These monitoring efforts are to be documented and summarized within an annual report prepared for the USFWS. These construction-related survey efforts are currently underway in sections 1-4 and will be the subject of later reports.

The current study, however, is tied to the development of an Environmental Impact Statement (EIS) that is expected to be completed in summer 2012. Indiana bat colonies are known to move across the landscape over time (Kurta et al. 2002, Kurta 2004, Kurta 2005, Whitaker and Sparks 2008, Sparks et al. 2009) and thus USFWS accepts survey results as being valid for periods of time ranging from 3 to 5 years. Because eight years have elapsed since Section 5 was initially sampled, USFWS has requested a resurvey of the section be included in the new EIS. This also provides a unique opportunity to examine community-wide changes in composition that may have occurred since the arrival of White Nose Syndrome (WNS) in Indiana in winter 2010/2011. To allow this comparison, the sites sampled in 2012 are placed as closely as possible to the initial sites sampled in 2004 (BHE 2004).

ESI and Indiana State University (ISU) biologists completed field efforts under Federal Endangered Species Permits TE02373A-4 (Issued to Dr. Virgil Brack), TE839763-9 (Issued to Dr. John O. Whitaker, Jr.), and TE206872-3 issued to (Dr. Joy O'Keefe). Indiana Department of Natural Resources permits were issued to individual biologists and included Dr. Dale W. Sparks (12-0141), Mr. Jason Duffey (12-0142), Mr. David Jeffcott (12-0147), Ms. Amanda Janicki (12-0151), Mr. Andrew Kniowski (12-0149), Mr. Jody Nicholson (12-0153), Ms. Beth Meyer (12-0150), Ms. Brianne Walters (12-042), Mr. Scott Bergeson (12-0185) and Mr. Jared Helms (12-045). Qualifications of surveyors are included as Appendix A of this report.

2.0 STUDY AREA

2.1 Location –

Sampling was conducted along Section 5 of the I-69 corridor which is approximately 35.4 kilometers (22 mi) in length from Bloomington to Martinsville (Figure 1). Figures are included in Appendix B of this report. The section extends along SR 37 from a point 4.8 kilometers (3 mi) southwest of Bloomington, to SR 39, approximately 2.4 kilometers (1.5 miles) southwest of Martinsville (Appendix B, Figure 1).

2.2 Physiography –

The Project area crosses two distinct physiographic units (Schneider 1966). The area immediately surrounding Bloomington is considered part of the Mitchell Plain, while the majority of the Project Area is part of the Norman Upland. By Indiana standards, the Norman Upland is an area of dramatic relief. Flat-topped, narrow divides are separated from one another by deep v-shaped valleys that are filled with small, short drainages without any true drainage basins. Brown County State Park and surrounding portions of Morgan/Monroe and

Yellowwood State forests are considered typical of the region,

Conversely, the Mitchell Plain is an area of low relief with much of the drainage being underground as is typical of areas underlain by karst. There are numerous natural caves in the St. Louis and Ste. Genevieve Limestone layers. In addition to natural caves, the Salem Limestone has been extensively quarried using both surface and subsurface techniques and is a common building material. Notable buildings that include this material in their construction include the Pentagon, the Empire State Building, and most county court houses in Indiana. Both caves and limestone mines are potential hibernacula for the Indiana bat.

2.3 Previous Studies –

2.3.1 Entire I-69 Corridor –

Much of the I-69 corridor has been sampled on three separate occasions. The initial sampling occurred in 1993 and was included in the Draft Environmental Impact Statement for the Southwest Indiana Highway Corridor which was prepared for INDOT in 1996. Dr. John O. Whitaker, Jr. surveyed 19 sites along the corridor from I-64 to Bloomington, Indiana. The only Indiana bats captured in that study were near the Patoka National Wildlife Refuge in Section 2. No evening bats (*Nycticeius humeralis*) were captured although echolocations consistent with those made by evening bats were heard along the East Fork of the White River.

In summer 2004, sampling efforts were completed along the entire I-69 corridor, which ranges from the junction of I-64 and I-164 near Evansville north and east to Bloomington and then northward to the junction of I-465 with SR 37 at Indianapolis. This effort resulted in the capture of 48 Indiana bats, which the USFWS Bloomington Field Office interpreted as evidence that 13 maternity colonies might be affected by construction of the highway. Scattered records of evening bats were also detected during these surveys.

In summer 2005, additional netting was conducted at 49 sites along the corridor in an effort to locate additional roost trees associated with each of the thirteen colonies. In 2010, an additional maternity colony was identified in Section 4 as a result of the pre-construction survey, making for a total of 14 colonies.

2.3.2 Section 5 –2004 Sampling

Twenty-four sites were sampled by BHE Inc. during the summer of 2004 (BHE 2004). This effort resulted in the capture of 185 bats including 41 big brown bats, 33 eastern pipistrelles, 33 eastern red bats, 30 little brown bats, 30 northern bats, 7 evening bats, 6 hoary bats, and 5 Indiana bats. Four of the Indiana bats captured were adult males. A single adult male was tracked to two roost trees immediately northwest of its capture site at 22. The four other Indiana bats were radio-tagged, but none were successfully tracked to roosts. Based on these data, USFWS concluded that a maternity colony of Indiana bats was located in the vicinity of site 19, where a post-lactating female was captured.

To allow direct comparison with the 2012 survey, data from 2004 were entered into a database and subjected to the same statistical analyses as used in this report.

2.4 Indiana Bat –

2.4.1 Status –

The USFWS listed the Indiana bat (*Myotis sodalis*) as endangered on 11 March 1967. The 2011 range-wide estimate of the population was 424,708 individuals (USFWS 2012), which represents about half of the estimated population of 1960. Long-term, detailed documentation of population changes are lacking across most of its range, with the exception of the state of Indiana (Brack et al. 1984, Johnson et al. 2002, Whitaker and Brack 2002, Brack et al. 2003, Sparks et al. 2008), although such information is now being acquired in most states. It is probable that rangewide habitat loss during summer (USFWS 2007) and winter disturbances during hibernation (Johnson et al. 1998) both contributed to the overall decline of the species.

The only official recovery plan for the species was completed on 14 October 1983. A new draft revised recovery plan was released in April 2007. Although widely used as a regulatory document, the 2007 version of the recovery plan has not been officially approved.

Critical habitat was designated on 24 September 1976, and includes 11 caves and 2 abandoned mines in Illinois, Indiana, Kentucky, Missouri, Tennessee, and West Virginia.

Federal Register Documents

41 FR 41914; 24 September 1976: Final Critical Habitat, Critical habitat-mammals

40 FR 58308 58312; 16 December 1975: Proposed Critical Habitat, Critical habitat-mammals

32 FR 4001; 11 March 1967: Final Listing, Endangered

2.4.2 Regional Occurrence –

The Indiana bat occurs throughout Indiana including the I-69 study area (Appendix B, Figure 2). Indiana bats occur either within or adjacent to the study area throughout the year. There are four ecologically distinct components of the annual life cycle: winter hibernation, spring staging and autumn swarming, spring and autumn migration, and the summer season of reproduction (Appendix B, Figure 3). Each of these components is discussed below with respect to regional occurrence of the Indiana bat in Indiana.

2.4.2.1 Winter hibernation / Spring Staging and Autumn Swarming –

As noted above, the Bloomington, Indiana area is home to a number of caves and mines, several of which are used by Indiana bats. The following known hibernacula are located within 32 kilometers (20 mi) of the Project:

Cave was designated as critical habitat on 24 September 1976 and is currently the largest known hibernacula for the species. The large number of bats that winter in the area would also indicate that male bats are likely to be present.

2.4.2.2 Summer Roosting –

During summer, males often remain at or near hibernacula, visiting them periodically, although some disperse longer distances from the hibernacula.

There is evidence of reproduction and maternity colonies in at least 40 counties in Indiana (Whitaker and Brack 2002). Maternity colonies may be more abundant in the northern part of the state. Previous studies (see above) completed along the I-69

corridor indicate that maternity colonies of Indiana bats have been found in the region. Analysis in the previous 2004 and 2005 studies showed one maternity colony in Section 5..

2.4.3 Ecology –

The Indiana bat is a "tree bat" in summer and a "cave bat" in winter. There are four ecologically distinct components of the annual life cycle: winter hibernation, spring staging and autumn swarming, spring and autumn migration, and the summer season of reproduction. The U.S. Fish & Wildlife Service Recovery Plan (2007) provides a description of the life history. Figure 3 in Appendix B provides an annual chronology of seasonal activities.

2.4.3.1 Winter Hibernation –

Although the winter range of the Indiana bat is large, it was originally restricted to regions of well-developed limestone caves. The species overwinters in approximately 300 known hibernacula. Most hibernacula are in caves, but relatively large numbers of Indiana bats hibernate in abandoned mines in Illinois (Kath 2002), New York (Hicks and Novak 2002) Ohio, and in smaller numbers in a variety of locations. There are large populations of Indiana bats in only a few caves and most hibernacula contain only a few bats. Hibernacula with large populations of Indiana bats are concentrated in southern Missouri and Indiana, and in Kentucky. Smaller wintering populations occur in Alabama, Arkansas, Connecticut, Georgia, Illinois, Iowa, Maryland, Massachusetts, Mississippi, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Vermont, Virginia, and West Virginia.

Hibernation is an adaptation that allows survival through the winter months when food and water are not abundant. Indiana bats hibernate from mid-November to mid-April. Many species of bats (including the Indiana bat) make relatively characteristic and recognizable use of hibernacula, including temperature regimes and spatial associations (Brack 1979, Brack and Twente 1985, Twente et al. 1985, Brack et al. 2003). Hibernating Indiana bats often form dense clusters on cave ceilings in portions of the cave where winter temperatures are suitable. Initially, this temperature was believed to be 4 to 8° Celsius (39.2–46.4° F) (or perhaps more narrowly 3 to 6° Celsius [37.4–42.8° F]) during mid-winter (USFWS 2007), but these assertions (Hall 1962, Henshaw and Folk 1966, Humphrey 1978) were supported with scant data. Recent analysis of long-term data in hibernacula with increasing numbers of Indiana bats indicates the optimal range is closer to 6 to 8° Celsius (42.8–46.4° F) (Brack et al. 2003, Brack et al. 2005), and is supported by other detailed studies (Myers 1964, Clawson et al. 1980). Therefore, Indiana bats use areas that are cool, but thermally stable. Colder areas, especially areas closer to the entrance, are often unstable. Clusters of bats are not sexually segregated.

Populations of hibernating bats in the northeastern United States have been dying in record numbers, and the specific cause of the deaths is unknown. However, this crisis is directly associated with WNS, named for a white fungus evident on the muzzles and wings of affected bats (Meteyer et al. 2009).

This affliction was first documented at four sites in eastern New York in the winter of 2006–2007 (Blehert et al. 2008; 2009). Since then, WNS has rapidly spread to multiple sites throughout the Northeast and Appalachians. Researchers associate WNS with a newly identified fungus (*Geomyces destructans*) that thrives in the cold and humid conditions characteristic of the caves and mines used by bats (Gargas et al. 2009). At present, the cause of mass mortality remains unproven, but recent data indicates disruption of water balance within wings infected by the fungus can lead to individual mortality (Cryan et al. 2010). Bats apparently have a reduced immune response while hibernating (Carey et al. 2003), which may predispose them to infection by *G. destructans*. Further, bat species such as the Indiana bat that are found in large groups during both summer and winter are both the most likely to be infected by the disease and also the most likely to reach abundances where colonies are no longer viable (Brack et al. 2010).

In the U.S., WNS or *G. destuctans* has been documented in every state ranging from Maine south to Tennessee and north to Indiana. The disease was first documented in southern Indiana in February 2011, and has now been confirmed in nine counties: Crawford, Greene, Harrison, Jefferson, Lawrence, Martin, Monroe, Orange, and Washington.

The disease can lead to severe wing damage (Reichard and Kunz 2009) which can be used as a "red flag" for infected individuals, although the majority of bats within an infected area have only slightly damaged or undamaged wings (Francl et al. 2011, Sparks et al. 2011). By combining sensitive molecular techniques (Lorch et al. 2010) with field observations of damaged wings, the fungal agent of WNS has now been documented as far west as Oklahoma.

2.4.3.2 Spring Staging –

Female Indiana bats leave hibernacula earlier in spring (beginning in mid-April) than do males (peak of departure in early May). This part of spring activity is referred to as staging. In spring, after emerging from hibernation, bats may remain near hibernacula for a few days before leaving for summer maternity areas. They may use this time to help prepare for migration.

2.4.3.3 Autumn Swarming –

Autumn swarming is a term used to describe the activity of microchiropterans at hibernacula in North America (Cope and Humphrey 1977) and Europe (Parsons et al. 2003) during autumn. It is the use and visitation of hibernacula and nearby habitats in late summer and early autumn, and for many species is associated with the opportunity for sexes to meet and mate.

In autumn, Indiana bats swarm at caves used for hibernation, although individuals probably come and go throughout the autumn season. Cope and Humphrey (1977) indicated that "waves" of Indiana bats begin to return to a hibernaculum in southern Indiana in low to moderate numbers in mid to late August. The earliest bats arrive as early as late July (Brack 1983) in Indiana and early August (LaVal and LaVal 1980) in Missouri.

During swarming, the abundance of females increases and decreases with the season, but males are always more common (Cope and Humphrey 1977, LaVal and LaVal 1980). Numbers of swarming females peak in September. By late September, many females are hibernating while many males remain active until mid-October or later,

apparently in an effort to breed late-arriving females. Small males with insufficient fat reserves to survive winter may remain active in hibernacula seeking to copulate before dying (Richter et al. 1993). Temperature and precipitation likely influence swarming chronology. For example, rain has been shown to depress swarming activity in Europe (Parsons et al. 2003). Large, wet, cold-weather systems may be part of the seasonal cycle driving timing of swarming (Brack 2006). Females store sperm through hibernation and delay fertilization until spring (Wimsatt 1944). It is not known if juvenile females mate their first autumn. Limited mating may occur in spring (Hall 1962).

During early stages of autumn swarming, Indiana bats visit hibernacula at night, but do not day roost in the cave. At smaller hibernacula, some individuals roost in woodlands near the cave: 0.8 kilometer (0.5 mi) in Virginia (Brack 2006) and 1.9 kilometers (1 mi) in Kentucky (Gumbert 2001). In Virginia, Indiana bats used a variety of species of live, dying, and dead roost trees (Brack 2006). Individual bats roosted in multiple roost trees, which were sometimes used for 2 to 3 consecutive days. Many roosts were near canopy openings including selective cut, clear-cut, and pastured woodlands with scattered trees. Roosts were also found near or along logging roads or powerline corridors. Bats also used roost trees in forests with moderate to high canopy closure. Compared to availability, roost trees were located disproportionately more often in open, intermediate, and closed deciduous forests rather than mixed deciduous/evergreen forest. Roosts found in agricultural areas bordered croplands. In Virginia, there was no difference between sizes of roost trees used by females and males (44.4 vs. 39.3 centimeters [17.5 vs. 15.5 in]), height of roost above ground (11.4 vs. 12.2 meters [37 vs. 40 ft]), or elevation where roost was found (839 vs. 900 meters [2,750 vs. 2,950 ft]). There was no significant difference between species of roost trees used by male and female bats throughout the autumn season, as well as no discrimination between living or dead trees (Brack 2006). As the autumn season progresses, more bats roost in the hibernacula.

In Virginia, nocturnal activity areas were 96 to 367 hectares; an average of 251 hectares (237–907 ac, average of 620.2 ac), with a great deal of overlap among activity areas of individuals (Brack 2006). Bats were active in open deciduous forests more than this type of habitat was available (19.0% vs. 9.5%), in agricultural lands and intermediate deciduous forests similar to availability, and in mixed deciduous-evergreen and closed deciduous forests less than available (Brack 2006). Thus, Indiana bats foraged in relatively open habitats, consisting primarily of pastures with scattered trees. Many pastures (agricultural lands) in the project area had scattered trees and they abutted woodlands, with a gradation from pasture to woodlands, and open woodlands were generally recently-logged tracts with a scattering of individual trees. Bats were active across all elevations in the study area. Many bats included an existing powerline right-of-way (ROW), a notable feature on a forested landscape, in their active area. Bat activity shifted among habitats over the autumn season (Brack 2006). Use of agricultural lands dropped steadily over the season; conversely, use of deciduous forests (combined open, intermediate, and closed) increased, possibly in response to insect availability.

As the autumn season progresses, nightly activity begins earlier in the evening (Parsons et al. 2003, Brack 2006). As temperatures cool seasonally, nocturnal insects have a limited activity period; consequently, so do the bats. Apparently many bats leave the hibernaculum area periodically during autumn swarming (Gumbert 2001, Brack 2006). It is not known why bats leave, but departures during swarming have implications for reproductive fitness since it reduces or eliminates the opportunity to mate. Possibly, bats visit and mate at other swarming locations. Alternatively, males actively seeking mating opportunities may need to intermittently leave the swarming area to forage and replenish energy supplies.

2.4.3.4 Spring and Autumn Migration / Transient Period –

Little is known about bats during migration. In general, females are more migratory than males (Brack 1983, Whitaker and Brack 2002). Females from a single hibernaculum may end up at maternity colonies over a large geographic area, and females from a single maternity colony may end up in different hibernacula (Barbour and Davis 1969, Gardner and Cook 2002, Kurta and Murray 2002). It is probable that bats use a variety of roosts, including trees, caves, mines, holes of various types, and possibly a variety of non-traditional roosts during migration. Bats migrating from hibernacula in southeastern New York to summer maternity sites roosted in trees and on a building — in a gap between a cinderblock wall and a joist under an elevated deck (Sanders and Chenger 2001), as well as in the siding of a house and in trees of suburban yards. In late summer, a juvenile Indiana bat was found on the side of a building in central Indiana that had a roughed cement exterior (Brack, unpublished data). In northern Ohio, several Indiana bats have been caught in autumn in sandstone crevices that likely serve as a migratory stop-over (Summit County Metro Parks 2003). During migration, other species of bats have been found in a variety of unlikely locations, including ships at sea, log piles, and rodent holes in treeless areas (Brack and Carter 1985).

As part of the studies related to development of I-69, a bridge was discovered to be a roost of Indiana bats during the 2004 pre-construction monitoring. Additional monitoring of the site by INDOT indicate that the site is used as a roost by migrating Indiana bats. Thus, migrating Indiana bats are likely within the study area.

2.4.3.5 Summer Roosting Ecology –

The summer range of the Indiana bat is large and includes much of the eastern deciduous forestlands between the Appalachian Mountains and Midwest prairies. Distribution throughout the range is not uniform and summer occurrences are more frequent in Indiana, northern Missouri, and southern portions of Iowa, Michigan, and Illinois. Historically, these areas were vegetated in a mix of prairies, forest, and savannas (Küchler 1964). Cooler summer temperatures associated with latitude or altitude likely affect reproductive success and the summer distribution of the species (Brack et al. 2002). Similarly, the warmer, drier climate of the Midwest allows rapid growth of young and short migration to suitable hibernacula.

2.4.3.5.1 Males –

Some males remain near hibernacula throughout summer while others migrate varying distances (Whitaker and Brack 2002). Males can be caught at hibernacula on most nights during summer (Brack 1983,

Brack and LaVal 1985), although there may be a large turnover of individuals between nights (Brack 1983).

Structurally, woodland roosts used by males are similar to those used by maternity colonies (Kiser and Elliott 1996, Schultes and Elliott 2002, Brack and Whitaker 2004, Brack et al. 2004). These trees are smaller (Kurta 2004), perhaps because males are often solitary or form small groups and thus need less space or because males may have different thermal requirements than females. Males appear somewhat nomadic; over time, the number of roosts and the size of an area used increases.

2.4.3.5.2 Females and Maternity Colonies –

When female Indiana bats emerge from hibernation, they migrate to maternity colonies that may be located up to several hundred miles from the hibernacula (Kurta and Murray 2002, Winhold and Kurta 2006). Females form nursery colonies under exfoliating bark of dead, dying, and living trees in a variety of habitat types, including uplands and riparian habitats. A wide variety of tree species (Kurta 2004), occasionally including pines (Britzke et al. 2003), are used as nursery colonies indicating that it is tree form, not species that is important for roosts (Kurta 2004, Winhold 2007, Whitaker and Sparks 2008). Because many roosts are in dead or dying trees, they are often ephemeral. Roost trees may be habitable for one to several years, depending on the species and condition of the tree (Callahan et al. 1997, Gumbert et al. 2002, Sparks 2003). Indiana bats exhibit strong site fidelity to summer roosting and foraging areas (Kurta and Murray 2002, Kurta et al. 2002, Sparks et al. 2004, Whitaker et al. 2004, Winhold et al. 2005, Whitaker and Sparks 2008, Sparks et al. 2009). This fidelity is to a larger landscape which can change over time. Between the discovery of a colony near the Indianapolis International Airport in 1994 and 2008, this colony of bats essentially abandoned foraging areas north of the expanded Interstate 70 and shifted their center of activity into a conservation area that was designed and managed for them (Sparks et al. 2009). This indicates that it is possible to move colonies of Indiana bats across a developing landscape if suitable long-term habitat is available or developed during the move.

A maternity colony typically consists of 25 to 325 adult females. Nursery colonies often use several roost trees (Kurta et al. 1993, Foster and Kurta 1999, Kurta and Murray 2002, Whitaker and Sparks 2008), moving among roosts within a season. Most members of a colony coalesce into one or a few roost trees about the time of parturition. Once young are volant, the bats spend less time in these major roosts and more time in minor roosts — often roosting alone under the bark of live trees. Roosts that contain large numbers of bats (more than 30 bats) are often called primary roosts, while secondary roosts hold fewer bats. Primary roost trees are often greater than 46 centimeters (18 in) diameter at breast height (dbh) and secondary roost trees are often greater than 23 centimeters (9 in) dbh (Gardner et al. 1991, Callahan et al. 1997, Kurta et al. 2002, Miller et al. 2002, Carter 2003). Numerous suitable roosts may be needed to support a single nursery colony, possibly about 45 stems per hectare (20/ac) (Gardner et al. 1991, Miller et al. 2002, Carter 2003).

Roost trees often have 10 hours of solar exposure per day, with 20 to 80 percent

canopy closure (Humphrey et al. 1977, Gardner et al. 1991, Kurta et al. 1993, Kurta et al. 1996, Kurta et al. 2002, Carter 2003), but the need for solar exposure may vary with latitude. Although Indiana bats typically roost under the exfoliating bark of dead and dying trees, they have also been found roosting in a variety of cracks and hollows in trees (L. C. Watkins in Humphrey et al. 1977, Kurta et al. 1993, Butchkoski and Hassinger 2002, Kurta et al. 2002, Kurta 2004), utility poles (ESI 2004, Hendricks et al. 2004), buildings (Butchkoski and Hassinger 2002, V. Brack Unpublished data, A. C. Hicks Personal communication), and bat boxes (Butchkoski and Hassinger 2002, Carter 2002, Butchkoski 2005, Ritzi et al. 2005, Whitaker et al. 2006). The colony of bats near the Indianapolis Airport have used a combination of both natural roosts (trees) and bat boxes every year since 2003 (Sparks et al. 2008).

Females are pregnant when they arrive at maternity roosts. Females produce one young per year, typical for the genus *Myotis* (Asdell 1964, Hayssen et al. 1993). Parturition typically occurs between late June and early July. Lactating females have been caught 11 June to 29 July in Indiana, 26 June to 22 July in Iowa, and 11 June to 6 July in Missouri (Humphrey et al. 1977, LaVal and LaVal 1980, Brack 1983, Clark et al. 1987). Juveniles become volant between early July and early August. Reproductive phenology is likely dependent upon seasonal temperatures and the thermal character of the roost (Humphrey et al. 1977, Kurta et al. 1996). Like many microchiropterans, Indiana bats are thermal conformists (Stones and Wiebers 1967), with prenatal, neonatal, and juvenile development temperature dependent (Racey 1982). Cooler summer temperatures associated with latitude or altitude likely affect reproductive success and therefore the summer distribution of the species (Brack et al. 2002).

Nightly non-foraging behavior of Indiana bats is poorly documented. In Michigan, pregnant bats from a maternity colony foraged most of the night, but lactating females returned two to four times to feed young. Both pregnant and lactating females roosted up to six times per night for 14 minutes (SD = 1) each (Murray and Kurta 2004). Foraging areas were 0.5 to 4.2 kilometers (0.3–2.5 mi) from diurnal roosts. Kiser et al. (2002) found 82 bats under three bridges over a 6-night period in late July and August. Temperatures under the bridges were warmer and less variable than ambient, apparently providing a location to roost and digest food between foraging bouts. These bridges were 1.0 to 1.9 kilometers (0.6–1.2 mi) from diurnal roost trees. Additional unpublished information about night roosting is available from the long-term study of a colony near the Indianapolis International Airport (D.W. Sparks Unpublished data). These bats regularly night roosted within wooded areas. When biologists entered woodlots to locate tagged bats to a specific tree, the bats moved to new roosts; this behavior was greatly reduced when human activity in the woodlot was restricted. When bats were located to a specific tree, they were hanging exposed on the tree rather than under bark. More rarely, individual bats night roosted in bat boxes. In one case, an Indiana bat night roosted in a prairie, apparently on big bluestem (*Andropogon gerardii*) or evening primrose (*Oenothera* sp.).

Indiana bats live on anthropogenic landscapes and recent research indicates females include roads in their active area.

Although bats do cross roads, the studies that document this behavior were typically not designed to gauge a graded response. On Camp Atterbury, Indiana, female and juvenile Indiana bats routinely night roosted under bridges on 2-lane paved roads (Kiser et al. 2002). Activity areas of nursery colonies in Illinois (Gardner et al. 1991) and Michigan (Kurta et al. 2002) included paved roads. On the campus of Wright State University, Ohio, a roost tree was at the edge of a large parking lot, and about 20 meters (60 ft) from a moderately traveled road. Emerging bats crossed the parking lot and radio-tagged bats crossed highway 444, a 4-lane divided highway, to forage in a 73-hectare (180 ac) woodlot (Brown et al. 2001). In eastern Indiana, adjacent to Newport Chemical Depot, a reproductive female Indiana bat was radio-tracked across a 4-lane divided highway to a maternity colony in a small, 0.7-hectare (1.7 ac) isolated woodlot (Brack and Whitaker 2006). The roost tree was on the west edge of the woodlot (adjacent to the highway) and the woodlot was surrounded on other sides by open, farmed agricultural lands. Based on Euclidean distance analysis, small, unimproved roads were the most preferred foraging habitat at Fishhook Creek Watershed in Illinois (Menzel et al. 2005).

Research into the response of Indiana bats to roadways has been ongoing in Indiana during the past decade. Indiana bats foraging near the Indianapolis airport cross roads ranging from unimproved tire paths to Interstate highways an average of 11.97 times per night, but most of this activity (11.54 crossings per night) is restricted to small rural roads, and this pattern holds when corrected for the much greater abundance of smaller roads (M. McGuire Unpublished data). Similarly, bats at this site were much more likely to abort attempts to cross a roadway when vehicles were present (Zurcher et al. 2010). By combining species-specific patterns of movement with these observations, it is possible to mathematically model the impacts of roadways on bats. The willingness of a bat to cross a roadway is in part determined by three factors: value of the habitat on the opposite side of the road, size of the road, and intensity of traffic (V. J. Bennett Personal communication). These results suggest that utility corridors are less of a barrier than roadways because they lack traffic. In addition, Indiana bats have been observed using such corridors as both commuting and foraging habitat (Brack and Whitaker 2006)

2.4.3.6 Foraging Ecology –

The diet of Indiana bats varies substantially among bats of different ages and sexes, and in relation to the availability of insects within different habitat types. Based on diets of males, Brack and LaVal (1985) considered the species selective opportunists. In Indiana, aquatic-based insects were more common in the diet of a maternity colony than in the diet of males collected at caves (Brack 1983). The maternity colony was located along the Big Blue River, where only about 11 percent of the land within 3.2 kilometers (2 mi) of the roost was forested (most was riparian), whereas males were caught at a cave where 42 percent of the area within 3.2 kilometers (2 mi) was forested and only a small portion was riparian. In late summer, the diets of males, females, and juveniles captured at caves were similar to one another and to summer diets of males. Diets reported by Belwood (1979) from a colony along a stream and by Kurta and Whitaker (1998) from a colony within a wooded wetland contained more aquatic-based insects than diets of males foraging in an upland habitat

(Brack and LaVal 1985). The repeated seasonal occurrence of the Asiatic oak weevil (*Cyrtepistomus castaneus*) and sporadic abundance of hymenopterans in the diet (Brack 1983, Brack and LaVal 1985, Brack and Whitaker 2004, Tuttle et al. 2006, Brack In press) are both indicative of opportunistic feeding. Insects may be less common late at night, forcing bats to eat a greater variety of insects (Brack 1983). Diet varied across weeks at a maternity colony in Indiana (Tuttle et al. 2006). The diet contains less diversity late in the season (Brack 1983, Brack and LaVal 1985). Diet also varies by lunar cycle (Brack 1983, Brack and LaVal 1985), because the cycle affects insects. Murray and Kurta (2002) found that the diet was flexible across the range and potentially affected by regional and local differences in bat assemblages and availability of foraging habitat and prey. Despite variability of the diet, it should be noted that this variability is a result of eating different amounts of insects belonging to five orders: Lepidoptera (moths), Coleoptera (beetles), Diptera (true flies), Trichoptera (caddisflies), and Hymenoptera (wasps and ants) (Tuttle et al. 2006).

Using a variety of techniques, authors have reported that Indiana bats travel a wide range of distances from their roosts, and the inherent benefits and biases of these techniques must be considered when interpreting the data (Sparks et al. 2004). Using reflective wristbands, Humphrey et al. (1977) found that a maternity colony foraged in areas ranging from 1.5 to 4.5 hectares (3.7–11.1 ac). Using telemetry, much larger distances have been recorded. In Illinois, individuals traveled up to 4.0 kilometers (2.49 mi) from maternity colonies (Gardner et al. 1991). In Michigan, foraging areas were 0.5 to 4.0 kilometers (0.3–2.49 mi) from diurnal roosts (Murray and Kurta 2004), and members of a maternity colony moved a maximum distance among roosts of 5.8 kilometers (3.6 mi) overnight, but 9.2 kilometers (5.7 mi) over 4 years (Kurta et al. 2002). In Missouri, adult males traveled 5 kilometers (3.1 mi) while foraging LaVal and LaVal (1980). Brack (1983) observed foraging light-tagged bats within 3.22 kilometers (2 mi) of caves used during autumn swarming. In Hoosier National Forest, the mean active foraging area of four adult male bats ranged from 95.1 to 151.9 hectares (235–375 ac) based on the method of estimation, while the means of individual bats across three methods of estimation (95% minimum convex polygon, capture radius, and non-circular) ranged from 43.1 to 314.2 hectares (107–776 ac) (Brack et al. 2004). At the Indianapolis Airport (Sparks et al. 2004, Sparks et al. 2005), maximum distance flown by Indiana bats averaged 3 kilometers (1.86 mi) but ranged from 0.8 to 8.4 kilometers (0.5–5.41 mi). Similarly, using 95 percent minimum convex polygons, home range size averaged 412 hectares (1081.07 ac) but ranged from 50 to 1168 hectares (123.55–2886.19 ac), and home ranges of individuals often overlapped (Sparks et al. 2004, Sparks et al. 2005). Individuals of many species of bats that roost colonially forage independently of one another (Kerth et al. 2001). Like many other species of microchiropterans, the Indiana bat often uses travel corridors that consist of open flyways such as streams, woodland trails, small infrequently used roads, and possibly utility corridors, regardless of suitability for foraging or roosting (Brown and Brack 2003). Such corridors may play an important role in allowing bats to access isolated foraging areas (Murray and Kurta 2004, Sparks et al. 2004), but may not be essential as Indiana

bats have been tracked crossing large open areas (Brack 1983).

Members of maternity colonies forage in a variety of woodland settings, including upland and floodplain forest (Humphrey et al. 1977, Brack 1983, Gardner et al. 1991). Foraging activity is concentrated above and around foliage surfaces, such as over the canopy in upland and riparian woods, around crowns of individual or widely spaced trees, and along edges (LaVal et al. 1977). They forage less frequently over old fields, and occasionally over bushes in open pastures (Brack 1983). Forest edges, small openings, and woodlands with patchy trees provide more foraging opportunities than dense woodlands. Most species of woodland bats forage prominently along edges, less in openings, and least within forests (Grindal 1996). Openings also provide a better supply of insects than do wooded areas (Tibbels and Kurta 2003).

When habitat selection is examined at the landscape scale, the species makes preferential use of forested habitat for foraging in both Illinois and Indiana (Menzel et al. 2005, Sparks et al. 2005). The Illinois study was on a wildlife management area with substantial blocks of bottomland hardwood forest. In this landscape, bats foraged closer to roads, forest, and riparian areas than chance alone would predict. Grassland was used in proportion to availability and agricultural areas were avoided. In suburban Indianapolis, Indiana bats preferentially used woodlands more than agricultural, low density residential, and open water, and these habitats more than pasture, parks, and commercial lands, with high density residential least preferred. It should be noted, however, that at this study site most such neighborhoods were new developments within what were previously large agricultural fields. The authors suggest that this pattern might not hold for residential areas where woodland habitat is retained. Finally, it is likely that in heavily forested areas, open habitats would be preferentially used by foraging Indiana bats (Sparks et al. 2004).

2.5 Evening Bat –

2.5.1 Status and Distribution –

The evening bat (*Nycticeius humeralis*) is abundant in the Deep South where it is one of the most commonly captured bats. In Indiana, the species appears to be associated with large river systems and is listed as endangered by the Indiana Department of Natural Resources (IDNR) (Whitaker and Gummer 2003, Whitaker et al. 2007). Population trends of evening bats are unknown in most parts of the range and the species has no federal protective status.

2.5.2 Regional Occurrence –

Conaway first reported the evening bat in Dearborn County (Kirkpatrick 1943), another was reported in Tippecanoe County in 1947 (Kirkpatrick and Conaway 1948). Mumford (1953) reported individuals from Tippecanoe and Clay counties. Lindsay (1956) documented the species in Ripley County. In 1982, Mumford and Whitaker documented it in 10 counties; however, known numbers of evening bats in the state declined until only a single colony was known in 1988 (Whitaker and Gummer 1988). No colonies were known in 1993 (Whitaker and Gummer 1993). It is interesting to note that the colony in Clark County may have been the longest-lasting colony in the state, with individuals taken from the same region of the county in 1961 (Cope et al. 1961), 1980 (Brack 1985), and 1987 to 1993 (Whitaker and Gummer 1988);

it was the last known colony to inhabit buildings. Evening bats were rediscovered in Indiana in 1994 in Vigo County (Whitaker 1996; 2006). During the following 10 years colonies were found using natural roosts in western and south-central Indiana, mainly along the Wabash and White rivers (Whitaker and Gummer 2003), all using natural tree roosts. Evening bats are now known throughout Indiana (Whitaker et al. 2007), but remain associated with larger streams and rivers and more common in the southern portion of the state.

Previous surveys along the I-69 corridor captured multiple evening bats occur. In section 5, seven evening bats (6 reproductive females and juvenile male) were captured during the 2004 sampling at site 23. As such, there is likely a maternity colony along nearby Indian Creek.

2.5.3 Ecology –

During summer, evening bats commonly roost in large numbers in man-made structures (Watkins 1970; 1972, Watkins and Shump 1981, Wilkinson 1992). In Indiana, this species was considered a house bat by Mumford and Whitaker (1982), as few natural roosts were known from the state at that time (Mumford 1953, Cope et al. 1961, Whitaker and Gummer 1988; 1993). However, the advent of small radio-transmitters has clearly demonstrated that this species most typically uses tree cavities in live trees, although occasional individuals roost under exfoliating bark (Whitaker 1996, Menzel et al. 2001, Whitaker and Gummer 2003, Duchamp et al. 2004, Miles et al. 2004; 2006, Whitaker and Mumford 2009). In Missouri, the species has been documented roosting in areas where prescribed fire has created snags and an open subcanopy (Boyles and Aubrey 2006), and these structural components were also an important predictor of this species' presence on the Savanna River Site in South Carolina (Ford et al. 2006).

It is not known when or where copulation occurs. In Indiana, female evening bats arrive at maternity colonies in May and remain until October; peak populations occur in mid-June, coincident with parturition (Clem 1992). Most females apparently have two young, as most pregnant females have been found to be carrying two embryos although fetal counts range from one to three (Watkins 1972, Hayssen et al. 1993, Sparks et al. 1999). Young become volant in about 20 days.

There are few records of evening bats during winter, especially in northern portions of the range (Whitaker and Gummer 1993). It is probable that the species migrates seasonally. Baker et al. (1968) noted a build-up of body fat in autumn suitable to sustain travel over long distances, and Humphrey and Cope (1968) recorded long-distance movements in August by three banded individuals. Baker and Ward (1967) collected 10 individuals in southern Arkansas in late December. In Missouri, most bats roosted in hollow trees (Boyles and Robbins 2006), although in extreme conditions they may burrow into leaf litter (Boyles et al. 2005).

3.0 METHODS

3.1 Mist Net Survey –

3.1.1 Site Selection –

Locations for the 2004 survey were selected by biologists at BLA and BHE in consultation with the Bloomington Field Office. The current survey effort returned as closely as possible to those sites, and all but site 14 were netted on the same parcel as netted in 2004. Site 14 was moved to an adjacent property due to issues with property access. In some cases, it was necessary to arrange nets differently than in 2004 due to changed conditions at the site.

Exact net placement at pre-selected sites was based upon canopy cover, presence of a flight corridor, water, and habitat conditions near the site. Nets were set to maximize the potential capture of Indiana bats. Riparian corridors often provide successful mist net sites; however, terrestrial corridors (e.g., trails or logging roads) also provide suitable sites (Brown and Brack 2003). Net locations are illustrated in Appendix B, Figures 1 and 4. GPS coordinates were obtained with handheld GPS units and recorded in UTMs. Biologists collected separate GPS coordinates for each net set. Tables are included as Appendix C of this report (Table 1).

3.1.2 Mist Netting –

Twenty-four mist net sites (total of 98 complete net nights), were surveyed between 15 and 30 May. In addition weather conditions including cold and rain resulted in 22 partial net nights (Appendix C, Table 1).

Efforts to survey for endangered bats are difficult to standardize because of the large amount of variability that exists at an individual survey site or between survey sites in the same project area. However, a number of practices used for summer surveys for Indiana bats have provided structure for implementation of netting guidelines provided by the USWFS (2007) in the most recent Draft of the Indiana Bat Recovery Plan (First Revision) (Appendix C, Table 2).

As required by both the USFWS and the IDNR, ESI and ISU biologists followed the latest WNS protocols (currently White-Nose Syndrome Decontamination Protocol and Supporting Decontamination Documentation for Researchers), distributed by USFWS on 15 March 2012. Per the request of USFWS, ESI biologists also categorized wing damage using the "Wing-Damage Index for Characterizing Wing Condition of Bats Affected by White-nose Syndrome" (Reichard and Kunz 2009).

3.1.3 Bat Capture –

The netting setup allows bats to be caught live and released unharmed near the point of capture. Bats were identified to species using a combination of morphological characteristics (e.g., ear and tragus, calcar, pelage, size/weight, length of right forearm, and overall appearance of the animal). The species, sex, reproductive condition, age, weight, length of right forearm, and time and location/net site of capture were recorded for all bats captured. Age (adult or juvenile) of bats is determined by examining ephiphyseal-diaphyseal fusion (calcification) of long bones in the wing. Weight was measured to 0.5 gram using a Pesola spring scale. Length of the right forearm of each bat was measured to the nearest 0.5 mm using either dial calipers or metric ruler.

The reproductive condition of captured bats was classified as non-descended male, descended male, non-reproductive female, pregnant female (based on gentle abdominal palpation), lactating female, or post-lactating female.

As noted above, ESI biologists also categorized wing damage associated with WNS by visually examining the membranes and forearms of each bat (Reichard and Kunz 2009). WNS damage (as well as other sources of wing injury) is visible, during warm months of the year, as necrotic tissue, tears, and scars on the membranes. Biologists transilluminated and examined wing membranes, uropatagia, and forearms of each bat and the damage was ranked based on the collective condition of the membranes. Damage was categorized into four levels with 0 representing "none" to 3 representing "high." It should be noted that this scarring becomes less apparent as bats heal during summer (Reichard and Kunz 2009, Francl et al. 2011).

Bat processing and data collection were completed for all species captured. Representative photographs and bat capture data sheets are provided in Appendices D and E, respectively. Bats were released near the capture site.

Data collected were used in comparative analyses with surveys from the 2004 study to examine changes in community structure. The species diversity index of MacArthur (1972) was used, where Diversity = $1/\sum P_i^2$, where P_i is the proportion of bats belonging to species i in each sample.

3.1.4 Net Site Habitat Assessment –

Habitat assessment at net sites focused on features indicative of suitability for Indiana bats. A habitat description of each net site was completed, and each net site was documented with a sketch. Completed field data sheets are provided in Appendix E. The emphasis of this description was habitat form: size and relative abundance of large trees and snags that potentially serve as roost trees, canopy closure, subcanopy clutter/openness, distance to water, stream or pond characteristics (if a net was placed over them), and flight corridors. Habitat form was emphasized because the Indiana bat roosts in many tree species. Tree species composition was included because it provides insight to edaphic conditions of each site.

Habitat characterization identifies components of canopy and subcanopy layers. Trees that reach into the canopy are canopy trees, regardless of their diameter/size. As defined in the Indiana Bat Habitat Suitability Index Model (3D/Environmental 1995), dominant trees are the large trees in the canopy (> 40 centimeters [16 in] dbh). Current literature seems to suggest that these trees have the greatest likelihood of being used by bat maternity colonies. Many smaller trees are often also found in the canopy, and in some situations, the canopy can be entirely composed of small-diameter trees. ESI's habitat characterization identifies both dominant and subdominant elements of the canopy.

The subcanopy vegetation layer is well defined in classical ecological literature. It is that portion of the forest structure between the ground vegetation [approximately 0.6 meter (2 ft)] and the canopy layers, usually beginning at about 7.6 meters (25 ft).

Vegetation in the subcanopy may come from:

- Lower branches of canopy trees
- Young canopy trees
- Small trees and shrubs that are confined to the subcanopy

The amount of vegetation in the subcanopy is termed clutter. Many species of bats, including the Indiana bat, tend to avoid areas of high clutter.

3.1.5 Weather –

Weather conditions were monitored during mist netting to ensure compliance with USFWS mist netting guidelines. Conditions recorded include temperature, wind speed and direction, percent cloud cover, and moon phase (if visible). A standard digital thermometer was used to record temperature, wind speed was determined by use of the Beaufort wind scale, and cloud cover was estimated. Weather data is recorded on the capture data sheets included in Appendix E.

3.2 Radio-telemetry –

3.2.1 Transmitter Application –

After collecting morphometric data, five Indiana bats were fitted with 0.35-gram radio-transmitters (Blackburn Transmitters, Nacogdoches, Texas or Holohill Systems Ltd, Carp Ontario, Canada) with a specific frequency. Transmitters were activated and tested before attachment to the bat. A small interscapular area was trimmed of fur and the transmitter was attached to this area with non-toxic surgical cement (Torbot Group, Inc., Cranston, Rhode Island or Perma-Type Inc, Plainfield, Connecticut). These adhesives degrade over time and the transmitter eventually falls off the bat. Transmitter weight, weight of the bat before and after transmitter attachment, and holding time were recorded on a Bat Transmitter Data sheet, included in Appendix F. Bats were released unharmed at the point of capture.

3.2.2 Bat Tracking –

After the radio-tagged bats were released, they were tracked for a minimum of 5 days using TRX-2000S PLL Synthesized Tracking Receivers by Wildlife Materials, Inc. attached to omnidirectional whip antennas or three or five element folding yagi directional antennas. Because all bats were located within 48 hours of capture, searches were concentrated near sites where the bats were captured.

4.0 RESULTS

4.1 Bat Captures –

The 2012 sampling produced three hundred thirty-four bat captures representing nine species including: 119 eastern red bats (*Lasiurus borealis*), 78 big brown bats (*Eptesicus fuscus*), 44 eastern pipistrelles (*Perimyotis subflavus*), 36 northern bats (*Myotis septentrionalis*), 28 little brown bats (*Myotis lucifugus*), 12 Indiana bats (*Myotis sodalis*), 7 hoary bats (*Lasiurus cinereus*), 7 silver-haired bats (*Lasionycteris noctivagans*), and 3 evening bats (*Nycticeius humeralis*) (Appendix C, Table 3,4).

Big brown, eastern pipistrelles and eastern red bats occurred most often, accounting for 72 percent of bat captures. Bats were captured at all sites, although only a single bat was captured at site 3 and 2 bats at site 7. The mean number of bats per net site was 13.92. The most productive sites were site 4 and 17. Sampling these sites produced 66 bats of 6 species — approximately 20

percent of all bats captured during 2012 mist netting efforts (Appendix C, Table 3, 4). Overall species diversity was 4.6.

Age was determined for all 334 captured bats, and adults accounted for 100 percent of the catch (Appendix C, Table 3). However, 14 out of the 334 captured bats escaped before sex could be determined. Thus, out of the 320 captured bats for which sex was determined, females accounted for 36 percent of the total catch (n = 115). Eighty-eight percent of adult females provided evidence of reproduction (n = 101).

4.2 Indiana Bat Captures and Radio-telemetry –

A total of twelve Indiana bats were captured (Appendix C, Table 5). Five of these bats received a radio-tag weighing 0.25 to 0.35 gram that broadcast a beacon signal (i.e. a beep) on a unique frequency. For ease of handling each bat is referenced below by the last three digits of this frequency. All of the transmitted bats were located in one or more specific trees (Appendix C, Table 6). Details of bat captures and subsequent telemetry data are discussed below. Roost tree locations are provided in Appendix B, Figure 5.

4.2.1 Indiana Bat 824 –

The first Indiana bat captured during the 2012 field study was an adult male captured at 2145 on 15 May 2012, which was the first night of netting at site 2. The bat received a 0.25-gram transmitter (frequency 172.824 megahertz) and was released at 2310 near the net site. This bat was found roosting along with five other bats in a dead 40-centimeter (18 in) dbh black walnut (roost 824-1) on 16 May. Roost 824-1 is located approximately 1.5 kilometers (0.9 mi) northwest from the capture site and within an upland forest used to graze livestock. Nightly emergence counts were conducted the nights of 16 through 18 May, when the tree was occupied by 5, 2, and 3 bats respectively. On 19 May, Bat 824 was found roosting along with 4 other bats in a dead 25.4-centimeter (10 in) dbh American elm (*Ulmus americana* [Roost 824-2]) in the

Park, approximately 0.2 kilometer (0.1 mi) west of the capture site. Although no further counts were completed, telemetry data indicated that the bat continued to roost in this tree until the night of 21 May. The bat was not located during the days of 22-29 May 2012, but telemetry efforts were restricted to the known roosting area near the park where it was captured.

4.2.2 Indiana Bat 869 –

The second Indiana bat captured during the 2012 field study was an adult male captured at 0015 on 16 May 2012, the second night of netting at site 2. The bat received a 0.25-gram transmitter (frequency 172.869 megahertz) and was released at 0140 near the net site. This bat was found roosting alone in a dead 12-centimeter (16.5 in) dbh red elm (*Ulmus rubra* [Roost 869-1]) on 17 May. Roost 869-1 is approximately 0.5 kilometer (0.3 mi) northwest of the capture site and within the same wetland area used by Bat 824, which was captured at the same site the previous night. Bat 869 roosted alone in tree 869-1 from 17 to 19 of May. Telemetry efforts located the bat in that same tree on 20-21 May. Biologists continued to search the area near the park on 22-29 May, but the bat was not relocated.

4.2.3 Indiana Bat 782 –

This bat was an adult male captured at 2208 on 18 May 2012, the first full night of netting at site 14A. The bat received a 0.25-gram transmitter (frequency 172.782 megahertz) and was released at 2238 at the

net site. On 19 May the bat was tracked to a three-chambered wooden bat box (Roost 782-1) on private property, but permission to count the box was not granted until 20 May. The bat box is in a residential area within a mature upland forest, approximately 0.6 kilometer (0.4 mi) north of the capture site. Interactions with the landowner complicated the first count on 20 May, but at least 4 bats (including the tagged bat) emerged. Emergence counts were conducted 20 to 21 May, when the box was occupied by 4 and 18 bats, respectively. Telemetry data indicated that Bat 782 continued to use the box until at least 26 May. A spotlight was used to estimate the number of bats present in the box on a daily basis until 29 May. On 24-26 May the box was occupied by 15-20 bats including Bat 782. On 27-29 May, the number of bats present decreased to approximately 10 individuals but the tagged bat was not detected. Efforts were made on several occasions to spot-light the box after emergence and no juvenile bats were observed. A follow-up count with a spotlight was made during the afternoon of 12 June, but no bats were present.

4.2.4 Indiana Bat 768 –

The fourth radio-tagged bat was a pregnant female captured at 2203 on 18 May 2012, the first night of netting site 24. The bat received a 0.35-gram transmitter (frequency 151.768) and was released at 2246 on a tree near the net site. This bat was found roosting along with 28 other bats in a 69.85-centimeter (27.5-in) dbh dead eastern cottonwood (*Populus deltoids*, [Roost 768-1]) on 19 May. Roost 768-1 was located approximately 1.5 kilometers (0.9 mi) southeast of the capture site near Lambs Creek, and was used by Bat 768 until 21 May. Nightly emergence counts were conducted from 19 to 22 May when the tree was occupied by 29, 31, 35, and 48 bats respectively. Additional emergence counts were conducted on 27 May (Bat 768 was not present) yielding 29 bats and 12 June when 80 bats were detected in tree 768-1.

On 22 May biologists tracked bat 768 along Lamb's Creek north of the capture site (24), but were unable to identify a roost tree due to an equipment failure. On 23 May, Bat 768 was again tracked along Lamb's Creek and located in a second tree (Roost 768-2) where it was roosting along with 42 other bats. Roost 768-2 is a dead 66.04-centimeter (26-in) American Elm located approximately 2.57 kilometers (1.6 mi) north of Roost 768-1. Nightly emergence counts were conducted from 23 to 28 May when 43, 22, 27, 36, 34, and 32 bats occupied the tree, respectively. On the nights of 27 and 28 May, the transmitter did not leave the tree and was thus assumed to be shed. A follow-up count the night of 12 June detected only a single bat.

4.2.5 Indiana Bat 927 –

The final Indiana bat radio-tagged in section 5 was a pregnant adult female captured at 2200 on 20 May 2012, the first night netting site 22. The bat received a 0.25-gram transmitter (frequency 172.927) and was released at 2221 at the net site. This bat was found roosting along with 50 other bats in a dead 73.66-centimeter (29-in) dbh eastern cottonwood (*Populus deltoides* [Roost 927-1]) on 22 May. Roost 927-1 is located on the northern bank of the White River, approximately 0.7 kilometer (0.4 mi) northwest of site 22. Nightly emergence counts were conducted from 22 through 28 May, when the tree was occupied by 51, 51, 52, 53, 40, 74, 66, and 63 bats, respectively. On the nights of 27 and 28 May, the transmitter did not leave the tree. Thus, it is assumed that the bat shed its transmitter

inside the roost on 27 May. A follow-up count on 12 June detected 72 bats in the roost.

4.3 Evening Bat Captures –

Three evening bats were captured; one at site 11 and two at site 23 (Appendix C, Table 4). All three were reproductive, adult females (Appendix C, Table 3). Neither transmitters nor bands were attached to evening bats.

4.4 Net Site Habitat Assessment –

Site 1 was located along Creek just east of Road (Appendix B, Figures 1 and 5). Net A and Net B were placed over Creek which had a bank height of 0.7 meter (2.3 ft), channel width of 9 meters (29.5 ft), and a stream width of 8 meters (26.2 ft). Average water depth was 5 centimeters (2 in), with moderate clarity. Dominant canopy trees (> 40 cm [16 in] dbh) included American sycamore (*Platanus occidentalis* and sugar maple (*Acer saccharum*). Subdominant canopy trees (< 40 cm dbh) included boxelder (*Acer negundo*), American elm, and green ash (*Fraxinus pennsylvanica)*. Common subcanopy species included boxelder, white ash (*Fraxinus americana)*, and black locust (*Robinia pseudoacacia*). Canopy closure was characterized as open with the subcanopy being moderately cluttered with saplings. Roost tree potential was moderate, with three snags near the site.

Site 2 was located in the Park and approximately 100 meters south of Creek (Appendix B, Figures 1 and 5). Both nets were placed over a gravel trail in relatively mature forest within the nature preserve. Dominant canopy trees included eastern white pine (*Pinus strobus*), black walnut (*Juglans nigra*), and tuliptree (*Liriodendron tulipifera*). Subdominant canopy trees included black cherry (*Prunus serotina*), white ash, and American sycamore. The canopy was moderately closed, with a closed subcanopy composed of shrubs, lower branches, and saplings. Roost tree potential was moderate, consisting of large trees and snags.

Site 3 was located east of and on the northern side of Lake (Appendix B, Figures 1 and 5). Net A was placed over a trail approximately 50 meters (164 ft) from the lakeshore. Net B was placed parallel to the lakeshore. An additional net site, Net C, was placed along the same trail as Net A, and was approximately 20 meters (65.6 ft) from the lakeshore. Dominant canopy trees included white oak (*Quercus alba*) and American sycamore. Subdominant canopy trees included American sycamore, white oak, and eastern white pine. The canopy was moderately closed, with a moderately closed subcanopy composed primarily of saplings, shrubs, and lower branches of canopy trees. Roost tree potential was low with only a few snags and small shagbark hickories (*Carya ovata)* located near the site.

Site 4 was located along Creek in between and Road (Appendix B, Figures 1 and 5). Both nets were placed over Creek which had a bank height of 0.5 meter (1.6 ft), channel width of 8 meters (26.2 ft), and stream width of 6 meters (19.7 ft). Average water depth was 1 meter (3.3 ft) with moderate clarity. Dominant canopy trees included shagbark hickory, American sycamore, and sugar maple. Subdominant canopy species included American sycamore and sugar maple. The canopy was moderately closed with a moderately closed subcanopy composed of shrubs and saplings. Roost

tree potential was high with several large trees and snags adjacent to the net site and open fields.

Site 5 was located along Creek in a young lowland forest just north of the intersection of Drive and Road (Appendix B, Figures 1 and 5). Both nets were placed over a portion of Creek which had a bank height of 1.5 meters (4.9 ft), channel width of 10 meters (32.8 ft), and stream width of 6 meters (19.7 ft). Average water depth was 0.5 meter (1.6 ft) with high clarity. Dominant canopy trees included American sycamore, white oak, and green ash. Subdominant canopy species included sugar maple, black walnut, and shagbark hickory. The canopy was closed with a subcanopy largely composed of saplings. Roost potential was moderate with several large trees adjacent to the stream.

Site 6 was located along Creek between Road and where this creek intersects with Creek (Appendix B, Figures 1 and 5). Both nets were placed over a portion of Creek that had a bank height of 4 meters (13.1 ft), channel width of 15 meters (49.2 ft), and stream width of 12 meters (39.4 ft). Dominant canopy trees included American sycamore and sugar maple. Subdominant canopy trees included shagbark hickory, black walnut, and sugar maple. The canopy was open with a closed subcanopy consisting of lower branches from the above trees. Roost potential was moderate with several large trees adjacent to the stream and other foraging areas.

Site 7 was located between and Road (Appendix B, Figures 1 and 5). Both nets were placed in a mature lowland forest over a vernal pool. The approximate width of the vernal pool ranged from 1 meter (3.3 ft) to 8 meters (26.2 ft) with an average depth of 5 centimeters (2 in). Water clarity was rated as low. Dominant canopy trees included red oak (*Quercus rubra*), sweetgum (*Liquidambar styraciflua*), and white oak. Subdominant species included shagbark hickory, red maple, and red oak. The canopy was moderately closed with an open subcanopy. Roost potential for this site was rated as moderate with several snags and medium-sized shagbark hickories in the area.

Site 8 was located along Creek near the intersection of and Road (Appendix B, Figures 1 and 5). Net A was placed over the stream, whereas Net B was placed perpendicular to it. This portion of the stream had an approximate bank height of 3 meters (9.8 ft), a channel width of 9 meters (29.5 ft), and a stream width of 7 meters (22.9 ft). Average water depth was 1 meter (3.3 ft) and water clarity was rated as moderate. The dominant tree canopy species was American sycamore. The subdominant canopy species included American sycamore, black walnut, and boxelder. The canopy was moderately closed with an open subcanopy. Roost potential for this site was rated as low due to the lack of large potential roost trees and snags.

Site 9 was located 5 meters (16.4 ft) east of near the intersection of Road and Pike (Appendix B, Figures 1 and 5). Net A was placed over a dirt road that led to an existing field. Net B was placed over a similar dirt road closer to the creek. Dominant canopy species included American sycamore, silver maple (*Acer saccharinum*), and shagbark hickory. Subdominant canopy species included boxelder, shagbark hickory, sassafras

(*Sassafras albidum*), black cherry, and silver maple. The canopy and subcanopy were moderately closed. Roost potential for this site was rated as moderate due to the presence of large trees and its location along a creek.

Site 10 was located near the intersection of Road and (Appendix B, Figures 1 and 5). Both nets were placed over a drainage ditch in an agricultural field close to the forest edge. This section of the drainage ditch had an approximate bank height of 3 meters (9.8 ft), a channel width of 18 meters (59.1 ft), and a stream width of 9 meters (29.5 ft). The average water depth was approximately 33 centimeters (13 in) with low water clarity. The tree canopy was dominated by silver maple, and the subdominant canopy species were silver maple and boxelder. The canopy and subcanopy were moderately closed. Roost potential for this site was rated as low due to the lack of large trees or snags.

Site 11 was located along Road, approximately 10 meters (32.8 ft) from Creek (Appendix B, Figures 1 and 5). Both nets were placed over the road. The dominant canopy species included green ash, silver maple, and black walnut. The subdominant canopy species were green ash, black walnut, and American elm. The canopy was moderately closed with a closed subcanopy. Roost potential for this site was rated as high due to the numerous large trees and snags in the area.

Site 12 was located along Creek just north of the intersection of and Road (Appendix B, Figures 1 and 5). Both nets were placed over . This section of the creek had an approximate bank height of 3 meters (9.8 ft), a channel width of 9 meters (29.5 ft), and a stream width of 3 meters (9.8 ft). The average water depth was 1 meter (3.3 ft) and water clarity was rate as high. The dominant canopy species included American sycamore, pin oak (*Quercus palustris*), and black walnut. The subdominant canopy species were sugar maple, black walnut, and flowering dogwood (*Cornus florida*). The canopy and subcanopy were moderately closed. Roost potential was rated as moderate due to the several large trees and flight corridors present at this site.

Site 13 was located in a mature upland forest north of Pike in the State Forest (Appendix B, Figures 1 and 5). Both nets were placed over a forested road. Dominant canopy species included chestnut oak (*Quercus prinus*) and sugar maple. Dominant subcanopy species included ash (*Fraxinus* spp.) and sugar maple. The canopy and subcanopy were moderately closed, and roost potential was moderate.

Site 14 was located along an unnamed tributary at the end of Road (Appendix B, Figures 1 and 5). Net A was placed parallel to the creek in the opening between two woodlots. Nets B and C were placed over the creek which had an approximate bank height of 1 meter (3.3 ft), a channel width of 5 meters (16.4 ft), and a stream width of 2 meters (6.6 ft). The average water depth was 5 meters (16.4 ft) with moderate water clarity. Dominant canopy species included American sycamore, black cherry, and red oak. The subdominant canopy species included red maple, sugar maple, and green ash. The canopy and subcanopy were moderately closed. Roost potential was rated as moderate due to several large trees and snags being present in the lowland area.

Site 15 was located along Creek just 36 meters (118.1 ft) northwest of the intersection of Road and (Appendix B, Figures 1 and 5). Both nets were placed over the stream which had an approximate bank height of 1 meter (3.3 ft), channel width of 8 meters (26.2 ft), and a stream width of 8 meters (26.2 ft). Average water depth was 50 centimeters (19.7 in) with moderate clarity. Dominant canopy species included sugar maple, American sycamore, and American elm. Subdominant canopy species included sugar maple and red elm. The canopy and subcanopy were moderately closed. The roost potential for this site was rated as low.

Site 16 was located along Road just east of (Appendix B, Figures 1 and 5). Both nets were placed over Creek which had an approximate bank height of 2.5 meters (8.2 ft), a channel width of 10 meters (32.8 ft), and a stream width of 6 meters (19.7 ft). Average water depth was 6 centimeters (2.4 in) with high water clarity. Both dominant and subdominant canopy species included green ash, black walnut, and American sycamore. The canopy was open with a moderately closed subcanopy. Roost potential for this site was rated as moderate with large trees and snags present, of which only one was considered as having high roost potential.

Site 17 was located near the intersection of Road and Creek (Appendix B, Figures 1 and 5). Both nets were placed over the stream and east of the bridge on Road. This section of the stream had an approximate bank height of 2 meters (6.6 ft), a channel width of 8 meters (26.2 ft), and a stream width of 5 meters (16.4 ft). Average water depth was 25 centimeters (9.8 in) and water clarity was high. Dominant canopy species included American sycamore, black walnut, and eastern cottonwood (*Populus deltoides*). Subdominant canopy species included white ash and black cherry. The canopy and subcanopy were moderately closed. Roost potential for this site was rated as moderate.

Site 18 was located along Creek just south of the intersection of and Roads (Appendix B, Figures 1 and 5). Both nets were placed over Creek within a young lowland forest. That section of the stream had an approximate bank height of 0.5 meter (1.6 ft), a channel width of 12 meters (39.4 ft), and a stream width of 6 meters (19.7 ft). Average water depth was 10 centimeters (3.9 in) with high water clarity. The tree canopy was dominated by American sycamore, whereas the dominant subcanopy species included black cherry, black walnut, and green ash. The canopy was open with a closed subcanopy. Roost potential for this site was rated as low due to the absence of both snags and large trees.

Site 19 was located along Creek south of the Road and Road intersection ((Appendix B, Figures 1 and 5). Both nets were placed over a portion of the stream that had an approximate bank height of 2.5 meters (8.2 ft), a channel width of 7 meters (23 ft), and a stream width of 7 meters (23 ft). Average water depth was 1 meter (3.3 ft) and water clarity was low. Dominant canopy species included American sycamore, boxelder, and black walnut. Subdominant canopy species included hackberry (*Celtis occidentalis*), sugar maple, and green ash. The canopy and subcanopy were moderately closed, and roost potential was rated as moderate.

Site 20 was located along Creek south of Road (Appendix B,

Figures 1 and 5). Both nets were placed over a section of the stream that had an approximate bank height of 3 meters (9.8 ft), a channel width of 3.5 meters (11.5 ft), and a stream width of 3 meters (9.8 ft). Average water depth was 50 centimeters (19.7 in) and water clarity was low. Dominant canopy species included American sycamore and eastern cottonwood. The subdominant canopy species was boxelder. The canopy and subcanopy were moderately closed. Roost potential was rated as high due to numerous large trees and snags near the site.

Site 21 was located along Creek, east of the Road and Road intersection (Appendix B, Figures 1, 5). Net A was placed over a woodlot diagonal to the stream and Road. Net B was placed over a section of the stream which had an approximate bank height of 1 meter (3.3 ft), a channel width of 6 meters (19.7 ft), and stream width of 1 meter (3.3 ft). Average water depth was 5 centimeters (2 in) and water clarity was high. Dominant canopy species included tuliptree, sugar maple, and American sycamore. Subdominant canopy species included red maple, sugar maple, and black walnut. The canopy and subcanopy were moderately closed. Roost potential was rated as low due to the absence of snags and large trees.

Site 22 was located in a mature lowland forest between the River and Road (Appendix B, Figures 1 and 5). Net A was placed over a road and a stream. Net B was placed over the road approximately 60 meters (196.8 ft) south of Net A. Net C replaced Net B on the third night, and was placed farther east down the road from where Net B had been located. The stream had an approximate bank height ranging from 1 meter (3.3 ft) to 3 meters (9.8 ft), a channel width ranging from 6 meters (19.7 ft) to 9 meters (29.5 ft), and a stream width ranging from 0.5 meter (1.6 ft) to 9 meters (29.5 ft). Average water depth ranged from 2.5 centimeters (0.9 in) to 20 centimeters (7.9 in), and water clarity was moderate. Dominant canopy species included eastern cottonwood, American sycamore, and green ash. Subdominant canopy species included green ash, eastern cottonwood, and boxelder. The canopy and subcanopy were moderately closed. Roost potential was rated as low due to the lack of potentially suitable roost trees.

Site 23 was located across Creek between and Lane (Appendix B, Figures 1 and 5). Both nets were placed over a section of Creek that had an approximate bank height of 2.5 meters (8.2 ft), a channel width of 20 meters (65.6 ft), and a stream width ranging from 10 meters (32.8 ft) to 16 meters (52.5 ft). Average water depth was 50 centimeters (19.7 in) and water clarity was moderate. Dominant canopy and subcanopy species included American sycamore and silver maple. The canopy and subcanopy were moderately closed, and roost potential was moderate.

Site 24 was located where crosses Creek (Appendix B, Figures 1 and 5). Both nets were placed over a section of Creek that had an approximated bank height of 3 meters (9.8 ft), a channel width of 12 meters (39.4 ft), and a stream width of 9 meters (29.5 ft). Average water depth was 16 centimeters (6.3 in) with high water clarity. Dominant canopy species included American sycamore and black walnut. Subdominant canopy species included black locust, black walnut, and sugar maple. The canopy and subcanopy were moderately closed, and roost potential was considered moderate.

5.0 DISCUSSION

Mist net surveys were conducted to improve understanding of the summer occurrence and habitat use by Indiana and evening bats in Section 5 of the I-69 corridor. Surveys conducted in summer 2012 provided information on the presence and distribution of Indiana and evening bats at pre-selected sites in this section.

By reviewing previous regional studies, data can be used to help identify important roosting areas for the Indiana bat near the corridor, and to aid the study design of future projects. The data also enhance the understanding of the species ecology in Indiana and throughout its range thus contributing to species management and recovery.

5.1 Bat Captures –

Nine bat species were captured at the pre-selected sites in Sections 5. With the exception of an occasional gray bat, this represents all the species that should be present in the area (Whitaker et al. 2007). As such species richness (number of species in a community) was average for the geographic location and habitat types. Data obtained from this and previous studies along I-69 showed Indiana bats to be present.

One of the potential effects of WNS is the loss of diversity. The MacArthur (1972) diversity index for bats captured during the 2004 sampling was 6.0, which is higher than the value of 4.6 obtained during the 2012 sampling effort. To understand this comparison one must also understand that diversity indices were specifically developed to allow comparisons of areas sampled using different methodologies. When sampling efforts are standardized (as they have been in this case) diversity indices can be overly sensitive to relatively minor variations in capture rates. In this case, the decline in diversity index is driven by the substantial increases in capture rates for big brown and eastern red bats, while capture rates for all other species remained relatively consistent. At a regional scale surveys at the Crane Naval Surface Warfare Center in Crane, northern Martin County, Indiana reported 4.76 in 2005 (ESI 2005), and the Hoosier National Forest reported a species diversity of 3.5 (Brack et al. 2004). All of these data indicate that bat diversity in the region has remained consistent since WNS was detected in Indiana during winter 2010/2011.

Overall, four species: eastern red bats (35.7 %), big brown bats (23.4%), eastern pipistrelles (13.2%), and little brown bats (10.8%), accounted for more than 80 percent of all bats captured. As noted above, cave bats (including *Myotis*) have not shown a dramatic decline in capture rates between the 2004 and 2012 sampling periods despite the arrival of WNS in Indiana.

5.2 Indiana Bats –

A total of twelve Indiana bats were captured during the 2012 monitoring effort along Section 5 of I-69. This included 8 pregnant females and four adult males. The capture of multiple pregnant females at two sites within 5 miles indicates that there is at least one maternity colony present (Appendix B, Figures 5 and 6). The two radio-tagged bats never shared a roost and were always located at least 5.63 kilometers (3.5 mi) apart. Indiana bats typically forage and roost within 4 kilometers (2.5 mi) of their roosts,

although some individuals fly as far as 8 kilometers (5 miles) (Sparks et al. 2004). As such these observations could be interpreted as indicating that two maternity colonies are present along the River south of . This hypothesis is also supported by the capture of multiple pregnant females at sites 22 and 24, whereas no pregnant females were captured at other sites.

The project is located approximately 13.9 kilometers (14.82 mi, measured from the closest roosts) south of a well-studied colony of Indiana bats at the Indianapolis International Airport (IND). This colony provides precedent for a single maternity colony having two separate areas of roosting activity. From 1997-2008, a single colony of Indiana bats at IND often used two areas for roosting (Sparks et al. 2008, Whitaker and Sparks 2008, Sparks et al. 2009). The first of these was a woodland dominated by shagbark hickory and primary roosts were typically large dead trees of that species. A second roosting area consisted of riparian woodlands associated with the East Fork of White Lick Creek. Most roosts in this area were large dead cottonwoods or artificial roosts (batboxes). These two roosting areas often were in use simultaneously with only limited exchange of individuals during pregnancy and lactation. These roosting areas are separated by a minimum of 2.3 kilometers (1.43 mi) and a maximum of 6 kilometers (3.73 mi). Exchange between the two roosting areas increased markedly after 15 July (Sparks et al. 2008).

To help elucidate the relationship between the 2 roosting areas associated with sites 22 and 24, mass emergence counts were conducted on 27 May and 12 June. Observers watched all three roosts on the same night and this allowed an estimate of the total number of bats present.

On 27 May, a total of 63 bats was observed exiting the 2 roosts associated with bat 768, and 66 bats exited tree 927-1. More than 2 weeks later, on 12 June, a count on the 2 trees associated with bat 768 yielded 81 bats only 1 of which exited roost 768-2. Roost 927-1 contained 72 bats. The number of Indiana bats counted at multiple roosts for a single colony increases until early June (Sparks et al. 2008). As such it is not surprising that a minor increase in the number of bats was associated with both sets of roosts. These counts provided no evidence of bats moving between the roost associated with bat 927 and the two roosts associated with bat 768.

5.3 Evening Bats –

Three evening bats were captured during the 2012 surveys of Section 5. This included the capture of two pregnant females at the same site (23) which yielded evening bats in summer 2004. As such, these captures suggest this colony is still present. Surprisingly, the third capture occurred at site 11, 16.1 kilometers (10 mi) to the southwest. Evening bats rarely travel more than 4.0 kilometers (2.49 mi) from their roosts (Duchamp et al. 2004) and thus Section 5 is likely home to two colonies of this state-endangered species.

6.0 ACKNOWLEDGEMENTS

Environmental Solutions & Innovations, Inc. extends their gratitude to the various organizations and individuals who contributed their time and talent to this project. Appreciation is extended to the

Indiana Department of Transportation (INDOT) and Bernardin, Lochmueller, and Associates (BLA) for providing us the opportunity to be involved in the project. We also thank the U.S. Fish and Wildlife Service (USFWS) and Indiana Department of Natural Resources (Indiana DNR) for their continuing support of our biological studies. Special thanks are extended to Tom Cervone, David Goffinet, and Rusty Yeager of BLA, and Robin McWilliams-Munson of USFWS for their guidance, assistance, and supportive efforts. Finally, we thank the numerous landowners who permitted us access to their properties along and near the corridor, and for showing an active interest in the project.

7.0 LITERATURE CITED

3D/Environmental. 1995. Literature summary and habitat suitability index model. Components of summer habitat for the Indiana bat, *Myotis sodalis.* Authors: R. C. Romme, K. Tyrell, V. Brack, Jr. Report submitted to the Indiana Department of Natural Resources, Division of Wildlife, Bloomington, Indiana by 3D/Environmental, Cincinnati, Ohio. Federal Aid Project E-1-7, Study No. 8, 38 pp.

Asdell, S. A. 1964. Patterns of mammalian reproduction, second edition. Cornell University Press, Ithaca, New York. 670 pp.

Baker, R. J. and C. M. Ward. 1967. Distribution of bats in southeastern Arkansas. Journal of Mammalogy 48:130-132.

Baker, W. W., S. G. Marshall, and V. B. Baker. 1968. (*Nycticeius humeralis*). Journal of Mammalogy 49:314-317.

Barbour, R. W. and W. H. Davis. 1969. Bats of America. University Press of Kentucky, Lexington, Kentucky.

Belwood, J. J. 1979. Feeding ecology of an Indiana bat community with emphasis on the endangered Indiana bat, *Myotis sodalis*. Unpublished M.S. thesis, University of Florida, Gainesville, Florida.

BHE. 2004. Investigating presence of the Indiana bat during the summer maternity season within the Mitchell Plain between Bloomington and Martinsville, Indiana. Final report by BHE Environmental, Cincinnati, Ohio for Indiana Department of Transportation. Authors: A. B. Henry, R. A. Slack, R. C. Romme. 352 pp.

Blehert, D. S., A. C. Hicks, M. Behr, C. U. Meteyer, B. M. Berlowski-Zier, E. L. Buckles, J. T. H. Coleman, S. R. Darling, A. Gargas, R. Niver, J. C. Okoniewski, R. J. Rudd, and W. B. Stone. 2008. Supporting online material for bat white-nose syndrome: An emerging fungal pathogen? Science:1-9.

Blehert, D. S., A. C. Hicks, M. Behr, C. U. Meteyer, B. M. Berlowski-Zier, E. L. Buckles, J. T. H. Coleman, S. R. Darling, A. Gargas, R. Niver, J. C. Okoniewski, R. J. Rudd, and W. B. Stone. 2009. Bat white-nose syndrome: An

emerging fungal pathogen? Science 323:227.

Boyles, J. G. and D. P. Aubrey. 2006. Managing forests with prescribed fire: implications for a cavity-dwelling bat species. Forest Ecology and Management 221:108-115.

Boyles, J. G., B. M. Mormann, and L. W. Robbins. 2005. Use of an underground winter roost by a male evening bat (*Nycticeius humeralis*). Southeastern Naturalist 4:375-377.

Boyles, J. G. and L. W. Robbins. 2006. Characteristics of summer and winter roost trees used by evening bats *(Nycticeius humeralis*) in southwestern Missouri. American Midland Naturalist 155:210-220.

Brack, V., Jr. 1979. The duration of the period of hibernation in *Eptesicus fuscus, Myotis lucifugus*, and *Pipistrellus subflavus* under natural conditions. Unpublished M.S. thesis University of Missouri, Columbia, Missouri.

Brack, V., Jr. 1983. The nonhibernating ecology of bats in Indiana with emphasis on the endangered Indiana bat, *Myotis sodalis*. Unpublished Ph.D. dissertation, Purdue University, West Lafayette, Indiana.

Brack, V., Jr. 1985. The foraging ecology of some bats in Indiana. Proceedings of the Indiana Academy of Science 94:231-237.

Brack, V., Jr. 2006. Autumn activity of *Myotis sodalis* (Indiana bat) in Bland County, Virginia. Northeastern Naturalist 13:421-434.

Brack, V., Jr. In press. Food habits and foraging ecology of the Indiana bat, *Myotis sodalis*. In submission to Northeastern Naturalist.

Brack, V., Jr. and J. C. Carter. 1985. Use of an underground burrow by Lasionycteris. Bat Research News 26:3.

Brack, V., Jr., S. A. Johnson, and R. K. Dunlap. 2003. Wintering populations of bats in Indiana, with emphasis on the endangered Indiana Myotis, *Myotis sodalis*. Proceedings of the Indiana Academy of Science 112:61-74.

Brack, V., Jr. and R. K. LaVal. 1985. Food habits of the Indiana bat in Missouri. Journal of Mammalogy 66:308-315.

Brack, V., Jr., R. J. Reynolds, W. Orndorff, J. Zokaites, and C. Zokaites. 2005. Bats of Skydusky Hollow, Bland County, Virginia. Virginia Journal of Science 56:93-106.

Brack, V., Jr., D. W. Sparks, J. O. Whitaker, Jr., B. L. Walters, and A. Boyer. 2010. Bats of Ohio. Indiana State University, Center for North American Bat Research and Conservation. Publication Number 4.

Brack, V., Jr., C. W. Stihler, R. J. Reynolds, C. M. Butchkoski, and C. S. Hobson. 2002. Effect of climate and elevation on distribution and abundance in the mid-eastern United States. Pages 21-28 *in* The Indiana Bat:

Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Brack, V., Jr. and J. W. Twente. 1985. The duration of the period of hibernation in three species of vespertilionid bats I: field studies. Canadian Journal of Zoology 63:2952-2954.

Brack, V., Jr. and J. O. Whitaker, Jr. 2004. Bats of the Naval Surface Warfare Center at Crane, Indiana. Proceedings of the Indiana Academy of Science 113:66-75.

Brack, V., Jr. and J. O. Whitaker, Jr. 2006. The Indiana Myotis (*Myotis sodalis*) on an anthropogenic landscape: Newport Chemical Depot, Vermillion County, Indiana. Proceedings of the Indiana Academy of Science 115:44-52.

Brack, V., Jr., J. O. Whitaker, Jr., and S. E. Pruitt. 2004. Bats of Hoosier National Forest. Proceedings of the Indiana Academy of Science 113:78-86.

Brack, V., Jr., A. M. Wilkinson, and R. E. Mumford. 1984. Hibernacula of the endangered Indiana bat in Indiana. Proceedings of the Indiana Academy of Science 93:463-468.

Britzke, E. R., M. J. Harvey, and S. C. Loeb. 2003. Indiana bat, *Myotis sodalis*, maternity roosts in the southern United States. Southeastern Naturalist 2:235-242.

Brown, R. J. and V. Brack, Jr. 2003. An unusually productive net site over an upland road used as a travel corridor. Bat Research News 44:187-188.

Brown, R. J., R. A. King, and R. Rommé. 2001. First documented maternity colony of the Indiana bat in Greene County, Ohio (Abstract). Bat Research News 42:27.

Butchkoski, C. 2005. Indiana bat (*Myotis sodalis*) radio tracking and telemetry studies – getting started. Pennsylvania Game Commission, Wildlife Diversity Section, Petersburg, Pennsylvania.

Butchkoski, C. M. and J. D. Hassinger. 2002. Ecology of a maternity colony roosting in a building. *in* The Indiana Bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.) Bat Conservation International, Austin, Texas.

Callahan, E. V., R. D. Drobney, and R. L. Clawson. 1997. Selection of summer roosting sites by Indiana bats (*Myotis sodalis*) in Missouri. Journal of Mammalogy 78:818-825.

Carey, H. V., M. T. Andrews, and S. L. Martin. 2003. Mammalian hibernation: cellular and molecular responses to depressed metabolism and low temperature. Physiological Reviews 83:1153–1181.

Carter, T. C. 2002. Bat houses for conservation of endangered

Indiana myotis. The Bat House Researcher 10:1-3.

Carter, T. C. 2003. Summer habitat use of roost trees by the endangered Indiana bat (*Myotis sodalis*) in the Shawnee National Forest of Southern Illinois. Ph.D. dissertation. Southern Illinois University, Carbondale, Illinois.

Clark, B. S., J. B. Bowles, and B. K. Clark. 1987. Summer occurrence of the Indiana bat, Keen's myotis, evening bat, silver-haired bat and eastern pipistrelle in Iowa. Pages 89-93 *in* Proceedings of the Iowa Academy of Science. 94:89-93.

Clawson, R. L., R. K. LaVal, M. L. LaVal, and W. Caire. 1980. Clustering behavior of hibernating *Myotis sodalis* in Missouri. Journal of Mammalogy 61:245-253.

Clem, P. D. 1992. Seasonal population and emergence patterns in the evening bat, *Nycticeuis humeralis*, at a west-central Indiana colony. Proceedings of the Indiana Academy of Science 101:33-44.

Cope, J. B., W. W. Baker, and J. Confer. 1961. Breeding colonies of four species of bats of Indiana. Proceedings of the Indiana Academy of Science 70:262-266.

Cope, J. B. and S. R. Humphrey. 1977. Spring and autumn swarming behavior in the Indiana bat, *Myotis sodalis*. Journal of Mammalogy 58:93-95.

Cryan, P. M., C. U. Meteyer, J. G. Boyles, and D. S. Blehert. 2010. Wing pathology of white-nose syndrome in bats suggests life-threatening disruption of physiology. BMC Biology 8:135.

Duchamp, J. E., D. W. Sparks, and J. O. Whitaker, Jr. 2004. Foraging-habitat selection by bats at an urban-rural interface: comparision between a successful and less successful species. Canadian Journal of Zoology 82:1157-1164.

ESI. 2004. Summer habitat for the Indiana bat (*Myotis sodalis*) within the Wabash Lowland Region from Oakland City to Washington, Indiana. Authors: Adam Mann, Jeanette Jaskula, Jason Duffey, and Virgil Brack, Jr. Report submitted to Indiana Department of Transportation by Environmental Solutions & Innovations, Inc. Cincinnati, Ohio. 34 pp+ appendices.

ESI. 2005. 2005 summer mist net survey for bats at naval support activity Crane, Crane, Indiana. Authors: Jason Duffey, Adam Mann, and Virgil Brack, Jr., Ph.D. Prepared for Indiana Department of Natural Resources, Division of Natural Preserves by Environmental Solutions & Innovations, Inc. Cincinnati, Ohio. 68 pp.

Ford, W. M., J. M. Menzel, M. A. Menzel, J. W. Edwards, and J. C. Kilgo. 2006. Presence and absence of bats across habitat scales in the upper coastal plain of South Carolina. Journal of Wildlife Management 70:1200-1209.

Foster, R. W. and A. Kurta. 1999. Roosting ecology of the northern

bat (*Myotis septentrionalis*) and comparisons with the endangered Indiana bat (*Myotis sodalis*). Journal of Mammalogy 80:659-672.

Francl, K., D. W. Sparks, V. Brack, Jr, and J. Timpone. 2011. White-nose syndrome and wing damage index scores among summer bats in the northeastern United States. Journal of Wildlife Diseases 47:41-48.

Gardner, J. E. and E. A. Cook. 2002. Seasonal and geographic distribution and quantification of potential summer habitat. Pages 9-20 *in* The Indiana bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Gardner, J. E., J. D. Garner, and J. E. Hofmann. 1991. Summer roost selection and roosting behavior of *Myotis sodalis* (Indiana bat) in Illinois. Unpublished report. Illinois Natural History Survey, Illinois Department of Conservation, Section of Faunistic Surveys and Insect Identification. Champaign, Illinois. 56 pp.

Gargas, A., M. T. Trest, M. Christensen, T. J. Volk, and D. S. Blehert. 2009. *Geomyces destructans* sp. nov. associated with bat white-nose syndrome. MYCOTAXON 108:147–154.

Grindal, S. D. 1996. Habitat use by bats in fragmented forests. Pages 260-272 *in* Bats and Forests Symposium (R. M. R. Barclay and R. M. Brigham, eds.), October 19-21, 1995. Research Branch, British Columbia Minister of Forests Research Program. Victoria, British Columbia, Canada.

Gumbert, M. W. 2001. Seasonal roost tree use by Indiana bats in the Somerset Ranger District of the Daniel Boone National Forest, Kentucky. M.S. Thesis, Eastern Kentucky University, Kentucky. 136 pp.

Gumbert, M. W., J. M. O'Keefe, and J. R. MacGregor. 2002. Roost fidelity in Kentucky. Pages 143-152 *in* The Indiana Bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Hall, J. S. 1962. A life history and taxonomic study of the Indiana bat, *Myotis sodalis*. Reading Public Museum and Art Gallery, Scientific Publications 12:1-68.

Hayssen, V., A. van Tienhoven, and A. van Tienhoven. 1993. Asdell's patterns of mammalian reproduction - a compendium of species-specific data. Cornell University Press, Ithaca, NewYork. 1023 pp.

Hendricks, W. D., R. Ijames, L. Alverson, J. Timpone, M. Muller, N. Nelson, and J. Smelser. 2004. Notable roosts for the Indiana bat (*Myotis sodalis*). Pages 133-138 *in* Indiana Bat and Coal Mining: A Technical Interactive Forum (K.C. Vories and A. Harrington, eds.). U.S. Department of the

Interior, Office of Surface Mining. Alton, Illinois.

Henshaw, R. E. and G. E. Folk. 1966. Relation of thermoregulation to seasonally changing microclimate of two species of bats (*Myotis lucifugus* and *Myotis sodalis*). Physiological Zoology 39:223-236.

Hicks, A. and P. G. Novak. 2002. History, status, and behavior of hibernating populations in the northeast. Pages 35-48 *in* The Indiana Bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Humphrey, S. R. 1978. Status, winter habitat, and management of the endangered Indiana bat, *Myotis sodalis*. Florida Scientist 41:65-76.

Humphrey, S. R. and J. B. Cope. 1968. Records of migration of the evening bat, *Nycticeius humeralis*. Journal of Mammalogy 49:329.

Humphrey, S. R., A. R. Richter, and J. B. Cope. 1977. Summer habitat and ecology of the endangered Indiana bat, *Myotis sodalis*. Journal of Mammalogy 58:334-346.

Johnson, S. A., V. Brack, Jr., and R. K. Dunlap. 2002. Management of hibernacula in the state of Indiana. Pages 100-109 *in* The Indiana Bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Johnson, S. A., V. Brack, Jr., and R. E. Rolley. 1998. Overwinter weight loss of Indiana bats (*Myotis sodalis*) from hibernacula subject to human visitation. American Midland Naturalist 139:255-261.

Kath, J. A. 2002. The UNIMIN Corporation Magazine Mine: a novel Indiana bat (*Myotis sodalis*) hibernaculum in southern Illinois. Pages 303-310 *in* Proceedings of the Illinois State Academy of Science. 95:303-310.

Kerth, G., M. Wagner, and B. Konig. 2001. Roosting together, foraging apart: information transfer about food is unlikely to explain sociality in female Bechstein's bats (*Myotis bechsteinii*). Behavioral Ecology and Sociobiology 50:283-291.

Kirkpatrick, C. M. 1943. Rafinesque's bat in Indiana. American Midland Naturalist 29:797.

Kirkpatrick, C. M. and C. H. Conaway. 1948. Some notes on Indiana mammals. American Midland Naturalist 39.

Kiser, J. D. and C. L. Elliott. 1996. Foraging habitat, food habits, and roost tree characteristics of the Indiana Bat (*Myotis sodalis)* during autumn in Jackson County, Kentucky. Unpublished report to Kentucky Department of Fish and Wildlife Resources. Frankfort, Kentucky. 75 pp.

Kiser, J. D., J. R. MacGregor, H. D. Bryan, and A. Howard. 2002. Use of concrete bridges as night

roosts. Pages 208-215 *in* The Indiana Bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International. Austin, Texas.

Küchler, A. W. 1964. Potential natural vegetation of the conterminous United States. American Geographical Society Special Publication 36.

Kurta, A. 2004. Roosting ecology and behavior of Indiana bats (*Myotis sodalis*) in summer. Pages 29-42 *in* Indiana Bat and Coal Mining, A Technical Interactive Forum (K.C. Vories and A. Harrington, eds.) Office of Surface Mining, U. S. Department of the Interior, Alton, Illinois.

Kurta, A. 2005. Ecology and behavior of Indiana bats in summer. Pages 29-42 *in* Indiana Bat and Coal Mining: A Technical Interactive Forum (K.C. Vories and A. Harrington, eds.). U.S. Department of the Interior, Office of Surface Mining. Alton, Illinois.

Kurta, A., D. King, J. A. Teramino, J. M. Stribley, and K. J. Williams. 1993. Summer roosts of the endangered Indiana bat (*Myotis sodalis*) on the northern edge of its range. American Midland Naturalist 129:132-138.

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

Kurta, A., S. W. Murray, and D. H. Miller. 2002. Roost selection and movements across the summer landscape. Pages 118-129 *in* The Indiana Bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Kurta, A. and J. O. Whitaker, Jr. 1998. Diet of the endangered Indiana bat (*Myotis sodalis*) on the northern edge of its range. American Midland Naturalist 140:280-286.

Kurta, A., K. J. Williams, and R. Mies. 1996. Ecological, behavioral, and thermal observations of a peripheral population of Indiana bats (*Myotis sodalis*). Pages 102-117 *in* Bats and Forests Symposium (R. M. R. Barclay and R. M. Brigham, eds.), October 19-21, 1995. Research Branch, British Columbia Minister of Forests Research Program. Victoria, British Columbia, Canada.

LaVal, R. K., R. L. Clawson, M. L. LaVal, and W. Caire. 1977. Foraging behavior and nocturnal activity patterns of Missouri bats, with emphasis on the endangered species *Myotis grisescens* and *Myotis sodalis*. Journal of Mammalogy 58:592-599.

LaVal, R. K. and M. L. LaVal. 1980. Ecological studies and management of Missouri bats, with emphasis on cave-dwelling species. Missouri Department of

Conservation: Terrestrial Series 8:1-53.

Lindsay, D. M. 1956. Additional records of Nycticeius in Indiana. Journal of Mammalogy 37:282.

Lorch, J. M., A. Gargas, C. Uphoff Meteyer, B. M. Berlowski-Zier, D. E. Green, V. Shearn-Bochsler, N. J. Thomas, and D. S. Blehert. 2010. Rapid polymerase chain reaction diagnosis of white-nose syndrome in bats. Journal of Veterinary Diagnostic Investigation 22:224-230.

MacArthur, R. H., J. M. Diamond, and J. R. Karr. 1972. Density compensation in island faunas. 53:330–342.

Menzel, J. M., W. M. Ford, M. A. Menzel, T. C. Carter, J. E. Gardner, J. D. Gardner, and J. E. Hofmann. 2005. Summer habitat use and home-range analysis of the endangered Indiana bat. Journal of Wildlife Management 69:430-436.

Menzel, M. A., T. C. Carter, W. M. Ford, and B. R. Chapman. 2001. Tree-roost characteristics of subadult and female adult evening bats (*Nycticeius humeralis*) in the upper coastal plain of South Carolina. American Midland Naturalist 145:112-119.

Meteyer, C. U., E. L. Buckles, D. S. Blehert, A. C. Hicks, D. E. Green, V. Shearn-Bochsler, N. J. Thomas, A. Gargas, and M. J. Behr. 2009. Histopathologic criteria to confirm white-nose syndrome in bats. Journal of Veterinary Diagnostic Investigation 21:411–414.

Miles, A. C., S. B. Castleberry, D. A. Miller, and L. M. Conner. 2004. Interesting observations at evening bat maternity colonies in southwest Georgia. *in* the 9th Annual Meeting of the Southeastern Bat Diversity Network and 14th Colloquium on Conservation of Mammals in the Southeastern United States. Southeastern Bat Diversity Network.

Miles, A. C., S. B. Castleberry, D. A. Miller, and L. M. Conner. 2006. Multi-scale roost-site selection by evening bats on pine-dominated landscapes in southwest Georgia. Journal of Wildlife Management 70:191-1199.

Miller, N. E., R. D. Drobney, R. L. Clawson, and E. V. Callahan. 2002. Summer habitat in northern Missouri. Pages 165-171 *in* The Indiana Bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Mumford, R. E. 1953. General Notes: Status of *Nycticeius humeralis* in Indiana. Journal of Mammalogy 34:121-122.

Mumford, R. E. and J. O. Whitaker, Jr. 1982. *Myotis sodalis* - Indiana myotis. Pages 155-163 *in* Mammals of Indiana. Indiana University Press, Bloomington, Indiana. 537pp.

Murray, S. W. and A. Kurta. 2002. Spatial and temporal variation in

diet. Pages 182-192 *in* The Indiana Bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Murray, S. W. and A. Kurta. 2004. Nocturnal activity of the endangered Indiana bat (*Myotis sodalis*). London Journal of Zoology 262:197-206.

Myers, R. F. 1964. Ecology of three species of myotine bats in the Ozark Plateau. Unpublished Ph.D. dissertation, University of Missouri, Columbia, Missouri. 210 pp.

Parsons, K. N., G. Jones, and F. Greenaway. 2003. Swarming activity of temperate zone Microchiropteran bats: effects of season, time of night and weather conditions. Journal of Zoology (London) 261:257-264.

Racey, P. A. 1982. Ecology of bat reproduction. Pages 57-104 *in* Ecology of bats (T.H. Kunz, ed.). Plenum Press, New York, New York.

Reichard, J. D. and T. H. Kunz. 2009. White-nose Syndrome inflicts lasting injuries to the wings of little brown myotis (*Myotis lucifugus*). Acta Chiropterologica 11:457-464.

Richter, A. R., S. T. Humphrey, J. B. Cope, and V. Brack, Jr. 1993. Modified cave entrances: Thermal effect on body mass and resulting decline of endangered Indiana bats (*Myotis sodalis*). Conservation Biology 7:407-415.

Ritzi, C. M., B. L. Everson, and J. O. Whitaker, Jr. 2005. Use of bat boxes by a maternity colony of Indiana myotis (*Myotis sodalis*). Northeasten Naturalist 12:217-220.

Sanders, C. and J. Chenger. 2001. Williams Lake telemetry study, April 10 - May 5, 2001. Bat Conservation and Management. 21 pp.

Schneider, A. 1966. Physiography. Chapter 3. *in* Natural features of Indiana (A. A. Lindsey, ed.). Proceedings of the Indiana Academy of Science, Indianapolis, Indiana.

Schultes, K. L. and C. L. Elliott. 2002. Roost tree selection by Indiana bats and northern bats on the Wayne National Forest, Ohio. Unpublished report to U.S. Fish & Wildlife Service, Reynoldsburg, Ohio Field Office and U.S. Department of Agriculture, Forest Service, Wayne National Forest.

Sparks, D. W. 2003. How does urbanization impact bats? Ph.D. Dissertation. Indiana State University, Terre Haute, Indiana. 121 pp.

Sparks, D. W., V. Brack, Jr., J. O. Whitaker, Jr., and R. Lotspeich. 2009. Reconciliation ecology and the Indiana Bat at Indianapolis International Airport, Chapter 3. *in* Airports: Performance, Risks, and Problems, (P. B. Larauge and M. E. Castille, eds.) Nova Science Publishers, Inc., Hauppauge, New York.

Sparks, D. W., J. R. Choate, and R. J. Winn. 1999. Observations on reproduction in three species of bats. Prairie Naturalist 31:245-248.

Sparks, D. W., K. E. Francl, and V. Brack Jr. 2011. Indexing at different scales: a response to Reichard et al. Journal of Wildlife Diseases 4:1052-1053.

Sparks, D. W., C. M. Ritzi, J. E. Duchamp, and J. O. Whitaker, Jr. 2005. Foraging habitat of the Indiana bat (*Myotis sodalis*) at an urban-rural interface. Journal of Mammalogy 86:713-718.

Sparks, D. W., J. O. Whitaker, Jr., N. G. Gikas, and D. J. Judy. 2008. Final Report: Developing techniques for estimating populations of Indiana bats. U.S. Geological Survey, Fort Collins Science Center.

Sparks, D. W., J. O. Whitaker, Jr., and C. M. Ritzi. 2004. Foraging ecology of the endangered Indiana bat. *in* Indiana Bat and Coal Mining: A Technical Interactive Forum (K.C. Vories and A. Harrington, eds.). U.S. Department of the Interior, Office of Surface Mining. Alton, Illinois.

Stones, R. C. and J. E. Wiebers. 1967. Temperature regulation in the little brown bat, *Myotis lucifugus*. Pages 97-109 *in* the 3rd International Symposium, Mammalian hibernation III (K.C. Fisher, A.R. Dawe, C.P. Lyman, E. Schonbaum, and F.E. South, Jr., eds.) Oliver and Boyd, Edinburgh and London.

Summit County Metro Parks. 2003. Preliminary inventory of bat species Pond Brook Metro Park and Twinsburg Park and Nature Preserve. Summit County Metro Parks, Akron, Ohio.

Tibbels, A. E. and A. Kurta. 2003. Bat activity is low in thinned and unthinned stands of red pine. Canadian Journal of Forest Research 33 (12):2436-2442.

Tuttle, N. M., D. P. Benson, and D. W. Sparks. 2006. Diet of *Myotis sodalis* (Indiana Bat) at an urban/rural interface. Northeastern Naturalist 13:435-442.

Twente, J. W., J. Twente, and V. Brack, Jr. 1985. The duration of the period of hibernation of three species of vespertilionid bats. II: Laboratory studies. Canadian Journal of Zoology 63:2955-2961.

USFWS. 2007. Indiana bat (*Myotis sodalis*) draft recovery plan: First revision. U.S. Department of Interior, Fish and Wildlife Service, Fort Snelling, Minnesota. 258 pp.

USFWS. 2012. 2011 Rangewide population estimate for the Indiana bat (*Myotis sodalis*) by USFWS region. U.S. Department of Interior, Fish and Wildlife Services, Ecological Services Field Office, Bloomington, Indiana.

Watkins, L. C. 1970. Observations on the distribution and natural history of the evening bat (*Nycticeius humeralis*) in northwestern Missouri and adjacent Iowa. Pages 330-336 *in*

Proceedings of the Kansas Academy of Science. 72:330-336.

Watkins, L. C. 1972. *Nycticeius humeralis*. Mammalian Species 23:1-4.

Watkins, L. C. and K. A. Shump, Jr. 1981. Behavior of the evening bat *Nycticeius humeralis* at a nursery roost. American Midland Naturalist 105:258-268.

Whitaker, J. O., Jr. 1996. Bats of Prairie Creek, Vigo County, Indiana. Proceedings of the Indiana Academy of Science 105:87-94.

Whitaker, J. O., Jr. 2006. Small mammals of the Wabash River bottoms. Proceedings of the Indiana Academy of Science 115:149–155.

Whitaker, J. O., Jr and S. L. Gummer. 1988. Bat colonies in Indiana, with emphasis on the evening bat, *Nycticeius humeralis*. Proceedings of the Indiana Academy of Science 98:595-598.

Whitaker, J. O., Jr and S. L. Gummer. 1993. The status of the evening bat, *Nycticeius humeralis*, in Indiana. Proceedings of the Indiana Academy of Science 102:283-291.

Whitaker, J. O., Jr and S. L. Gummer. 2003. Current status of the evening bat, *Nycticeius humeralis*, in Indiana. Proceedings of the Indiana Academy of Science 112:55-60.

Whitaker, J. O., Jr and D. W. Sparks. 2008. Roosts of Indiana bats (*Myotis sodalis*) near the Indianapolis International Airport (1997-2001). Proceedings of the Indiana Academy of Science 117:193-202.

Whitaker, J. O., Jr, D. W. Sparks, and V. Brack, Jr. 2006. Use of artificial roost structures by bats at the Indianapolis International Airport. Environmental Management 38:28-36.

Whitaker, J. O., Jr. and V. Brack, Jr. 2002. Distribution and summer ecology in Indiana. Pages 48-54 *in* The Indiana Bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Whitaker, J. O., Jr., V. Brack, Jr., D. W. Sparks, J. B. Cope, and S. Johnson. 2007. Bats of Indiana. Indiana State University, Center for North American Bat Research and Conservation, Publication number 1. 59 pp.

Whitaker, J. O., Jr. and R. E. Mumford. 2009. Mammals of Indiana Indiana University Press. Bloomington, Indiana, 661 pp.

Whitaker, J. O., Jr., D. W. Sparks, and V. Brack, Jr. 2004. Bats of the Indianapolis International airport area, 1991-2001. Proceedings of the Indiana Academy of Science 113:151-161.

Wilkinson, G. S. 1992. Information transfer at evening bat colonies. Animal Behaviour 44:501-518.

Wimsatt, W. A. 1944. Further studies on the survival of spermatozoa in the female reproductive tract of the

bat. The Anatomical Record 88:193-204.

Winhold, L. 2007. Community ecology of bats in southern Lower Michigan, with emphasis on roost selection by Myotis. Masters thesis, Eastern Michigan University, Ypsilanti, Michigan.

Winhold, L., E. Hough, and A. Kurta. 2005. Long-term fidelity by tree-roosting bats to a home area. Bat Research News 46:9-10.

Winhold, L. and A. Kurta. 2006. Aspects of migration by the endangered Indiana bat, *Myotis sodalis*. Bat Research News 47:1-6.

Zurcher, A. A., D. W. Sparks, and V. J. Bennett. 2010. Why the bat did not cross the road? Acta Chiropterologica 12:337–340.

APPENDIX A
QUALIFIED SURVEYORS

ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.
Résumé
Dale W. Sparks, Ph.D.

EDUCATION

Ph.D., Biology, Indiana State University, 2003. Dissertation: "How does urbanization impact bats?"
M.S., Biology, Fort Hays State University, 1996. Thesis: "Distribution, Natural History, Conservation Status, and Biogeography of Bats in Kansas"
B.S., Biology, Murray State University, 1993.

PROFESSIONAL CERTIFICATIONS

Certified Wildlife Biologist: The Wildlife Society, 2012

QUALIFICATIONS AND EXPERIENCE

Dr. Sparks is a wildlife biologist involved in a variety of terrestrial ecology research positions involving herpetology, ornithology, ichthyology, and mammalogy and has extensively studied bats and their habitat. Many of Dr. Sparks' projects concern federally endangered Indiana bats (*Myotis sodalis*). He is experienced in many ecological field techniques, including: species identification, habitat assessment, trapping, netting, radio-telemetry and tracking, guano analysis, AnaBat sampling and analysis, GPS/GIS, mapping and orientation

Dr. Sparks directed long-term studies in support of a Biological Assessment (Sec. 7 of the ESA) and a Habitat Conservation Plan (Sec. 10) associated with developments at the Indianapolis International Airport and the near-by Six-Points highway project, respectively. Studies included mist-net, AnaBat, population estimates using both emergence counts and DNA-based approaches, and radiotelemetry studies, requiring coordination with state, federal, and local agencies. These combined projects were the first large-scale mitigation for loss of summer habitat for the Indiana bat and they have produced some of the most definitive research on the interaction of the Indiana bat with human developments, with many resulting publications that bear the name of Dr. Sparks. One of the more recent of these is "*Reconciliation ecology and the Indiana bat at an urban/rural interface*" published as a chapter in the book Airports: Performance, Risks, and Problems.

Dr. Sparks is an experienced public speaker, having taught university-level courses, presented educational lectures to the public, and presented technical papers to professional organizations. Dr. Sparks serves as a technical advisor to U.S. Fish and Wildlife Service for summer habitat conservation and population characteristics of the endangered Indiana bat. He is also a member of the Indiana Department of Natural Resources Mammal Technical Advisory Committee and chairs the Legislation and Regulations Committee of the American Society of Mammalogists.

Dr. Sparks has authored and co-authored numerous papers, poster and oral presentations, and book chapters and is a technical reviewer for Journal of Wildlife Management; Journal of Mammalogy; The Southwestern Naturalist; The Prairie Naturalist; Special Publications of Fort Hays State University; Sixth Chihuahuan Desert Research Symposium; USFWS Indiana Bat Recovery Plan; Biology of Cambarid Crayfishes: Conservation, Ecology, and Natural History; and the National Science Foundation.

PROJECT EXPERIENCE

Project Manager – Forest Preserve District of Kane County: 2011. Managed summer bat mist net and acoustic surveys at four forest preserves in Kane County, Illinois. Coordinated with client and completed associated reporting.

Project Manager – Confidential Client, Wind Resource Area: 2011. Completed acoustic surveys of bats using a combination of detectors on MET towers and ground-based detectors at a site in Huron County, Michigan. Responsible for project management and data analysis.

Project Manager – Confidential Client, Wind Resource Area: 2011. Implemented a mortality study on a site containing 20 turbines along a 3-mile stretch of Backbone Mountain in Garrett County, Maryland. Managed project including development of survey protocol.

Project Manager – Confidential Client, Wind Resource Area: 2011. Completed habitat assessment for potential use by endangered bats on a 45,293-acre site in Sanilac and Lapeer Counties, Michigan as part of Tier II analysis.

Project Manager – Confidential Client, Wind Resource Area: 2011. Managed mist netting, acoustic surveys, and telemetry for the federally endangered Indiana bat within a 23,468.7-acre wind resource area in Jay and Randolph counties, Indiana. Coordinated with prime consultant and completed associated reporting.

Project Manager – Confidential Client, Wind Resource Area: 2011. Managed endangered bat mist net and acoustic surveys and telemetry within a 19,926-acre wind resource area in Seneca and Crawford counties, Ohio. Coordinated with prime consultant and completed associated reporting.

Project Manager – Confidential Client, Wind Resource Area: 2011. Managed endangered bat mist net and acoustic surveys and telemetry within a 39,607-acre wind resource area in Seneca and Sandusky counties, Ohio. Coordinated with prime consultant and completed associated reporting.

Project Manager – Confidential Client, Wind Resource Area: 2011. Managed endangered bat mist net and acoustic surveys within an 8151-acre wind resource area in Darke County, Ohio. Coordinated with prime consultant and completed associated reporting.

Biologist – American Electric Power, Bonnyman-Softshell 138kV Transmission Line: 2011. Completed summer mist netting survey along a 19.6-mile transmission line in Perry and Knott counties, Kentucky. Responsible for mist net site set up and habitat

assessment, bat identification, morphometric processing and implementation of White Nose Syndrome protocols.

Biologist – American Electric Power, Wyoming-Jackson's Ferry 765 kV Transmission Line: 2004-2009. Participated in mist net surveys at three wildlife mitigation ponds along a transmission line ROW in Virginia.

Project Manager – Confidential Client, Wind Resource Area: 2010. Completed bat sampling, using mist netting and ground-based acoustic detectors, on a site proposed to contain 100-130 wind turbines, in Montgomery and Boone counties, Indiana.

Biologist – Indiana Department of Transportation, Interstate 69, Pre- and Post-construction Surveys: 2010 and 2011. Conducted summer mist net survey for federally endangered Indiana bat along final ROW for Sections 1, 2 and 3.

Project Manager – Confidential Client, Wind Resource Area: 2010. Conducted summer mist netting and associated acoustic studies for endangered bats on a 61,256-acre, 300-megawatt wind energy generation facility in Wells, Adams, Blackford, and Jay counties, Indiana. 2011, Contributing author to Habitat Conservation Plan including development of a new and comprehensive technique of estimating take.

Biologist – Equitrans, LP, Sunrise Pipeline: 2010. Conducted Indiana bat summer mist net survey in Greene County, Pennsylvania, and Doddridge, Marion, Harrison, and Taylor and Wetzel counties, West Virginia.

Project Manager – Burr Oak Wind Resource Area: 2010. Completed desk-top analysis of bat impacts for a proposed wind energy facility in Marshall and Fulton counties, Indiana.

Project Manager – Fayette Wind Resource Area: 2010. Completed desk-top analysis of bat impacts and phase II surveys for bat habitat for a proposed wind energy facility in Fayette, Rush and Henry counties, Indiana.

Biologist – Duke Energy, Lawrenceburg Road Site: 2010. Conducted summer mist net survey for the federally endangered Indiana bat on a 220-acre parcel near the confluence of the Great Miami and Ohio rivers in Hamilton County, Ohio.

Biologist – Confidential Client: 2010. Prepared Protection and Enhancement Plan for federally endangered Indiana bats in partial mitigation for construction at a mine in Greene County, Pennsylvania.

Biologist – Entergy James A. FitzPatrick Nuclear Power Plant: 2009. Completed data analysis for Indiana bat habitat evaluation for expanding nuclear facility in Oswego County, New York. Coauthored technical report.

Biologist – Indiana Department of Transportation, SR 641 Bypass (Phases III and IV): 2009. Author for Biological Assessment to investigate effects along approximately six miles of proposed new roadway in Vigo County, Indiana.

Biologist – Cincinnati Metropolitan Sewer District, Mt. Airy forest sewer replacement: 2009. Analyzed habitat quality measurements taken during surveys for federally endangered Indiana bat, cave salamander, hellbender and running buffalo clover on a 1469-acre urban forest in Hamilton County, Ohio.

Biologist – Confidential Client, Wind Farm: 2009. Completed technical report sections for endangered species studies and biological assessment at 84 windmill, 250-megawatt capacity wind farm on an island in the Great Lakes in Jefferson and Oswego counties, New York

Biologist – Consol Pennsylvania Coal Company, Bailey Mine: 2009. Author for Biological Assessment to investigate effects of coal refuse disposal on Indiana bats. Responsible for analysis of effects of coal mining related to competition of Indiana bats to both other bats and conspecifics, effects of acid mine drainage, and groundwater.

Project Manager – The Conservation Fund: 2009-2010. Managed project involving multiple field teams to complete AnaBat studies across the eastern range of the Indiana bat in nine states. Studies include examination of species distribution in potentially impacted areas and forest condition surveys. Coordinate and oversee field work (including on-site visits to ensure sampling QA/QC), interpret collected data, and coordinate with client, resource agencies, and landowners.

Field Supervisor – AES Sparrows Point LNG, LLC and Mid-Atlantic Express, LLC: 2009. Completed endangered bat surveys along the 88-mile Sparrows Point LNG Terminal and Mid-Atlantic Express Pipeline in Baltimore, Hartford, and Cecil counties, Maryland and Lancaster and Chester counties, Pennsylvania. Responsible for mist net site set up and habitat assessment, bat identification, morphometric processing and implementation of White Nose Syndrome protocols.

Research Scientist – Indianapolis International Airport: 1997-2009. Directed a mitigation project for Sec. 7 and Sec. 10 (HCP) of ESA including, conducting artificial roosts studies and directing mist-net and AnaBat surveys. These studies required extensive use of radiotelemetry, and coordination of mitigation activities with state, federal, and local agencies, directing field work, interviewing and hiring student workers, and preparing final reports. In addition provided assistance to the airport on a variety of wildlife management issues ranging from crop deprivation to animal hazards at the airfield and on local roadways.

Project Manager – Interactions with bats and roadways: 2004-Present. Used a combination of radio-telemetry data, direct field observation of bats crossing roads, and behavioral models in an effort to understand the impacts of roadways on bats.

Project Manager – Community structure and behavior of small mammals along interstate highways: 2007. Used Sherman Live Traps to capture small mammals in medians and along roadsides of Interstate 70 in Eastern Illinois. Between trapping sessions, behavioral approaches were used to compare the perceived habitat quality between roadsides and medians. In this study area, highways provided high-quality habitat for a community of small mammals comparable with that found in local nature preserves.

Project Manager – Comparison of traditional and molecular techniques to estimate summer Indiana bat colony sizes: 2006-2008. Directed field work and conducted regular emergence counts at known roost trees of Indiana bats at least twice per week in an effort to determine colony sizes. Results were used for further study and were

compared with mark-recapture estimations obtained by developing and using DNA signatures of individual bats in a manner similar to traditional mark-recapture analysis.

Project Manager – Food resources of bats across an urban/rural gradient: 2005-2008. Supervised research project in which GIS was used to select points within landscape classes that were later sampled for insects. Captured insects were compared to those eaten by Indiana bats from this site and to the diets of other species in Indiana. Findings indicated urban areas provide sufficient food for bats; however, telemetry data indicated rare use of urban areas when rural habitats were available.

Project Manager – Nocturnal habitat of the Eastern Red Bat (*Lasiurus borealis*) at an urban/rural interface: 2003-2004. Supervised research project using radio-telemetry, and GIS to examine habitat selection by eastern pipistrelles near the Indianapolis Airport. This work also resulted in the only published use of radio-telemetry to track free-ranging eastern red bats during migration.

Project Manager – Diet of black and turkey vultures in a forested landscape. Directed research project involving identification of hair, scale, and bone fragments within pellets of black and turkey vultures. These data were then combined with movement data to inform Bird Avoidance Models.

Project Manager – Habitat use by a juvenile hoary bat at an urban/rural interface: 2004. Used radio-telemetry and GIS techniques to provide insight into the behavior of a rarely captured species.

Project Manager – Nocturnal habitat selection by the federally-endangered Indiana bat (*Myotis sodalis*) at an urban/rural interface: 2002. Used a combination of radio-telemetry and GIS to examine Indiana bat habitat selection near the Indianapolis Airport.

Project Manager – Comparison of habitat selection by big brown and evening bats at the Indianapolis International Airport: 2001. Supervised research project involving the use of radio-telemetry and GIS to compare habitats used by evening bats (a locally endangered species) and big brown bats (locally abundant) near the Indianapolis Airport. Published field data were the first to support the hypothesis that loss of foraging habitat is a primary cause of endangerment for bats.

Project Manager – Changes in fish community structure along an urban to rural gradient in an Indianapolis steam: 2002. Conducted fish sampling at 10 sites on multiple occasions to demonstrate changes in community structure (using Index of Biological Integrity, and species richness).

Project Manager – Amphibians and reptiles of the Indianapolis International Airport: 2001-2002. Conducted reptile and amphibian surveys at the Indianapolis Airport site using field observation techniques ranging from searching under debris to modified frog call routes to detect herps throughout an urban and rural matrix.

Research Associate – Sternberg Museum of Natural History: 1994-1996. Conducted a state-wide survey of bats of Kansas including capturing and preparing specimens, recruiting and directing volunteer field assistants, interacting with landowners, conducting public education programs, reexamining existing specimens, photographing

bats, and preparing reports for publication. QMC Models 1 and 2 bat detectors were also used to detect echolocation signals.

Project Director – Indiana State University, Hardwood Ecosystem Experiment: 2006-2008. Initiated protocols for determining effects of timber harvest on bats and other species in Morgan-Monroe and Yellowwood State Forests. Conducted mist netting surveys including net site reconnaissance, bat habitat assessments; mist net set-up, bat handling and identification, and AnaBat surveys. Also directed multiple research projects involving fish, herp, and insect surveys and several studies that examined wildlife response to highways.

Wildlife Technician – Kansas Department of Wildlife and Parks: 1994-1995. Aided in efforts to understand the decline of ring-necked pheasant in Kansas. Sampled agricultural habitats for evidence of use by pheasants, song birds, and short-eared owls.

AmeriCorps Volunteer – USDA Natural Resources Conservation Service: 1995-1996. Provided assistance in Hays Kansas and surrounding area to help restore habitats damaged by historic floods in 1993. Bio-engineering techniques were extensively used including crib walls, willow fascines, and shaping and restoring vegetation to areas damaged by flood waters. Efforts were also made to improve access to disabled citizens by building a handicapped access ramp, development of fisheries habitat including adding lunker boxes to the stream, and expanding a local biking trail.

Wildlife Technician – Kentucky Department of Fish and Wildlife Resources: 1993. Aided in efforts to reintroduce peregrine falcons in Kentucky including growth and behavior monitoring, general public and media liaison, arranging for treatment and conducting first aide for injured falcons.

Wildlife Technician – USDA Forest Service: 1992. Conducted surveys of federally-threatened northern spotted owls, and several species of local conservation concern in the Pacific Northwest including: northern goshawks, red-legged frogs, and Townsend's big-eared bats.

Research Scientist – Indiana State University, Department of Biology: 2007-2009. Responsible for teaching courses including wildlife management, mammalogy, herpetology, vertebrate zoology, and museum biology; recruiting and mentoring graduate students; preparing grants, and developing an undergraduate student chapter of The Wildlife Society.

Assistant Curator – Indiana State University, Vertebrate Collection: 2000-2009. Responsible for day-to-day operation of the collection including recruiting, interviewing, and hiring student workers and volunteers, preparing specimens; answering information requests, processing loan requests; updating data handling, and oversight for database development for all collections.

Lecturer – Indiana State University: 2003-2006. Responsibilities included preparing and teaching classes in vertebrate zoology, general ecology, herpetology, and museum biology.

Graduate Assistant – Indiana State University, Office of Sponsored Programs/Office of Research: 1996-1998. Aided principal investigators in finding, applying for, and

managing grants and contracts. Served as assistant editor of campus-wide newsletter and performed general secretarial work.

Teaching Assistant – Fort Hays State University: 1993-1995. Responsible for preparing and teaching labs in general zoology and general biology.

Coordinator – Murray State University Student Chapter of The Wildlife Society Raptor Rehabilitation Center: 1991-1993. Supervised day-to-day operation of a student-run rehabilitation center including supervising and training volunteers, administering first aid to injured birds, coordinating treatment with veterinarian, presenting public education programs, and coordinating an education program at the National Museum of the Boy Scouts of America.

Undergraduate Teaching Assistant – Murray State University: 1991-1993. Responsible for preparing and teaching labs in general botany and general biology.

Wildlife Technician – U.S. Forest Service, McKenzie River District: 1992. Conducted surveys for spotted owls, goshawks, Townsend's big eared bats, and red-legged frogs.

Assistant Zoologist – Kentucky State Nature Preserves Commission: 1991. Conducted biological inventory of the Jackson Purchase region.

PUBLICATIONS

Sparks, D. W., K. Francl, and V. Brack, Jr. 2011. Indexing at different scales: A response to Reichard et al. Journal of Wildlife Diseases 47: 1052-1053.

Timpone, J., K. Francl, D. W. Sparks, V. Brack, Jr., and J. Beverly. 2011. Bats of the Cumberland Plateau and Ridge and Valley Provinces, Virginia. Southeastern Naturalist 10:515-528.

Francl, K., D. W. Sparks, V. Brack, Jr., and J. Timpone. 2011. White-nose syndrome and wing damage index scores among summer bats in the northeastern United States. Journal of Wildlife Diseases 47:41-48.

Zurcher, A. A., D. W. Sparks, and V. J. Bennett. 2010. Why the bat did not cross the road. Acta Chiroptologica, 12:337-340.

Judy, D. J., D. W. Sparks, J. O. Whitaker, Jr., and C. M Ritzi. 2010. Unusual migratory behavior by an Indiana bat (*Myotis sodalis*). Proceedings of the Indiana Academy of Science, 119:99-100.

Judy, D. J., D. W. Sparks, J. O. Whitaker, Jr., and S. Oyler-McCance. 2010. Bat guano is useful for more than diet studies. Proceedings of the Indiana Academy of Science, 119:95-98.

Karns, D. R., D. G. Ruch, R. D. Brodman, J. S. Castrale, J. R. Gammon, P. E. Rothrock, D. W. Sparks, and J. R. Stahl. 2010. Results of a BioBlitz at Wesselman Woods Nature Preserve, Vanderburgh, County, Indiana. Proceedings of the Indiana Academy of Science, 119:4-6.

Duchamp, J. E., D. W. Sparks, and R. K. Swihart. 2010. Exploring the nutrient hotspot hypothesis at trees used by bats. Journal of Mammalogy, 91:48-53.

Sparks, D. W., V. Brack, Jr., J. O. Whitaker, Jr., and R. Lotspeich. 2009. Reconciliation ecology and the Indiana Bat at Indianapolis International Airport, Chapter 3. *In* Airports: Performance, Risks, and Problems, (P. B. Larauge and M. E. Castille, eds.) Nova Science Publishers, Inc., Hauppauge, New York.

Sparks, D. W., 2008. Escape behavior of northern long-eared bats (*Myotis septentrionalis*) following diurnal disturbance. Proceedings of the Indiana Academy of Science, 117: 203-209.

Whitaker, J. O., Jr., and D. W. Sparks. 2008. Roosts of Indiana bats (*Myotis sodalis*) near the Indianapolis International Airport (1997-2001). Proceedings of the Indiana Academy of Science, 117:193-202.

Kelly, N. E., D. W. Sparks, T. L. DeVault, and O. E. Rhodes, Jr. 2007. Diet of black and turkey vultures in a forested landscape. Wilson Journal of Ornithology, 119:267-270.

Krochmal, A. R. and D. W. Sparks. 2007. Timing of birth and estimation of age for juvenile *Myotis septentrionalis* and *Myotis lucifugus* from west-central Indiana. Journal of Mammalogy, 88:649-656.

Walters, B. L., C. M. Ritzi, D. W. Sparks, and J. O. Whitaker, Jr. 2007. Foraging behavior of the eastern red bat (*Lasiurus borealis*) at an urban-rural interface. American Midland Naturalist, 157:365-373.

Tuttle, N. M., D. P. Benson, and D. W. Sparks. 2006. Diet of *Myotis sodalis* (Indiana bat) at an Urban/Rural Interface. Northeastern Naturalist, 13:435-442.

Whitaker, J. O., Jr., D. W. Sparks, and V. Brack, Jr. 2006. Use of artificial roost structures by bats at the Indianapolis International Airport. Environmental Management, 38:28-36.

Walters, B. L., C. M. Ritzi, D. W. Sparks, and J. O. Whitaker, Jr. 2006. Timing of migration by eastern red bats (*Lasiurus borealis*) through central Indiana. Acta Chiroptologica, 8:259-263.

Tuttle, N. M., D. W. Sparks, and C. M. Ritzi. 2005. Extralimital record of the gray bat (*Myotis grisescens*) in Indiana. Bat Research News, 46:147.

Sparks, D. W., J. O. Whitaker, Jr, and C. M. Ritzi. 2005. Foraging ecology of the endangered Indiana bat. Pp 15-27 *In* Indiana Bats and Coal Mining, A Technical Interactive Forum (K. C. Vories and A. Harrington, eds). Office of Surface Mining, U.S. Department of the Interior, Alton, Illinois.

Sparks, D. W., C. M. Ritzi, J. E. Duchamp, and J. O. Whitaker, Jr. 2005. Foraging habitat of the Indiana bat (*Myotis sodalis*) at an urban-rural interface. Journal of Mammalogy, 86:713-718.

Sparks, D. W., C. M. Ritzi, and B. L. Everson. 2005. Nocturnal behavior and roosting ecology of a juvenile *Lasiurus cinereus* near Indianapolis, Indiana. Proceedings of the Indiana Academy of Science, 114:70-72.

Ulrey, W. A., D. W. Sparks, and C. M. Ritzi. 2005. Bat communities in highly impacted areas: comparing Camp Atterbury to the Indianapolis Airport. Proceedings of the Indiana Academy of Science, 114:73-76.

Ritzi, C. M., B. C. Bartells, and D. W. Sparks. 2005. Food habits and ectoparasites of Elliot's short-tailed shrew (*Blarina hylophaga*) from Kansas. The Southwestern Naturalist, 50:88-93.

Whitaker, J. O., Jr., D. W. Sparks, and V. Brack, Jr. 2004. Bats of the Indianapolis International Airport Area, 1991-2001. Proceedings of the Indiana Academy of Science 113:151-161.

Sparks, J. K. F, . B. J. Foster, and D. W. Sparks. 2004. Utility pole used as a roost by a northern myotis, *Myotis septentrionalis*. Bat Research News, 45:94.

Duchamp, J. E., D. W. Sparks, and J. O. Whitaker, Jr. 2004. Foraging-habitat selection by bats at an urban-rural interface: comparison between a successful and a less successful species. Canadian Journal of Zoology, 82:1157-1164.

Ritzi, C. M., B. L. Everson, B. J. Foster, J. J. Sheets, and D. W. Sparks. 2004. Urban ichthyology: changes in the fish community along an urban-rural creek in Indiana. Proceedings of the Indiana Academy of Science, 113:42-52

Foster, B. J., D. W. Sparks, and J. E. Duchamp. 2004. Urban Herpetology II: Amphibians and Reptiles of the Indianapolis International Airport Conservation Properties. Proceedings of the Indiana Academy of Science, 113:53-59.

Foster, B. J., D. W. Sparks, and J. E. Duchamp. 2003. Urban Herpetology I: new distribution records of amphibians and reptiles from Hendricks County, Indiana. Herpetological Review, 34:395.

Sparks, D. W., K. C. Chapman, and C. M. Ritzi. 2003. Additional ectoparasitic records of bats from Kansas. Prairie Naturalist, 35:49-52.

Sparks, D. W., M. T. Simmons, C. L. Gummer, and J. E. Duchamp. 2003. Disturbance of roosting bats by woodpeckers and raccoons. Northeastern Naturalist, 10:105-108.

Sparks, D. W., and E. W. Valdez. 2003. Food habits of *Nyctinomops macrotis* at a maternity roost in New Mexico, as indicated by analysis of guano. Southwestern Naturalist, 48:132-135

Ritzi, C. M., and D. W. Sparks. 2002. New ectoparasite records for the rock squirrel (*Spermophilus variegatus grammurus*) in Socorro County, New Mexico. Southwestern Entomologist, 27:257-262.

Ritzi, C. M., and E. W. Valdez, and D. W. Sparks. 2002. New host and locality records of bat ectoparasites from Arizona and New Mexico. The Southwestern Naturalist, 47:453-456.

Sparks, D. W., and J. R. Choate. 2000. Distribution, natural history, conservation status, and biogeography of bats in Kansas. Pp: 173-228 *In* Reflections of a naturalist: papers honoring professor Eugene D. Fleharty (J. R. Choate, ed.), Fort Hays Studies, Special Issue 1: 1-241.

Sparks, D. W., K. J. Roberts, and C. Jones. 2000. Vertebrate predators on bats in North America North of Mexico. Pp: 229-241 In Reflections of a naturalist: papers honoring professor Eugene D. Fleharty (J. R. Choate, ed.), Fort Hays Studies, Special Issue 1: 1-241.

Sparks, D. W., A. G. Burr, M. N. Bass, and G. A. Liggett. 1999. New county distribution records of amphibians and reptiles from southwestern Kansas. Herpetological Review, 30:120-121.

Sparks, D. W., J. R. Choate, and R. J. Winn. 1999. Observations on reproduction in three species of bats. The Prairie Naturalist, 31:245-248.

Sparks, D. W., J. A. Laborda, and J. O. Whitaker, Jr. 1998. Bats of the Indianapolis International Airport as compared to a more rural community of bats at Prairie Creek. Proceedings of the Indiana Academy of Science, 107:171-179.

Sparks, D. W., and J. R. Choate. 1996. New distribution records of mammals from Kansas. The Prairie Naturalist, 27:185-192.

Sparks, D. W., and J. R. Choate. 1995. Attempted predation on a short-tailed shrew by a common grackle. The Kentucky Warbler, 71:48.

EDUCATIONAL PUBLICATIONS

Sparks, D. W., C. J. Schmidt, and J. R. Choate. 2011. Bats of Kansas. Publication Number 5, Indiana State University Center for North American Bat Research and Conservation. 62 pp.

Brack, V. Jr., D. W. Sparks, J. O. Whitaker Jr., B. L. Walters, and A. Boyer. 2010. Bats of Ohio. Occasional Papers of the Center for North American Bat Research and Conservation, 4:1-92.

Beilfuss, M., D. W. Sparks, and K. Henman. 2008. Echolocation (Can you tell where the sound is coming?). The Hoosier Science Teacher, 33:84-86.

Whitaker, J. O., Jr., V. Brack, Jr, D. W. Sparks, J. B. Cope, and S. Johnson. 2007. Bats of Indiana. Occasional Papers of the Center for North American Bat Research and Conservation, 1:1-59.

Beilfuss, M., D. W. Sparks, and K. Henman. 2007. The Indiana Bat. The Hosier Science Teacher, 32:69-71.

SUBMITTED MANUSCRIPTS

Francl, K. M., W. M. Ford, D. W. Sparks, and V. Brack, Jr. Quantifying Wing Damage of Summer Bats in the Northeastern United States. Submitted to Northeastern Naturalist. Significance: Examines precision and accuracy with which field biologists access wing damage on bats.

Francl, K. M., W. M. Ford, D. W. Sparks, and V. Brack, Jr. Capture and reproductive trends in summer bat communities in West Virginia: Assessing the impact of White-nose syndrome. Tentatively Accepted to the Journal of Fish and Wildlife Management. Significance: Doccuments rapid change in community structure

following the arrival of White Nose Syndrome in West Virginia and documents changes in reproductive parameters including timimg and success rate.

McGuire, M. A., V. Brack, Jr., J. O. Whitaker, Jr., and D. W. Sparks. Indiana bats and roadways: size does matter. Submitted To: Biological Conservation. Significance: Demonstrates that the frequency with which Indiana bats cross roads is correlated with the size of the road.

Judy, D. J., D. W. Sparks, J. O. Whitaker, Jr., and J. D. Roberts-Judy. Seasonal changes and wind dependence in thermal conductance of the pelage of two bat species with different roosting strategies. Submitted to: Journal of Mammalogy. Significance: Experimental study that measures and compares the insulative value of bat furs in two species of bats.

Judy, D. J., D. W. Sparks, J. O. Whitaker, Jr., and J. D. Roberts-Judy. Hair today, gone tomorrow: a review of molting in bats. Submitted to: Acta Chiroptologica. Significance: Reviews the limited data about molting in bats.

Storm, J. J, D. W. Sparks, E. W. Valdez, and J. O. Whitaker, Jr. Harmful insects eaten by bats. Manuscript to be published as part of the ISU Center for North American Bat Research and Conservation's Public Education Series. Significance: This booklet reviews the literature on bat diets from the perspective of an ecological service—control of harmful insects.

POSTER AND ORAL PRESENTATIONS

Sparks, D. W. and V. Brack, Jr.: 2011. Conservation and Management of Habitat for Maternity Colonies of the Indiana bat: Possibilities for Transportation Projects. Presented at 2011 International Conference on Ecology and Transportation: Sustainability in Motion. August 21-25, Seattle, Washington.

Francl, K.E., J. Timpone, **D. W. Sparks**, and V. Brack, Jr. 2010. Tracking White-nose Syndrome in summer bat communities – spatial and temporal patterns in the eastern United States. Presented at joint meeting of the Virginia Chapters of The Wildlife Society and American Fisheries Society, Wirtz, VA.

Carter, T. C. and **D. W. Sparks**. The future of bats and wind, the pending storm. Presented to Midwest Bat Working Group.

Brack, V., Jr., **D. W. Sparks**, and J. O. Whitaker, Jr. 2009. Landscape Scale Movements of Maternity Colonies of the Indiana bat Through Time: Examples and Possibilities. Paper Presented To: National Military Fish and Wildlife Federation.

Lebsack, W. A., and D. W. Sparks. 2008. Things that go bump in the night: nocturnal activity and information transfer of an Indiana bat colony. Poster Presented To: North American Bat Research Symposium and Indiana Academy of Science.

Gonzalez-Olimon, G., J. R. St. Juliana, and D. W. Sparks. 2008. Small mammal communities along highways: species composition and behavior. Poster Presented To: American Society of Mammalogists.

Gonzalez-Olimon, G., J. R. St. Juliana, W. A. Mitchell, and D. W. Sparks. 2007. Small mammal antipredator behavior in highway triangles, medians, and road sides in selected areas in Terre Haute, IN. Poster Presented To: Indiana Academy of Science.

Farrell Sparks, J. K., D. W. Sparks, and V. Brack, Jr. 2007. Utility poles as bat roosts. Poster Presented to: American Society of Mammalogists.

Tuttle, N. M. and D. W. Sparks. 2007. Indiana bats may be avoiding urban habitats for reasons other than prey availability. Poster Presented to: American Society of Mammalogists and American Society of Mammalogists (2006).

Sheets, J. J. D. W. Sparks, V. Brack, Jr., and J. O. Whitaker, Jr. 2007. Bats of Indiana State Forests. Poster Presented To: American Society of Mammalogists.

Helms, J. S., D. W. Sparks, and J. O. Whitaker, Jr. 2007 Nocturnal behavior and roosting ecology of *Perimyotis subflavus* (Eastern Pipistrelle) near Indianapolis International Airport. Poster Presented To: American Society of Mammalogists, Indiana Academy of Science (2006), and North American Bat Research Symposium (2006)

Judy, D. J., D. W. Sparks, and J. O. Whitaker. 2006. Obtaining fecal samples under Indiana bat roosts: a word of caution. Poster Presented to: American Society of Mammalogists.

Sparks, D. W., C. M. Ritzi, and B. L. Everson. 2005. Nocturnal Behavior and Roosting Ecology of a juvenile *Lasiurus cinereus* near Indianapolis, Indiana. Poster Presented to: American Society of Mammalogists.

Tuttle, N. M., D. P. Benson, and D. W. Sparks. 2005. Diet of the endangered Indiana bat at an urban/rural interface near Indianapolis, Indiana. Poster Presented to: American Society of Mammalogists.

Everson., B. L., C. M. Ritzi, Sparks, D. W., and J. O. Whitaker, Jr. 2005. Foraging behavior of eastern red bats in central Indiana. Poster Presented to: American Society of Mammalogists.

Kelly, N. E., D. W. Sparks, T. L. DeVault, and O. E. Rhodes, Jr. 2005. Diet of black and turkey vultures in a forested landscape. Poster Presented to: Indiana Academy of Science.

Sparks, D. W. and J. O. Whitaker, Jr. 2004. Batboxes and Indiana bats a conundrum. Poster Presented to: Midwest Fish and Wildlife Conference.

Everson., B. L., C. M. Ritzi, Sparks, D. W., and J. O. Whitaker, Jr. 2004. Foraging behavior of eastern red bats in central Indiana. Poster Presented to: Indiana Academy of Science.

Sparks, D. W. and J. O. Whitaker, Jr. 2004. Why batboxes are not the answer for managing Indiana bats. Poster Presented to: Indiana Academy of Science.

Tuttle, N. M. J. O. Whitaker, Jr., D. P. Benson, and D. W. Sparks. 2004. Food habits of Indiana bats at the Indianapolis International Airport. Poster Presented to: Indiana Academy of Science.

Everson., B. L., C. M. Ritzi, Sparks, D. W., and J. O. Whitaker, Jr. 2004. Foraging behavior of eastern red bats in central Indiana. Poster Presented to: Indiana Academy of Science.

Sparks, D. W., and E. W. Valdez. 2001. Food habits of *Nyctinomops macrotis* as indicated by analysis of guano. Poster presented to: Southwestern Association of Naturalists.

Valdez, E. W. and D. W. Sparks. 2001. Food habits of he western small-footed myotis (*Myotis ciliolabrum*) in New Mexico. Poster presented to: Southwestern Association of Naturalists.

Sparks, D. W., and J. A. Laborda. 1999. Orientation of northern myotis (*Myotis septentrionalis*) following release in daytime. Poster presented to: North American Bat Research Symposia and American Society of Mammalogists.

Zurcher, A. A., D. W. Sparks, and V. J. Bennett. 2008. Why the bat did not cross the road. Paper Presented To: Indiana Academy of Science.

Gikas, N. S, W. A. Lebsack, and D. W. Sparks. 2008. Information sharing about roosting areas by Indiana bats (*Myotis sodalis*). Paper Presented To: Indiana Academy of Science.

Gonzalez-Olimon, G., J. R. St. Juliana, and D. W. Sparks. 2008. Small mammal communities along highways: species composition and behavior. Paper Presented To: Indiana Academy of Science.

Helms, J. S., D. W. Sparks, and J. O. Whitaker, Jr. 2008. Nocturnal behavior and roosting ecology of *Perimyotis subflavus* (Eastern Pipistrelle) near Indianapolis International Airport. Paper Presented To: American Society of Mammalogists.

McGuire, M. A., D. W. Sparks, Virgil Brack, Jr., and John O. Whitaker, Jr. 2007. Indiana bats and roadways: size does matter. Presented to: Indiana Academy of Science.

Sparks, D. W., M. A. McGuire, Virgil Brack, Jr., and John O. Whitaker, Jr. 2007. Indiana bats and roadways: size does matter. Presented to: American Society of Mammalogists.

Sparks, D. W., B. J. Foster, and J. K. F. Sparks. 2006. Roosting ecology and colony dynamics of northern myotis (*Myotis septentrionalis*) in a managed forest. Presented to: Indiana Academy of Science and American Society of Mammalogists.

Boyles, J. G., D. J. Judy, D.W. Sparks, and G. S. Bakken. 2006. Seasonal changes in thermal conductance of fur in small mammals. Presented to: American Society of Mammalogists.

Tuttle, N. M. and D. W. Sparks. 2006. Indiana bats may be avoiding urban habitats for reasons other than prey availability. Presented to: Indiana Academy of Science.

Judy, D. J., D. W. Sparks, and J. O. Whitaker, Jr. 2005. Obtaining fecal samples under Indiana bat roosts: a word of caution. Presented to: Indiana Academy of Science.

Bast, M. D., M. S. Burt, . DW. Sparks. 2005. Prey selection within a Southeastern Missouri Bat Community. Presented to: Truman State University Research Showcase.

Sparks, D. W., C. M. Ritzi, and J. O. Whitaker, Jr. 2004. What do Indiana myotis do when they lose a roost. Presented to: American Society of Mammalogists.

Sparks, D. W., C. M. Ritzi., B. L. Everson. 2003. The Indiana bat as an umbrella species for wildlife near Indianapolis. Presented to: Indiana Academy of Science.

Everson., B. L., C. M. Ritzi, Sparks, D. W., and J. O. Whitaker, Jr. 2003. Foraging behavior of eastern red bats, *Lasiurus borealis*, in central Indiana. Presented to: Indiana Academy of Science.

Sparks, D. W., C. M. Ritzi, Joseph E. Duchamp, and J. O. Whitaker, Jr. 2003. Foraging ecology of the Indiana myotis at the Indianapolis International Airport. Presented to: American Society of Mammalogists

Sheets, J. J., C. M. Ritzi., B. L. Everson, B. J. Foster, S. S. Nard, and D. W. Sparks. 2002. Fishes of the Indianapolis International Airport, Marion and Hendricks Counties, Indiana. Presented to: Indiana Academy of Science.

Everson, B. L., Sparks, D. W., C. M. Ritzi., and J. E. Duchamp. 2002. Foraging behavior of Indiana bats at the Indianapolis International Airport. Presented to: Indiana Academy of Science.

Nard, S. S., B. J. Foster, Sparks, D. W., and J. E. Duchamp. 2002. Urban Herpetology: Amphibians and Reptiles of the Indianapolis International Airport. Presented to: Indiana Academy of Science.

Sparks, D. W., J. E. Duchamp, and C. M. Ritzi. 2002. Comparison of the roosting ecology of *Myotis septentrionalis* and *Nycticeius humeralis*. Presented to: American Society of Mammalogists

Duchamp, J. and D. W. Sparks. 2002. Movement across a rural/suburban gradient, a comparison of foraging in *Nycticeius humeralis* and *Eptesicus fuscus*. Presented to: American Society of Mammalogists

Sparks, D. W., J. E. Duchamp, and C. M. Ritzi. 2001. Do cavity-roosting bats partition roosts? Presented to: Indiana State University Graduate/Undergraduate Research Showcase.

Sparks, D. W., A. R. Krochmal, and W. A. Mitchell. 2001. Comparison of the reproductive biology of the northern myotis (*Myotis septentrionalis*) and the little brown myotis (*Myotis lucifugus*) in Indiana. Presented to: Indiana Academy of Science.

Duchamp, J. and D. W. Sparks. 2001. Habitat preference of the evening bat, *Nycticeius humeralis*, in a developing urban area. Presented to: Indiana Academy of Science.

Farrell, J. K., B. J. Foster, and D. W. Sparks. 2001. Roosting habitat of the northern myotis *Myotis septentrionalis* at the Indianapolis International Airport. Presented

to: Southwestern Association of Naturalists and Indiana State University Graduate/Undergraduate Research Showcase.

Sparks, D. W., and A. R. Krochmal. 2001. Evidence for geographic variation in birth size of *Myotis lucifugus*. Presented to: Indiana State University Graduate/Undergraduate Research Showcase.

Sparks, D. W., and A. R. Krochmal. 2000. Growth and Development of (*Myotis lucifugus*) in Poland, Indiana. Presented to: North American Bat Research Symposia.

Farrell, J. K., D. W. Sparks, and B. J. Foster. 2000. Vegetation surrounding the roost s of *Myotis septentrionalis*—a preliminary analysis. Presented to: Indiana Academy of Science.

Sparks, D. W., and A. R. Krochmal. 2000. Development of (*Myotis lucifugus*) in Poland, Indiana with comments on geographic variation. Presented to: Indiana Academy of Science.

Sparks, D. W., B. J. Foster, and J. O. Whitaker, Jr. 1999. Behavioral correlates of swarming bats. Presented to: American Society of Mammalogists

Farrell, J. K., D. W. Sparks, and J. A. Laborda. 2000. Preliminary analysis of the vegetation surrounding the roosts of *Myotis septentrionalis*. Presented to: Indiana State University Graduate/Undergraduate Research Showcase. Winner (JKF): Outstanding Undergraduate Presentation (Science).

Sparks, D. W., T. S. Crowe, and A. R. Krochmal. 2000. Patterns of growth and development of little brown myotis (*Myotis lucifugus*) at Poland, Indiana. Presented to: Indiana State University Graduate/Undergraduate Research Showcase.

Sparks, D. W., B. J. Foster, and J. O. Whitaker, Jr. 1999. Notes on bats swarming at Copperhead Cave. Presented to: Indiana Academy of Science.

Sparks, D. W., J. A. Laborda, and P. A. Zollner. 1998. Orientation of northern myotis following release in daytime. Presented to: Indiana State University Graduate/Undergraduate Research Showcase.

Sparks, D. W., J. A. Laborda, and P. A. Zollner. 1998. Orientation of northern myotis following release in daytime. Presented to: Indiana Academy of Science.

Sparks, D. W., and J. R. Choate. 1998. Impacts of settlement on three species of bats in status of bats in Kansas. Presented to: American Society of Mammalogists and Indiana State University Graduate/Undergraduate Research Showcase.

Sparks, D. W., and J. R. Choate. 1997. Impacts of settlement on the distribution and conservation status of bats in Kansas. Presented to: Indiana Academy of Sciences

Sparks, D. W., and J. R. Choate. 1995. Preliminary notes on the distribution and biogeography of bats in Kansas. Presented to: American Society of Mammalogists.

Sparks, D. W., and J. R. Choate. 1995. Preliminary notes on the distribution and biogeography of bats in Kansas. Presented to: Southwestern Association of Naturalists.

Sparks, D. W. 2008. Demography of the endangered Indiana bat. Presented to: USFWS Indiana Bat Demographic Model Rapid Prototyping and Structured Decision Making Workshop, National Conservation Training Center.

Sparks, D. W. 2007. How Biologists Use Museum Specimens. Presented to: Department of Forestry and Natural Resources, Purdue University.

Sparks, D. W. 2007. Indiana Bats and Urbanization—Lessons Learned at the Indianapolis International Airport. Presented to: Department of Forestry and Natural Resources, Purdue University and Center for Urban and Environmental Change, Indiana State University, Department of Geography, Geology, and Anthropology.

Sparks, D. W. 2006. Over-view of the Indianapolis Airport Project: What is the Benefit of Research for the Regulated? Presented to American Association of State Transportation Officials workshop on Indiana Bats.

Sparks, D. W. 2005. Landscape ecology of the endangered Indiana bat. Presented to: Indiana Bat Survival Workshop, National Conservation Training Center.

Sparks, D. W. 2005. Natural history of the endangered Indiana bat. Presented to: Indiana Bat Survival Workshop, National Conservation Training Center.

Sparks, D. W., J. O. Whitaker, Jr, and C. M. Ritzi. 2004. Foraging ecology of the endangered Indiana bat. Presented to: Indiana Bats and Coal Mining, An Interactive Technical Forum.

Sparks, D. W. 2004. Bats and Urbanization Near Indianapolis, Indiana. Presented to: Murray State University Wildlife and Fisheries Society.

Sparks, D. W. C. M. Ritzi, and J. O. Whitaker, Jr. 2004. Managing a forest bat in the suburban jungle: conserving the Indiana myotis near Indianapolis. Presented to: Second Bats and Forest Symposium (Section on Managing Indiana Bats).

Sparks, D. W. 2003. How does urbanization impact bats? Presented as: Sternberg Museum Lecture Series.

Sparks, D. W. , and T. P. Simon. 2002. Managing small collections. Presented to: Indiana Academy of Science.

Sparks, D. W. 2002. Reproductive biology of the northern myotis. Presented to: Department of Life Sciences, Indiana State University.

Sparks, D. W. 2000. Copulation, growth, development, and roosting ecology of the northern myotis, *Myotis septentrionalis*. Presented to: Ball State University Student Wildlife Society.

Sparks, D. W. 1998. Distribution, conservation status, and historical biogeography of bats in Kansas. Presented to: Department of Life Sciences, Indiana State University.

Sparks, D. W. 1998. Orientation of northern myotis, *Myotis septentrionalis*, following release in Daytime. Presented to: Department of Biology, Fort Hays State University.

GRANTS, CONTRACTS, AND HONORS

Whitaker, J. O., Jr., and D. W. Sparks. 2008. Proposal to monitor the Indiana myotis in a habitat conservation area near the proposed Six-Points Road Interchange. Indianapolis Airport Authority

Brack, V., Jr, J. O. Whitaker, Jr ., and., D. W. Sparks. 2007. Hardwood Ecosystem Experiement: Impact on bats using bat detectors and mist-net captures. Purdue University

Whitaker, J. O. Jr., R.R. Eidels, D. W. Sparks, and M.J. Lydy. 2007. Environmental contaminants and the decline of bats near Lake Michigan. US Environmental Protection Agency

Whitaker, J. O. Jr. and D. W. Sparks. 2007. Using molecular genetic techniques to investigate colony dynamics of the endangered Indiana bat (Myotis sodalis). Subcontract with US Geological Survey

Sparks, D. W. 2007. Contract to train USFWS personnel to capture bats. US Fish and Wildlife Service

Sparks, D. W. 2007. Supplemental funding to develop a student chapter of TWS at Indiana State University. The Wildlife Society, Indiana Chapter

Brack, V., Jr, J. O. Whitaker, Jr., and., D. W. Sparks. 2007. Hardwood Ecosystem Experiement: Impact on bats using bat detectors and mist-net captures. Purdue University.

Brack, V., Jr., D. W. Sparks, and J. O. Whitaker, Jr. 2006. Hardwood Ecosystem Experiment: Impact on bats using bat detectors and mist-net captures. Purdue University

Whitaker, J. O., Jr., and D. W. Sparks. 2006. Proposal to monitor the Indiana myotis in a habitat conservation area near the proposed Six-Points Road Interchange. Indianapolis Airport Authority

Sparks, D. W., and J. O. Whitaker, Jr. 2005. Using and Comparing traditional field techniques and genetic tools to obtain insight into colony dynamics of the endangered Indiana bat (Myotis sodalis). Subcontract with US Geological Survey

Sparks, D. W., and J. O. Whitaker, Jr. 2004. Identification of Bats in Potential Indiana Bat Habitat East of Flynn Road. Burns Construction Company

Sparks, D. W., and J. O. Whitaker, Jr. 2004. Evaluation of potential Indiana bat habitat east of Flynn Road in Suburban Indianapolis. Burns Construction Company

Whitaker, J. O., Jr., and D. W. Sparks, and C. M. Ritzi. 2004. Proposal to monitor the Indiana myotis in a habitat conservation area near the proposed Six-Points Road Interchange. Indianapolis Airport Authority

Sparks, D. W., and C. M. Ritzi. 2003. A proposal to study the ectoparasites and food habits of Blarina hylophaga from Kansas. Indiana Academy of Science

Whitaker, J. O., Jr., and D. W. Sparks. 2003. Proposal to monitor the Indiana myotis in a habitat conservation area near the proposed Six-Points Road Interchange. Indianapolis Airport Authority

Whitaker, J. O., Jr., and D. W. Sparks. 2002. Proposal to monitor the Indiana myotis in a habitat conservation area near the proposed Six-Points Road Interchange. Indianapolis Airport Authority

Sparks, D. W. 2001. Preliminary assessment of potential habitat for the evening bat at Thoroughbred Power Station. Hutton and Williams

Whitaker, J. O., Jr., J. A. Laborda, and D. W. Sparks. 1999. Proposal for 1999 field studies for interim mitigation of Indiana myotis (Myotis sodalis) at Indianapolis International Airport Marion and Hendricks Counties, Indiana. American Consulting Engineers

Sparks, D. W. 1998. Swarming and copulation of bats in Indiana. Indiana Academy of Science, $800.00.

Sparks, D. W., and J. O. Whitaker, Jr. 2008. A graduate student to help bring a bat festival to Terre Haute. Center for Community Engagement and Experiential Learning

Whitaker, J. O. Jr. J. G. Boyles, V. Brack, Jr., and D. W. Sparks. 2008. Recording of Habitat Selection and Behavior of Hibernating Bats with a Remote Monitoring System. ISU Technology Grant

Whitaker, J. O. Jr., D. W. Sparks, and V. Brack. 2007. A graduate student to help bring a bat festival to Terre Haute. Center for Community Engagement and Experiential Learning

Brack, V, Jr., Sparks, D. W., and J. O. Whitaker, Jr. 2007. An undergraduate student to help bring a bat festival to Terre Haute. Center for Community Engagement and Experiential Learning

Whitaker, J. O., Jr. and D. W. Sparks. 2007. A museum technician for the ISU vertebrate collection. Center for Community Engagement and Experiential Learning

Sparks, D. W. and J. O. Whitaker, Jr. 2006. Does food limitation force bats to avoid urban areas. Center for Community Engagement and Experiential Learning

Sparks, D. W. and J. O. Whitaker, Jr. 2006. How do roadways influence bats? Center for Community Engagement and Experiential Learning

2009: Listed in “Princeton Review.”

2006: Named to “Who’s Who in America.”

2000: Outstanding Presentation in Zoology, Indiana Academy of Science Annual Meeting.

2000: Outstanding Graduate Research Presentation, Indiana State University Graduate/Undergraduate Research Showcase.

1999: Outstanding Presentation in Zoology, Indiana Academy of Science Annual Meeting.

1995: Graduate Professional Paper Honorarium, Fort Hays State University

1995: President of Biology Club, Fort Hays State University

1993: Book Award for Outstanding Graduating Wildlife Student, Murray State University

1992: Outstanding Wildlife Student, Murray State University

1992: Collegiate Conservationist of the Year, Kentucky League of Sportsmen—Presented by Governor B.C. Jones

1991-1993: Kentucky Wildlife Federation/Kentucky League of Sportsmen Collegiate Scholarship.

1989-1990: Academic Achievement Scholarship, Murray State University.

PROFESSIONAL AFFILIATIONS

American Society of Mammalogists, Life member
Great Plains Natural Science Society, Life member
Southwestern Association of Naturalists, 1994
Indiana Academy of Science, 1977-Present
Society for Conservation Biology, 1996-2006
The Wildlife Society, 2000-Present

ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.
Résumé
Jason A. Duffey

EDUCATION

B.S., Environmental Science, Ohio State University, 1999

CERTIFICATIONS AND TRAINING

Endangered Species Consultation in Ohio, USFWS, 2005
Interagency Coordination – Section 7 of the Endangered Species Act, USFWS, 2006
Acoustical Monitoring for Indiana Bats, USFWS, 2007
Qualitative Habitat Evaluation Index (QHEI) / Biocriteria Training – Ohio EPA, 2007
Stream Habitat (QHEI) Certified Level 2 Qualified Data Collector – Ohio EPA 2008
Habitat Conservation Planning – Sec 10 of the Endangered Species Act, USFWS, 2008
Ohio Wetlands – CLE International, 2008
38 Hour Army Corps of Engineers Wetland Delineation Training, 2011
Ecological Training, Ohio Department of Transportation, 2011

QUALIFICATIONS AND EXPERIENCE

Mr. Duffey is entering his tenth year of working as a wildlife biologist. He has worked on various development projects throughout the eastern U.S., primarily in the areas of bat and stream ecology. He has participated in dozens of field studies for bats and possesses experience with capture (mist nets and bat traps), identification (including *Myotis sodalis* and *Myotis grisescens*), radio and light tagging and tracking, day and night bridge and other roost structure surveys, and winter in-cave hibernacula surveys (including *Corynorhinus townsendii virginianus*). Mr. Duffey also has experience with fishes and aquatic invertebrates, habitat characterization, and water quality analysis using a variety of probes, automatic samplers, and flow meters. He is familiar with standard field ecological stream assessment techniques and equipment, including Ohio EPA Qualitative Habitat Evaluation Index (QHEI) and Primary Headwater Habitat Evaluation Index (HHEI).

On most projects he is involved in, Mr. Duffey functions as the Project Manager, Field Supervisor, and Team Leader. He possesses exceptional expertise with managing large field survey crews, changing project routes and difficult land access situations. He also understands changing project timelines and scopes, client and agency information needs, and the link between the quality of field data and report quality. He has been the primary author on dozens of technical reports, several Biological Assessments and a contributing author on other ESA and NEPA documents.

PROJECT EXPERIENCE

Project Manager – Indiana Department of Natural Resources: 2005, 2007, 2009, 2011. Team member for Indiana bat biennial winter survey in known hibernacula of Indiana, statewide. Assisted in identification and counting of over 200,000 Indiana bats. Coordinated with various state agencies including Indiana DNR, USFWS, Missouri DoC

and IKC biologists to quantify hibernating Indiana bat populations including surveys of several Priority 1 hibernacula. Assisted with data analysis and coauthored technical report.

Project Manager / Field Supervisor– Ohio Department of Natural Resources: 2006, 2009, 2011. Coordinated efforts and performed counts of hibernating bats in Lewisburg Mine in 2006. The mine is currently distinguished as a Priority 2 and the largest Indiana bat hibernaculum in Ohio. Identified and counted all bats and recorded microclimate data for a large portion of the mine, coordinated federal and state agencies, the landowner, organized volunteer participation, and completed technical report. Documented several hundred bats of five species, including the Indiana bat (*Myotis sodalis*). Field Supervisor in 2009 and 2011.

Field Supervisor – Confidential Client, Wind Resource Area: 2011. Completed summer mist net surveys within a 19,926-acre site in Seneca and Crawford counties, Ohio. Responsible for mist net site operation and habitat assessment, bat identification, morphometric processing, and implementation of White Nose Syndrome protocols.

Field Supervisor – Confidential Client, Wind Resource Area: 2011. Completed summer mist net surveys within an 8151-acre site in Darke County, Ohio. Responsible for mist net site operation and habitat assessment, bat identification, morphometric processing, and implementation of White Nose Syndrome protocols.

Project Manager– Indiana Department of Transportation, SR25: 2011. Conducted summer mist net surveys for endangered bats in Carroll County, Indiana. Responsible for mist net site operation and habitat assessment, bat identification, morphometric processing, and implementation of White Nose Syndrome protocols.

Field Supervisor– M3 Midstream, LLC, Appalachia Pipeline: 2011. Completed mist net surveys for the federally endangered Indiana bat along a 130-mile natural gas pipeline ROW in Monongalia and Marion counties, West Virginia. Responsible for mist net site operation and habitat assessment, bat identification, morphometric processing, and implementation of White Nose Syndrome protocols.

Field Supervisor– Paramont Coal Company, Black Bear #1 Surface Mine: 2011. Completed mist net surveys for the federally endangered Indiana bat in Dickenson County, Virginia. Responsible for mist net site operation and habitat assessment, bat identification, morphometric processing, and implementation of White Nose Syndrome protocols.

Field Supervisor– Indiana Department of Transportation, Interstate 69, Pre- and Post-construction Surveys: 2011. Conducted summer mist net and AnaBat survey for federally endangered Indiana bat along final ROW for Sections 1, 2 and 3.

Project Manager– Indiana Department of Transportation, SR 641 Bypass (Phases III and IV): 2008-2010. Jurisdictional stream delineation, QHEI/HHEI stream habitat evaluation, and endangered bat survey along approximately six miles of proposed new roadway in Vigo County, Indiana. Responsible for all aspects of project, including field work, client and agency coordination (including ESA Section 7 formal consultation after *Myotis sodalis* capture), reporting and budget. Author for Biological Assessment.

Project Manager – Superior Appalachian Pipeline, LLC Snow Shoe Pipeline: 2010. Project manager for the completion of Indiana bat summer mist net survey along 14.5 miles of new natural gas pipeline in Centre County, Pennsylvania. At the request of PADCNR, ESI successfully tracked *Myotis leibii* to multiple roosts in Sproul State Forest.

Project Manager – Columbia County Airport Obstruction Removal: 2010. Project manager for mist net surveys, radio-telemetry, and acoustic monitoring for a captured federally endangered Indiana bat on a 12-acre tract of airport property and a portion of an adjacent golf course in Columbia County, New York.

Project Manager – Confidential Client: 2010. Prepared multiple Protection and Enhancement Plans for federally endangered Indiana bats in partial mitigation for construction at a coal mine in Greene County, Pennsylvania.

Field Supervisor – Superior Appalachian Pipeline, LLC. Karthaus Pipeline: 2010. Conducted a summer mist net survey to determine the presence or absence of Indiana bats along a 7-mile natural gas pipeline in Centre and Clearfield counties, Pennsylvania.

Project Manager – Equitrans, LP, Sunrise Pipeline: 2010. Conducted Indiana bat summer mist net survey on approximately 113 miles of natural gas pipeline in Greene County, Pennsylvania, and Doddridge, Marion, Harrison, Taylor and Wetzel counties, West Virginia. Managed all aspects of project, including direction of field efforts, reporting, and coordination with clients and agencies. One federally endangered Indiana bat was captured.

Project Manager – Entergy, James A. FitzPatrick Nuclear Power Plant: 2009. Managed completion of an Indiana bat habitat evaluation for expanding nuclear facility in Oswego County, New York. Managed all aspects of project, including direction of field efforts, reporting, and coordination with clients and agencies.

Project Manager – Paramont Coal Company, Dry Fork and Cabin Ridge Surface Mines: 2009. Completed summer mist net surveys for endangered bats in Wise (Dry Fork) and Dickenson (Cabin Ridge) counties, Virginia. Responsible for mist net site operation and habitat assessment, bat identification, morphometric processing, and implementation of White Nose Syndrome protocols. Managed all aspects of project, including direction of field efforts, reporting, and coordination with clients and agencies.

Project Manager – Paramont Coal Company, Doe Branch Surface Mine: 2009. Completed abandoned mine portal trapping, summer mist netting, and acoustic monitoring for endangered bats in Dickenson County, Virginia. Responsible for mist net site operation and habitat assessment, bat identification, morphometric processing, and implementation of White Nose Syndrome protocols. Managed all aspects of project, including direction of field efforts, reporting, and coordination with clients and agencies.

Biologist– Tennessee Gas Pipeline Company, 300 Line: 2009. Participated in eastern massasauga phase II survey at a compressor station site in Venango County, Pennsylvania. Responsibilities included checking cover boards and recording field data on 20 acres of potentially suitable habitat.

Project Manager – Consol Pennsylvania Coal Company, Enlow Beltline, Slurry Injection Boreholes, and 15I Powerline and Airshaft: 2009. Completed Indiana bat

habitat and mist net surveys in Greene and Washington counties, Pennsylvania. Responsible for mist net site operation and habitat assessment, bat identification, morphometric processing and implementation of White Nose Syndrome protocols. Managed all aspects of project, including direction of field efforts, reporting, and coordination with clients and agencies.

Project Manager – Consol Pennsylvania Coal Company, Bailey Mine: 2008, 2009, 2010, and 2011. Principal author for Biological Assessment to investigate effects of an overland conveyor belt and associated facilities on the federally endangered Indiana bat in Greene County, Pennsylvania. Principal author for Biological Assessment to investigate effects of coal refuse disposal on Indiana bats. Responsible for all aspects of ongoing Indiana bat monitoring, telemetry studies and reporting, associated revegetation management plan and conservation property management plan for Indiana bats. Participated in formal and informal ESA Section 7 consultation.

Biologist– Chief Gathering, Poor Shot Natural Gas Pipeline: 2009. Completed Indiana bat summer mist net survey along 10-mile natural gas pipeline right-of-way in Lycoming County, Pennsylvania. Responsible for mist net site operation and habitat assessment, bat identification, morphometric processing and implementation of White Nose Syndrome protocols.

Project Manager – Oswego County Airport: 2008. Indiana bat survey for airport obstruction removal project in Oswego County, New York. Responsible for all aspects of project, including field work, client and agency coordination (including ESA Section 7 informal consultation after *Myotis sodalis* capture), reporting, and budget.

Field Supervisor– TW Philips, Bionol Clearfield Pipeline: 2008. Mist net survey for the endangered Indiana bat associated with a proposed 8-mile pipeline in Clearfield County, Pennsylvania.

Field Supervisor – Confidential Client, Treated Effluent Line: 2008. Jurisdictional stream delineation, QHEI/HHEI stream habitat evaluation, and endangered bat netting survey for a proposed 10-mile pipeline in Stark County, Ohio. Responsible for all field data collection for streams and bats, water resources reporting, as well as client and staff coordination for field activities.

Biologist – Confidential Client, Natural Gas Transmission Pipeline: 2007-2008. Mist net survey for the endangered Indiana bat along a 250-mile pipeline running through portions of Ohio, West Virginia, and Pennsylvania.

Biologist – West Virginia Department of Natural Resources, Hellhole Cave Survey: 2005, 2007. Two time team member for biennial winter survey of Hellhole Cave, Pendleton County, West Virginia. Assisted in identification and counting of hibernating populations of more than ten thousand federally endangered Virginia big-eared and Indiana bats on the Plecotus Room Survey Route (Team Leader) in 2005 and the North Passage Survey Route in 2007. Hellhole is the most significant bat hibernaculum in the eastern U.S. with nearly 113,000 bats.

Biologist – American Electric Power, Wyoming-Jackson's Ferry 765 kV Transmission Line: 2004-2009. Participated in mist net surveys along 90-mile transmission line ROW in West Virginia and Virginia in 2004. Selected mist net site and captured one of the

very few Indiana bats ever documented in the state of Virginia, including the first in Tazewell County. Conducted mist net and acoustic AnaBat sampling at three wildlife mitigation ponds in 2007 and 2009. Installed 30 bat boxes along the Virginia portion of the ROW within the Jefferson National Forest during spring 2008.

Project Manager – Dutchess County Airport. 2007. Oversaw successful completion of field surveys where 11 Indiana bats (*Myotis sodalis*) were captured, diurnal radio telemetry was conducted for seven of those individuals, and 18 roosts were located. Principal author for Biological Assessment to evaluate effects of the Runway Safety Area Improvement and Obstruction Removal project on the federally endangered Indiana bat in Dutchess County, New York.

Project Manager – Continental Steel Superfund Site: 2007. Conducted Indiana bat roost tree inventory and emergence counts in Howard County, Indiana.

Project Manager – Columbia Gas, Hardy Storage Pipeline: 2005 – 2007. Completed presence/absence Indiana bat mist net survey along 28 miles of natural gas transmission ROW in West Virginia. Managed aspects of project, including conducting field surveys, coordinating with Federal and state agencies, landowners, reporting, Client coordination, including daily updates, and budget management.

Project Manager – Rockford Homes: 2007. Mist net survey for the endangered Indiana bat associated with 86-acre residential development in Franklin County, Ohio.

Biologist – Department of Defense, Fort Drum Army Installation: 2007. Participated in base-wide Indiana bat capture and radio-telemetry study initiated as a consequence of ESI's documentation of an Indiana bat on base property from telemetry studies conducted for a different Client in 2006.

Biologist – Kentucky Department of Fish & Wildlife Resources Vertebrate Inventory: 2007. All-inclusive vertebrate taxa inventory for amphibians, reptiles, birds, terrestrial mammals, and bats on five land tracts of two Wildlife Management Areas in Ballard, Hickman, and Fulton counties, Kentucky.

Project Manager – Panoramic Properties: 2007. Conducted wetland determination and Indiana bat habitat assessment on an 80-acre property in New York. Assessed site soil, vegetation and hydrological characteristics for making the wetland determination. Assessed habitat focusing on features indicative of suitability for Indiana bats.

Biologist – Equitrans, Big Sandy Pipeline: 2006 – 2007. Conducted abandoned mine portal search and assessed mines for potential winter bat habitat in 2006. Conducted Indiana bat potential roost tree and habitat assessments in Carter, Lawrence, Johnson, and Floyd counties, Kentucky in 2007.

Biologist – Indiana Department of Transportation, Route 62 Bridge: 2007. Conducted bat survey at Wabash River crossing in Posey County, Indiana. Investigated bat use of bridge for diurnal or nocturnal roost sites and conducted AnaBat sampling.

Project Manager – Dominion, Virginia City Hybrid Energy Center: 2007. Conducted endangered bat survey and portal searches on solid waste facility Wise County, Virginia.

Project Manager – Columbia Gas, Eastern Market Pipeline Expansion: 2007. Performed Indiana bat habitat assessment and abandoned mine portal search along 10 miles of natural gas pipeline and 24 well sites in Ohio and West Virginia.

Biologist – American Electric Power, Amos Plant: 2006. Effects Determination: Informal Section 7 Consultation for the Federally Endangered Indiana bat. Lead author on informal Biological Assessment of potential impacts to Indiana bats by a power plant expansion project in Putnam County, West Virginia.

Project Manager – Indiana Department of Transportation, Interstate 69: 2004 – 2006. Managed multi-year autumn, winter, and spring hibernacula survey of 38 caves in Greene, Monroe, and Lawrence counties, Indiana. Also participated in field collection survey and reporting for cave macroinvertebrates at caves in Monroe and Greene counties. Documented previously unknown species.

Project Manager– Clover Construction Management, Eagle Ridge Townhouses: 2006. Endangered bat survey on a proposed 105-acre development. Captured and performed radio-telemetry studies on Indiana bats. Primary author for comprehensive report of field survey, interpretation of collected data and comparison of data to relevant literature for Informal Section 7 Consultation.

Project Manager – Paramont Coal, No. 88 Surface Mine: 2006. Bat mist net survey on a 1378-acre surface mine development in Dickenson and Buchanan counties, West Virginia.

Project Manager – Beazer Homes, Francisco's Cave Winter Hibernaculum Survey: 2006. Performed counts of hibernating bats at a cave located within a proposed housing development site in Sussex County, New Jersey. Identified bats and recorded microclimate data to determine potential suitability for Indiana bats.

Project Manager – Columbia Gas, Virginia Looping Pipeline: 2005 – 2006. Managed and completed mist net survey for endangered bats along 34 miles of natural gas transmission line ROW in Virginia. Completed winter hibernaculum survey of Madden's Cave in Shenandoah County to determine use and potential suitability for endangered bats.

Biologist – Millennium Pipeline: 2005. Completed mist net surveys for the Indiana bat along a 45-mile proposed natural gas pipeline expansion in Orange and Rockland counties New York. Survey efforts included radio tracking of multiple bats to several roosts.

Biologist – Dominion Transmission, Cove Point Pipeline Expansion PL-1 Extension 2: 2005. Completed presence/absence surveys for the Indiana bat along an 80-mile proposed natural gas pipeline expansion in Pennsylvania.

Biologist – Department of Defense, Naval Support Activity, Crane Bat Inventory: 2005. Authored report for survey of 30 mist net sites located across approximately 100 square miles in Martin, Greene, and Lawrence counties Indiana.

Project Manager – Dominion Transmission, Wolf Run Compressor Station: 2005. Habitat and summer mist net survey for the Indiana bat on a 24-acre proposed natural

gas transmission compressor station site and associated access roads in Lewis County, West Virginia.

Biologist – Indiana Department of Natural Resources, Department of Forestry Habitat Conservation Plan: 2003 – 2006. Participated in multi-year field studies of Indiana bat autumn swarming/foraging behavior. Completed autumn harp trapping, Indiana bat light-tag and radio transmitter attachment, light-tag visual searches, day and night ground and aerial radio-tracking to locate roosts, and roost emergence counts. Assisted in production of technical report and sections of preliminary drafts of the combined Habitat Conservation Plan/Environmental Impact Statement.

Biologist – McCoy Elkhorn Coal, Frasure Creek Mining, Bear Fork Resources: 2004. Completed summer netting surveys for endangered bats and completed ground surveys to search for coal mine portals and perform suitability assessments along Long Fork and Robinson Creek, Pike County, Kentucky, and Mud Creek, Floyd County, Kentucky.

Biologist – Ohio Department of Transportation, U.S. Route 33, Pomeroy-Mason Bridge Replacement: 2004. Analyzed ultrasound (AnaBat) data for technical report on presence/absence of the Indiana bat in association with bridge replacement project.

Project Manager – Indiana Department of Transportation, State Route 66: 2004. Summer bat mist net survey for proposed roadway expansion project in Vanderburgh County, Indiana.

Project Manager – Department of Defense, Ravenna Training and Logistics Site, Bat Inventory: 2004. Inventory involving 28 mist net survey sites across approximately 34 square miles of an Ohio Army National Guard facility.

Project Manager – Indiana Department of Transportation, US 31 Kokomo Corridor: 2004. Managed summer mist net survey for the presence/absence of the Indiana bat on three crossings of Kokomo and Wildcat creeks. Directed field crews and conducted surveys.

Biologist – Pennsylvania Department of Environmental Protection, Bureau of Abandoned Mine Reclamation: 2002, 2004. Completed spring harp trap and acoustic AnaBat surveys of abandoned coal mine entrances to determine their suitability as winter hibernacula for the Indiana bat.

Biologist– American Electric Power, 765kv Transmission Line: 2003. Survey for endangered, threatened, and regional sensitive plant species along a 90-mile powerline right-of-way corridor in Virginia and West Virginia, including a crossing of Jefferson National Forest.

Biologist – USDA-FS, Chippewa National Forest: 2002 Participated in a playback survey for rare birds on nearly 7000 acres in Minnesota.

Field Assistant – Kentucky Department of Transportation, Mammoth Cave Survey: 2002. Assisted with summer presence/absence mist net survey and summer habitat assessment for endangered bats in association with Kentucky SR 70 Expansion Project at the Flint Ridge / Mammoth Cave system, Barren and Edmonson counties.

Water Quality Technician – Ohio EPA, Division of Surface Water: 1998 – 1999. Conducted biological fish sampling and chemical water quality surveys on major Ohio watersheds, including the Olentangy, Scioto, Kokosing, and Mohican.

Quality Assurance/Quality Control Lab Technician – Ohio EPA, Division of Environmental Services: 1998-1999. Responsible for receiving, logging (chain of custody), and sorting of water, air, sediment, and fish tissue samples.

PUBLICATIONS

Brack, V. Jr., and J. A. Duffey. 2006. Bats of Ravenna Training and Logistics Site, Portage and Trumbull Counties, Ohio. Ohio Journal of Science 106(5):186-190

Brack, V., Jr., J. A. Duffey, R. K. Dunlap, and S. A. Johnson. 2005. Flooding of hibernacula in Indiana: when are caves population sinks? Bat Research News 46:71-74.

ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.
Résumé
David Jeffcott

QUALIFICATIONS AND EXPERIENCE WITH BATS

Mr. Jeffcott has been a wildlife biologist with ESI and participated in field surveys for threatened and endangered species for ten years. He has worked on various development projects in the eastern U.S. and has experience in mist netting, and identifying, processing, and radio-tracking federally endangered Indiana bats. Mr. Jeffcott has served on survey teams for both small and large projects, including the Indiana DNR's Habitat Conservation Plan and the Indianapolis to Evansville I-69 expressway project. His participation in the I-69 project included bat capture, radio-tagging, tracking, and emergence counts at diurnal roosts. He also participated in winter surveys for bats in caves along the proposed I-69 ROW.

Mr. Jeffcott's field experience includes bat handling, identification and proficiency with the following equipment and techniques:

- Bat processing to determine species, weight, gender, and various measurements
- Mist netting
- Harp trapping
- Habitat suitability assessment
- Roost tree identification
- Ultrasound detectors
- Spring/autumn cave/mine (hibernacula) entrance surveying
- Summer bat surveys
- Winter Hibernacula surveys

PROJECT EXPERIENCE

Field Supervisor – CNX Gas Company, LLC, Tygart Valley Pipeline: 2012. Completed portal searches along a 33-mile pipeline in Upshur and Barbour counties, West Virginia.

Field Supervisor – American Electric Power, Bonnyman – Soft Shell 138kV Transmission Line: 2011 and 2012. Conducted portal searches, acoustic sampling, and summer mist netting along a 19.6-mile transmission line in Perry and Knott counties, Kentucky.

Field Supervisor – Confidential Client, Wind Resource Area: 2011. Completed mist netting and acoustic surveys for the federally endangered Indiana bat in Whitley County, Indiana.

Field Supervisor – Paramont Coal Company, Black Bear #1 Surface Mine: 2011. Completed mist net surveys for the federally endangered Indiana bat in Dickenson County, Virginia.

Field Supervisor – Confidential Client, Wind Resource Area: 2011. Completed mist netting, acoustic surveys, and telemetry for the federally endangered Indiana bat within a 23,468.7-acre site in Jay and Randolph counties, Indiana.

Field Supervisor – ANR Pipeline Company- Interstate 269 Pipeline Relocation: Completed endangered bat survey along 0.7-mile pipeline ROW in Fayette and Shelby counties, Tennessee.

Field Supervisor – Forest Preserve District of Kane County: 2011. Completed summer bat mist net and acoustic surveys at four forest preserves in Kane County, Illinois.

Field Supervisor – American Electric Power, Mayo Trail Extension: 2011. Conducted Indiana bat spring portal searches, portal emergence counts, acoustic monitoring, and summer mist netting on a proposed 1.2-mile 69 kV transmission line in Johnson County, Kentucky.

Field Supervisor – Confidential Client, Wind Resource Area: 2011. Completed summer mist net surveys within a 19,926-acre site in Seneca and Crawford counties, Ohio.

Field Supervisor – Confidential Client, Wind Resource Area: 2011. Completed summer mist net surveys within an 8151-acre site in Darke County, Ohio.

Field Supervisor – American Electric Power, Sand Hill-Wharton Hill 138kV Transmission Line: 2011. Completed bat habitat assessment and portal searches along a new 7-mile transmission line and associated access roads in Marshall County, West Virginia.

Field Supervisor – Chief Gathering Natural Gas Pipeline: 2011. Completed summer mist net survey, portal search, and small-footed bat habitat survey along 30.1-mile pipeline in Luzerne and Wyoming counties, Pennsylvania.

Field Supervisor – American Electric Power, Fleming to Freemont Transmission Line Rebuild: 2010-2011. Performed portal searches, habitat assessments, and mist netting on two transmission line upgrade segments in Wise and Dickenson counties, Virginia.

Field Supervisor – Clintwood Elkhorn Mining Company, Spring Branch Surface Mine: 2010. Conducted summer mist net surveys for endangered bats on a 285-acre mine site in Buchanan County, Virginia.

Field Supervisor– American Electric Power and U.S. Department of Energy, Mountaineer CCS II, CO_2 Pipeline and Injection Well Sites: 2010. Conducted summer mist net survey for federally endangered Indiana bat for a CO_2 transport and injection project in Mason County, West Virginia. Responsible for mist net site set up and habitat assessment, bat identification, morphometric processing and implementation of White Nose Syndrome protocols.

Field Supervisor – American Electric Power, Middle Creek 46 kV to 138 kV Upgrade: 2010. Conducted federally endangered Indiana bat surveys and portal searches along a 6.33 mile long transmission ROW in Floyd County, Kentucky. Responsible for mist net

site set up and habitat assessment, bat identification, morphometric processing and implementation of White Nose Syndrome protocols.

Field Supervisor – Paramont Virginia Coal Company, LLC, Kiwanis Park Surface Mine: 2010. Completed endangered bat surveys in in Dickenson County, Virginia. Responsible for mist net site set up and habitat assessment, bat identification, morphometric processing and implementation of White Nose Syndrome protocols.

Field Supervisor – American Electric Power, Mayo Trail - West Paintsville 69 kV Line: 2010. Conducted federally endangered Indiana bat surveys and portal searches along a 1.86-mile transmission line in Johnson County, Kentucky. Responsible for mist net site set up and habitat assessment, bat identification, morphometric processing and implementation of White Nose Syndrome protocols.

Field Supervisor – Columbia Transmission LLC, Line 1278 – Line K Pipeline Replacement: 2010. Conducted endangered bat surveys along a 17-mile natural gas pipeline replacement in Pike County, Pennsylvania and Orange County, New York. Responsible for mist net site set up and habitat assessment, bat identification, morphometric processing and implementation of White Nose Syndrome protocols.

Team Leader – Equitrans, LP, Sunrise Pipeline: 2010. Conducted Indiana bat summer mist net survey in Greene County, Pennsylvania, and Doddridge, Marion, Harrison, and Taylor and Wetzel counties, West Virginia. Responsible for mist net site set up and habitat assessment, bat identification, morphometric processing and implementation of White Nose Syndrome protocols.

Biologist– Global Geophysical Services Rolling Rock 3-D Seismic Survey: 2010. Assisted with rare plant surveys and habitat assessments in Fayette County, Pennsylvania.

Team Leader – Wells Prairie Wind Project: 2010. Conducted acoustic studies for endangered bats on a 61,256-acre, 300-megawatt wind energy generation facility in Wells, Adams, Blackford, and Jay counties, Indiana.

Field Supervisor – American Electric Power, Beaver Creek - Hazard 138 kV Relocation (Leeco): 2010. Conducted a habitat assessment and mist net survey for federally endangered Indiana bat along 1.4 miles of ROW for a power line relocation in Perry County, Kentucky. Responsible for mist net site set up and habitat assessment, bat identification, morphometric processing and implementation of White Nose Syndrome protocols.

Field Supervisor – Entergy James A. FitzPatrick Nuclear Power Plant: 2009. Completed fieldwork for Indiana bat habitat evaluation for expanding nuclear facility in Oswego County, New York.

Team Leader – Tennessee Gas Pipeline Company, 300 Line: 2009. Completed portal trapping and net site reconnaissance along a 120-mile natural gas pipeline looping project in Passaic and Sussex counties, New Jersey. Also Completed Indiana bat habitat and mist net surveys in Potter, Tioga, Bradford, Susquehanna, Wayne, Pike, Venango, and McKean counties, Pennsylvania and Passaic and Sussex counties, New Jersey.

Team Leader – Paramont Coal Company, Dry Fork and Cabin Ridge Surface Mines: 2009. Completed summer mist net surveys for endangered bats in Wise (Dry Fork) and Dickenson (Cabin Ridge) counties, Virginia. Responsible for mist net site set up and habitat assessment, bat identification, morphometric processing and implementation of White Nose Syndrome protocols.

Team Leader – Paramont Coal Company, Doe Branch Surface Mine: 2009. Completed abandoned mine portal searches and summer mist net surveys for endangered bats in Dickenson County, Virginia. Responsible for mist net site set up and habitat assessment, bat identification, morphometric processing and implementation of White Nose Syndrome protocols.

Field Supervisor – Fola Coal Company, Tomahawk Surface Mine: 2009. Completed federally endangered Indiana bat summer mist net survey in Nicholas County, West Virginia. Responsible for mist net site set up and habitat assessment, bat identification, morphometric processing and implementation of White Nose Syndrome protocols.

Field Supervisor – Consol Pennsylvania Coal Company, Bailey Mine: 2008, 2009. Environmental inspections to investigate effects of overland conveyor belt and associated facilities on the federally endangered Indiana bat in Greene County, Pennsylvania. Responsibilities included confirming project activities did not impact known day roosts and providing oversight to spill prevention and sediment and erosion control programs.

Field Supervisor – Chief Gathering, Poor Shot Natural Gas Pipeline: 2009. Completed Indiana bat winter habitat assessment and summer mist net survey along 10-mile natural gas pipeline right-of-way in Lycoming County, Pennsylvania.

Biologist – Chestnut Flats Wind, LLC Wind Farm: 2008. Participated in endangered northeastern bulrush surveys for a project involving the construction of all aspects of a wind farm including clearing/grubbing and the subsequent construction of concrete pads, towers, access roads, buried cable lines, an overhead transmission line and an electrical substation near Altoona, Blair, and Cambria counties, Pennsylvania.

Biologist – Equitable Resources, Amity Pipeline: 2008. Assisted with plant survey for leaf-cup, gray-headed prairie coneflower, and mistflower along 12-mile pipeline corridor in Greene and Washington counties, Pennsylvania.

Biologist – Columbia Gas Line O-1821: 2008. Participated in potential roost tree marking along approximately 3.1 miles of pipeline ROW in Guernsey County, Ohio.

Biologist – Equitrans, Ranger Pipeline: 2008. Participated in summer mist net survey for the Indiana bat (*Myotis sodalis*) in Martin County, Kentucky.

Biologist – Confidential Client, Treated Effluent Line: 2008. Team leader for summer mist net survey for endangered Indiana bat for a proposed 10-mile pipeline in Stark County, Ohio. Efforts included mist netting, bat handling and morphometric processing, bat identification, and implementation of White Nose Syndrome protocols.

Biologist – Consol Pennsylvania Coal Company, Bailey Mine: 2008. Participated in field survey activities related to production of a Biological Assessment Evaluation to

investigate effects of overland conveyor belt and associated facilities on the federally endangered Indiana bat in Greene County, Pennsylvania.

Biologist – Columbia Gas, Ohio Storage Expansion: 2008. Led field team to conduct a survey for Indiana bats and their potential roosting habitat in two separate natural gas storage fields in Ohio.

Field Assistant – Confidential Client, Natural Gas Transmission Pipeline: 2008. Assisted with threatened/endangered plant survey along a 250-mile pipeline running through portions of Ohio, West Virginia, and Pennsylvania. Also served as team leader for endangered bat survey. Efforts included mist netting, bat handling and morphometric processing, bat identification, and implementation of White Nose Syndrome protocols.

Biologist – Equitrans, Big Sandy Pipeline: 2007. Conducted Indiana bat habitat assessment along proposed 68-mile natural gas transmission line in Carter, Lawrence, Johnson, and Floyd counties, Kentucky.

Biologist – Department of Defense, Fort Drum Army Installation: 2007. Facility-wide bat survey focusing on Indiana bat capture and radio-telemetry. This survey was initiated due to ESI's documentation of an Indiana bat on base property in 2006. Survey efforts included over 80 mist net sites and Indiana bat radio-tagging. Responsible for conducting mist net sampling, identifying captured bats, and assessing habitat at net sites.

Biologist – Indiana Department of Transportation: 2007. Participated in study of Route 42 bridge over Cataract Lake in Owen County, and Route 62 bridge over Wabash River in Posey County, Indiana to determine use by bats.

Biologist – American Electric Power 138 kV Transmission Line: 2007. Assisted with endangered bat mist net survey, AnaBat and portal searches along an 8.3-mile electric transmission line ROW in Floyd County, Kentucky

Biologist – Columbia Gas, Eastern Market Pipeline Expansion: 2007. Participated in Indiana bat habitat assessment and abandoned mine portal search along 10 miles of natural gas pipeline and 24 well sites in Ohio and West Virginia.

Biologist – Columbia Gas Line O-1821: 2007. Participated in endangered bat survey along approximately 3.1 miles of pipeline ROW in Guernsey County, Ohio.

Biologist – Rockford Homes. 2007. Participated in mist net survey for the endangered Indiana bat on an 8.8-acre woodlot and associated fencerows associated with a proposed residential housing development.

Biologist – Summerfields at Franklin. 2007. Assisted with a mist net survey to determine the presence/absence of the endangered Indiana bat on 17.7 acres of a 176-acre proposed residential housing development site.

Biologist – American Electric Power Amos Plant: 2006. Indiana bat Habitat Assessment for a power plant expansion project in Putnam County, West Virginia: Conducted roost tree surveys to determine the presence of potential roost trees within the affected area. Trees likely to provide potential roosting habitat were observed to

determine whether bats were currently using them. Also completed numerous sample plots within a 2.5-mile radius of the project site to verify habitat composition. Data were used to prepare a Biological Assessment.

Biologist – Eagle Ridge Townhouses: 2006. Conducted endangered bat radio-telemetry survey for a proposed 105-acre townhouse development associated with Fort Drum. Conducted emergence counts, and collected data on foraging areas through use of simultaneous radio-telemetry triangulation.

Team Leader – USDA – FS, Allegheny National Forest: 2006. Led a 55-site bat survey covering potentially impacted areas in Elk, Forest, McKean, and Warren counties, Pennsylvania. As a team leader, responsibilities included, conducting mist net sampling, identifying captured bats, and assessing habitat at net sites.

Team Leader – Algonquin Ramapo Pipeline Expansion: 2006. Completed presence/absence mist net survey for the Indiana bat, along approximately 5 miles of existing natural gas pipeline and three associated compressor stations in three counties of New York and New Jersey. Mist netting was conducted from late June to mid July, and utilized alternative mist netting methods, including non-conductive netting poles, while surveying in proximity to high-tension powerlines.

Team Leader – Tuxedo Reserve: 2006. Conducted presence/absence mist net survey for the Indiana bat as part of consultation for endangered species on a new housing development in southeastern New York. Completed net site reconnaissance, bat habitat assessments; mist net set-up, and bat handling and identification.

Team Leader – Garden Homes: 2006. Completed presence/absence surveys for the Indiana bat as part of consultation for endangered species on a 100-acre site in Essex County, New Jersey.

Team Leader – Pocono Manor Endangered Bat Survey: 2006. Conducted an Indiana bat survey for a 5000-acre commercial and residential development in Pennsylvania. As a team leader, responsibilities included, selecting sites and conducting mist net sampling, identifying captured bats, and assessing habitat at net sites.

Field Assistant – Equitrans, Big Sandy Pipeline: 2006. Participated in a field search for potential winter bat hibernacula along 68-mile natural gas pipeline in Carter, Lawrence, Johnson, and Floyd counties, Kentucky.

Field Assistant – Lewisburg Mine Hibernaculum Count: 2006. Conducted bat counts in the largest hibernacula in Ohio for the Ohio Division of Natural Resources. Assisted a team of 10 people identifying and counting bats in two of the nine sections within the mine complex. Responsibilities included navigation throughout the mine and data collection.

Field Director – Northeast Storage Gas Pipeline: 2005. Summer mist net survey for endangered bats along the 21-mile Northeast Storage natural gas pipeline in Potter and McKean counties, Pennsylvania, and Cattaraugus County, New York. Responsibilities include oversight of all aspects of the bat field survey, net location, trapping, netting, net site selection, bat capture and identification, and habitat characterization.

Field Director – Dominion Transmission TL 453 Endangered Bat Surveys: 2005. Summer mist net survey for endangered bats along the 12-mile natural gas pipeline in Potter County, Pennsylvania. Responsibilities include oversight of all aspects of the field survey including net site delineation, trapping, netting, selection of survey netting sites, capture and identification of bats, and habitat characterization.

Field Director – Dominion Transmission TL 536 Endangered Bat Surveys: 2005. Summer mist net survey for endangered bats along the 9-mile natural gas line in Potter County, Pennsylvania. Responsibilities include oversight of all aspects of the field survey including net site delineation, trapping, netting, selection of survey netting sites, capture and identification of bats, and habitat characterization.

Team Leader – Indiana Department of Transportation, Interstate 69 Tier II Environmental Studies, Segments 1, 2, and 4: 2004. Completed summer netting surveys and radio-telemetry studies of microhabitat use by the Indiana bat along three sections of the proposed interstate corridor in Indiana.

Team Leader – Gohman Asphalt Highway Project: 2004. Completed summer netting surveys of the Indiana bat along a highway near Evansville, Indiana.

Team Leader – McCoy Elkhorn Coal: 2004. Completed summer netting surveys for endangered bats and completed a ground surveys to search for coal mine portals and perform suitability assessments along Long Fork, Pike County, Kentucky.

Team Leader – Frasure Creek Mining: 2004. Completed summer netting surveys for endangered bats and completed a ground surveys to search for coal mine portals and perform suitability assessments along Mud Creek, Floyd County, Kentucky.

Team Leader – Bear Fork Resources: 2004. Completed summer netting surveys for endangered bats and completed a ground surveys to search for to search for coal mine portals and perform suitability assessments along Robinson Creek, Pike County, Kentucky.

Team Leader – Elkhorn Coal: 2004. Completed summer netting surveys for endangered bats and completed a ground surveys to search for to search for coal mine portals and perform suitability assessments along Frasier Creek, Floyd County, Kentucky.

Field Assistant – Indiana Department of Natural Resources, Department of Forestry Habitat Conservation Plan: 2004. Conducted summer and autumn surveys and radiotelemetry microhabitat studies for incorporation into the Indiana DNR's Habitat Conservation Plan for the endangered Indiana Bat, Harrison-Crawford State Forest, Harrison and Crawford counties, Indiana.

Team Leader – Indiana Department of Transportation, Interstate 69 Tier II Environmental Studies: 2004–2006. Conducted autumn harp trap surveys for bats at cave openings and completed winter in-cave surveys for all species of bats in 7 caves along proposed Interstate 69 corridor in Greene, Monroe, and Lawrence counties, Indiana.

Team Leader – Ohio Department of Transportation, Millikin Road and State Route 747 Road Expansion: 2003. Conducted Indiana bat roost tree emergence count and Anabat survey. within the roadway corridor in Butler County, Ohio.

Team Leader – Department of Transportation, Portsmouth Bypass: 2003. Conducted mist net surveys and summer habitat assessments for the Indiana bat for a highway development in Scioto County, Ohio.

Field Director – Coal-Mac Stripmine Surveys: 2003. Conducted mist net surveys and summer habitat assessments for endangered bats for 3 sites of 296.31 acres, 838.58 acres, and 601 acres for a coal mine development in Logan County, West Virginia.

Team Leader – Phelps Stripmine Surveys: 2002. Conducted mist net surveys and summer habitat assessments for the Indiana bat for a 1459-acre coal mine development in Pike County, Kentucky.

Field Assistant – Kentucky Transportation Cabinet, Kentucky State Route 30 Reconstruction: 2002. Completed summer mist net survey and summer habitat assessment for road construction project in Jackson County, Kentucky.

Field Assistant – Ohio Department of Transportation, Route 33 Nelsonville Bypass: 2002. Bypass project in Hocking and Athens counties, Ohio. Completed (1) Spring survey of mine portal for bats using bat traps, mist nets and Anabat, (2) Autumn harp trap and mist net sampling of mine portals along the proposed ROW, and (3) Endangered Indiana bat Summer mist net survey and summer habitat assessment.

Field Assistant – Department of Defense, Fort McClellan Army National Guard Training Center: 2002. Gray bat netting and radiotelemetry studies (roosting and foraging).

Field Assistant – K. Hovnanian Properties: 2002. Completed Indiana bat summer mist net survey and summer habitat assessment for property development in Essex County, New Jersey.

Field Assistant – USDA – FS, Allegheny National Forest: 2002. Assisted with Indiana bat Summer mist net survey and habitat assessment on the forest in Pennsylvania.

Field Assistant – Lewisburg Mine Winter Hibernaculum Survey: 2002. Assisted with winter survey of a limestone mine used as a hibernaculum by 9,600 endangered Indiana bats.

Field Assistant – Kentucky Transportation Cabinet, US Route 68/KY 80 Lake to Canton: 2002. Completed summer mist net survey and summer habitat assessment along highway expansion project at Land Between the Lakes in Trigg County, Kentucky.

Botanical Assistant – USDA – FS, Chippewa National Forest: 2002. Survey for endangered, threatened, and regional sensitive plant species in areas proposed for timber harvest on the forest in Minnesota.

Field Assistant – Red River Coal Company Backbone Ridge Mine Permit Area: 2002. Assisted with survey for the federally threatened small whorled pogonia (*Isotria medeoloides*) and its habitat in Wise County, Virginia.

Field Assistant – Virginia Department of Transportation Coalfields Expressway Corridor and Route 460 Connector: 2001. Harp Trap/mist net/bat detector survey of mine portals along proposed highway project in Wise, Dickenson, and Buchanon counties, Virginia. The project assessed potential bat use of over 100 portals and sampling was completed at 23 locations that potentially provide non-maternity habitat for the Indiana bat.

Field Assistant – Meg-Lynn Land Company Straight Fork Surface Mine Permit Area: 2001. (1) Completed spring trapping for endangered bats of a coal mine system proposed for closure as part of a mining development, (2) Completed spring mist netting to further characterize the chiropterafauna of the project area, and (3) Characterized the habitat of 2,200 acres of project lands for suitability as summer habitat for the endangered Indiana bat.

Field Assistant – White Oak Marina Development: 2001. Completed summer mist net survey and summer habitat assessment for a marina development, LaSalle County, Illinois.

Field Assistant – Red River Coal Company Backbone Ridge Mine Permit Area: 2001. Completed mist net survey and summer habitat assessment in Wise County, Virginia.

Field Assistant – Infra-Metals Industrial Barge Facility: 2001. Completed summer mist net survey and summer habitat assessment for an industrial development site in LaSalle County, Illinois.

Botanical Assistant– American Electric Power 765kv Transmission Line: 2001-2002. Survey for endangered, threatened, and regional sensitive plant species along a 90-mile powerline right-of-way corridor in Virginia and West Virginia, including a crossing of Jefferson National Forest.

ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.
Résumé
Amanda F. Janicki

EDUCATION

Ph.D., Ecology and Evolutionary Biology, University of Tennessee, In progress
M.S., Biology, Missouri State University, 2010. Thesis: "Effects of White-Nose Syndrome on Winter Energetics of Little Brown Bats (*Myotis lucifugus*)"
B.S., Biology, Susquehanna University, 2008.

QUALIFICATIONS AND EXPERIENCE

Ms. Janicki is a wildlife biologist involved in a variety of terrestrial ecology research projects and has extensively studied bats and their habitat for over six years. While completing her undergraduate degree at Susquehanna University, she participated in a project involving summer trapping and pit tagging of little brown bats at a barn in Selinsgrove, Pennsylvania. She also completed a project in the Nantahala National Forest, North Carolina involving trapping and radio tracking Indiana bats to learn more about the effects of different logging techniques on the species and its habitat. Ms. Janicki got involved in White-Nose Syndrome bat research for her master's degree at Missouri State University. Her research led her to compare the metabolic rates and blood samples of little brown bats from Williams Lake Hotel mine in New York, Woodward Cave in Pennsylvania, and Brooks Cave in Missouri to better understand how the disease kills affected bats. While in Missouri, she also assisted the Missouri Department of Conservation to complete bat fall swarming counts and winter hibernacula census counts at sites used by Indiana and gray bats.

Ms. Janicki is experienced in many ecological field techniques, including: species identification, habitat assessment, trapping, netting, radio-telemetry and tracking, acoustic sampling and analysis, and the collection of wing punches, blood, and fecal samples.

She is an experienced public speaker, having taught university-level courses, and presented numerous technical papers to professional organizations such as the American Society of Mammalogists, the North American Society for Bat Research, the Pennsylvania Chapter of the Wildlife Society, the Southeastern Bat Diversity Network, the National Council on Undergraduate Research, and the Northeast Bat Working Group**.** Much of her public speaking is on the topic of White Nose Syndrome and she is completing her PhD on the subject at the University of Tennessee. She recently assisted the Tennessee Wildlife Resources Agency to monitor Indiana and gray bat hibernacula for the spread of White-Nose Syndrome.

PROJECT EXPERIENCE

Biologist – Confidential Client: 2011. Conducted summer bat mist net pre-construction surveys for proposed wind turbine sites.

Laboratory Assistant – Smithsonian Institution: 2009. Assisted with analysis of wing damage in connection with White-Nose Syndrome research.

Research Assistant – Missouri State University: 2008-2010. Assisted with project to compare metabolic rates of little brown bats in New York, Pennsylvania, and Missouri and the relationship to White-Nose Syndrome.

Field Assistant – Missouri State University and U.S. Forest Service: 2008. Conducted summer mist netting for bats in Mark Twain National Forest in the Ava Ranger District, Missouri.

Biologist – Susquehanna University: 2007- 2008. Developed an independent research project on the effect of body mass on the emergence time of little brown bats at a maternity colony.

Field Assistant – Southeastern Bat Diversity Network: 2007-2011. Conducted summer mist netting for bats in Cherokee National Forest, Tennessee; Bankhead National Forest, Alabama; Mark Twain National Forest, Missouri; Chattahoochee National Forest, Georgia; and Pisgah National Forest, North Carolina.

Field Assistant – Clemson University and U.S. Forest Service: 2007. Conducted mist netting, radio-telemetry, and acoustic monitoring for bats in Nantahala National Forest, North Carolina.

Biologist – University of Kansas Neotropical Bat Ecology program: 2007. Assisted with project in Costa Rica to analyze emergence times in 33 neotropical bat species.

Field Assistant – Pennsylvania Trappers Association Coyote Hunt: 2007 and 2008. Collected coyote stomachs and assisted with analysis of stomach contents to determine the animals' diet.

Research Assistant – Susquehanna University: 2006-2008. Assisted with project involving trapping and surveying vertebrates in Shikellamy State Park and PP & L Montour Preserve, Pennsylvania.

TEACHING EXPERIENCE

Graduate Assistant – University of Tennessee: 2010-present. Taught several courses including Humankind in the Biotic World lab, Biodiversity lab and Human Anatomy lab.

Graduate Assistant – Missouri State University: 2008-2010. Taught three sections of Principles of Biological Science lab.

PUBLICATIONS

Janicki, A. F. 2008. Does Fatness Matter? The Effect of Body Mass on the Emergence Time of Little Brown Bats (*Myotis lucifugus*) at a Maternity Colony in Central Pennsylvania *in* Proceedings of The National Conference on Undergraduate Research 2008.

PRESENTATIONS

Janicki, A. F., J. Caddle, J. Cooper, T. Guldan, S. Haque, and P. Armsworth. Modeling a Theoretical "Cleaning" Agent for White-Nose Syndrome at 2011 White-Nose Syndrome Symposium, Little Rock, AR (May 17-19, 2011)

Janicki, A. F. and T. E. Tomasi. What Does the Body Condition of Little Brown Bats (*Myotis lucifugus*) reveal about White-Nose Syndrome? at 90th American Society of Mammalogists Annual Meeting, University of Wyoming, Laramie, WY (June 11-15, 2010)

Tomasi, T. E. and A. F. Janicki. White-Nose Syndrome and Winter Energetics of Little Brown Bats at 2010 White-Nose Syndrome Symposium, Pittsburgh, PA (May 25-27, 2010)

Janicki, A. F. Winter Energetics of Little Brown Bats (*Myotis lucifugus*) Affected by White-Nose Syndrome Thesis Defense, Missouri State University, Springfield, MO (April 19, 2010)

Janicki, A. F. and T. E. Tomasi. One Piece of the White-Nose Syndrome Puzzle: Torpid Metabolic Rates of *Myotis lucifugus* at 39th North American Society for Bat Research, Portland, OR (November 4-7, 2009)

Janicki, A. F. and T. E. Tomasi. The Effect of White-Nose Syndrome on Torpid Metabolic Rates of *Myotis lucifugus* at 89th American Society of Mammalogists Annual Meeting, University of Alaska, Fairbanks, AK (June 24-28, 2009)

Janicki, A. F. and T. E. Tomasi. Energetics of Little Brown Bats (*Myotis lucifugus*) with White-Nose Syndrome at PA Chapter of the Wildlife Society, Penn State University, State College, PA (March 28, 2009)

Janicki, A. F. Summer and Winter Energetics of Little Brown Bats (*Myotis lucifugus*) Affected by White-Nose Syndrome at a biology department senior seminar at Susquehanna University, Selinsgrove, PA (March 20, 2009)

Janicki, A. F. and T. E. Tomasi. Does White-Nose Syndrome Affect Summer Energetics of *Myotis lucifugus*? at Southeastern Bat Diversity Network Annual Meeting, Arkansas State University, Jonesboro, AR (February 12-13, 2009)

Janicki, A. F. and T. E. Tomasi. Summer Energetics of *Myotis lucifugus* in Areas Affected and Unaffected with White-Nose Syndrome at 38th North American Symposium for Bat Research, University of Scranton, Scranton, PA (October 22-25, 2008)

Janicki, A. F. and C. A. Iudica. Emergence Time of *Myotis lucifugus*: Effect of Body Mass and Climatic Conditions at 88th American Society of Mammalogists Annual Meeting, South Dakota State University, Brookings, SD (June 22-25, 2008)

Janicki, A. F. and C. A. Iudica. Does Fatness Matter? The Effect of Body Mass on the Emergence Time of Little Brown Bats (*Myotis lucifugus*) at a Maternity Colony in Central Pennsylvania at The National Council on Undergraduate Research, Salisbury University, Salisbury, MD (April 10-12, 2008)

Janicki, A. F. and C. A. Iudica. Factors Impacting Emergence Time of Little Brown Bats (*Myotis lucifugus*) at a Maternity Colony in Central PA at Joint Meeting of Northeast Bat Working Group and Southeastern Bat Diversity Network, Virginia Tech, Blacksburg, VA (Feb 20-22, 2008)

Janicki, A. F. Really, You Are As Blind As a Bat? Too Bad Bats Are Not Blind at a weekly group meeting at the Town of Pittsford VanHuysen Senior Center, Pittsford, NY (Dec 18, 2007)

Janicki, A. F. and C. A. Iudica. Documented Color Abnormality on Pelage of the Northern Short-tailed Shrew (*Blarina brevicauda*) in Montour County, PA at Seeking Common Ground Along the Susquehanna, Bucknell University, Lewisburg, PA (Sept 29, 2007)

Janicki, A. F., S. M. Khalafalla, C. E. Veeck, and C. A. Iudica. Data From the 1st Year of a Long Term Ecological Study of Terrestrial Vertebrates from the Susquehanna River Basin at Seeking Common Ground Along the Susquehanna, Bucknell University, Lewisburg, PA (Sept 29, 2007)

Janicki, A. F. and C. A. Iudica. A Long Term Ecological Study of Mammals in Central Pennsylvania: the 1st Year Survey at 87th American Society of Mammalogists Annual Meeting, University of New Mexico, Albuquerque, NM (June 5-10, 2007)

Iudica, C. A. and A. F. Janicki. Albinistic Northern Short-Tailed Shrew (*Blarina brevicauda*) in Montour County, PA at 87th American Society of Mammalogists Annual Meeting, University of New Mexico, Albuquerque, NM (June 5-10, 2007)

Janicki, A. F. and C. A. Iudica. What Terrestrial Vertebrates Do We Have Out There? A Methodology for Monitoring Biodiversity at From the Branches of Confluence: The Upper Susquehanna River Basin and its Communities Conference, Bucknell University, Lewisburg, PA (Sept 23, 2006)

Janicki, A. F. and C. A. Iudica. A Long Term Ecological Study of Terrestrial Vertebrates in Central Pennsylvania at 86th American Society of Mammalogists Annual Meeting, University of Massachusetts, Amherst, MA (June 18-21, 2006)

HONORS AND AWARDS

University of Tennessee Graduate Assistantship (Fall 2010 – present)
Missouri State University Graduate Interdisciplinary Forum best poster (Spring 2009)
Missouri State University Graduate Assistantship (Fall 2008 – Spring 2010)
Susquehanna University Dean's List (all semesters) and National Dean's List (Spring 2006, 2007)
Susquehanna University Selected Profile Video (posted Fall 2006)
Member of ΣΑπ National Society of Leadership and Success (Fall 2007 – present)
Member of Beta Beta Beta Biology Honor Society (Fall 2005 – present)
Susquehanna University Scholarship for Distinguished Achievement in Science and Mathematics Recipient (Fall 2004 – Spring 2008)
Wildlife Highest Score in Monroe County' NY Envirothon (2002, 2003, 2004)

PROFESSIONAL AFFILIATIONS

North American Society for Bat Research – member (2008 – present) and student representative of the NASBR Board of Directors (2010 – 2011)
American Society of Mammalogists – member and participant in Membership and Resolutions Committees (2006 – present)

ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.
Résumé
Andrew B. Kniowski

EDUCATION

M.S., Environment and Natural Resources, The Ohio State University, 2011
B.S., Biology, Liberty University, 2006

CERTIFICATIONS AND TRAINING

Wildland Firefighter, Red Card certification

QUALIFICATIONS AND EXPERIENCE

Mr. Kniowski has been involved with a variety of aquatic and terrestrial ecology research positions, working closely with herpetofauna (amphibians and reptiles), birds, and bats. He is familiar with the physiology, taxonomy, and ecology of many extant vertebrates and has completed surveys for a variety of species in the eastern United States. He has experience coordinating multiple field survey teams, maintaining contact with property owners, and producing follow-up documentation.

He has experience with the following techniques and equipment:

- Mist net set up, bat handling and morphometric processing (species, weight, gender, and various measurements), roost tree identification, emergence counts, and habitat assessments
- Radio telemetry
- Use of handheld, sub-meter accurate Trimble GPS unit
- Bird point counts

PROJECT EXPERIENCE

Team Leader – Confidential Client, Wind Resource Area: 2011. Completed mist net surveys and telemetry for the federally endangered Indiana bat within a 39,607-acre site in Seneca and Sandusky counties, Ohio.

Team Leader – Confidential Client, Wind Resource Area: 2011. Completed mist netting, acoustic surveys, and telemetry for the federally endangered Indiana bat within a 23,468.7-acre site in Jay and Randolph counties, Indiana.

Team Leader – Confidential Client, Wind Resource Area: 2011. Completed summer mist net surveys within a 19,926-acre site in Seneca and Crawford counties, Ohio.

Team Leader – American Electric Power, Bonnyman-Softshell 138kV Transmission Line: 2011. Completed summer mist netting activities along a 19.6-mile transmission line in Perry and Knott counties, Kentucky.

Biologist – Migration Investigation: 2010-Present. Serve as co-principle investigator for ongoing study examining migratory flight paths and migration timing of Lasiurine bats

along Lake Erie. Developed a system to track migrating bats along using telemetry and automated tracking stations. Project tasks include engineering tracking stations, and selecting and leading field team.

Biologist – Endangered Bat Summer Ecology: 2008 – 2011. Completed graduate research associated with summer ecology of the endangered Indiana bat in an agricultural landscape. Mist-netting, banding, emergence counts, telemetry, and vegetation surveys were conducted in the Big Darby Watershed in central Ohio. Responsibilities included implementation of the study, technician hiring and training, landowner contact, site selection, field work including team supervision, and data analysis. Contributing author to technical report. Developed and distributed quarterly newsletter for landowners and individuals interested in the project.

Field Technician – Indiana State University's Center for North American Bat Research and Conservation: 2007. Completed surveys for the federally endangered Indiana bat as part of a long-term bat ecology study. Participated in mist-netting, banding, emergence counts and telemetry.

Biologist – Peaks of Otter and Red-backed Salamander Study: 2005-2006. Completed study associated with population dynamics of sympatric populations of two salamander species. The Peaks of Otter salamander is a species of very restricted range and is completely surrounded by the Red-backed salamander. This is the first study to examine population dynamics where the species are found sympatrically. During this study we discovered and documented the development of a Peaks of Otter salamander egg mass, the first ever seen. Two peer-reviewed publications have resulted from this study.

Biologist – Broad-winged Hawk Migration Study: 2005. Completed survey during fall hawk migration season to examine differences in ridge versus piedmont migration routes in central Virginia.

Field Assistant – Peaks of Otter Salamander Study: 2004. Participated in a 12-year study of timbering impacts on the species.

Field Assistant – Northern Saw-whet Owl Migration Study: 2002-2004. Participated in a multi-year survey to investigate migration routes. Conducted mist-netting and banding.

PUBLICATIONS AND PRESENTATIONS

Kniowski, A. and S. Gehrt. 2010. Bat Community Structure of the Big Darby Watershed. Presented to: Ohio Fish and Wildlife Conference.

Kniowski, A. and N. Reichenbach. 2009. The Ecology of the Peaks of Otter Salamander (*Plethodon hubrichti*) in sympatry with the Eastern Red-backed Salamander (*P. cinereus)*. Herpetological Conservation and Biology. 4:285-294.

Kniowski, A. and N. Reichenbach. 2006. *Plethodon hubrichti* (Peaks of Otter salamander) reproduction. Herpetological Review 37:332.

Kniowski, A. and N. Reichenbach. 2005. The Peaks of Otter salamander in the contact zone with the Redback salamander. Presented to: Virginia Herpetological Society.

ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.
Résumé
Jody C. Nicholson

EDUCATION

B.S., Biology/Environmental Studies, Marian College, 2008

QUALIFICATIONS AND EXPERIENCE

Mr. Nicholson's bat experience includes species identification, radio-telemetry, habitat identification, and emergence counts. He has particular experience with the federally endangered Indiana bat (*Myotis sodalis*) and has participated in the long-term, ongoing research studies at the Indianapolis Airport mitigation site. He has participated in bat surveys throughout the bat's range, including Indiana, Ohio, West Virginia, Kentucky, Pennsylvania, and New York and is familiar with a variety of aspects of summer mist netting including site set-up, habitat assessment, bat identification, implementation of White Nose Syndrome protocols and data recording.

PROJECT EXPERIENCE

Team Leader – Chief Gathering Natural Gas Pipeline: 2011. Completed summer mist net and radio-telemetry survey, portal searches, and a habitat survey along 30.1-mile pipeline in Luzerne and Wyoming counties, Pennsylvania. Responsible for mist netting, bat identification, assessing the project for potential summer and winter habitat for Indiana bat and eastern small-footed bat, and performing radio-telemetry of eastern small-footed bats captured while mist netting.

Team Leader – Indiana Department of Transportation, Interstate 69, Pre- and Post-construction Surveys: 2011. Under the direct and on-site supervisoin of Dr. Dale Sparks conducted summer mist net survey for federally endangered Indiana bat along Section 3 of the interstate corridor. Responsible for mist netting, bat identification, and placing bat detectors. Captured, identified, and radio-tagged multiple Indiana bats, which he then tracked to roosting areas.

Team Leader – Bluff Point Wind Resource Area: 2011. Under the direct and on-site supervisoin of Drs. Dale Sparks and Virgil Brack conducted summer mist net survey for federally endangered Indiana bat at a Wind Resource Area in East-Central Indiana. Responsible for mist netting, bat identification, and field collection of accoustic data. Helped captured and radio-tag multiple Indiana bats.

Team Leader – Cross Roads Wind Resource Area: 2011. Under the direct and on-site supervisoin of Dr. Virgil Brack conducted summer mist net survey for federally endangered Indiana bat at a Wind Resource Area in East-Central Indiana. Responsible for mist netting, bat identification, and field collection of accoustic data.

Team Leader – Tennessee Gas Pipeline, Northeast Upgrade: 2010. Conducted Indiana bat mist net surveys along a natural gas pipeline project that included 17 miles in Sussex, Passaic, and Bergen counties, New Jersey and 30 miles in Bradford, Wayne, and Pike counties, Pennsylvania. Responsible for mist netting and bat identification.

Team Leader – Equitrans, LP, Sunrise Pipeline: 2010. Conducted Indiana bat summer mist net survey in Greene County, Pennsylvania, and Doddridge, Marion, Harrison, and Taylor and Wetzel counties, West Virginia. Responsible for mist netting and bat identification.

Team Leader – Tennessee Gas Pipeline Company 300 Line: 2009. Completed Indiana bat habitat and mist net surveys in Potter, Tioga, Bradford, Susquehanna, Wayne, Pike, Venango, and Mckean counties, Pennsylvania. Responsible for mist netting and bat identification.

Team Leader – Dominion Hybrid Energy/Clinch River Transmission Line: 2008. Led field team in summer mist net survey and portal search along a proposed 9-mile transmission line corridor in Wise and Russell counties, Virginia. Responsible for mist netting, bat identification, radio transmitter attachment, and day and night ground radio-tracking to locate roosts.

Team Leader – Consol Pennsylvania Coal Company, Bailey Mine: 2008. Endangered bat survey focusing on Indiana bat capture and radio-telemetry in Washington and Greene counties, Pennsylvania. This survey was initiated due to documentation of Indiana bats on Consol property, near Bailey Mine, in 2007. Survey efforts included 16 mist net sites, resulting in the capture of 13 Indiana bats. Six bats were radio-tagged in summer to document diurnal roosts and night time foraging home ranges.

Team Leader – Equitrans, Ranger Pipeline: 2008. Participated in mist net survey for the endangered Indiana bat along a proposed 70-mile, natural gas pipeline in Martin and Floyd counties, Kentucky. Responsible for mist net set up and habitat assessment, AnaBat data collection, bat identification, handling and morphmometric processing.

Team Leader – TW Philips, Bionol Clearfield Pipeline: 2008. Participated in mist net survey for the endangered Indiana bat along a proposed 8-mile pipeline in Clearfield County, Pennsylvania. Responsible for mist net site set up and habitat assessment, bat identification, handling, and morphmometric processing.

Team Leader – Confidential Client, Natural Gas Transmission Pipeline: 2007-2008. Participated in mist net survey for the endangered Indiana bat along a 250-mile pipeline running through seven counties in Pennsylvania. Responsible for mist net site set up and habitat assessment, bat identification, handling and morphmometric processing.

Team Leader -- Pennsylvania Turnpike Commission Southern Beltway Project, Interstate 79 to Mon/Fayette Expressway and Interstate 79 to US Route 22: 2008. Participated in summer mist net surveys for the endangered Indiana Bat along 25 miles of proposed roadway corridor in Allegheny and Washington counties, Pennsylvania. Performed mist net site set up and habitat assessment, bat identification, handling and morphometric processing.

Field Assistant – Equitrans, Big Sandy Pipeline: 2007. Participated in Indiana bat potential roost tree and habitat assessments along proposed 68-mile natural gas transmission line in Carter, Lawrence, Johnson, and Floyd counties, Kentucky. Assisted with mist net site set up and habitat assessment, AnaBat data collection, and bat handling and morphometric processing.

Field Assistant – Columbia Gas, Eastern Market Pipeline Expansion: 2007. Participated in Indiana bat habitat assessment and abandoned mine portal search along 10 miles of natural gas pipeline and 24 well sites in Ohio and West Virginia. Assisted with mist net site set up and habitat assessment, bat handling, morphometric processing and data recording.

Field Assistant – American Electric Power, Maytown-Hays Branch 138 kV Transmission Line: 2007. Assisted with endangered bat mist net survey field activities along a proposed 8.3-mile electric transmission line ROW in Floyd County, Kentucky.

Field Assistant – Dutchess County Airport. 2007. Oversaw successful completion of field mist net surveys; 11 Indiana bats (*Myotis sodalis*) were captured and diurnal radio telemetry was conducted for seven of those individuals. Eighteen roosts were located and based upon emergence counts of greater than twenty individuals, approximately five were categorized as maternity roosts.

Field Assistant – Marathon, Dayton-Heath Pipeline: 2007. Assisted with bat survey along an existing petroleum pipeline running from Dayton (Montgomery County) to Heath (Licking County) Ohio. Survey efforts focused on mist netting and evaluating potential bat roosts along several portions of the pipeline in Clark and Franklin counties, Ohio.

Intern – Marian College Ecolab Restoration. 2006-present. Participated in EcoLab, a 30-acre functioning wetland marsh, fen, and swamp affiliated with Marian's environmental study program. Assisted with projects including non-native, invasive plant removal, native plant installation and keeping trails cleared.

Research Technician – Indiana State University Center for North American Bat Research and Conservation: 2006. Participated in a long term Indiana bat (*Myotis sodalis*) monitoring and surveying project at Indianapolis International Airport. Assisted with field work and bat house installation. Employed mist nets for bat capture and conducted radio-telemetry studies to track bats to day roosts and nocturnal foraging areas. Conducted emergence counts at primary roosts twice weekly and counted secondary roost counts while bats were present. Used spotlighting techniques for investigating bats roosting in bat boxes. Assisted with bat identification for captured bats.

ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.
Résumé
Beth Meyer

EDUCATION

B.S., Biology, Radford University, 2009

QUALIFICATIONS AND EXPERIENCE

Ms. Meyer has assisted with numerous wildlife research and management activities. She has participated in bat, mammal, and herpetological surveys. Her experience includes field surveys and data analysis. She has specialized experience with bats and can identify most eastern bats to species (including endangered Indiana and Virginia big-eared bats), and has handled and independently identified numerous bats of both these species. Ms. Meyer's general experience includes:

- Mist net set up, bat identification, bat handling and morphometric processing (species, weight, gender, and various measurements), roost tree identification, emergence counts, and habitat assessments
- Indiana bat radio-telemetry (ground and aerial)
- Use of handheld, sub-meter accurate Trimble GPS unit
- Use of vegetation-surveying instruments (clinometer, densiometer, DBH tape, range poles)
- Identification of small mammals
- Identification of trees and herbaceous plants
- Use of Sherman live traps, snap traps, tomahawk traps and others

Ms. Meyer studied under Dr. Karen Francl of Radford University, where she gained multiple years of experience working with bats. She has dedicated time to volunteer projects such as Salvation Army Camp Redwood Glen where she developed program materials and activities, as well as implementing a program on the Wonderful World of Bats and has constructed bat houses for placement around the camp. Her volunteer work also includes participation in multiple years of bat swarming surveys conducted with regard to White Nose Syndrome effects in cooperation with the Virginia Department of Conservation and Recreation and Virginia Department of Game and Inland Fisheries. This volunteer work has provided valuable experience handling and identifying large groups of individuals of multiple cave-hibernating bat species, including the federally endangered Indiana and Virginia big-eared bats.

ESI PROJECT EXPERIENCE

Biologist– American Electric Power, Hernshaw 138 kV Extension and Substation: 2011. Conducted Indiana bat habitat assessment and portal searches along approximately 5 miles of new transmission line right-of-way and associated access roads in Kanawha County, West Virginia.

Biologist– CNX Gas Company, LLC, Morris to Majorsville Pipeline: 2011. Conducted Indiana bat habitat assessment in Greene County, Pennsylvania and Marshall County, West Virginia.

Field Supervisor– Roth Rock Wind Generation: 2011. Supervised and conducted a mortality study on a wind farm site containing 20 turbines along a 3-mile stretch of Backbone Mountain in Garrett County, Maryland.

Field Supervisor / Team Leader – Public Service Electric and Gas, Roseland-Bushkill Transmission Line: 2011. Completed summer mist net survey along a 45-mile transmission line corridor in Warren, Sussex, Morris, and Essex counties, New Jersey. Supervised up to three crews, coordinated with the client, and performed mist net site reconnaissance, site set up, habitat assessment, bat handling and identification, and morphometric processing.

Team Leader – Tennessee Gas Pipeline, Northeast Upgrade: 2011. Conducted Indiana bat mist net and portal surveys along portions of a pipeline looping project in Sussex County, New Jersey and Wayne and Pike counties, Pennsylvania. Performed mist net site set up and habitat assessment and bat identification, bat handling, and morphometric processing, also conducted radio-telemetry of eastern small-footed bats.

Field Assistant – Chief Gathering Natural Gas Pipeline: 2011. Completed summer mist net and radio-telemetry survey along 30.1-mile pipeline in Luzerne and Wyoming counties, Pennsylvania. Assisted with mist net site set up and bat identification, performed habitat assessments, bat handling, morphometric processing, and conducted radio-telemetry of eastern small-footed bats.

Field Assistant – Department of Defense, Fort Drum Army Installation: 2010. Completed Indiana bat habitat assessments, mist net surveys, and ground/aerial radio-telemetry in Jefferson and Lewis counties, New York. Assisted with mist net site set up, habitat assessment, bat handling and identification, morphometric processing, diurnal radio-telemetry, and emergence counts. Independently identified Indiana bats and tracked them to diurnal roosts.

Field Assistant – Equitrans, LP, Sunrise Pipeline: 2010. Conducted Indiana bat summer mist net survey in Greene County, Pennsylvania, and Doddridge, Marion, Harrison, and Taylor and Wetzel counties, West Virginia. Assisted with mist net site set up and habitat assessment, bat identification, morphometric processing, and radio-telemetry.

Field Assistant– Tennessee Gas Pipeline Company, 300 Line: 2009. Completed Indiana bat habitat and mist net surveys along a 120-mile natural gas pipeline in Potter, Tioga, Bradford, Susquehanna, Wayne, Pike, Venango, and McKean counties, Pennsylvania and Passaic and Sussex counties, New Jersey.

Field Assistant– Chief Gathering, Poor Shot Natural Gas Pipeline: 2009. Completed Indiana bat summer mist net survey along 10-mile natural gas pipeline right-of-way in Lycoming County, Pennsylvania. Assisted with mist net site operation and habitat assessment, bat identification, and morphometric processing.

Research Assistant – Radford University Biology Department and Smithsonian Tropical Research Institute, Gamboa, Panama: 2009. Participated in research project to evaluate effects of predator stress on Red-eyed treefrog (*Agalychnis callidryas*) growth and life history switch points, as well as predator survival and growth in aquatic pond ecosystems.

Field Technician– The Conservation Fund: 2009. Assisted with AnaBat studies across the eastern range of the Indiana bat in nine states. Studies include examination of species distribution in potentially impacted areas and forest condition surveys.

Research Technician – Radford University Biology Department: 2008-2009. Environmental internship including investigation of vegetation variations in karst sinkholes at Selu Conservancy, Montgomery County, Virginia. Responsibilities included vegetation (tree, shrub, herb) identification, utilization of multiple vegetation-surveying instruments (clinometer, densiometer, DBH tape, range poles), soil collection and analysis, and data analysis utilizing Microsoft Excel and ArcGIS.

Research Assistant – George Washington National Forest: 2007-2009. Assisted with study to determine sustainable harvest of black cohosh (*Actaea racemosa; Ranunculaceae*) in Reddish Knob, Virginia.

Field Assistant – Equitrans, Ranger Pipeline: 2008. Participated in field surveys for the endangered Indiana bat along a proposed 70-mile, natural gas pipeline in Martin and Floyd counties, Kentucky. Assisted with mist net set up and habitat assessment, AnaBat data collection and analysis, and bat identification.

Field Assistant – TW Philips, Bionol Clearfield Pipeline: 2008. Completed mist net survey for federally endangered Indiana bat along a proposed 8-mile pipeline in Clearfield County, Pennsylvania. Assisted with mist net set up and habitat assessment, bat identification, and morphometric processing.

Field Assistant – Confidential Client, 250-mile Proposed Natural Gas Pipeline: 2008. Conducted portal searches and mist net site reconnaissance in Greene County, Pennsylvania.

Research Assistant – Selu Conservancy: 2008. Assisted with salamander study to determine species use of karst sinkholes in Montgomery County, Virginia. Responsibilities included identification and tissue sample collection for genetic analysis.

Research Assistant – Selu Conservancy: 2007. Assisted with small mammal survey in Montgomery County, Virginia. Species were captured using Sherman live traps, snap traps, tomahawk traps, and mist nets.

Laboratory Technician – Environmental laboratory: 2007-2008. Processed stream samples for benthic macroinvertebrates including sorting, identification, and midge mounting.

PUBLICATIONS AND PRESENTATIONS

Francl, K., C. J. Small and B. Meyer. In progress. Quantifying long- and short-term fire effects on small mammal communities and habitat composition and structure at Caldwell Fields, Montgomery County, Virginia.

Small, C. J., Francl, K. E., Meyer, B. N. In progress. Vegetation diversity of karst sinkholes at the Selu Conservancy, southwestern Virginia.

Meyer, B., C. J. Small, and K. Francl. 2009. Biotic Diversity of Karst Sinkholes at the Selu Conservancy, Southwestern Virginia. Talk presented at winter meeting of the Virginia Chapter of The Wildlife Society, Palmyra, Virginia, as well as the Big South Undergraduate Research Symposium, Asheville, North Carolina.

Small, C. J., Mathews, D. S., and Meyer, B. N. 2008-2009. Classification of the Ecological Communities of the Selu Conservancy. Faculty-Student Collaborative Grant, Radford University.

Meyer, B. and K. Francl. 2008. "Milvus milvus" (On-line), Animal Diversity Web. http://animaldiversity.ummz.umich.edu/site/accounts/information/Milvus_milvus.html.

PROFESSIONAL AFFILIATIONS

Radford University Student Chapter of The Wildlife Society, 2008-present; Co-President, 2008-2009

BRIANNE LORRAINE WALTERS

HOME ADDRESS:
7024 W 1200N
Kingman, IN 47952
(765)492-3871
Cell: (812)242-0212
brianne.walters@indstate.edu

PROFESSIONAL ADDRESS:
Center for North American Bat Research and Conservation
Department of Biology
Indiana State University
Terre Haute, In 47809
Office: (812)237-2808

EDUCATION:
2003-2005: Indiana State University, Terre Haute, IN
Degree Earned: Master of Science
Advisor: John O. Whitaker, Jr.
Thesis Topic: Foraging Behavior and Seasonal Movements of Eastern Red Bats

1999-2003: Indiana State University, Terre Haute, IN
Degree Earned: Bachelor of Science
Advisor: Diana Hews
Major/Minor: Life Sciences/Chemistry
Overall GPA: 3.45

1995-1999: Turkey Run High School
Degree Earned: High School Diploma
Organizations: National Honor Society, Science Club, Class Vice President, Peer Tutors.

SELECTED COURSES:
Animal Behavior, Conservation Biology, Dendrochronology, Ecology, Entomology, Food Habits Analysis, Herpetology, Ichthyology, Mammalogy, Ornithology, Plant Taxonomy, Systematics Seminar, Vertebrate Zoology, Wildlife Management.

PROFESSIONAL EXPERIENCE:
Present: Assistant Director, ISU Center for North American Bat Research and Conservation
Duties: Conduct surveys for mammals including the federally endangered Indiana bat (10 years experience; have federal permit). Prepare proposals and reports, grant writing, direct field crew, coordinate with consulting firms and state and federal agencies, permitting, public outreach, organize annual bat festival.

2003-2005: Research Assistant.
Research collaborator on the Indianapolis International Airport Bat Monitoring grant.
Duties: Prepare annual report, direct field crew in summer data collection, coordinate with private landowners, use GIS to analyze foraging data collected via radio telemetry.

2003-Present: Curatorial Assistant of Mammals and Birds at the ISU Vertebrate Collection.
Duties: Prepare and curate mammal, reptile and bird specimens, supervise curatorial aids.

2002-2003: Curatorial Aid, Indiana State University Vertebrate Collection.
Duties: Prepare and curate mammal and bird specimens, prepare and maintain public displays.

2002-2003: Field assistant for Indiana State University. Aided in conducting a project aimed at understanding the ecology of the Indiana Bat at the Indianapolis International Airport. Used biotelemetry, mistnetting, dusk counts, and bat banding to develop a habitat use model for this bat. Also participated with a fish study involving seining and studying the effects of urbanization on fish community structure.

SELECTED PUBLICATIONS:

Boyles, J. G., **B. L. Walters,** J. O. Whitaker, Jr., and J. B. Cope. 2007. A reanalysis of apparent survival rates of Indiana myotis (*Myotis sodalis*). Acta Chiropterologica 9(1): 127–132.

Brack, V., Jr., D. W. Sparks, J. O. Whitaker, Jr., **B. L. Walters**, and A. Boyer. 2010. Bats of Ohio. Publication no. 4, ISU Center for North American Bat Research and Conservation. Indiana State University. 92 pp.

Gikas, N. S., J. G. Boyles, A. A. Zurcher, **B. L. Walters** and J. O. Whitaker, Jr. 2009. The first records of the eastern small-footed bat (Myotis leibii) in Indiana. Proceedings of the Indiana Academy of Science 118(2):203-204.

Ritzi, C. M., **B. L. Everson**, B. J. Foster, J. J. Sheets, and D. W. Sparks. 2004. Urban Ichthyology: Changes in a fish community along an urban-rural creek in Indiana. Proceedings of the Indiana Academy of Science 113(1):42-52.

Ritzi, C. M., **B. L. Everson**, and J. O. Whitaker, Jr. 2005. Use of bat boxes by a maternity colony of Indiana myotis (*Myotis sodalis*). Northeastern Naturalist 12(2):217-220.

Sparks, D.W., C. M. Ritzi, and **B. L. Everson**. 2005. Nocturnal behavior and roosting ecology of a hoary bat (*Lasiurus cinereus*) near Indianapolis, Indiana. Proceedings of the Indiana Academy of Science 114(1): 70-72.

Walters, B. L., D. W. Sparks, J. O. Whitaker, Jr., and C. M. Ritzi. 2006. Timing of migration by Eastern red bat (*Lasiurus borealis)* through Central Indiana. Acta Chiropterologica 8:259-263.

Walters, B. L., D. W. Sparks, J. O. Whitaker, Jr., and C. M. Ritzi. 2007. Foraging behavior of the Eastern red bat (*Lasiurus borealis)* at an Urban-Rural Interface. American Midland Naturalist 157:365-373.

Walters, B. L., J. O. Whitaker, Jr., N. S. Gikas, and W. Wrenn. 2011. Host and distribution lists of chiggers (Trombiculidae and Leeuwenhoekiidae), of North American wild vertebrates north of Mexico. http://digitalcommons.unl.edu/parasitologyfacpubs/697/

Whitaker, J. O., Jr., **B. L. Walters**, L. K. Castor, C. M. Ritzi, and N. Wilson. 2007. Host and distribution lists of mites (Acari), parasitic and phoretic, in the hair or on the skin of North American wild mammals north of Mexico: records since 1974. http://digitalcommons.unl.edu/parasitologyfacpubs/1

Whitaker, J. O., Jr., **B. L. Walters**, and Scott Johnson. 2007. Terrestrial mammals of the Naval Support Activity (NSA Crane) in Martin County, and of the Crane Division of the Naval Surface Warfare Center (Glendora Site) in Sullivan County, Indiana. Proceedings of the Indiana Academy of Science 116: 84-89.

PROFESSIONAL REFERENCES:

Dr. Joy O'Keefe
Assistant Professor
Department of Biology
Indiana State University
Terre Haute, IN 47809

Dr. John O. Whitaker, Jr.
Director ISU Bat Center
Department of Biology
Indiana State University
Terre Haute, IN 47809

Scott Bergeson

Ball State University, Department of Biology, Muncie, IN 47304
Phone: (630) 947-4565
E-mail: smbergeson@bsu.edu

Education

Doctor of Philosophy
Indiana State University; Terre Haute, IN 47809
Major:
Dates Enrolled: In progress

Masters of Science
Ball State University; Muncie, IN 47306
Major: Biology
Dates Enrolled: Fall 2010 – May 2012
GPA: 4.0

Bachelors of Science
Southern Illinois University; Carbondale, IL 62901-6899
Major: Zoology
Minor: Environmental Studies
Dates Enrolled: Fall 2005 – Fall 2009
GPA: 3.795

GRE Scores

Total Verbal & Quantitative: 1220

Verbal:	590	Quantitative:	630
Analytical Writing:	4.0		

Work and Volunteer Experience

Graduate Teaching Assistant
Ball State University
Department of Biology
Advisor: Dr. Tim Carter
U.S.F.S. project: Monitoring Indiana Bat Maternity Colonies in Southern Illinois
Shawnee National Forest, IL
Dates of Employment: May 2010 - Present

Studied bat acoustical monitoring methodologies and the ecology of little brown bats and endangered Indiana bats in the bottomland hardwoods of Southern Illinois. Data collected on Indiana bats were used to determine colony condition, management implications for the Shawnee National Forest, and to study Indiana bat maternity roost characteristics. Data on both species were used to conduct research on the effectiveness of surrogate use between the species, and thermal dynamics of bat colonies within their roosts. Acoustical monitoring was conducted using several methodologies to determine their effectiveness.

Experience in:

Mist-netting, bat ID, bat handling, bat banding, radio transmitters, radio telemetry, tree snag surveys, strenuous hiking, orienteering, acoustic bat surveys, GPS, WNS disinfection procedures, data-loggers, conducting research in swamps, and leading research teams

Consultant for Endangered Bat Species Survey
Copperhead Consulting
Paint Lick, KY
Dates of Employment: July 2010 - August 2010

Ball State University, Department of Biology, Muncie, IN 47304
Phone: (630) 947-4565
E-mail: smbergeson@bsu.edu

Conducted mist-net surveys for Indiana bats in the southern portion of Illinois. Surveys were conducted to determine whether the endangered bats were in the area and whether there was a risk for potential wind turbine induced mortality of individuals from the species.
Experience in:
Mist-netting, bat ID, bat handling, GPS, and WNS disinfection procedures

Small Mammal Research Technician
Southern Illinois University
Cary Institute of Ecosystem Studies (Millbrook, NY)
Graduate Student's thesis project
Dates of Employment: May 2009 - August 2009; February 2010 - May 2010
Assisted with research studying the effects of manipulating spatial heterogeneity of small mammal populations on gypsy moth larva density and the transmission of Lyme disease. Also, I helped gather data concerning environmental factors that determine small mammal densities in the area.
Experience in:
Sherman traps, invertebrate burlap traps, pitfall traps, seed collection baskets, tick sampling, track plates, orienteering, strenuous hiking, sweep netting, vegetation sampling, give-up-density boxes, large amounts of data entry and organization, and photographic tree canopy cover estimation

Naturalist
Saint Charles Parks Department
Saint Charles, IL
Dates of Employment: May – August 2006, 2007, 2008
Maintained city natural parks and Illinois state nature preserves. I was responsible for maintaining nature trails, removing invasive species from environmental areas with mechanical and chemical equipment, and staffing nature camps.
Experience in:
Herbicides, Environmental interpretation, Invasive species maintenance, Habitat management, Brush mowers, Sting/blade trimmers, ATVs, and Child education

SBDN Bat Blitz Attendee
Southeastern Bat Diversity Network
2 Years
Dates of Activity: Fort Mountain State Park Chatsworth, GA, August 2010; Pisgah National Forest Crossnore, NC, August 2011.
Attended Bio Blitz programs focused on surveying natural areas for bats. Attendees assist with mist-net surveys to capture, identify, and gather data on the areas' bats.
Experience in:
Mist-netting, bat ID, bat handling, bat banding, acoustic bat surveys, WNS disinfection procedures

Annual Wildlife Conference Staff Volunteer
The 2nd Joint Meeting Northeastern Bat Working Group, Midwest Bat Working Group,
Southeastern Bat Diversity Network (16th Annual), and 21st Colloquium on the Conservation
Of Mammals in the Southeastern United States.
Louisville, KY
Dates of Activity: October 2010 - March 2011
Collected and organized registrations and registration fees as well as assisted conference host during the conference. Created maintained registration database.
Experience in:
Large database creation and management, registration, staffing a large event

Neotropical Bird Research Assistant

Ball State University, Department of Biology, Muncie, IN 47304
Phone: (630) 947-4565
E-mail: smbergeson@bsu.edu

International Student Volunteers Inc.
Kekoldi Indigenous Reserve, Talamanca, Costa Rica
Dates of Activity: June 2007 – July 2007.
Volunteer Effort Contributed: 120hrs

Conducted understory bird surveys in various habitats including: abandoned cocoa plantations, active cocoa plantations, and tropical rainforests. Used mist nets to capture understory birds and hummingbirds. Measured wing length, beak length, determined sex and age, and banded/marked all birds captured. Lived on site with limited amenities.

Experience in:

Mist-netting, ageing & sexing birds, bird handling, bird banding, body measurements, and conducting research in neotropical ecosystems

Research Experience

Endangered Bat Hibernacula Research Assistant

Dr. Tim Carter
Southern Illinois University, Carbondale
Ball State University
Dates of Activity: December 2005, December - January 2010

Conducted bat hibernacula surveys in caves/mines located in the Shawnee National Forest, IL. Surveyed bat population densities and hibernaculum environmental conditions.

Experience in:

Bat ID, hibernacula surveys, caving, and infrared non-contact thermometers, roosting bat density estimation, low light photography

Small Mammal Undergraduate Research

Zool 393, Advisor: Dr. Eric Schauber
Southern Illinois University, Carbondale
Dates of Activity: November 2008 – May 2009

Conducted time-lapse photography on white-footed mice in order to study their foraging behavior, focusing on give-up-density ecology and visit frequency. I measured density of bait before and after visits to measure the effort spent before individuals moved on to other foraging areas. Created trapping transects in order to capture, measure, band, and mark white-footed mice.

Experience in:

Sherman traps, small mammal trapping, small mammal handling, AV equipment, give-up-density boxes, time-lapse photography, and designing/conducting my own experiment.

Other Research

- Conducted carnivore trapping in Cooper Farm Muncie, IN. Helped deploy and check self-made weasel traps. Caught and released several weasels throughout the trapping season.
- Helped conduct research on Rafinesque big-eared bat roosting behavior in Mammoth Cave National Park. Captured and pit-tagged bats roosting in an abandoned church using harp-traps over a time span of two days. The goal was to pit-tag the whole colony and to use the round pass-through antennas that were already assembled in the exits of the church to gather data on exit/entrance times, # of visits, and roost loyalty.
- Conducted fall swarm surveys on cave bats in southern Illinois. Used harp-traps to survey mines and caves in order to determine the condition of populations of endangered species within the area, during the fall swarm season.
- Conducted rabbit eye lens desiccation and weighing to determine the approximate age of several dozen rabbits for an Indiana DNR research project focusing on the effects of hunting on rabbit recruitment.
- Assisted with saw-whet owl mist-netting during fall migration.

Ball State University, Department of Biology, Muncie, IN 47304
Phone: (630) 947-4565
E-mail: smbergeson@bsu.edu

- Assisted with wood duck population surveys in southern Illinois. Used rocket-nets to capture ducks. Data was collected on age, sex, weight, and molt. All ducks were banded for use in capture-recapture research.
- Conducted literature review and created a research paper and presentation on the evolution of snake fang and venom morphology/physiology.
- Assisted with an alligator snapping turtle reintroduction program. Turtles were reintroduced into the waterways of southern Illinois by the Illinois Department of Natural Resources. I conducted radio-telemetry to track and capture reintroduced turtles to confirm survival.
- Conducted small mammal surveys for the spring and fall 2011 and 2012 biannual Craddock Wetland Eco Blitzes. Used 10in Sherman traps as well as ocular observations to identify small mammals in the area.
- Conducted bird surveys for the spring 2012 biannual Craddock Wetland Eco Blitz.

Technical Skills

- Experience with ARCGIS, Minitab, and Microsoft Excel/Word/Access software.
- Experience in landscape equipment including: lawnmowers, brush-hogs, whip and blade weed eaters, hedge trimmers, chainsaws, chippers, and leave blowers.
- Experience in prescribed fire lighting and control in prairie areas.
- Experience in applying herbicides. Previously possessed an herbicide license.
- Experience in roofing, and shelter/building renovation.
- Experience in tending deer check stations and taking samples for use in diagnosing chronic wasting disease and bovine tuberculosis.
- Rabies vaccinated.
- Experience in identifying and handling endangered species.

Chiropteran Handling and Identification Experience

Mist-Netting Experience

- 2011: Southeastern Bat Diversity Network Bat Blitz participant, Pisgah National Forest, NC.
- 2011: Craddock Wetland BioBlitz in Muncie, IN. Supervised by Dr. Tim Carter.
- 2010-2011**: Thesis research (comparison of Indiana bat and little brown bat maternity roosts, home ranges, and habitat use) in The Shawnee National Forest, IL. Supervised by Dr. Tim Carter.
- 2010**: Indiana bat presence consulting in Carbondale, IL. Supervised by Copperhead Environmental Consulting and Dr. Tim Carter.
- 2010: Southeastern Bat Diversity Network Bat Blitz participant, Fort Mountain State Park, GA

Harp-Trapping Experience

- 2011: Rafinesque's big eared bat pit tag survey in Mammoth Cave National Park, KY. Supervised by Dr. Tim Carter and the U.S. Forest Service.
- 2010**[+]: Indiana bat fall swarm survey in The Shawnee National Forest, IL. Supervised by Dr. Tim Carter and the Illinois DNR.

Hibernaculum Survey Experience

- 2010-2011**[+]: Indiana bat and grey bat hibernaculum survey in The Shawnee National Forest, IL. Surveyed both caves and mines, including Magazine Mine. Supervised by Dr. Tim Carter and the U.S. Forest Service.

Endangered Bat Species Identification Experience

- Identified and handled a total of 460 endangered animals
    - 360 Indiana bats (*Myotis sodalis*)
    - 100 Gray bats (*Myotis grisescens*)
- Identified and observed thousands more during hibernaculum surveys.

** Indicates projects in which Indiana bats were captured, handled, or observed.
[+] Indicates projects in which Grey bats were captured, handled, or observed.

Scott Bergeson

Ball State University, Department of Biology, Muncie, IN 47304
Phone: (630) 947-4565
E-mail: smbergeson@bsu.edu

Teaching and Advisement Experience

Mammalogy (Zool 446/546); T.A.
Ball State University
Dr. Tim Carter
Semesters taught: Spring 2011
My responsibilities included: teaching lab students the life history and ID techniques of local and exotic mammals, substituting for lectures when needed, conducting and proctoring lab practicals, grading, and maintaining the mammalogy collection.

Wildlife Biology (Zool 483/583); T.A.
Ball State University
Dr. Tim Carter
Semesters taught: Fall 2010
My responsibilities included: teaching and constructing labs, creating and proctoring lab practicals, and grading. Topics covered included: using a GPS, orienteering, firearms, trapping, and radio-telemetry.

Introduction to Biology for Biology Majors (Bio 112L); T.A.
Ball State University
Dr. Randy Bernot and Dr. Tim Carter
Semesters taught: Fall 2010, Fall 2011
My responsibilities included teaching and grading 1-3 lab sections each semester. Topics covered included: the scientific method, natural selection, phylogenies, vertebrate morphology, embryology, and the nervous system.

Advisement Opportunities

- Co-Advisor for Honors thesis:
  - Kathryn A. Ruhrold. 2011-2012. Microhabitat characteristics of small mammal capture locations, with an emphasis on *Microtus spp.*
- Advisor for Costal Research (Bio 420, Field Biology of Distant Areas):
  - Brittany Ross. 2012.
  - Matt Ross. 2012
  - Anna Simmons. 2012
  - Brooke Speedy. 2012

Publications, Reports, and Presentations

Bergeson, S.M., T.C. Carter, and M.D. Whitby. 2012. Horizontal resource partitioning between sympatric populations of the endangered Indiana bat (*Myotis sodalis*) and the little brown bat (*M. lucifugus*). Oral Presentation. 4th Annual Midwest Bat Working Group Meeting. Terre Haute, IN.

Bergeson, S.M., T.C. Carter, and M.D. Whitby. 2012. Little brown bats don't all roost in attics!: examining the use of natural roosts by little brown bats. Oral Presentation. 4th Annual Midwest Bat Working Group Meeting. Terre Haute, IN.

Bergeson, S.M., M.D. Whitby, S.A. Rutan, and T.C. Carter. 2011. Do little brown bats (*Myotis lucifugus*) make effective surrogates for endangered Indiana bats (*Myotis sodalis*)? Oral Presentation. 72nd Midwest Fish and Wildlife Conference. Des Moines, IA.

Bergeson, S.M., M.D. Whitby, S.A. Rutan, and T.C. Carter. 2011. Do little brown bats (*Myotis lucifugus*) make effective surrogates for endangered Indiana bats (*Myotis sodalis*)? Oral Presentation. Proposed Agenda and Goals for the USFS Shawnee National Forest and Ball State University Meeting. Harrisburg, IL.

Bergeson, S.M., M.D. Whitby, and T.C. Carter. 2011. Preliminary results of a comparison of foraging behavior between little brown bats (*Myotis lucifugus*) and Indiana bats (*Myotis sodalis*). Poster Presentation. 2nd Joint Meeting Northeastern Bat Working Group, Midwest Bat Working Group, Southeastern Bat Diversity Network (16th Annual), and 21st Colloquium On The Conservation Of Mammals in the Southeastern United States. Louisville, KY.

Bergeson, S.M., M.D. Whitby, S.A. Rutan, and T.C. Carter. 2011. Do dissimilarities in the natural maternity roosts of *Myotis sodalis* and *Myotis lucifugus* hinder surrogate use? Poster Presentation. North American Society for Bat Research 2011 Annual Conference. Toronto, Canada.

Bergeson, S.M., M.D. Whitby, and T.C. Carter. 2012. Do little brown bats (*Myotis lucifugus*) make effective surrogates for endangered Indiana bats (*Myotis sodalis*)? Oral Presentation. 17th Annual Meeting of the Southeastern Bat Diversity

Ball State University, Department of Biology, Muncie, IN 47304
Phone: (630) 947-4565
E-mail: smbergeson@bsu.edu

Network and the 22nd Colloquium on the Conservation of Mammals in the Southeastern United States. Louisville, MS. Awarded SBDN Best Student Oral Presentation on Bats Award.

Bergeson, S.M., and T.C. Carter. In Prep. Do dissimilarities in the natural maternity roosts of *Myotis sodalis* and *Myotis lucifugus* hinder surrogate use?

Bergeson, S.M., and T.C. Carter. In Prep. The simultaneous usage of roost trees by multiple bat species.

Bergeson, S.M., M.D. Whitby, and T.C. Carter. In Prep. Similarities in home range and habitat use affect surrogate use effectiveness on an endangered bat species.

Carter, T.C., S.M. Bergeson, and M.D. Whitby. 2010. Monitoring Indiana bat maternity colonies in southern Illinois. US Forest Service-Shawnee National Forest, Project: Project Number: 08-PA-11090800-023. Annual Report.

Carter, T.C., S.M. Bergeson, M.D. Whitby, and S.A. Rutan. 2011. A review of half a dozen grad students and over a decade of bat work on the Shawnee National Forest. Oral Presentation. Proposed Agenda and Goals for the USFS -Shawnee National Forest and Ball State University Meeting. Harrisburg, IL.

Carter, T.C., S.M. Bergeson, and E. Welker. 2012. Bats in Indiana. Oral Presentation. Family Math & Science Night, Mitchell Elementary School, Muncie, Indiana.

Carter, T.C., M.D. Whitby, and S.M. Bergeson. 2012. Bats in Indiana and bat research. Oral Presentation. Robert Cooper Audubon Society Meeting. Muncie, In.

Rutan, S.A., S.M. Bergeson, M.D. Whitby, and T.C. Carter. 2011. Thermodynamics of bat maternity colonies – why do they form them? Oral Presentation. Proposed Agenda and Goals for the USFS -Shawnee National Forest and Ball State University Meeting. Harrisburg, IL.

Whitby, M.D., T.C. Carter, and S.M. Bergeson. 2011. Evaluating the effectiveness of mobile acoustic transects conducted on roads and rivers. Oral Presentation. 72nd Midwest Fish and Wildlife Conference. Des Moines, IA.

Whitby, M.D., S.M. Bergeson, S.A. Rutan, and T.C. Carter. 2011a. Evaluating the effectiveness of 3 acoustic monitoring techniques for landscape level bat population monitoring. Proposed Agenda and Goals for the USFS -Shawnee National Forest and Ball State University Meeting. Harrisburg, IL.

Whitby, M.D., S.M. Bergeson, S.A. Rutan, and T.C. Carter. 2011b. Monitoring Indiana bat maternity colonies in southern Illinois. US Forest Service-Shawnee National Forest, Project: Project Number: 08-PA-11090800-023. Annual Report.

Whitby, M.D., S.M. Bergeson, and T.C. Carter. 2011. Evaluating the Effectiveness of Mobile Acoustic Transects Conducted On Roads and Rivers. Poster presentation. 2nd Joint Meeting Northeastern Bat Working Group, Midwest Bat Working Group, Southeastern Bat Diversity Network (16th Annual), and 21st Colloquium On The Conservation Of Mammals in the Southeastern United States. Louisville, KY.

Whitby, M.D., S.M. Bergeson, S.A. Rutan, and T.C. Carter. 2011. The discovery of a breeding population of the eastern small-footed *Myotis* (*Myotis leibii*) in Illinois. Poster Presentation. 72nd Midwest Fish and Wildlife Conference. Des Moines, IA.

Whitby, M.D., S.M. Bergeson, S.A. Rutan, and T.C. Carter. 2011. The newly documented presence of Eastern small-footed bats (*Myotis leibii*) within Illinois. Poster Presentation. North American Society for Bat Research 2011 Annual Conference. Toronto, Canada.

Whitby, M.D., S.M. Bergeson, S.A. Rutan, and T.C. Carter. 2012. The discovery of a breeding population of the eastern small-footed *Myotis* (*Myotis leibii*) in Illinois. Poster Presentation. 4th Annual Midwest Bat Working Group Meeting. Terre Haute, IN.

Whitby, M.D., S.M. Bergeson, S.A. Rutan, and T.C. Carter. 2012. The discovery of a breeding population of the eastern small-footed *Myotis* (*Myotis leibii*) in Illinois. Poster Presentation. 17th Annual Meeting of the Southeastern Bat Diversity Network and the 22nd Colloquium on the Conservation of Mammals in the Southeastern United States. Louisville, MS.

Whitby, M.D., T.C. Carter, and S.M. Bergeson. 2012. Evaluating the effectiveness of mobile acoustic transects conducted on roads and rivers. Oral Presentation. 4th Annual Midwest Bat Working Group Meeting. Terre Haute, IN.

Whitby, M.D., T.C. Carter, and S.M. Bergeson. 2012. Evaluating the effectiveness of mobile acoustic transects conducted on roads and rivers. Oral Presentation. 17th Annual Meeting of the Southeastern Bat Diversity Network and the 22nd Colloquium on the Conservation of Mammals in the Southeastern United States. Louisville, MS.

Whitby, M.D., S.M. Bergeson, S.A. Rutan, and T.C. Carter. In Review. The newly documented presence of Eastern small-footed bats (*Myotis leibii*) within Illinois. American Midland Naturalist.

Grants

Bergeson, S.M., and T.C. Carter. 2010. Similarities and differences in foraging habitat use of little brown and Indiana bats: can little brown bats be used as a surrogate for Indiana bats? Bat Conservation International Inc. Student Research Scholarship. $5,000. Unfunded.

Scott Bergeson

Ball State University, Department of Biology, Muncie, IN 47304
Phone: (630) 947-4565
E-mail: smbergeson@bsu.edu

Bergeson, S.M., and T.C. Carter. 2011. Little brown bat roosting and foraging ecology research in the Shawnee National Forest, IL. Illinois Department of Natural Resources. $3,000. Funded.

Bergeson, S.M., and T.C. Carter. 2011. 2011 Midwest Fish & Wildlife Conference Presentations. Ball State University ASPiRE Grant Program. $100. Funded.

Memberships and Awards

Awarded Certificate of Achievement in recognition of significant academic accomplishments at the graduate level. 2011 2012.
SBDN Best Student Oral Presentation on Bats Award. Awarded at the 22nd Colloquium on the Conservation of Mammals in the Southeastern United States. Southeastern Bat Diversity Network. 2012.
Graduate Merit Fellowship. Ball State University. 2011.
Dean's list in Southern Illinois University, Carbondale. Spring 2006, Spring 2007, Spring 2008, Fall 2008, Spring 2009, Fall 2009
Midwest Bat Working Group 2012-Present
Bat Conservation International 2012-Present
Western Bat Working Group 2011
The Wildlife Society 2010-Present
The Wildlife Society; Ball State University Chapter 2010-Present
The Wildlife Society; Southern Illinois University, Carbondale Chapter 2005-2009
Southeastern Bat Diversity Network 2010-Present
Society for the Study of Amphibians and Reptiles 2009-2011
Boy Scouts of America 1995-2009
Rank: Eagle Scout

Scott Bergeson

Ball State University, Department of Biology, Muncie, IN 47304
Phone: (630) 947-4565
E-mail: smbergeson@bsu.edu

References

Dr. Timothy Carter
Assistant Professor, Biology
Ball State University
Department of Biology
Muncie, IN 47306
Phone: (765) 285-8842
E-mail: tccarter@bsu.edu

Dr. Gary Dodson
Professor, Biology
Ball State University
Department of Biology
Muncie, IN 47306
Phone: (765) 285-8859
E-mail: gdodson@bsu.edu

Dr. Eric Schauber
Assistant Professor, Wildlife Ecology
Southern Illinois University
269C Life Science 2
Carbondale, IL 62901
Phone: (618) 453-6940
E-mail: schauber@siu.edu

Tyler Schartel
PH.D. Candidate
Mississippi State University
Department of Biological Sciences
Mississippi State, MS 39762
Phone: (618) 412-1002
E-mail: tes164@msstate.edu

ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.
Résumé
Jared S. Helms

EDUCATION

M.S., Life Sciences, Indiana State University, In progress
B.S., Life Sciences, Indiana State University, 2006

QUALIFICATIONS AND EXPERIENCE

Mr. Helms works with herpetofauna (amphibians and reptiles), fish, and bats, including the federally endangered Indiana bat. He is experienced in many ecological field techniques, including:

- Mist net set up, bat handling and morphometric processing (species, weight, gender, and various measurements),
- Roost tree identification
- Emergence counts
- Habitat assessments
- Radio telemetry
- AnaBat (acoustic monitoring) site selection, recording, and analysis
- Use of handheld, sub-meter accurate Trimble GPS unit
- Fish preservation and care

Mr. Helms is familiar with a variety of GIS software including ArcGIS 9.2 and Imagine 9.2 and he was responsible for updating all historical data from ArcView 3.2 to ArcView 9.2 for a projected conducted at the Indianapolis International Airport. Mr. Helms participates in scientific writing, and has co-authored several technical reports and presentations.

PROJECT EXPERIENCE

Field Supervisor – Indiana State University: 2009-2011. Participated in Indiana bat surveys for various research projects associated with the university. Responsible for mist net site set up and habitat assessment, bat identification, morphometric processing, data collection, and implementation of White Nose Syndrome protocols.

Field Supervisor – Indiana Department of Transportation, Interstate 69, Segment 1: 2009. Conducted post-construction mist netting survey for the Indiana bat in southern and central Indiana. Responsible for mist net site set up and habitat assessment, bat identification, morphometric processing, data collection, and implementation of White Nose Syndrome protocols.

Field Supervisor – Center for North American Bat Research and Conservation, Indiana State University: 2009. Led field team to complete population monitoring at Ray's cave in Greene County Indiana. Responsible for setting harp trap at cave entrance, bat

identification, morphometric processing, data collection, and implementation of White Nose Syndrome protocols.

Research Assistant – Center for North American Bat Research and Conservation, Indiana State University. 2006-2009. Participated in monitoring Indiana bat populations. Supervised research technicians, coordinated with law enforcement, conducted study of nocturnal behavior of eastern pipistrelles. Performed GIS-based analyses of habitat selection by two bat species and assisted with a study to determine potential impacts of opening a portion of a conservation area as a public park.

Lab Technician – Indiana State University: 2006-2008. Participated in study related to thermal regulation of a python species. Responsibilities included caring for snakes, running snakes through a maze, and collecting and analyzing data.

Research Technician – Indiana State University: 2004-2005. Participated in a study of Indiana's bat species (including the federally endangered Indiana bat). Assisted with monitoring a population of endangered Indiana bats. Responsibilities included mist netting, bat capture, radio-telemetry to track the bat to both day roosts and nocturnal habitats and habitat analysis using both GIS and field-based techniques. Also completed a turtle survey including trapping, identification, and marking.

Curatorial Aid – Indiana State University: 2004-2005. Assisted curator with maintenance of herpetology and ichthyology museum collections. Responsibilities included identifying species, preparing specimens, and cataloging reptiles, amphibians, and fishes in the museum collection. Entered data in museum records.

PUBLICATIONS AND PRESENTATIONS

Whitaker, J. O. Jr., D. W. Sparks, D. J. Judy, J. S. Helms, N. S. Gikas, and N. M. Tuttle. 2007. 2007 Monitoring Program for the Indiana myotis (*Myotis sodalis*) near the six points interchange in Hendricks and Marion counties, Indiana as required under the six points interchange habitat conservation plan. Presented to Indianapolis Airport Authority on 1 December 2007.

Whitaker, J. O. Jr., D. W. Sparks, D. J. Judy, A. L. Fairbairn, J. S. Helms, J. J. Sheets, and J. L. Burskey. 2006. 2006 Monitoring Program for the Indiana myotis (*Myotis sodalis*) near the six points interchange in Hendricks and Marion counties, Indiana as required under the six points interchange habitat conservation plan. Presented to Indianapolis Airport Authority on 1 December 2006.

Helms, J. S., D. W. Sparks, and J. O. Whitaker, Jr. 2007. Bats of State Forests in Indiana. Poster Presented To: American Society of Mammalogists.

Helms, J. S., D. W. Sparks, and J. O. Whitaker, Jr. 2006. Nocturnal behavior and roosting ecology of *Perimyotis subflavus* (Eastern Pipistrelle) near Indianapolis International Airport. Poster Presented To: Indiana Academy of Science and North American Bat Research Symposium.

PROFESSIONAL AFFILIATIONS

Indiana Academy of Science (Student Member)
Indiana State University Fish & Wildlife Ecology Club

APPENDIX B
FIGURES

Figure 1. ("Mist net sites for the 2012 survey on I-69 Section 5, Morgan and Monroe counties, Indiana") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

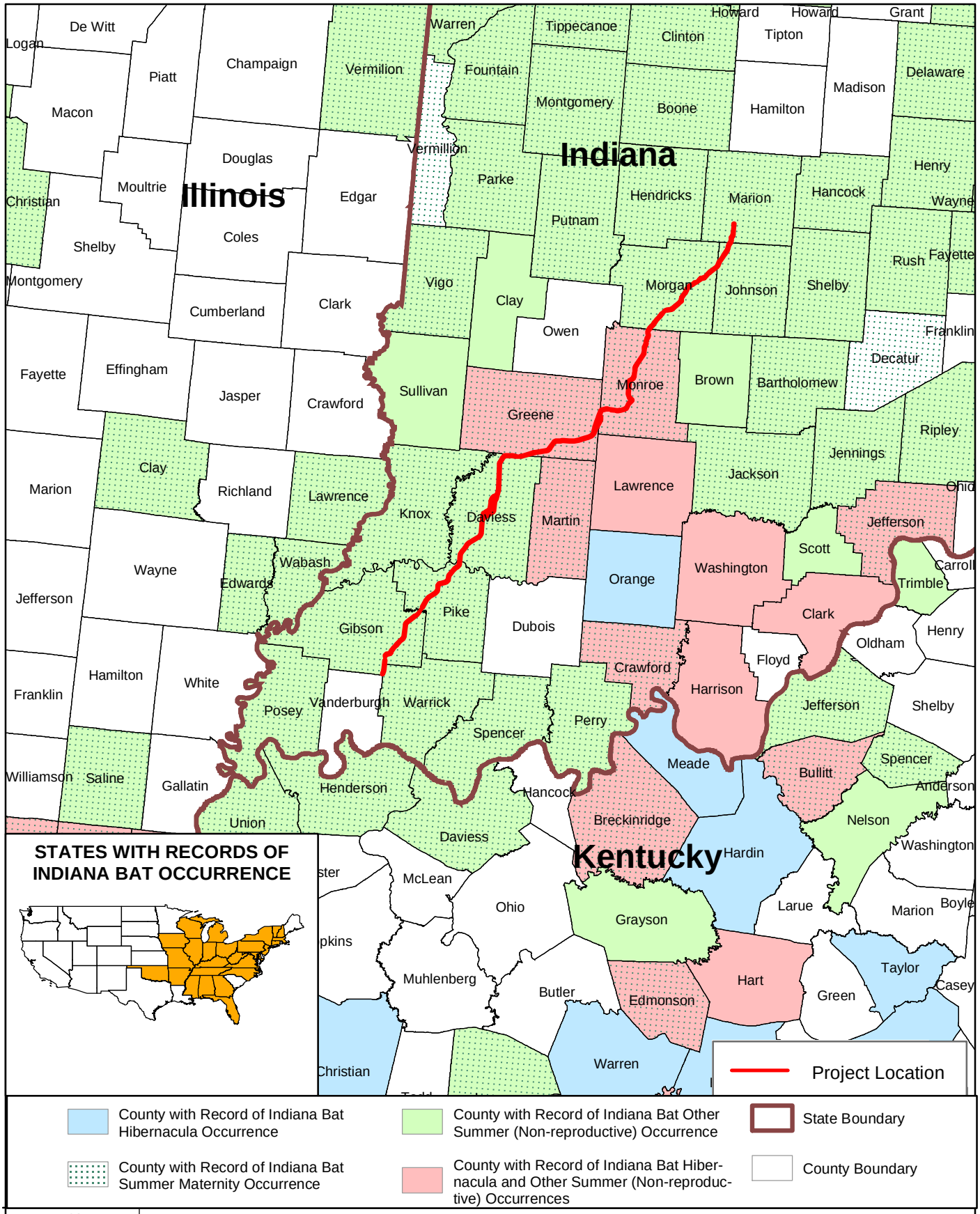


Figure 2. Counties near the Project area with hibernacula, summer maternity, and other summer (non-reproductive) records for the Indiana bat (*Myotis sodalis*).

Project No. 123.17	Sources: USFWS, Indiana Bat Revised Recovery Plan, Agency Draft, 2007. Updated November 2011	ESI ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.

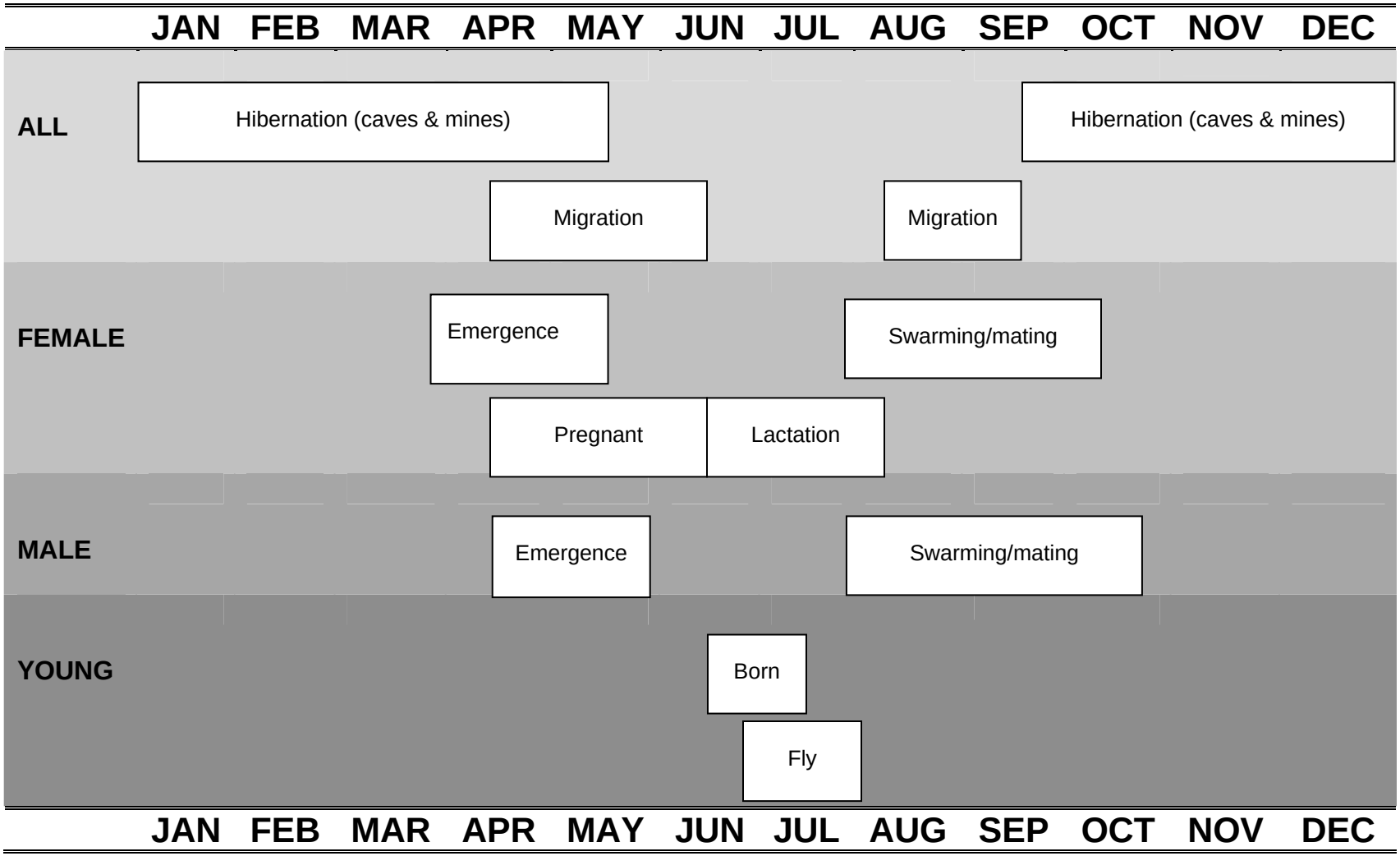


Figure 3. Seasonal chronology of Indiana bat activities.

Figure 4. ("Indiana bat and evening bat capture sites during 2012 survey on I-69 Section 5, Morgan and Monroe counties, Indiana") has been removed for confidentially reasons related to the federally endangered Indiana bat.

Figure 5. ("Indiana bat roost trees located during the 2012 survey on I-69 Section 5 Morgan and Monroe counties, Indiana") has been removed for confidentially reasons related to the federally endangered Indiana bat.

Figure 6. ("Indiana bat roost trees during the 2012 survey on I-69 Section 5, Morgan and Monroe counties, Indiana") has been removed for confidentially reasons related to the federally endangered Indiana bat.

APPENDIX C
TABLES

Table 1. Mist net site information for the 2012 mist net survey on I-69 Section 5 in Morgan and Monroe counties, Indiana.

Site #	Name	Date	Northing	Easting	UTM zone	County
1	A	15, 16 May				Monroe
	B					
2	A	15, 16 May				Monroe
	B					
3	A	15 May				Monroe
	B	15, 16 May				
	C	16 May				
4	A	20*, 21, 22 May				Monroe
	B					
5	A	15, 16 May				Monroe
	B					
6	A	17, 18 May				Monroe
	B					
7	A	17*, 18, 19 May				Monroe
	B					
8	A	15, 16 May				Monroe
	B					
9	A	15, 16 May				Monroe
	B					
10	A	18, 19 May				Monroe
	B					
11	A	15, 16 May				Monroe
	B					
12	A	17*, 18, 19 May				Monroe
	B					
13	A	15, 16 May				Monroe
	B					

Site #	Name	Date	Northing	Easting	UTM zone	County
14	A	17*, 18, 19 May				Monroe
	B	17*, 18, 19 May				
	C	18, 19 May				
15	A	15, 16 May				Monroe
	B					
16	A	17*, 18, 19 May				Monroe
	B					
17	A	17*, 18, 19 May				Monroe
	B					
18	A	19, 20*, 21 May				Morgan
	B					
19	A	20*, 21, 22 May				Morgan
	B					
20	A	29, 30 May				Morgan
	B					
21	A	20*, 21, 22 May				Morgan
	B					
22	A	20*, 21, 22 May				Morgan
	B	20*, 21 May				
	C	22 May				
23	A	20*, 21, 22 May				Morgan
	B					
24	A	18, 19 May				Morgan
	B					

* Netting discontinued because of weather

Table 2. USFWS mist netting guidelines.

NETTING GUIDELINES

1. Netting Season: 15 May to 15 August, when Indiana bats occupy summer habitat
2. Equipment (Mist Nets): constructed of the finest, lowest visibility mesh commercially available – monofilament or black nylon – with the mesh size approximately 38 millimeters (1.5 in)
3. Net Placement: mist nets extend approximately from water or ground level to tree canopy and are bounded by foliage on the sides. Net width and height are adjusted for the fullest coverage of the flight corridor at each site. A "typical" net set consists of three (or more) nets "stacked" on top of one another; width may vary up to 18 meters (60 ft)
4. Net Site Spacing:
   - Streams – one net site per 1 kilometer (0.6 mi)
   - Land Tracts – two net sites per 1 square kilometer (246 ac)
5. Minimum Level of Effort Per Net Site:
   - Two net locations (sets) per net site, with locations (sets) at least 30 meters apart
   - Two (calendar) nights of netting
   - At least four net–nights (1 net–night = 1 net set deployed for 1 night); typically, two net sets are deployed at one site for two nights, resulting in four net nights
   - Sample Period: begin at dusk and net for 5 hours (approximately 0200h)
   - Nets are monitored at approximately 10-minute intervals
   - No disturbance near the nets between checks
6. Weather Conditions: net only if the following weather conditions are met:
   - No precipitation
   - Temperature $\geq$ 10° Celsius (50° F)
   - No strong winds

Source: U.S. Fish and Wildlife Service, 2007

Table 3. Total bat capture data for the 2012 mist net survey on I-69 Section 5 in Morgan and Monroe counties, Indiana.

Species	Adult Male	Adult Female[1]					Juvenile			Total
		P	L	PL	NR	UNK	Male	Female	Escape[2]	
Big Brown Bat	48	24	3		2				1	**78**
Eastern Red Bat	89	16	1		3	2			8	**119**
Hoary Bat	1	5							1	**7**
Silver-haired Bat	7									**7**
Little Brown Bat	18	8							2	**28**
Northern Bat	21	15								**36**
Indiana Bat	4	8								**12**
Evening Bat		3								**3**
Eastern Pipistrelle	17	18			6	1			2	**44**
Total	**205**	**97**	**4**	**0**	**11**	**3**	**0**	**0**	**14**	**334**

[1] P = pregnant; L = lactating; PL = post lactating; NR = non-reproductive
[2] Escape = escaped from net or hand before processing was complete

Table 4. Bats captured at each site during the 2012 mist net survey on I-69 Section 5 in Morgan and Monroe counties, Indiana.

	Site																								
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**Total**
Big Brown Bat	2	14		21	3	3				1	1	5	1	1				2	6	1	4	7	6		**78**
Eastern Red Bat	1	5		7	2	2			2	4	7	7	1	3	1	23	19	4	5	1	10	7	7	1	**119**
Hoary Bat											1						2	2					1	1	**7**
Silver-haired Bat	1				1											1	1	1	1			1			**7**
Little Brown Bat	2	2				2			2		2	2				1	2	2	6			1	2	2	**28**
Northern Bat		3	1	3			1	1	3				2	4	1		5		2		5	5			**36**
Indiana Bat		2												1								3		6	**12**
Evening Bat											1												2		**3**
Eastern Pipistrelle	1			1		7	1	3	5		2	4	1		2	2	2	1	4	1		2	2	3	**44**
Total	**7**	**26**	**1**	**32**	**6**	**14**	**2**	**4**	**12**	**5**	**14**	**18**	**5**	**9**	**4**	**27**	**31**	**12**	**24**	**3**	**19**	**26**	**20**	**13**	**334**

Table 5. Indiana bat capture data for the 2012 mist net survey on I-69 Section 5 in Morgan and Monroe counties, Indiana.

Indiana Bat	Capture Date	Capture Site	Capture Time	Age	Sex	Reproductive Condition	Weight (g)	Right Forearm (mm)	Transmitter Frequency (MHz)
824	15 May	2	2145	Adult	Male	Non-reproductive	7	39	172.824
869	16 May	2	0015	Adult	Male	Non-reproductive	8.1	37	172.869
782	18 May	14A	2208	Adult	Male	Non-reproductive	7.5	38	172.782
768	18 May	24	2203	Adult	Female	Pregnant	8	38	151.768
Untagged1	18 May	24	2203	Adult	Female	Pregnant	7.75	38	None
Untagged2	18 May	24	2203	Adult	Male	Non-reproductive	6	37	None
Untagged3	19 May	24	2150	Adult	Female	Pregnant	8.25	37	None
Untagged4	19 May	24	2150	Adult	Female	Pregnant	7.75	38	None
Untagged5	19 May	24	2150	Adult	Female	Pregnant	7.25	37	None
927	20 May	22	2200	Adult	Female	Pregnant	8.6	35.5	172.927
Untagged 6	21 May	22	0100	Adult	Female	Pregnant	9.5	37	None
Untagged7	22 May	22	0000	Adult	Female	Pregnant	11.2	39	None

Table 6. Bat use of roost trees during the 2012 mist netting survey on I-69 Section 5 in Morgan and Monroe counties, Indiana.

Roost	Date (2012)	Tagged Bat(s) Present	Time of First Emergence	Time of Last Emergence	Total Bats Emerged
824-1	16 May	824	2103	2121	5
824-1	17 May	824	2045	2115	2
824-1	18 May	824	2047	2115	3
824-2	19 May	824	2114	2124	5
824-2	20 May	824			No Count
824-2	21 May	824			No Count
869-1	17 May	869	2110	2110	1
869-1	18 May	869	2117	2117	1
869-1	19 May	869	2125	2125	1
869-1	20 May	869			No Count
869-1	21 May	869			No Count
782-1	19 May	782			No Count
782-1	20 May	782	2115	2123	4
782-1	21 May	782	2117	2128	18
782-1	22 May	782			No Count
782-1	23 May	782			No Count
782-1	24 May	782			15-20[1]

Roost	Date (2012)	Tagged Bat(s) Present	Time of First Emergence	Time of Last Emergence	Total Bats Emerged
782-1	25 May	782			15-20[1]
782-1	26 May	782			15-20[1]
782-1	27 May	None			10[1]
782-1	28 May	None			10[1]
782-1	29 May	None			10[1]
782-1	12 June	None			0[1]
768-1	19 May	768	2121	2136	29
768-1	20 May	768	2115	2130	31
768-1	21 May	768	2114	2128	35
768-1	22 May	None	2113	2233	48
768-1	27 May	None	2125	2149	29
768-1	12 June	None	2115	2155	80
768-2	23 May	768	2118	2140	43
768-2	24 May	768	2113	2137	22
768-2	25 May	768	2118	2140	27
768-2	26 May	768	2119	2139	36
768-2	27 May	768[2]	2121	2139	34
768-2	28 May	768[2]	2118	2142	32
768-2	12 June	None	2144	2144	1
927-1	22 May	927	2116	2130	51
927-1	23 May	927	2117	2141	51
927-1	24 May	927	2117	2141	53
927-1	25 May	927	2121	2145	40
927-1	26 May	927	2129	2145	74
927-1	27 May	927[2]	2120	2144	66
927-1	28 May	927[2]	2124	2144	63
927-1	12 June	None	2118	2158	74

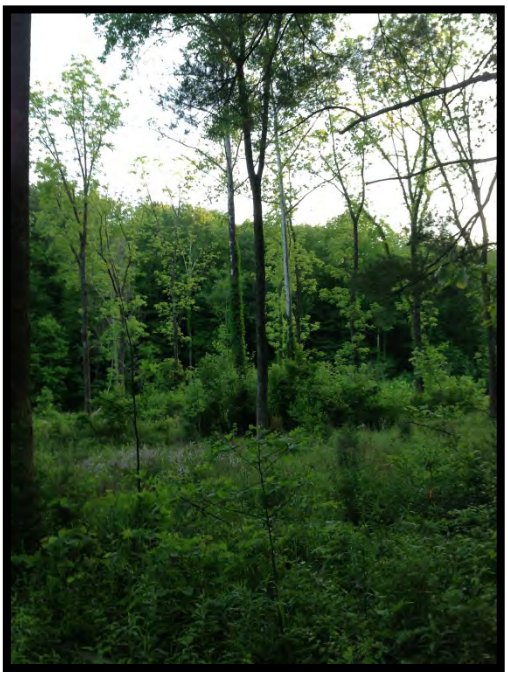
[1]Number of bats estimated using a spot-light
[2] Transmitted bat remained in the roost; transmitter likely shed.

APPENDIX D
REPRESENTATIVE PHOTOGRAPHS

Site 1 – Net B

Site 1 – Anabat

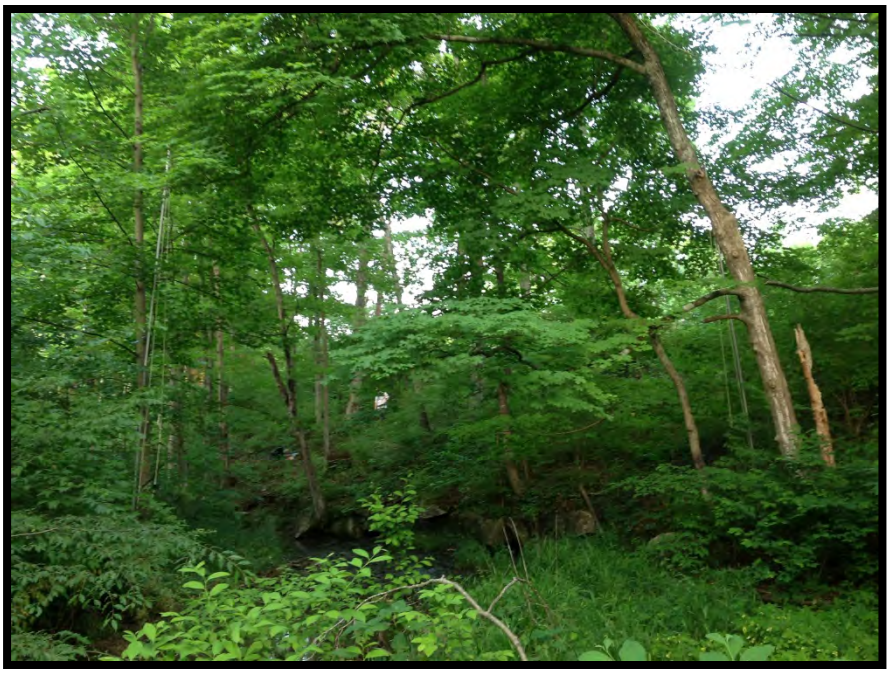
Site 2 – Net A



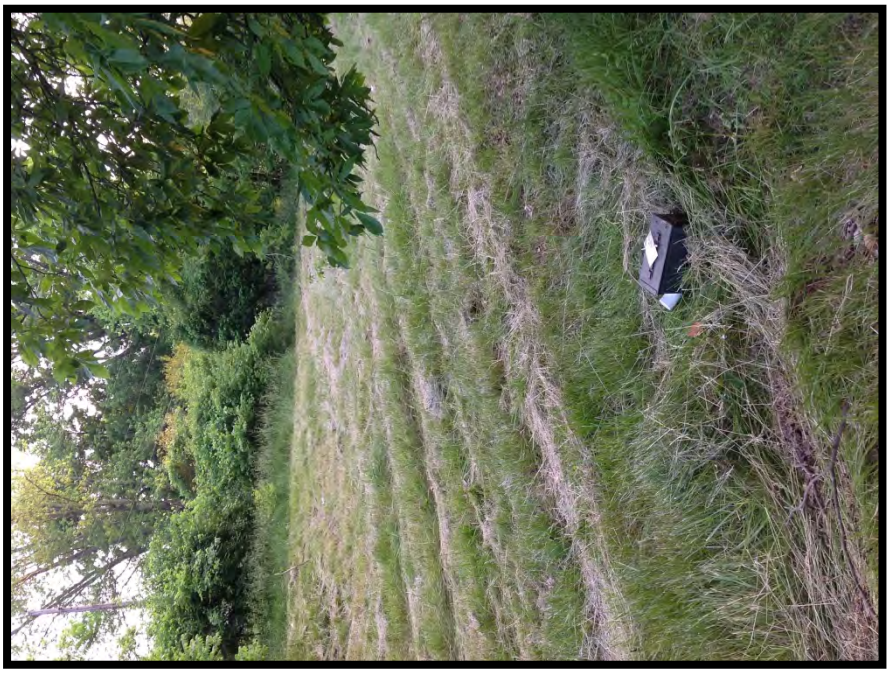
Site 2 – Anabat

Site 3 – Net A

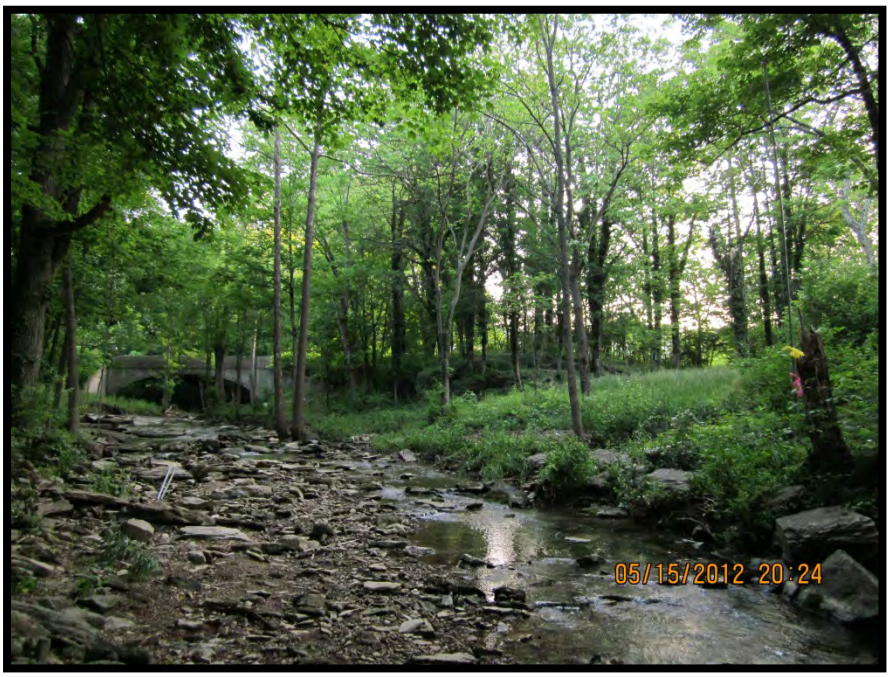
Site 3 – Net B



Site 4 – Net B



Site 4 – Anabat



Site 5 – Net B

Site 5 – Anabat

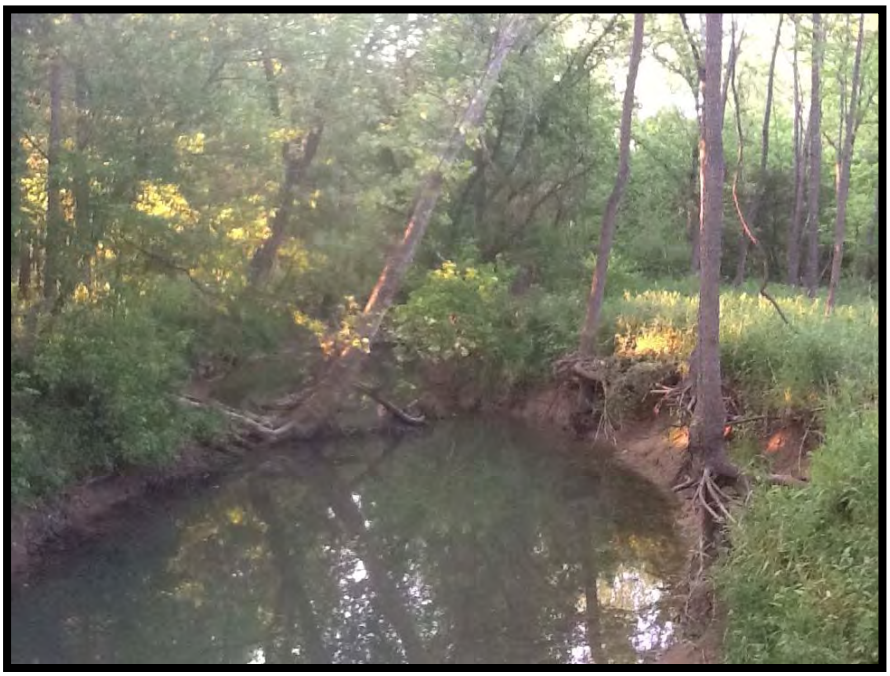
Site 6 – Net A

Site 6 – Anabat

Site 7 – Net A

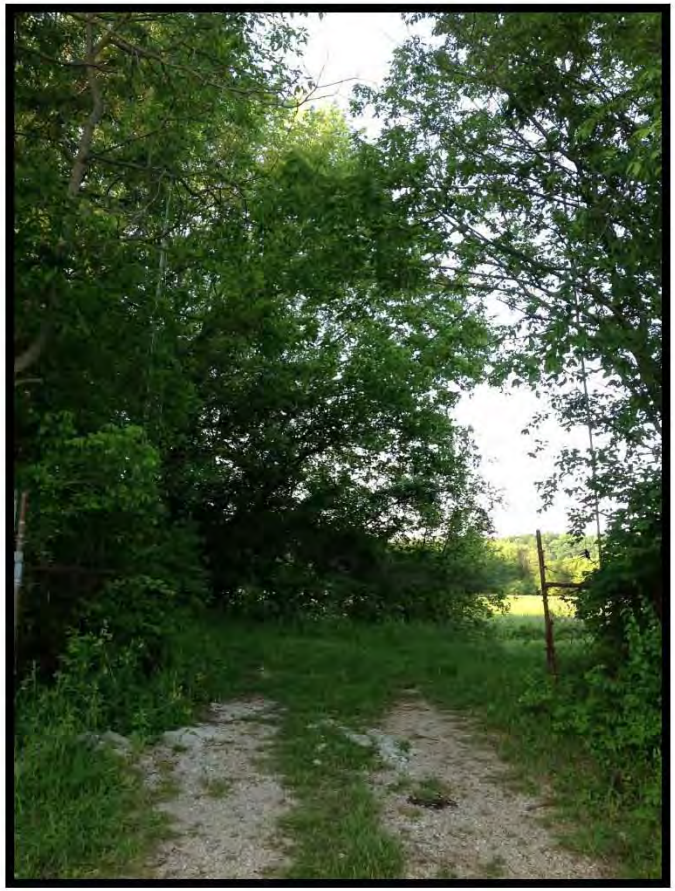
Site 7 – Net B

Site 8 – Net A



Site 8 – Net B

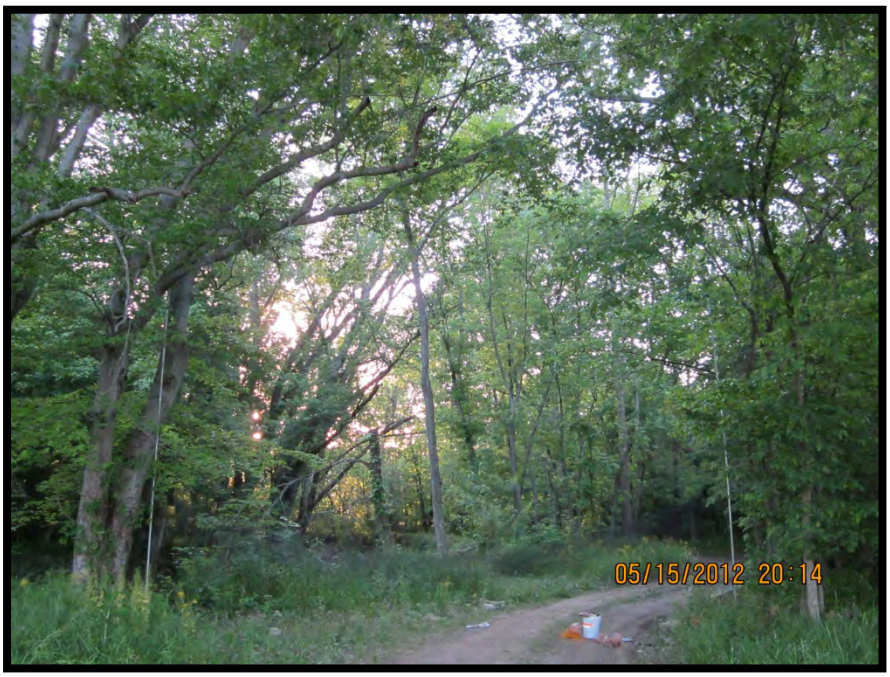
Site 9 – Anabat



Site 9 – Net A

Site 10 – Net A

Site 10 – Net B

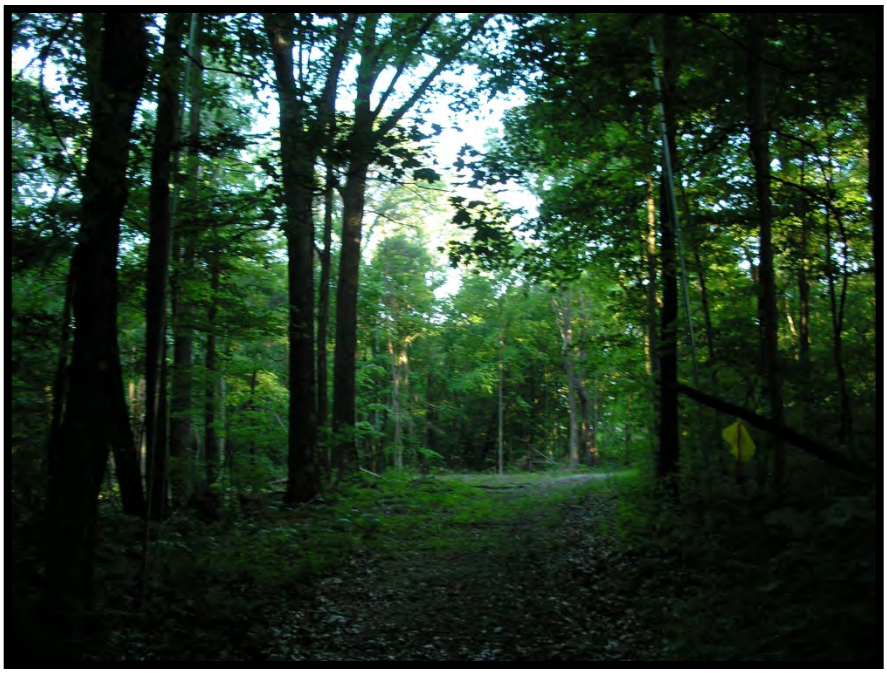


Site 11 – Net A

Site 11 – Net B

Site 12 – Anabat

Site 12 – Net B



Site 13 – Net A

Site 13 – Net B

Site 14 – Anabat

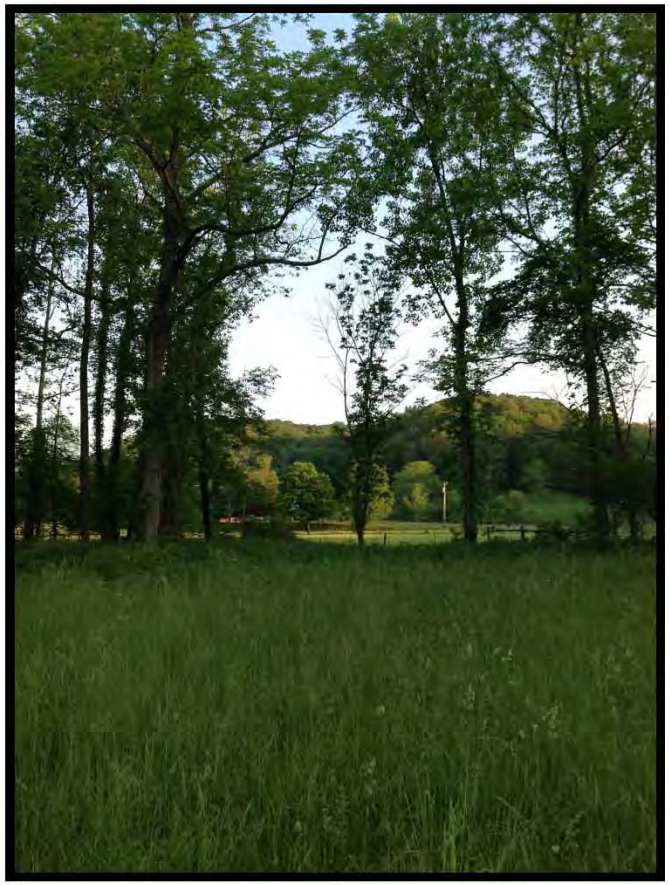
Site 14 – Net B

Site 15 – Net B

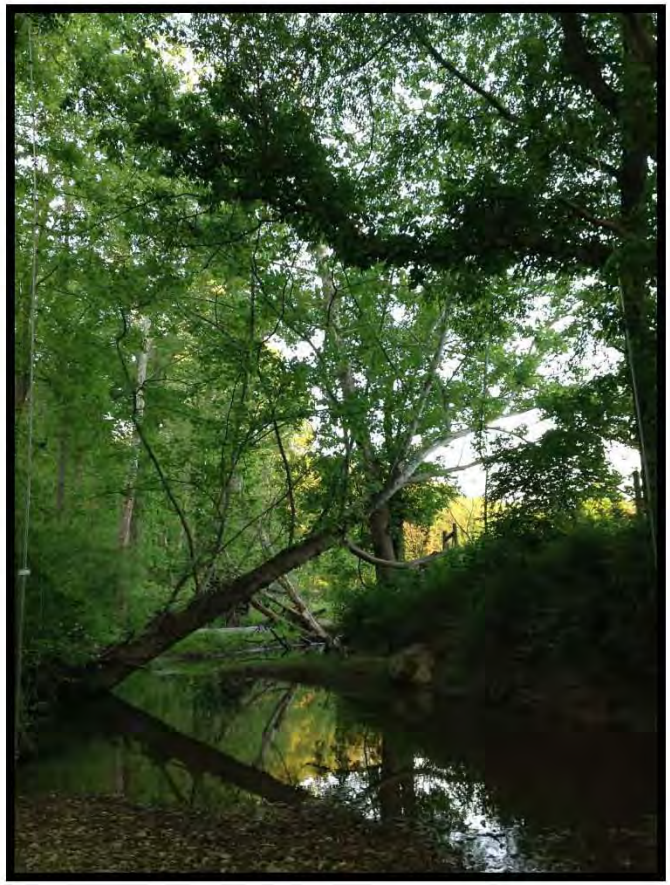
Site 15 – Anabat

Site 16 – Net A

Site 16 – Net B



Site 17 – Anabat



Site 17 – Net A

Site 18 – Net A

Site 18 – Anabat

Site 19 – Net A

Site 19 – Anabat

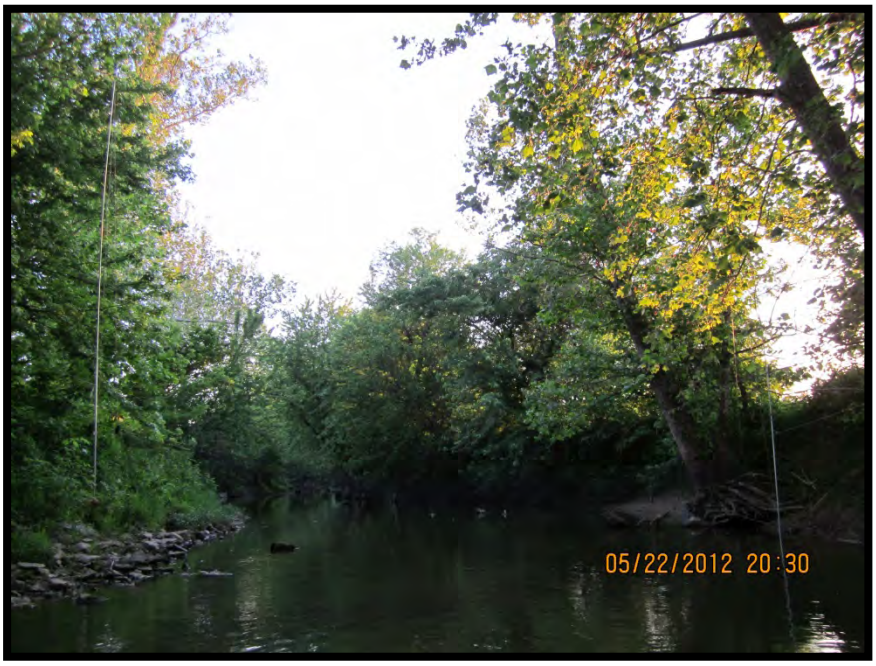
Site 20 – Net B

Site 20 – Anabat

Site 22 – Net B

Site 22 – Net C

Site 23 – Net A



Site 23 – Net B

Site 24 – Net A

Site 24 – Net B

Bat 782

Bat 782

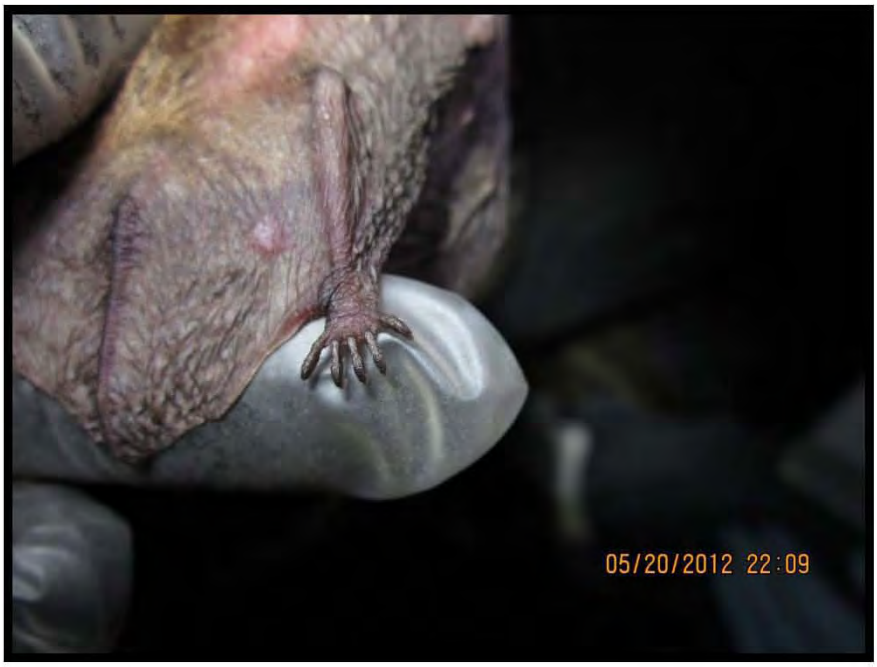
Bat 824

Bat 824

Bat 869

Bat 869

Bat 927

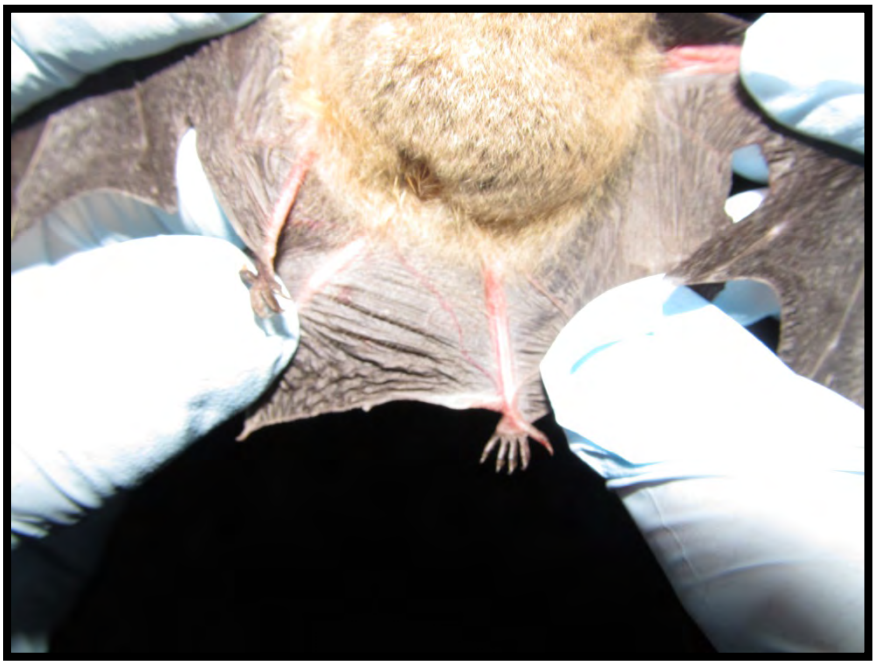


Bat 927

Untagged Bat 6

Untagged Bat 6

Untagged Bat 7



Untagged Bat 7

Bats in Roost 782-1

Roost 782-1

Roost 824-2

Roost 824-1

Roost 927-1

Roost 869-1

Roost 768-2

Roost 768-1

APPENDIX E

COMPLETED MIST NET DATA SHEETS

Appendix E: Data Sheets have been removed for the confidentiality reasons related to the federally endangered Indiana bat.

APPENDIX F

COMPLETED TELEMETRY DATA SHEETS

Appendix F: Data Sheets have been removed for the confidentiality reasons related to the federally endangered Indiana bat.

Identification of Indiana Bat Roost Trees Along the Proposed Interstate 69 Between Bloomington and Indianapolis, Indiana

April 5, 2006

Prepared by
BHE Environmental, Inc.
11733 Chesterdale Road
Cincinnati, OH 45246

IDENTIFICATION OF INDIANA BAT ROOST TREES ALONG THE PROPOSED INTERSTATE 69 BETWEEN BLOOMINGTON AND INDIANAPOLIS, INDIANA

Amy B. Henry[1] and Russell C. Rommé[2]
[1]*BHE Environmental, Inc., 7041 Maynardville Highway, Knoxville, TN 37918*
[2]*BHE Environmental, Inc., 11733 Chesterdale Road, Cincinnati, OH 45246*

Abstract

BHE Environmental, Inc. (BHE) investigated roost trees used by four reproductive female Indiana bats during the summer 2005 maternity season along the proposed Interstate Highway 69 between Bloomington and Indianapolis in Morgan and Johnson counties, Indiana. Mist nets were used at ten sites to trap bats. Captures included four reproductive adult female Indiana bats from four sites. Radio transmitters were attached to each of the four bats, which were each tracked to diurnal roost trees. Between two and four roost trees were identified for each individual. Emergence counts were conducted at roost trees to determine the number of bats present, and to estimate the size of maternity colonies. Two of the ten roost trees identified were occupied by greater than 30 individuals on several occasions. Eight were occupied by fewer than 30 individuals during each of the emergence counts. Based upon distances between groups of roost trees, we concluded maternity colonies are present near Bryant Creek, Clear Creek, and Pleasant Run Creek. None of the roost trees identified in 2005 is located within the proposed I-69 corridor. However, the roosting and foraging areas that may be used by the three maternity colonies include the proposed road corridor.

Key words: Indiana bat, *Myotis sodalis*, radio telemetry, mist net, maternity roost

---

Introduction

The Indiana Department of Transportation (INDOT) and the Federal Highway Administration (FHWA) are completing six Tier 2 Environmental Impact Statements for the proposed Interstate Highway 69 (I-69) from Indianapolis to Evansville, Indiana. A detailed description of the proposed road corridor was presented in the Tier 1 Final Environmental Impact Statement (Tier 1 FEIS; FHWA and INDOT 2003a). The study described herein is part of the Tier 2 Environmental Impact Statement (EIS) for the proposed I-69 project. The proposed I-69 interstate is approximately 142 miles (228.5 kilometers [km]) in length and is divided into six sections to facilitate Tier 2 EIS studies. Investigations described herein address Section 5 between Bloomington and Martinsville, and Section 6 between Martinsville and Indianapolis. Studies were conducted in Morgan, Johnson, and Marion counties along Corridor 3C, which was identified as the preferred alternative in the Tier 1 FEIS (FHWA and INDOT 2003a).

The FHWA and the U.S. Fish and Wildlife Service (USFWS) are conducting ongoing consultation under Section 7 of the Endangered Species Act to evaluate potential impacts of the proposed action. Methods used in these investigations were developed in consultation with the USFWS, Bloomington Field Office.

The purpose of this study was to identify maternity roost trees used by Indiana bats in Sections 5 and 6. Each Indiana bat maternity colony typically has at least one roost ("primary") that is used by a majority of the bats during most of the summer (Callahan et al. 1997, USFWS 1999). An Indiana bat maternity colony also inhabits other roosts ("alternate"), which typically are used intermittently and by fewer bats (USFWS 1999, Kurta et al. 2002, Kurta and Williams 1992).

Callahan (1993) described primary and alternate maternity roost trees. Primary roost trees in Missouri were characterized as large dead trees that are exposed to direct sunlight, and occupied by greater than 30 bats on more than one occasion. Alternate roosts in Missouri were either dead or live trees usually occupied by fewer than 30 individuals. Alternate roost trees in Missouri were similar to primary roost trees, except that many were located in the forest interior and were shaded by tree canopy (Callahan 1993). The terms primary and alternate roost tree, as defined by Callahan (1993) are used herein to maintain consistency with terminology established by the USFWS Bloomington Field Office for this study. However, those terms must be used with caution. While 30 individuals may be an appropriate threshold for distinguishing primary and alternate roosts among trees studied by Callahan, other maternity colonies may vary in size. Long-term studies of two Indiana bat maternity colonies in Michigan indicated fewer than 30 Indiana bats typically occupy a single tree during one night (Kurta et al. 2002). In Tennessee, three trees identified as primary Indiana bat roosts contained a maximum of 28, 23, and 81 bats (Britzke et al. 2003). Additionally, the number of bats using a certain tree may vary among years. In Michigan, of 38 Indiana bat roost trees identified during a four-year study, only six trees were occupied by bats for more than one year (Kurta et al. 2002).

During surveys in July 2004, five reproductive female and five juvenile Indiana bats were captured in Sections 5 and 6 (Henry et al. 2004, Hendricks et al. 2004). Using radio telemetry, several of the Indiana bats captured were followed to roost trees. Two roost trees were identified in Section 5, and four were identified in Section 6 (Henry et al. 2004, Hendricks et al. 2004). However, except for three roost trees in Section 6, none of the roost trees identified in 2004 was occupied by more than 15 bats on nights when emergence counts were conducted. Primary maternity roosts likely exist near sites where reproductive female and juvenile Indiana bats were captured in 2004, but primary roost trees could not be identified for all capture areas in 2004. The purpose of this study conducted in 2005 was to return to Bryant Creek in Section 5, and Clear Creek and Pleasant Run Creek in Section 6 to capture and track Indiana bats to primary maternity roost trees. Documenting the location of primary maternity roosts and the number of bats using those roosts supports the evaluation of potential effects to Indiana bats from the proposed I-69.

Secondarily, results of this study will provide data regarding the evening bat (*Nycticeius humeralis*), which is not listed by the USFWS, but is designated by the State of Indiana as endangered.

Materials and Methods

Sections 5 and 6 cover approximately 48 miles (77 km) of the proposed I-69 in Indiana. The proposed road alignment will be within a corridor extending 1000 feet (305 meters [m]) on each side of the Corridor 3C centerline (total width of 2000

feet [610 m]). The 2000-foot wide corridor represents the area in which a preferred alignment would be located. The actual width of the alternative is expected to range from 240 to 470 feet. In some instances, interchanges and connector roads may extend outside the corridor. The Corridor 3C Indiana Bat Study Area is defined by a 5-mile (8-km) wide corridor, 2.5 miles (4 km) wide along either side of the corridor centerline. The 2.5-mile (4 km) distance approximates the maximum distance an Indiana bat travels from its daytime roost to its foraging area (1.5 miles in Gardner et al. 1991; 2.8 miles in Butchkoski and Hassinger 2002). The Tier 1 Biological Assessment established the 5-mile (8 km) wide Study Area and identifies it as the "Indiana bat summer action area" (FHWA and INDOT 2003b). This survey was conducted in the same Study Area as investigations conducted during summer 2004 (Henry et al. 2004, Hendricks et al. 2004).

Access permission was sought and provided by landowners prior to implementation of the mist net survey, radio telemetry study, and roost tree identification described below.

Mist Net Survey

The goal of the 2005 mist net survey was to capture reproductive female or juvenile Indiana bats suitable for radio telemetry. Mist netting was conducted near Bryant Creek (Section 5), Clear Creek (Section 6) and Pleasant Run Creek (Section 6), where Indiana bats were captured but not tracked to primary roost trees in 2004 (Appendix A, Figures 1–3). Mist net sites were also established at the White River, Travis Creek, Honey Creek, and Goose Creek.

Ten mist net sites were surveyed between July 12 and July 19, 2005 (Appendix A, Figures 1–3, Appendix B, Table 1). The ten net sites were selected in consultation with FHWA, INDOT, and the USFWS, Bloomington Field Office (BFO). All ten net sites were located within the Indiana bat summer action area. Mist net sites were between approximately 200 and 11,000 feet (61 and 3,353 meters) from the corridor centerline, with four of the ten net sites within the proposed corridor (Appendix A, Figures 1–3; Appendix B, Table 1). Mist net sites are identified herein using site numbers assigned in 2004 (Henry et al. 2004, Hendricks et al. 2004), preceded by the section number, i.e., Site 22 in Section 6 is Site 6-22.

Mist nets were deployed at one upland and nine stream sites. Detailed descriptions of mist net sites are provided in Appendix C and in previous reports (Henry et al. 2004, Hendricks et al. 2004).

Two mist nets were deployed at each net site for two nights, or until two Indiana bats suitable for radio telemetry were captured. The survey was conducted in accordance with Indiana Bat Recovery Team guidance regarding the seasonal timing of surveys, equipment, net placement, and acceptable weather conditions (USFWS 1999). One mist net was composed of 2–4 nets stacked vertically and suspended by a system of poles, ropes, and pulleys (Gardner et al. 1989). Nets were constructed of two-ply, 50-denier nylon with a mesh size no larger than 1.75 inches (4.4 cm). Mist nets were 18–42 feet (5.6–13.8 m) wide and 20–30 feet (6.6–9.9 m) tall. When possible, nets were bounded by vegetation above and on both sides to facilitate capturing bats. Mist nets were monitored at least every 20 minutes. Disturbance near nets between checks was minimized.

Upon capture, bats were removed from mist nets, identified to species, measured, and

released unharmed at the capture site. Data recorded for each bat captured included species, age, gender, reproductive condition, right forearm length (RFA), and body weight. Bats were identified to species based upon distinctive morphological characteristics (e.g., body size, hair color, ear length, tragus length and shape, presence/absence of a keeled calcar). Adult female bats were classified as reproductive if they were pregnant (determined by palpation of abdomen), lactating (i.e., teats conspicuous and enlarged, lack of hair around teats), or post-lactating (visible regrowth of hair around teats). Male bats with testicles descended into the scrotum were considered reproductive. Young-of-the-year of both sexes were classified as juveniles. Young-of-the-year were distinguished from adults by examining ossification (bone growth) in phalangeal joints.

Weather conditions were documented hourly during the mist net survey; air temperature, wind speed, cloud cover, precipitation, and visibility of the moon were recorded. A standard thermometer was used to record temperature. Wind speed, percent cloud cover, and moon phase were estimated (Appendix C). Each net site was photographed and the location recorded using a hand-held Global Positioning System (GPS) receiver (Garmin International, Inc., Olathe, Kansas).

Each captured Indiana bat was photographed, specifically the face, the whole body, and the calcar (Appendix D).

Radiotelemetry

The primary goal of radiotelemetry was to identify Indiana bat maternity colonies and their primary and alternate roost trees.

Upon capture, a 0.25-ounce (0.7-gram) radio transmitter (Wildlife Materials, Inc., Carbondale, Illinois) was attached to the mid–scapular fur of each bat using non-toxic surgical cement. A TRX-2000 radio receiver (Wildlife Materials, Carbondale, Illinois) was used to ensure each transmitter was functioning properly before the transmitter was attached. Transmitter-equipped bats were released unharmed from the point of capture (Appendix C).

Attempts were made to locate radio signals from transmitters on day-roosting Indiana bats for ten days following release of each bat. Radiotracking generally was conducted between approximately 1000 h and 1600 h each day. Searches for radio signals were conducted most intensively within the 2000-foot (609-meter) wide proposed corridor, but occurred throughout the Indiana bat Study Area (summer action area) in Sections 5 and 6.

Roost Tree Characterization and Emergence Counts

Upon identification of a transmitter-equipped Indiana bat roosting in a tree, characteristics of the tree were recorded and the tree was observed to monitor emergence of bats.

We recorded the tree species (if recognizable), status (live or dead), estimated diameter-at-breast-height (dbh), area type (riparian/upland), distance from roost tree to capture site, percent of the tree exhibiting exfoliating bark, and the stage of tree decay (USFS 1979) (Appendix C). To characterize habitat surrounding the roost tree, dominant and co-dominant tree species; estimated canopy closure, average dbh of canopy trees, and topographic slope; estimated distance to nearest water source; estimated distance to nearest flight corridor (i.e., space beneath the tree canopy that

offers protected foraging and travel space for bats); and estimated height from ground to roost were recorded (Appendix C). A GPS receiver was used to record the tree location, and each roost tree was photographed (Appendix D). The location of each roost tree was identified with plastic flagging; care was taken to avoid marking the roost tree to avoid attracting passersby that may disturb roosting bats.

Emergence counts were conducted at each roost tree. The counts commenced at dusk and emerging bats were counted for at least one hour per night. An ultrasound detector (QMC Instruments, Ltd., London, UK) was used to assist in detection of bats at some roost tree sites. Emergence counts were conducted for at least five nights at trees where 15 or more bats were detected emerging during any one of the first three nights of monitoring. Emergence counts were conducted for at least three nights at trees containing fewer than 15 bats.

Documenting Colony Size

An Indiana bat maternity colony may use several roosts up to approximately 5 miles (8 km) apart (Kurta et al. 2002). Alternate roosts have been reported as far as 2 miles (3.2 km) from the primary roost tree. During a 4-year study in Michigan, the greatest distance between roost trees was 5.7 miles (9.2 km) (Kurta et al. 2002). Roost trees greater than 6 miles (9.6 km) apart are likely used by different colonies. To collect data on the population of Indiana bats in maternity colonies, BHE simultaneously monitored emergence from all roost trees believed to be associated with a colony.

Simultaneous counts of bats emerging from roost trees identified in a colony were conducted for at least two nights. Four roost trees in Section 5 were monitored on July 26 and 27. Two roost trees in Section 6 near Pleasant Run Creek were monitored on July 25, 26, and 27. Four other roost trees in Section 6 near Clear Creek were monitored on July 27 and 28. Methods for the emergence count were identical to those previously described.

Data from emergence counts must be interpreted carefully. Because emergence counts document the number of bats emerging, only adults and newly-volant juveniles would be included in the count. Non-volant juveniles, which could comprise up to half the individuals in a maternity colony, would not be observed during an emergence count.

Results of simultaneous emergence counts will be interpreted using a formula developed by the USFWS, Bloomington Field Office to estimate the size of an Indiana bat maternity colony. Developing such estimates is outside the scope of this report.

Results

Mist Net Survey

Between July 12 and 19, 2005, ten net sites were surveyed using mist nets (Appendix A, Figures 1–3). Eighty-five bats representing eight species were captured, including four reproductive adult female Indiana bats and 15 evening bats (Appendix B, Table 2). The little brown bat (*Myotis lucifugus*) was the species most commonly encountered, making up 38 percent of the total capture. Other species captured included the northern long-eared bat (*M. septentrionalis*), big brown bat (*Eptesicus fuscus*), eastern pipistrelle (*Pipistrellus subflavus*), red bat (*Lasiurus borealis*), and hoary bat (*L. cinereus*).

Captures at four sites included a reproductive female Indiana bat (Appendix A, Figures 1–3; Appendix B, Table 3).

Lactating adult female Indiana bats were captured at Net Sites 5-22, 6-8, and 6-23. A post-lactating adult female Indiana bat was captured at Net Site 6-7. All four Indiana bats were equipped with radio transmitters.

Fourteen evening bats (six adult males, four reproductive females and four juveniles) were captured at Net Site 6-23 over Pleasant Run Creek. One juvenile evening bat was captured at Net Site 6-10 over an unnamed tributary to the White River.

Radiotelemetry and Roost Tree Identification

In the following discussion, and in Appendix A, Figures 1–3, Indiana bats are identified by the frequency of the radio transmitter attached to each bat (Appendix B, Table 3).

Lactating female Indiana bat No. 150.046 was released near Net Site 6-8 on July 12 at 0235 h (Appendix A, Figure 2). The radio signal was detected to the northeast of the net site until 0320 h. On July 13, the bat was tracked to Roost Tree 6-1, approximately 5085 feet (1550 m) east of Net Site 6-8. The bat was observed in the roost tree beneath a crack in the bark. Bat No. 150.046 was not detected near Net Site 6-8 during the night of July 13. On July 14, Bat No. 150.046 was detected southeast of Telemetry Station 6S-13, toward Roost Tree 6-1, at 1110 h. However, the bat was not present in Roost Tree 6-1 during the emergence count the evening of July 14. On July 15, the radio signal was detected in Roost Tree 6-2, approximately 5100 feet (1554 m) northwest of Roost Tree 6-1 and 2700 feet (823 m) from Mist Net Site 6-8. Between July 17 and 21, telemetry was conducted from several stations around Clear Creek (Appendix C) but the signal was not detected. The transmitter may have failed or fallen off the bat due to heavy rains that occurred the night of July 16. After July 21, while tracking Bat No. 150.025 near Clear Creek, BHE occasionally attempted to detect Bat No. 150.046, but the radio signal was not detected.

Lactating female Indiana bat No. 150.025 was released near Net Site 6-7 on July 17 at 2245 h (Appendix A, Figure 2). The radio signal was detected southwest and southeast of the mist net site, and crossing over State Route 37 several times until 0055 h. On July 18, the bat was tracked to Roost Tree 6-3, approximately 6360 feet (1938 m) north of Net Site 6-7. The bat was detected emerging from Roost Tree 6-3 at dusk on July 18. On July 19 and 20, Bat No. 150.025 was detected in Roost Tree 6-3 during the day and later during the evening emergence count. However, the radio signal remained located at Roost Tree 6-3 after dusk on July 20. Bearings to the signal were recorded from several locations throughout the night of July 20, with the signal apparently remaining in Roost Tree 6-3. On July 21, 22, and 23 the signal was detected from Roost Tree 6-3 and we suspected the transmitter had fallen off the bat into the tree. However, on July 25, Bat No. 150.025 was tracked to the bank of the White River opposite Roost Tree 6-3, indicating the radio-equipped bat had moved. No roost tree was located on July 25. On July 27 and 28 the radio signal was detected in Roost Tree 6-3. During the evening of July 28, the radio signal was detected near, but not in, Roost Tree 6-3. On July 29, Bat No. 150.025 was tracked to Roost Tree 6-4, approximately 85 feet (26 m) from Roost Tree 6-3 and 6470 feet (1972 m) from Mist Net Site 6-7. During the evening of July 29, the radio signal faded during telemetry monitoring, and the signal was not detected during monitoring attempts around Clear Creek conducted on July 30 or 31. No telemetry was conducted after July 31.

Lactating female Indiana bat No. 151.046 was released near Net Site 5-22 on July 17 at 0220 h (Appendix A, Figure 1). The radio signal was detected to the west of the net site until 0404 h. On July 18, the bat was tracked to Roost Tree 5-1, approximately 3300 feet (1005 m) from Net Site 5-22. During the evening of July 18, the radio signal was detected at Roost Tree 5-1, and the signal faded, suggesting the bat emerged from the tree. The radio signal was detected in Roost Tree 5-1 during the day and evening of July 19. On July 20, Bat No. 151.046 was detected in Roost Tree 5-1 at 1330 h. During the night of July 20, the radio signal was detected northeast of Telemetry Station 5-2, toward the White River, where the bat was likely foraging. On July 21, the bat was tracked to Roost Tree 5-2, approximately 2700 feet (823 m) west of Net Site 5-22 and 1540 feet (469 m) south of Roost Tree 5-1. The radio signal was detected from Roost Tree 5-2 during the evening of July 21, then the signal faded, suggesting emergence from the tree. On July 22, Bat No. 151.046 was tracked to Roost Tree 5-3, approximately 4500 feet (1372 m) west of Net Site 5-22 and 1820 feet (555 m) west of Roost Tree 5-2. On July 23, the signal was tracked to Roost Tree 5-4, approximately 3750 feet (1143 m) west of Net Site 5-22 and 1130 feet (344 m) southeast of Roost Tree 5-3. No telemetry was attempted on that signal between July 24 and 26. Between July 27 and 31, telemetry monitoring was attempted daily from several stations around Bryant Creek (Appendix C), but the signal from 151.046 was not detected. No telemetry was attempted after July 31.

Lactating female Indiana bat No. 150.068 was released near Net Site 6-23 on July 19 at 2200 h (Appendix A, Figure 3). The radio signal was detected southeast of the net site until 2335 h. The signal was not detected again that night during attempts made between 2336 h and 0129 h. On July 20 at 1651 h, the bat was tracked to Roost Tree 6-5, approximately 1300 feet (396 m) northwest of Net Site 6-23. The radio signal was not detected at Roost Tree 6-5 during emergence counts the evening of July 20, suggesting the bat may have moved to another roost during the day. The radio signal was tracked to Roost Tree 6-5 on July 21 at 1130 h, but again was not detected in that tree during the emergence count. On July 22, the radio signal was detected from Telemetry Station 6N-7 toward the northwest, i.e., toward Roost Tree 6-5, but high water from heavy rains the previous night prevented tracking the bat to a tree. On July 23, Bat No. 150.068 was detected in Roost Tree 6-6 approximately 1230 feet (375 m) north of Net Site 6-23 and 700 feet (213 m) east of Roost Tree 6-5. However, the radio signal was not detected in Roost Tree 6-6 during the emergence count the evening of July 23. This radio signal was not monitored during daytime between July 24 and 26. The radio signal was not detected in Roost Trees 6-5 or 6-6 during emergence counts conducted on July 25. The radio signal from Bat No. 150.068 was detected in Roost Tree 6-6 on July 27 and July 28. Between July 29 and 31, monitoring was attempted from stations around Pleasant Run Creek (Appendix C), but the radio signal was not detected.

Roost Tree Characterization and Emergence Counts

Roost Tree 5-1 is a dead American elm (*Ulmus americana*) located in a wooded riparian strip adjacent to the White River approximately 3,300 feet (1,005 m) from Net Site 5-22 (Appendix A, Figure 1; Appendix B, Table 4). The tree is approximately south of the White River, which provides the nearest

water source and the nearest apparent flight corridor. It is approximately west of the center line of the proposed I-69 corridor.

Roost Tree 5-1 has a dbh of 9.8 in (25 cm). Most bark is intact, and about 5 percent of bark is exfoliating. The tree is at the edge of the woodlot, and there is no canopy vegetation covering the tree. During emergence counts, bats were observed emerging from under a section of loose bark approximately 15 feet (4.5 m) above the ground. The radio signal from Bat No. 151.046 was detected in Roost Tree 5-1 between July 18 and July 20. Emergence counts at Roost Tree 5-1 were conducted for five evenings between July 18 and 27 (Appendix B, Table 5). Between 1 and 3 individuals were observed emerging during three of the counts, and no bats were observed on two occasions.

Roost Tree 5-2 is a live silver maple (*Acer saccharinum*) located in a woodlot bordering the White River approximately 2,700 feet (832 m) west of Net Site 5-22 (Appendix A, Figure 1; Appendix B, Table 4). Canopy closure over the tree is approximately 30 percent. The tree is approximately south of the White River, which provides the nearest water source and the nearest apparent flight corridor. It is approximately west of the proposed I-69 center line.

Roost Tree 5-2 has a dbh of 18 in (45 cm) and has no exfoliating bark. Bats were observed emerging from the top of the tree approximately 40 feet (12 m) above the ground. The presence of a crevice or loose bark in the top of the tree is assumed, but could not be clearly distinguished from the ground. The radio signal from Bat No. 151.046 was detected in Roost Tree 5-2 on July 21. Emergence counts were conducted at Roost Tree 5-2 for five evenings between July 21 and 27 (Appendix B, Table 5). Between one and four individuals emerged from the tree on each of the five nights.

Roost Tree 5-3 is a dead tree that could not be identified to species. The tree is broken at the trunk and the tree top has fallen away. Bat No. 151.046 was tracked to the tree. Roost Tree 5-3 is located in the same wooded area as roost trees 5-1, 5-2, and 5-4. The tree is approximately 4,500 feet (1,371 m) west of Net Site 5-22, where Bat No. 151.046 was released (Appendix A, Figure 1; Appendix B, Table 4). The tree is approximately south of the White River, which provides the nearest water source and the nearest apparent flight corridor. It is approximately from the proposed I-69 center line.

Roost Tree 5-3 has a dbh of 14 in (35 cm). The bark is intact, with no loose or exfoliating patches. Bats were observed emerging from the broken top of the tree 23 feet (7 m) above the ground. Canopy closure over the tree is approximately 75 percent. The radio signal from Bat No. 151.046 was detected in Roost Tree 5-3 on July 22. Emergence counts at Roost Tree 5-3 were conducted for three evenings between July 22 and 27 (Appendix B, Table 5). Between three and 13 individuals were observed emerging from the tree on each of the three nights.

Roost Tree 5-4 is a dead tree that could not be identified to species. Bat No. 151.046 was tracked to the tree. It is located in the same wooded area as roost trees 5-1, 5-2, and 5-3. The tree is approximately 3,750 feet (1,143 m) from Net Site 5-22 (Appendix A, Figure 1; Appendix B, Table 4). The tree is about) from the nearest water source (tributary to the White River) and 10 feet (3 m) from the nearest apparent

flight corridor. It is about south of the White River, and approximately west of the centerline of the proposed corridor.

Roost Tree 5-4 has a dbh of 25.5 in (65 cm), and 50 percent exfoliating bark. Bats were observed emerging from under loose bark above a fork in the trunk approximately 33 feet (10 m) above the ground. Canopy closure above the tree is approximately 75 percent. The radio signal from Bat No. 151.046 was detected in Roost Tree 5-4 on July 23. Emergence counts at Roost Tree 5-4 were conducted for five evenings between July 23 and 29 (Appendix B, Table 5). Six individuals were observed emerging on July 23. The number of emerging bats increased each subsequent night and a maximum of 128 bats was observed leaving the tree on July 29.

Roost Tree 6-1 is a dead silver maple located in a riparian area approximately 5,085 feet (1,550 m) east of Net Site 6-8 (Appendix A, Figure 2; Appendix B, Table 4). The tree is in a woodlot adjacent to the White River, approximately southwest of the river, and approximately 32 feet (10 m) from the nearest apparent flight corridor. The tree is approximately northwest of the centerline of the proposed corridor.

Roost Tree 6-1 has a dbh of 16.5 in (42 cm). Much of the bark is gone; the remaining ten percent is loose. Canopy closure over the tree is approximately ten percent. Bat No. 150.046 was observed roosting near the bottom of a crack in the bark that begins approximately 15 feet (4.5 m) above the ground and extends to the top of the tree. Bat No. 150.046 was detected roosting in Roost Tree 6-1 on July 13 but was not detected there on the other nine days the radio signal was tracked. Roost Tree 6-1 was monitored for five evenings between July 13 and 28 (Appendix B, Table 5). Between 1 and 2 individuals were observed emerging on four nights, and no bats emerged on one night.

Roost Tree 6-2 is a dead American elm to which Bat No. 150.046 was tracked. It is located in a fence line approximately 2730 feet (832 m) north of Net Site 6-8 (Appendix A, Figure 2; Appendix B, Table 4). This tree was identified during 2004 Tier 2 studies as an Indiana bat roost tree. The tree is approximately southwest of the White River, which provides the nearest water source and the nearest apparent flight corridor. It is approximately west of the proposed centerline of the proposed corridor.

Roost tree 6-2 is 8.6 in (22 cm) in diameter. About 60 percent of the bark is gone, and the remaining 40 percent is loose. Bats were observed emerging from a cavity approximately 26 feet (8 m) above the ground. Canopy closure over the tree is about ten percent. The radio signal from Bat No. 150.046 was detected in Roost Tree 6-2 each day between July 15 and July 17. Emergence counts were conducted at Roost Tree No. 6-2 for five evenings between July 15 and 28. Between 1 and 5 bats emerged from the tree on four evenings, and no bats emerged from the tree during the last count. In 2004, emergence counts were conducted at Roost Tree 6-2 during four nights. Between 11 and 15 bats emerged from the tree on each of the four nights.

Roost Tree 6-3 is a live silver maple with no loose bark (all bark is intact), and a dbh of 16.5 in (42 cm). Canopy closure over the tree is approximately 30 percent. The limb of a large cottonwood (*Populus deltoides*) is lodged in a fork of the silver maple, and the

bats apparently roost in the space between the limb and the silver maple, approximately 20 feet (6 m) above the ground. Bat No. 150.025 was tracked to the tree, which is located in a riparian area approximately 6,360 feet (1,939 m) north of Net Site 6-7, where the bat was released (Appendix A, Figure 2; Appendix B, Table 4). The tree is approximately west of the proposed corridor centerline. Of all ten roost trees found, this is the closest to the proposed road alignment (. The tree is approximately south of the White River, which provides the nearest water source and the nearest apparent flight corridor.

Bat No. 150.025 was detected roosting in Roost Tree 6-3 from July 18 to July 22; the tree was monitored for five evenings between July 19 and 28. Between 6 and 7 bats were observed emerging during four of the evenings, and no bats emerged from the tree during the last count.

Roost Tree 6-4 is a dead silver maple to which Bat No. 150.025 was tracked. The tree is broken at the trunk, with the top half of the trunk leaning at a 220-degree angle to the bottom half (Appendix D). It is located in the same woodlot as roost trees 6-1 and 6-3, approximately 6,470 feet (1,972 m) from Net Site 6-7, where Bat No. 150.025 was released (Appendix A, Figure 2; Appendix B, Table 4). The tree is approximately from the White River, which provides the nearest water source and the nearest apparent flight corridor. The tree is approximately west of the proposed centerline.

Roost Tree 6-4 has a dbh of 11 in (28 cm), and intact bark. Bats appeared to be roosting in a cavity 23 feet (7 m) above the ground. Canopy closure over the tree is about 25 percent. The radio signal from Bat No. 150.025 was detected in Roost Tree 6-4 on July 29. Emergence counts at Roost Tree No. 6-4 were conducted for five evenings between July 29 and August 2. Between 29 and 52 bats were observed emerging from the tree on each of the five nights (Appendix B, Table 5).

Roost Tree 6-5 is a dead cottonwood to which Bat No. 150.068 was tracked. The tree is located approximately 1300 feet (396 m) northwest of Net Site 6-23 where the bat was released (Appendix A, Figure 3; Appendix B, Table 4). The tree is approximately east of the White River, which provides the nearest water source and the nearest apparent flight corridor. The tree is about west of the proposed corridor centerline.

Roost Tree 6-5 has a dbh of 24 in (61 cm), and intact bark. Bats appeared to be roosting in a cavity located 20 feet (6 m) above the ground. Canopy closure over the tree is approximately 50 percent. The radio signal from Bat No. 150.068 was detected in Roost Tree 6-5 on July 20 and 21. It is likely the bat roosted in Tree 6-5 on July 22 as well, but high water in the White River prevented access to the tree. Emergence counts at Roost Tree No. 6-5 were conducted for four evenings between July 20 and 27. No bats were observed emerging from the tree during the counts.

Roost Tree 6-6 is a live silver maple in which Bat No. 150.068 was detected. It is located in the same woodlot as Roost Tree 6-5 approximately 1230 feet (374 m) northwest of Net Site 6-23. The tree is approximately east of the White River, which provides the nearest water source and the nearest apparent flight corridor. It is west of the proposed corridor centerline.

Roost Tree 6-6 has a dbh of 16 in (41 cm), and intact bark. Bats appeared to be roosting in a cavity located 25 feet (7.62 m) above the ground. Canopy closure over the tree is approximately 70 percent. The radio signal from Bat No. 150.068 was detected in Roost Tree 6-6 on July 23, 27, and 28. Emergence counts were conducted at Roost Tree No. 6-6 for three evenings between July 25 and 27. One bat was observed emerging from the tree on July 26, but none was observed during the other two nights. The presence of other trees and vegetation around Roost Tree 6-6 made observation of the cavity and emerging bats difficult.

Documenting Colony Size

In 2005, groups of roost trees used by lactating or post-lactating female Indiana bats were identified near Bryant Creek, Clear Creek, and Pleasant Run Creek (Appendix A, Figures 1–3). Two additional roost trees used by reproductive Indiana bats were identified in 2004 near Crooked Creek in Section 6, approximately 4 miles (6.4 km) northeast of Roost Tree 6-2 (Hendricks et al. 2004).

The minimum distance between roost trees near Bryant Creek and near Clear Creek is approximately and the minimum distance between roost trees near Clear Creek and Pleasant Run Creek is about Distances among roost trees used by a maternity colony may vary, in part due to habitat conditions. During a 4-year study in Michigan, an Indiana bat maternity colony used roost trees up to 5.7 miles (9.2 km) apart (Kurta et al. 2002). In Missouri, known roost trees used by a single maternity colony were within 0.9 miles (1.5 km; Callahan et al. 1997).

On July 26 and 27, all four roost trees near Bryant Creek (5-1, 5-2, 5-3 and 5-4) were monitored at dusk to assess the number of bats in the colony. A total of 31 bats emerged from the four roost trees on July 26, and a total of 81 emerged on July 27. However, on July 28 and 29, the number of bats emerging from Roost Tree 5-4 was 115 and 128, respectively.

On July 27 and 28 we monitored emergence from roost trees 6-1, 6-2, 6-3, and from 203R1, which was identified in 2004 (Hendricks et al. 2004). Although none of the Indiana bats radio-tagged in 2005 was tracked to Roost Tree 203R1, it is within 2.5 miles of roost trees 6-1, 6-2, and 6-3, and is within the range of the Clear Creek Colony. Roost Tree 6-4 was not monitored on those dates because it was not identified until July 29. A total of 15 bats emerged from the four roost trees monitored on July 27, and two bats emerged from the four trees on July 28. However, between 29 and 52 bats emerged from Roost Tree 6-4 between July 29 and August 2. Because Roost Tree 6-4 is only 85 feet (26 m) from Roost Tree 6-3, and Bat No. 150.025 roosted in both 6-3 and 6-4, we conclude Roost Tree 6-4 was also used by the Clear Creek maternity colony.

Furthermore, data collected in 2004 from roost trees near Clear and Crooked creeks should be considered. Roost trees near Clear and Crooked creeks are approximately apart. On July 19, 2004, a total of 140 bats was observed emerging from Roost Tree 6-2 and the two trees upstream along Crooked Creek.

On July 25, 26, and 27 emergence counts were conducted simultaneously at roost trees 6-5 and 6-6, used by the Pleasant Run Creek Maternity Colony. No bats were observed emerging from the trees on July 25 or 27, and a single bat emerged from one tree on July 26. Because no primary roost tree was identified for the Pleasant Run Creek colony, emergence counts from roost trees

6-5 and 6-6 likely do not represent the actual size of the colony.

Discussion

Reproductive female Indiana bats were captured at four net sites in Sections 5 and 6. All four Indiana bats were captured between approximately 600 feet (183 m) and 1.5 miles (2.4 km) from the proposed corridor centerline. The bat trapped at Net Site 6-7 was captured within 1000 feet (2400 m) of existing State Road 37, an established, four-lane divided highway. All Indiana bats were captured over tributaries to the White River.

Between two and four roost trees used by each radio-equipped Indiana bat were found. Near Bryant Creek (Section 5), four roost trees occupied by Bat No. 151.046 were identified. Three of the trees (5-1, 5-2, and 5-3) each contained fewer than 15 individuals, and meet Callahan's (1993) definition of alternate roost trees. Roost Tree 5-1 has a small amount of exfoliating bark, while roost trees 5-2 and 5-3 have no loose bark but provide broken tops or cavities as roost sites.

Between 76 and 128 bats emerged from Roost Tree 5-4 during three evenings, indicating the tree is a primary roost tree for the Bryant Creek Colony. Roost Tree 5-4 is larger in diameter and has more exfoliating bark than the other three roost trees used by this colony. Previous studies indicate primary maternity roost trees tend to be exposed to sunlight, whereas alternate roost trees tend to be shaded by canopy vegetation (Callahan 1993; Kurta et al. 1993). However, canopy closure over Roost Tree 5-4 was greater than over roost trees 5-1 and 5-2.

All four roost trees near Bryant Creek are located greater than 1.9 miles (3 km) from the proposed centerline of the I-69 corridor. The three alternate roost trees are within 2110 feet (643 m) of each other. However, Kurta (2001 and Kurta et al. 2002) found Indiana bat maternity colonies using up to 18 roosts, which were up to 5.7 miles (9.2 km) apart.

Four roost trees used by two reproductive female bats were identified near Clear Creek. Roost trees 6-1 and 6-2 were occupied by Bat No. 150.046 and roost trees 6-3 and 6-4 were used by Bat No. 150.025. Bat No. 150.046 used two trees nearly 1.0 mile (1.6 km) apart. Although Roost Tree 6-3 is within about 200 feet (61 m) of roost trees 6-1, Bat No. 150.046 was not detected roosting in Tree 6-3. Because all four trees are less than 1.0 mile (1.6 km) apart, we conclude all four trees are used by a single maternity colony. Roost Trees 6-1, 6-2, and 6-3 each contained 15 or fewer bats during emergence counts in 2004 and 2005, and are therefore alternate roost trees. Roost Tree 6-4 contained between 40 and 52 bats during four evenings, and therefore meets this study's definition of a primary maternity roost tree.

All four roost trees near Clear Creek are somewhat atypical of maternity roost trees identified in some other studies. Roost trees near Clear Creek are between 8.6 and 17.7 inches (22 and 45 centimeters) dbh, which is smaller than many roost trees reported in some other studies. Callahan et al. (1997) found primary maternity roost trees averaged 23 inches (58.4 cm) dbh and alternate maternity roost trees averaged 21 ± 1.6 inches (53 ± 4.1 cm) dbh. However, Gardner et al. (1991) found the diameter of maternity roost trees in Illinois averaged 14.4 inches (36.7 cm). Two of the roost trees near Clear Creek, including the primary roost tree, have no exfoliating bark; bats apparently roost in cavities in those trees. Roost Tree 6-2 has 40 percent loose

bark, but is a small tree (8.6 inches dbh) and bats occupying the tree roost in a cavity. Previous studies suggest alternate roosts are typically in forest interiors mostly shaded from sunlight and primary roost trees more exposed to sunlight (Callahan 1993). However, canopy closure at all roosts identified near Clear Creek does not exceed 30 percent. Variation from the "traditional" characteristics of Indiana bat roosts is demonstrated in other recent studies. Greater than 100 Indiana bats were identified roosting beneath a sheath covering an electric transmission line pole (Hendricks et al. 2004). In Tennessee, three Indiana bats were identified roosting in three conifers, each between 15 and 43 inches (39 and 109 cm; Britzke et al. 2003). These studies indicate the characteristics of Indiana bat roosts may be more variable than previously thought.

All four roost trees near Clear Creek are located greater than 2330 feet (710 m) from the proposed centerline of the I-69 corridor, and at least 1330 feet (405 m) from the proposed road corridor.

Two roost trees used by a single lactating female Indiana bat were identified near Pleasant Run Creek. No more than a single bat was observed emerging from roost trees 6-5 and 6-6 during emergence counts, indicating both are alternate roost trees. No primary roost tree was identified for the colony near Pleasant Run Creek. However, at least one primary roost tree is likely to exist within 5.7 miles of roost trees 6-5 and 6-6.

Bats inhabiting trees 6-5 and 6-6 appeared to roost in cavities, as neither tree has loose bark. Both trees are within a woodlot and are shaded by 50 percent or greater overstory canopy closure.

Roost trees 6-5 and 6-6 are approximately 1.0 mile (1.6 km) from the proposed centerline of the I-69 corridor.

The two primary and eight alternate roost trees identified in this study are located in woodlots bordering the White River. The trees are 98 to 2,000 feet (30 to 610 m) from the river, suggesting these riparian woodlots provide important roost habitat for Indiana bat maternity colonies. Three of six roost trees identified in Section 5 and 6 in 2004 were similarly located in woodlots along the White River. None of the ten roost trees identified in 2005 is within the proposed I-69 corridor. However, potential roosting and foraging areas for the Bryant Creek, Clear Creek, and Pleasant Run Creek maternity colonies do overlap the corridor.

Fourteen evening bats were captured at Net Site 6-23, which is located 4650 feet (1417 m) from the proposed corridor centerline. Captures included reproductive females and juveniles, suggesting an evening bat maternity colony is located near Net Site 5-23. Evening bats typically roost during summer in buildings or under exfoliating bark of trees.

In addition to Indiana bats and evening bats, six other bat species were captured. Each commonly occurs in southeastern Indiana, and none of the species was unexpected in Morgan, Monroe, and Johnson counties. None of the six species is listed by the USFWS or the State of Indiana as rare, threatened, or endangered.

Acknowledgements

We appreciate the cooperation and access landowners provided during the surveys. Special thanks to INDOT, FHWA, Tom Cervone, Jason DuPont, and Kia Gillette of Bernardin, Lochmueller and Associates, Inc., and Andrew King, Scott Pruitt, and

Lori Pruitt of the U.S. Fish and Wildlife Service (Bloomington Field Office) for their roles and support throughout the project.

Literature Cited

Britzke E., M. Harvey, and S. Loeb. 2003. Indiana bat, *Myotis sodalis*, maternity roosts in the southern United States. Southeastern Naturalist 2(2):235-42.

Butchkoski, C. and J. Hassinger. 2002. Ecology of a maternity colony roosting in a building *in* A. Kurta and J. Kennedy (eds.) The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International, Austin, Texas. 253 pp.

Callahan, E.V. 1993. Indiana bat summer habitat requirements. Unpublished Ph.D. Dissertation. University of Missouri, Columbia.

Callahan, E.V., R.D. Drobney, and R.L. Clawson. 1997. Selection of summer roosting sites by Indiana bats (*Myotis sodalis*) in Missouri. Journal of Mammalogy 78:818–825.

Federal Highway Administration (FHWA) and Indiana Department of Transportation (INDOT). 2003a. Final Environmental Impact Statement & Section 4(f) Evaluation: I-69 Evansville to Indianapolis, Indiana. United States Department of Transportation, Federal Highway Administration and Indiana Department of Transportation. FHWA-IN-EIS-02-01-F. Prepared by Bernardin, Lochmueller and Assoc., Inc. http://www.deis.i69indyevn.org/FEIS/index.html.

Federal Highway Administration (FHWA) and Indiana Department of Transportation (INDOT). 2003b. Tier 1 Biological Assessment for Threatened and Endangered Species: I-69 Indianapolis to Evansville. Prepared by Bernardin, Lochmueller and Assoc., Inc. Evansville, Indiana.

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.

Gardner, J.E., J.D. Garner, and J.E. Hofmann. 1991. Summary of *Myotis sodalis* summer habitat studies in Illinois: with recommendations for impact assessment. Unpublished report prepared for the Indiana/Gray Bat Recovery Team Meeting, Columbia, Missouri, Illinois Natural History Survey, Section of Faunistic Surveys and Insect Identification. 28 pp.

Hendricks, W.D., R.D. Ijames, L. Alverson, M. Muller, J. Timpone, and N. Nelson. 2004. Summer habitat for the Indiana bat (*Myotis sodalis*) within the Martinsville Hills from Martinsville to Indianapolis, Indiana. Unpublished report to J.F. New, Walkerton, Indiana.

Henry, A.B., R.A. Slack, and R.C. Rommé. 2004. Investigating presence of the Indiana bat during the summer maternity season within the Mitchell Plain between Bloomington and Martinsville, Indiana. Unpublished report submitted to Michael Baker, Jr., Inc. Bloomington, Indiana.

Kurta A. 2001. Conservation and management of an endangered species: the Indiana bat in the eastern United States. The Wildlife Society 2001 Conference, Reno/Tahoe, Nevada.

Kurta A., J. Kath, E.L. Smith, R. Foster, M.W. Orick, and R. Ross. 1993. A maternity roost of the endangered Indiana bat (*Myotis sodalis*) in an unshaded, hollow, sycamore tree (*Platanus occidentalis*). American Midland Naturalist 130(2):405-7.

Kurta, A., S. Murray, and D. Miller. 2002. Roost selection and movements across the summer landscape *in* A. Kurta and J. Kennedy (eds.) The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International, Austin, Texas. 253 pp.

Kurta, A. and K. Williams. 1992. Roosting habitat, microclimate, and behavior of the endangered Indiana bat (*Myotis sodalis*) in southern Michigan. Report to the Nongame Program, Department of Natural Resources, Michigan. 24 pp.

U.S. Fish and Wildlife Service (USFWS). 1999. Agency Draft Indiana bat (*Myotis sodalis*) Revised Recovery Plan. Fort Snelling, Minnesota. 53 pp.

U.S. Department of Agriculture, Forest Service (USFS). 1979. Wildlife habitats in managed forests, the Blue Mountains of Oregon and Washington. Agricultural Handbook 553. J.W. Thomas (ed.) Washington, DC.

Appendix A
Figures

Figure 1. ("Mist net sites, radiotelemetry stations and Indiana bat roost trees identified near Creek in Section 5 of the proposed I-69 between July and August 1, 2005") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 2. ("Mist net sites, radiotelemetry stations and Indiana bat roost trees identified near Creek in Section 5 of the proposed I-69 between July and August 1, 2005") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 3. ("Mist net sites, radiotelemetry stations and Indiana bat roost trees identified near Creek in Section 5 of the proposed I-69 between July and August 1, 2005") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Appendix B
Tables

Table 1. Location of ten sites surveyed with mist nets during 2005 in the Section 5 and Section 6 Indiana Bat Study Areas.

Site no.	County	Habitat feature surveyed	Approximate distance to proposed Corridor 3C centerline in feet (meters)
5-16	Morgan	Bryant Creek	830 (253)
5-19	Morgan	Bryant Creek	11,370 (3,466)
5-22	Morgan	Unnamed tributary to White Fork and adjacent gravel road	7,676 (2,340)
6-7	Morgan	Clear Creek	600 (183)
6-8	Morgan	Clear Creek	5,830 (1,777)
6-10	Morgan	Tributary to the White River	3,380 (1,030)
6-19	Morgan	Tributary to Bluff Creek	200 (61)
6-20	Morgan	Goose Creek	9,050 (2,758)
6-22	Johnson	Honey Creek	220 (67)
6-23	Johnson	Pleasant Run Creek	4,650 (1,417)

Table 2. Number of Indiana bats captured and radio-tagged, number of Indiana bat roost trees identified, and number of other species captured from ten mist net sites during 2005 in Sections 5 and 6.

Site no.	Survey dates (2005)	Reproductive adult female *M. sodalis*	No. radio-tagged *M. sodalis*	Total no. diurnal roosts identified	*M. lucifugus*	*M. septentrionalis*	*E. fuscus*	*P. subflavus*	*L. borealis*	*L. cinereus*	*N. humeralis*	Total no. bats captured
5-16	7/18, 7/19					1	2			1		4
5-19	7/12, 7/13				2		1	1	2			6
5-22	7/14, 7/17	1	1	4	4		1					6
6-7	7/17	1	1	2	7	1						9
6-8	7/12	1	1	2	1				1			3
6-10	7/14, 7/15				5	2	1	1			1	10
6-19	7/12, 7/13				1	1	1					3
6-20	7/14, 7/15				8		4					12
6-22	7/19											0
6-23	7/17, 7/18, 7/19	1	1	2	4	2	10		1		14	32

Table 3. Description of Indiana bats captured during 2005 within the Section 5 and Section 6 Indiana Bat Study Areas.

Site no.	Date captured (2005)	Time captured	Gender	Age	Reproductive condition*	Weight (g)	Radio-transmitter frequency (mHz)	Dates of radiotracking
6-8	7/12	0100	F	A	L	7.75	150.046	7/12-7/21
5-22	7/17	0145	F	A	L	8.0	151.046	7/17-7/31
6-7	7/17	2140	F	A	PL	8.25	150.025	7/17-7/31
6-23	7/19	2130	F	A	L	6.25	150.068	7/19-7/31

*L= lactating, PL=post-lactating

Table 4. Description of roost trees used by Indiana bats within the Section 5 and Section 6 Indiana Bat Study Areas.

Roost tree no.	Latitude[1]	Longitude[1]	Species	Condition	Diameter at breast height inches (cm)	Percent exfoliating bark	Percent canopy closure at roost	Distance to capture site feet (meters)	Distance to proposed Corridor 3C centerline feet (meters)
5-1			*Ulmus americana*	dead	9.8 (25)	5	0	3,300 (1,005)	10,975 (3,345)
5-2			*Acer saccharinum*	live	18 (45)	0	30	2,700 (832)	10,100 (3,079)
5-3			could not be identified	dead	14 (35)	0	75	4,500 (1,371)	11,760 (3,584)
5-4			could not be identified	dead	25.5 (65)	50	75	3,750 (1,143)	10,660 (3,249)
6-1			*A. saccharinum*	dead	16.5 (42)	10	10	5,085 (1,550)	2,330 (710)
6-2			*U. Americana*	dead	8.6 (22)	40	5	2,730 (832)	7,150 (2,179)
6-3			*A. saccharinum*	live	17.7 (45)	0	30	6,360 (1,939)	2,340 (713)
6-4			*A. saccharinum*	dead	11 (28)	0	25	6,470 (1,972)	2,430 (741)
6-5			*Populus deltoides*	dead	24 (61)	0	50	1,300 (396)	5,610 (1,710)
6-6			*A. saccharinum*	live	16 (41)	0	70	1,230 (375)	4,950 (1,509)
203R1[2]			*Fraxinus* sp.	Dead	unknown	unknown	unknown	n/a[3]	844 (257)

[1]Latitude and longitude provided in decimal degrees
[2]Data describing this roost from Hendricks et al. 2004
[3]No bats equipped with transmitters described herein utilized this roost tree.

Table 5. Number of bats observed in 2005 emerging from each Indiana bat roost tree identified in Sections 5 and 6.

Roost tree no.	Date identified	Roost of bat no.	Emergence Count										Primary/ Alternate Roost[1]
			Date	No. bats	Date	No. bats	Date	No. bats	Date	No. bats	Date	No. bats	
5-1	7/19/2005	151.046	7/18	2	7/19	1	7/21	0	7/26	3	7/27	0	Alternate
5-2	7/21/2005	151.046	7/21	4	7/22	4	7/23	3	7/26	2	7/27	1	Alternate
5-3	7/22/2005	151.046	7/22	13	7/26	3	7/27	4					Alternate
5-4	7/23/2005	151.046	7/23	6	7/26	23	7/27	76	7/28	115	7/29	128	Primary
6-1	7/13/2005	150.046	7/13	2	7/14	1	7/15	0	7/27	2	7/28	1	Alternate
6-2	7/15/2005	150.046	7/15	4	7/16	5	7/17	3	7/27	1	7/28	0	Alternate
6-3	7/19/2005	150.025	7/18	6	7/19	7	7/20	7	7/27	6	7/28	0	Alternate
6-4	7/29/2005	150.025	7/29	40	7/30	42	7/31	52	8/1	29	8/2	41	Primary
6-5	7/20/2005	150.068	7/20	0	7/25	0	7/26	0	7/27	0			Alternate
6-6	7/23/2005	150.068	7/25	0	7/26	1	7/27	0					Alternate
203R1[2]	2004	203	7/27	7	7/28	1							Alternate

[1]As defined in Callahan 1993
[2]Roost tree identified in Hendricks et al. 2004. The Hendricks et al. report identified an emergence count (unspecified date in 2004) of 64 bats at this tree.

Appendix C

Field Data Sheets

Appendix C: Field Data Sheets have been removed for confidentiality reason related to the federally endangered Indiana bat.

Appendix D
Selected Photographs of Indiana Bats and Roost Trees Used by Indiana Bats

Bat No. 150.046, lactating female *M. sodalis* captured at Net Site 6-8 on July 12, 2005.

Bat No. 151.046, lactating female *M. sodalis* captured at Net Site 5-22 on July 17, 2005.

Bat No. 150.025, post-lactating female *M. sodalis* captured at Net Site 6-7 on July 17, 2005.

Bat No. 150.068, lactating female *M. sodalis* captured at Net Site 6-23 on July 19, 2005.

Roost Tree No. 5-1

Roost Tree No. 5-2

Roost Tree No. 5-3

Roost Tree No. 5-4

Roost Tree No. 6-1

Roost Tree No. 6-2

Roost Tree No. 6-3

Roost Tree No. 6-4

Roost Tree No. 6-5

Roost Tree No. 6-6

Surveys for Indiana Bats in Caves in Greene and Monroe Counties, Indiana 2006

February 21, 2006

Prepared by
BHE Environmental, Inc.
11733 Chesterdale Road
Cincinnati, OH 45246

SURVEYS FOR INDIANA BATS IN CAVES IN GREENE AND MONROE COUNTIES, INDIANA 2006

Amy B. Henry[1] and Russell C. Rommé[2]
[1]*BHE Environmental, Inc. 7041 Maynardville Highway, Knoxville TN 37918*
[2]*BHE Environmental, Inc. 11733 Chesterdale Road, Cincinnati, OH 45246*

Abstract

The Indiana Department of Transportation (INDOT) is preparing a second Environmental Impact Statement for the proposed Interstate Highway 69 (I-69) from Evansville to Indianapolis, Indiana. BHE Environmental, Inc. (BHE) was contracted to investigate the presence of the federally endangered Indiana bat (*Myotis sodalis*) and assess winter habitat use by the species along a portion of the proposed I-69 corridor. The studies were designed to provide data to evaluate, and avoid/minimize effects to the species within the proposed road corridor.

The U.S. Fish and Wildlife Service (USFWS), the Indiana Geological Survey, and Bernardin Lochmueller and Associates (BLA) identified caves potentially suitable for hibernating Indiana bats. BHE evaluated presence of bats in eight caves during autumn swarming and/or winter hibernation. During autumn 2005, BHE conducted surveys with harp traps at eight caves for two nights each (n=16 trap nights). Two male Indiana bats were captured, along with 82 other bats of three species. Indiana bats were captured at [redacted]

Surveys within the same eight caves were conducted during December 2005, following a schedule approved by USFWS Bloomington Indiana Field Office. Bats were observed in four of the eight caves; no Indiana bats were observed during winter surveys. Four other species were identified. Air temperature and other characteristics were measured to assess habitat suitability for hibernating Indiana bats within each cave. While none of the caves appeared to provide optimal winter habitat for Indiana bats, seven of the caves provide suitable winter habitat. None of the caves was occupied by hibernating Indiana bats.

Key words: Indiana bat, *Myotis sodalis*, cave, harp trap, hibernaculum

---

Introduction

The Indiana Department of Transportation (INDOT) and the Federal Highway Administration (FHWA) are completing six Tier 2 Environmental Impact Statements for the proposed Interstate Highway 69 (I-69) from Indianapolis to Evansville, Indiana. A detailed description of the proposed road corridor was presented in the Tier 1 Final Environmental Impact Statement (Tier 1 FEIS; FHWA and INDOT 2003a).

The proposed interstate highway is approximately 142 miles in length and is divided into six sections to facilitate Tier 2 EIS studies. This study is part of the Tier 2 Environmental Impact Statements (EIS) for Sections 4 and 5 of the I-69 alignment in Greene and Monroe counties, where karst and caves are prevalent (Appendix A, Figure 1). Studies were conducted along the Corridor 3C, identified as the preferred alternative in the Tier 1 FEIS (FHWA and INDOT 2003a). The proposed road will be within a corridor extending 1000 feet on each side of the Corridor 3C centerline (total width of 2000 feet). In some areas the corridor is narrowed or widened from the 2000-foot width to avoid known resources or to avoid anticipated environmental concerns. The generally 2000-foot wide corridor represents the area in which a preferred alignment would be located. The actual width of ground disturbance is expected to range from 240 to 470 feet. In some instances, interchanges and connector roads may extend outside the corridor.

The FHWA and the U.S. Fish and Wildlife Service (USFWS) are conducting ongoing consultation under Section 7 of the Endangered Species Act to evaluate potential impacts to threatened and endangered species. Surveys described in this report were conducted in accordance with requirements of the Tier 1 Biological Assessment (FHWA and INDOT 2003b). The purpose of these studies was to investigate the presence of the federally listed endangered Indiana bat (*Myotis sodalis*) and identify winter habitat use by the species along the proposed I-69 corridor. Caves within 5 miles of the proposed corridor, a buffer established in consultation with the USFWS, were surveyed during the autumn swarming and winter hibernation periods to investigate presence of Indiana bats. Habitat suitability within the caves was evaluated during the winter survey.

Methods used in these investigations were developed in consultation with the USFWS, Bloomington Field Office (Appendix B), and follow those implemented at other caves in the corridor in autumn 2004 and winter 2004/2005 (Henry et al. 2005). Results of these studies will assist in evaluating and minimizing effects to the Indiana bat from the proposed road.

Locations of Potential Hibernacula Surveyed

The Indiana Geological Survey (IGS) identified caves and karst features near the proposed corridor within a 5-mile buffer established in consultation with the USFWS. In December 2005, BHE inspected eight potential Indiana bat hibernacula located in Monroe and Greene counties (Appendix A, Figure 1). Caves surveyed in this study are between 1 and 5 miles from the proposed corridor centerline (Appendix C, Table 1). The Congressional Township location description of each cave entrance is provided in Appendix C, Table 1, and maps of each cave are provided in Appendix D.

Materials and Methods

Landowner contact and permission to enter caves were obtained where possible.
Notice-of-Survey letters were sent by BLA

and their contractors to property owners in the Winter Action Area.

Autumn Surveys

Between September 6 and October 12, 2005, harp traps were used to survey eight caves to assess presence of Indiana bats during the autumn swarming period. Autumn surveys were timed to coincide with dates when Indiana bats typically swarm at hibernacula. At each cave, a double-framed harp trap (Tuttle 1974) was erected and operated for two nights. Traps were constructed with two banks of 8-pound test monofilament fishing line, strung vertically and spaced 1 inch apart. Strands of the two banks were offset by 0.5 inches. Bird-X® plastic mesh was hung to prevent bats from flying around the trap. Traps and Bird-X® mesh were removed from cave openings at the end of the survey period each night. Trapping began each night at dusk and continued for five hours; traps were checked every hour.

Captured bats were identified to species, and the gender, reproductive condition, weight, and right forearm length were recorded (Appendix E). Indiana bats were photographed and banded with a uniquely-numbered celluloid band. Every hour during the survey, we recorded air temperature and estimated wind speed and percent cloud cover. Moon phase and precipitation events were noted for each survey night (Appendix E).

During the autumn survey, characteristics of each cave opening were recorded, including dimensions, apparent stability of the cave entrance, airflow at the cave entrance, and slope of the cave from the entrance.

Winter Surveys

Between December 20 and 29, 2005, BHE investigated eight caves to identify presence of hibernating bats and evaluate habitat suitability for hibernating bats. These were the same eight caves surveyed with harp traps in autumn 2005.

BHE entered each cave, in some cases using vertical single rope techniques, and inspected the extent of the interior accessible to humans. Bats observed inside caves were identified to species. Bats were not handled, and care was taken to minimize disturbance to them. The number of bats within the cave was recorded. Guano or other signs of bats were also documented.

We recorded detailed descriptions of each cave interior, including tunnel dimensions, presence or absence of standing water, evidence of flooding, barriers to human movement, and description of the entrance (Appendix D, E). We used a Raynger® MiniTemp MT4 infrared thermometer (Raytek Corporation, Santa Cruz, CA) to record air temperatures at the ceiling and at the floor of each cave at the entrance, near bats, at other selected interior sites, and at the stopping point of the survey. At the same sites, wind speed was estimated using the Beaufort scale (Appendix F).

Assessment of habitat suitability was based upon literature and guidance provided by the USFWS. Habitat suitability for Indiana bats was primarily determined by air temperature. Indiana bats typically hibernate in caves where temperatures during mid-winter are between 4 and 8 degrees Celsius (°C; USFWS 1999). Recent long-term monitoring in hibernacula indicates temperatures of 3–6ºC are ideal for Indiana bats (USFWS 1999). However, mean air temperatures of up to 11ºC have been recorded during December–February in Priority I hibernacula (Tuttle and Kennedy 1999) and other hibernacula containing significant populations of Indiana bats (Brack and Dunlap 1997). Because we used

air temperature measured on a single occasion, we established a conservative threshold for suitability; air temperatures ≥13°C were considered unsuitable for hibernating Indiana bats.

When determining habitat suitability, we also considered air flow within the cave, presence of bats, especially *Myotis,* and signs of past flooding to the ceiling of the cave, which could kill hibernating bats and influence air temperatures.

Results

Autumn Surveys

Between September 6 through October 12, 2005, BHE used harp traps to survey eight caves for two nights each (n=16 trap nights). A total of 84 bats was captured at the eight caves (Appendix C, Table 2). Two male Indiana bats were captured at [redacted]

Other species captured during the autumn survey included little brown bats (*M. lucifugus*) (n=33), northern long-eared bats (*M. septentrionalis*) (n=39), and eastern pipistrelles (*Pipistrellus subflavus*) (n=10). The greatest number of bats was captured at [redacted] (n=23). The greatest number of a single species was captured at [redacted] (n=17 northern long-eared bats). No bats were captured at [redacted]

Winter Surveys

Surveys of eight potential Indiana bat hibernacula were conducted during December 20–29, 2005 (Appendix C, Table 3). Each cave was inspected to the extent it was passable by humans. No Indiana bats were identified in any of the caves during the winter survey. Detailed descriptions of surveys in each cave are provided below. Photographs and detailed maps of the caves can be found in Appendix D.

[redacted]

BHE surveyed [redacted] on December 27, 2005. The entrance is approximately 5-feet wide by 2-feet high. About 40 feet past the entrance is a pit approximately 15-feet deep that leads to the rest of the cave. A small waterfall descends into this pit. The remainder of the cave is a passage approximately 240 feet long. No stream or standing water was present in the cave during the survey and there was no evidence of flooding.

Near the floor, air temperature varied from 8.2ºC near the entrance to 13.2°C at the back of the cave. At the ceiling, air temperature was 9.2°C at the entrance and 13.4 C at the back. No airflow was apparent within the cave.

Fifteen eastern pipistrelles and two big brown bats were counted during the survey. No dead bats, or signs of substantial use by bats (e.g., guano, urine staining) were observed in the cave. Temperatures inside portions of [redacted] were within the range considered suitable, but appear to be too warm to provide optimal winter habitat for Indiana bats.

[redacted]

BHE surveyed [redacted] on December 29, 2005. The entrance measures approximately 3 feet by 5 feet, and is within a sinkhole approximately 20 feet across and 10 feet deep. From the entrance, the passage slopes down into a large room. Total length of the cave is approximately 120 feet. No stream or standing water was present in the cave during the survey and there was no evidence of flooding. Near the floor, air temperature varied from 9.2ºC in the entrance room, to 12.8°C at the back of the cave. At the ceiling, air temperature was

8.8°C at the entrance and 13 C at the back. No airflow was detected within the cave.

Thirteen eastern pipistrelles and seven little brown bats were counted during the survey. No dead bats or any signs of substantial use by bats (e.g., guano, urine staining) were observed in the cave.

Temperatures inside [redacted] were within the range considered suitable, but appear to be too warm to provide optimal winter habitat for Indiana bats.

[redacted]

BHE surveyed [redacted] on December 28, 2005. The entrance is a pit containing areas of unstable, loose rock, with an opening approximately 15 feet at the widest point. The pit descends about 45 feet into the entrance room. Upper and lower passages extend from the pit. The upper passage is approximately 100 feet long and terminates in a belly-crawl. The lower passage is accessed via a loose breakdown passage from the floor of the entrance pit. There was no stream and no evidence of flooding apparent within the cave. Air temperatures ranged from 5.8 to 12.6 C and no airflow was apparent within the cave.

No live or dead bats, or signs of use by bats were observed in the cave. While conditions within [redacted] are within the range considered suitable for hibernating Indiana bats, no Indiana bats were identified there in autumn or winter. Therefore, we conclude the cave was not occupied by Indiana bats.

[redacted]

BHE surveyed [redacted] on December 29, 2005. The cave is accessed via a short crawl through an opening approximately 3 feet high and 2 feet wide. The passage widens slightly into a small room approximately 30 feet long, at which point a significant deposit of sediment constricts the passage to about 6 inches in height. The cave beyond this location is currently inaccessible to humans. A map of the cave prepared in 1969 indicates the cave continues for approximately 200 feet (Appendix D).

No bats were observed in the portion of [redacted] we surveyed. No dead bats, guano, or signs of use by bats were observed in the cave. Air temperatures at the entrance were 6.6ºC near the ceiling, and 6.2ºC near the floor. A very slight flow of air (0–3 miles per hour) out of the cave was observed.

Air temperatures in the surveyed portion of the [redacted] are within the optimal range for hibernating Indiana bats. However, no Indiana bats or other bats were observed during winter, and no Indiana bats were captured during autumn. Conditions within much of the cave could not be inspected. It is possible for bats to land and crawl through the 6-inch high opening into the unsurveyed portion of the cave. However, we observed no guano and no markings in the sediment (e.g., markings from bat claws) that suggested bats recently traversed the small opening.

[redacted]

BHE surveyed [redacted] on December 27, 2005. The entrance is 3 feet high by 1.5 feet wide. A stream approximately 12 inches deep flows out of the opening. The cave is an L-shaped passage about 30 feet long. About 10 feet inside the entrance is a small chamber, which contained an occupied beaver den at the time of the survey.

At the entrance, air temperature was 10.2ºC near the ceiling, and 7.8ºC near the surface of the water. No airflow was detected

within the cave. There was no evidence that the passage floods to the ceiling, and given the creek channel and topography outside the entrance, it is unlikely that the water level within the cave ever exceeds the level observed during the survey. Anecdotal information appears to imply a fully or partially flooded passage exists beyond the entrance room.

No live or dead bats, or signs of use by bats were observed in [redacted] during the winter survey. While air temperature during the winter survey was within the range considered suitable for hibernating Indiana bats, it is likely temperatures in the small cave are significantly influenced by air temperatures outside the cave. No bats of any species were identified there in autumn or winter. Therefore, we conclude the cave was not occupied by Indiana bats.

[redacted]

BHE surveyed [redacted] on December 28, 2005. The entrance is a pit approximately 2.5 feet in diameter. The pit is about 35 feet deep, and leads to a horizontal passage approximately 120 feet long. About 60 feet into the cave, the passage drops vertically about 15 feet. Extensive boulders and breakdown are present along the southern 40 feet of passage. BHE did not enter the final 40 feet, but the ceiling and walls of the entire cave were visible and inspected by the surveyors.

No water was present in the cave and we observed no evidence of flooding. Temperatures ranged from 10.4 C at the entrance to 11.2 C near the floor at the end of the survey. No airflow was detected within the cave.

No live or dead bats, or signs of use by bats were observed in [redacted] during the winter survey. While air temperature is within the range considered suitable for hibernating Indiana bats, no Indiana bats were identified there in autumn or winter. Therefore, we conclude the cave was not occupied by Indiana bats.

[redacted]

BHE surveyed [redacted] on December 27, 2005. The entrance is approximately 8 feet high by 15 feet wide and leads to a horizontal passage. The survey included the main cave passage, which is greater than 3000 feet long, and several side passages, each no more than 200 feet long. The main passage of the cave is generally 5 to 7 feet in height along most of its length. Domes are absent.

Water is present at various locations in [redacted] Near Stop 4 is a pool approximately 6 inches deep in which blind crayfish were observed. Near Stop 5 is a waterfall. There is evidence of flooding (e.g., gravel, sediment) in the main passage, but we observed no signs that floodwater reaches the cave ceiling.

Air temperature near the entrance was 1.6 C near the floor and 3.4 C near the ceiling. Slight airflow (1–3 miles per hour) into the cave was evident at the entrance. Within the cave, air temperatures ranged from 6.4 to 12.8 C near the floor, and 8.4 to 12.8 C near the ceiling. Slight flow of air out of the cave was noted at Stop 1, but no airflow was detected past that stop.

No Indiana bats were observed during the winter survey of [redacted] Twenty-six eastern pipistrelles, two little brown bats, five big brown bats, and one northern long-eared bat were counted during the survey. No dead bats were observed in the cave. A small amount of bat guano was observed throughout the cave. Conditions in a portion

of [redacted] are within the range considered suitable for hibernating Indiana bats, although none of the temperatures near the ceiling were within the optimal range of 4–8ºC. Two Indiana bats were identified at the cave in autumn 2005, but no Indiana bats were identified during winter. Therefore, we conclude the cave is not a hibernaculum, but may be used by Indiana bats during migration and/or swarming.

[redacted]

BHE surveyed [redacted] on December 20, 2004. The entrance is approximately 5 feet in diameter. According to the cave survey map completed in 1978, the cave consists of approximately 7,000 feet of horizontal passage (Appendix D). About 700 feet past the entrance, the cave splits into two passages, referred to here as the North and South passages.

The North passage consists of approximately 2400 feet of horizontal passage, with several large rooms. Approximately 600 feet of the North passage was not surveyed because it became too narrow to access. Another 200-foot long portion of the North passage was not surveyed due to unsafe conditions.

The South passage is approximately 1800 feet long. Except for about 100 feet where the passage became too narrow, BHE surveyed the entire South passage as shown on the map (Appendix D).

Water is present throughout much of the cave, and flooding is evident in certain locations. About 100 feet into the cave, at Stop 1, is the "Bridges Bathtub," an area where the cave ceiling is low over water. Water at this location is known to flood and/or freeze to the cave ceiling.

Air temperature at the cave entrance was -7.2ºC. Ice was present at Bridges Bathtub. Slight airflow (1–3 miles per hour) into the cave was detected. Within the cave, air temperature near the Bridges Bathtub (Stop 1) was 5.2ºC near the ceiling and 4.3ºC near the floor. Airflow near Stop 1 was 4–7 miles per hour into the cave. Beyond Stop 1, air temperatures near the ceiling ranged from 12.6 to 13.0ºC, and no airflow was detected.

No Indiana bats were observed inside [redacted] Twenty-seven eastern pipistrelles were observed in the North passage, and eastern pipistrelles (n=78) and little brown bats (n=70) were observed in the South passage. Except for the portion between the entrance and Bridges Bathtub (approximately 100 feet), the majority of [redacted] does not appear to provide suitable habitat for hibernating Indiana bats due to high air temperatures. No Indiana bats were detected there during autumn or winter surveys, therefore we conclude the species did not occupy the cave.

Discussion

BHE conducted surveys of eight caves during autumn and winter to investigate the presence of Indiana bats and to assess suitability of the caves for hibernating Indiana bats. Surveys were timed to occur during autumn swarming and winter hibernation. Surveys were conducted according to guidance provided by the US Fish and Wildlife Service, Bloomington Field Office.

Except for [redacted] none of the caves were occupied by Indiana bats during autumn or winter. Two adult male Indiana bats were captured at [redacted] during the autumn swarming period. No Indiana bats were observed inside [redacted]

during winter, and air temperatures inside [redacted] do not appear to provide optimal conditions for hibernating Indiana bats.

[redacted] was surveyed to a point approximately 30 feet within the entrance where the passage is constricted by sediment to within 6 inches or less of the ceiling. This blockage appeared to extend 50 feet or more and it is therefore likely the sediment buildup functionally blocks access by bats to the remaining portion of the cave. No signs were observed that bats land and crawl through the 6-inch tall opening that remains. Eight bats were captured at [redacted] during autumn swarming. Neither autumn nor winter surveys suggest a large number of bats occupy [redacted]

In [redacted] BHE could not access three portions of the North passage, but air temperatures in the remainder of the cave suggest the uninspected portions are not suitable for hibernating Indiana bats.

Five of the eight caves surveyed appear to provide suitable winter habitat for Indiana bats. Assessment of habitat suitability was based primarily upon air temperature near the cave ceiling, as described above. [redacted] does not provide suitable habitat for hibernating Indiana bats because the small size of the cave likely would expose bats to freezing temperatures. While a small portion of [redacted] provides suitable temperatures, air temperatures in the majority of the cave were nearly 13ºC, which is warmer than typical Indiana bat hibernacula.

In all eight of the caves surveyed, air temperature near the ceiling was <13ºC in all or a portion of the cave. However, none of the caves surveyed contained areas, other than the entrance inside the twilight zone, where air temperatures were within the optimal range of 4–8ºC. Based upon the results of harp trap surveys and winter inspections, the eight caves inspected were not occupied by hibernating Indiana bats during the winter of 2005/2006.

Acknowledgements

We appreciate the cooperation and access that landowners provided during surveys of caves. Special thanks to Anmar Mirza and Dave Everton for assistance with cave surveys. Thanks to INDOT; Federal Highway Administration (FHWA); Tom Cervone, Garre Conner, and Josh Sherretz of Bernardin, Lochmueller and Associates Inc.; the Indiana Geological Survey; and Andrew King, Scott Pruitt, and Lori Pruitt of the U.S. Fish and Wildlife Service (Bloomington Field Office) for their roles and support throughout the project.

Literature Cited

BHE Environmental, Inc. (BHE). 2003. Summary of the on-going climate monitoring study in the Lewisburg limestone mine, Preble County, Ohio, July 2002–July 2003. Submitted to the U.S. Fish and Wildlife Service, Reynoldsburg, Ohio Field Office. 10 pp + appendices.

Brack, V. Jr. and K. Dunlap. 1997. A 1996–1997 winter survey for Indiana bats (*Myotis sodalis*) in hibernacula of Indiana. Submitted to the Indiana Department of Natural Resources, Indianapolis, Indiana. 62pp.

Federal Highway Administration (FHWA) and Indiana Department of Transportation (INDOT). 2003a. Final Environmental Impact Statement & Section 4(f) Evaluation: I-69 Evansville to Indianapolis, Indiana. United States Department of Transportation, Federal

Highway Administration and Indiana Department of Transportation. FHWA-IN-EIS-02-01-F. Prepared by Bernardin, Lochmueller and Associates, Inc. http://www.deis.i69indyevn.org/FEIS/index.html.

Federal Highway Administration (FHWA) and Indiana Department of Transportation (INDOT). 2003b. Tier 1 Biological Assessment for Threatened and Endangered Species: I-69 Indianapolis to Evansville. Prepared by Bernardin, Lochmueller and Associates, Inc. Evansville, Indiana.

Henry, A.B, B.A. Slack, D.L. Crane, and R.C. Rommé. 2005. Surveys for Indiana bats in Greene and Monroe counties, Indiana, 2005. Unpublished report prepared for Bernardin, Lochmueller, and Associates, Inc. Evansville, Indiana.

Tuttle, M.D. 1974. An improved trap for bats. Journal of Mammalogy 55:475–477.

Tuttle, M.D. and J. Kennedy. 1999. Indiana bat hibernation roost evaluation: Phase II—Results from the first annual cycle. Bat Conservation International, Austin, Texas. 12pp+ appendix.

U.S. Fish and Wildlife Service (USFWS). 1999. Agency Draft Indiana bat (*Myotis sodalis*) Revised Recovery Plan. Fort Snelling, Minnesota. 53 pp.

Appendix A
Figure

(Cave Locations are Confidential)

Figure 1 ("Caves near the proposed Interstate 69 in Monroe and Greene counties, Indiana that were surveyed in autumn and winter 2005 to investigate presence of the Indiana bat") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Appendix B
Agency Correspondence

Marilyn Carbone

From: Andrew_King@fws.gov
Sent: Friday, September 02, 2005 3:01 PM
To: Drew Crane
Cc: Amy Henry; tcervone@blainc.com; Scott_Pruitt@fws.gov; Lori_Pruitt@fws.gov; gconner@blainc.com; kgsmith@dnr.state.in.us; sjohnson@dnr.IN.gov
Subject: Re: BHE's Fall Harp Trapping for I-69 Tier 2 Studies
Attachments: Fall 2005 harp-trapping.pdf

Dear Drew,

We have received and reviewed BHE's letter requesting the Bloomington Field Office's (BFO) site-specific authorization to conduct harp trap surveys at the eight caves in Monroe County listed below as part of the ongoing I-69 Tier 2 Studies of the Indiana bat. You and others listed on BHE's federal permit may proceed as proposed. Please use this e-mail response as your written authorization from the BFO as required by your Federal permit.

List of 8 Caves to Be Inspected by BHE during Fall 2005

-
-
-
-

Should we be contacted by a third party or choose to join you in the field, I request that you keep me informed (via e-mail or otherwise) of your nightly schedule so that we know in advance where you will be surveying. If possible, please inform us of any *M. sodalis* captures within 24 hours.

Sincerely,

Andy King
Acting Supervisor

R. Andrew King
U.S. Fish and Wildlife Service
Bloomington Field Office
620 S. Walker Street
Bloomington, IN 47403
Phone: 812-334-4261 x216
Fax: 812-334-4273

"Drew Crane" <dcrane@bheenvironmental.com>

09/02/2005 01:24 PM

To <Andrew_King@fws.gov>
cc "Amy Henry" <ahenry@bheenvironmental.com>
Subject Fall Harp Trapping

Andy,
Please find the attached document for your concurrence concerning our proposed methods and time frame for Fall 2005 Harp Trapping efforts for the proposed I-69.

Thank you

BHE Environmental, Inc.
Drew Crane
Biologist
11733 Chesterdale Road
Cincinnati, Ohio 45246
Office: 513.326.1500
Direct: 513.326.1174
Cell Phone: 765.412.6331
Fax: 513.326.1178
Email: dcrane@bheenvironmental.com
Website: www.bheenvironmental.com

NOTICE: This electronic mail transmission is for the use of the named individual or entity to which it is directed and may contain information that is privileged or confidential. It is not to be transmitted to or received by anyone other than the named addressee (or person authorized to deliver it to the named addressee). It is not to be copied or forwarded to any unauthorized persons. If you have received this electronic mail transmission in error, please delete it from your system without copying or forwarding it, and notify the sender of the error by replying via email or by calling BHE Environmental, Inc. at 513.326.1500 (collect), so that our address record can be corrected.

Marilyn Carbone

From: Andrew_King@fws.gov
Sent: Monday, December 12, 2005 5:14 PM
To: Amy Henry
Cc: tcervone@blainc.com; gconner@blainc.com; sjohnson@dnr.IN.gov
Subject: Re: Request concurrence for winter cave surveys

Dear Amy,

We have received and reviewed BHE's letter requesting the Bloomington Field Office's (BFO) site-specific authorization to conduct winter surveys at the eight caves in Monroe County listed below as part of the ongoing I-69 Tier 2 Studies of the Indiana bat. You and others listed on BHE's federal permit may proceed as proposed. Please use this e-mail response as your written authorization from the BFO as required by your Federal permit.

List of 8 Caves to Be Inspected by BHE during Winter 2005/2006

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

Should we be contacted by a third party or choose to join you in the field, I request that your crew please keep me informed (via e-mail or otherwise) of your daily schedule so that we know in advance where you will be surveying. If possible, please inform us of any *M. sodalis* observations within 24 hours.

Sincerely,

Andy King
Acting Supervisor

R. Andrew King
U.S. Fish and Wildlife Service
Bloomington Field Office
620 S. Walker Street
Bloomington, IN 47403
Phone: 812-334-4261 x216
Fax: 812-334-4273

"Amy Henry" <ahenry@bheenvironmental.com>

12/12/2005 04:09 PM

To <Andrew_King@fws.gov>

cc

Subject Request concurrence for winter cave surveys

Hi there,
Garre asked that I get this letter out to you today. Our crew is really looking forward to those wet caves!

Thanks,
Amy

BHE Environmental, Inc.
Amy Henry
Biologist/Project Manager
7041 Maynardville Highway
Knoxville, Tennessee 37918
Office: 865.922.4305
Fax: 865.922.8495
Direct: 865.925.4276
Cell: 865.310.2127
Email:Ahenry@bheenvironmental.com
Web: www.bheenvironmental.com

NOTICE: This electronic mail transmission is for the use of the named individual or entity to which it is directed and may contain information that is privileged or confidential. It is not to be transmitted to or received by anyone other than the named addressee (or person authorized to deliver it to the named addressee). It is not to be copied or forwarded to any unauthorized persons. If you have received this electronic mail transmission in error, please delete it from your system without copying or forwarding it, and notify the sender of the error by replying via email or by calling BHE Environmental, Inc. at 513.326.1500 (collect), so that our address record can be corrected.

Appendix C
Tables

Table 1. (Location and legal description of eight caves near the proposed Interstate 69 that were surveyed during autumn and winter 2005) has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Table 2. Results of harp trapping conducted at eight caves between September 6 and October 12, 2005.

Cave name	Date surveyed (2005)	Indiana bat	Little brown bat	Northern long-eared bat	Eastern pipistrelle	Total
[redacted]	Oct 9	0	1	1	0	2
	Oct 10	0	0	0	0	0
[redacted]	Sep 28 (rain out)	0	0	0	0	0
	Sep 29	0	2	0	0	2
	Oct 2	0	1	3	2	6
[redacted]	Oct 11	0	2	5	0	7
	Oct 12	0	2	3	0	5
[redacted]	Sep 8	0	0	3	1	4
	Sep 9	0	2	1	1	4
[redacted]	Sep 6	0	0	0	0	0
	Sep 7	0	0	0	0	0
[redacted]	Sep 26	0	0	2	0	2
	Sep 27	0	12	2	0	14
[redacted]	Oct 3	1	1	0	5	7
	Oct 5	1	4	2	1	8
[redacted]	Oct 6	0	3	17	0	20
	Oct 7	0	3	0	0	3
Total (percent of total)		2 (2.4%)	33 (39.3%)	39 (46.4%)	10 (11.9%)	84

Table 3. Number and species of bats observed in eight caves surveyed between December 20 and December 29, 2005.

Cave name	Date surveyed (2005)	Indiana bat	Little brown bat	Northern long-eared bat	Eastern pipistrelle	Big brown bat	Total
[redacted]	Dec 27	0	0	0	15	2	17
[redacted]	Dec 29	0	7	0	13	0	20
[redacted]	Dec 28	0	0	0	0	0	0
[redacted]	Dec 29	0	0	0	0	0	0
[redacted]	Dec 27	0	0	0	0	0	0
[redacted]	Dec 28	0	0	0	0	0	0
[redacted]	Dec 27	0	2	1	26	6	35
[redacted]	Dec 20	0	71	0	105	0	176
Total		0	80	1	159	8	248

Table 4. Summary of bat captures/observations in eight caves surveyed between September 6, 2005 and December 29, 2005.

Cave name	Fall	Winter	Suitable winter habitat?	
[redacted]	X	X	Yes	Air temperatures <13°C in most of cave, no flooding
[redacted]	X	X	Yes	Air temperatures <13°C in most of cave, no flooding
[redacted]	X	0	Yes	Air temperatures <13°C, no flooding
[redacted]	X	0	Yes*	Air temperatures <13°C in first 30 feet. Suitability of remainder of cave unknown; bats would have to crawl through a 6-inch diameter opening.
[redacted]	0	0	No	Cave very small, would expose bats to freezing temperatures
[redacted]	X	0	Yes	Air temperatures <13°C, no flooding
[redacted]	XX	X	Yes	Air temperatures <13°C in most of cave, no flooding
[redacted]	X	X	Partial	Except for small section near the entrance, air temperatures ≥13°C in most of cave, potential for flooding in some areas

X – bat captured/observed; XX – Indiana bat captured/observed; O- no bats captured/observed; -- - not surveyed
* Assessment based upon partial survey of the cave; suitability of the unsurveyed portion is unknown

Appendix D
Photographs and Maps of Caves Surveyed

Appendix D: (Photographs and Maps of Caves Surveyed) has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Appendix E
Datasheets

Appendix E: (Data Sheets) has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Pesi 123.04,05

AUTUMN 2005 AND WINTER 2006 HABITAT FOR THE INDIANA BAT (*MYOTIS SODALIS*) WITHIN THE CRAWFORD UPLAND AND MITCHELL PLAIN FROM SCOTLAND TO BLOOMINGTON, INDIANA

27 April 2006

Prepared for:

Bernardin, Lochmueller, and Associates
6200 Vogel Rd.
Evansville, IN 47715

Indiana Department of Transportation
100 N. Senate Avenue
Indianapolis, IN 46204

FINAL REPORT

Prepared by:

Jason A. Duffey, Jeffrey A. Hawkins, and Virgil Brack, Jr. Ph.D.

Environmental Solutions & Innovations, Inc.

MAIN OFFICE
781 Neeb Road
Cincinnati, Ohio 45233
Phone: (513) 451-1777
Fax: (513) 451-3321

SATELLITE OFFICES
Richmond, Kentucky
(859) 624-4988

Chicago, Illinois
(513) 324-3223

Terre Haute, Indiana
(513) 235-1076

TABLE OF CONTENTS

Page

1.0 INTRODUCTION.....1

2.0 STUDY AREA.....1

2.1 Location –.....1

2.2 Physiography –.....1

2.3 Indiana bat –.....2

2.3.1 Description –.....2

2.3.2 Status –.....2

2.3.3 Regional Occurrence –.....3

2.3.3.1 Winter Hibernation / Spring Staging and Autumn Swarming –.....3

2.3.3.2 Spring and Autumn Migration –.....3

2.3.3.3 Summer Roosting –.....3

2.3.4 Ecology –.....4

2.3.4.1 Winter Hibernation –.....4

2.3.4.2 Spring Staging and Autumn Swarming –.....5

2.3.4.2.1 Spring –.....5

2.3.4.2.2 Autumn –.....5

2.3.4.3 Spring and Autumn Migration/ Transient Period –.....7

2.3.4.4 Summer Reproductive Season –.....7

2.3.4.4.1 Males –.....7

2.3.4.4.2 Females and Maternity Colonies –.....7

2.3.4.5 Food Habits and Foraging Ecology –.....9

2.3.4.6 Survivorship –.....10

2.3.4.7 Causes of Past/Current Decline –.....10

3.0 METHODS.....11

3.1 Autumn Entrance Surveys –.....11

3.1.1 Site Selection –.....11

3.1.2 Harp Trapping –.....11

3.1.3 Bat Capture –.....11

3.1.4 Habitat Assessment and Entrance Description –.....12

3.1.5 Weather –.....13

3.2 Winter In-Cave Surveys –.....13

3.2.1 Site Selection –.....13

3.2.2 Bat Identification During Hibernation –.....13

3.2.3 Bat Counting –.....14

3.2.4 Temperature –.....14

3.2.5 Portions of Caves Surveyed –.....14

4.0 RESULTS.....14

4.1 Autumn Entrance Surveys –.....14

4.1.1 Total Bat Captures –.....14

4.1.2 Species Diversity –.....15

4.1.3 Occurrence by Sex and Age –.....15

4.1.4 Indiana Bat Captures – 15
4.1.5 Habitat Assessment and Entrance Description – 15
4.2 Winter In-Cave Surveys – 16
4.2.1 Total Count – 16
4.2.2 Species Diversity – 16
4.2.3 Occurrence by Sex and Age – 16
4.2.4 Indiana Bats – 16
4.2.5 Survey Descriptions – 17

5.0 DISCUSSION 19
5.1 Bat Occurrence and Species Diversity – 19
5.2 Occurrence by Sex – 20
5.3 Indiana Bat Occurrence – 20

6.0 ACKNOWLEDGEMENTS 20

7.0 LITERATURE CITED 21

APPENDIX A. FIGURES
APPENDIX B. TABLES
APPENDIX C. PHOTOGRAPHS
APPENDIX D. DATA SHEETS

AUTUMN 2005 AND WINTER 2006 HABITAT FOR THE INDIANA BAT (*MYOTIS SODALIS*) WITHIN THE CRAWFORD UPLAND AND MITCHELL PLAIN FROM SCOTLAND TO BLOOMINGTON, INDIANA

Jason A. Duffey, Jeffrey A. Hawkins, and Virgil Brack, Jr., PhD
Environmental Solutions and Innovations, Inc., 781 Neeb Road, Cincinnati, OH 45233

Abstract

In fulfillment of Tier II Environmental Impact Studies of the proposed I-69 corridor from Evansville to Indianapolis, Indiana, 7 caves (8 cave entrances) in the vicinity of Section 4 were harp trapped during autumn 2005 for the federally endangered Indiana bat (*Myotis sodalis)*. A total of 384 bats representing 4 species was captured: 217 northern bats (*Myotis septentrionalis*), 118 little brown bats (*Myotis lucifugus*), 47 eastern pipistrelles (*Pipistrellus subflavus*), and 2 Indiana bats (*Myotis sodalis*). Indiana bats were captured at (aka Cave). The same caves were entered in winter 2006 to search for hibernating Indiana bats. A total of 216 bats representing 3 species was found: 136 eastern pipistrelles, 79 little brown bats, and 1 Indiana bat. Like the autumn survey, the Indiana bat was found in harbored 35 percent and 32 percent, respectively of bats found during autumn and winter censuses.

Key Words – Indiana bat, *Myotis sodalis*, Indiana, harp trapping, hibernacula, cave

1.0 Introduction

The federal Endangered Species Act (ESA) [16 U.S.C. 1531 *et seq*.] became law in 1973 and provides for the listing, conservation, and recovery of endangered and threatened species of plants and wildlife. Under ESA, the U.S. Fish and Wildlife Service (USFWS) is mandated to protect and monitor the numbers and populations of listed species. Many states enacted similar laws.

Section 7(a)(2) of the Act states that each federal agency shall insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in destruction or adverse modification of designated critical habitat. Federal actions include (1) expenditure of federal funds for roads, buildings, or other construction projects, and (2) approval of a permit or license, and the activities resulting from such permit or license. This is true regardless of whether involvement is apparent, such as issuance of a federal permit, or less direct, such as federal oversight of a state-operated program.

Section 9 of the Act prohibits take of listed species. Take is defined by the Act as "*to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect.*" The definition of harm includes adverse habitat modification. Actions of federal agencies that do not result in jeopardy or adverse modification, but that could result in a take, must be addressed under Section 7.

This study is part of the Tier 2 Environmental Impact Studies for Section 4 and the Section 4/5-junction area of the proposed I-69 from Evansville to Indianapolis, Indiana. Environmental Solutions and Innovations, Inc (ESI) was contracted by Bernardin, Lochmueller and Associates, Inc. (BLA), and their client, the Indiana Department of Transportation, to conduct autumn and winter hibernacula surveys of 7 caves (8 cave entrances) near Section 4 of the proposed I-69 corridor for the endangered Indiana bat (*Myotis sodalis*).

ESI completed field efforts under federal Endangered Species Permit TE 023664-15 and State of Indiana Department of Natural Resources permits 3083, 3085, 3287, 3289, and 3293.

2.0 Study Area

2.1 Location –

Section 4 of the proposed I-69 corridor begins at US 231 in southeast Greene County north of SR 58 near the northwest corner of Naval Support Activity Crane. It proceeds northeast into Monroe County and ends at SR 37 near Victor Pike south of Bloomington (Figure 1). The total length of Section 4 is approximately 27 miles. The caves surveyed by ESI were in Greene, Monroe, and Lawrence counties, in the vicinity of the I69 winter action area of Section 4.

2.2 Physiography –

The project area is in the Crawford Upland Section of the Shawnee Hills Natural Region and the Mitchell Plain Section of the Highland Rim Natural Region in southwest Indiana (Homoya et al. 1985). The Crawford Upland Section is characterized by rugged hills with sandstone cliffs and rockhouses, and well-drained acid silt loam

soils. The majority of natural communities are upland forest types, although a few sandstone and limestone glades, gravel washes, and barrens are known. To the east, the Mitchell Plain Section is characterized by relatively low relief and marked by sinkholes and extensive cave systems developed in Mississippian age limestone bedrock (Homoya et al. 1985). Upland forest types are common although swamps, flatwoods, and barrens are present. Examples of medium and high gradient streams with rocky bottoms in this area include Indian Creek, Clear Creek, and Popcorn Creek.

2.3 Indiana bat –

2.3.1 Description –

The Indiana bat is a medium-sized bat in the genus *Myotis*. The forearm length has a range of 1.4 to 1.6 inches (35 – 41 mm). The head and body length range from 1.6 to 1.9 inches (41 – 49 mm). Its appearance

most closely resembles that of congeners little brown bat (*M. lucifugus*) and northern bat (*M. septentrionalis*). Indiana bats differ from similar *Myotis* species in that they have a distinctly keeled calcar (cartilage that extends from the ankle to support the tail membrane). Other minor differences include smaller and more delicate hind feet, shorter hairs on the feet that do not extend past the toenails, and a pink nose. The fur lacks luster, and the wing and ear membranes have a dull, flat coloration that does not contrast with the fur (USFWS 1999). Fur on the chest and belly is lighter than fur on the back, but is not as strongly contrasting as that of similar *Myotis* species. Overall color is slightly grayer, while the little brown bat and northern bat are browner. The skull has a crest and tends to be smaller, flatter, and narrower than that of the little brown bat (USFWS 1999).

2.3.2 Status –

The USFWS listed the Indiana bat (*Myotis sodalis*) as endangered on March 11, 1967. The most current range-wide estimate of the population is 457,374 individuals (USFWS unpublished data 2005), which represents about half of the estimated population of 1960. Long-term, detailed documentation of population changes are lacking across most of its range, with the exception of the state of Indiana (Brack et al. 1984, 2003; Johnson et al. 2002). It is probable that summer habitat loss (USFWS 1999) and winter disturbances during hibernation (Johnson et al. 1998) both contributed to the overall decline of the species.

Federal Register Documents

41 FR 41914; 24 September 1976: Final Critical Habitat, Critical habitat-mammals

40 FR 58308 58312; 16 December 1975: Proposed Critical Habitat, Critical habitat- mammals

32 FR 4001; 11 March 1967: Final Listing, Endangered

A recovery plan for the species was completed on 14 October 1983. In October 1996, the Indiana Bat Recovery Team released an Indiana Bat Recovery Plan Technical Draft. In October 1997, a

preliminary version entitled "Agency Draft of the Indiana Bat Recovery Plan," which incorporated changes from the 1996 Technical Draft, was released. Subsequently, an agency draft entitled "Indiana Bat (*Myotis sodalis*) Revised Recovery Plan" was distributed for comments in March 1999. A new draft revised recovery plan is being prepared. Critical habitat was designated on 24 September 1976, and includes 11 caves and 2 abandoned mines in Illinois, Indiana, Kentucky, Missouri, Tennessee, and West Virginia.

2.3.3 Regional Occurrence –

The Indiana bat is known to occur within the vicinity of Section 4 (Figure 2). There are four ecologically distinct components of the annual life cycle, which include winter hibernation, spring staging and autumn swarming, spring and autumn migration, and the summer season of reproduction. Each of these components is discussed below with respect to regional occurrence of the Indiana bat in Greene and Monroe counties.

2.3.3.1 Winter Hibernation / Spring Staging and Autumn Swarming –

The Indiana bat is known to hibernate in 12 caves in the vicinity of Section 4 (Figure 3). Eight hibernacula are known from western Monroe County. Hibernacula are classified based on sizes of winter populations of Indiana bats in each cave. Priority I hibernacula exceed 30,000 bats, Priority II caves contain populations between 1,000 and 30,000 bats, and Priority III caves contain less than 1,000 individuals.

(, and caves are Priority III hibernacula. and caves are Priority II hibernacula. These caves range from 1.0 (Cave) to 4.6 miles (Cave) from the Section 4 corridor (BLA 2003).

Eastern Greene County contains four known Indiana bat hibernacula. and caves are Priority III hibernacula approximately 0.5 miles from the Section 4 corridor. Cave, another Priority III cave, is 10 miles from the corridor. Cave is a Priority I hibernacula and is federally designated Critical Habitat with 50,941 Indiana bats documented in 2003 (Brack et al. 2003), and 54,325 bats in 2005 (Brack et al. 2005a). Cave lies approximately 6 miles from the I-69 corridor.

2.3.3.2 Spring and Autumn Migration –

Because winter hibernacula are known from Greene and Monroe Counties in Indiana, it is reasonable to assume migration of transient bats occurs during spring and autumn within the study area.

2.3.3.3 Summer Roosting –

There are summer records of adult male Indiana bats from 24 counties in Indiana, including Greene and Monroe counties (Whitaker and Brack 2002; Figure 2). During summer, males often remain at or near hibernacula, visiting them periodically, although some disperse longer distances from hibernacula.

There is evidence of reproduction and maternity colonies in at least 40 counties in Indiana (Whitaker and Brack 2002). Maternity colonies may be more abundant in the northern part of the state. Female Indiana bats had not been found in either Greene or Monroe counties until summer 2004 (ESI 2004), when two reproductive adults were captured. However, records of female Indiana bats exist for neighboring counties including Jackson, Knox, Martin, and Vigo counties.

The Draft Environmental Impact Statement on the Southwest Indiana Highway Corridor prepared for INDOT included information on 1993 mist net surveys for Indiana bats. Dr. John Whitaker Jr. surveyed 19 sites along the proposed corridor from I-64 to Bloomington, Indiana. Eleven sites were located within the Section 4 corridor. A total of 41 bats were captured; no Indiana bats were caught.

2.3.4 Ecology –

Indiana bats roost in trees during summer and hibernate in caves during winter. There are four ecologically distinct components of the annual life cycle: winter hibernation, spring staging and autumn swarming, spring and autumn migration, and the summer reproductive season. The USFWS Recovery Plan (1999) provides a description of the life history of the Indiana bat and Figure 4 provides an annual chronology of seasonal activities.

2.3.4.1 Winter Hibernation –

The winter range of the Indiana bat is restricted to regions of well-developed limestone caves, where it overwinters in approximately 300 known hibernacula. Most hibernacula are in caves, but abandoned mines in Illinois (Kath 2002), New York, (Hicks and Novak 2002), and Ohio (Brack in prep) are sometimes used. Only a few caves contain large populations of Indiana bats, while most contain only a few bats. The most recent range-wide estimate found Indiana bats, hibernating in 363 hibernacula (USFWS unpublished data 2005). Ten "Priority One" hibernacula contained approximately 272,888 Indiana bats, or 59.7 percent of the total known population. The 90 hibernacula classified as "Priority Two" contained 177,856 Indiana bats, or 38.9 percent of the total known population. The remaining 263 hibernacula in which Indiana bats have been found since 1960 contained only 6,661 bats in 2005, less than two percent of the total population.

Hibernacula with large populations of Indiana bats are concentrated in southern Missouri, Indiana, and Kentucky. Smaller wintering populations occur in Alabama, Arkansas, Connecticut, Georgia, Illinois, Iowa, Maryland, Massachusetts, Mississippi, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Vermont, Virginia, and West Virginia (Figure 5).

Hibernation is an adaptation that allows survival through the winter months when food and water are not abundant. Indiana bats hibernate from mid-November to mid-April. During this time, they form dense clusters on cave ceilings in portions of the cave where winter temperatures are suitable. Thus, hibernacula used by Indiana bats (and many other species of bats) have characteristic temperature regimes and spatial associations (Brack 1979; Brack et al. 2003; Brack and Twente 1985; Twente et al. 1985). Initially, the suitable temperature was believed to be 4 to 8ºC (or perhaps more narrowly 3 to 6°C during mid-winter (USFWS 1999), but these assertions (Hall 1962; Henshaw and Folk 1966; Humphrey 1978) were supported with scant data. Recent analysis of long-term data in hibernacula with increasing numbers of Indiana bats indicates the optimal range is closer to 6 to 8º C (Myers 1964; Clawson et

al. 1980; Brack et al. 2003; Brack in prep; Brack and Reynolds in prep; Brack et al. 2005d). Therefore, Indiana bats use areas that are cool, but thermally stable. Colder areas, especially areas closer to the entrance, are often unstable.

Hibernating clusters of Indiana bats are not sexually segregated, and the incidence of white or leucistic Indiana bats, although rare, is a reoccurring phenomenon (Brack and Johnson 1990; Brack et al. 2005c). A review of ecological and physiological aspects of hibernation is provided in Brack (2004).

2.3.4.2 Spring Staging and Autumn Swarming –

2.3.4.2.1 Spring –

Female Indiana bats leave hibernacula earlier in spring (beginning in mid-April) than do males (peak of departure in early May). This part of spring activity is referred to as staging. In spring, after emerging from hibernation, bats may remain near hibernacula caves for a few days before leaving for summer maternity areas. They may use this time to help prepare for migration

2.3.4.2.2 Autumn –

Autumn swarming is a term used to describe the activity of microchiropteran bats at hibernacula in North America (Cope and Humphrey 1977) and Europe (Parsons et al. 2003) during autumn. It is the use and visitation of hibernacula and nearby habitats in late summer and early autumn, and for many species is associated with the opportunity for sexes to meet and mate.

In autumn, Indiana bats swarm at caves used for hibernation, although individuals probably come and go throughout the autumn season. Cope and Humphrey (1977) indicated that "waves" of Indiana bats begin to return to hibernacula in southern Indiana in low to moderate numbers in mid-August to late-August. Also in Indiana, Brack (1983) found the first individuals arriving as early as late July. In Missouri, LaVal and LaVal (1980) indicated that individuals begin to return to hibernacula in early August.

During swarming, the abundance of females increases and decreases with the season, but males are always more common (Cope and Humphrey 1977; LaVal and LaVal 1980). Numbers of swarming females peak in September. By late-September, many females are hibernating while many males remain active until mid-October or later, apparently in an effort to breed late-arriving females. Small males with insufficient fat reserves to survive winter may remain active in hibernacula seeking to copulate before dying (Richter et al. 1993). Temperature and precipitation likely influence swarming chronology. For example, rain has been shown to depress swarming activity in Europe (Parsons et al. 2003). Large, wet cold-weather systems may be part of the seasonal cycle driving the timing of swarming (Brack in submission). Females store sperm through hibernation and delay fertilization until spring (Wimsatt 1944). It is not known if juvenile females mate their first autumn and limited mating may occur in spring (Hall 1962).

During early stages of autumn swarming, Indiana bats visit hibernacula at night and t may roost in woodlands near the cave during the day. In Bland County Virginia, roosts were located within 0.5 mile (0.8 km) of known hibernacula (Brack 2005) and within 1 mile (1.6 km) in Kentucky (Gumbert 2001). In Virginia, Indiana bats used a

variety of species of live, dying, and dead roost trees (Brack 2005). Individual bats roosted in multiple trees, which were sometimes used for two to three consecutive days. Many roosts were near canopy openings including selective cut, clear-cut, and pastured woodlands with scattered trees. Roosts were also found near or along logging roads or powerline corridors. Bats also used roost trees in forests with moderate to high canopy closure. Compared to availability, roost trees were located disproportionately more often in open, intermediate, and closed deciduous forests rather than mixed deciduous/evergreen forest. Roosts found in agricultural areas bordered croplands. In Virginia, there was no difference between sizes of roost trees used by females and males (17.5 versus 15.5 in; 44.5 versus. 39.4 cm), height of roost above ground (37 versus 40 ft, 11.3 versus 12.2 m), or elevation where roost trees were found (2,750 versus 2,950 ft; 838 versus 900 m). There was no difference between species of roost trees used by male and female bats throughout the autumn season, as well as no discrimination between living or dead trees (Brack 2005). As the autumn season progresses, more bats roost in the hibernacula caves.

In Virginia, nocturnal activity areas were 237 to 907 acres (96 - 367 ha; $\bar{X}$ = 251 ha), with a great deal of overlap among activity areas of individuals (Brack 2005). Bats in the Virginia project area were proportionately more active in open deciduous forests, even though there was less of that habitat available in the area (19.0 percent versus 9.5 percent). They were less active in mixed deciduous-evergreen forests and closed deciduous forests, even though the habitat types were significantly more abundant in the area (Brack 2005). Thus, Indiana bats foraged in relatively open habitats, consisting primarily of pastures with scattered trees, within this Virginia project area. Many pastures (agricultural lands) in the Virginia project area had scattered trees that abutted woodlands, with a gradation from pasture to woodlands, and open woodlands were generally recently-logged tracts with a scattering of individual trees. Bats were active across all elevations in the Virginia project area. Many bats included an existing powerline ROW in their active area. Bat activity shifted among habitats over the autumn season (Brack 2005). Use of agricultural lands dropped steadily over the season; conversely, use of deciduous forests (combined open, intermediate, and closed) increased, possibly in response to insect availability.

As the autumn season progresses, nightly bat activity begins earlier in the evening. As temperatures cool seasonally, nocturnal insects have a limited activity period; consequently, so do the bats (Brack in submission; Parsons et al. 2003). It is probable that many bats leave the hibernaculum area periodically during autumn swarming (Brack in submission; Gumbert 2001). It is not known why bats leave, but departures during swarming have implications for reproductive fitness since it reduces or eliminates the opportunity to mate. Possibly, bats visit and mate at other swarming locations. Alternatively, males actively seeking mating opportunities may need to intermittently leave the swarming area to forage and replenish energy supplies.

2.3.4.3 Spring and Autumn Migration/ Transient Period –

Little is known about bats during migration. In general, females are more migratory than males (Whitaker and Brack 2002; Brack 1983). Females from a single hibernaculum may end up at maternity colonies over a large geographic area, and females from a single maternity colony may end up in different hibernacula (Barbour and Davis 1969; Gardner and Cook 2002; Kurta and Murray 2002). It is probable that bats use a variety of roosts, including trees, caves, mines, holes of various types, and possibly a variety of non-traditional roosts during migration. Bats migrating from hibernacula in southeastern New York to summer maternity sites roosted in trees and on a building - in a gap between a cinderblock wall and a joist under an elevated deck (Sanders and Changer 2001), as well as in the siding of a house and in trees of suburban yards. In late summer, a juvenile Indiana bat was found on the side of a building in central Indiana that had a roughed cement exterior (Brack unpublished data). In northern Ohio, several Indiana bats have been caught in autumn in sandstone crevices that likely serve as a migratory stop over (Summit County Metro Parks 2003). During migration, other species of bats have been found in a variety of unlikely locations, including ships at sea, log piles, and rodent holes in treeless areas (Brack and Carter 1985).

2.3.4.4 Summer Reproductive Season –

The summer range of the Indiana bat is large and includes much of the eastern deciduous forestlands between the Appalachian Mountains and Midwest prairies (Figure 6). Distribution throughout the range is not uniform and summer occurrences are more frequent in southern Iowa and Michigan, northern Missouri, Illinois, and Indiana. Greater tree densities do not equate to more bats (Brack et al. 2002). Cooler summer temperatures associated with latitude or altitude likely affect reproductive success and the summer distribution of the species (Brack et al. 2002).

2.3.4.4.1 Males –

Some males remain near hibernacula throughout summer while others migrate varying distances (Whitaker and Brack 2002). Males can be caught at hibernacula on most nights during summer (Brack 1983; Brack and LaVal 1985), although there may be a large turnover of individuals between nights (Brack 1983).

Woodland roosts appear similar to maternity roosts (Kiser and Elliott 1996; Schultes and Elliott 2002; Brack et al. 2004; Brack and Whitaker 2004), although smaller diameter trees may be used. Less space may be required for a single bat than a colony of bats, or thermal requirements may differ. Males appear somewhat nomadic; over time, the number of roosts and the size of an area used increases. Activity areas encompass roads of all sizes, from trails to interstate highways. Roosts have also been located near roads of all sizes (Kiser and Elliott 1996; Schultes and Elliott 2002; Brack et al. 2004), including adjacent to an interstate highway (Brack et al. 2004).

2.3.4.4.2 Females and Maternity Colonies –

When female Indiana bats emerge from hibernation, they migrate to maternity colonies that may be located up to several hundred miles away (Kurta and Murray 2002). Females form nursery colonies under exfoliating bark of dead, dying, and living trees in a variety of habitat types, including uplands and riparian habitats. A wide variety of tree species, including occasional

pines (Britzke et al. 2003) are used as nursery colonies indicating that it is tree form, not species that is important for roosts. Since many roosts are in dead or dying trees, they are often ephemeral. Roost trees may be habitable for one to several years, depending on the species and condition of the tree (Callahan et al. 1997). Indiana bats exhibit strong site fidelity to summer roosting and foraging areas (Kurta and Murray 2002; Kurta et al. 2002).

A maternity colony typically consists of 25 to 325 adult females. Nursery colonies often use several roost trees (Kurta et al. 1993; Foster and Kurta 1999; Kurta et al. 2002), moving among roosts within a season. Most members of a colony coalesce into a single roost tree about the time of parturition, which begins to break up again as soon as young are volant. Roosts that contain large numbers of bats (more than 20 bats) are often called primary roosts, while secondary roosts hold fewer bats. Primary roost trees are often greater than 18 inches dbh and secondary roost trees are often greater than nine inches dbh (Gardner et al. 1991; Callahan et al. 1997; Kurta et al. 2002; Miller et al. 2002; Carter 2003). Numerous suitable roosts may be required to support a single nursery colony, possibly about 20 stems per acre (Gardner et al. 1991; Miller et al. 2002; Carter 2003).

Roost trees are often located where they have solar exposure, with 20 to 80 percent canopy closure (Humphrey et al. 1977; Gardner et al. 1991; Kurta et al. 1993, 1996, 2002; Carter 2003). They are often exposed to 10 or more hours of solar radiation per day (Kurta et al. 2002). The need for solar exposure may vary with latitude. Although maternity colonies of Indiana bats typically roost under the exfoliating bark of dead and dying trees, they have also been found roosting in buildings, one in Pennsylvania (Butchkoski and Hassinger 2002) and one in a barn in Iowa (unpublished report), and bat boxes (Whitaker et al. in submission). Individuals that were likely part of maternity colonies have been found in bat boxes (Carter 2002), and various tree hollows and tree cracks (L. C. Watkins in Humphrey et al. 1977; Kurta et al. 1993, 2002).

Females are pregnant when they arrive at maternity roosts. Fecundity of the species is low, for females produce only one young per year. Parturition typically occurs between late June and early July. Lactating females have been caught June 11 to July 29 in Indiana, June 26 to July 22 in Iowa, and June 11 to July 6 in Missouri (Humphrey et al. 1977; LaVal and LaVal 1980; Brack 1983; Clark et al. 1987). Juveniles become volant between early July and early August. Reproductive phenology is likely dependent upon seasonal temperatures and the thermal character of the roost (Humphrey et al. 1977; Kurta et al. 1996). Like many microchiropterans, Indiana bats are thermal conformists (Stones and Wiebers 1967), with prenatal, neonatal, and juvenile development temperature dependent (Racey 1982). Cooler summer temperatures associated with latitude or altitude likely affect reproductive success and therefore the summer distribution of the species (Brack et al. 2002).

Nightly non-foraging behavior of Indiana bats is poorly documented. In Michigan,

pregnant bats from a maternity colony foraged most of the night, but lactating females returned two to four times to feed young. Both pregnant and lactating females roosted up to six times per night for 14 minutes each (*SD* = 1; Murray and Kurta 2004). Foraging areas were 0.3 to 2.5 miles (0.5 – 4.0 km) from diurnal roosts. Kiser et al. (2002) found 82 bats under three bridges over a six-night period in late July and August. Temperatures under the bridges were warmer and less variable than ambient, apparently providing a location to hang and digest food between foraging bouts. These bridges were 0.6 to 1.2 miles (1.0 - 1.9 km) from diurnal roost trees.

Indiana bats live on anthropogenic landscapes and recent research indicates females do include roads in their active area. Although bats do cross roads, the studies that document this behavior were not designed to gauge a graded response. On Indiana, female and juvenile Indiana bats routinely night roosted under bridges on 2-lane paved roads (Kiser et al. 2002). Activity areas of nursery colonies in Illinois (Gardner et al. 1991) and Michigan (Kurta et al. 2002) included paved roads. On the campus of Ohio, a roost tree was located at the edge of a large parking lot, and about 60 feet (18 m) from a moderately traveled road. Emerging bats crossed the parking lot and radio-tagged bats crossed Highway a four-lane divided highway to forage in a 180-acre (73 ha) woodlot (Brown et al. 2001). A female Indiana bat from a maternity roost tree on the west edge of the Indianapolis, Indiana and north of Interstate routinely crossed this six-lane interstate to forage (Brack unpublished data). In eastern Indiana, adjacent to a reproductive female Indiana bat was radio-tracked across a four-lane divided highway to a maternity colony in a small (1.7 acre; 0.7 ha), isolated woodlot (Brack and Whitaker in prep). The roost tree was on the west edge of the woodlot, adjacent to the highway and the woodlot was surrounded on other sides by open, farmed agricultural lands.

2.3.4.5 Food Habits and Foraging Ecology –

The diet of Indiana bats differs depending on age and sex, but include a variety of insects, which vary by habitat and season. Based on diets of males, Brack and LaVal (1985) considered the species selective opportunists. In Indiana, aquatic-based insects were more common in the diet of a maternity colony than in the diet of males collected at caves (Brack 1983). The maternity colony was located along the Big Blue River, where only about 11 percent of the land within two miles (3.2 km) of the roost was forested (most was riparian), whereas males were caught at a cave where 42 percent of the area within two miles (3.2 km) was forested and only a small portion was riparian. In late summer, the diets of males, females, and juveniles captured at caves were similar to one another and to males' summer diets. Diets reported by Belwood (1979) from a colony along a stream and by Kurta and Whitaker (1998) from a colony within a wooded wetland contained more aquatic-based insects than diets of males foraging in an upland habitat (Brack and LaVal 1985). The repeated seasonal occurrence of the Asiatic oak weevil, *Cyrtepistomus castaneus* and sporadic abundance of hymenopterans in the diet (Brack 1983; Brack and LaVal 1985; Brack and Whitaker 2004; Brack in submission) are both indicative of opportunistic feeding. Insects may be less common upland and riparian woods, around crowns of individual or widely spaced trees,

and along edges. They forage less frequently over old fields, and occasionally over bushes in open pastures. Forest edges, small openings, and woodlands with patchy trees provide more foraging opportunities than dense woodlands. Most species of woodland bats forage prominently along edges, less in openings, and least within forests (Grindal 1996). Openings also provide a better supply of insects than do wooded areas (Tibbels and Kurta 2003).

2.3.4.6 Survivorship –

Detailed studies of survivorship of the Indiana bat have not been completed. Humphrey and Cope (1977) found survival rates high for years one through six after banding, 75.9 percent annually for females and 69.9 percent for males (72.9 percent combined), lower after six years, at 66.0 percent for females and 36.3 percent for males (51.2 percent combined), and only 4.1 percent (females) after 10 years. Paradiso and Greenhall (1967) and Humphrey and Cope (1977) determined a terminal age of between 12 and 13 years after marking.

Humphrey and Cope (1977) could not determine survivorship for young of the year, but total survival was much lower the first year after marking (ca. 41 percent), which was attributed to low survivorship of young-of-the-year. Brack et al. (2005c) found that survivorship of white and leucistic *M. sodalis* was low, about 7.7 percent (assuming individuals were 0.5 years old when first found). This calculated rate may be low because bats may have been 1.5 years of age when first found, and they may have survived an additional year without being found. Low survivorship during adolescence is representative of many mammalian species, although white coloration may make bats more susceptible to predation by visually oriented nocturnal predators.

2.3.4.7 Causes of Past/Current Decline –

Long-term, detailed documentation of population changes are lacking in most areas. Summer habitat degradation (USFWS 1999), pesticides, and winter disturbance (Johnson et al. 1998) are believed to have contributed to an overall decline.

The Indiana bat uses a variety of wooded summer habitats, from large tracts of woodlands to riparian strips and woodlots on a human-dominated landscape. Summer habitat losses include tree removal or land clearing for a variety of land use practices: agriculture, urban development, surface mining, and utility and transportation ROWs. Removal of standing dead trees, especially during summer months, is potentially harmful. Removal of riparian forest along streams and ditches also degrades summer habitat. Loss of wooded lands can lead to increased forest fragmentation, and a compounding of adverse effects. In many portions of their core range, Indiana bats utilize savanna-like habitats, with large trees, an open canopy, and an uncluttered understory. However, suppression of fire and removal of dominant grazing herbivores, combined with frequent tree harvest, has often produced wooded lands of smaller trees with a closed canopy and a cluttered understory, which may have affected the quality of maternity habitat (USFWS 1999).

Chemical contamination in non-winter habitats has been implicated in the decline of most North American bats (USFWS 1999). However, the importance of this role on a species-by-species basis is not clearly

documented, and additional studies are needed.

Documented anthropogenic threats to winter habitats include: (1) disturbance and vandalism, (2) improper cave gates and structures, (3) indiscriminate collecting, and (4) flooding of caves from reservoir construction. Natural hazards include flash flooding of hibernacula (Brack et al. 2005b), ceiling collapse of mines and caves, colder or warmer than average winters, and severe summer storms. Natural and/or human-caused changes in the microclimate of caves and mines used as hibernacula can adversely affect the species.

3.0 Methods

3.1 Autumn Entrance Surveys –

3.1.1 Site Selection –

Seven caves (eight cave entrances) were selected by BLA and underwent field reviews and assessment of suitability for bat habitat in conjunction with the USFWS Bloomington Field Office, Indiana Geological Survey (IGS), Indiana Karst Conservancy (IKC), and ESI (Figure 7, Table 1). Caves were selected based on estimated likelihood of serving as Indiana bat (*Myotis sodalis*) hibernacula and/or swarming sites, as well as proximity to Section 4 of the proposed I-69 corridor. Selected caves were within 5 miles of the corridor.

Cave's two entrances were trapped separately, adding an additional entrance and two additional trap nights.
All caves were on private property. Property owners were provided Notice of Survey letters and were contacted when feasible prior to survey efforts.

3.1.2 Harp Trapping –

Eight cave entrances were surveyed for 2 nights each over the period 13 – 26 September 2005 for a total of at least 2 nights of effort per entrance. Based on USFWS recommendations, surveys were completed between 12 September and 3 October, when greatest swarming activity was anticipated.

Harp trapping was the sampling method at all cave entrances. Traps were set to maximize coverage of flight paths used by bats at cave entrances. Typically, traps are placed at entrances, adjusted for height, and situated across (parallel to) the entrance. Areas of the entrance not covered by the trap are typically covered with garden netting to direct bats into the trap. Additional entrances were either trapped or excluded with garden netting. Because
Cave had two distinct entrances, two harp traps were used, one at each entrance.

Efforts to survey for endangered bats are difficult to standardize because of the large amount to variability that exists in a field situation. However, the USFWS Bloomington Field Office's adaptation of protocols used by the Pennsylvania Game Commission (Table 2) provides structure for implementation of standardized procedures for bat surveys at cave entrances.

3.1.3 Bat Capture –

The trapping setup allows bats to be caught live and released unharmed near the point of capture. Bats were identified to species using a combination of morphological characteristics (e.g., ear and tragus, calcar, pelage, size/weight, length of right forearm, and overall appearance of the animal). The species, sex, age, reproductive condition,

weight, length of right forearm, and time and location/site of capture were recorded for all bats captured. Age (adult or juvenile), as determined by examining ephiphyseal-diaphyseal fusion (calcification) of long bones in the wing, is difficult to determine in autumn. As a result, most individuals were recorded as adults. Reproductive condition of female bats (pregnant, lactating, or post lactating), determined by gentle abdominal palpation or examination of teat wear, is generally not applicable in autumn and is very difficult to determine in spring. As a result, most individuals were recorded as non-reproductive, unknown, or not available. Evidence of past pregnancies carried to term (parous versus nonparous) can sometimes be determined by palpation of the pubic symphysis. Reproductive condition of male bats was classified as descended or non-descended. Weight was measured to 0.1 grams using a Pesola spring scale. Length of the right forearm of each bat was estimated to at least the nearest 1.0 mm using either calipers or a ruler. When feasible, gentle palpation of the belly is used to determine whether individuals fed before capture, as an indication of whether an individual is entering or exiting the cave.

High capture rates and captures of Indiana bats at (aka Cave) did not allow recording of complete morphometric measurements for all individuals. However, all bats were identified to species and sex.

Indiana bats were banded with a uniquely numbered white plastic band. Bands were placed on the right forearm of each male and the left forearm of each female. Fecal samples were also taken from Indiana bats (and other species) when feasible and provided to the USFWS Bloomington Ecological Services Field Office for analysis not associated with INDOT or its operating mission. Bat processing and data collection was completed within 30 minutes of the time the bat was removed from the trap (bat capture data sheets are provided in Appendix D).

To compare species diversity among other surveys, the MacArthur index (1972) was calculated, where Diversity = $1/\sum P_i^2$, where P_i is the proportion of bats belonging to species **i** in each sample.

Chi-square analysis, where $\chi^2 = \sum [(O - E)^2 / E]$, where O is the observed frequency and E is the expected frequency, was used to test for statistical significance between sexes and species. .

3.1.4 Habitat Assessment and Entrance Description –

General habitat assessments at survey sites focused on features near cave entrances indicative of suitability for Indiana bats. A habitat description of each entrance was completed (Appendix D). The emphasis of this description was habitat form: size and relative abundance of large trees and snags that potentially serve as roost trees, canopy closure, understory clutter/openness, distance to water, nearby stream or pond characteristics, and flight corridors. Habitat form was emphasized because the Indiana bat roosts in many species of trees, especially during the autumn and spring seasons. Tree species composition was included because it provides insight to edaphic conditions of each site.

Habitat assessments identify components of canopy and subcanopy layers. Trees that reach into the canopy are canopy trees, regardless of their diameter/size. As defined in the Indiana Bat Habitat Suitability Index

Model (3D/Environmental 1995), dominant trees are the large trees in the canopy (>16" dbh) that have the greatest likelihood of being used by maternity colonies of Indiana bats. Smaller trees are often found in the canopy, and in some situations, the canopy can be entirely composed of small-diameter trees. ESI's habitat assessment identifies dominant and subdominant elements of the canopy.

The subcanopy vegetation layer is well defined in classical ecological literature. It is that portion of the forest structure between the ground vegetation (to approximately 2 feet [0.6 m]) and the canopy layers, usually beginning at about 25 feet (7.6 m).

Vegetation in the understory may come from: lower branches of overstory trees, young overstory trees, small trees, and shrubs that are confined to the understory. The amount of vegetation in the understory is termed clutter. Many species of bats, including the Indiana bat, tend to avoid areas of high clutter.

Other site-specific parameters pertinent to assessing the quality of the habitat near cave entrances were also recorded such as distance to water, stream habitat (if present), standing water in an upland site, and travel corridors – or lack thereof. Each site was documented with a sketch (Appendix D).

Characteristics of each entrance that potentially relate to bat use were recorded on Cave Entrance Description Data Sheets (Appendix D). Characteristics included size of entrance, type (vertical or horizontal), apparent stability, airflow, water, etc. Photographs of cave entrances are provided in Appendix C.

3.1.5 Weather –

Temperature, percent cloud cover, wind, and precipitation were monitored and recorded hourly while sampling to ensure compliance with weather conditions outlined in the entrance trapping guidelines (Table 2).

In general, temperatures and precipitation were normal for the project area during the survey period, as they were regionally for most of the 2005 autumn trapping season. Nighttime lows ranged from 57.9 to 77.9°F, and high temperatures ranged from 63 to 81.1°F during the project. The nightly difference in high and low temperatures ranged from 2 to 5°F (Table 3). Appendix D contains completed Weather Data Sheets.

3.2 Winter In-Cave Surveys –

3.2.1 Site Selection –

The eight cave entrances surveyed in autumn were visited over the period 2 to 4 January 2006 (Figure 7, Table 1). This total included two separate entrances to Cave. Based on USFWS guidelines, standardized hibernacula survey and reporting methods (Brack et al. 1995) were followed to ensure accurate data collection, interpretation, and comparison over time (Table 4).

Property owners were provided Notice of Survey letters and were contacted when feasible prior to survey efforts.

3.2.2 Bat Identification During Hibernation –

Bats were identified to species by a variety of characteristics that do not disrupt hibernation or include handling. Many characteristics are subtle and are used in combination with one another, rather than reliance on any single observation. Defining

characteristics include: pelage color, texture, and contrast with ears and other membranes; absolute and relative size; individual and intracluster posture; cluster shape, size, compactness, and location; and cave morphology, temperature, and hydrologic regime.

3.2.3 Bat Counting –

Bats were tallied by species and location in the cave. Species of bats other than Indiana bats were counted directly. Individual and small clusters of Indiana bats were counted directly, while larger clusters within reach were measured with a carpenter's rule. Size of clusters on high ceilings was estimated with laser calipers (Brack et al. in prep), 10x50 binoculars, and a 1,250,000 candlepower spotlight (Collins Dynamics "Magnum" model search light). For consistency, Indiana bats in clusters were estimated at 300 bats per square foot (LaVal and LaVal, 1980). Banded bats were noted, and when possible, band color and number were recorded. Appendix D contains completed Cave Survey Data Sheets.

3.2.4 Temperature –

Temperatures were taken at cave entrances, in the twilight area, near clusters of Indiana bats when possible, near concentrations of other species of bats, and at intervals throughout the caves. Temperatures were generally taken with a Raytek Raynger® ST20, with a range of –32 to 400ºC, an accuracy of ±1% of reading, and a display to the nearest 0.2°C, although a Raytek Raynger® MiniTemp MT4, with a range of –18 to 260ºC, an accuracy of ±2% of reading, and a display to the nearest 0.5°C and a Schultheis quick recording thermometer, calibrated by 0.2°C increments, were occasionally used. Appendix D contains completed Cave Survey Data Sheets.

3.2.5 Portions of Caves Surveyed –

Surveys for bats were completed in portions of each cave that had a reasonable potential to provide suitable winter habitat. Hibernation suitability is determined by cave morphology, which affects airflow into and through the cave, thus influencing cave temperatures. Bats tend to hibernate in areas that are cold (4 – 8ºC) and thermally stable. Typically, cooler areas are closer to anterior portions of the cave because of the influx of outside air, however, temperature changes are often more frequent and extreme near entrances.

Final determination of portions of caves surveyed was made in the field and based on cave length and morphology, temperature (generally <10ºC), presence of bats of any species, and the experience of ESI's biologists. Appendix D contains completed Cave Survey Data Sheets.

4.0 Results

4.1 Autumn Entrance Surveys –

4.1.1 *Total Bat Captures –*

A total of 384 bats representing 4 species was captured over 16 complete trap nights at 7 caves (Cave had two entrances): 217 northern bats (*Myotis septentrionalis*), 118 little brown bats (*Myotis lucifugus*) 47 eastern pipistrelles (*Pipistrellus subflavus*), and 2 Indiana bats (*Myotis sodalis*; Table 5).

(aka Cave), and produced the most bats, with 135, 81, and 59 individuals captured, respectively. No bats were captured at (Table 6). The mean number of individuals captured per

cave was 55, or 24 per trap night (Table 7).

4.1.2 Species Diversity –

Species complement in the project area was typical for the geographic location, type of habitat, and season. In addition to the Indiana bat, three other species of bats were captured. Collectively, northern bats and little brown bats accounted for 87 percent of all individuals captured. Species were not evenly represented ($\chi^2 = 274.6$, $P < 0.0001$).

The average number of species represented at cave entrances was 2.6, or 3 per cave. Species richness was highest at (aka Cave) where four species were captured. The MacArthur (1972) diversity index for bats captured on this portion of Section 4 in autumn 2005 was 2.3 evenly distributed species.

4.1.3 Occurrence by Sex and Age –

In total, significantly more adult males than females were captured ($\chi^2 = 164.1$, $P = 0.0001$), with adult males ($n = 318$) and females ($n = 66$) accounting for 82.8 percent and 17.2 percent of the total capture, respectively. No juvenile bats were captured.

Adult males and females of each species were captured with the exception of the Indiana bat, which was represented by adult males only. Significantly more male than female little brown bats were captured ($\chi^2 = 78.1$, $P<0.0001$), significantly more male than female northern bats were captured ($\chi^2 = 74.3$, $P < 0.0001$), and significantly more male than female eastern pipistrelle bats were captured ($\chi^2 = 15.5$, $P = 0.0001$; Table 7).

4.1.4 Indiana Bat Captures –

Two Indiana bats were captured, at (aka Cave; Figure 8). Both were adult males and both were banded (Table 8) and released in good condition at or near the point of capture.

4.1.5 Habitat Assessment and Entrance Description –

The following descriptions of habitat were grouped according to relative proximity and similar habitat types. Cave Site Habitat Descriptions and Entrance Descriptions are provided in Appendix D.

Cave and are in bluffs immediately adjacent to streams. Both have horizontal entrances in mid-successional bottomland forests. While cave is near an abandoned quarry, borders a pasture. Airflow was detected at each entrance.

Dominant canopy trees (>16 inches [40 cm] dbh) included many bottomland species such as tulip poplar (*Liriodendron tulipifera*), silver maple (*Acer saccharinum*), and sycamore (*Platanus occidentalis*). Subdominant (<16 inches [40 cm] dbh) canopy trees included tulip poplar, box elder (*Acer negundo*), sycamore, black walnut (*Juglans nigra*), and sugar maple (*Acer saccharum*). Canopy closure was moderate to closed with moderate subcanopy clutter. Roost tree potential was moderate to low and consisted of both large trees and snags.

Cave and Cave are in small, mid-successional, ravine woodlots immediately adjacent to crop and pastureland. Because of the unique location of both caves, habitat near entrances also exhibited signs of young upland forests as well.

Dominant canopy trees included black maple (*Acer nigrum*), black oak (*Quercus nigra*), shagbark hickory (*Carya ovata*), and white ash (*Fraxinus americana*). Subdominant canopy trees included tulip poplar, black walnut, black maple, sugar maple, and slippery elm (*Ulmus rubra*). Canopy closure was moderate with moderate subcanopy clutter. Roost tree potential was moderate to low and consisted of both large trees and snags.

(aka Cave) and Cave are in large tracts of upland forest. has a vertical entrance in a bluff at the head of a ravine and cave has two vertical entrances, both in sinkholes. Airflow was detected at all entrances.

Dominant canopy trees included beech (*Fagus grandifolia*), tulip poplar, red maple (*Acer rubrum*), and bitternut hickory (*Carya cordiformis*). Subdominant canopy trees included tulip poplar, beech, red oak (*Quercus rubra*), shagbark hickory, and black walnut. Canopy closure was closed to moderate with moderate to low subcanopy clutter. Roost tree potential was moderate to low and consisted of both large trees and snags.

is in an early successional pasture, with few trees nearby. The vertical entrance is uphill from a small stream. Little airflow was detected.

Dominant canopy trees included sycamore and black maple. Subdominant canopy trees included black walnut and honey locust (*Gleditsia triacanthos*). Canopy closure was open with low subcanopy clutter. Roost tree potential was low and consisted of large trees.

4.2 Winter In-Cave Surveys –

4.2.1 Total Count –

A total of 216 bats representing 3 species was found: 136 eastern pipistrelles, 79 little brown bats, and 1 Indiana bat (Table 9).

Cave harbored 43.5 percent of the total census (n = 94 individuals). No bats were found at or The mean number of individuals per cave was 31.

4.2.2 Species Diversity –

Species complement in the project area was typical for the geographic location, type of habitat, and season. In addition to the Indiana bat, two other species of bats were captured. Collectively, eastern pipistrelles accounted for 62.9 percent of all individuals, and species were not evenly represented (χ^2 = 127.6, P <0.0001).

The average number of species per cave was 1.3. Species richness was highest at (aka Cave), where all three species found during winter 2006 were encountered. The MacArthur (1972) diversity index for bats found in caves on this portion of Section 4 in winter 2006 was 1.9 evenly represented species.

4.2.3 Occurrence by Sex and Age –

Sex and age were not determined during winter surveys.

4.2.4 Indiana Bats –

(aka Cave) contained the only Indiana bat encountered during winter 2006 surveys (Figure 9, Table 9).

4.2.5 Survey Descriptions –

The following survey descriptions follow standardized reporting methods (Brack et al. 1995). Appendix D contains Completed Cave Survey Data Sheets, which include cave maps (when feasible) showing temperature locations and portion of caves surveyed.

Cave

The entrance to this cave is on a steep bluff above and east of Indian Creek. The entrance slumps and was nearly collapsed at the time of survey. Digging opened the entrance considerably, but it will likely fill again over time. Beyond the entrance, cave consists of over 2300 feet of dry and river passage.

Portion of Cave Visited: During the 2006 survey the entire cave was searched for bats.

Date: 2 January 2006.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: Temperatures inside the cave ranged from 9.9 to 11.0°C.

Other Species of Bats: Eighty eastern pipistrelles and 14 little brown bats were found randomly located throughout the cave.

Equipment or Safety Considerations: There are no special requirements although the entrance is slightly unstable.

This cave is sometimes referred to as Cave. The entrance to this cave is on a small bluff above and west of Dry Branch. Passages within the cave are narrow. Total estimated length of the cave is 50 feet.

Portion of Cave Visited: During the 2006 survey the entire cave was searched for bats.

Date: 3 January 2006.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 4.4°C, and it was 4.7°C at the end of survey.

Other Species of Bats: No other species of bats were found.

Equipment or Safety Considerations: There are no special requirements.

Cave

The entrance to Cave is essentially a swallow hole at the end of an intermittent and ephemeral stream. The main passage of the cave consists of a large room approximately 60 feet wide.

Portion of Cave Visited: During the 2006 survey the entire cave was searched for bats.

Date: 3 January 2006.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 9.6°C, and it was 11.0°C at the end of survey.

Other Species of Bats: Four eastern pipistrelles were found randomly throughout the cave.

Equipment or Safety Considerations: There are no special requirements.

Cave

The entrance to Cave is under a rock overhang above a spring. A 10-foot climbdown pit connects the upper dry passage to the lower stream passage. The low stream passage is heavily silted, suggesting it likely floods. Total length of the cave is approximately 1000 feet.

Portion of Cave Visited: During the 2006 survey the entire cave was searched for bats.

Date: 4 January 2006.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance, at the top of the pit was 11.0°C. Temperatures in the stream passage ranged from 10.8°C, at the base of the pit, to 12.4°C, at the end of the survey.

Other Species of Bats: Thirty-three eastern pipistrelles were found randomly scattered throughout the cave.

Equipment or Safety Considerations: There are no special requirements, although the cave likely floods.

(aka Cave)

Historical graffiti on a rock face adjacent to the entrance gives this cave its name. The words, " DC Cave 1905" and an ax symbol are carved into the rock. A 10-foot climbdown entrance leads to 2,431 feet of dry and stream passage

Portion of Cave Visited: During the 2006 survey the entire cave was searched for bats.

Date: 3 January 2006.

Number of Indiana Bats: A single Indiana bat was found.

Location of Indiana Bats: The Indiana bat was found just inside the entrance (Appendix D).

Hibernaculum Temperatures: The temperature inside the entrance was 6.6°C, and increased to 11.3°C at the end of survey. The temperature near the Indiana bat was 6.0°C.

Other Species of Bats: Fifty-three little brown bats and 16 eastern pipistrelles were also found in the cave.

Equipment or Safety Considerations: There are no special requirements.

Cave

Cave has two vertical entrances. The south entrance is a tight climbdown through the bottom of a sinkhole that leads to the upper dry part of the cave. The north pit entrance is approximately a 20 foot drop that leads to the lower part of he cave. The entire length of the cave is 700 feet.

Portion of Cave Visited: During the 2006 survey the entire cave was searched for bats.

Date: 2 January 2006.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the pit entrance was 7.1°C. The temperature in the lower cave was 6.8°C. The temperature in the upper cave was 9.8°C – 11.5°C.

Other Species of Bats: Twelve little brown bats were found in a cluster in the lower cave and three eastern pipistrelles were found scattered throughout the cave.

Equipment or Safety Considerations: At least partial vertical equipment is required to enter and exit the pit entrance. An exposed 30-foot wall separates the upper and lower cave.

The vertical entrance to this cave is in a sinkhole and does not lead to any physical passage. The entire length of this cave is approximately 4 feet.

Portion of Cave Visited: During the 2006 survey the entire cave was searched for bats. Date: 3 January 2006.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature in the entrance was 6.6°C.

Other Species of Bats: No other species of bats were found.

Equipment or Safety Considerations: There are no special requirements.

5.0 Discussion

The objective of cave surveys was to improve understanding of the autumn and winter occurrence and habitat use by the Indiana bat (*Myotis sodalis*) on this portion of Section 4 of the proposed I-69 and a 5-mile buffer zone. Autumn and winter surveys conducted during 2004 – 2006 provide information about the following:

- Presence and distribution of Indiana bats on this portion of Section 4 and a 5-mile buffer zone
- Autumn, winter, and spring habitat selection and use by male and female Indiana bats on this portion of Section 4 and a 5-mile buffer zone

By adding and comparing our results with previous regional studies, data can be used to help identify important hibernacula for the Indiana bat near the Section 4 corridor and to aid the design of future studies. These data can also contribute to the management and recovery of the species by building upon the body of knowledge on the ecology of the species in Indiana and throughout its range.

5.1 Bat Occurrence and Species Diversity –

The species complement and number of bats captured in the project area was typical for the geographic location and type of habitat found there. In addition to the Indiana bat, three other species of bats were captured as a part of this study in 2005 - 2006.

Proportions of bat species using cave entrances in spring and autumn varied from populations hibernating in the same caves.

Northern bats, a species commonly found at cave entrances in autumn (Whitaker and Rissler 1992, Brack et al. in submission), composed 57 percent of the total captures in autumn, but were not found in any caves in winter. Little evidence has been found of the species using the area in winter (Brack et al. 2005a), although it is likely.

5.2 Occurrence by Sex –

It is common to find larger proportions of male bats at cave entrances in autumn (Cope and Humphrey 1977; Laval and LaVal 1980). Male little brown bats were nearly ten times more abundant than females in autumn, compared to nearly 20 times more abundant during similar surveys in 2004 (ESI 2005).

5.3 Indiana Bat Occurrence –

Autumn surveys revealed Indiana bats at (aka Cave). Winter surveys showed evidence that at least one Indiana bat used this cave as a hibernaculum. During swarming it is believed that males visit many caves in an attempt to mate before hibernating (Hall 1962). The bats may not use the cave as a hibernaculum.

Winter surveys found a single Indiana bat in (aka Cave). Presence of a single Indiana bat in hibernation in a cave has been documented in the region in the past (Brack et al. 2003, 2005a; ESI 2005). The temperature in the area where the bat was located was 6.6°C. Although the optimal range of temperatures preferred by Indiana bats is 6 – 8°C (Brack et al. 2003, 2005a; Brack and Reynolds in prep), hibernacula have been found with temperatures ranging from –1.6 to 17°C (Barbour and Davis 1969; Humphrey 1978). Although the cave lacked many characteristics of typical hibernacula, such as noticeable air flow (Henshaw 1965), the area where the Indiana bat was hibernating seemed thermally stable.

Little is known about autumn and spring activity of the Indiana bat at cave entrances in the region. Further research in the area is needed to gain a better understanding of the behavior of Indian bats during this important period.

6.0 Acknowledgements

Environmental Solutions and Innovations, Inc. (ESI) sincerely thanks the numerous organizations and individuals that contributed time and talent to this project. Appreciation is extended to FHWA, INDOT, BLA, and USFWS, for providing us the opportunity to be involved in this project. We especially wish to thank Dr. Tom Cervone, Jason DuPont, Garre Conner, of BLA, and R. Andrew King of USFWS, for guidance, assistance, and participation in this study. We are grateful to the many landowners who allowed us access to caves on their property to conduct our research. The preparers of this report would like to thank Jeanette Jaskula of ESI for providing location, physiography, and species occurrence text as well as the overall framework and format.

7.0 Literature Cited

Barbour, R. W., and W. H. Davis. 1969. Bats of America. University Press of Kentucky, Lexington.

Belwood, J. J. 1979. Feeding ecology of an Indiana bat community with emphasis on the endangered Indiana bat, *Myotis sodalis*. Unpublished M.S. thesis, University of Florida, Gainesville.

BLA-Bernardin-Lochmueller & Associates. 2003. Tier 1 biological assessment for threatened and endangered species, Interstate 69, Indianapolis to Evansville [dated July 18, 2003, revised October 27, 2003; submitted to the Bloomington Field Office of the U.S. Fish and Wildlife Service by the Federal Highway Administration and Indiana Department of Transportation.

Brack, V., Jr. 1979. The duration of the period of hibernation in *Eptesicus fuscus*, *Myotis lucifugus*, and *Pipistrellus subflavus* under natural conditions. Unpublished M.S. thesis, University of Missouri, Columbia.

Brack, V., Jr. 1983. The nonhibernating ecology of bats in Indiana with emphasis on the endangered Indiana bat, *Myotis sodalis*. Unpublished Ph.D. dissertation, Purdue University, West Lafayette, Indiana.

Brack, V. Jr. 2004. The biology and life history of the Indiana bat: hibernacula. Pages xx-xx In Indiana Bat and Coal Mining (K. C. Vories, ed.). US DOI, Office of Surface Mining, Washington, D.C.

Brack, V. Jr. In submission. Autumn activities of the endangered Indiana bat (*Myotis sodalis*) near a hibernaculum in Bland County, Virginia. Tentatively accepted with suitable revisions, Northeastern Naturalist.

Brack, V., Jr. In submission. Food habits and foraging ecology of the Indiana bat, *Myotis sodalis*, In Indiana. In submission to Northeastern Naturalist.

Brack, V., Jr. In prep. Temperatures and locations used by hibernating bats, including the endangered Indiana bat (*Myotis sodalis*), in a limestone mine in Ohio.

Brack, V., Jr., and J. C. Carter. 1985. Use of an underground burrow by Lasionycteris. Bat Research News 26:28-29.

Brack, V. Jr., J. Duffey, and K. Dunlap. 2005a. A 2004 – 2005 winter survey for Indiana bats (*Myotis sodalis*) in hibernacula of Indiana. Unpublished technical report for the Indiana Department of Natural Resources, Division of Fish and Wildlife, Nongame and Endangered Wildlife Program, Indianapolis.

Brack, V., Jr., J. A. Duffey, R. K. Dunlap, and S. A. Johnson. 2005b. Flooding of hibernacula in Indiana: when are caves population sinks? Bat Research News 46:71-74.

Brack, V. Jr., R. K. Dunlap, S. J. Collins, and S. A. Johnson. In prep. Laser calipers: a device for estimating the size of clusters of hibernating bats. In prep for Wildlife Society Bulletin.

Brack, V., Jr., R. K. Dunlap, and S. A. Johnson. 2005c. Albinism in the Indiana bat, *Myotis sodalis*. Bat Research News: In press.

Brack, V., Jr., and S. A. Johnson. 1990. An albino Indiana bat (*Myotis sodalis*). Bat Research News, 31:8.

Brack, V. Jr., S. A. Johnson, and R. K. Dunlap. 2003. Wintering populations of bats in Indiana, with emphasis on the endangered Indiana myotis, *Myotis sodalis*. Proceedings of the Indiana Academy of Science 112:61-74.

Brack, V., Jr., and R. K. LaVal. 1985. Food habits of the Indiana bat in Missouri. Journal of Mammalogy 66:308-315.

Brack, V. Jr., W. Orndoroff, R. J. Reynolds, J. Zokaites, and C. Zokaites. 2005d. Bats of Skydusky Hollow, Bland County, Virginia. Virginia Journal of Science 56:93-106.

Brack, V. Jr., and R. J. Reynolds. In Prep. Temperatures used by bats hibernating in Skydusky Hollow, Bland County, Virginia.

Brack, V. Jr., C. W. Stihler, R. J. Reynolds, C. Butchkoski, and C. S. Hobson. 2002. Effects of climate and elevation on distribution and abundance in the mideastern United States. Pages 21-28, In The Indiana bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Brack, V., Jr., and J. W. Twente. 1985. The duration of the period of hibernation in three species of vespertilionid bats I: field studies. Canadian Journal of Zoology 63:2952-2954.

Brack, V. Jr., K. Tyrell, and K. Dunlap. 1995. A 1994-1995 winter census for the Indiana bat (Myotis sodalis) in hibernacula of Indiana. Unpublished technical report for the Indiana Department of Natural Resources, Division of Fish and Wildlife, Nongame and Endangered Wildlife Program, Indianapolis, Indiana.

Brack, V., Jr., and J. O. Whitaker, Jr. 2004. Bats of the Navel Surface Warfare Center, Crane, Indiana. Proceedings of the Indiana Academy of Sciences 113:66-75.

Brack, V., Jr., and J. O. Whitaker, Jr. In prep. The Indiana myotis on an anthropogenic landscape.

Brack, V., Jr., J. O. Whitaker, Jr., and S. Pruitt. 2004. Bats of Hoosier National Forest, Indiana. Proceedings of the Indiana Academy of Science 113:76-86.

Brack, V., Jr., A. M. Wilkinson, and R. E. Mumford. 1984. Hibernacula of the endangered Indiana bat in Indiana. Proceedings of the Indiana Academy of Science 93:463-468.

Britzke, E. R., M. J. Harvey, and S.C. Loeb. 2003. Indiana bat, *Myotis sodalis*, Maternity roosts in the Southern United States. Southeastern Naturalist 2: 235-242.

Brown, R. J., and V. Brack, Jr. 2003. An unusually productive net site over an upland road used as a travel corridor. Bat Research News 44:187-188.

Brown, R. J., R. A. King, and R. Romme. 2001. First documented maternity colony of the Indiana bat in Greene County, Ohio. Abstracted in: Bat Research News 42:27.

Butchkoski, C. M., and J. D. Hassinger. 2002. Ecology of a maternity colony in a building. In: The Indiana Bat: Biology and Management of an Endangered Species (A. Kurta, ed.). Bat Conservation International, Austin, Texas.

Callahan, E. V., R. D. Drobney, and R. L Clawson. 1997. Selection of summer roosting sites by Indiana bats (*Myotis sodalis*) in Missouri. Journal of Mammalogy 78:818–825.

Carter, T. 2002. Bat houses for conservation of endangered Indiana myotis. The Bat House Researcher 10:1-3.

Carter, T. C. 2003. Summer habitat use of roost trees by the endangered Indiana bat (*Myotis sodalis*) in then Shawnee National Forest of Southern Illinois. Ph.D. dissertation, Southern Illinois University, Carbondale.

Clark, B., J. Bowles, and B. Clark. 1987. Summer occurrences of the Indiana bat, Keen's Myotis, evening bat, silver-haired bat and eastern pipistrelle in Iowa. Iowa Academy of Science 94:89-93.

Clawson, R. L., R. K. LaVal, M. L. LaVal and W. Caire. 1980. Clustering behavior of hibernating *Myotis sodalis* in Missouri. Journal of Mammalogy 61:245-253.

Cope, J., and S. Humphrey. 1977. Spring and autumn swarming behavior in the Indiana bat, *Myotis sodalis*. Journal of Mammalogy 58:93-95.

ESI-Jaskula, J.M., and V. Brack, Jr. 2004. Summer habitat for the Indiana bat (*Myotis sodalis*) within the Crawford upland and Mitchell Plain from Scotland to Bloomington, Indiana. A Report to DLZ, Indiana, LLC.

ESI-Duffey, J. A. and V. Brack, Jr. 2005. Autumn, winter, and spring habitat for the Indiana bat (*Myotis sodalis*) within the Crawford upland and Mitchell Plain from Scotland to Bloomington, Indiana. A Report Bernardin, Lochmueller and Associates.

Foster, R. W., and A. Kurta. 1999. Roosting ecology of the northern bat (*Myotis septentrionalis*) and comparisons with the endangered Indiana bat (*Myotis sodalis*). Journal of Mammalogy 80:659-672.

Gardner, J. E., and E. A. Cook. 2002. Seasonal and geographic distribution and quantification of potential summer habitat. Pages 9-20 in The Indiana bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Gardner, J. E., J. D. Garner, and J. E. Hofmann. 1991. Summer roost selection and roosting behavior of *Myotis sodalis* (Indiana bat) in Illinois. Unpublished report, Illinois Natural History Survey, Section of Faunistic Surveys and Insect Identification.

Grindal, S. D. 1996. Habitat use by bats in fragmented forests, Pages 260 – 272, In Bats and Forest Symposium October 19 – 21, 1995 Victoria, British Columbia, (R. M. R. Barclay and R. M. Brigham, eds.) Research Branch, British Columbia Ministry of Forests, Victoria.

Gumbert, M. W. 2001. Seasonal roost tree use by Indiana bats in the Somerset Ranger District of the Daniel Boone National Forest, Kentucky. M.S. thesis, Eastern Kentucky University, Richmond.

Hall, J. 1962. A life history and taxonomic study of the Indiana bat, *Myotis sodalis*. Reading Public Museum and Art Gallery Science Publication 12:1-68.

Henshaw, R. E. 1965. Physiology of hibernation and acclimation in two species of bats (*Myotis lucifugus* and *Myotis sodalis*). Ph.D. dissertation, State University Iowa, Ames.

Henshaw, R. E. and G. E. Folk, Jr. 1966. Relation of thermoregulation to seasonally changing microclimate of two species of bats (*Myotis lucifugus* and *M. sodalis*). Physiological Zoology 39:223-236.

Hicks, A., and P. G. Novak. 2002. History, status, and behavior of hibernating populations in the Northeast. Pages 35-47 *In* The Indiana bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Homoya, M. A., D. B. Abrell, J. R. Aldrich, and T. W. Post. 1985. The natural regions of Indiana. Proceedings of the Indiana Academy of Science 94:245-268.

Humphrey, S. R. 1978. Status, winter habitat, and management of the endangered Indiana bat, *Myotis sodalis*. Florida Scientist 41:65-76.

Humphrey, S. R., and J. B. Cope. 1977. Survival rates of the endangered Indiana bat, *Myotis sodalis*. Journal of Mammalogy 58:32–36.

Humphrey, S. R., A. R. Richter, and J. B. Cope. 1977. Summer habitat and ecology of the endangered Indiana bat, *Myotis sodalis*. Journal of Mammalogy 58:334-346.

Johnson, S. A., V. Brack, Jr. and R. K. Dunlap. 2002. Management of hibernacula in the state of Indiana. Pages 106-115 *In* The Indiana bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Johnson, S. A., V. Brack, Jr., and R. E. Rolley. 1998. Overwinter weight loss of Indiana bats (*Myotis sodalis*) from hibernacula subjected to human visitation. American Midland Naturalist 139:255-261.

Kath, J. A. 2002. A review of the hibernacula in Illinois, with emphasis on the Magazine Mine. Pages 110-117, In The Indiana bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Kerth, G., M. Wagner and B. Konig. 2001. Roosting together, foraging apart: information transfer about food is unlikely to explain sociality in female Bechstein's bats (*Myotis bechsteinii*). Behavioral Ecology and Sociobiology 50:283-291.

Kiser, J. D., and C. L Elliott. 1996. Foraging habitat, food habits, and roost tree characteristics of the Indiana bat (*Myotis sodalis*) during autumn in Jackson County, Kentucky. Unpublished. Report to

Kentucky Department of Fish and Wildlife Resources, Frankfort. Kentucky.

Kiser, J. D., J. R. MacGregor, H. D. Bryan, and A. Howard. 2002. Use of concrete bridges as night roosts. Pages 208-215, *In* The Indiana bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International.

Kurta, A., D. King, J. A. Teramino, J. M. Stribley, and K. J. Williams. 1993. Summer roosts of the endangered Indiana bat (*Myotis sodalis*) on the northern edge of its range. American Midland Naturalist 129:132-138.

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

Kurta, A., S. W. Murray, and D. H. Miller. 2002. Roost selection and movements across the summer landscape. Pages 118-129, In The Indiana bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Kurta, A, and J. O. Whitaker, Jr. 1998. Diet of the endangered Indiana bat (*Myotis sodalis*) on the northern edge of its range. American Midland Naturalist 140:280-286.

Kurta, A., K. J. Williams, and R. Mies. 1996. Ecological, behavioral, and thermal observations of a peripheral population of Indiana bats (*Myotis sodalis*). Pages 102-117, In Bats and Forests Symposium (R. M. R. Barclay and R. M. Brigham, eds.). Research Branch, British Columbia Minister of Forests, Victoria.

LaVal, R. K., and M. L. LaVal. 1980. Ecological studies and management of Missouri bats, with emphasis on cave-dwelling species. Missouri Department of Conservation Terrestrial Series 8:1-53.

MacArthur, R. H. 1972. Geographical Ecology. Harper and Row, New York.

Miller, N. E., R. D. Drobney, R. L. Clawson, and E. V. Callahan. 2002. Summer habitat in northern Missouri. Pages 165-171, In The Indiana bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin.

Murray, S.W., and A. Kurta. 2002. Spatial and temporal variation in diet. Pages 182–192, In The Indiana Bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Murray, S. W., and A. Kurta. 2004. Nocturnal activity of the endangered Indiana bat (*Myotis sodalis*). London Journal Zoology 262:197-206.

Myers, R. F. 1964. Ecology of three species of species of myotine bats in the Ozark Plateau. Unpublished Ph.D. Dissertation, University of Missouri, Columbia.

Paradiso, J. L., and A. M. Greenhall. 1967. Longevity records for American bats. American Midland Naturalist 78:251-252.

Parsons, K. N., G. Jones, and F. Greenway. 2003. Swarming activity of temperate zone microchiropteran bats: effects of season, time of night and weather conditions. London Journal Zoology 261:257-264.

Racey, P. A. 1982. Ecology of bat reproduction. Pages 57-103, In Ecology of bats (T. H. Kunz, ed.). Plenum Publishing Corporation, New York.

Richter, A. R., S. R. Humphrey, J. B. Cope, and V. Brack, Jr. 1993. Modified cave entrances, thermal effects on body mass, and resulting decline of endangered Indiana bats (*Myotis sodalis*). Conservation Biology 7:407-415.

Sanders, C., and J. Changer. 2001. Williams Lake telemetry study: New York Indiana bat spring migration tracking. Report to the Independence Pipeline Company.

Schultes, K. L., and C. L. Elliott. 2002. Roost tree selection by Indiana bats and northern bats on Wayne National Forest, Ohio, Unpublished report to U.S. Fish and Wildlife Service, Reynoldsburg Field Office and USDA Forest Service, Wayne National Forest.

Stones, R. C., and J. E. Wiebers. 1967. Temperature regulation in the little brown bat, *Myotis lucifugus*. Pages 97-109, In Mammalian hibernation III (Fisher, K. C., A. R. Dawe, C. P. Lyman, E. Schonbaum, and F. E. South, Jr., eds.). Oliver and Boyd, Edinburgh and London.

Summit County Metro Parks. 2003. Preliminary inventory of bat species Pond Brook Metro Park and Twinsburg Park and Nature Preserve. Summit County Metro Parks, Akron, Ohio.

3D/Environmental. 1995. Literature summary and habitat suitability index model. Components of summer habitat for the Indiana bat, Myotis sodalis. Cincinnati.

Tibbels, A. E., and A. Kurta. 2003. Bat activity is low in thinned and unthinned stands of red pine. Canadian Journal of Forest Research 33:2436-2442.

Twente, J. W., J. Twente, and V. Brack, Jr. 1985. The duration of the period of hibernation of three species of vespertilionid bats II: laboratory studies. Canadian Journal of Zoology 63:2955-2961.

(USFWS) U.S. Fish and Wildlife Service. 1999. Indiana Bat (*Myotis sodalis*) revised recovery plan, Agency Draft. Ft. Snelling, Minnesota.

(USFWS) U.S. Fish and Wildlife Service. 2005. Bat survey protocol for assessing use of potential hibernacula (I-69 Tier 2 Studies). Bloomington, Indiana.

Whitaker, J. O., Jr., and V. Brack Jr. 2002. *Myotis sodalis* in Indiana. Pages 53-59, In The Indiana bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Whitaker, J. O., Jr., and L. J. Rissler. 1992. Winter activity of bats at a mine entrance in Vermillion County, Indiana. American Midland Naturalist 127:52-59.

Whitaker, J. O., Jr., D. W. Sparks, and V. Brack Jr. In submission. Use of Artificial Roost Structures by bats at the Indianapolis International Airport. In submission to Environmental Management.

Wimsatt, W. 1944. Further studies on the survival of spermatozoa in the female reproductive tract of the bat. Anatomical Record 88:193-204.

Appendix A

Figures

N
W E
S

Figure 1. Location of Section 4 of the proposed I-69 corridor in Greene and Monroe counties, Indiana

Project No. 123

ESI ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.

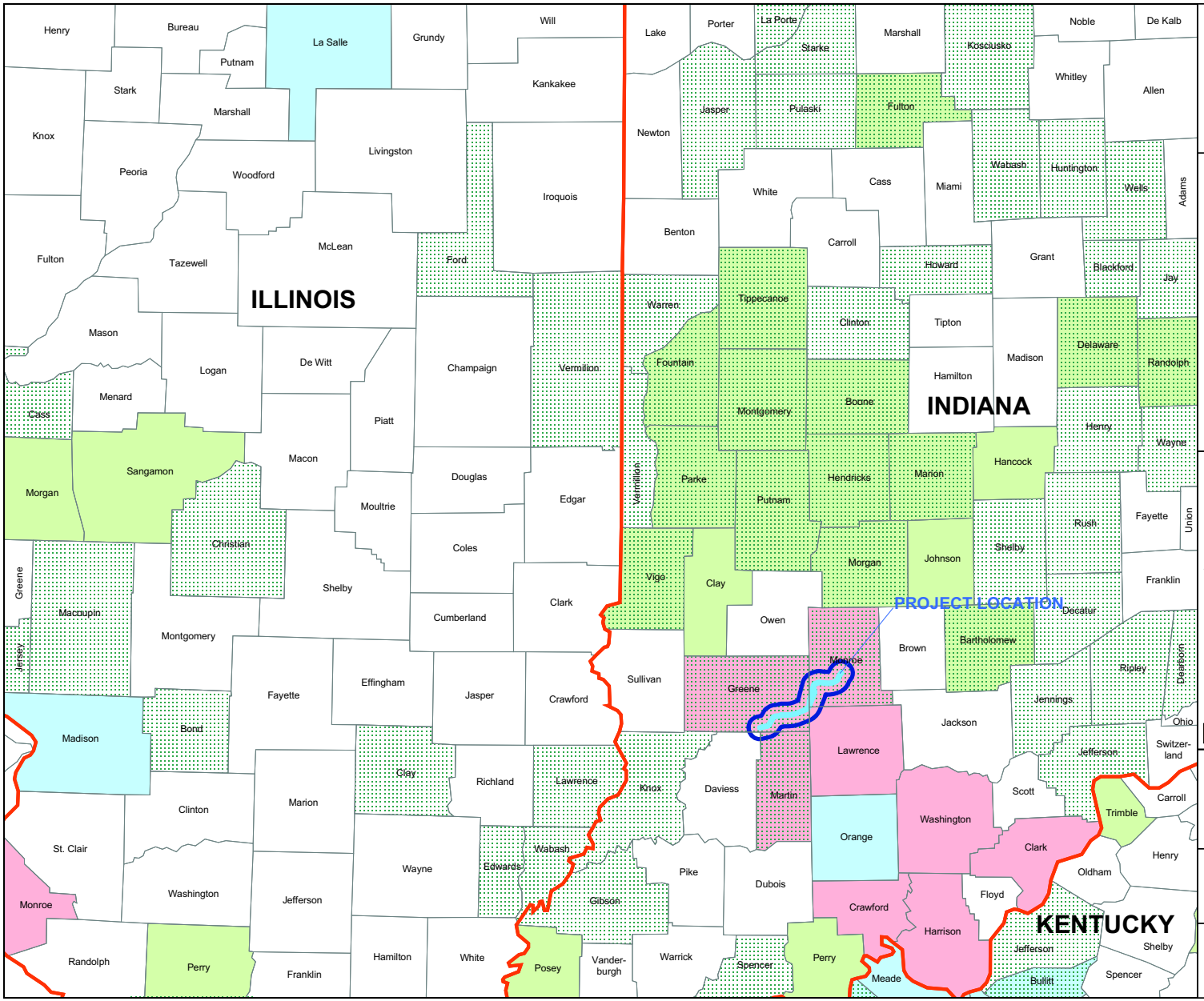


Figure 2. Counties near the project area with hibernacula, summer maternity, and other summer (nonreproductive) records for the Indiana bat (*Myotis sodalis*).

- County with Record of Indiana Bat Hibernacula Occurrence
- County with Record of Indiana Bat Summer Maternity Occurrence
- County with Record of Indiana Bat Other Summer (Nonreproductive) Occurrence
- County with Record of Indiana Bat Hibernacula and Other Summer (Nonreproductive) Occurrences
- State Boundary
- County Boundary

Sources: USFWS, Indiana Bat Revised Recovery Plan, Agency Draft, 1999.

ESI ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.

Project No. 123

Figure 3 ("Locations of winter hibernacula (caves) of the Indiana bat (*Myotis sodalis*) in Greene and Monroe counties, Indiana") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

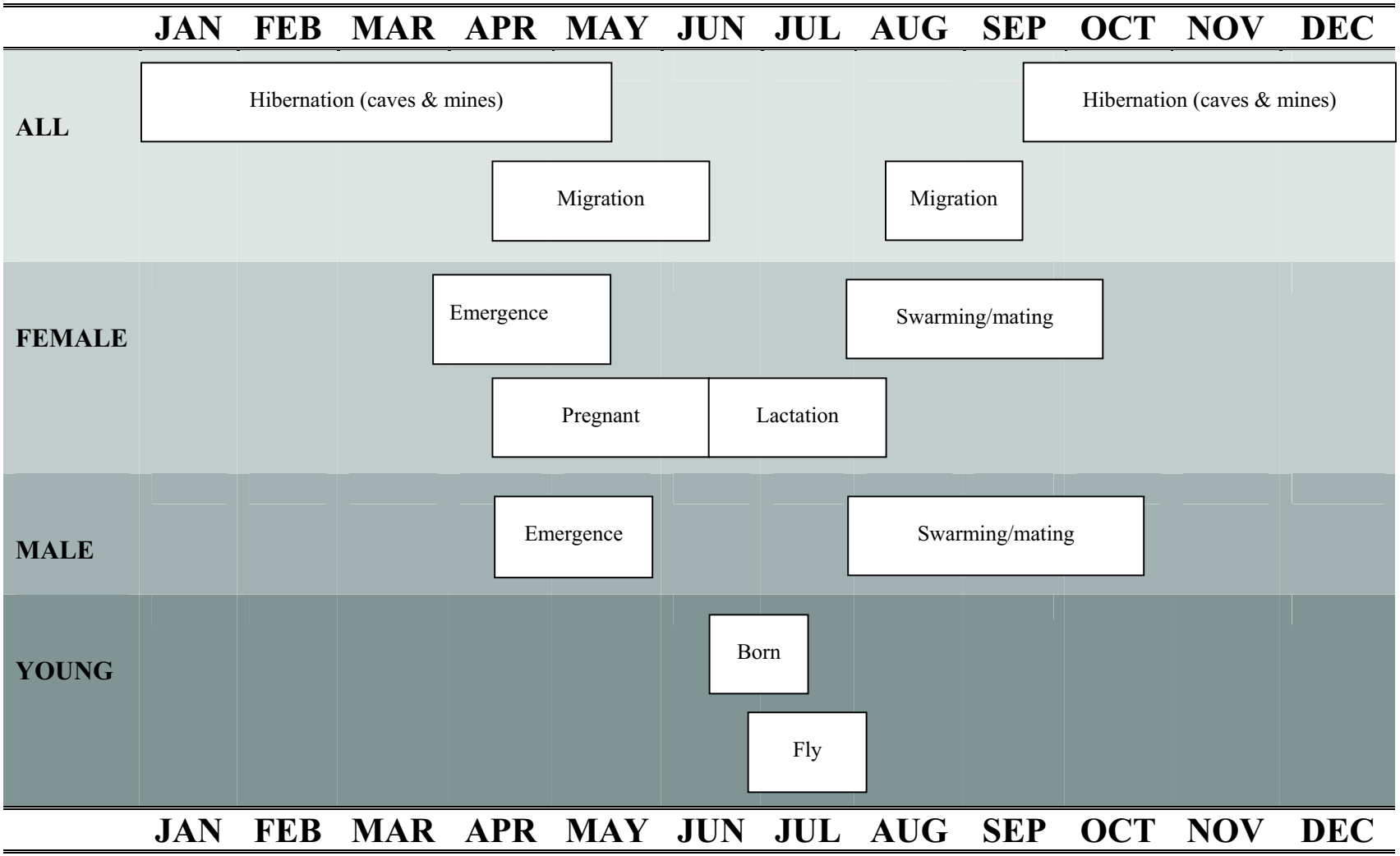
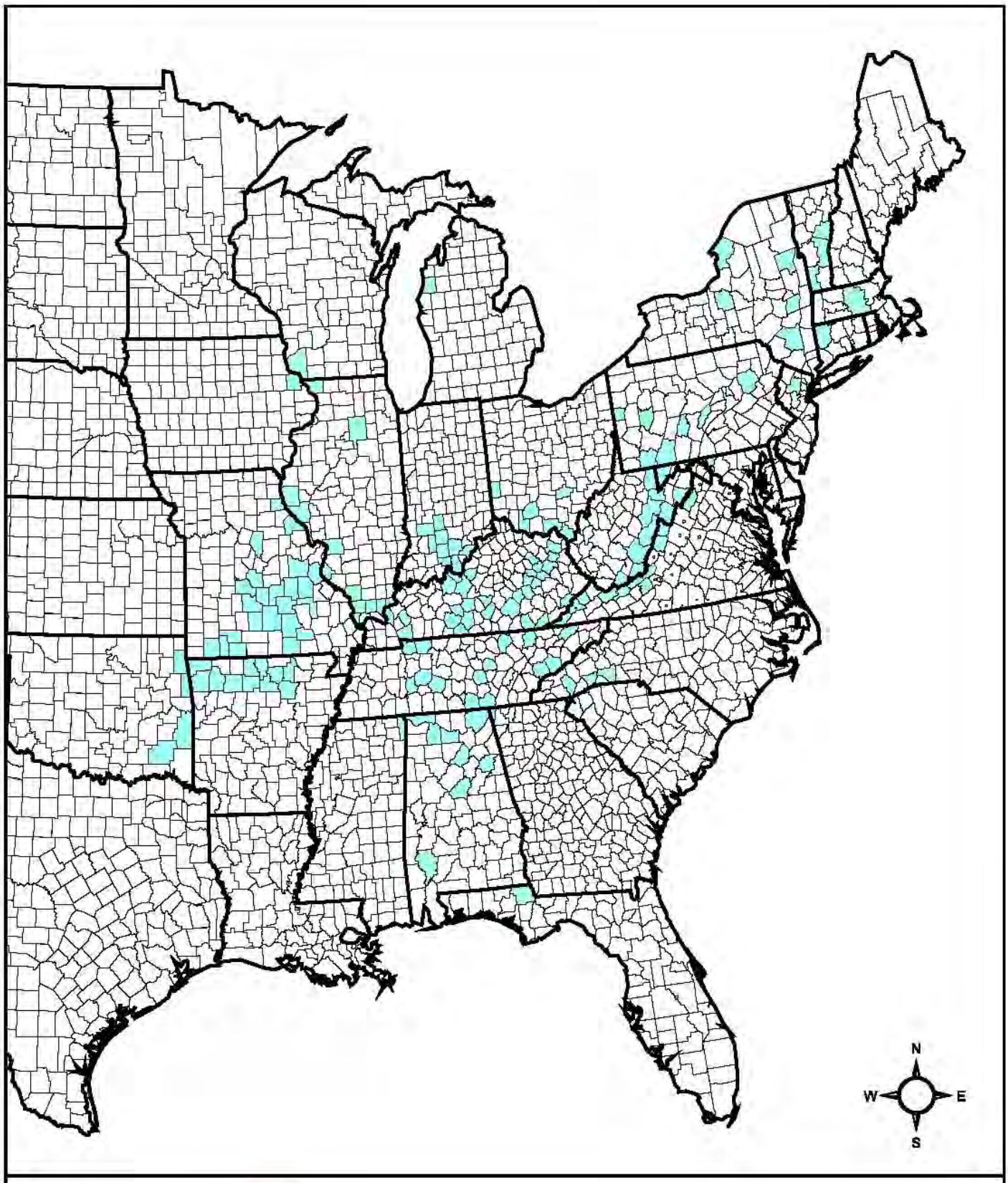


Figure 4. Seasonal chronology of Indiana bat activities.



County with Record of Indiana Bat Hibernacula Occurrence

Figure 5. Range-wide distribution of the Indiana bat during winter, showing counties with hibernacula records.

Project No. 123 Task 05	Sources: USFWS, Indiana Bat Revised Recovery Plan, Agency Draft, 1999. Updated: September 2005	ESI ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.

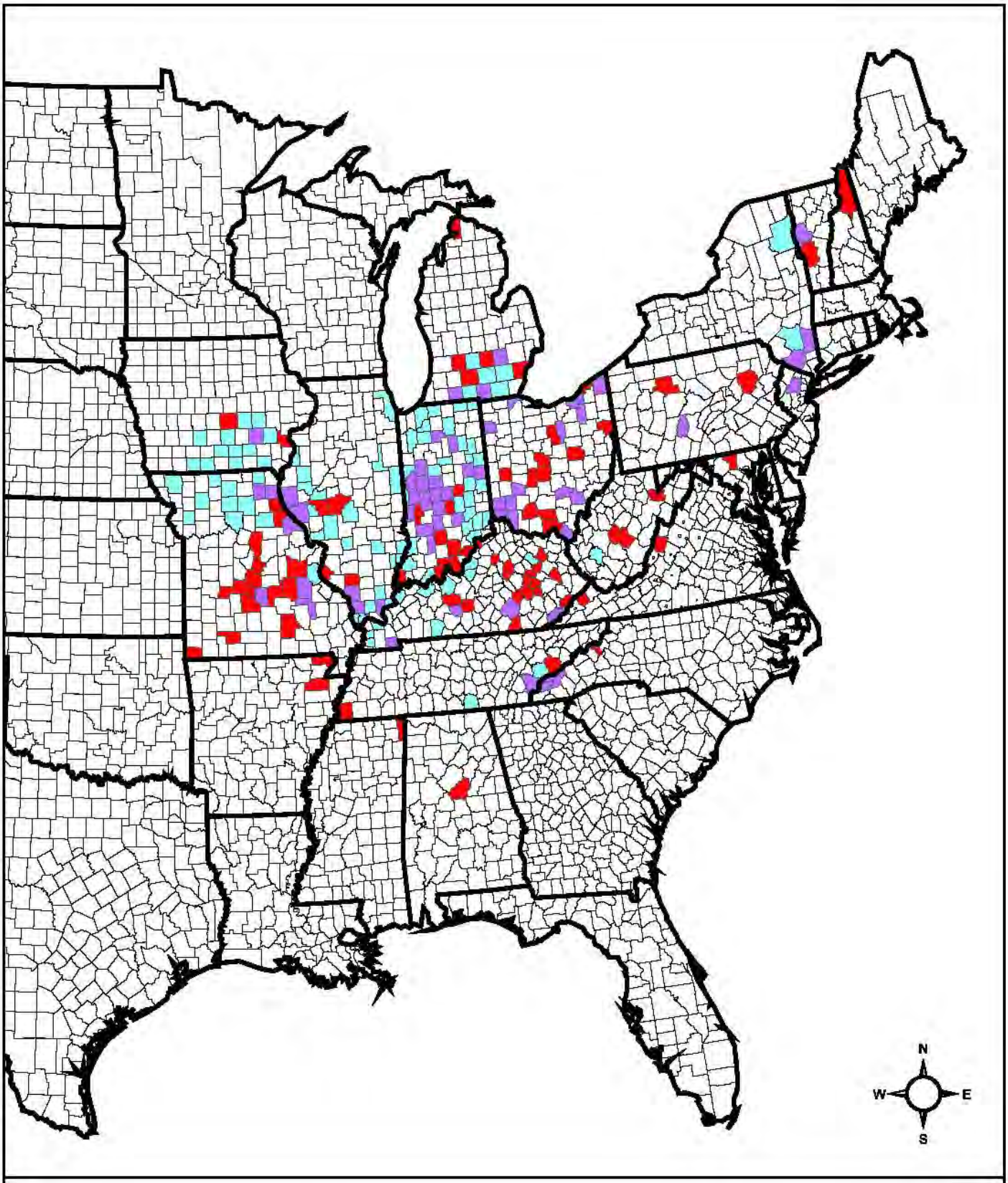


Figure 6. Range-wide distribution of the Indiana bat during summer, showing counties with reproductive (adult female and/or young-of-the-year) and nonreproductive records.

County with Record of Indiana Bat Reproductive Occurrence

County with Record of Indiana Bat Summer Non-Reproductive Occurrence

County with Record of Indiana Bat Reproductive and Summer Non-Reproductive Occurrence

Project No. 123 January 2006	Sources: USFWS, Indiana Bat Revised Recovery Plan, Agency Draft, 1999. Updated: September 2005	ESI ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.

Figure 7 ("Location of cave entrances surveyed on Section 4 of the proposed I-69 corridor Autumn 2005 and Winter 2006.") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 8 ("Locations of cave entrances on Section 4 of the proposed I-69 corridor where Indiana bats (*Myotis sodalis*) were captured, autumn 2005.") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 9 ("Locations of cave entrances on Section 4 of the proposed I-69 corridor where Indiana bats (*Myotis sodalis*) were found hibernating, winter 2006.") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Appendix B

Tables

Table 1. Congressional Township locations for 8 cave entrances surveyed on a portion of Section 4 and the 5-mile buffer of the proposed I-69, autumn 2005 and winter 2006.

No.	Cave Entrance Name	County	Location
1		Greene	
2		Monroe	
3		Monroe	
4		Greene	
5		Greene	
6		Greene	
7	N	Lawrence	
8	S	Lawrence	

Table 2. Entrance trapping guidelines followed on surveys related to a portion of Section 4 of the proposed I-69, autumn 2005.

Entrance Trapping Guidelines

1. Trapping/Netting Season: 25 August to 15 October for autumn sampling, 9 April to 30 April for spring sampling
2. Equipment:
   - Harp Traps (first choice): Placed in front of entrance, blocking flight path
   - Mist Nets (second choice): 50 denier, 38mm mesh placed in front of or around openings that can not be harp trapped
   - Alternative Monitoring Techniques: When caves can not be safely/effectively trapped or netted, bat detectors and/or night-vision/infrared/thermal-imaging recorders should be used to monitor bat activity at entrances
   - Bat Detector: an ultrasonic bat detector should be on site to periodically monitor bat activity and assess general effectiveness of trap placement
3. Sample Period: Begin 30 minutes before sunset and trap for at least five hours
4. Minimum Level of Effort Per Site:
   - Each entrance is trapped for 2 consecutive (preferred) or non-consecutive nights.
   - If no bat captures (of any species) occur and no bat activity is noted with a bat detector on the first evening during acceptable weather conditions, sampling may be suspended for the site
   - Traps are monitored at approximately 20-minute intervals (preferred), or at least once per hour, depending on capture rates and weather
5. Weather must provide for temperatures at or above 50°F (10°C) for the first two hours of sampling and not fall below 35°F(1.6°C) by midnight, and at least three hours of the sampling time be free of heavy rain and thunderstorms
6. Noise, and the shining of lights are kept to a minimum with no smoking near the sample site; use of radios, campfires, running vehicles, punk sticks, citronella candles, and other disturbances are not permitted within 300 feet (91 m) of the survey site

Source: USFWS 2005

Table 3. High and low temperatures (°F) recorded during entrance trapping surveys related to a portion of Section 4 of the proposed I-69, autumn 2005.

Survey Dates (2005)	**Survey Period (approx. 1830 – 2330 h)**	
	High Temp. °F	**Low Temp. °F**
13 September	70.7	63.3
14 September	71.6	64.4
15 September	71.6	64.9
16 September	66.4	62.6
17 September	66.9	57.9
17 September	62.9	59.0
18 September	69.4	63.9
19 September	77.2	73.9
20 September	71.8	62.2
21 September	73.2	66.9
22 September	81.1	77.9
23 September	71.6	67.3
24 September	73.6	69.6
25 September	68.7	61.0

Table 4. Hibernacula survey and reporting guidelines followed for surveys related to a portion of Section 4 of the proposed I-69, winter 2006.

Hibernacula Survey and Reporting Guidelines

1. To ensure accurate comparison over time, the following factors will be considered:
    - Data must be collected consistently across caves and years
    - Hibernacula must be appropriately searched
    - Methods must provide reproducible results
    - Safety of surveyors must be assured
    - Other data of potential value, now or in the future, and compatibility over time
2. The following items are essential to standardize collection, interpretation, and comparison of data over time:
    - Cave name, location, legal description, and date of visit
    - A general description of the cave, including published accounts of the cave (when available)
    - Portion of the cave surveyed, including a map showing features of the cave important to the survey (when available)
    - Number of Indiana bats found
    - Locations of Indiana bats, including maps (when available) marking locations where bats were found
    - Temperatures of areas where Indiana bats hibernate (at a minimum) and other related temperature data such as of areas where other species hibernate and where no bats were found
    - Other species and numbers of bats using the cave
3. In reporting, each cave is introduced with a brief description of its morphology and character. The name and legal description, including county, USGS quadrangle, and quarter section are provided in a table. Other data are standardized using the following headings:
    - Portion of Cave Visited
    - Date
    - Number of Indiana Bats
    - Location of Indiana Bats
    - Hibernaculum Temperatures
    - Other Species of Bats
    - Equipment or Safety Considerations

Source: Brack et al. 1995

Table 5. Total bat captures by sex, reproductive condition, and age during entrance surveys related to a portion of Section 4 of the proposed I-69, autumn 2005.

Species	Adult Male	Adult Female[1]				Juvenile		Escape[2]	Total
		P	L	PL	NA	Male	Female		
Northern bat	172	0	0	0	45	0	0	0	**217**
Little brown bat	107	0	0	0	11	0	0	0	**118**
Eastern pipistrelle	37	0	0	1	9	0	0	0	**47**
Indiana bat	2	0	0	0	0	0	0	0	**2**
Total	**318**	**0**	**0**	**1**	**65**	**0**	**0**	**0**	**384**

[1] P = pregnant; L = lactating; PL = Post lactating; NA = not available
[2] Escape = escaped from trap or hand before processing was complete

Table 6. Summary of total bat captures by cave and Indiana bat (*Myotis sodalis*) captures by sex and age for surveys related to a portion of Section 4 of the proposed I-69, autumn 2005.

No.	Cave Name	Survey Dates	No. of Adult Female *M. sodalis*	No. of Adult Male *M. sodalis*	Total No. of *M. sodalis*	*Little brown bat*	*Northern bat*	*Eastern pipistrelle*	Total
1	Cave	17-18 September				7	21	11	**39**
2	Cave	17-18 September					9	5	**14**
3		15-16 September							**0**
4		13-14 September				9	49	1	**59**
5	Cave	22-23 September		2	2	56	61	16	**135**
6		24-25 September				38	36	7	**81**
7	Cave (North)	19-21 September				5	25	3	**33**
8	Cave (South)	19-21 September				3	16	4	**23**
Total			**0**	**2**	**2**	**118**	**217**	**47**	**384**

Table 7. Numbers of adult bats captured, catch per net-night, and chi-square analysis of males and females captured in surveys related to a portion of Section 4 of the proposed I-69, autumn 2005.

Species	Adult Male		Adult Female				Catch/trap-night
	Bats	%	Bats	%	X^2	*P*	Total
Northern bat	172	44.8	45	11.7	74.3	<0.0001	**13.56**
Little brown bat	107	27.9	11	2.9	78.1	<0.0001	**7.38**
Eastern pipistrelle	37	9.6	10	2.6	15.5	0.0001	**2.94**
Indiana bat	2	0.5	0	0.0			**0.13**
Total	**318**	**82.8**	**66**	**17.2**	**164.1**	**0.0001**	**24.00**

Table 8. Biology and capture information of banded Indiana bats (*Myotis sodalis*) for surveys related to a portion of Section 4 of the proposed I-69, autumn 2005.

Band Number	Capture Date	Cave Name	County	Sex	Age Class	Reproductive Condition
1721	22 September		Greene	Male	Adult	Descended
1722	23 September		Greene	Male	Adult	Descended

Table 9. Summary of total bat census by cave for surveys related to a portion of Section 4 of the proposed I-69, winter 2006.

No.	Cave Name	Survey Date	*Indiana bat*	*Little brown bat*	*Eastern pipistrelle*	Total
1		2 January		14	80	**94**
2		3 January			4	**4**
3		3 January				**0**
4		3 January				**0**
5	(aka	3 January	1	53	16	**70**
6		4 January			33	**33**
7	(North and South)	2 January		12	3	**15**
Total			**1**	**79**	**136**	**216**

Appendix C

Photographs

Appendix C: (Photographs) has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Appendix D

Data Sheets

Appendix D: (Data Sheets) has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Reconnaissance of Caves in West-Central Indiana, As Part of Tier-2 Environmental Impact Investigations Of Winter Hibernacula of the Indiana Bat (*Myotis sodalis*) For the Proposed Interstate-69 Transportation Corridor

Final Report
To Bernardin, Lochmueller and Associates, Inc.
August 22, 2005

From the
Indiana Geological Survey
Bloomington, Indiana

Principal Investigators:
Samuel Frushour and Denver Harper

Reconnaissance of Caves in West-Central Indiana, as Part of Tier-2 Environmental Impact Investigations of Winter Hibernacula of the Indiana Bat (*Myotis sodalis*) for the Proposed Interstate-69 Transportation Corridor

By **Denver Harper and Samuel Frushour, Indiana Geological Survey**

Introduction

The Indiana bat (*Myotis sodalis*) is an endangered species. As part of Tier-2 environmental impact investigations being conducted in association with the proposed Interstate-69 transportation corridor through southwestern Indiana, it was necessary to determine if any caves within 5 miles of the proposed corridor (including parts of Monroe, Greene, and Lawrence Counties) are winter hibernacula for this species. Thorough biological assessments were needed to avoid or mitigate any negative impacts of the proposed highway on the endangered species.

In summer 2004, the Indiana Geological Survey (IGS) was contracted by Bernardin, Lochmueller and Associates, Inc. (BLA) and the Indiana Department of Transportation (INDOT) to perform a reconnaissance of all known caves within the study area. The purpose of the investigation was to identify and visit caves that represented potential winter hibernacula for the Indiana bat and make recommendations regarding independent, more detailed investigations that were to be conducted later by teams of biologists.

Method

The reconnaissance began with the compilation of a database of known cave locations by Samuel Frushour (IGS). The locations were derived from various publications and from oral and unpublished reports and maps made by cave explorers over a period of decades. While a few of the locations had been derived from global positioning system (GPS) surveys, most were obtained from points plotted on 1:24,000-scale topographic quadrangle maps of the United States Geological Survey and were in the Public Land Survey System (Township, Range, and Section). The accuracy of such locations varied widely; in some cases, footage information was available, but where footage information was not available, the point was located to the center of the smallest quarter-section given.

The location information was converted from the Public Land Survey System into Universal Transverse Mercator (UTM) coordinates. Geographic information system (GIS) software was then used to convert the database into ESRI ArcGIS shapefile format and to eliminate those caves that were more than 5 miles from either side of the proposed transportation corridor. The resulting shapefile, which includes 330 points, is named "CAVES_I69_IGS" (Table 1 and Figure 1) and accompanies this report on CD-ROM. A Microsoft Excel spreadsheet derived from the shapefile's database is included in Appendix 1, and metadata for the shapefile are included in Appendix 2.

Based on knowledge of Frushour and other cave explorers with considerable Indiana experience, 96 of the caves were eliminated from consideration as winter hibernacula for the Indiana bat because they were too small, too warm in winter, too wet, or subject to flooding. Eight other records from the original database were eliminated because they were recognized as duplicate entries appearing under different cave names. Five caves could not be visited because access to the property was not granted by landowners.

Table 1. Summary of CAVES_I69_IGS Original database that was used to guide the search		
Total number of records	330	
Duplicate records	8	
Caves deemed "not worth visiting"	96	Indicated by a value of "NV" ("not visited") in the field named "Visited" and a value of "1" ("not a habitat") in the field named "Bat_Potent."
Access to property denied	5	Indicated by a value of "NV" ("not visited") in the field named "Visited" and a value of "0" (status unknown) in the field named "Bat_Potent."
Caves searched for, but not found	14	Indicated by a value of "NF" ("not found") in the field named "Visited."
Caves that were visited	207	Indicated by a value of "Y" ("yes") in the field named "Visited."

Figure 1 has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 1. Map showing final status of the search for caves in the original database (CAVES_I69_IGS). Some caves were not visited because they were known to be unsuitable as winter hibernacula, access to the property was denied, or searches were unsuccessful because of poor location data.

Beginning on July 20, 2004, field investigations were undertaken to visit each of the caves. The investigators used the locations contained in CAVES_I69_IGS to guide their search, as waypoints in GPS instruments. Fourteen of the caves were never found in the field. In most cases, failure to locate those caves can be attributed to bad location data. In addition to 207 caves from the original database, 41 caves were visited that were not part of the original database; these include newly discovered caves, as well as previously known caves that did not happen to be included in the original database. Also, two abandoned railroad tunnels were visited and evaluated as possible winter hibernacula.

When each cave was visited in the field, investigators determined accurate locations by using Garmin 76CS GPS instruments, photographed the caves, and made notes regarding the potential suitability of the cave as a winter hibernaculum for the Indiana bat. The evaluations for suitability as hibernacula were subjective and based upon observations by Samuel Frushour and Drew Packman (IGS) of cave-opening dimensions, cave geometry, air flow, susceptibility to flooding, and other factors. Such factors are discussed in detail in Kurta and Kennedy (2002). Five values

of potential suitability as winter hibernacula appear in the field named "Bat_Potent" in CAVES_I69_IGS: (1) "Status unknown," (2) "Not a habitat," (3) "Possible but unlikely," (4) "Possible," and (5) "Definitely a habitat."

During each visit to a cave, field investigators recorded measurements and observations on paper records referred to as "Cave and Karst Feature Reports." Selected data for visited caves were later compiled in a Microsoft Excel spreadsheet, which was subsequently converted into shapefile format. The shapefile, which is named "CAVES_I69_GPS_IGS," accompanies this report (Table 2 and Figure 2). A Microsoft Excel spreadsheet derived from the shapefile's database is included in Appendix 1, and metadata for the shapefile are included in Appendix 2. At the suggestion of personnel of the U.S. Fish and Wildlife Service, the subjective categorization of caves as potential winter hibernacula was increased from five to six values: (1) "Not a habitat," (2) "Unlikely," (3) "Weak Possible," (4) "Medium Possible," (5) "Strong Possible," and (6) "Definitely a habitat."

Table 2. Summary of CAVES_I69_GPS_IGS
Database of caves that were visited

Total number of caves that were visited		250		
New caves (not included in CAVES_I69_IGS)		41		
Railroad tunnels (not included in CAVES_I69_IGS)		2		
Evaluation of caves as potential habitat			Netted 2004	Recommended for netting 2005
	Not habitat	113	0	0
	Unlikely	61	14	3
	Weak possible	25	16	6
	Medium possible	29	21	8
	Strong possible	11	8	3
	Definite habitat	11	0	0

Figure 2 has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 2. Map showing evaluation of visited caves (CAVES_I69_GPS_IGS) as possible winter hibernacula.

During field visits, investigators also took photographs of cave openings. Selected images are included on the CD-ROM that accompanies this report.

Results

In August 2004, personnel of the IGS, in consultation with personnel of BLA and the U.S. Fish and Wildlife Service, used the evaluations contained in CAVES_I69_GPS_IGS to recommend 59 caves for intensive investigations as winter hibernacula. In CAVES_I69_GPS_IGS, these caves are indicated by a value of "Y" ("yes") in the field named "Net." Biological teams subsequently conducted mist-netting at the entrances to the recommended caves in autumn 2004 and entered and explored selected caves in winter 2004-2005. (Note that an additional cave—Cave—was also netted, but it was later determined that the cave is outside the 5-mile buffer, and so it does not appear in the database.)

In August 2005, an additional 20 caves were recommended for investigations in autumn and winter 2005. In CAVES_I69_GPS_IGS, these caves are indicated by a value of "R" ("recommended") in the field named "Net."

The results of the biological investigations will be reported separately by the responsible agencies.

Reference

Allen Kurta and Jim Kennedy (eds.), 2002, The Indiana Bat—Biology and Management of an Endangered Species: Bat Conservation International, Austin, Texas, 253 p.

Appendix 1

Spreadsheets Extracted from Shapefiles

This spreadsheet has been removed for confidentiality reasons related to caves

CAVES_I69_IGS

Explanation of fields and coded values:

UTMX83 and UTMY83: Location according to the original database. Coordinates are in Universal Transverse Mercator (UTM), Zone 16, NAD83.

NOTES2004: Explanation of why a cave was not found or not visited, or identification of a cave that was re-named or identified as a duplicate of another record.

VISITED:

- NF = Not found, even though an attempt was made to find the cave.
- NV = Not visited, either because access to the property was denied (Bat_Potent = 0) or because the cave was deemed not worthy of visiting (Bat_Potent = 1).
- Y = Yes, the cave was visited by field investigators of IGS.

BAT_POTENT:

0 = Status unknown.
1 = Not a habitat.
2 = Unlikely habitat.
3 = Possible habitat.
4 = Definitely a habitat.

CAVES_I69_GPS_IGS

Explanation of fields and coded values:

CAVE_NAME: Name of the cave. The designation of "New Cave" indicates that the cave was not included in the original database.

DATE_VISIT: The date on which the cave was visited by field investigators of IGS.

FLAG_ID: The unique identification number assigned to the cave by IGS field investigators. The alphanumeric identification consists of the date visited (MM/DD/YYYY), followed by the initials of the individual who completed the "Cave and Karst Feature Report" (SF, Samuel Frushour; DP, Drew Packman; DH, Denver Harper), followed by a number indicating the sequence in which the cave was visited on that day.

UTMX83 and UTMY83: Location obtained in the field by field investigators of IGS using GPS instruments. Coordinates are in Universal Transverse Mercator (UTM), Zone 16, NAD83.

PARK_X and PARK_Y: Location of parking area that was used by IGS field investigators. These locations may not necessarily provide the best access to the cave. Coordinates are in Universal Transverse Mercator (UTM), Zone 16, NAD83.

ENT_SIZE_F: Entrance dimensions of the cave (in feet).

AIRFLOW: Qualitative estimate of airflow

IND_BAT_HAB: Subjective evaluation by Samuel Frushour or Drew Packman of the likelihood that the cave serves as a winter hibernaculum for *Myotis sodalis*. Values include: "No," "Unlikely," "Weak Possible," "Medium Possible," "Strong Possible," and "Definite."

NET: A value of "Y" indicates that the cave was investigated by biological teams (mist netting and possibly cave exploration) in autumn and winter, 2004-2005). A value of "R" indicates that the cave was recommended for intensive biological investigation in autumn and winter, 2005-2006.

HAB_NOTE: Notes regarding suitability of the cave as a winter hibernaculum.

Appendix 2

Metadata for Shapefiles

Metadata for CAVES_I69_IGS

Identification_Information:
  Citation:
    Citation_Information:
      Originator: Indiana Geological Survey (IGS)
      Originator: Samuel Frushour (Data collection)
      Originator: Denver Harper (Data collection and GIS compiler)
      Originator: Drew Packman (Data collection)
      Originator: Chris Dintaman (Data collection and GIS compiler)
      Originator: Chris Walls (Data collection)
      Originator: Chris Parks (Data collection)
      Publication_Date: 20050804
      Title:
        CAVES_I69_IGS: Caves in Southwestern Indiana that Were Included in a Tier-2 Environmental Impact Investigation for a Proposed
        Interstate 69 Transportation Corridor (Indiana Geological Survey, Point Shapefile)
      Geospatial_Data_Presentation_Form: Vector digital data
      Publication_Information:
        Publication_Place: Bloomington, Indiana
        Publisher: Indiana Geological Survey
      Other_Citation_Details:
        The Microsoft Excel database from which this shapefile was derived was compiled by Samuel Frushour of the Indiana Geological Survey. This shapefile was produced in association with another shapefile named "CAVES_I69_GPS_IGS."
  Description:
    Abstract:
        CAVES_I69_IGS is a point shapefile that shows the distribution of caves in southwestern Indiana that are located within 5 miles of a transportation corridor associated with a proposed extension of Interstate 69 from Indianapolis to Evansville, Indiana. The locations of the caves are derived from a database that was compiled by Samuel Frushour (Indiana Geological Survey). The accuracy of these locations varies greatly because the data were collected over a period of decades from various sources, including oral and unpublished written reports, as well as published material.

        As part of the Tier-2 environmental impact investigation of the proposed corridor, as many of the caves as possible were visited by personnel of the Indiana Geological Survey. The investigators used the locations contained in this shapefile to guide their search, as waypoints in GPS instruments. When the investigators found a cave, they collected more accurate locational data by using the GPS instruments. Those more accurate coordinates were used to create an associated shapefile named "CAVES_I69_GPS_IGS."
    Purpose:
        The purpose of this shapefile was to assist researchers in locating caves within a 5-mile buffer around a proposed extension of Interstate 69 through southwestern Indiana as part of a Tier-2 environmental impact investigation.
  Time_Period_of_Content:
    Time_Period_Information:
      Range_of_Dates/Times:
        Beginning_Date: 1959
        Ending_Date: 20050804
    Currentness_Reference: Publication date
  Status:
    Progress: Complete
    Maintenance_and_Update_Frequency: None planned
  Spatial_Domain:
    Bounding_Coordinates:
      West_Bounding_Coordinate: -86.8621

East_Bounding_Coordinate: -86.5000
North_Bounding_Coordinate: 39.2617
South_Bounding_Coordinate: 38.9058
Keywords:
Theme:
Theme_Keyword_Thesaurus: Metadata Service Keyword Thesaurus
Theme_Keyword: geoscientificInformation
Theme:
Theme_Keyword_Thesaurus: IGS Metadata Keyword Thesaurus
Theme_Keyword: Indiana Geological Survey (IGS)
Theme_Keyword: cave
Theme_Keyword: caves
Theme_Keyword: karst
Theme_Keyword: Interstate 69 (I69)
Theme_Keyword: Indiana bat
Theme_Keyword: Myotis sodalis
Place:
Place_Keyword_Thesaurus: None
Place_Keyword: Indiana
Place_Keyword: Greene County
Place_Keyword: Lawrence County
Place_Keyword: Monroe County
Access_Constraints:
This file is available to anyone, but access may be contingent on written request, specific terms relevant to the agency or person making the request, and (or) current freedom of information statutes in the state of Indiana.
Use_Constraints:
INDIANA GEOLOGICAL SURVEY DATA DISCLAIMER
This data set is provided by Indiana University, Indiana Geological Survey, and contains data believed to be accurate; however, a degree of error is inherent in all data. This product is distributed "AS-IS" without warranties of any kind, either expressed or implied, including but not limited to warranties of suitability of a particular purpose or use. No attempt has been made in either the designed format or production of these data to define the limits or jurisdiction of any federal, state, or local government.

These data are intended for use only at the published scale or smaller and are for reference purposes only. They are not to be construed as a legal document or survey instrument. A detailed on-the-ground survey and historical analysis of a single site may differ from these data.

CREDIT
It is requested that the Indiana Geological Survey be cited in any products generated from this data set. The following source citation should be included: CAVES_I69_IGS: Caves in Southwestern Indiana that Were Included in a Tier-2 Investigation for a Proposed Interstate 69 Transportation Corridor (Indiana Geological Survey, Point Shapefile).

Point_of_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: Indiana Geological Survey
Contact_Person: Denver Harper
Contact_Position: Geologist
Contact_Address:

Address_Type: Mailing and physical address
Address: 611 North Walnut Grove
City: Bloomington
State_or_Province: Indiana
Postal_Code: 47405-2208
Country: USA
Contact_Voice_Telephone: 812-855-7636
Contact_Facsimile_Telephone: 812-855-2862
Contact_Electronic_Mail_Address: IGSinfo@indiana.edu
Hours_of_Service: 0800 to 1700 Eastern Standard Time
Contact_Instructions: Monday through Friday, except holidays
Native_Data_Set_Environment: ESRI ArcGIS version 9.1 shapefile format, approximately 65 Kb

Data_Quality_Information:
Attribute_Accuracy:
Attribute_Accuracy_Report:
The locations of the caves are derived from a database that was compiled by Samuel Frushour (Indiana Geological Survey) from various publications and from oral and unpublished reports and maps by various cave explorers over a period of decades. While a few of the locations were derived from GPS surveys, most were obtained from points plotted on 1:24,000-scale USGS topographic quadrangle maps. The coordinates estimated from those points were compiled into a database and converted from the Public Land Survey System into UTM coordinates using Geographix software.

Evaluations of caves for suitability as winter hibernacula for the Indiana bat (Myotis sodalis) are highly subjective and based upon observations by Samuel Frushour and Drew Packman of cave-opening dimensions, cave geometry, air flow, susceptibility to flooding, and other factors.
Logical_Consistency_Report:
Subjective evaluations of caves for suitability as winter hibernacula for the Indiana bat (Myotis sodalis) were made by either of two different field investigators (Samuel Frushour and Drew Packman).
Completeness_Report:
This shapefile includes all cave locations contained in the database provided by Samuel Frushour that are situated within 5 miles of the transportation corridor for the proposed extension of Interstate 69.
Positional_Accuracy:
Horizontal_Positional_Accuracy:
Horizontal_Positional_Accuracy_Report:
Most of the locations were obtained from hand-plotted points on 1:24,000-scale USGS topographic quadrangle maps. Geographix software was then used to convert the locational data from the Public Land Survey System to UTM coordinates. In some cases footage information was available, and this was used in the conversion. Where footage information was not available, the point was located to the center of the smallest quarter-section given. A few of the locations were derived from GPS surveys.
Vertical_Positional_Accuracy:
Vertical_Positional_Accuracy_Report: Not a factor in the production of this shapefile.
Lineage:
Source_Information:
Source_Citation:
Citation_Information:
Originator: Indiana Geological Survey
Publication_Date: Unpublished material
Title: None
Geospatial_Data_Presentation_Form: Tabular digital data
Publication_Information:
Publication_Place: Bloomington, Indiana
Publisher: Indiana Geological Survey
Type_of_Source_Media: Tabular digital data

Source_Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: 1959
Ending_Date: 20040611
Source_Currentness_Reference: 20040611
Source_Citation_Abbreviation: DRAFTI69CavesJuneil2004.xls
Source_Contribution: Cave locations
Process_Step:
Process_Description:
A Microsoft Excel spreadsheet named "DRAFTI69CavesJuneil2004.xls" was obtained from Samuel Frushour, Indiana Geological Survey. This spreadsheet contained records for 378 caves. Although the spreadsheet contained locational information in the Public Land Survey System (Township, Range, and Section), the coordinate information had previously been processed using Geographix software, so that the spreadsheet also contained coordinate information in Universal Transverse Mercator (UTM) Zone 16, NAD27.

The spreadsheet was opened and saved as a TXT file, which was then added to an ESRI ArcView project. The "Add Event Theme" and "Convert to Shapefile" functions were then used to create a shapefile. ESRI ArcToolbox was then used to convert the shapefile from NAD27 to NAD83.

Except for the field giving the names of the caves, all the fields in the shapefile were deleted, new fields were added, and the shapefile was saved as "Caves_I69_IGS."
Source_Used_Citation_Abbreviation: PDRAFTI69CavesJuneil2004.xls
Process_Date: 20040701
Source_Produced_Citation_Abbreviation: CAVES_I69_IGS.SHP
Process_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Organization: Indiana Geological Survey
Contact_Person: Denver Harper
Contact_Position: Geologist
Contact_Address:
Address_Type: Mailing and physical address
Address: 611 North Walnut Grove
City: Bloomington
State_or_Province: Indiana
Postal_Code: 47405-2208
Country: USA
Contact_Voice_Telephone: 812-855-1369
Contact_Facsimile_Telephone: 812-855-2862
Contact_Electronic_Mail_Address: dharper@indiana.edu
Hours_of_Service: 0800 to 1700 Eastern Standard Time
Contact_Instructions: Monday through Friday, except holidays
Process_Step:
Process_Description:
This metadata file was pre-parsed and parsed using CNS (Chew and Spit, v. 2.6.1) and MP (Metadata Parser, v. 2.7.1) software written by Peter N. Schweitzer (U.S. Geological Survey). The errors generated by MP were all addressed and corrected, except that no values were assigned to "Abscissa_Resolution" and "Ordinate_Resolution."
Process_Date: 20050805
Process_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Organization: Indiana Geological Survey
Contact_Person: Denver Harper

Contact_Position: Geologist
Contact_Address:
Address_Type: Mailing and physical address
Address: 611 North Walnut Grove
City: Bloomington
State_or_Province: Indiana
Postal_Code: 47405-2208
Country: USA
Contact_Voice_Telephone: 812-855-1369
Contact_Facsimile_Telephone: 812-855-2862
Contact_Electronic_Mail_Address: dharper@indiana.edu
Hours_of_Service: 0800 to 1700 Eastern Standard Time
Contact_Instructions: Monday through Friday, except holidays

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Point
Point_and_Vector_Object_Information:
SDTS_Terms_Description:
SDTS_Point_and_Vector_Object_Type: Point
Point_and_Vector_Object_Count: 330

Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Planar:
Grid_Coordinate_System:
Grid_Coordinate_System_Name: Universal Transverse Mercator
Universal_Transverse_Mercator:
UTM_Zone_Number: 16
Transverse_Mercator:
Scale_Factor_at_Central_Meridian: 0.999600
Longitude_of_Central_Meridian: -87.000000
Latitude_of_Projection_Origin: 0.000000
False_Easting: 500000.000000
False_Northing: 0.000000
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: Row and column
Coordinate_Representation:
Abscissa_Resolution:
Ordinate_Resolution:
Planar_Distance_Units: Meters
Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1983
Ellipsoid_Name: GRS 80
Semi-major_Axis: 6378137.0000000
Denominator_of_Flattening_Ratio: 298.26

Entity_and_Attribute_Information:
Detailed_Description:
Entity_Type:
Entity_Type_Label: CAVES_I69_IGS.DBF
Entity_Type_Definition: Shapefile Attribute Table
Entity_Type_Definition_Source: None
Attribute:
Attribute_Label: Shape
Attribute_Definition: Feature geometry
Attribute_Definition_Source: ESRI software generated

Attribute_Domain_Values:
Unrepresentable_Domain: Coordinates defining the features
Attribute:
Attribute_Label: Cave_name
Attribute_Definition: Name of the cave
Attribute_Definition_Source: Indiana Geological Survey
Attribute_Domain_Values:
Unrepresentable_Domain: Character Field
Attribute:
Attribute_Label: Utmx83
Attribute_Definition: X-coordinate (UTM Zone 16, NAD83) of the feature, as derived from a database compiled by Samuel Frushour of the Indiana Geological Survey
Attribute_Definition_Source: Indiana Geological Survey
Attribute_Domain_Values:
Range_Domain:
Range_Domain_Minimum: 514179.64
Range_Domain_Maximum: 543138.89
Attribute:
Attribute_Label: Utmy83
Attribute_Definition: Y-coordinate (UTM Zone 16, NAD83) of the feature, as derived from a database compiled by Samuel Frushour of the Indiana Geological Survey
Attribute_Definition_Source: Indiana Geological Survey
Attribute_Domain_Values:
Range_Domain:
Range_Domain_Minimum: 4306437.76
Range_Domain_Maximum: 4345823.52
Attribute:
Attribute_Label: Notes2004
Attribute_Definition:
Miscellaneous notes regarding reasons why a cave was not visited or not found.
Also, notes regarding caves that were renamed or had multiple names.
Attribute_Definition_Source: Indiana Geological Survey
Attribute_Domain_Values:
Unrepresentable_Domain: Character Field
Attribute:
Attribute_Label: Visited
Attribute_Definition: Has the cave been visited by field researchers?
Attribute_Definition_Source: Indiana Geological Survey
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: NF
Enumerated_Domain_Value_Definition: Not found. At attempt was made to find the cave in the field, but the attempt was unsuccessful.
Enumerated_Domain_Value_Definition_Source: Indiana Geological Survey
Enumerated_Domain:
Enumerated_Domain_Value: NV
Enumerated_Domain_Value_Definition:
Not visited. There are two possible reasons why a cave was not visited --

1. The cave might not have been visited because access to the property was denied by the landowner (this is indicated by a value of "0" in the field named "Bat_Potent").

2. The cave was not considered to be worth visiting for evaluation as a potential bat hibernaculum, as determined by Samuel Frushour, based upon his knowledge of the feature (this is indicated by a value of "1" in the field named "Bat_Potent").
Enumerated_Domain_Value_Definition_Source: Indiana Geological Survey

Enumerated_Domain:
Enumerated_Domain_Value: Y
Enumerated_Domain_Value_Definition:
Yes. The cave has been visited by field investigators of the Indiana Geological Survey. More detailed information that was recorded during the visit can be obtained from the shapefile named "CAVES_I69_GPS_IGS.SHP."
Enumerated_Domain_Value_Definition_Source: Indiana Geological Survey
Attribute:
Attribute_Label: Bat_potent
Attribute_Definition:
Subjective evaluation of field investigators regarding the suitability of the cave as possible winter hibernaculum for the Indiana bat (Myotis sodalis).
Attribute_Definition_Source: Indiana Geological Survey
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: 0
Enumerated_Domain_Value_Definition:
Unknown status. The cave has not been visited by field researchers of the Indiana Geological Survey, and there is no preexisting information that disqualifies the feature as a possible winter hibernaculum for the Indiana bat (Myotis sodalis).
Enumerated_Domain_Value_Definition_Source: Indiana Geological Survey
Enumerated_Domain:
Enumerated_Domain_Value: 1
Enumerated_Domain_Value_Definition:
No. The cave is definitely not suitable as a winter hibernaculum for the Indiana bat (Myotis sodalis). This evaluation may be based on either (1) field observations by researchers of the Indiana Geological Survey, or (2) prior knowledge by Samuel Frushour of the Indiana Geological Survey.
Enumerated_Domain_Value_Definition_Source: Indiana Geological Survey
Enumerated_Domain:
Enumerated_Domain_Value: 2
Enumerated_Domain_Value_Definition:
Possible but unlikely. Based on field observations by researchers of the Indiana Geological Survey, it is unlikely that the cave serves as a winter hibernaculum for the Indiana bat (Myotis sodalis), but the possibly cannot be entirely ruled out.
Enumerated_Domain_Value_Definition_Source: Indiana Geological Survey
Enumerated_Domain:
Enumerated_Domain_Value: 3
Enumerated_Domain_Value_Definition:
Possible. Based on field observations by researchers of the Indiana Geological Survey, the cave may serve as a winter hibernaculum for the Indiana bat (Myotis sodalis).
Enumerated_Domain_Value_Definition_Source: Indiana Geological Survey
Enumerated_Domain:
Enumerated_Domain_Value: 4
Enumerated_Domain_Value_Definition:
Definite. The cave is known to serve as a winter hibernaculum for the Indiana bat (Myotis sodalis).
Enumerated_Domain_Value_Definition_Source: Indiana Geological Survey

Distribution_Information:
Distributor:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: Indiana Geological Survey
Contact_Person: Publication Sales

Contact_Position: Publication Sales Coordinator
Contact_Address:
Address_Type: Mailing and physical address
Address: 611 North Walnut Grove
City: Bloomington
State_or_Province: Indiana
Postal_Code: 47405-2208
Country: USA
Contact_Voice_Telephone: 812-855-7636
Contact_Facsimile_Telephone: 812-855-2862
Contact_Electronic_Mail_Address: IGSinfo@indiana.edu
Hours_of_Service: 0800 to 1700 Eastern Standard Time
Contact_Instructions: Monday through Friday, except holidays
Resource_Description: Downloadable data

Distribution_Liability:
CREDIT
It is requested that the Indiana Geological Survey be cited in any products generated from this data set. The following source citation should be included: CAVES_I69_IGS: Caves in Southwestern Indiana that Were Included in a Tier-2 Investigation for a Proposed Interstate 69 Transportation Corridor (Indiana Geological Survey, Point Shapefile).

WARRANTY
Indiana University, Indiana Geological Survey warrants that the media on which this product is stored will be free from defect in materials and workmanship for ninety (90) days from the date of acquisition. If such a defect is found, return the media to, Publication Sales, Indiana Geological Survey, 611 North Walnut Grove, Bloomington, IN 47405-2208, and it will be replaced free of charge.

LIMITATION OF WARRANTIES AND LIABILITY
Except for the expressed warranty above, the product is provided "AS IS", without any other warranties or conditions, expressed or implied, including, but not limited to, warranties for product quality, or suitability to a particular purpose or use. The risk or liability resulting from the use of this product is assumed by the user. Indiana University, Indiana Geological Survey shares no liability with product users indirect, incidental, special, or consequential damages whatsoever, including, but not limited to, loss of revenue or profit, lost or damaged data or other commercial or economic loss. Indiana University, Indiana Geological Survey is not responsible for claims by a third party. The maximum aggregate liability to the original purchaser shall not exceed the amount paid by you for the product.

Metadata_Reference_Information:
Metadata_Date: 20050804
Metadata_Review_Date: 20050805
Metadata_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: Indiana Geological Survey
Contact_Person: Denver Harper
Contact_Position: Geologist
Contact_Address:
Address_Type: Mailing and physical address

Address: 611 North Walnut Grove
City: Bloomington
State_or_Province: Indiana
Postal_Code: 47405-2208
Country: USA
Contact_Voice_Telephone: 812-855-1369
Contact_Facsimile_Telephone: 812-855-2862
Contact_Electronic_Mail_Address: dharper@indiana.edu
Hours_of_Service: 0800 to 1700 Eastern Standard Time
Contact_Instructions: Monday through Friday, except holidays
Metadata_Standard_Name: FGDC CSDGM
Metadata_Standard_Version: FGDC-STD-001-1998

Metadata for CAVES_I69_GPS_IGS

Identification_Information:
  Citation:
    Citation_Information:
      Originator: Indiana Geological Survey (IGS)
      Originator: Samuel Frushour (Data collection)
      Originator: Denver Harper (Data collection and GIS compiler)
      Originator: Drew Packman (Data collection)
      Originator: Chris Dintaman (Data collection and GIS compiler)
      Originator: Chris Walls (Data collection)
      Originator: Chris Parks (Data collection)
      Publication_Date: 20050804
      Title:
        CAVES_I69_GPS_IGS: Caves in Southwestern Indiana that Were Visited by Field Researchers as part of a Tier-2 Environmental Impact Investigation for a Proposed Interstate 69 Transportation Corridor (Indiana Geological Survey, Point Shapefile)
      Geospatial_Data_Presentation_Form: Vector digital data
      Publication_Information:
        Publication_Place: Bloomington, Indiana
        Publisher: Indiana Geological Survey
      Other_Citation_Details: This shapefile was produced in association with another shapefile named "CAVES_I69_IGS."
  Description:
    Abstract:
      CAVES_I69_GPS_IGS is a point shapefile that shows the distribution of caves in southwestern Indiana that are located within 5 miles of a transportation corridor associated with a proposed extension of Interstate 69 from Indianapolis to Evansville, Indiana, and that have been visited by field researchers. The locations of the caves are derived from GPS measurements made by the researchers during their visits.

      Also, the investigators made notes and subjectively evaluated the suitability of each feature as a possible winter hibernaculum for the Indiana bat (Myotis sodalis). Their evaluations were subsequently used to identify and prioritize caves for later biological investigations.
    Purpose:
      The purpose of this shapefile was to assist researchers in prioritizing subsequent biological investigations of caves as winter hibernacula within a 5-mile buffer around a proposed extension of Interstate 69 through southwestern Indiana.
  Time_Period_of_Content:
    Time_Period_Information:
      Range_of_Dates/Times:
        Beginning_Date: 20040720
        Ending_Date: 20050804
    Currentness_Reference: Publication date
  Status:
    Progress: Complete
    Maintenance_and_Update_Frequency: None planned
  Spatial_Domain:
    Bounding_Coordinates:
      West_Bounding_Coordinate: -86.8621
      East_Bounding_Coordinate: -86.5000
      North_Bounding_Coordinate: 39.2617
      South_Bounding_Coordinate: 38.9058
  Keywords:
    Theme:

Theme_Keyword_Thesaurus: Metadata Service Keyword Thesaurus
Theme_Keyword: geoscientificInformation
Theme:
Theme_Keyword_Thesaurus: IGS Metadata Keyword Thesaurus
Theme_Keyword: Indiana Geological Survey (IGS)
Theme_Keyword: cave
Theme_Keyword: caves
Theme_Keyword: karst
Theme_Keyword: Interstate 69 (I69)
Theme_Keyword: global positioning system (GPS)
Theme_Keyword: tools and techniques
Theme_Keyword: Indiana bat
Theme_Keyword: Myotis sodalis
Place:
Place_Keyword_Thesaurus: None
Place_Keyword: Indiana
Place_Keyword: Greene County
Place_Keyword: Lawrence County
Place_Keyword: Monroe County
Access_Constraints:
This file is available to anyone, but access may be contingent on written request, specific terms relevant to the agency or person making the request, and (or) current freedom of information statutes in the state of Indiana.
Use_Constraints:
INDIANA GEOLOGICAL SURVEY DATA DISCLAIMER
This data set is provided by Indiana University, Indiana Geological Survey, and contains data believed to be accurate; however, a degree of error is inherent in all data. This product is distributed "AS-IS" without warranties of any kind, either expressed or implied, including but not limited to warranties of suitability of a particular purpose or use. No attempt has been made in either the designed format or production of these data to define the limits or jurisdiction of any federal, state, or local government.
These data are intended for use only at the published scale or smaller and are for reference purposes only. They are not to be construed as a legal document or survey instrument. A detailed on-the-ground survey and historical analysis of a single site may differ from these data.
CREDIT
It is requested that the Indiana Geological Survey be cited in any products generated from this data set. The following source citation should be included: CAVES_I69_GPS_IGS: Caves in Southwestern Indiana that Were Visited by Field Researchers as part of a Tier-2 Environmental Impact Investigation for a Proposed Interstate 69 Transportation Corridor (Indiana Geological Survey, Point Shapefile).

Point_of_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: Indiana Geological Survey
Contact_Person: Denver Harper
Contact_Position: Geologist
Contact_Address:
Address_Type: Mailing and physical address
Address: 611 North Walnut Grove
City: Bloomington
State_or_Province: Indiana
Postal_Code: 47405-2208

Country: USA
Contact_Voice_Telephone: 812-855-7636
Contact_Facsimile_Telephone: 812-855-2862
Contact_Electronic_Mail_Address: IGSinfo@indiana.edu
Hours_of_Service: 0800 to 1700 Eastern Standard Time
Contact_Instructions: Monday through Friday, except holidays
Native_Data_Set_Environment: ESRI ArcGIS version 9.1 shapefile format, approximately 65 Kb

Data_Quality_Information:
Attribute_Accuracy:
Attribute_Accuracy_Report:
The locations of the caves were obtained from field-averaged measurements that were made using hand-held Garmin 76CS GPS units.

Evaluations of caves for suitability as winter hibernacula for the Indiana bat (Myotis sodalis) are highly subjective and based upon observations by Samuel Frushour and Drew Packman of cave-opening dimensions, cave geometry, air flow, susceptibility to flooding, and other factors.
Logical_Consistency_Report:
Subjective evaluations of caves for suitability as winter hibernacula for the Indiana bat (Myotis sodalist) were made by either of two field investigators (Samuel Frushour and Drew Packman).
Completeness_Report:
This shapefile includes locations for 269 cave openings that were visited by field researchers. These caves are all situated within 5 miles of the transportation corridor for the proposed extension of Interstate 69.
Positional_Accuracy:
Horizontal_Positional_Accuracy:
Horizontal_Positional_Accuracy_Report: Plus or minus 10 meters.
Vertical_Positional_Accuracy:
Vertical_Positional_Accuracy_Report: Not a factor in the production of this shapefile.
Lineage:
Source_Information:
Source_Citation:
Citation_Information:
Originator: Indiana Geological Survey
Publication_Date: Unpublished material
Title: Cave and Karst Feature Report
Geospatial_Data_Presentation_Form: Paper field notes
Publication_Information:
Publication_Place: Bloomington, Indiana
Publisher: Indiana Geological Survey
Type_of_Source_Media: Paper
Source_Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: 20040720
Ending_Date: 20050804
Source_Currentness_Reference: 20050804
Source_Citation_Abbreviation: Cave and Karst Feature Reports
Source_Contribution:
Cave locations and observations by Sam Frushour and Drew Packman regarding suitability of caves as winter hibernacula for the Indiana bat (Myotis sodalis).
Process_Step:
Process_Description:
A Microsoft Excel spreadsheet named "Caves_I69_GPS_IGS.xls" was compiled from field notes by Samuel Frushour and Drew Packman (IGS). These field notes contained measurements of cave locations and the locations where the researchers parked their vehicles before visiting the caves

(derived from hand-held Garmin 76CS GPS units), as well as a unique identification number for each cave. The field notes also contain observations regarding the dimensions of the cave, air flow directions and outside temperatures, moisture conditions, susceptibilities to flooding, and miscellaneous other notes. In most cases, the caves were not entered by the field researchers; when caves were entered, notes were taken regarding the presence of bats and other conditions.

Source_Used_Citation_Abbreviation: Cave and Karst Feature Reports
Process_Date: 20050804
Source_Produced_Citation_Abbreviation: Caves_I69_GPS_IGS.xls
Process_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Organization: Indiana Geological Survey
Contact_Person: Denver Harper
Contact_Position: Geologist
Contact_Address:
Address_Type: Mailing and physical address
Address: 611 North Walnut Grove
City: Bloomington
State_or_Province: Indiana
Postal_Code: 47405-2208
Country: USA
Contact_Voice_Telephone: 812-855-1369
Contact_Facsimile_Telephone: 812-855-2862
Contact_Electronic_Mail_Address: dharper@indiana.edu
Hours_of_Service: 0800 to 1700 Eastern Standard Time
Contact_Instructions: Monday through Friday, except holidays

Process_Step:
Process_Description:
Caves_I69_GPS_IGS.xls was opened and saved as a tab-delimited TXT file, which was then added to an ESRI ArcView 3.3 project. The "Add Event Theme" and "Convert to Shapefile" functions were then used to create a shapefile named "CAVES_I69_GPS_IGS."

Source_Used_Citation_Abbreviation: CAVES_I69_GPS_IGS.xls
Process_Date: 20050630
Source_Produced_Citation_Abbreviation: CAVES_I69_GPS_IGS.SHP
Process_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Organization: Indiana Geological Survey
Contact_Person: Denver Harper
Contact_Position: Geologist
Contact_Address:
Address_Type: Mailing and physical address
Address: 611 North Walnut Grove
City: Bloomington
State_or_Province: Indiana
Postal_Code: 47405-2208
Country: USA
Contact_Voice_Telephone: 812-855-1369
Contact_Facsimile_Telephone: 812-855-2862
Contact_Electronic_Mail_Address: dharper@indiana.edu
Hours_of_Service: 0800 to 1700 Eastern Standard Time
Contact_Instructions: Monday through Friday, except holidays
Process_Step:
Process_Description:

This metadata file was pre-parsed and parsed using CNS (Chew and Spit, v. 2.6.1) and MP (Metadata Parser, v. 2.7.1) software written by Peter N. Schweitzer (U.S. Geological Survey). The errors generated by MP were all addressed and corrected, except that no values were assigned to "Abscissa_Resolution" and "Ordinate_Resolution."

Process_Date: 20050805
Process_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Organization: Indiana Geological Survey
Contact_Person: Denver Harper
Contact_Position: Geologist
Contact_Address:
Address_Type: Mailing and physical address
Address: 611 North Walnut Grove
City: Bloomington
State_or_Province: Indiana
Postal_Code: 47405-2208
Country: USA
Contact_Voice_Telephone: 812-855-1369
Contact_Facsimile_Telephone: 812-855-2862
Contact_Electronic_Mail_Address: dharper@indiana.edu
Hours_of_Service: 0800 to 1700 Eastern Standard Time
Contact_Instructions: Monday through Friday, except holidays

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Point
Point_and_Vector_Object_Information:
SDTS_Terms_Description:
SDTS_Point_and_Vector_Object_Type: Point
Point_and_Vector_Object_Count: 250

Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Planar:
Grid_Coordinate_System:
Grid_Coordinate_System_Name: Universal Transverse Mercator
Universal_Transverse_Mercator:
UTM_Zone_Number: 16
Transverse_Mercator:
Scale_Factor_at_Central_Meridian: 0.999600
Longitude_of_Central_Meridian: -87.000000
Latitude_of_Projection_Origin: 0.000000
False_Easting: 500000.000000
False_Northing: 0.000000
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: Row and column
Coordinate_Representation:
Abscissa_Resolution:
Ordinate_Resolution:
Planar_Distance_Units: Meters
Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1983
Ellipsoid_Name: GRS 80
Semi-major_Axis: 6378137.0000000
Denominator_of_Flattening_Ratio: 298.26

Entity_and_Attribute_Information:
  Detailed_Description:
    Entity_Type:
      Entity_Type_Label: CAVES_I69_GPS_IGS.DBF
      Entity_Type_Definition: Shapefile Attribute Table
      Entity_Type_Definition_Source: None
    Attribute:
      Attribute_Label: Shape
      Attribute_Definition: Feature geometry
      Attribute_Definition_Source: ESRI software generated
      Attribute_Domain_Values:
        Unrepresentable_Domain: Coordinates defining the features
    Attribute:
      Attribute_Label: Cave_name
      Attribute_Definition: Name of the cave
      Attribute_Definition_Source: Indiana Geological Survey
      Attribute_Domain_Values:
        Unrepresentable_Domain: Character Field
    Attribute:
      Attribute_Label: Date_Visit
      Attribute_Definition:
        The date (MM/DD/YYYY) on which the cave was visited by field researchers of
        the Indiana Geological Survey.
      Attribute_Definition_Source: Indiana Geological Survey
      Attribute_Domain_Values:
        Unrepresentable_Domain: Character Field
    Attribute:
      Attribute_Label: Flag_ID
      Attribute_Definition:
          The identification number of flagging that was placed near the cave opening by
          field researchers of the Indiana Geological Survey. The number consists of the date (MMDDYY),
          followed by the initials of a member of the visiting research team. The initials are as follows: SF,
          Sam Frushour; DP, Drew Packman; DH, Denver Harper. The number that appears after the initials
          indicates the sequence in which the cave was visited on that day.
      Attribute_Definition_Source: Indiana Geological Survey
      Attribute_Domain_Values:
        Unrepresentable_Domain: Character Field
    Attribute:
      Attribute_Label: Utmx83
      Attribute_Definition:
        X-coordinate (UTM Zone 16, NAD83), as determined using a hand-held Garmin 76CS
        GPS unit.
      Attribute_Definition_Source: Indiana Geological Survey
      Attribute_Domain_Values:
        Range_Domain:
          Range_Domain_Minimum: 514171
          Range_Domain_Maximum: 541494
    Attribute:
      Attribute_Label: Utmy83
      Attribute_Definition:
        Y-coordinate (UTM Zone 16, NAD83), as determined using a hand-held Garmin 76CS
        GPS unit.
      Attribute_Definition_Source: Indiana Geological Survey
      Attribute_Domain_Values:
        Range_Domain:
          Range_Domain_Minimum: 4305977

Range_Domain_Maximum: 4345819
Attribute:
Attribute_Label: Park_X
Attribute_Definition:
X-coordinate (UTM Zone 16, NAD83) of the location where the field researchers parked their vehicle, as determined using a hand-held Garmin 76CS GPS unit.
Attribute_Definition_Source: Indiana Geological Survey
Attribute_Domain_Values:
Range_Domain:
Range_Domain_Minimum: 514209
Range_Domain_Maximum: 541285
Attribute:
Attribute_Label: Park_Y
Attribute_Definition:
Y-coordinate (UTM Zone 16, NAD83) of the location where the field researchers parked their vehicle, as determined using a hand-held Garmin 76CS GPS unit.
Attribute_Definition_Source: Indiana Geological Survey
Attribute_Domain_Values:
Range_Domain:
Range_Domain_Minimum: 4306078
Range_Domain_Maximum: 4345697
Attribute:
Attribute_Label: Ent_Size_F
Attribute_Definition: Estimated dimensions (in feet) of the cave opening.
Attribute_Definition_Source: Indiana Geological Survey
Attribute_Domain_Values:
Unrepresentable_Domain: Character Field
Attribute:
Attribute_Label: Airflow
Attribute_Definition:
Subjective evaluation of air flow through the cave opening at the time the cave was visited.
Attribute_Definition_Source: Indiana Geological Survey
Attribute_Domain_Values:
Unrepresentable_Domain: Character Field
Attribute:
Attribute_Label: Ind_Bat_Ha
Attribute_Definition:
Subjective evaluation by Samuel Frushour or Drew Packman (IGS) regarding the possible suitability of the cave as a winter hibernaculum for the Indiana bat (Myotis sodalis). Values in increasing likelihood of suitability are as follows -- "No," "Unlikely," "Weak Possible," "Medium Possible," "Strong Possible," "Definite."
Attribute_Definition_Source: Indiana Geological Survey
Attribute_Domain_Values:
Unrepresentable_Domain: Character Field
Attribute:
Attribute_Label: Net
Attribute_Definition: Has the cave been netted by field biology teams?
Attribute_Definition_Source: Indiana Geological Survey
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: blank
Enumerated_Domain_Value_Definition: No, the cave has not been netted by field biology teams.
Enumerated_Domain_Value_Definition_Source: Indiana Geological Survey
Enumerated_Domain:
Enumerated_Domain_Value: Y

Enumerated_Domain_Value_Definition: Yes, the cave was netted by field biology teams in 2004.
Enumerated_Domain_Value_Definition_Source: Indiana Geological Survey
Enumerated_Domain:
Enumerated_Domain_Value: R
Enumerated_Domain_Value_Definition: The cave was recommended for netting in 2005.
Enumerated_Domain_Value_Definition_Source: Indiana Geological Survey
Attribute:
Attribute_Label: Hab_Notes
Attribute_Definition:
Notes by Samuel Frushour or Drew Packman (IGS) regarding the possible suitability of the cave as a winter hibernaculum for the Indiana bat (Myotis sodalis).
Attribute_Definition_Source: Indiana Geological Survey
Attribute_Domain_Values:
Unrepresentable_Domain: Character Field

Distribution_Information:
Distributor:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: Indiana Geological Survey
Contact_Person: Publication Sales
Contact_Position: Publication Sales Coordinator
Contact_Address:
Address_Type: Mailing and physical address
Address: 611 North Walnut Grove
City: Bloomington
State_or_Province: Indiana
Postal_Code: 47405-2208
Country: USA
Contact_Voice_Telephone: 812-855-7636
Contact_Facsimile_Telephone: 812-855-2862
Contact_Electronic_Mail_Address: IGSinfo@indiana.edu
Hours_of_Service: 0800 to 1700 Eastern Standard Time
Contact_Instructions: Monday through Friday, except holidays
Resource_Description: Downloadable data

Distribution_Liability:
CREDIT
It is requested that the Indiana Geological Survey be cited in any products generated from this data set. The following source citation should be included: CAVES_I69_GPS_IGS: Caves in Southwestern Indiana that Were Visited by Field Researchers as part of a Tier-2 Environmental Impact Investigation for a Proposed Interstate 69 Transportation Corridor (Indiana Geological Survey, Point Shapefile).
WARRANTY
Indiana University, Indiana Geological Survey warrants that the media on which this product is stored will be free from defect in materials and workmanship for ninety (90) days from the date of acquisition. If such a defect is found, return the media to, Publication Sales, Indiana Geological Survey, 611 North Walnut Grove, Bloomington, IN 47405-2208, and it will be replaced free of charge.
LIMITATION OF WARRANTIES AND LIABILITY
Except for the expressed warranty above, the product is provided "AS IS", without any other warranties or conditions, expressed or implied, including, but not limited to, warranties for product quality, or suitability to a particular purpose or use. The risk or liability resulting from the use of this product is assumed by the user. Indiana

University, Indiana Geological Survey shares no liability with product users indirect, incidental, special, or consequential damages whatsoever, including, but not limited to, loss of revenue or profit, lost or damaged data or other commercial or economic loss. Indiana University, Indiana Geological Survey is not responsible for claims by a third party. The maximum aggregate liability to the original purchaser shall not exceed the amount paid by you for the product.

Metadata_Reference_Information:
  Metadata_Date: 20050804
  Metadata_Review_Date: 20050805
  Metadata_Contact:
    Contact_Information:
      Contact_Organization_Primary:
        Contact_Organization: Indiana Geological Survey
        Contact_Person: Denver Harper
      Contact_Position: Geologist
      Contact_Address:
        Address_Type: Mailing and physical address
        Address: 611 North Walnut Grove
        City: Bloomington
        State_or_Province: Indiana
        Postal_Code: 47405-2208
        Country: USA
      Contact_Voice_Telephone: 812-855-1369
      Contact_Facsimile_Telephone: 812-855-2862
      Contact_Electronic_Mail_Address: dharper@indiana.edu
      Hours_of_Service: 0800 to 1700 Eastern Standard Time
      Contact_Instructions: Monday through Friday, except holidays
  Metadata_Standard_Name: FGDC CSDGM
  Metadata_Standard_Version: FGDC-STD-001-1998

SURVEYS FOR INDIANA BATS IN CAVES IN GREENE AND MONROE COUNTIES, INDIANA 2005

Amy B. Henry[1], Brooke A. Slack[2], Drew L. Crane[2] and Russell C. Rommé[2]
[1]*BHE Environmental, Inc., 7041 Maynardville Highway, Knoxville TN 37918*
[2]*BHE Environmental, Inc. 11733 Chesterdale Road, Cincinnati, OH 45246*

Abstract

The Indiana Department of Transportation (INDOT) is preparing a second Environmental Impact Statement for the proposed Interstate Highway 69 (I-69) from Evansville to Indianapolis, Indiana. BHE Environmental, Inc. (BHE) was contracted to investigate the presence of the federally endangered Indiana bat (*Myotis sodalis*) and assess winter habitat use by the species along the proposed I-69 corridor. The studies were designed to provide data to evaluate, and avoid/minimize effects to the species within the proposed road corridor.

The U.S. Fish and Wildlife Service, the Indiana Geological Survey, and Bernardin Lochmueller and Associates (BLA) identified caves potentially suitable for hibernating Indiana bats. BHE evaluated presence of bats in 31 caves during autumn swarming, winter hibernation, and/or spring staging periods. During autumn 2004, BHE conducted surveys with harp traps at 30 caves for 2 nights each (n=60 trap nights). Nine male and two female Indiana bats were captured, along with 708 other bats of four species. Indiana bats were captured at , , , , and caves.

Surveys of 30 potential Indiana bat hibernacula were conducted during winter 2004/2005. Bats were observed in 18 of the 30 caves surveyed. Three Indiana bats were observed hibernating in Cave; Indiana bats were not observed in any other cave surveyed during winter. Four other species were observed during the winter survey. We measured air temperature and other characteristics to assess habitat suitability for hibernating Indiana bats within each cave. While none of the caves appeared to provide optimal winter habitat for Indiana bats, 21 caves provide suitable winter habitat. Except for Cave, none of the caves was occupied by hibernating Indiana bats.

Between April 10 and 29, 2005, BHE used harp traps to investigate presence of bats at six caves where winter surveys could not be completed. No Indiana bats were captured during the spring survey. Twenty-seven bats of four species were captured.

During the autumn and spring surveys, BHE used an Anabat II ultrasound detector to record bat activity at Cave, a known Indiana bat hibernaculum. Results were used to verify the timing of bat activity associated with autumn swarming and spring staging.

Key words: Indiana bat, *Myotis sodalis*, cave, harp trap, hibernaculum, Cave, Anabat

---

Introduction

The Indiana Department of Transportation (INDOT) is completing a second Environmental Impact Statement for the proposed Interstate Highway 69 (I-69) from Evansville to Indianapolis, Indiana. A detailed description of the proposed road corridor was presented in the Tier 1 Final Environmental Impact Statement (Tier 1 FEIS; FHWA and INDOT 2003a). This study is part of the Tier 2 Environmental Impact Statement (EIS) for the proposed I-69 project. The proposed interstate is approximately 142 miles (228.5 kilometers [km]) in length and is divided into six sections to facilitate Tier 2 EIS studies. Studies were conducted along the preferred alternative, Alternative 3C (FHWA and INDOT 2003a). The proposed road alignment will be within a corridor extending 1000 feet (304.8 meters [m]) on each side of the Alternative 3C centerline (total width of 2000 feet [609.6 m]). The proposed alignment represents the maximum width of direct construction impacts under Alternative 3C. Investigations described herein address Sections 4 and 5, in Greene and Monroe counties, where karst and caves are prevalent (Appendix A, Figure 1).

The INDOT, Federal Highway Administration (FHWA), and the U.S. Fish and Wildlife Service (USFWS) are conducting ongoing consultation under Section 7 of the Endangered Species Act to evaluate potential impacts within the proposed corridor. Surveys described in this report were conducted in accordance with requirements of the Tier 1 Biological Assessment (FHWA and INDOT 2003b). The purpose of these studies was to investigate the presence of the federally listed endangered Indiana bat (*Myotis sodalis*) and identify winter habitat use by the species along the proposed I-69 corridor. Caves along the proposed road were surveyed during the autumn swarming and winter hibernation periods to investigate presence of Indiana bats. Detailed habitat suitability evaluation was conducted during the winter survey. Six caves that could not be fully inspected during winter were surveyed during the spring staging period to assess presence of Indiana bats.

Methods used in these investigations were developed in consultation with the USFWS, Bloomington Field Office (Appendix B). Results of these studies will assist in evaluating and minimizing effects to the Indiana bat from the proposed road.

Locations of Potential Hibernacula Surveyed

The Indiana Geological Survey (IGS) identified caves and karst features near the proposed road alignment. Using available data on cave structure, internal air temperatures, air flow at the entrance, and historic records of bats, the USFWS ranked each cave as having high, moderate, or low potential to provide suitable habitat for hibernating Indiana bats (Appendix B). BHE inspected 31 potential Indiana bat hibernacula located in Greene and Monroe counties, near the proposed I-69 alignment (Appendix A, Figure 1).

Caves surveyed by BHE are located in Monroe County, except and caves, which are in Greene County. Caves we surveyed are between 850 feet and 4.7 miles of the proposed corridor centerline (Appendix C, Table 1). The legal description of each cave entrance is provided in Appendix C, Table 1, and maps of each cave are provided in Appendix D.

Materials and Methods

Access permission was sought and granted by landowners prior to implementation of

autumn, winter, and spring surveys described below.

Autumn and Spring Surveys

Between August 30 and October 15, 2004, harp traps were used to survey 30 caves to assess presence of Indiana bats during the autumn swarming period. Six caves were surveyed with harp traps between April 10 through 29, 2005 to investigate presence of Indiana bats during the spring staging period. Autumn and spring surveys were timed to coincide with dates when Indiana bats typically swarm and stage, respectively, at hibernacula. During the autumn survey, eight high priority caves were surveyed between September 21 and October 1, 2004, which was estimated to be the peak of the swarming period. Methods used for harp trap surveys in autumn and spring are described below.

At each cave, a double-framed harp trap (Tuttle 1974) was erected and operated for two nights. Traps were constructed with two banks of 8-pound monofilament fishing line, strung vertically and spaced 1 inch apart. Strands of the two banks were offset by 0.5 inches. Bird-X® plastic mesh was hung to prevent bats from flying around the trap. Traps and Bird-X® mesh were removed from cave openings at the end of the survey period each night. Trapping began each night at dusk and continued for five hours; traps were checked every hour.

Captured bats were identified to species, and the gender, reproductive condition, weight, and right forearm length were recorded. Photographs were taken of each Indiana bat captured depicting the face, tragus, and calcar. All Indiana bats captured were banded with uniquely-numbered celluloid band. We collected hair samples from Indiana bats and samples of nearby water in accordance with protocol from Clemson University. We attempted to collect guano samples from all bats captured.

Every hour during the survey, we recorded air temperature and estimated wind speed, and percent cloud cover. Moon phase and precipitation events were noted for each survey night.

During the autumn survey, characteristics of each cave opening were recorded, including dimensions, apparent stability, airflow from cave, and slope of the tunnel from the entrance.

During the autumn and spring surveys, BHE used an Anabat II ultrasound detector to record bat vocalizations at the mouth of Cave, an Indiana bat hibernaculum located in Monroe County. Recordings were made in autumn on nine nights between September 13 and October 1, 2004, and in spring on six nights between April 10 and 28, 2005.

One Anabat II detector was placed at the mouth of the cave, and a second detector was placed in the forest approximately 60 feet from the cave. The distance between the detectors minimized the likelihood that both detectors would record the same vocalization. Bat vocalizations were recorded for five hours each night beginning at dusk. Resulting files were filtered to eliminate ultrasound not generated by bats (e.g., noise from insects). To evaluate relative levels of bat activity, the number of vocalizations recorded was compared among nights. BHE did not attempt to identify the bat species generating vocalizations.

Results of the recordings were used to assess the timing of autumn swarming and spring staging activity in the vicinity of potential hibernacula BHE inspected. We evaluated the relative levels of bat activity at

Cave to ensure surveys of potential hibernacula were conducted when Indiana bats were swarming or staging.

Winter Surveys

Between December 15 2004 and January 24 2005, BHE investigated 30 caves to identify presence of hibernating bats and evaluate habitat suitability for hibernating bats. Twenty nine of the caves had been surveyed with harp traps in autumn 2004. Because cave was surveyed during winter 2004 by the USFWS and Indiana Department of Natural Resources (IDNR), BHE did not conduct a winter survey of Cave. Additionally, BHE surveyed Cave during winter, although no survey was conducted there during autumn 2004.

The 30 caves were surveyed during January and February 2005, except for and caves, which were surveyed during 15-16 December 2004 to avoid potential winter flooding.

BHE entered each cave, in some cases using vertical single rope techniques, and inspected the extent of the interior accessible to humans.

Bats observed inside caves were identified to species, or to the most specific taxonomic level possible. Bats were not handled, and care was taken to minimize disturbance to them. The number of bats and their location within the cave were recorded. Guano or other signs of bats were also documented.

We recorded detailed descriptions of each cave interior, including tunnel dimensions, presence or absence of standing water, evidence of flooding, barriers to human movement, and description of the entrance (Appendix D, E). We used a Raynger® MiniTemp MT4 infrared thermometer (Raytek Corporation, Santa Cruz, CA) to record air temperatures at the ceiling and floor of each cave at the entrance, near bats, at other selected interior sites, and at the stopping point of the survey. At the same sites, wind speed was estimated using the Beaufort scale (Appendix F). At the three caves we could not enter, we recorded air temperature and estimated wind speed at the entrance.

Assessment of habitat suitability was based upon the literature and guidance provided by the USFWS. Habitat suitability for Indiana bats was primarily determined by air temperature. Indiana bats typically hibernate in caves where temperatures during mid-winter are between 4 and 8 degrees Celsius (°C; USFWS 1999). Recent long-term monitoring in hibernacula indicates temperatures of 3-6°C are ideal for Indiana bats (USFWS 1999). However, mean air temperatures of up to 11°C have been recorded during December-February in Priority I hibernacula (Tuttle and Kennedy 1999) and other hibernacula containing significant populations of Indiana bats (Brack and Dunlap 1997). Because we used air temperature measured on a single occasion, we established a conservative threshold for suitability; air temperatures ≥13°C were considered unsuitable for hibernating Indiana bats.

When determining habitat suitability, we also considered air flow within the cave, presence of bats, especially *Myotis,* and signs of past flooding to the ceiling of the cave, which could kill hibernating bats and influence air temperatures.

Results

Autumn Surveys

Between August 30 through October 15, 2004, BHE used harp traps to survey 30 caves for 2 nights each (n=60 trap nights).

The survey was timed to coincide with the autumn swarming period when Indiana bats are active near hibernacula prior to hibernation.

A total of 719 bats was captured at 20 caves (Appendix C, Table 2). Indiana bats (n=11) were captured at , , , , and caves. A single female Indiana bat was captured from Cave and one from Cave. Nine male Indiana bats were captured from Cave, Cave, , and Cave. The greatest number of Indiana bats was captured at Cave (n=6).

Other species captured during the autumn survey included little brown bats (*M. lucifugus*) (n=296), eastern pipistrelles (*Pipistrellus subflavus*) (n=282), northern long-eared bats (*M. septentrionalis*) (n=129), and big brown bats (*Eptesicus fuscus*) (n=1). The greatest number of bats was captured at Cave (n=285). The greatest number of one species, the eastern pipistrelle, was captured at Cave (n=139). No bats were captured from ten caves.

Bat vocalizations (calls) were recorded near cave on nine occasions between September 13 and October 1, 2004 (Appendix G). At the mouth of Cave, the minimum number (353 calls) was recorded on September 13, and the maximum number (27,655 calls) was recorded on September 22. The number of calls recorded at the mouth of Cave generally increased between September 13 and 22, and generally decreased between September 22 and October 1. During emergence counts we conducted one-half hour after dusk on the nights of September 13 and 15, we observed approximately 100 bats emerge on September 13, and 220 bats emerge on September 15. Comparing the number of calls recorded in the forest with those recorded in the cave mouth suggests the relative bat activity was greatest near the cave mouth during nearly every night between September 14 and October 1. These data suggest the peak of swarming activity at Cave occurred on September 22. On October 1, 12,771 bat calls were recorded at the mouth of Cave, indicating bats were still active near the hibernacula. We infer from these data that swarming activity at nearby hibernacula occurred on similar dates, and that bats remained active near hibernacula through October 1.

Winter Surveys

Surveys of 30 potential Indiana bat hibernacula were conducted during December 15-16, 2004 and January 10-24, 2005 (Appendix C, Table 3). In nine caves, a portion of the cave was not surveyed due to unstable or unsafe entrance, high water, or passages that were inaccessible to humans. Three caves (, , and) could not be entered because the entrance was too small to admit humans. Indiana bats were identified only in Cave. Detailed descriptions of surveys in each cave are provided below. Pictures and detailed maps of the caves can be found in Appendix D.

<u>Cave</u>

BHE surveyed Cave on January 12, 2005. The entrance is a 3-foot wide by 4-foot tall crevice. From the entrance, cave continues approximately 80 feet toward the east along a 3-foot wide by 10-foot tall canyon-like passage with an upper and lower crawl (Appendix D). The lower crawl was too narrow to survey. The upper passage continued approximately 60 feet toward the south along a 3-foot wide by 3-

foot tall passage. At the end of the narrow passage is a perpendicular section about 3 feet wide by 3 feet tall and about 20 feet long passage. No stream or standing water was present in the cave during the survey and there was no evidence of flooding. Near the floor, air temperature varied from 8.6°C near the entrance to 12.8°C at the back of the cave. At the ceiling, air temperature was 10°C at the entrance and 13.4°C at the back. Air outflow was 1–3 mph at the entrance and was <1 mph further into the cave.

No Indiana bats were observed during the survey of Cave. Two eastern pipistrelles and two unknown Myotis sp. were counted during the survey. The unknown bats were on the ceiling in a small crevice and could not be identified to species. No dead bats or any signs of use by bats (e.g. guano, urine staining) were observed in the cave. Temperatures inside the Cave appear to be too warm to provide suitable winter habitat for Indiana bats.

Cave is a long, dry passage with no stream. It is possible to walk in the first 80 feet of passage but crawling is necessary to survey the remainder of the cave. Total time to survey the cave was approximately 1 hour. Gear used to perform single rope ascents/descents is not required to survey Bauer Cave.

BHE attempted to survey on January 20, 2005. Entry into the cave was not possible due to the dirt and debris that had washed into the sinkhole. The entrance was approximately 10 inches by 2 feet wide at the widest point. The cave map indicates about 800 feet of passage are present beyond the entrance. While the entrance cannot be accessed by humans, it is wide enough to admit bats. Because we were unable to inspect the interior, BHE surveyed Cave during the spring swarming period (Appendix C, Table 4).

BHE surveyed on January 20, 2005. There are two entrances to the cave but only one was accessible by humans. This entrance was a 6-foot vertical climb down leading to a small passage containing a stream. The passage continued for 75 feet where it ended in a tight crawl (Appendix D). The passage averaged 4 feet high by 5 feet wide. The stream was 2–3 inches deep, and no evidence of flooding was apparent. Air temperatures ranged from 8.2 to 11.6°C and air outflow was <1 mph in the cave.

No Indiana bats or other bats were observed during the survey of . No dead bats or signs of use by bats were observed in the cave. While conditions within Cave are within the range considered suitable for hibernating Indiana bats, no Indiana bats were identified there in autumn or winter. Therefore, we conclude the cave was not occupied by Indiana bats.

A hand line was necessary to climb into and out of the entrance. Total time spent in the cave was 15 minutes. A 2 mile hike is required to reach the cave.

Cave

BHE surveyed on January 11, 2005. The entrance is a narrow crawl located at the bottom of a sinkhole. The cave is dry except for a small stream that flows into the cave during significant precipitation. Shortly beyond the entrance, is a narrow canyon passage approximately 10 feet tall and 3 feet wide (Appendix D). This passage continues for 15 feet where it

becomes blocked by a large boulder. Water continues beyond the boulder through an opening 1 foot in diameter near the base of the boulder. A strong flow of air (4–7 mph) was blowing out of the opening, which may indicate is the entrance to a larger passage. Air temperatures in the cave was approximately 7°C.

No Indiana bats or other bats were observed during the survey of . No dead bats or any signs of use by bats were observed in the cave. Because air temperatures in the cave appear to be suitable, and a potentially significant length of passage that could not be surveyed may be accessible by bats, BHE surveyed during the spring swarming period.

can be wet and the small, tight entrance makes it difficult to enter. A large boulder at the entrance appears hazardous. If further exploration of the cave is to be done, the entrance area should be braced to insure its stability. Total time to survey the cave was approximately 15 minutes.

BHE surveyed Cave on January 14, 2005. The entrance is a 10-foot wide by 6-foot tall horizontal opening at the bottom of a very steep sinkhole. The entrance opens into a 20-foot wide by 10-foot high room that is approximately 70 feet long and scattered with breakdown (Appendix D). The south end of the room is blocked by a pile of breakdown. A passage 5 feet wide by 3 feet tall and 200 feet long extends to the north and terminates in a room 15 feet wide by 9 feet tall by 25 feet long. The north passage is also littered with breakdown which is coated with sediment. Air temperatures near the ceiling ranged from 10.4°C to 13°C increasing further into the cave. Air flow speed was <1 mph throughout the cave.

No Indiana bats were observed during the survey of Cave. Nine eastern pipistrelles and one big brown bat were counted during the survey. No dead bats were observed in the cave. A small amount of bat guano was observed in the north room where the survey ended. Conditions in a portion of Cave are within the range considered suitable for hibernating Indiana bats, although none of the temperatures were within the optimal range of 4–8°C. An Indiana bat was identified there in autumn, but no Indiana bats were identified during winter. Therefore, we conclude the cave is not a hibernaculum, but may be used by Indiana bats during migration.

Cave is a short, dry passage with a stream flowing into the entrance. It is possible to walk in the large room, but crawling is necessary to survey the northern passage of the cave. Total time to survey the cave was approximately 1.5 hours. Equipment used to perform single rope ascents/descents was not required.

Cave

BHE surveyed Cave January 27, 2005. The entrance is a 10-foot vertical climb down leading to a narrow segment that opens in to a small, muddy, canyon passage averaging 4 feet high by 1.5 feet wide (Appendix D). The passage became impassable by humans approximately 75 feet from the entrance, where accumulated mud blocked further exploration. A small stream present in most of the cave averaged 3 inches deep during the survey. We observed no evidence of flooding inside the cave. Temperatures ranged from 0.4°C near the floor at the entrance to 10.4°C near the ceiling at the back of the cave. Air inflow at the entrance was 1–3 mph and became stronger near the end of the survey,

suggesting presence of more cave beyond this point.

No Indiana bats were observed during the survey of Cave. One eastern pipistrelle was roosting in the cave. No dead bats or signs of use by bats were observed. Because Cave was not surveyed in autumn, and had characteristics potentially suitable for bats, BHE surveyed this cave during the spring staging period.

Cave is a short muddy cave but potentially connects to a larger system. Time inside the cave was less than 30 minutes and no special equipment was necessary for the survey.

Cave

BHE surveyed Cave on January 18, 2005. The entrance is an 8 foot vertical descent that opens into a small room 8 feet wide, 10 feet long, and 8 feet tall (Appendix D). From this point a walking passage leads to the larger "Junction Room," from which multiple passages extend in several directions. To the north from the Junction Room, BHE surveyed to the North Waterfall. Beyond the North Waterfall, a lengthy passage to the north, named "Methane Meander," was not surveyed because high water was hazardous for surveyors.

BHE surveyed the South Waterfall Passage, which extends south west from the Junction Room. BHE also surveyed the Crystal Falls Passage, which extends south east from the Junction Room. BHE was unable to survey approximately 1200 feet of Cave.

Air temperatures near the ceiling ranged from 7°C near the entrance to 14.2°C at the ends of the South Waterfall passage and in the Crystal Falls Room. Air temperature near the ceiling along the North Waterfall passage was between 13.3 and 16.1°C. The temperature of air near the ceiling was consistently greater than that near the floor. Air flow was <1 mph at the entrance and air outflow was detected throughout the cave. We observed evidence of recent flooding to the ceiling along portions of the South Waterfall and Crystal Falls passages.

No Indiana bats were observed during the survey of Cave. Thirty-four eastern pipistrelles, five little brown bats, and one big brown bat were counted during the survey. No signs of use by bats and no dead bats were observed in the cave. Air temperatures inside Cave are greater than those considered suitable for hibernating Indiana bats. Results of autumn and winter surveys indicate Cave is not occupied by Indiana bats during those seasons.

Cave is an extensive maze cave that required three hours to survey with three teams of two people. High water levels in the Methane Meander and other "bathtub" areas are potential hazards. A hand line was necessary to exit and enter the cave.

Cave

Cave has two entrances and was classified by the USFWS as having low potential suitability for Indiana bats. BHE surveyed both entrances to Cave on December 15, 2004. The larger entrance opens into a large tunnel which ends approximately 50 feet from the entrance in breakdown that prevents further human movement, but may be passable by bats (Appendix D). The smaller entrance leads to a mud-floored room. A stream begins 100 feet inside the room and flows through the rest of the cave. During the survey, the depth of the stream was approximately 12–24 inches. Flooding is evident in much of the cave, with sediment deposits reaching

the ceiling in some areas. A few small domes are located toward the rear of the cave but the majority of the passage is a tube 2-4 feet high and 4–8 feet wide. From the smaller entrance, BHE inspected approximately 1800 feet of the interior (Appendix D). Air temperature near the ceiling was 12 to 13°C at the three locations we sampled (Appendix D), and air near the entrance was 9°C. Airflow was not apparent within the tunnel except in the rear areas where there was <1 mile per hour (mph) inflow.

No Indiana bats were observed inside Cave. Seven eastern pipistrelles were observed throughout the cave. No dead bats or any signs of use by bats were observed in the cave.

Approximately 400 feet of the cave was not inspected. Based upon the cave map and previous surveys (Connor, pers. com), BHE concluded the remaining 400 feet of tunnel is similar to the 1800 feet we surveyed. Because air temperatures are warm and there is evidence of flooding to the ceiling of the cave, we conclude Cave does not provide suitable winter habitat for Indiana bats.

Cave is wet and muddy. Flooding is a serious threat for this cave and it should not be entered during or just after heavy rain or snowmelt. Total time to traverse 1800 feet and back was approximately 3.5 hours, with much of that time spent crawling on hands and knees through 1–2 feet of water. Gear used to perform single rope ascents/descents is not required to survey Cave.

Cave

BHE surveyed Cave on January 11, 2005. The entrance is a 1-foot by 2-foot hole at the bottom of a sinkhole. A narrow crawlway leads to a pit approximately 5 feet in diameter and 12 feet deep (Appendix D). At the bottom of the pit is a small passage where water exits the cave but is impassable by humans. The sides of the pit are decorated with flowstone and there are several small stalagmites located in the ceiling of the pit area. There was no evidence of flooding in the cave. Water was present on the walls and ceiling and a small stream was flowing at the bottom of the pit. Air temperature was 10.8°C near the floor and to 11.6°C near the ceiling at the entrance. Air outflow was <1 mph at the entrance.

No Indiana bats or other bats were observed during the survey of Cave. No dead bats or any signs of use by bats were observed in the cave. Conditions in Cave are within the range considered suitable for hibernating Indiana bats, although none of the temperatures were within the optimal range of 4–8°C. No Indiana bats were identified during autumn or winter. Therefore, we conclude the cave is not occupied by Indiana bats during autumn or winter.

Cave is wet and the small entrance makes it difficult to enter. Total time to survey the cave was approximately 0.5 hours due to the descent into and ascent from the pit. Gear used to perform single rope ascents/descents is required to survey Cave.

Cave

was surveyed by BHE on January 26, 2005. The entrance is a narrow crawl that opens into a room 12 feet wide by 20 feet long by 12 feet high, which is filled with breakdown (Appendix D). From the room, a narrow passage containing a stream with high water leads to the north, and an impassable tunnel extends to the south. The

north passage is accessible only during drought conditions and could not be surveyed on January 26. Air temperatures near the cave ceiling ranged from 5.8°C near the entrance to 9.4°C in the room. Air outflow was <1 mph in the cave.

No Indiana bats were observed during the survey of . Six eastern pipistrelles were counted during the survey. No dead bats or signs of use by bats were observed in the cave. Conditions in are within the range considered suitable for hibernating Indiana bats. No Indiana bats were identified during autumn or winter. Therefore, we conclude the cave is not occupied by Indiana bats during autumn or winter.

is a small wet cave that contains two impassable tunnels. Past surveys indicate that there may be a submerged passage leading to a larger system toward the back of the cave. Vertical caving equipment is not required to visit the cave. Total time to survey the cave was 20 minutes.

BHE surveyed Cave on January 25, 2005. The entrance to the cave is a narrow passage located at the bottom of a large sinkhole. The cave contained one passage/room measuring 80 feet long by 10 feet wide by 4 feet tall (Appendix D). A stream and pool occupied most of the floor and the ceiling was very wet. There was no evidence of recent flooding inside the cave. Air temperatures near the ceiling ranged from 6.8 to 11.2°C and air outflow was slight (<1 mph).

No Indiana bats or other bats were observed during the survey of Cave. No dead bats or signs of use by bats were observed in the cave. Conditions in are within the range considered suitable for hibernating Indiana bats. No Indiana bats were identified during autumn or winter. Therefore, we conclude the cave is not occupied by Indiana bats during autumn or winter.

was historically part of the Blair System and was connected to , but the connection is now underwater. The cave is 0.25 mile from the road, and took approximately 15 minutes to survey.

BHE surveyed on January 24, 2005. The entrance is a small vertical passage located at the bottom of a large sinkhole. The cave consists of a single narrow canyon passage approximately 5 feet tall, 2 feet wide, and 200 feet long (Appendix D). A stream was flowing throughout the cave; water depth averaged 6 inches. At both ends of the passage, the tunnel becomes too narrow for humans to access. We could not discern the length of the portions that could not be surveyed. Air temperature near the ceiling ranged from 3.2°C at the entrance to 12.8°C at the stopping point of the survey. Air outflow was <1 mph in the cave.

No Indiana bats were observed during the survey of . Five eastern pipstrelles were counted during the survey. No dead bats or signs of use by bats were observed in the cave. Conditions in Cave are within the range considered suitable for hibernating Indiana bats. However, no Indiana bats were identified during autumn or winter. Therefore, we conclude the cave is not occupied by Indiana bats during autumn or winter.

BHE spent approximately 1 hour surveying . The tight passage required

extra time to navigate, but no special equipment was required to survey the cave.

Cave

BHE surveyed cave on January 19, 2005. The entrance to the cave is a large passage that leads to a small waterfall and splash-pool. The waterfall must be climbed to access to the rest of the cave. The passage behind the waterfall splits into two separate parallel passageways (Appendix D). Streams flow along the entire length of both passages. The southern passage is approximately 1500 feet and is wide enough to travel walking or stooping. The southern passage contains several dome rooms. The northern passage is narrower and requires crawling. At the "Crevice" the passage narrowed significantly and we terminated the survey. Approximately 1800 feet of the north passage was not surveyed.

There were no signs of significant flooding in either passage; water depth in both streams averaged sixteen inches. Air temperature near the ceiling ranged from 9.4 near the entrance, to 13°C along the north passage and 15.2°C along the south passage. Air outflow was very slight (<1 mph) throughout the cave.

No Indiana bats were observed during the survey of Cave. No dead bats or signs of use by bats were observed in the cave either. Thirty eastern pipistrelles and nine little brown bats were counted during the survey. Air temperatures tended to be warmer than those in caves typically occupied by hibernating bats. However, because we were unable to survey a significant portion of the cave, BHE surveyed Cave during the spring swarming period.

Cave is extensive and wet in places. A ladder was required to climb the waterfall. The portion that was surveyed required three hours by two teams (one for each passage).

BHE surveyed on January 11, 2005. The entrance is a vertical shaft located at the bottom of a large sinkhole. The shaft is approximately 47 feet deep and terminates in a small room (Appendix D). Air temperature at the bottom of the pit was 9.6°C and slight (<1 mph) airflow was detected, but the direction of air flow could not be determined.

No Indiana bats or other bats were observed during the survey of . No dead bats or any signs of use by bats were observed in the cave. Conditions in are within the range considered suitable for hibernating Indiana bats, although air temperature was greater than the range considered optimal. No Indiana bats were identified during autumn or winter. Therefore, we conclude the cave is not occupied by Indiana bats during autumn or winter.

is 0.25 mile from the road, and the parking area is restricted with a locked gate. Total time to survey the cave was approximately 0.5 hours. Gear used to perform single rope ascents/descents is required to survey the cave.

is a pit that is also identified as on some diagrams. BHE surveyed on January 11, 2005. The entrance is a sinkhole 1.5–2 feet in diameter, that opens into a room 8 feet wide by 15 foot tall by 10 feet long (Appendix D). The room consists of flowstone and is marked with features such as draperies and soda straws. Two small, crescent shaped tunnels extend from the north and south corners of the room. The south passageway was 4

inches wide by 2 feet tall. The north passage was 5 inches wide by 6 feet tall. Both passageways were impassible to humans or bats. Water flowed down the walls of the pit and dripped from the ceiling. A trickle of a stream present at the bottom of the pit, which seemed to flow through the south passage, as well as through several crevices and small, porous openings in the floor. Because the cave is mainly a vertical opening into a room, air temperature and air movement were only recorded at the entrance and the floor. The air temperature ranged from 9 to 10°C and air flow was 1–3 mph at the entrance and <1 mph at the floor. Direction of air flow was not determined.

No Indiana bats or other bats were observed during the survey of . No dead bats or any signs of use by bats were observed in the cave. Conditions in are within the range considered suitable for hibernating Indiana bats, although air temperature was greater than the range considered optimal. No Indiana bats were identified during autumn or winter. Therefore, we conclude the cave is not occupied by Indiana bats during autumn or winter.

is very wet and the small, tight entrance makes it difficult to enter. Total time to vertically traverse the 15 feet was approximately 0.5 hours. Gear used to perform single rope ascents/descents is required to survey .

BHE surveyed on January 11, 2005. The entrance is a sinkhole which extends to a vertical shaft for about 22 feet (Appendix D). Approximately 10 feet down the shaft is a small horizontal tunnel to the north measuring 2 feet wide by 4 feet tall. We were able to access approximately 5 feet of the horizontal tunnel, and it appears to end after approximately 10 feet. At the bottom of the vertical shaft is a room approximately 5 feet wide, 10 feet high, and 11 feet long. A tunnel leading from the room becomes too narrow for human passage and continues an unknown distance. This tunnel at the bottom of the shaft is blocked by large breakdown piles but may be passable by bats. There was no stream present at the bottom of the cave. A column extending from the cave floor to the entrance limits space in the vertical passage. Air temperature and air movement were recorded at the entrance and the bottom of the vertical shaft. Air temperature ranged from 8 to 9°C and air inflow was 1–3 mph at the entrance.

No Indiana bats or other bats were observed during the survey of . No dead bats or any signs of use by bats were observed in the cave. Conditions in are within the range considered suitable for hibernating Indiana bats, although air temperature was slightly greater than the range considered optimal. No Indiana bats were identified during autumn or winter. Therefore, we conclude the cave is not occupied by Indiana bats during autumn or winter.

is wet and narrow. Standing is possible in the majority of the cave with some crouching to maneuver around the column in the shaft. Total time to traverse the 22 to 25 feet of vertical passage and explore the side tunnels was approximately 0.5 hour. Gear used to perform single rope ascents/descents is required to survey .

BHE attempted to inspect on January 27, 2005. The entrance is horizontal and is approximately 4 feet wide by 1 foot high. A stream 2–3 inches deep

flowed out of the entrance (Appendix D), making entry into the cave impossible. Air temperature just inside the entrance of the cave was at 7.8°C and no air movement was detected.

Because the entrance is very narrow, may be difficult for bats to enter. However, because we were unable to inspect the interior, habitat suitability is unclear. BHE surveyed during the spring swarming period (Appendix C, Table 4).

Cave

BHE surveyed Cave on December 16, 2004. The entrance opens into a tunnel 3.5 feet wide by 4 feet tall, which continues approximately 400 feet until a 30-foot long segment of high water (a "bathtub") restricts further access by humans (Appendix D). The map indicates the tunnel continues for an additional 750 feet and may be passable by bats. A stream begins 75 feet inside the entrance and flows through the rest of the cave. During the survey, the depth of the stream was approximately 1 foot. Flooding is evident in much of the cave, with sediment deposits reaching the ceiling in some areas. The majority of the passage is a tube 2.5–4 feet wide by 3–4.5 tall. A PVC pipe was present along the length of the surveyed passage. Air temperatures inside the cave were consistently 12 to 14°C, with the entrance being significantly cooler at 2°C. Air inflow was <1 mph throughout the tunnel.

No Indiana bats were observed during the survey of Cave. Two eastern pipistrelle bats were observed near the end of the surveyed portion of the cave. No dead bats or any signs of use by bats were observed in the cave. Air temperatures in Cave tend to be greater than those considered ideal for hibernating Indiana bats. Although approximately 750 feet of the cave was not inspected, we concluded that section would not be readily accessible to bats because there was only approximately 4 inches of air space over the bathtub. Evidence of flooding to the ceiling also suggests the cave is not suitable for hibernating bats.

Visiting Cave requires nearly total immersion. Flooding is a serious threat for this cave and it should not be entered during or just after heavy rain or snowmelt. Total time to traverse 450 feet and back out took approximately 0.5 hours. Gear used to perform single rope ascents/descents is not required to survey Cave.

Cave

BHE surveyed Cave on January 13, 2005. The entrance is a 5 foot wide by 3 foot tall horizontal tunnel on the side of a former quarry wall (Appendix D). Breakdown at the entrance has created a short slope which leads to the cave floor, which is 7 feet below the entrance. The passageway continues east for approximately 55 feet. It is 4 feet wide by 10 tall and becomes blocked by breakdown. A perpendicular tunnel extends to the south for about 15 feet down a short drop to a room approximately 4 feet wide by 12 foot tall by 10 foot long, which ends in a pile of breakdown. This area contains a 1-foot diameter puddle with standing water that appears to continue east, but is not accessible. On the west side of the room is a connecting room measuring 6 feet by 8 feet wide by 15 feet tall. This room is 6 feet above the cave floor and can only be reached by a ladder. No stream was noted in the cave and there was no evidence of flooding. Air temperatures ranged from 9.4 to 11.6°C and were consistent further into the cave. Air inflow was <1 mph

throughout and air flow direction was not detected at the back/end the cave.

No Indiana bats were observed during the survey of Cave. Three eastern pipistrelles were counted during the survey. No dead bats or any signs of use by bats were observed in the cave. Conditions in are within the range considered suitable for hibernating Indiana bats, although air temperature was greater than the range considered optimal. No Indiana bats were identified during autumn or winter. Therefore, we conclude Cave is not occupied by Indiana bats during autumn or winter.

Cave is a short, dry passage relatively easy to access. Total time to survey the cave was approximately 0.5 hour. Gear used to perform single rope ascents/descents is not required, but a ladder is necessary to reach the west room.

Cave

BHE attempted to survey Cave on January 12, 2005. The entrance was 2 feet wide by 1 foot tall and consisted of unstable rock that had partially collapsed blocking some of the entrance (Appendix D). The stream flowing out of the cave had a swift current and was 3–4 inches deep inside the cave. There was evidence of flooding and due to the amount of water inside the cave. Hazards associated with the unstable entrance and high water within the cave prevented inspection of the cave interior.

Air temperature just inside the entrance and 5 feet into the cave was 10.4°C and 12.2°C, respectively, and slight air flow (<1 mph) was detected in both locations.

Because we were unable to inspect the interior, BHE surveyed Cave during the spring swarming period (Appendix C, Table 4).

Cave

BHE surveyed Cave on January 26, 2005. The horizontal entrance is narrow and is negotiated by belly crawling or crawling on hands and knees. The tunnel extends approximately 400 feet where it opens into a room measuring 20 feet wide by 15 feet long by 8 feet high (Appendix D). A narrow tunnel leads from this room to the main passage that is 4 feet wide by 15 feet high. The stream and associated trunk passage are located at the end of this section and continue for approximately 2000 feet. Several domes and breakdown areas are encountered along this route up to Thunder Hall, which is a large room 40 feet wide by 50 feet long by 40 feet tall. It is located near the surface and tree roots can be seen growing through the ceiling. Large amounts of mud have accumulated in this section. BHE did not survey several short narrow passages extending from the main passage.

We observed evidence of flooding nearly to the cave ceiling apparent in the entry passageway. Air temperature near the ceiling ranged from 3.4°C at the entrance to 12.6°C near the rear of the cave. Air flow was strong at the entrance of the cave and averaged 4–7 mph but was <1 mph further into the cave.

No Indiana bats were observed during the survey of Cave. One hundred and seven eastern pipistrelles, 86 little brown bats, 1 northern long-eared bat and two unidentified Myotis were counted during the survey. Two dead bats that could not be identified also were collected. One area (see map) contained small clusters of little brown bats.

Conditions in Cave are within the range considered suitable for hibernating Indiana bats, although air temperature in the main tunnel was greater than the range considered optimal. No Indiana bats were identified during autumn or winter. Therefore, we conclude Cave was not occupied by Indiana bats during autumn or winter.

is an extensive cave that is wet and narrow in places. Survey time in the cave was approximately 4 hours and no special equipment was required. The cave is 0.25 mile from the road.

Cave

BHE surveyed Cave on January 18, 2005. The entrance is a horizontal narrow tunnel about 2 feet in diameter. Beyond the entrance is a 200-foot long tunnel that terminates in a room 15 feet in diameter and 7 feet high (Appendix D). A stream and a pool of standing water are present in the tunnel. We observed evidence of flooding to the ceiling within the tunnel. Beyond the room, the cave continues, and may extend up to 1300 feet. Because the cave had not previously been mapped, the extent of Cave is unknown. The survey was discontinued just past the room due to high water and low ceilings.

Air temperature near the ceiling was 9.4°C near the entrance and 14.4°C approximately 100 feet into the cave. Air outflow was <1 mph throughout the cave.

No Indiana bats or other bats were observed during the survey of Cave. No dead bats were observed in the cave. No signs of use by bats were observed in the cave. Air temperatures in Cave were to be greater than those considered suitable for hibernating Indiana bats. Evidence of flooding to the ceiling also suggests the cave is not suitable for hibernating bats.

Cave is a long, wet and narrow passage. Total time to survey a portion of the cave was approximately 1.0 hour. Gear used to perform single rope ascents/descents is not required to survey Cave.

BHE surveyed on January 12, 2005. The horizontal entrance is 10 feet wide by 5 feet tall and opens to a tunnel 10 feet wide by 8 feet tall by 150 feet long (Appendix D). Standing water was about 3 feet deep throughout the tunnel. A layer of silt 6–7 inches deep also covers the floor. Air temperatures near the ceiling ranged from 10.0°C near the entrance to 7.8 C inside the cave. Air flow was slight (<1 mph) throughout the tunnel; air flow direction was not determined.

No Indiana bats were observed during the survey of . Seven big brown bats and two eastern pipistrelles were counted during the survey. No dead bats or any signs of use by bats were observed in the tunnel. Conditions in are within the range considered suitable for hibernating Indiana bats. An Indiana bat was identified there in autumn, but no Indiana bats were identified during winter. Therefore, we conclude the cave is not a hibernaculum for the species, but may be used by Indiana bats during migration.

is a short, wet passage. It is possible to walk the entire tunnel. Total time to survey the cave was approximately 0.5 hour. Gear used to perform single rope ascents/descents is not required but chest waders or a full wet suit is necessary.

Cave

BHE surveyed Cave on January 13, 2005. The entrance is a 3 foot wide by 4 foot tall sinkhole on the side of a small hill. Breakdown in and around the entrance has partially filled the tunnel, creating a slope down into the cave. From the entrance, the tunnel winds north and contains large amounts of breakdown (Appendix D). A passage 8 feet wide by 1.5 tall extends about 6 feet land opens into a large room. The room is 60 feet wide by 20 feet tall by 200 feet long and also contains large amounts of breakdown. At the north end of the room, the cave ends in a pile of breakdown. A lower level room branches to the west but was too narrow to survey. A stream flowed into the cave, but no standing water was present and there was no evidence of flooding. Air temperature ranged from 11.6 to 15.4°C becoming warmer further into the cave. Air inflow was slight (<1 mph) throughout the cave.

No Indiana bats were observed during the survey of Cave. One little brown bat and 68 eastern pipistrelles were counted during the survey. No signs of use by bats or dead bats were observed in the cave. Air temperatures are above the range suitable for hibernating Indiana bats within nearly all of Cave. Two male Indiana bats was identified there in autumn, but no Indiana bats were identified during winter. Therefore, we conclude the cave is not a hibernaculum, but may be used by Indiana bats during migration.

Cave is a short, mostly dry tunnel. It is possible to walk through most of the cave after crawling into the entrance. Total time to survey the cave was approximately 2 hours. Gear used to perform single rope ascents/descents is not required to survey Cave.

Cave

BHE surveyed Cave on January 13, 2005. The entrance is a 3 foot wide by 2 foot tall horizontal opening in a rock outcrop next to a stream (Appendix D). The entrance opens into a narrow 1-foot wide by 4-inch tall passage which could not be surveyed. No evidence of flooding was noted. No airflow was detected and it is unclear if the cave continued past this point. Ceiling temperatures were 11.4°C and 10.6°C.

No Indiana bats or other bats were observed during the survey. No dead bats or any signs of use by bats were observed in the cave. Because no bats were observed during autumn or winter surveys, we conclude Cave is not occupied by Indiana bats during autumn or winter.

Gear used to perform single rope ascents/descents is not required to survey Cave.

Cave

BHE surveyed Cave on January 20, 2005. The cave entrance is a 6 foot vertical descent that leads into a tunnel large enough to walk through (Appendix D). The tunnel opens into a large domed room containing several piles of breakdown. A tunnel to the lower stream level passage branches from the room. Several other large rooms, domes, and smaller passages are located along the lower stream passage. BHE surveyed the entirety of the cave. No evidence of flooding was apparent. Air temperature near the ceiling ranged from 10.6 to 12.2°C. Air flowed out slightly (<1 mph) in the northern passage, and in slightly the southern passage.

No Indiana bats were observed during the survey of Cave. No dead bats were observed but there were several areas

that contained guano. One hundred seventy-nine eastern pipistrelles, 56 little brown bats, and eight northern long-eared bats were counted during the survey. One area of the cave (Appendix D) contained small clusters of little brown bats. Air temperature within Cave is within the range suitable for hibernating Indiana bats, but is warmer than the range considered optimal. Because no Indiana bats were observed in the cave during autumn or winter, we conclude the cave is not occupied by Indiana bats during those seasons.

Cave contains extensive passages with large rooms. Survey time in the cave was approximately 3.5 hours and no special equipment was required. The cave is 2 miles from the road.

BHE surveyed Cave on January 18, 2005. The entrance to the cave is a 9 foot vertical descent into a narrow passage. The passage leads to a large room that contains a upper and lower tunnel (Appendix D). These two routes eventually link with each other but also contain various dead end branches and connections to other portions of the cave. There was no evidence of flooding in the cave but the entrance can be blocked by flood water during heavy precipitation. Air temperature near the ceiling ranged from 11.6 to 12.8°C and air outflow averaged <1 mph.

No Indiana bats were observed during the survey of Cave. No dead bats or signs of use by bats were observed in the cave either. Twenty six eastern pipistrelles and seven little brown bats were counted during the survey. Air temperatures are within the range suitable for hibernating Indiana bats, but are warmer than temperatures considered optimal. No Indiana bats were captured or observed in the cave during autumn or winter. Therefore, we conclude Cave is not occupied by Indiana bats during autumn or winter.

Cave is an easy cave to survey with a little more than 1400 feet of walking and crawling passageway. This cave should not be visited when heavy rains are forecasted because the entrance may flood shut. No special equipment is necessary to survey the cave.

Cave

BHE surveyed Cave on two separate occasions in 2005. The first survey occurred on January 21, and the second on January 25. The entrance is a narrow descent into a room measuring 12 feet wide, 20 feet long, and 5 feet high (Appendix D). A steep slope leads from this room to the trunk passage that contains large piles of breakdown. A segment of the cave named Aqua Avenue contains "bathtubs" where the combination of low ceiling and high water can restrict airspace in the tunnel. BHE surveyed upstream and downstream throughout the cave, up to the Reid Room, which connects with the Cave system.

Air temperature near the ceiling of the cave ranged from 11.4 to 12.6°C during the first survey, and was as high as 14.6°C during the second visit. Slight air outflow was detected throughout the cave.

Three Indiana bats were observed roosting singly in a dead-end trunk passage that connected with High Hall (Appendix D). The ceiling temperature near the Indiana bats was 12.4°C. is part of the same system as r, a known Indiana bat hibernacula, but the Indiana bats in are found mainly at the entrance,

approximately 2 miles from the Indiana bats found in .

No dead bats were observed but there were several areas that contained guano. Five hundred and two eastern pipistrelles and six hundred fifty-five little brown bats were also counted during the survey.

is an extensive, maze cave that involves vertical free climbs, low wet crawls, and tight passages. Surveys should be completed by no less than four people for safety reasons. Flooding is a definite hazard and the cave should not be done during, or shortly after heavy rain events. Total time to survey the cave was seven hours and no special equipment was required.

Cave

BHE surveyed Cave on January 20, 2005. The entrance is a 4 foot by 6 foot opening located at the bottom of a large sinkhole. The entrance opens to a large room from which extend a main passage and several smaller dead-end passages (Appendix D). The main route leads to several large rooms containing piles of breakdown. One of the tunnels contains a stream and eventually narrows to less than 3 feet high. There was evidence of flooding in the stream passage, but flooding apparently does not reach the ceiling. Some areas contained pools of water approximately 10 inches deep. Air temperature near the ceiling ranged from 12.2 to 13.6°C and air outflow was <1 mph.

No Indiana bats were observed during the survey of Cave. No dead bats were observed but guano was observed in several areas. We observed 166 eastern pipistrelles, 10 little brown bats, and one northern long-eared bat during the survey. Air temperature within a portion of Cave is within the range suitable for hibernating Indiana bats, but tends to be warmer than the range of optimal temperatures. Results of autumn and winter surveys indicate the cave is not occupied by Indiana bats during autumn or winter.

Cave is an extensive cave that is easy to survey. A detailed map is necessary to navigate through convoluted passages. Total time to survey the cave was three hours and no special equipment was required.

BHE surveyed Cave on January 12, 2005. The entrance is a sinkhole 10 feet by 5 feet wide that opens on the ceiling of a room 40 feet wide, 30 feet tall, and 50 feet long (Appendix D). The room consists of flowstone and is marked with features such as stalactites, stalagmites, and cave popcorn. Large piles of breakdown litter the floor. The south end of the room narrows into a 15-foot long passage which ends in an 18-foot tall domed chamber. A stream flowed through the cave near the west wall, but the tunnel was too narrow to be explored. There was no evidence of flooding in the room or passages. Water flowed down the walls and dripped from the ceiling of the large room. Air temperature was 10.6°C near the entrance, but decreased to 4.5°C in the domed chamber at the bottom of the pit. Air flow was slight in an undetermined direction.

No Indiana bats were observed during the survey of Cave. Fifteen little brown bats and 11 eastern pipistrelles were counted during the survey. Nineteen of those bats were located in the eastern portion of the cave along the ceiling and wall near the vertical shaft entrance. Seven bats were located near the 15 foot passage. No dead bats or any signs of use by bats

were observed in the cave. Conditions in Cave are within the range considered suitable for hibernating Indiana bats. A female Indiana bat was identified there in autumn, but no Indiana bats were identified during winter. Therefore, we conclude the cave is not a hibernaculum, but may be used by Indiana bats during migration.

Cave is a sinkhole with a vertical drop into a large room. Total time to survey the cave was approximately 2.0 hours. Gear used to perform single rope ascents/descents is required to survey Cave.

[redacted]

During spring 2005, BHE surveyed five of the caves that could not be fully inspected during winter. , , and caves could not be entered during winter due to hazardous conditions or narrow entrances. In and caves, significant portions of the interiors could not be inspected, and presence of Indiana bats could not be fully determined during the winter survey. We also surveyed Cave during spring because that cave had not been surveyed during autumn. Surveys were timed to coincide with the spring staging period when Indiana bats are active near hibernacula prior to migration.

Between April 10 and 29, 2005, BHE used harp traps to survey 6 caves for 2 nights each (n=12 trap nights). A total of 27 bats was captured at 4 caves (Appendix C, Table 4). No Indiana bats were captured during the spring survey. Species of bats captured included little brown bats (n=4), eastern pipistrelles (n=17), northern long-eared bats (n=4), and big brown bats (n=2). The greatest number of bats was captured at Cave (n=24).

Bat vocalizations were recorded near cave on six occasions between April 10 and 28 (Appendix G). Recordings were made near the mouth of Cave, and about 60 feet away, in the same locations as sampling conducted during autumn 2004.

At the mouth of Cave, the minimum number of vocalizations (352 calls) was recorded on April 28, and the maximum number (7655 calls) was recorded on April 10. The number of calls recorded at the mouth of Cave generally decreased between April 10 and 28. Comparing the number of calls recorded in the forest with those recorded in the cave mouth suggests the relative bat activity was greatest near the cave mouth on April 10, then generally decreased to about 40 percent of the total bat activity detected on April 28. These data suggest the peak of staging activity at Cave occurred on or before April 10. We infer from these data that staging activity at nearby hibernacula occurred on similar dates, and that some bats remained active near hibernacula through April 28.

Discussion

BHE conducted surveys of 31 caves during autumn, winter, and spring to investigate the presence of Indiana bats and to assess suitability of the caves for hibernating Indiana bats. Surveys were timed to occur during autumn swarming, winter hibernation, and spring staging periods. Results of monitoring at a known hibernaculum verified that our surveys were conducted when bats were active near hibernacula. Surveys were conducted according to guidance provided by the U.S. Fish and Wildlife Service, Bloomington Field Office.

None of the caves were occupied by Indiana bats during more than one season. One

cave, , was occupied by Indiana bats during winter hibernation. Three individual Indiana bats were observed inside Cave. The species was not captured during autumn at Cave. However, because it is used by hibernating Indiana bats, presence of the species at Cave during autumn swarming and spring staging cannot be ruled out. is connected to the system, in which greater than 600 hibernating Indiana bats have been observed (Brack and Dunlap 1997). Connection to a hibernaculum may increase the likelihood Indiana bats use Cave. Air temperature inside Cave is warmer than the range (4–8°C) considered optimal for hibernating Indiana bats. While the majority of Indiana bats hibernating in Cave were observed where air temperature was 8°C, some of them were found where air temperature was 12.4°C (Brack and Dunlap 1997), just as in Cave. Therefore, while Cave does not appear to provide optimal winter habitat, results of this survey indicate it is suitable and occupied by hibernating Indiana bats.

During the winter survey of and caves, BHE observed hibernating bats that were identified as *Myotis*, but could not be identified to species due to their position (e.g., high on the ceiling or hidden in a crevice). In Cave, no other *Myotis* bats were observed. Air temperatures inside Cave were warmer than those considered optimal for hibernating Indiana bats, and were >13°C near the end of the cave. No bats were captured at Cave during the autumn survey. Without additional investigation, presence of Indiana bats in Cave cannot be completely ruled out.

In Cave, 86 little brown bats were observed in addition to the two unidentified *Myotis*. During the autumn survey, 25 *M. lucifugus* and eight *M. septentrionalis* were captured from Cave. Air temperatures near the ceiling of Cave were warmer than the optimal range for hibernating Indiana bats. Therefore, it is likely the two *Myotis* in were not Indiana bats.

Five caves were occupied by Indiana bats during the autumn swarming period. When BHE inspected four of the caves during winter, we determined three provide suitable winter habitat, but were not occupied by Indiana bats. The fourth cave, , does not appear to provide suitable winter habitat; air temperatures within the cave exceeded 13°C. Cave, where six Indiana bats were captured during autumn, was not inspected by BHE during winter, so suitability of winter habitat of Cave is unknown. Results of this investigation confirm , , , , and caves are used by Indiana bats during autumn swarming.

No Indiana bats were captured at the six caves surveyed during spring. Results of spring surveys indicate , , , , and caves were not occupied by Indiana bats during spring, and suggest those caves were not used by hibernating bats during the winter of 2004/2005.

Of the 30 caves we inspected during winter, six appear to be unsuitable for hibernating Indiana bats because air temperature near the ceiling exceeds 13°C. In Cave, the portion of the cave surveyed was unsuitable due to warm air temperatures. Habitat suitability of the 1800 feet that could not be surveyed is unknown. Similarly, habitat suitability inside , , and was not assessed because the interior of those caves

could not be inspected. However, results of autumn and spring surveys indicate , , and were not occupied by Indiana bats between Autumn 2004 and Spring 2005.

Twenty-one of the caves surveyed appear to provide suitable winter habitat for Indiana bats. Assessment of habitat suitability was based primarily upon air temperature near the cave ceiling, where bats roost. Evidence of flooding to the cave ceiling was also considered. Because temperatures were measured on a single day for each cave, we conservatively established 13°C as the maximum suitable temperature. Previous long-term studies of air temperature in Indiana bat hibernacula indicate fluctuations >10°C over several days (Dunlap 1997, Tuttle and Kennedy 1999). While most hibernating Indiana bats are found where temperatures are 4–8°C (USFWS 1999), they have been observed where air temperature is >11°C (BHE 2003, Brack and Dunlap 1997). In 21 of the caves surveyed, air temperature near the ceiling was <13°C in all or a substantive portion of the cave. However, none of the caves surveyed contained areas, other than the entrance inside the twilight zone, where air temperatures were within the optimal range of 4–8°C. Based upon the results of harp trap surveys and winter inspections, those 21 caves were not occupied by hibernating Indiana bats during the winter of 2004/2005.

Acknowledgements

We appreciate the cooperation and access that landowners provided during surveys of caves. Special thanks to Anmar Mirza, Dave Everton, and Tim Laun for assistance with cave surveys. Thanks to INDOT; Federal Highways Administration (FHWA); Tom Cervone, Garre Connor, and Josh Sherretz of Bernardin, Lochmueller and Associates Inc.; the Indiana Geological Survey; and Andrew King, Scott Pruitt, and Lori Pruitt of the U.S. Fish and Wildlife Service (Bloomington Field Office) for their roles and support throughout the project.

Literature Cited

BHE Environmental, Inc. (BHE). 2003. Summary of the on-going climate monitoring study in the Lewisburg limestone mine, Preble County, Ohio July 2002–July 2003. Submitted to the U.S. Fish and Wildlife Service, Reynoldsburg, Ohio Field Office. 10 pp + appendices.

Brack, V. Jr. and K. Dunlap. 1997. A 1996–1997 winter survey for Indiana bats (*Myotis sodalis*) in hibernacula of Indiana. Submitted to the Indiana Department of Natural Resources, Indianapolis, Indiana. 62pp.

Federal Highway Administration (FHWA) and Indiana Department of Transportation (INDOT). 2003a. Final Environmental Impact Statement & Section 4(f) Evaluation: I-69 Evansville to Indianapolis, Indiana. U.S. Department of Transportation, Federal Highway Administration and Indiana Department of Transportation. FHWA-IN-EIS-02-01-F. Prepared by Bernardin, Lochmueller and Associates, Inc. http://www.deis.i69indyevn.org/FEIS/index.html.

Federal Highway Administration (FHWA) and Indiana Department of Transportation (INDOT). 2003b. Tier 1 Biological Assessment for Threatened and Endangered Species: I-69 Indianapolis to Evansville. Prepared by Bernardin, Lochmueller and Associates, Inc. Evansville, Indiana.

Dunlap, K. 1997. Temperature monitoring in three *Myotis sodalis* bat hibernacula. Special Project E2-A121. Submitted to the Indiana Department of Natural Resources, Indianapolis, Indiana. 11pp + appendices.

Tuttle, M.D. 1974. An improved trap for bats. Journal of Mammalogy 55:475–477.

Tuttle, M.D. and J. Kennedy. 1999. Indiana bat hibernation roost evaluation: Phase II--Results from the first annual cycle. Bat Conservation International, Austin, Texas. 12pp + appendix.

U.S. Fish and Wildlife Service (USFWS). 1999. Agency Draft Indiana bat (*Myotis sodalis*) Revised Recovery Plan. Fort Snelling, Minnesota. 53 pp.

Appendix A
Figure

Figure 1 ("Caves near the proposed Interstate 69 in Morgan and Monroe counties, Indiana surveyed autumn 2004 and winter 2004/2005 to investigate presence of the Indiana bat") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Appendix B
Agency Correspondence

United States Department of the Interior
Fish and Wildlife Service

Bloomington Field Office (ES)
620 South Walker Street
Bloomington, IN 47403-2121
Phone: (812) 334-4261 Fax: (812) 334-4273

27 August 2004

Amy Henry
BHE Environmental, Inc.
7041 Maynardville Highway
Knoxville, TN 37918

Virgil Brack, Jr.
Environmental Solutions and Innovations, Inc.
781 Neeb Road
Cincinnati, OH 45233

RE: Pre-survey site-specific coordination and BFO authorization for conducting fall surveys for the Federally endangered Indiana bat at potential hibernacula within 5 miles of INDOT's proposed I-69 corridor in Greene and Monroe counties, Indiana.

Dear Amy and Virgil,

This letter is in response to your letters from BHE Environmental, Inc. (BHE) and Environmental Solutions and Innovations, Inc. (ESI) (dated 13 and 23 August 2004 respectively) requesting authorization from the U.S. Fish and Wildlife Service's Bloomington Field Office (BFO) to conduct fall surveys and radiotelemetry on the Federally endangered Indiana bat (*Myotis sodalis*). These requests regarded conducting fall surveys for the presence of Indiana bats at the entrances of 60 caves (30 by BHE, and 30 by ESI) in association with the above referenced project.

This work would be conducted under BHE's and ESI's Federal permits (TE 809227-16 and TE-023664-12 respectively). BFO Biologist, Andy King, has been in close coordination with the staff of Bernardin, Lochmueller & Associates, Inc. (BLA) and the Indiana Geological Survey regarding which specific caves merit being surveyed in the fall of 2004, their field locations, and access. You are authorized to conduct bat surveys at the 30 caves assigned to your company by BLA as designated in the enclosed attachments. You are authorized to survey the cave entrances using harp traps. If you are unable to safely or effectively erect a harp trap at a cave entrance (e.g., a pit entrance that is too large to safely/completely seal with plastic netting), you may use mist nets or an alternative technique as described in the attached survey protocol.

This letter serves as authorization for you and others specifically named on your Federal permits to conduct bat surveys using harp traps or mist nets at the 30 caves assigned to your respective companies in Greene and Monroe counties between 27 August and 15 October 2004 (Note: a separate authorization

letter will be required from the BFO before any winter cave surveys for Indiana bats associated with this project may be initiated).

The caves in the attached lists have been color-coded according to their perceived likelihood of serving as an Indiana bat hibernaculum and/or a swarming site. The priority of some caves was also elevated because of their close proximity to the I-69 corridor (e.g., , , , and caves). Weather permitting; surveys of all red-shaded caves (highest priority) should be completed from 12 September to 3 October 2004. Similarly, an effort should be made to survey as many of the orange-shaded caves during the 12 September to 3 October time frame as possible. The yellow-shaded caves can be surveyed anytime between 27 August and 15 October.

This letter must be carried with your Federal permit when conducting work at these sites. All captures of Indiana bats should be reported directly to Andy King at this office within 24 hours (voice mail should be left at 812-334-4261 ext. 216 or e-mail Andrew_King@fws.gov).

We understand a potential need to survey alternative caves may arise if access to a previously approved cave is denied. If a cave substitution is warranted/needed, we request that you or BLA coordinate this on a case-by-case basis with Andy King prior to surveying at a new cave. We request that you keep BFO abreast of the anticipated dates and specific caves that you will be surveying on a weekly basis so FWS staff will have an opportunity to visit you in the field. Finally, we remind you and your staff to review your State permits, and amend them as appropriate, if you have not already done so.

If you have questions please contact Andy King (812-334-4261, extension 216).

Sincerely,

Scott E. Pruitt
Field Supervisor

cc: Catherine Gremillion-Smith, Indiana Department of Natural Resources
Tom Cervone, BLA

The following two Cave Lists that accompanied this letter for BHE and ESI have been removed for confidentiality reasons related to the federally endangered Indiana bat.

BAT SURVEY PROTOCOL*
FOR ASSESSING USE OF POTENTIAL HIBERNACULA
(I-69 Tier 2 Studies)

RATIONALE

A typical cave or mine portal survey is an attempt to determine presence or probable absence of the species; it does not provide sufficient data to determine population size or structure. Following these guidelines will standardize procedures for bat surveys at cave and mine portals. Although the capture of Indiana bats confirms their presence, failure to catch Indiana bats does not absolutely confirm their absence.

ASSESSING CAVES/ABANDONED MINES FOR BAT SURVEYS

In general, openings can be dismissed from bat surveys when:

- There is only one horizontal opening less than 6 inches in diameter and no or very little airflow is detected.
- Vertical shafts <1 foot in diameter.
- Passage continues less than 50 feet and terminates with no fissures that bats can access.
- Mines/caves that are prone to flooding, collapsed shut and completely sealed, or otherwise inaccessible to bats.
- Openings, which have occurred recently (within 1 year) due to subsidence.

SAMPLING DATES, TIMES AND TEMPERATUE CRITERIA

- In 2004, fall sampling may be conducted from 29 August thru 15 October.

- Sampling will start ½ hour before sunset and continue for at least 5 hours.

- Weather must provide for:
  1. Temperatures >50° F (10°C) for first 2 hours of sampling and not fall below 35°F (1.6°C) by midnight.
  2. At least 3 hours free of heavy rain and thunderstorms.

- Sampling will be conducted on two evenings. If no bat captures (of any species) occur and no bat activity is noted with a bat detector on the first evening during acceptable weather conditions, sampling can be suspended for the site.

- The shining of lights, and noise will be kept to a minimum with no smoking around the sample site. The use of radios, campfires, running vehicles, punk sticks, citronella candles and other disturbances will not be permitted within 300 feet of site during surveys.

- Before conducting surveys, local residents and/or law enforcement agencies should be informed of the scheduled nighttime activities.

* Adapted from the protocol used by the Pennsylvania Game Commission

EQUIPMENT

No equipment, litter or other debris will be left unattended at site that could result in the capture or entanglement of any animals. Any equipment stored at site between sampling sessions will be clearly labeled with contact information.

Harp Traps (first choice): Place in front of opening and block surrounding space with plastic sheeting or bird netting. Traps should be tended at least once per hour. When the catch rate is high (>25 bats per hour) or during inclement weather, traps should be tended more frequently.

Mist Nets (second choice): 50 denier, 38mm mesh. Place in front or around openings that can not be harp trapped. Nets need to be monitored closely and checked at least once every 20 minutes. At sites with a heavy bat swarm, the net may need to be monitored continuously.

Bat Detector: In addition to the harp trap or mist nets, an ultrasonic bat detector should be on site to periodically monitor general bat activity and to assess the general effectiveness of the harp trap or mist net placement.

Alternative Monitoring Techniques: In situations where cave/mine entrances can not be safely/effectively trapped or netted, bat detectors (e.g., heterodyne or AnaBat) and/or night-vision/infrared/thermal-imaging recording devices should be used to monitor and record bat activity to determine bat use of the site. Bat activity in or around the entrance can be monitored by counting bat passes with a bat detector, or night vision/infrared video tapes can be made providing actual counts of bats entering the opening. As with trapping, monitoring should be conducted for 5 hours. Reporting format will be: Start and end time for 1-hour sample period and bat passes for that hour. If a bat detector is used to monitor a cave/mine entrance, the biologist should 1) manually operate a tunable detector to quantify the amount of bat activity (i.e., tally # of bat passes/hour for 5 hours) at the cave entrance, 2) write down the peak frequency associated with each bat pass, and 3) take field notes describing the bat activity throughout the 5-hour sampling period (e.g., are bats entering and/or exiting the entrance, just passing by etc...).

If alternative monitoring techniques are needed to complete a survey, these should be coordinated with Andy King at the BFO on a case-by-case basis prior to being employed.

CAPTURED BATS

Standard measurements should be taken and recorded for all captured bat species. Photo documentation of Indiana bats is also encouraged.

Fecal Samples: Fecal samples should be collected from Indiana bats (and other species as time allows), clearly labeled, placed within separate Ziploc bags, and stored on ice or in a freezer. Fecal samples may be hand delivered to Andy King at the BFO at any time during normal working hours.

Banding (*M.sodalis* only): A single, uniquely numbered/embossed band (preferably celluloid/plastic) of a high- contrast color (e.g., white) should be placed on the right forearm of each male and the left forearm of each female Indiana bat. If many bats are captured at one time, it is acceptable to only band a subset of the individuals to avoid having to hold them for a long period of time. Please use your best professional judgment.

United States Department of the Interior
Fish and Wildlife Service

Bloomington Field Office (ES)
620 South Walker Street
Bloomington, IN 47403-2121
Phone: (812) 334-4261 Fax: (812) 334-4273

8 April 2005

Amy Henry
BHE Environmental, Inc.
7041 Maynardville Highway
Knoxville, TN 37918

Virgil Brack, Jr.
Environmental Solutions and Innovations, Inc.
781 Neeb Road
Cincinnati, OH 45233

RE: Pre-survey site-specific coordination and BFO authorization for conducting spring surveys for the Federally endangered Indiana bat at potential hibernacula within 5 miles of INDOT's proposed I-69 corridor in Greene, Lawrence, and Monroe counties, Indiana.

Dear Amy and Virgil,

This letter is in response to your letters from BHE Environmental, Inc. (BHE) and Environmental Solutions and Innovations, Inc. (ESI) (dated 4 and 5 April 2005 respectively) requesting authorization from the U.S. Fish and Wildlife Service's Bloomington Field Office (BFO) to conduct spring surveys and radiotelemetry on the Federally endangered Indiana bat (*Myotis sodalis*). These requests regarded conducting spring surveys for the presence of Indiana bats at the entrances of 9 caves (6 by BHE, and 3 by ESI) in association with the above referenced project.

This work would be conducted under BHE's and ESI's Federal permits (TE 809227-16 and TE-023664-13 respectively). BFO Biologist, Andy King, has been in coordination with Garre Conner of Bernardin, Lochmueller & Associates, Inc. (BLA) regarding the specific circumstances prompting the need for each these caves to be resurveyed this spring, their field locations, and access issues. You are authorized to conduct bat surveys at the 9 caves assigned to your respective company by BLA as designated in the table at the end of this letter. You are authorized to survey the cave entrances using harp traps as outlined in the enclosed survey protocol. If you are unable to safely or effectively erect a harp trap at a cave entrance (e.g., a pit entrance that is too large to safely/completely seal with plastic netting), you may use mist nets or an alternative technique as described in the survey protocol.

This letter serves as authorization for you and others specifically named on your Federal permits to conduct bat surveys using harp traps or mist nets at the caves assigned to your respective companies in Greene, Lawrence, and Monroe counties between 9 and 30 April 2005.

This letter must be carried with your Federal permit when conducting work at these sites. All captures of Indiana bats should be reported directly to Andy King at this office within 24 hours (voice mail should be left at 812-334-4261 ext. 216 or e-mail Andrew_King@fws.gov).

If for some reason a cave substitution is warranted/needed, we request that you or BLA coordinate this on a case-by-case basis with Andy King prior to surveying at a new cave. We request that you keep BFO abreast of the anticipated dates and specific order of caves that you will be surveying on a weekly basis so FWS staff will have an opportunity to visit you in the field. Finally, we remind you and your staff to review your State permits, and amend them as appropriate, if you have not already done so.

If you have questions please contact Andy King (812-334-4261, extension 216).

Sincerely,

Scott E. Pruitt
Field Supervisor

BHE's Cave List	ESI's Cave List
Cave Cave Cave Cave Cave (Cave)	Cave Cave Cave

cc: Catherine Gremillion-Smith, Indiana Department of Natural Resources
Tom Cervone, BLA

Enclosures

BAT SURVEY PROTOCOL*
FOR ASSESSING USE OF POTENTIAL HIBERNACULA
(I-69 Tier 2 Studies)

RATIONALE

A typical cave or mine portal survey is an attempt to determine presence or probable absence of the species; it does not provide sufficient data to determine population size or structure. Following these guidelines will standardize procedures for bat surveys at cave and mine portals. Although the capture of Indiana bats confirms their presence, failure to catch Indiana bats does not absolutely confirm their absence.

ASSESSING CAVES/ABANDONED MINES FOR BAT SURVEYS

In general, openings can be dismissed from bat surveys when:

- There is only one horizontal opening less than 6 inches in diameter and no or very little airflow is detected.
- Vertical shafts <1 foot in diameter.
- Passage continues less than 50 feet and terminates with no fissures that bats can access.
- Mines/caves that are prone to flooding, collapsed shut and completely sealed, or otherwise inaccessible to bats.
- Openings, which have occurred recently (within 1 year) due to subsidence.

SAMPLING DATES, TIMES AND TEMPERATUE CRITERIA

- In 2005, spring sampling may be conducted from 9 April thru 30 April.
- Sampling will start ½ hour before sunset and continue for at least 5 hours.
- Weather must provide for:
  1. Temperatures >50° F (10EC) for first 2 hours of sampling and not fall below 35°F (1.6EC) by midnight.
  2. At least 3 hours free of heavy rain and thunderstorms.
- Sampling will be conducted on two evenings. If no bat captures (of any species) occur and no bat activity is noted with a bat detector on the first evening during acceptable weather conditions, sampling can be suspended for the site.
- The shining of lights, and noise will be kept to a minimum with no smoking around the sample site. The use of radios, campfires, running vehicles, punk sticks, citronella candles and other disturbances will not be permitted within 300 feet of site during surveys.
- Before conducting surveys, local residents and/or law enforcement agencies should be informed of the scheduled nighttime activities.

* Adapted from the protocol used by the Pennsylvania Game Commission

EQUIPMENT

No equipment, litter or other debris will be /eft unattended at site that could result in the capture or entanglement of any animals. Any equipment stored at site between sampling sessions will be clearly labeled with contact information.

Harp Traps (first choice): Place in front of opening and block surrounding space with plastic sheeting or bird netting. Traps should be tended at least once per hour. When the catch rate is high (>25 bats per hour) or during inclement weather, traps should be tended more frequently.

Mist Nets (second choice): 50 denier, 38mm mesh. Place in front or around openings that can not be harp trapped. Nets need to be monitored closely and checked at least once every 20 minutes. At sites with a heavy bat swarm, the net may need to be monitored continuously.

Bat Detector: In addition to the harp trap or mist nets, an ultrasonic bat detector should be on site to periodically monitor general bat activity and to assess the general effectiveness of the harp trap or mist net placement.

Alternative Monitoring Techniques: In situations where cave/mine entrances can not be safely/effectively trapped or netted, bat detectors (e.g., heterodyne or AnaBat) and/or night-vision/infrared/thermal-imaging recording devices should be used to monitor and record bat activity to determine bat use of the site. Bat activity in or around the entrance can be monitored by counting bat passes with a bat detector, or night vision/infrared video tapes can be recorded to provide actual counts of bats entering the opening. As with trapping, monitoring should be conducted for 5 hours. Reporting format will be: Start and end time for 1-hour sample period and bat passes for that hour. If a bat detector is used to monitor a cave/mine entrance, the biologist should 1) manually operate a tunable detector to quantify the amount of bat activity (i.e., tally # of bat passes/hour for 5 hours) at the cave entrance, 2) write down the peak frequency associated with each bat pass, and 3) take field notes describing the bat activity throughout the 5-hour sampling period (e.g., are bats entering and/or exiting the entrance, just passing by etc…).

If alternative monitoring techniques are needed to complete a survey, these should be coordinated with Andy King at the BFO on a case-by-case basis prior to being employed.

CAPTURED BATS

Standard measurements should be taken and recorded for all captured bat species. Photo documentation of Indiana bats is also encouraged.

Fecal Samples: Fecal samples should be collected from Indiana bats (and other species as time allows), clearly labeled, placed within separate Ziploc bags, and stored on ice or in a freezer. Do not hold a bat for longer than 30 minutes regardless of whether it has produced a fecal sample or not. Fecal samples may be hand delivered to Andy King at the BFO at any time during normal working hours.

Banding (*M.sodalis* only): A single, uniquely numbered/embossed band (preferably celluloid/plastic) of a high-contrast color (e.g., white) should be placed on the right forearm of each male and the left forearm of each female Indiana bat. If many bats are captured at one time, it is acceptable to only band a subset of the individuals to avoid having to hold them for a long period of time. Please use your best professional judgment.

United States Department of the Interior
Fish and Wildlife Service

Bloomington Field Office (ES)
620 South Walker Street
Bloomington, IN 47403-2121
Phone: (812) 334-4261 Fax: (812) 334-4273

10 December 2004

Amy Henry
BHE Environmental, Inc.
7041 Maynardville Highway
Knoxville, TN 37918

Dr Virgil Brack, Jr.
Environmental Solutions and Innovations, Inc.
781 Neeb Road
Cincinnati, OH 45233

RE: Pre-survey site-specific coordination and BFO authorization for conducting winter cave surveys for the Federally endangered Indiana bat at potential hibernacula within 5 miles of INDOT's proposed I-69 corridor in Greene and Monroe counties, Indiana.

Dear Amy and Virgil,

This letter is in response to your letters from BHE Environmental, Inc. (BHE) and Environmental Solutions and Innovations, Inc. (ESI) (dated 30 November 2004 and 2 December 2004 respectively) requesting authorization from the U.S. Fish and Wildlife Service's Bloomington Field Office (BFO) to conduct winter surveys for the presence of Federally endangered Indiana bats (*Myotis sodalis*) within 60 caves (30 by BHE, and 30 by ESI) in association with the above referenced project.

This work would be conducted under BHE's and ESI's Federal permits (TE 809227-16 and TE-023664-12 respectively). BFO Biologist, Andy King, has coordinated with the staff of Bernardin, Lochmueller & Associates, Inc. (BLA) and the Indiana Geological Survey regarding the caves listed in your letters. Individuals named on your respective permits are authorized to conduct bat surveys within the 30 caves assigned to your company by BLA and listed below Please note that we have coordinated with BLA and have removed cave from BHE's survey list, because the Indiana DNR, Division of Fish and Wildlife, Wildlife Diversity Section plans to have it surveyed by Dr. Virgil Brack, who has been contracted to conduct the routine biennial winter surveys of Indiana bat hibernacula on behalf of the state. A suitable substitute cave has yet to be named to replace This cave substitution and any others that may be warranted/required should be coordinated with Andy King prior to conducting surveys. In addition, BLA, BHE, and Dr. Brack must coordinate with one another to ensure that their proposed survey areas within the Cave System (, , and) do not overlap and to ensure disturbance to hibernating bats will be minimized.

This letter serves as authorization for you and others specifically named on your Federal permits to

conduct winter bat surveys at the 30 caves assigned to your respective companies in Greene and Monroe counties (lists enclosed). All cave surveys should be conducted during January and February 2005, except for and caves, which may be surveyed by BHE as early as mid-December in order to avoid potential winter flooding. The valid winter survey period for this project will not be extended beyond 10 March. Survey methods should generally follow those of Brack et al. (1995; enclosed) to ensure consistency.

If any dead bats (of any species) are encountered, they should be salvaged and submitted to the BFO for ongoing contaminants studies. Hair samples may be collected from Indiana bats (preferably females) to support Dr. Eric Britzke's ongoing stable isotope study. However, removal of hibernating Indiana bats from clusters for the sole purpose of collecting a hair sample is prohibited. Hair samples may only be collected opportunistically from individual bats that have already been aroused from hibernation and/or, fallen from cave ceilings, accidentally been injured etc. Hair samples should be collected following the protocol provided by Dr. Britzke (enclosed). Collection of tissue samples from Indiana bats is not authorized at this time.

This letter must be carried with your Federal permit when conducting work at these sites. If you observe Indiana bats within a previously unknown hibernaculum, you should report this to Andy King at this office within 24 hours (voice mail should be left at 812-334-4261 ext. 216 or e-mail Andrew_King@fws.gov). In addition, we request that you keep Mr. King abreast of your anticipated survey schedule of specific caves on a weekly basis so BFO staff will have an opportunity to assist you in the field when feasible. Finally, we remind you and your staff to ensure your State permits are in order and to amend them as needed, if you have not already done so.

If you have questions please contact Andy King (812-334-4261, extension 216).

Sincerely,

Scott E. Pruitt
Field Supervisor

cc: Catherine Gremillion-Smith, IDNR, Wildlife Diversity Section
Scott Johnson, IDNR, Wildlife Diversity Section
Tom Cervone, BLA

I-69 Winter Hibernacula Surveys for Indiana Bats

Please follow the same survey and reporting methodology used by Brack et al. (1995) below.

Brack, V., Jr., K. Tyrell, and K. Dunlap. 1995. A 1994-1995 winter census for the Indiana bat (*Myotis sodalis*) in hibernacula of Indiana. Unpublished technical report for the Indiana Department of Natural Resources, Division of Fish and Wildlife, Nongame and Endangered Wildlife Program, Indianapolis, Indiana prepared by

MATERIALS AND METHODS

Twenty-two caves were visited in January and February 1995 (Table 1). One of these, Cave, is a Priority I hibernacula for the Indiana bat. Seventeen caves were known non-Priority I hibernacula containing smaller numbers of Indiana bats. Four caves, , (Crawford County), , and , were entered because they had the potential to serve as a hibernaculum because of their physical configuration or because cavers reported clusters of bats.

The methods followed were those of Brack et al. (1993). Bats were tallied by species and by location in the cave. Individuals and small clusters of Indiana bats were counted directly. Larger clusters were measured with a tape measure or engineer's rule when they could be reached; at other times cluster areas were estimated. In and caves, where clusters form on high ceilings, 10x50 binoculars and a 1,250,000 candlepower spot light (Collins Dynamics "Magnum" model search light) were used to count bats. Cluster densities were estimated at 300 bats per square foot (LaVal and LaVal, 1980). Species of bats other than Indiana bats were counted directly. Banded bats were noted, and when possible, band color and number were recorded.

Temperatures were taken at cave entrances, in the twilight area, near clusters of Indiana bats when possible, near concentrations of other species of bats, and at intervals throughout the caves. Temperatures were generally taken with a Raytek Model ST2 infrared thermometer, with a range of -18 to 400°C, an accuracy of + or -2% of reading, and a display to the nearest °C or °F. Occasionally a Schultheis quick recording thermometer was used. It is calibrated by 0.2°C increments.

STANDARDIZATION OF DATA

The reason for this survey, and surveys completed every other year for the past 14 years, is to obtain an accurate estimate of the number of bats hibernating in non-Priority I hibernacula in Indiana. This census is part of a range-wide effort to monitor, over time, the numbers of this endangered bat.

To assure an accurate comparison over time, a number of factors must be considered:

- Data must be collected consistently across years
- Hibernacula must be appropriately searched
- Methods must provide reproducible results
- Safety of the surveyors must be ensured
- Other data potentially of value, now or in the future, and compatibility over time

Using the protocol of Brack et al. (1993), the following items are considered essential to standardize collection, interpretation, and comparison of data over time:

1. Cave name, location, and legal description
2. Date of visit
3. A general description of the cave, including published accounts of the cave (when available)
4. The portion of the cave visited during the survey, including a map locating features of

the cave important to the survey (when available)

5. The number of Indiana bats found
6. The locations of Indiana bats, including maps marking locations where bats were found (when maps are available)
7. Temperatures of areas where Indiana bats hibernate (at a minimum) and other related data such as temperatures of areas where other species hibernate and where no bats were found
8. Other species and numbers of bats using the cave

In an effort to standardize data collection and reporting, the following format was adopted by Brack et al. (1993). It is followed in this report, with the addition of a section to describe equipment or safety considerations.

Each cave is introduced with a brief description of its morphology and character. The name and legal description, including county, U.S.G.S. quadrangle, and quarter section description are in Table 1. Other data are standardized by using the following headings.

Portion of Cave Visited:
Date:
Number of Indiana Bats:
Location of Indiana bats:
Hibernaculum Temperatures:
Other Species of Bats:
Equipment or Safety Considerations:

The text for each cave that contained Indiana bats is accompanied by a map showing the area where the bats were found and the extent of the survey within each cave. Data that reflect the location within the cave where bats were found, hibernacula temperatures, and survey dates are also supplied in Table 2.

The following Cave Lists for BHE and ESI have been removed for confidentiality reasons related to the federally endangered Indiana bat.

Appendix C
Tables

Appendix C: (Tables) has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Appendix D
Photographs and Descriptions of Caves Surveyed

Appendix D: (Photographs and Descriptions of Caves Surveyed) has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Appendix E
Datasheets

Appendix E: (Data Sheets) has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Pesi 123.01.02.03

AUTUMN, WINTER, AND SPRING HABITAT FOR THE INDIANA BAT (*MYOTIS SODALIS*) WITHIN THE CRAWFORD UPLAND AND MITCHELL PLAIN FROM SCOTLAND TO BLOOMINGTON, INDIANA

7 September 2005

Prepared for:

Bernardin, Lochmueller, and Associates
6200 Vogel Rd.
Evansville, IN 47715

Indiana Department of Transportation
100 N. Senate Avenue
Indianapolis, IN 46204

FINAL REPORT

Prepared by:

Jason A. Duffey and Virgil Brack, Jr. Ph.D.

Environmental Solutions & Innovations, Inc.

781 Neeb Road
Cincinnati, Ohio 45233
Phone: (513) 451-1777
Fax: (513) 451-3321

Virgil Brack, Jr., Principal Scientist
VBrack@EnvironmentalSI.com

238 North Second Stree Suite 2
Richmond, Kentuc 40475
Phone: (859) 4-4988
Fax: (859) 4-4992

TABLE OF CONTENTS

Page

1.0 INTRODUCTION.....1

2.0 STUDY AREA.....1

2.1 Location –.....1

2.2 Physiography –.....1

2.3 Indiana bat –.....2

2.3.1 Status –.....2

2.3.2 Regional Occurrence –.....2

2.3.2.1 Winter Hibernation / Spring Staging and Autumn Swarming –.....2

2.3.2.2 Spring and Autumn Migration –.....3

2.3.2.3 Summer Roosting –.....3

2.3.3 Ecology –.....3

2.3.3.1 Winter Hibernation –.....3

2.3.3.2 Spring Staging and Autumn Swarming –.....4

2.3.3.2.1 Spring –.....4

2.3.3.2.2 Autumn –.....4

2.3.3.3 Spring and Autumn Migration / Transient Period –.....6

2.3.3.4 Summer Roosting Ecology –.....6

2.3.3.4.1 Males –.....6

2.3.3.4.2 Females and Maternity Colonies –.....7

2.3.3.5 Food Habits and Foraging Ecology –.....8

3.0 METHODS.....9

3.1 Autumn Entrance Surveys –.....9

3.1.1 Site Selection –.....9

3.1.2 Harp Trapping –.....10

3.1.3 Bat Capture –.....10

3.1.4 Habitat Assessment and Entrance Descriptions –.....11

3.1.5 Weather –.....12

3.1.6 Anabat –.....12

3.1.7 Cave Emergence Counts –.....12

3.2 Cave Surveys –.....13

3.2.1 Site Selection –.....13

3.2.2 Bat Identification During Hibernation –.....13

3.2.3 Bat Counting –.....13

3.2.4 Temperature –.....13

3.2.5 Portions of caves surveyed –.....13

3.3 Spring Entrance Surveys –.....14

3.3.1 Site Selection –.....14

3.3.2 Harp Trapping –.....14

3.3.3 Bat Capture –.....14

3.3.4 Habitat Assessment and Entrance Description –.....14

3.3.5 Weather –.....14

3.3.6 Anabat – 15
3.3.7 Cave Emergence Counts – 15

4.0 RESULTS 15
4.1 Autumn Entrance Surveys – 15
4.1.1 Total Bat Captures – 15
4.1.2 Species Diversity – 15
4.1.3 Occurrence by Sex and Age – 15
4.1.4 Indiana Bat Captures – 15
4.1.5 Habitat Assessment and Entrance Description – 16
4.1.6 Anabat – 18
4.2 Cave Surveys – 18
4.2.1 Total Count – 18
4.2.2 Species Diversity – 18
4.2.3 Occurrence by Sex and Age – 19
4.2.4 Indiana Bats – 19
4.2.5 Survey Descriptions – 19
4.3 Spring Entrance Surveys – 29
4.3.1 Total Bat Captures – 29
4.3.2 Species Diversity – 29
4.3.3 Occurrence by Sex and Age – 29
4.3.4 Indiana Bat Captures – 29

5.0 DISCUSSION 29
5.1 Bat Occurrence and Species Diversity – 30
5.2 Occurrence by Sex – 30
5.3 Indiana Bat Occurrence – 30

6.0 ACKNOWLEDGEMENTS 31

7.0 LITERATURE CITED 31

APPENDIX A. FIGURES
APPENDIX B. TABLES
APPENDIX C. PHOTOGRAPHS
APPENDIX D. DATA SHEETS

AUTUMN, WINTER, AND SPRING HABITAT FOR THE INDIANA BAT (*MYOTIS SODALIS*) WITHIN THE CRAWFORD UPLAND AND MITCHELL PLAIN FROM SCOTLAND TO BLOOMINGTON, INDIANA

Jason A. Duffey and Virgil Brack, Jr., Ph.D.
Environmental Solutions and Innovations, Inc., 781 Neeb Road, Cincinnati, OH 45233

Abstract

In fulfillment of Tier II Environmental Impact Studies of the proposed I-69 corridor from Evansville to Indianapolis, Indiana, 30 caves within Section 4 were harp trapped during autumn 2004 for the federally endangered Indiana bat (*Myotis sodalis)*. A total of 1,081 bats representing 5 species was captured: 424 northern bats (*Myotis septentrionalis*), 417 little brown bats (*Myotis lucifugus*) 232 eastern pipistrelles (*Pipistrellus subflavus*), 6 Indiana bats (*Myotis sodalis*), and 2 big brown bats (*Eptesicus fuscus*). Indiana bats were captured at three caves. Surveyed caves were entered in winter 2005 to search for hibernating Indiana bats. A total of 627 bats representing 5 species was found: 382 little brown bats, 206 eastern pipistrelles, 29 Indiana bats, 6 big brown bats, and 4 northern bats. Indiana bats were found in two caves, one of which harbored 78 percent of the winter census of all species combined. Two caves that were inaccessible in winter were again harp trapped during spring 2005 for the Indiana bat. A total of 296 bats representing 3 species was captured: 189 northern bats, 88 little brown bats, and19 eastern pipistrelles. No Indiana bats were captured in spring.

Key Words – Indiana bat, *Myotis sodalis*, Indiana, harp trapping, hibernacula, emergence counts

1.0 Introduction

The federal Endangered Species Act (ESA) [16 U.S.C. 1531 *et seq*.] became law in 1973 and provides for the listing, conservation, and recovery of endangered and threatened species of plants and wildlife. Under ESA, the U.S. Fish and Wildlife Service (USFWS) strives to protect and monitor the numbers and populations of listed species. Many states enacted similar laws.

Section 7(a)(2) of the Act states that each federal agency shall insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in destruction or adverse modification of designated critical habitat. Federal actions include (1) expenditure of federal funds for roads, buildings, or other construction projects, and (2) approval of a permit or license, and the activities resulting from such permit or license. This is true regardless of whether involvement is apparent, such as issuance of a federal permit, or less direct, such as federal oversight of a state-operated program.

Section 9 of the Act prohibits take of listed species. Take is defined by the Act as "*to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect.*" The definition of harm includes adverse habitat modification. Actions of federal agencies that do not result in jeopardy or adverse modification, but that could result in a take, must be addressed under Section 7.

This study is part of the Tier 2 Environmental Impact Studies for a portion of Section 4 of the proposed I-69 from Evansville to Indianapolis, Indiana. Environmental Solutions and Innovations, Inc (ESI) was contracted by Bernardin, Lochmueller and Associates, Inc. (BLA), and their client, the Indiana Department of Transportation, to conduct autumn, winter, and spring hibernacula surveys of 30 caves near Section 4 of the proposed I-69 corridor for the endangered Indiana bat (*Myotis sodalis*).

ESI completed field efforts under federal Endangered Species Permit TE 023664-13 and State of Indiana Division of Natural Resources permits 2940, 2941, 2944, 2989, 2990, 2994, 3081, 3085, 3086, and 3088.

2.0 Study Area

2.1 Location –

Section 4 of the proposed I-69 corridor begins at US 231 in southeast Greene County north of SR 58 near the northwest corner of the Naval Support Activity Crane. It proceeds northeast into Monroe County and ends at SR 37 near Victor Pike south of Bloomington (Figure 1). The total length of Section 4 is approximately 27 miles. The caves surveyed by ESI were in the southern portion of Section 4 in Greene, Monroe, and Lawrence counties.

2.2 Physiography –

The project area is located in the Crawford Upland Section of the Shawnee Hills Natural Region and the Mitchell Plain Section of the Highland Rim Natural Region in southwest Indiana (Homoya et al. 1985). The Crawford Upland Section is characterized by rugged hills with sandstone

cliffs and rockhouses, and well-drained acid silt loam soils. The majority of natural communities are upland forest types, although a few sandstone and limestone glades, gravel washes, and barrens are known. To the east, the Mitchell Plain Section is characterized by relatively low relief and marked by sinkholes and extensive cave systems developed in Mississippian age limestone bedrock. Upland forest types are common although swamps, flatwoods, and barrens are present. Examples of medium and high gradient streams with rocky bottoms in this area include Indian Creek, Clear Creek, and Popcorn Creek.

2.3 Indiana bat –

2.3.1 Status –

The USFWS listed the Indiana bat (*Myotis sodalis*) as endangered on 11 March 1967. The most current range-wide estimate of the population is 382,000 individuals (Clawson 2002), which represents about 43 percent of the estimated population of 1960. Long-term, detailed documentation of population changes are lacking in many areas, although Indiana is an exception (Brack et al. 1984, 2003; Johnson et al. 2002). It is probable that summer habitat losses (USFWS 1999) and winter disturbances (Johnson et al. 1998) contributed to the overall decline of the species.

Federal Register Documents
41 FR 41914; 24 September 1976: Final Critical Habitat, Critical habitat—mammals
40 FR 58308 58312; 16 December 1975: Proposed Critical Habitat, Critical habitat—mammals
32 FR 4001; 11 March 1967: Final Listing, Endangered

2.3.2 Regional Occurrence –

The Indiana bat is known to occur in the region that includes the southern portion of Section 4 (Figure 2). There are four ecologically distinct components of the annual life cycle: winter hibernation, spring staging and autumn swarming, spring and autumn migration, and the summer season of reproduction. Each of these components is discussed below with respect to regional occurrence of the Indiana bat in Greene, Monroe, and Lawrence counties.

2.3.2.1 Winter Hibernation / Spring Staging and Autumn Swarming –

The Indiana bat is known to hibernate in 12 caves in the region that includes this portion of Section 4 (Figure 3). Eight hibernacula are known from western Monroe County. Hibernacula are classified based on sizes of winter populations of Indiana bats in each cave. Priority I hibernacula exceed 30,000 bats, Priority II caves contain populations between 1,000 and 30,000 bats, and Priority III caves contain less than 1,000 Indiana bats. (, and caves are Priority III hibernacula. and caves are Priority II hibernacula. These caves range from 1.0 (Cave) to 4.6 miles (Cave) from the Section 4 corridor (BLA 2003).

Eastern Greene County contains four known Indiana bat hibernacula. and caves are Priority III hibernacula approximately 0.5 miles from the Section 4 corridor. Cave, another Priority III cave, is 10 miles from the corridor. Cave, however, is a Priority I hibernacula and is federally designated Critical Habitat with 50,941 Indiana bats documented in 2003 (Brack et al. 2003), and

54,325 bats in 2005 (Brack et al. unpub. data). Cave is approximately 6 miles from the I-69 corridor.

2.3.2.2 Spring and Autumn Migration –

Because winter hibernacula are known from Greene and Monroe Counties in Indiana, it is reasonable to assume migration of transient bats occurs during spring and autumn within the study area.

2.3.2.3 Summer Roosting –

There are records of adult male Indiana bats in summer from 24 counties in Indiana, including Greene and Monroe counties (Whitaker and Brack 2002) (Figure 2). During summer, males often remain at or near hibernacula, visiting them periodically, although some disperse longer distances from hibernacula.

There is evidence of reproduction and maternity colonies in at least 40 counties in Indiana (Whitaker and Brack 2002). Maternity colonies may be more abundant in the northern part of the state. Female Indiana bats were not known from either Greene or Monroe counties until the summer 2004 mist netting season (ESI 2004), when two reproductive adults were captured. However, records of female Indiana bats exist for neighboring counties including Jackson, Knox, Martin, and Vigo counties.

The Draft Environmental Impact Statement on the Southwest Indiana Highway Corridor prepared for INDOT included information on 1993 mist net surveys for Indiana bats. Dr. John Whitaker, Jr. surveyed 19 sites along the proposed corridor from I-64 to Bloomington, Indiana. Eleven sites were located within this portion of the Section 4 corridor. A total of 41 bats were captured; no Indiana bats were caught.

2.3.3 Ecology –

The Indiana bat is a "tree bat" in summer and a "cave bat" in winter. There are four ecologically distinct components of the annual life cycle: winter hibernation, spring staging and autumn swarming, spring and autumn migration/transient period, and the summer season of reproduction. The U.S. Fish and Wildlife Service Recovery Plan (1999) provides a description of the life history. Figure 4 provides an annual chronology of seasonal activities.

2.3.3.1 Winter Hibernation –

Although the winter range of the Indiana bat is large, it was originally restricted to regions of well-developed limestone caves and the species overwinters in approximately 300 known hibernacula. Most hibernacula are in caves, but relatively large numbers of Indiana bats hibernate in abandoned mines in Illinois (Kath 2002), New York (Hicks and Novak 2002) and Ohio (Brack in prep), and in smaller numbers in a variety of locations. There are large populations of Indiana bats in only a few caves and most hibernacula contain only a few bats. Hibernacula with large populations of Indiana bats are concentrated in southern Missouri and Indiana, and in Kentucky. Smaller wintering populations occur in Alabama, Arkansas, Connecticut, Georgia, Illinois, Iowa, Maryland, Massachusetts, Mississippi, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina,

Tennessee, Vermont, Virginia, and West Virginia (Figure 5).

Hibernation is an adaptation that allows survival through the winter months when food and water are not abundant. Indiana bats hibernate from mid-November to mid-April. Many species of bats (including the Indiana bat) make relatively characteristic and recognizable use of hibernacula, including temperature regimes and spatial associations (Brack 1979, Brack et al. 2003; Brack and Twente 1985; Twente et al. 1985). Hibernating Indiana bats often form dense clusters on cave ceilings in portions of the cave where winter temperatures are suitable. Initially, this temperature was believed to be 4 to 8ºC (or perhaps more narrowly 3 to 6°C during mid-winter (USFWS 1999), but these assertions (Hall 1962; Henshaw and Folk 1966; Humphrey 1978) were supported with scant data. Recent analysis of long-term data in hibernacula with increasing numbers of Indiana bats indicates the optimal range is closer to 6 to 8ºC (Brack et al. 2003; Brack et al. in prep) and is supported by other detailed studies (Myers 1964; Clawson et al. 1980). Therefore, Indiana bats use areas that are cool, but thermally stable. Colder areas, especially areas closer to the entrance, are often unstable. Clusters of bats are not sexually segregated.

2.3.3.2 Spring Staging and Autumn Swarming –

2.3.3.2.1 Spring –

Female Indiana bats leave hibernacula earlier in spring (beginning in mid-April) than do males (peak of departure in early May). This part of spring activity is referred to as staging. In spring, after emerging from hibernation, bats may remain near hibernacula caves for a few days before leaving for summer maternity areas. They may use this time to help prepare for migration.

2.3.3.2.2 Autumn –

Autumn swarming is a term used to describe the activity of microchiropterans at hibernacula in North America (Cope and Humphrey 1977) and Europe (Parsons et al. 2003) during autumn. It is the use and visitation of hibernacula and nearby habitats in late summer and early autumn, and for many species is associated with the opportunity for sexes to meet and mate.

In autumn, Indiana bats swarm at caves used for hibernation, although individuals probably come and go throughout the autumn season. Cope and Humphrey (1977) indicated that "waves" of Indiana bats begin to return to a hibernaculum in southern Indiana in low to moderate numbers in mid to late August. Also in Indiana, Brack (1983) found the first individuals arriving as early as late July. In Missouri, LaVal and LaVal (1980) indicated that the earliest arrivals were in early August.

During swarming, the abundance of females increases and decreases with the season, but males are always more common (Cope and Humphrey 1977; Laval and LaVal 1980). Numbers of swarming females peak in September. By late September, many females are hibernating while many males remain active until mid-October or later, apparently in an effort to breed late-arriving females. Small males with insufficient fat reserves to survive winter may remain active in hibernacula seeking to copulate before dying (Richter et al. 1993). Temperature and precipitation likely influence swarming chronology; rain depresses swarming activity in Europe (Parsons et al. 2003). Large, wet, cold-weather systems may be

part of the seasonal cycle driving timing of swarming (Brack in prep). Females store sperm through hibernation and delay fertilization until spring (Wimsatt 1944). It is not known if juvenile females mate their first autumn. Limited mating may occur in spring (Hall 1962).

Early during autumn swarming, Indiana bats visit hibernacula at night, but do not day roost in the cave. At smaller hibernacula, some individuals roost in woodlands near the cave: 0.5 mi (0.8 km) in Virginia (Brack in prep) and 1 mi (1.9 km) in Kentucky (Gumbert 2001). At larger hibernacula, many or most bats apparently do not remain close to the cave (Brack unpub. data). In Virginia, Indiana bats used a variety of species of live, dying, and dead roost trees (Brack in prep). Individual bats roosted in multiple roost trees, which were sometimes used for 2 to 3 consecutive days. Many roosts were near canopy openings including selective cut, clear-cut, and pastured woodlands with scattered trees. Roosts were also found near or along logging roads or powerline corridors. Bats also used roost trees in forests with moderate to high canopy closure. Compared to availability, roost trees were located disproportionately more often in open, intermediate, and closed deciduous forests rather than mixed deciduous/evergreen forest. Roosts found in agricultural areas bordered croplands. In Virginia, there was no difference between sizes of roost trees used by females and males (17.5 vs. 15.5 in; 44.4 vs. 39.3 cm), height of roost above ground (37 vs. 40 ft; 11.4 vs. 12.2 m), or elevation where roost was found (2,750 vs. 2,950 ft; 839 vs. 900 m). There was no significant difference between species of roost trees used by male and female bats throughout the autumn season, as well as no discrimination between living or dead trees (Brack in prep). As the autumn season progresses, more bats roost in the hibernacula caves.

In Virginia, nocturnal activity areas were 237 to 907 ac (96 - 367 ha; $\bar{X}$ = 251 ha), with a great deal of overlap among activity areas of individuals (Brack in prep). Bats were active in open deciduous forests more than this type of habitat was available (19.0% vs. 9.5%), in agricultural lands and intermediate deciduous forests similar to availability, and in mixed deciduous-evergreen and closed deciduous forests less than available (Brack in prep). Thus, Indiana bats foraged in relatively open habitats, consisting primarily of pastures with scattered trees. Many pastures (agricultural lands) in the project area had scattered trees and they abutted woodlands, with a gradation from pasture to woodlands, and open woodlands were generally recently-logged tracts with a scattering of individual trees. Bats were active across all elevations in the study area. Many bats included an existing powerline ROW, a notable feature on a forested landscape, in their active area. Bat activity shifted among habitats over the autumn season (Brack in prep). Use of agricultural lands dropped steadily over the season; conversely, use of deciduous forests (combined open, intermediate, and closed) increased, possibly in response to insect availability.

As the autumn season progresses, nightly activity begins earlier in the evening (Brack in prep; Parsons et al. 2003). As temperatures cool seasonally, nocturnal insects have a limited activity period; consequently, so do the bats. Apparently many bats leave the hibernaculum area periodically during autumn swarming (Brack unpub. data; Gumbert 2001). It is not known why bats leave, but departures during swarming have implications for

reproductive fitness since it reduces or eliminates the opportunity to mate. Possibly, bats visit and mate at other swarming locations. Alternatively, males actively seeking mating opportunities may need to intermittently leave the swarming area to forage and replenish energy supplies.

2.3.3.3 Spring and Autumn Migration / Transient Period –

Little is known about bats during migration and during portions of spring and autumn when they are not actively engaged in migration. In general, females are more migratory than males (Whitaker and Brack 2002; Brack 1983). Females from a single hibernaculum may end up at maternity colonies over a large geographic area, and females from a single maternity colony may end up in different hibernacula (Barbour and Davis 1969; Gardner and Cook 2002; Kurta et al. 2002). It is probable that bats use a variety of roosts, including trees, caves, mines, holes of various types, and possibly a variety of non-traditional roosts during migration. Bats migrating from hibernacula in southeastern New York to summer maternity sites roosted in trees and on a building – in a gap between a cinderblock wall and a joist under an elevated deck (Sanders and Chenger 2001), as well as in the siding of a house and in trees of suburban yards (Hicks pers. comm.). In late summer, a juvenile Indiana bat was found on the side of a building in central Indiana that had a roughed cement exterior (Brack unpub. data). In northern Ohio, several Indiana bats have been caught in autumn in sandstone crevices that likely served as a migratory stopover (Summit County Metro Parks 2003). During migration, other species of bats have been found in a variety of unlikely locations, including ships at sea, log piles, and rodent holes in treeless areas (Brack and Carter 1985).

2.3.3.4 Summer Roosting Ecology –

The summer range of the Indiana bat is large and includes much of the eastern deciduous forestlands between the Appalachian Mountains and Midwest prairies (Figure 6). Distribution throughout the range is not uniform and summer occurrences are more frequent in southern Iowa and Michigan, northern Missouri, Illinois, and Indiana. Greater tree densities do not equate to more bats (Brack et al. 2002). Cooler summer temperatures associated with latitude or altitude likely affect reproductive success and the summer distribution of the species (Brack et al. 2002).

2.3.3.4.1 Males –

Some males remain near hibernacula throughout summer while others migrate varying distances (Whitaker and Brack 2002). Males can be caught at hibernacula on most nights during summer (Brack 1983; Brack and LaVal 1985), although there may be a large turnover of individuals between nights (Brack 1983).

Woodland roosts used by males appear similar to maternity roosts (Kiser and Elliott 1996; Schultes and Elliott 2002; Brack et al. 2004; Brack and Whitaker 2004), although smaller diameter trees may be used. Space required for a single bat may be less than for a colony, or thermal requirements may differ. Males appear somewhat nomadic; over time, the number of roosts and size of area used increases. Activity areas encompass roads of all sizes, from trails to interstate highways and roosts have been located near roads of all sizes (Kiser and Elliott 1996; Schultes and Elliott 2002; Brack et al. 2004), including adjacent to an interstate highway (Brack et al. 2004).

2.3.3.4.2 Females and Maternity Colonies –

When female Indiana bats emerge from hibernation, they migrate to maternity colonies that may be located up to several hundred miles away (Kurta and Murray 2002). Females form nursery colonies under exfoliating bark of dead, dying, and living trees in a variety of habitat types, including uplands and riparian habitats. A wide variety of tree species, including occasional pines (Britzke et al. 2003) are used as nursery colonies indicating that it is tree form, not species that is important for roosts. Since many roosts are in dead or dying trees, they are often ephemeral. Roost trees may be habitable for one to several years, depending on the species and condition of the tree (Callahan et al. 1997). Indiana bats exhibit strong site fidelity to summer roosting and foraging areas (Kurta and Murray 2002; Kurta et al. 2002).

A maternity colony typically consists of 25 to 325 adult females. Nursery colonies often use several roost trees (Kurta et al. 1993; Foster and Kurta 1999; Kurta et al. 2002), moving among roosts within a season. Most members of a colony coalesce into a single roost tree about the time of parturition, which begins to break up again as soon as young are volant. Roosts that contain large numbers of bats (>20 bats) are often called primary roosts, while secondary roosts hold fewer bats. Primary roost trees are often greater than 45 cm dbh (**d**iameter at **b**reast **h**eight) and secondary roost trees are often greater than 22 cm dbh (Gardner et al. 1991; Callahan et al. 1997; Kurta et al 2002; Miller et al. 2002; Carter 2003). Numerous suitable roosts may be required to support a single nursery colony, possibly about 20 stems per acre (45/ha; Gardner et al. 1991; Miller et al. 2002; Carter 2003).

Roost trees are often located where they have solar exposure, with 20 to 80 percent canopy closure (Humphrey et al. 1977; Gardner et al. 1991; Kurta et al. 1993, 1996, 2002; Carter 2003). They are often exposed to 10 or more hours of solar radiation per day (Kurta et al. 2002). The need for solar exposure may vary with latitude. Although maternity colonies of Indiana bats typically roost under the exfoliating bark of dead and dying trees, they have also been found roosting in buildings in Pennsylvania (Butchkoski and Hassinger 2002), New York (Hicks pers. comm.), and Iowa (unpub. report), and in bat boxes (Whitaker et al. in prep). Individuals that were likely part of maternity colonies have also been found in various tree hollows and tree cracks (L. C. Watkins in Humphrey et al. 1977; Kurta et al. 1993, 2002) and bat boxes (Carter 2002).

Females are pregnant when they arrive at maternity roosts. Fecundity of the species is low, for females produce only one young per year. Parturition typically occurs between late June and early July. Lactating females have been caught 11 June to 29 July in Indiana, 26 June to 22 July in Iowa, and 11 June to 6 July in Missouri (Humphrey et al. 1977; LaVal and LaVal 1980; Brack 1983; Clark et al. 1987). Juveniles become volant between early July and early August. Reproductive phenology is likely dependent upon seasonal temperatures and the thermal character of the roost (Humphrey et al. 1977; Kurta et al. 1996). Like many microchiropterans, Indiana bats are thermal conformists (Stones and Wiebers 1967), with prenatal, neonatal, and juvenile development temperature dependent (Racey 1982). Cooler summer temperatures associated with latitude or altitude likely affect reproductive success and therefore the summer distribution of the species (Brack et al. 2002).

Nightly non-foraging behavior of Indiana bats is poorly documented. In Michigan, pregnant bats from a maternity colony foraged most of the night, but lactating females returned two to four times to feed young. Both pregnant and lactating females roosted up to six times per night for 14 minutes each (*SD* = 1; Murray and Kurta 2004). Foraging areas were 0.3 to 2.5 mi (0.5 - 4.2 km) from diurnal roosts. Kiser et al. (2002) found 82 bats under three bridges over a 6-night period in late July and August. Temperatures under the bridges were warmer and less variable than ambient, apparently providing a location to hang and digest food between foraging bouts. These bridges were 0.6 to 1.2 mi (1.0 - 1.9 km) from diurnal roost trees.

Indiana bats live on anthropogenic landscapes and recent research indicates females do include roads in their active area. Although bats do cross roads, the studies that document this behavior were not designed to gauge a graded response. On Indiana, female and juvenile Indiana bats routinely night roosted under bridges on 2-lane paved roads (Kiser et al. 2002). Activity areas of nursery colonies in Illinois (Gardner et al. 1991) and Michigan (Kurta et al. 2002) included paved roads. On the campus of Ohio, a roost tree was located at the edge of a large parking lot, and about 60 feet (20 m) from a moderately traveled road. Emerging bats crossed the parking lot and radio-tagged bats crossed highway 444, a 4-lane divided highway to forage in a 180-ac (73 ha) woodlot (Brown et al. 2001). A female Indiana bat from a maternity roost tree on the west edge of the Indianapolis, Indiana Airport and north of routinely crossed this 6-lane interstate to forage (Brack unpub. data). In eastern Indiana, adjacent to a reproductive female Indiana bat was radio-tracked across a 4-lane divided highway to a maternity colony in a small (1.7 ac; 0.7 ha), isolated woodlot (Brack and Whitaker in prep). The roost tree was on the west edge of the woodlot, adjacent to the highway and the woodlot was surrounded on other sides by open, farmed agricultural lands.

2.3.3.5 Food Habits and Foraging Ecology –

The diet of the Indiana bat differs depending on age and sex, but includes a variety of insects, which vary by habitat and season. Based on diets of males, Brack and LaVal (1985) considered the species a selective opportunist. In Indiana, aquatic-based insects were more common in the diet of a maternity colony than in the diet of males collected at caves (Brack 1983). The maternity colony was located along the Big Blue River, where only about 11 percent of the land within 2 mi (3.2 km) of the roost was forested (most was riparian), whereas males were caught at a cave where 42 percent of the area within 2 mi (3.2 km) was forested and only a small portion was riparian. In late summer, the diets of males, females, and juveniles captured at caves were similar to one another and to males' summer diets. Diets reported by Belwood (1979) from a colony along a stream and by Kurta and Whitaker (1998) from a colony within a wooded wetland contained more aquatic-based insects than diets of males foraging in an upland habitat (Brack and LaVal 1985). The repeated seasonal occurrence of the Asiatic oak weevil, *Cyrtepistomus castaneus* and sporadic abundance of hymenopterans in the diet (Brack 1983; Brack and LaVal 1985; Brack and Whitaker 2004; Brack in submission) are both indicative of opportunistic feeding. Insects may be less common late at night,

forcing bats to eat a greater variety of insects (Brack 1983). Later in the season when insect abundance is greater, they may eat a less diverse diet (Brack and LaVal 1985; Brack 1983). Diet also varies by lunar cycle (Brack 1983; Brack and LaVal 1985; Brack in submission), because the cycle affects insects. Murray and Kurta (2002) found that the diet was flexible across the range and potentially affected by regional and local differences in bat assemblages and availability of foraging habitat and prey.

Distances Indiana bats travel to forage may be quite variable. Using reflective wristbands, Humphrey et al. (1977) found that a maternity colony foraged in areas only 3.7 to 11.1 ac (1.5 - 4.5 ha). In Illinois, individuals traveled up to 2.5 mi (4.2 km) from maternity colonies (Gardner et al. 1991). In Michigan, foraging areas were 0.3 to 2.5 mi (0.5 - 4.2 km) from diurnal roosts (Murray and Kurta 2004), and members of a maternity colony moved a maximum distance among roosts of 3.6 mi (5.8 km) overnight, but 5.7 mi (9.2 km) over 4 years (Kurta et al. 2002). In Missouri, adult males traveled 3.1 miles while foraging (LaVal and LaVal 1980), and Brack (1983) observed foraging light-tagged bats within 2 miles of caves used during autumn swarming. In Hoosier National Forest, the mean active foraging area of four adult male bats ranged from 95.1 to 151.9 ha based on the method of estimation, while the means of individual bats across three methods of estimation (95% minimum convex polygon, capture radius, and non-circular) ranged from 43.1 to 314.2 ha (Brack et al. 2004). Active areas used by individual bats often overlap. Individuals of many species of bats that roost colonially forage independently of one another (Kerth et al. 2001). Like many other species of microchiropterans, the Indiana bat often uses travel corridors that consist of open flyways such as streams, woodland trails, small infrequently used roads, and possibly utility corridors, regardless of suitability for foraging or roosting (Brown and Brack 2003).

Members of maternity colonies forage in a variety of woodland settings, including upland and floodplain forest (Humphrey et al. 1977; Brack 1983; Gardner et al. 1991). Foraging activity is concentrated above and around foliage surfaces, such as over the canopy in upland and riparian woods, around crowns of individual or widely spaced trees, and along edges. They forage less frequently over old fields, and occasionally over bushes in open pastures. Forest edges, small openings, and woodlands with patchy trees provide more foraging opportunities than dense woodlands. Most species of woodland bats forage prominently along edges, less in openings, and least within forests (Grindal 1996). Openings also provide a better supply of insects than do wooded areas (Tibbels and Kurta 2003).

3.0 Methods

3.1 Autumn Entrance Surveys –

3.1.1 Site Selection –

Thirty caves were selected by BLA and underwent field reviews and assessment of suitability for bat habitat in conjunction with the USFWS Bloomington Field Office, Indiana Geological Survey (IGS), Indiana Karst Conservancy (IKC), and ESI (Figure 7, Table 1). Caves were prioritized based on estimated likelihood of serving as Indiana bat (*Myotis sodalis*) hibernacula and/or swarming sites, as well as proximity to

Section 4 of the proposed I-69 corridor. Selected caves were within a 5-mile range of the corridor.

All caves were on private property. Property owners were provided Notice of Survey letters and were contacted by the Project Manager when feasible prior to survey efforts.

3.1.2 Harp Trapping –

Entrances of the 30 selected caves were surveyed for two nights each over the period 2 September to 19 October 2004 for a total of at least 2 nights of effort per site. Based on USFWS recommendations, surveys of high and intermediate priority caves were completed between 12 September and 3 October, when greatest swarming activity was anticipated.

Harp trapping was the preferred method of sampling at most cave entrances. Mist netting provided the most effective sampling method at Cave and Cave. AnaBat systems were used to record ultrasonic bat calls at Cave and Cave, neither of which could be safely or effectively trapped or netted.

Traps are set to maximize coverage of flight paths used by bats at cave entrances. Typically, traps are set at entrances, adjusted for height, and placed across (parallel to) the entrance. Areas of the entrance not covered by the trap are typically covered with garden netting to direct bats into the trap. Additional entrances were either trapped or excluded with garden netting.

Efforts to survey for endangered bats are difficult to standardize because of the large amount to variability that exists in a field situation. However, the USFWS Bloomington Field Office's adaptation of protocols used by the Pennsylvania Game Commission (Table 2) provides structure for implementation of standardized procedures for bat surveys at cave entrances (USFWS 2005).

3.1.3 Bat Capture –

The trapping setup allows bats to be caught live and released unharmed near the point of capture. Bats were identified to species using a combination of morphological characteristics (e.g., ear and tragus, calcar, pelage, size/weight, length of right forearm, and overall appearance of the animal). The species, sex, age, reproductive condition, weight, length of right forearm, and time and location/site of capture were recorded for all bats captured. Age (adult or juvenile), determined by examining ephiphyseal-diaphyseal fusion (calcification) of long bones in the wing, is difficult to determine in autumn or spring, and resulted in most individuals being recorded as adults. Reproductive condition of female bats (pregnant, lactating, or post lactating), determined by gentle abdominal palpation or examination of teat wear, is also very difficult to determine in autumn or spring, and resulted in most individuals being recorded as non-reproductive, unknown, or not available. Evidence of past pregnancies carried to term (parous versus nonparous) can sometimes be determined by palpation of the pubic symphysis. Reproductive condition of male bats was classified as descended or non-descended. Weight was measured to 0.1 grams using a Pesola spring scale. Length of the right forearm of each bat was estimated to at least the nearest 1.0 mm using either dial calipers or a ruler. When feasible, gentle palpation of the belly is used to determine whether bats have fed before capture, as an indication of whether an individual is entering or exiting the cave.

High capture rates at and caves did not allow recording of complete morphometric measurements for all individuals. However, all bats were identified to species and sex.

Indiana bats were banded with a uniquely numbered, white celluloid band. Bands were placed on the right forearm of each male and the left forearm of each female Indiana bat. Fecal samples were also taken from Indiana bats (and other species) when feasible and provided to the USFWS Bloomington Ecological Services Field Office for analysis not associated with INDOT or its operating mission. Bat processing and data collection was completed within 30 minutes of the time the bat was removed from the trap or net (bat capture data sheets are provided in Appendix D).

Data collected may be used in comparative analyses with other surveys to show species diversity. The species diversity index of MacArthur (1972) was used, where Diversity = $1/\sum P_i^2$, where P_i is the proportion of bats belonging to species **i** in each sample.

Chi-square analysis was used to test for statistical significance between sexes and species. Chi-square analysis was used, where $\chi^2 = \sum [(O - E)^2 / E]$, where O is the observed frequency and E is the expected frequency.

3.1.4 Habitat Assessment and Entrance Descriptions –

General habitat assessment at survey sites focused on features near cave entrances indicative of suitability for Indiana bats. A habitat description of each entrance location was completed (Appendix D). The emphasis of this description was habitat form: size and relative abundance of large trees and snags that potentially serve as roost trees, canopy closure, understory clutter/openness, distance to water, nearby stream or pond characteristics, and flight corridors. Habitat form was emphasized because the Indiana bat roosts in many species of trees, especially during the autumn and spring seasons. Tree species composition was included because it provides insight to edaphic conditions of each site.

Habitat assessment identifies components of canopy and subcanopy layers. Trees that reach into the canopy are canopy trees, regardless of their diameter/size. As defined in the Indiana Bat Habitat Suitability Index Model (3D/Environmental 1995), dominant trees are the large trees in the canopy (>16" dbh) that have the greatest likelihood of being used by maternity colonies of Indiana bats. Many smaller trees are often also found in the canopy, and in some situations, the canopy can be entirely composed of small-diameter trees. ESI's habitat assessment identifies dominant and subdominant elements of the canopy.

The subcanopy vegetation layer is well defined in classical ecological literature. It is that portion of the forest structure between the ground vegetation (to approximately 2 feet (0.6 m)) and the canopy layers, usually beginning at about 25 feet (7.6 m).

Vegetation in the understory may come from: lower branches of overstory trees, young overstory trees, small trees and shrubs that are confined to the understory. The amount of vegetation in the understory is termed clutter. Many species of bats, including the Indiana bat, tend to avoid areas of high clutter.

Other site-specific parameters pertinent to assessing the quality of the habitat near cave entrances were also recorded such as distance to water, stream habitat (if present), standing water in an upland site, and travel corridors – or lack thereof. Each site was also documented with a sketch (Appendix D).

A variety of characteristics of each entrance that potentially relate to bat use were recorded on Cave Entrance Description Data Sheets (Appendix D). Characteristics included size of entrance, type (vertical or horizontal), apparent stability, airflow, water, etc. Photographs of cave entrances are provided in Appendix C.

3.1.5 Weather –

Temperature, percent cloud cover, wind, and precipitation were monitored and recorded hourly while sampling to ensure compliance with weather conditions outlined in the entrance trapping guidelines (Table 2).

In general, precipitation was lower than normal and temperatures were normal for the project area during the survey period, as they were regionally for most of the 2004 autumn trapping season. Over the entire project time period, nighttime lows ranged from 44 to 70°F, and high temperatures ranged from 55 to 78°F. The nightly difference in high and low temperatures ranged from 4 to 22°F (Table 3). Temperatures below 50°F during the first two hours of surveys on 5 October resulted in extra trap nights at Cave and Cave. Appendix D contains completed Weather Data Sheets.

3.1.6 Anabat –

Bats use echolocation to efficiently maneuver in a nocturnal environment and detect prey. Anabat systems are designed to detect and record echolocation calls in the immediate vicinity of a study site. Each call is represented graphically and stored as an individual file that can be analyzed at a later time. Anabat II bat detectors (manufactured by Titley Electronics, PTY, LTD) and corresponding file storage devices were placed at cave entrances during surveys when low capture numbers were expected, mist nets were used, or the cave entrance could not be safely or efficiently trapped or netted. Microphones were positioned along the flight corridor to maximize call detection, and were typically functional for 5 hours. Calls were recorded at Cave, Cave, Cave, Cave, Cave, Cave, Cave, Cave, and Cave. On 3 December 2004, all Anabat files were sorted and sent to Andrew King (USFWS) for analysis. Appendix D contains Anabat Data Sheets.

In addition to Anabat, a tunable heterodyne bat detector was occasionally used to monitor bat activity where low capture numbers were expected. Calls were monitored at Cave, Cave, and Cave. Notes on calls detected were recorded on Cave Site Habitat Description and Bat Capture Data Sheets (Appendix D).

3.1.7 Cave Emergence Counts –

Emergence counts were conducted at Cave, a known Priority I hibernaculum (Figure 3), regularly during 2004 autumn entrance surveys. Beginning at dusk, emerging bats were counted until darkness precluded accurate counting. The relative numbers of bats exiting the cave during this period was used as an indication of the use Indiana bats are making of a cave that is a known hibernaculum (Table 4).

3.2 Cave Surveys –

3.2.1 Site Selection –

Thirty selected caves that were surveyed in autumn were visited over the period 14 January to 19 February 2005 (Figure 7, Table 1). Cave was not entered because passages became too narrow. Cave was not entered as requested by the owner. Based on USFWS guidelines, standardized hibernacula survey and reporting methods (Brack et al. 1995) were followed to ensure accurate data collection, interpretation, and comparison over time (Table 5).

Property owners were provided Notice of Survey letters and were contacted by the Project Manager when feasible prior to survey efforts.

3.2.2 Bat Identification During Hibernation –

Bats were identified to species by a variety of characteristics that do not disrupt hibernation or include handling. Many characteristics are subtle and are used in combination with one another, rather than reliance on any single observation. Defining characteristics include: pelage color, texture, and contrast with ears and other membranes; absolute and relative size; individual and intracluster posture; cluster shape, size, compactness, and location; and cave morphology, temperature, and hydrologic regime.

3.2.3 Bat Counting –

Bats were tallied by species and location in the cave. Species of bats other than Indiana bats were counted directly. Individual and small clusters of Indiana bats were counted directly, while larger clusters within reach were measured with a carpenter's rule. Size of clusters on high ceilings was estimated with laser calipers (Brack et al. in prep), 10x50 binoculars, and a 1,250,000 candlepower spotlight (Collins Dynamics "Magnum" model search light). For consistency, Indiana bats in clusters were estimated at 300 bats per square foot (LaVal and LaVal, 1980). Banded bats were noted, and when possible, band color and number were recorded. Appendix D contains completed Cave Survey Data Sheets.

3.2.4 Temperature –

Temperatures were taken at cave entrances, in the twilight area, near clusters of Indiana bats when possible, near concentrations of other species of bats, and at intervals throughout the caves. Temperatures were generally taken with a Raytek Raynger® ST20, with a range of –32 to 400ºC, an accuracy of ±1% of reading, and a display to the nearest 0.2°C, although a Raytek Raynger® MiniTemp MT4, with a range of –18 to 260ºC, an accuracy of ±2% of reading, and a display to the nearest 0.5°C and a Schultheis quick recording mercury thermometer, calibrated by 0.2°C increments, were occasionally used. Appendix D contains completed Cave Survey Data Sheets.

3.2.5 Portions of caves surveyed –

Surveys for bats were completed in portions of each cave that had a reasonable potential to provide suitable winter habitat. Hibernation suitability is determined by cave morphology, which affects airflow into and through the cave, thus influencing cave temperatures. Bats tend to hibernate in areas that are cold (4 – 8ºC) and thermally stable. Typically, cooler areas are closer to anterior portions of the cave because of the influx of outside air, however, temperature changes are often more frequent and extreme near entrances.

Final determination of portions of caves surveyed was made in the field and based on cave length and morphology, temperature (generally <10ºC), presence of bats of any species, and the experience of ESI's biologists. Appendix D contains completed Cave Survey Data Sheets.

3.3 Spring Entrance Surveys –

3.3.1 Site Selection –

Of the 30 selected caves, those not entered in winter and those of special biological interest underwent additional entrance surveys in spring.

Property owners were provided Notice of Survey letters and were contacted by the Project Manager when feasible prior to survey efforts.

3.3.2 Harp Trapping –

Entrances of two pre-selected caves were surveyed for two nights each over the period 13 April to 17 April 2005 for a total of at least 2 nights of effort per site.
Cave was surveyed because its narrow entrance passage could not be entered in winter. Cave was surveyed because it was of special biological interest, particularly, the high capture number in fall compared to the low hibernating number in winter. Access to Cave, not entered in winter by request of the owner, was again denied in spring (Figure 7, Table 1). Harp trapping was the preferred method of sampling at both caves.

USFWS guidelines for conducting harp trapping (Table 2) implemented for autumn entrance surveys were again followed for spring entrance surveys.

3.3.3 Bat Capture –

Methods and parameters for collection of morphometric data implemented for autumn entrance surveys were again followed for spring entrance surveys.

High capture rates at Cave did not allow recording of complete morphometric measurements for all individuals. However, all bats were identified to species and sex. Bat Capture Data Sheets are provided in Appendix D.

No bats were banded. Hair samples were taken from bats when feasible and provided to Dr. Eric Britzke of Clemson University for analysis not associated with INDOT or its operating mission. No guano samples were taken.

3.3.4 Habitat Assessment and Entrance Description –

General habitat assessment at each entrance location was completed in autumn and provided in Appendix D.

3.3.5 Weather –

Temperature, percent cloud cover, wind, and precipitation were monitored and recorded hourly while sampling to ensure compliance with weather conditions outlined in the entrance trapping guidelines (Table 2).

In general, temperatures and precipitation were normal for the project area during the survey period. Over the entire project time period, nighttime lows ranged from 42 to 50°F, and high temperatures ranged from 53 to 69°F. The nightly difference in high and low temperatures ranged from 7 to 19°F (Table 6). Temperatures below 50°F during the first two hours of surveys on 14 April resulted in an extra trap night at

Cave. Appendix D contains completed Weather Data Sheets.

3.3.6 Anabat –

Anabat systems were not used to record bat echolocation calls during spring entrance surveys.

3.3.7 Cave Emergence Counts –

Emergence counts were not conducted at Cave in spring 2005 because landowner permission could not be acquired.

4.0 Results

4.1 Autumn Entrance Surveys –

4.1.1 Total Bat Captures –

A total of 1081 bats representing 5 species was captured: 424 northern bats (*Myotis septentrionalis*), 417 little brown bats (*Myotis lucifugus*) 232 eastern pipistrelles (*Pipistrellus subflavus*), 6 Indiana bats (*Myotis sodalis*), and 2 big brown bats (*Eptesicus fuscus*) (Table 7). Two bats escaped before sex and morphometric data were collected, although each was identified to species.

Cave, and Cave produced the most bats, with 326, 138, and 108 individuals captured, respectively. No bats were captured at Cave, Cave, or Cave (Table 8). The mean number of individuals captured per cave was 38.6, or 19.3 per trap night (Table 9).

4.1.2 Species Diversity –

Species complement in the project area was typical for the geographic location, type of habitat, and season. In addition to the Indiana bat, four other species of bats were captured. Collectively, northern bats and little brown bats accounted for 78 percent of all individuals captured. A chi-square test confirmed that species were not evenly represented ($\chi^2 = 803.9$, $P < 0.0001$).

The average number of species represented at cave entrances was 2.4. Species richness was highest at Cave, Cave, Cave, Cave, and Cave, where four species were captured. The MacArthur (1972) diversity index for bats captured on this portion of Section 4 in autumn 2004 was 2.9 evenly distributed species.

4.1.3 Occurrence by Sex and Age –

Adult males and females accounted for 80 percent (866 individuals) and 17 percent (184 individuals) of the total capture, respectively. A chi-square test of the data indicated a significant difference between the number of adult males and females ($\chi^2 = 442.9$, $P < 0.0000$). Juvenile males and females accounted for nearly 3 percent (29 individuals) of the total bats captured.

Adult males and females of each species were captured. Assuming sexes should be equally represented, male little brown bats were significantly more abundant than females ($\chi^2 = 341.5$, $P < 0.0001$). Male northern bats were significantly more abundant than females ($\chi^2 = 111.9$, $P < 0.0001$). Male eastern pipistrelles were significantly more abundant than females ($\chi^2 = 35.2$, $P < 0.0001$; Table 9).

4.1.4 Indiana Bat Captures –

A total of six Indiana bats was captured at Cave, Cave, and Cave (Figure 8). Bats captured included one adult female and five

adult males (Table 8). All Indiana bats were removed from the harp traps and processed for data on sex, reproductive condition, and morphometric measurements. Five of the bats were banded (Table 10); guano was collected from some individuals. All bats were released in good condition at or near the point of capture.

4.1.5 Habitat Assessment and Entrance Description –

The following descriptions of habitat were grouped according to relative proximity and similar habitat types. Cave Site Habitat Descriptions and Entrance Descriptions are provided in Appendix D.

Cave, Cave, Cave, Cave, and Cave are all in an upland area of southern Monroe County. Entrances are vertical and located in mid/late-successional upland forests, with the exception of Cave, which has a horizontal entrance located in mixed upland/riparian forest. No airflow was detected at entrances.

Dominant canopy trees (>16 inches [40 cm] dbh) included many upland species such as red oak (*Quercus rubra*), shagbark hickory (*Carya ovata*), white oak (*Quercus alba*), tulip poplar (*Liriodendron tulipifera*), black oak (*Quercus velutina*), and sugar maple (*Acer saccharum*). Subdominant canopy trees (<16 inches [40 cm] dbh) included an identical species compliment to dominant canopy trees with the addition of red maple (*Acer rubrum*). Canopy closure was moderate to closed with low subcanopy clutter. Roost tree potential was moderately high, and consisted of snags and large trees.

Cave, Cave and Cave are in open early-successional habitats with little canopy cover. Cave and Cave have vertical entrances while Cave has a horizontal spring entrance. No airflow was detected at entrances.

Dominant canopy trees (>16 inches [40 cm] dbh) included only sugar maple. Subdominant canopy trees (<16 inches [40 cm] dbh) included many successional species such as red cedar (*Juniperus virginiana*), black walnut (*Juglans nigra*), black locust (*Robinia pseudo-acacia*), tulip poplar, shagbark hickory, red oak, and honey locust (*Gleditsia triacanthos*). Canopy closure was moderate to open with moderately low subcanopy clutter. Roost tree potential was low and consisted of snags and large trees.

Cave and Cave are in an upland area above Little Indian Creek. Entrances are horizontal and located in mid-successional upland forests. Recent timbering near Cave had thinned canopy layers considerably. No airflow was detected at entrances.

Dominant canopy trees (>16 inches [40 cm] dbh) included black oak, sycamore (*Platanus occidentalis*), and sugar maple. Subdominant canopy trees (<16 inches [40 cm] dbh) included shagbark hickory, sugar maple, hornbeam (*Ostrya virginiana*), and slippery elm (*Ulmus rubra*). Canopy closure was moderate with moderate subcanopy clutter. Roost tree potential was moderately high and consisted of snags and large trees.

Cave, Cave, Cave, and Cave are in bottomland/riparian forests in the Little Indian Creek valley.

Cave has a small vertical entrance while Cave, Cave, and Cave have horizontal entrances. Slight airflow was detected at Cave, Cave, and Cave.

Dominant canopy trees (>16 inches [40 cm] dbh) included sugar maple, sycamore, black maple (*Acer nigrum*), chestnut oak (*Quercus prinus*), beech (*Fagus grandifolia*), and white oak. Subdominant canopy trees (<16 inches [40 cm] dbh) included sugar maple, beech, and shagbark hickory. Canopy closure was moderate to closed with moderate subcanopy clutter. Roost tree potential was moderately low and consisted of snags and large trees.

Cave and Cave are in a deeply eroded valley on Clifty Branch of Plummer Creek. Both caves have horizontal entrances in riparian areas within close proximity to one another. Airflow was detected at entrances to both caves.

Dominant canopy trees (>16 inches [40 cm] dbh) included some bottomland species such as sycamore, red oak, and American basswood (*Tilia americana*). Subdominant canopy trees (<16 inches [40 cm] dbh) included sugar maple, ironwood (*Carpinus caroliniana*), and beech. Canopy closure was open with moderate subcanopy clutter. Roost tree potential was low and consisted of snags.

Cave and Cave are in a shallow valley within close proximity to one another. Cave is in riparian forest while Cave sits higher, in upland forest. Both entrances are vertical. No airflow was detected at entrances.

Dominant canopy trees (>16 inches [40 cm] dbh) included white oak, red oak, tulip poplar, shagbark hickory, and green ash (*Fraxinus pennsylvanica*). Subdominant canopy trees (<16 inches [40 cm] dbh) included sugar maple, shagbark hickory, and red maple. Canopy closure was moderate to closed with moderately high subcanopy clutter. Roost tree potential was moderately high and consisted of snags and large trees.

Cave and Cave are on intermittent and perennial streams and are essentially swallow holes. Cave is in bottomland/riparian forest while Cave is in mixed upland/riparian forest. Both caves have horizontal entrances. Slight airflow was detected at

Dominant canopy trees (>16 inches [40 cm] dbh) included tulip poplar, beech, and sycamore. Subdominant canopy trees (<16 inches [40 cm] dbh) included an identical species compliment to dominant canopy trees with the addition of sugar maple and black walnut. Canopy closure was moderate to closed with moderately high subcanopy clutter. Roost tree potential was moderate and consisted of snags and large trees.

Cave, Cave, Cave, and Cave have entrances in mid successional upland forest. Cave has a horizontal entrance while Cave, Cave, and Cave have vertical entrances. Slight airflow was detected at Cave.

Dominant canopy trees (>16 inches [40 cm] dbh) included tulip poplar, beech, and sycamore. Subdominant canopy trees (<16 inches [40 cm] dbh) included an identical species compliment to dominant canopy

trees with the addition of sugar maple and shagbark hickory. Canopy closure was moderate to closed with moderately low subcanopy clutter. Roost tree potential was low and consisted of snags and large trees.

Cave, and Cave are in mid-successional upland forests. and Cave have horizontal entrances while Cave has a vertical entrance. Slight airflow was detected at

Dominant canopy trees (>16 inches [40 cm] dbh) included sugar maple, white oak, sycamore, and post oak (*Quercus stellata*). Subdominant canopy trees (<16 inches [40 cm] dbh) included shagbark hickory, black gum (*Nyssa sylvatica*), sugar maple, and ironwood. Canopy closure was moderate to closed with moderate subcanopy clutter. Roost tree potential was moderate and consisted of snags and large trees.

Cave and Cave have entrances that were at or above spring level. Both have horizontal entrances that were located on large rock outcrops that serve as known landmarks. Airflow was detected at entrances to both caves.

Dominant canopy trees (>16 inches [40 cm] dbh) included sugar maple, sycamore, white oak, beech, and black walnut. Subdominant canopy trees (<16 inches [40 cm] dbh) included sugar maple, green ash, and ironwood. Canopy closure was closed at Cave, and open at Cave. Subcanopy clutter was moderately low. Roost tree potential was moderate and consisted of snags and large trees.

4.1.6 Anabat –

AnaBat systems were used to record ultrasonic bat calls at Cave and Cave, neither of which could be safely or effectively trapped or netted. A total of 43 calls was recorded at Cave, and a total of 141 calls was recorded at Cave.

4.2 Cave Surveys –

4.2.1 Total Count –

A total of 627 bats representing 5 species was found: 382 little brown bats (*Myotis lucifugus*), 206 eastern pipistrelles (*Pipistrellus subflavus*), 29 Indiana bats (*Myotis sodalis*), 6 big brown bats (*Eptesicus fuscus*), and 4 northern bats (*Myotis septentrionalis*) (Table 11).

Cave harbored 78 percent of the total census, with 488 individuals, including 28 Indiana bats. No bats were found at Cave, Cave, Cave, Cave, Cave, Cave, or Cave. Disregarding Cave, the mean number of individuals counted per cave was 5.1.

4.2.2 Species Diversity –

Species complement in the project area was typical for the geographic location, type of habitat, and season. In addition to the Indiana bat, four other species of bats were counted. Collectively, little brown bats accounted for 61 percent of all individuals captured. A chi-square test confirmed that species were not evenly represented (χ^2 = 882.2, P <0.0001).

The average number of species represented in caves was 1.2. Species richness was highest at where all five species

identified during winter 2005 were found. The MacArthur (1972) diversity index for bats found in caves on this portion of Section 4 in winter 2005 was 2.1.

4.2.3 Occurrence by Sex and Age –

Sex and age were not determined during winter hibernation.

4.2.4 Indiana Bats –

Cave contained 28 Indiana bats, while Cave contained one individual (Figure 9, Table 11).

4.2.5 Survey Descriptions –

The following survey descriptions follow standardized reporting methods (Brack et al. 1995). Appendix D contains Completed Cave Survey Data Sheets containing cave maps (when feasible) showing temperature locations and portion of caves surveyed. and caves were not surveyed.

Cave

The entrance to this cave is on the northeast side of a ridge. An intermittent stream leads to several swallow holes outside and inside the entrance. is a very shallow horizontal cave with structural features similar to a rockhouse. Total horizontal extent is approximately 30 feet.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 4 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature at the entrance was 7.2°C. In the crawlway to the back of the cave, the temperature was 7.0°C.

Other Species of Bats: No other species of bats were found.

Equipment or Safety Considerations: There are no special requirements.

Cave

The entrance to this cave is near a residence in a maintained yard. Rolls of old fence line the edges of the small collapsing entrance. Any past connection the entrance had to the lower spring has collapsed and been silted shut. Total length of the current cave is approximately 15 feet. Passage from the lower spring to the upper entrance has also collapsed.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 5 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature at the entrance and inside the cave was 8.6°C.

Other Species of Bats: No other species of bats were found.

Equipment or Safety Considerations: There are no special requirements, although the entrance is collapsing.

Cave

Cave is located in close proximity to Cave, a known

Indiana bat hibernaculum. The entrance is at the bottom of a small sinkhole on the west side of a ridge, above Little Indian Creek. A narrow climb-down leads to approximately 40 feet of walking passage.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.
Date: 6 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperatures inside the cave ranged from 9.3 to 9.8°C.

Other Species of Bats: Three eastern pipistrelles were found randomly throughout the cave.

Equipment or Safety Considerations: There are no special requirements.

The entrance to this cave is on a steep north-facing slope above Spring. A steep downward debris slide leads to a low junction room where one of several short passages leads to a small breakdown room. Total estimated length of this cave is 50 feet.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 7 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 10.4°C, and 11.5°C in the breakdown room.

Other Species of Bats: Two eastern pipistrelles were found in the breakdown room.

Equipment or Safety Considerations: A handline may be helpful in negotiating the entrance.

Cave

is a well-known spring located at the bottom of a large bluff face just 50 feet from a county road. Graffiti decorate the several spring entrances to this cave. A dry entrance leads through a 12-inch squeeze to 1589 feet of low stream passage.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 18 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 4.4°C, and 7.6°C before the 300 Foot Bathtub.

Other Species of Bats: Two little brown bats and six eastern pipistrelles were found randomly in the cave's many domes.

Equipment or Safety Considerations: Low wet crawlway with little air space is frequent. Clothing and equipment will be completely submerged. Rain, and subsequent flooding of passages, may be a hazard.

Cave

The entrance pit to
is on a steep south-facing slope. A narrow crack drops 25 feet to a steeply sloping pile of breakdown. Approximately 500 feet of

passage lead to a low spring entrance. Low visitation to this cave has resulted in little impact to its wet domes and passages.

Portion of Cave Visited: During the 2005 survey, all passages in the anterior portion of the cave were searched for bats.

Date: 13 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 10.2°C, and 11.9°C in passages before the end of survey.

Other Species of Bats: Three eastern pipistrelles were found randomly in the cave's many interconnected passages near the entrance.

Equipment or Safety Considerations: Vertical equipment should be used to enter and exit the cave's entrance pit. The entrance pit is narrow, and complete vertical gear may be too restrictive.

Cave

This cave is located at the edge of a pasture at the bottom of a shallow ravine. A spring issues from the west-facing entrance and fills the low passage within a few inches of the ceiling, preventing entry in the winter. Surveyed length of the cave is approximately 400 feet.

Portion of Cave Visited: During the 2005 survey, the entrance of the cave was searched for bats. Absence of an adequate flight path for bats ceased further inspection.

Date: 13 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 5.1°C.

Other Species of Bats: No other species of bats were found.

Equipment or Safety Considerations: This is a very wet cave, but there are no other special requirements.

Cave

serves as a swallow hole situated on a perennial and intermittent stream at the base of a wooded upland ravine. The entrance is behind a residence, and is in close proximity to Cave, a known Indiana bat hibernaculum. Surveyed length of the cave is 400 feet, with a 50-foot vertical extent.

Portion of Cave Visited: During the 2005 survey, the entrance was searched for bats. Absence of an adequate flyway ceased further inspection.

Date: 6 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 9.7°C. Temperatures in the rest of the cave ranged from 9.6°C at the base of the pit to 11.1°C in the upper passage.

Other Species of Bats: Six eastern pipistrelles were found in the main and upper passage, while six were found in the passage at the base of the pit.

Equipment or Safety Considerations: Vertical equipment is required to enter and exit the pit, likely in or near a waterfall during periods of moderate stream levels.

Cave

has served as a root cellar for a maple sugaring operation located outside its improved entrance. Numerous buckets, bottles, and other debris line its silted entrance. The cave contains a total of 547 feet of low muddy passage.

Portion of Cave Visited: During the 2005 survey, the entrance and anterior passage was searched for bats. Absence of an adequate flight path for bats ceased further inspection.

Date: 6 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 6.0°C. Just beyond the entrance, temperatures ranged from 7.2 to 7.4°C.

Other Species of Bats: No other species of bats were found.

Equipment or Safety Considerations: No special equipment is required.

Cave

The entrance to this 2-mile long cave is at the edge of an upland pasture at the head of a small ravine. The narrow meandering passages of the dry upper level lead to large, open, stream level passage.

Portion of Cave Visited: During the 2005 survey, passages leading to the stream passage were searched for bats

Date: 11 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 10.2°C. Just beyond the entrance the temperature was 10.4°C. Temperatures for the rest of the survey ranged from 12.2°C to 12.8°C.

Other Species of Bats: Bats found randomly throughout the survey included: 1 northern bat, 3 little brown bats, and 26 eastern pipistrelles.

Equipment or Safety Considerations: No special equipment is required.

Cave

The entrance to is a narrow vertical crack that tapers to less than 12 inches wide. The entrance pit drops approximately 20 feet to a second pit, which drops an additional 20 feet to the base of the cave.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 12 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 11.0°C. The temperature at the base of the second pit was 12.0°C.

Other Species of Bats: No other species of bats were found.

Equipment or Safety Considerations: Vertical gear is required to enter and exit the cave entrance pit. The entrance pit is narrow, and ascending with complete vertical gear through the crack may be too restrictive.

Cave

The entrance to Cave is under a rock overhang above a spring. A 10-foot climb-down pit connects the upper dry passage to the lower stream passage. The low stream passage is heavily silted, suggesting it likely floods. Total length of the cave is approximately 1000 feet.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 13 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance, at the top of the pit was 10.2°C. Temperatures in the stream passage ranged from 9.8°C, at the base of the pit, to 11.6°C, at the end of the survey.

Other Species of Bats: A single northern bat was documented.

Equipment or Safety Considerations: No special equipment is required.

Cave

Cave is a small, well-known cave at the base of a ravine. A perennial spring issues from its large entrance. Total length of the cave is approximately 150 feet.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 31 January 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 6.6°C. The temperature at the end of the cave was 9.1°C.

Other Species of Bats: Two big brown bats were found in the entrance.

Equipment or Safety Considerations: No special equipment is required.

is located in an upland area in close proximity to several classic Indiana pit caves. A 20-foot climb-down from the entrance leads to a second, 12-foot climb down into a lower pit. Total horizontal length of the cave is approximately 20 feet.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 19 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 5.8°C. The temperature at the base of the second pit was 7.8°C.

Other Species of Bats: Three eastern pipistrelles were found in the cave.

Equipment or Safety Considerations: A handline and safety Jumar are recommended to enter and exit this cave.

Cave

Below the narrow gated entrance, bells out into a 20-foot wide, 52-foot deep pit. Approximately 100 feet of additional passage, laced with additional small pits and domes, exist beyond the entrance pit.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 19 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature at the base of the pit was 7.7°C. The temperature in the farthest reach of the cave was 9.9°C.

Other Species of Bats: Four eastern pipistrelles were found in the cave.

Equipment or Safety Considerations: Vertical equipment is required to enter and exit the cave.

Cave

The entrance to this cave is in a large rock alcove above a pond created by damming the spring issuing from below the entrance. An extremely narrow entrance passage leads to approximately 75 feet of additional narrow passage. No connection was found to the lower spring.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 11 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 6.8°C. The temperature in the farthest reach of the cave was 8.9°C.

Other Species of Bats: No other species of bats were found.

Equipment or Safety Considerations: No special equipment is required.

Cave

The small spring entrance to this cave is located on Clifty Branch Plummer Creek. Low passage near the entrance is nearly filled to the ceiling with water in winter. Additional low, wet passage becomes nearly impassible. A dry entrance, located nearly 1200 feet away, also becomes restrictive and nearly impassible.

Portion of Cave Visited: During the 2005 survey, approximately 200 feet of passage from the spring entrance was searched for bats. Approximately 200 feet of the dry entrance were also searched for bats. Absence of an adequate flight path for bats ceased further inspection.

Date: 4 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 5.4°C, while the temperature at the end of survey was 7.2°C. The temperature inside the dry entrance was 11.3°C.

Other Species of Bats: A single eastern pipistrelle was recorded.

Equipment or Safety Considerations: Low wet crawlway with little air space is frequent in the spring entrance. Clothing and equipment will be completely submerged.

Cave

The narrow entrance to drops slightly to the spring level, which continues, wet and low, for the entire length of the cave. Siltation and debris on the 3 to 4 foot ceilings, as well as in the several higher domes suggest the cave is prone to flooding. Approximately 600 feet into the cave's approximately 3000-foot length, a small breakdown room raises the ceiling an additional five feet above the rest of the cave. This appears to be the only area of the cave not prone to frequent flooding.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 18 February 2005.

Number of Indiana Bats: One Indiana bat was found.

Location of Indiana Bats: The Indiana bat was found on the ceiling of the breakdown room (Appendix D).

Hibernaculum Temperatures: The temperature inside the entrance was 6.8°C. The following temperatures were recorded in the rest of the cave: 9.1°C in the passage before the breakdown room, 10.8°C in the breakdown room, near the Indiana bat, and 11.9°C after the breakdown room.

Other Species of Bats: Eight eastern pipistrelles were recorded randomly in domes, the breakdown room, and flood-prone areas of the cave.

Equipment or Safety Considerations: No special equipment is required.

Cave

(also known as and Quarry) Cave is located on the south bluff face of an old limestone quarry. The cave has several large rooms, waterfall domes, and breakdown rooms.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 7 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 5.3°C. Temperatures in the rest of the cave ranged from 8.0 to 9.2°C.

Other Species of Bats: Bats found in the cave included: 24 eastern pipistrelles, 1 northern bat, and 1 little brown bat. Bats were found randomly throughout the cave, however the passage leading from the first large room to the first waterfall dome harbored the majority of the bats.

Equipment or Safety Considerations: A high, exposed, traverse is required to travel from the first room to the rest of the cave.

Cave

The Cave is high on a bluff face overlooking Clifty Branch Plummer Creek. The large entrance is approximately 15 feet above the stream. Several smaller entrances are located nearby, however, no connection

was found. Approximately 50 feet of passage was found during surveys.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 4 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 8.1°C. Temperatures at the other entrances ranged from 8.4 to 12.6°C.

Other Species of Bats: One big brown bat was found.

Equipment or Safety Considerations: No special equipment is required.

Cave

is located at the bottom of a steep sinkhole at the top of a shallow ravine. The sinkhole is approximately 30 feet deep. The entrance pit drops 55 feet to the top of a steep breakdown slope, which then descends an additional 35 feet to the bottom of the cave. The total horizontal extent of this cave is approximately 72 feet.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 5 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature at the base of the pit ranged from 7.6 to 10.8°C.

Other Species of Bats: Two eastern pipistrelles and two big brown bats were found on the lower walls of the cave.

Equipment or Safety Considerations: Vertical equipment is required to enter and exit this cave.

Cave

The entrance to Cave is in a small sinkhole midway up the side of a steep ravine. A 15-foot climb-down entrance pit leads to narrow, sinuous passage with various pits and domes. The total surveyed length of this cave is 360 feet.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 5 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature at the base of the entrance pit was 9.2°C. Elsewhere in the cave, temperatures ranged from 10.4 to 11.1°C.

Other Species of Bats: Nine eastern pipistrelles were found in the cave.

Equipment or Safety Considerations: A handline and safety Jumar is helpful in negotiating the entrance pit.

Cave

is located in the same ravine and slightly upslope from Cave. The small, restrictive entrance is at the base of a small sinkhole. A short climb-down from the entrance opens up into a moderately sized breakdown room. Low,

muddy passage continues beyond the room for approximately 300 feet.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.
Date: 5 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 10.2°C. The temperature was 11.3°C near the End of Survey.

Other Species of Bats: Eleven eastern pipistrelles were found in the cave.

Equipment or Safety Considerations: No special equipment is required.

Cave

Cave is a shallow, collapsing pit on the east side of a moderately steep ridge. The pit is approximately 25 feet in diameter and 15 feet deep. No real passage exists, however undercut walls are present.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 12 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: Temperatures inside the pit ranged from 3.0 to 3.2°C.

Other Species of Bats: No other species of bats were found.

Equipment or Safety Considerations: A handline and safety Jumar is helpful in entering and exiting this cave.

Cave

is on a shallow ravine in Linden Hollow. The 33-foot entrance pit leads to approximately 160 feet of passage ranging in height from 12 to 20 feet. A 30-foot high dome occupies the north end of the cave.

Portion of Cave Visited: During the 2005 survey, the entire cave was searched for bats.

Date: 14 January 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 5.3°C. Elsewhere in the cave, temperatures ranged from 6.5 to 7.3°C.

Other Species of Bats: One eastern pipistrelle was found.

Equipment or Safety Considerations: Vertical equipment is required to enter and exit this cave.

Cave

Cave, also in Linden Hollow, is located near the top of a shallow ridge. The climb-down entrance is in a small sinkhole. Below the entrance, a narrow passage leads to the main body of the cave, consisting of approximately 200 feet of multi-level domes and pits

Portion of Cave Visited: During the 2005 survey, approximately 100 feet of the anterior portion of the cave was searched for bats.

Date: 14 January 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance was 6.8°C. Elsewhere in the cave, temperatures ranged from 8.9 to 10.4°C.

Other Species of Bats: Four eastern pipistrelles and three little brown bats were found.

Equipment or Safety Considerations: No special equipment is required.

Cave

The shallow, 8-foot entrance pit to Cave is near the top of a moderately sloped ravine. A junction room inside leads to several dead-end passages. Previously existing passages are no longer accessible. Current horizontal extent is about 50 feet.

Portion of Cave Visited: During the 2005 survey, the junction room and short passages was searched for bats.

Date: 6 February 2005.

Number of Indiana Bats: No Indiana bats were found.

Hibernaculum Temperatures: The temperature inside the entrance pit was 7.2°C.

Other Species of Bats: One eastern pipistrelle was found.

Equipment or Safety Considerations: A handline and safety Jumar is helpful in negotiating the entrance pit.

Cave

The entrance located near several residences, is a pit approximately 70 feet deep. A steep breakdown slope leads from the bottom of the pit to a broad upper level and large, high ceiling. From there, low passage extends approximately 150 feet, giving the cave a total horizontal extent of 363 feet.

Date: 31 January 2005.

Number of Indiana Bats: A total of 28 Indiana bats were documented.

Location of Indiana Bats: The Indiana bats were found in a cluster near the back of the upper level, Area B, where the ceiling became low, to approximately 7 feet (Appendix D).

Hibernaculum Temperatures: A temperature of 4.8°C was recorded at the base of the entrance pit. At the top of the breakdown slope the temperature was 6.8°C, near the cluster of Indiana bats. The temperature on the ceiling, where the little brown bats were located was 6.9. The end of survey temperature in the passage extending beyond the upper level was 10.6°C.

Other Species of Bats: Other species of bats found included 373 little brown bats, 85 eastern pipistrelles, 1 northern bat and 1 big brown bat.

Equipment or Safety Considerations: Vertical equipment is required to enter and exit this cave.

4.3 Spring Entrance Surveys –

4.3.1 Total Bat Captures –

A total of 296 bats representing 3 species was captured: 189 northern bats (*Myotis septentrionalis*), 88 little brown bats (*Myotis lucifugus*), and 19 eastern pipistrelles (*Pipistrellus subflavus*) (Table 12).

Cave produced 284 bats, while Cave yielded 12. (Table 13). Because high capture numbers were recorded from Cave, and only two caves were sampled, the mean number of individuals captured per cave was high, 148, or 74 per trap night (Table 14).

4.3.2 Species Diversity –

Species complement in the project area was typical for the geographic location, type of habitat, and season. Three species of bats were captured. Collectively, northern bats and little brown bats accounted for 94 percent of all individuals captured. A chi-square test confirmed that species were not evenly represented ($\chi^2 = 148.2$, $P < 0.0001$).

The average number of species represented at cave entrances was 2.5. Species richness was highest at Cave, where three species were captured. The MacArthur (1972) diversity index for bats captured on this portion of Section 4 in spring 2005 was 2.0 evenly distributed species.

4.3.3 Occurrence by Sex and Age –

Adult males and females accounted for 58 percent (172 individuals) and 42 percent (124 individuals) of the total capture, respectively. A chi-square test of the data indicated no significant difference between the number of adult males and females ($\chi^2 = 7.8$, $P = 0.005$). No juveniles were captured because sampling preceded parturition.

Adult males and females of each species were captured. Assuming sexes should be equally represented, male little brown bats were significantly less abundant than females ($\chi^2 = 14.7$, $P = 0.0001$). Male northern bats were significantly more abundant than females ($\chi^2 = 43.8$, $P < 0.0001$). There was no significant difference between male and female eastern pipistrelles ($\chi^2 = 2.6$, $P = 0.11$; Table 14).

4.3.4 Indiana Bat Captures –

No Indiana bats were captured on this portion of Section 4 of the proposed I-69 corridor during spring 2005 entrance surveys.

5.0 Discussion

The objective of cave surveys was to improve understanding of the autumn, winter, and spring occurrence and habitat use by the Indiana bat (*Myotis sodalis*) on this portion of Section 4 of the proposed I-69 or within a 5-mile buffer zone. Surveys conducted in autumn 2004, winter 2005, and spring 2005 provide information about the following:

- Presence and distribution of Indiana bats on this portion of Section 4 and within a 5-mile buffer zone
- Autumn, winter, and spring habitat selection and use by male and female Indiana bats on this portion of Section 4 and within a 5-mile buffer zone

By adding to and comparing with previous regional studies, data can be used to help identify important hibernacula for the Indiana bat near the Section 4 corridor, and it can be used to aid the study design of future projects. These data also add to an understanding of the ecology of the species in Indiana and throughout its range, and thereby contribute to management and recovery of the species.

5.1 Bat Occurrence and Species Diversity –

The species complement and number of bats captured in the project area was typical for the geographic location and type of habitat. In addition to the Indiana bat, five other species of bats were captured on this portion of Section 4 in 2004.

Proportions of species of bats using cave entrances in spring and autumn varied from populations hibernating in the same caves. Northern bats (*Myotis septentrionalis*), a species commonly found at entrances in autumn and spring (Whitaker and Rissler 1992, Brack et al. in prep), composed 21 and 64 percent of the total capture in autumn and spring, respectively, only accounted for less than 1 percent of bats found in winter. Little evidence has been found of the species using the area in winter (Brack et al. 2003).

5.2 Occurrence by Sex –

It is common to find larger proportions of male bats at cave entrances in autumn (Cope and Humphrey 1977; Laval and LaVal 1980). Male little brown bats were nearly 20 times more abundant than females in the autumn. Sex ratios for the species were not as skewed in spring.

Based on the entire autumn sample, the proportion of male to female Indiana bats was similar to expected. Overall, Indiana bats were under represented in autumn compared to winter.

5.3 Indiana Bat Occurrence –

Autumn surveys detected Indiana bats at Cave, Cave, and Cave. Winter surveys showed no evidence that Indiana bats use these caves as hibernacula. During swarming it is believed that males visit many caves in an attempt to mate before hibernating (Hall 1962).

One result of the winter surveys was a single Indiana bat in Cave. Presence of a lone Indiana bat in hibernacula has been documented in the region in the past (Brack et al. 2003). The temperature in the area where the bat was located was 10.8°C. Although the optimal range of temperatures preferred by Indiana bats is 6 - 8°C (Brack et al. 2003; Brack and Reynolds in prep), hibernacula have been found with temperatures ranging from –1.6 to 17°C (Barbour and Davis 1969; Humphrey 1978).

Cave, in addition to harboring a small cluster of Indiana bats, held a large population of little brown bats, as well as three other species of bats. Although the cave lacked many characteristics of typical hibernacula, such as noticeable air flow (Henshaw 1965), the area where the Indiana bats were hibernating seemed thermally stable.

Little is known about autumn and spring activity of the Indiana bat at cave entrances in the region. As the Tier II Environmental Impact Studies of the Proposed I-69 corridor continue, and large sample sizes are collected, data will be more confidently analyzed for trends.

6.0 Acknowledgements

Environmental Solutions and Innovations, Inc. (ESI) sincerely thanks the numerous organizations and individuals that contributed time and talent to this project. Appreciation is extended to FHWA, INDOT, BLA, and USFWS, for providing us the opportunity to be involved in this project. We especially wish to thank Dr. Tom Cervone, Jason DuPont, and Garre Conner of BLA, and R. Andrew King of USFWS, for guidance, assistance, and participation in this project. We are grateful to the many landowners who allowed us access to caves on their property to conduct our research. The preparers of this report would like to thank Jeanette Jaskula of ESI for providing location, physiography, and species occurrence text for the report as well as the overall framework and format.

7.0 Literature Cited

Barbour, R. W., and W. H. Davis. 1969. Bats of America. University Press of Kentucky, Lexington.

Belwood, J. J. 1979. Feeding ecology of an Indiana bat community with emphasis on the endangered Indiana bat, *Myotis sodalis*. M.S. thesis, University of. Florida, Gainesville.

BLA-Bernardin-Lochmueller & Associates. 2003. Tier 1 biological assessment for threatened and endangered species, Interstate 69, Indianapolis to Evansville [dated July 18, 2003, revised October 27, 2003; submitted to the Bloomington Field Office of the U.S. Fish and Wildlife Service by the Federal Highway Administration and Indiana Department of Transportation.

Brack, V., Jr. 1979. The duration of the period of hibernation in *Eptesicus fuscus*, *Myotis lucifugus*, and *Pipistrellus subflavus* under natural conditions. M.S. thesis, University of Missouri, Columbia.

Brack, V., Jr. 1983. The nonhibernating ecology of bats in Indiana with emphasis on the endangered Indiana bat, *Myotis sodalis*. Ph.D. dissertation, Purdue University, West Lafayette, Indiana.

Brack, V., Jr. In submission. Food habits and foraging ecology of the Indiana bat, *Myotis sodalis*, in Indiana. In submission to the Northeastern Naturalist.

Brack, V., Jr. In Prep. Autumn activities of the endangered Indiana bat (*Myotis sodalis*) near a hibernaculum in Bland

County, Virginia. In preparation for the Northeastern Naturalist.

Brack, V., Jr. In Prep. Temperatures and locations used by hibernating bats, including the endangered Indiana bat (*Myotis sodalis*), in a limestone mine in Ohio.

Brack, V., Jr., and J. C. Carter. 1985. Use of an underground burrow by *Lasionycteris*. Bat Research News 26:28-29.

Brack, V. Jr., R. K. Dunlap, S. J. Collins, and S. A. Johnson. In prep. Laser calipers: a device for estimating the size of clusters of hibernating bats. In preparation for Wildlife Society Bulletin.

Brack, V. Jr., S. A. Johnson, and R. K. Dunlap. 2003. Wintering populations of bats in Indiana, with emphasis on the endangered Indiana myotis, *Myotis sodalis*. Proceedings of the Indiana Academy of Science 112:61-74.

Brack, V., Jr., and R. K. LaVal. 1985. Food habits of the Indiana bat in Missouri. Journal of Mammalogy 66:308-315.

Brack, V. Jr., W. Orndorff, R. J. Reynolds, and J. Zokaites. In Prep. Seasonal use of Skydusky Hollow Cave system, Bland County, Virginia, by bats. In preparation for Virginia Journal of Science.

Brack, V. Jr., and R. J. Reynolds. In Prep. Temperatures used by bats hibernating in Skydusky Hollow, Bland County, Virginia. In preparation for Virginia Journal of Science.

Brack, V. Jr., C. W. Stihler, R. J. Reynolds, C. Butchkoski, and C. S. Hobson. 2002. Effects of climate and elevation on distribution and abundance in the mideastern United States. Pp. 21-28 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Brack, V., Jr., and J. W. Twente. 1985. The duration of the period of hibernation in three species of vespertilionid bats I: field studies. Canadian Journal of Zoology 63:2952-2954.

Brack, V. Jr., K. Tyrell, and K. Dunlap. 1995. A 1994-1995 winter census for the Indiana bat (*Myotis sodalis*) in hibernacula of Indiana. Unpublished technical report for the Indiana Department of Natural Resources, Division of Fish and Wildlife, Nongame and Endangered Wildlife Program, Indianapolis, Indiana.

Brack, V., Jr., and J. O. Whitaker, Jr. 2004. Bats of the Navel Surface Warfare Center, at Crane, Indiana. Proceedings of the Indiana Academy of Sciences 113:66-75.

Brack, V. Jr., and J.O. Whitaker, Jr. In prep. The Indiana myotis on an anthropogenic landscape.

Brack, V. Jr., J. O. Whitaker, Jr., & S. E. Pruitt. 2004. Bats of Hoosier National Forest. Proceedings of the Indiana Academy of Science 113:76-86.

Brack, V., Jr., A. M. Wilkinson, and R. E. Mumford. 1984. Hibernacula of the endangered Indiana bat in Indiana. Proceedings of the Indiana Academy of Science 93:463-468.

Britzke, E. R., M. J. Harvey, and S.C. Loeb. 2003. Indiana bat, *Myotis sodalis*, Maternity roosts in the Southern United States. Southeastern Naturalist 2:235-242.

Brown, R. J., and V. Brack, Jr. 2003. An unusually productive net site over an upland road used as a travel corridor. Bat Research News 44:187-188.

Brown, R. J., R. A. King, and R. Romme. 2001. First documented maternity colony of the Indiana bat in Greene County, Ohio. Abstract Bat Research News 42:27.

Butchkoski, C. M., and J. D. Hassinger. 2002. Ecology of a maternity colony in a building. Pp. 130-142 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Callahan, E. V., R. D. Drobney, and R. L Clawson. 1997. Selection of summer roosting sites by Indiana bats (Myotis sodalis) in Missouri. Journal of Mammalogy 78:818–825.

Carter, T. 2002. Bat houses for conservation of endangered Indiana myotis. The Bat House Researcher 10:1-3.

Carter, T. C. 2003. Summer habitat use of roost trees by the endangered Indiana bat (*Myotis sodalis*) in then Shawnee National Forest of Southern Illinois. Ph.D. dissertation, Southern Illinois University, Carbondale.

Clark, B., J. Bowles, and B. Clark. 1987. Summer occurrences of the Indiana bat, Keen's Myotis, evening bat, silver-haired bat and eastern pipistrelle in Iowa. Iowa Academy of Science 94:89-93.

Clawson, R. L. 2002. Trends in population size and current status. Pp. 2-8 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Clawson, R. L., R. K. LaVal, M. L. LaVal and W. Caire. 1980. Clustering behavior of hibernating *Myotis sodalis* in Missouri. Journal of Mammalogy 61:245-253.

Cope, J., and S. Humphrey. 1977. Spring and autumn swarming behavior in the Indiana bat, *Myotis sodalis*. Journal of Mammalogy 58:93-95.

ESI-Jaskula, J.M., and V. Brack, Jr. 2004. Summer habitat for the Indiana bat (*Myotis sodalis*) within the Crawford upland and Mitchell Plain from Scotland to Bloomington, Indiana. A Report to DLZ Indiana, LLC.

Foster, R. W., and A. Kurta. 1999. Roosting ecology of the northern bat (*Myotis septentrionalis*) and comparisons with the endangered Indiana bat (*Myotis sodalis*). Journal of Mammalogy 80:659-672.

Gardner, J. E., and E. A. Cook. 2002. Seasonal and geographic distribution and quantification of potential summer habitat. Pp. 9-20 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Gardner, J. E., J. D. Garner, and J. E. Hofmann. 1991. Summer roost selection and roosting behavior of *Myotis sodalis* (Indiana bat) in Illinois. A report prepared for U. S. Fish and Wildlife Service, Region 3 Endangered Species Coordinator, Twin Cities, Minnesota.

Grindal, S. D. 1996. Habitat use by bats in fragmented forests. Pp. 260 – 272 in Bats and Forest Symposium October 19 – 21, 1995 Victoria, British Columbia, Canada (R. M. R. Barclay and R. M.

Brigham, eds.). Research Branch, British Columbia Ministry of Forests, Victoria, Canada.

Gumbert, M. W. 2001. Seasonal roost tree use by Indiana bats in the Somerset Ranger District of the Daniel Boone National Forest, Kentucky. M.S. thesis, Eastern Kentucky University, Lexington.

Hall, J. 1962. A life history and taxonomic study of the Indiana bat, *Myotis sodalis*. Reading Public Museum and Art Gallery Science publication 12:1-68.

Henshaw, R. E. 1965. Physiology of hibernation and acclimation in two species of bats (*Myotis lucifugus* and *Myotis sodalis*). Ph.D. dissertation, State University Iowa, Ames.

Henshaw, R. E. and G. E. Folk, Jr. 1966. Relation of thermoregulation to seasonally changing microclimate of two species of bats (*Myotis lucifugus* and *M. sodalis*). Physiological Zoology 39:223-236.

Hicks, A., and P. G. Novak. 2002. History, status, and behavior of hibernating populations in the Northeast. Pp. 35-47 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin.

Homoya, M. A., D. B. Abrell, J. R. Aldrich, and T. W. Post. 1985. The natural regions of Indiana. Proceedings of the Indiana Academy of Science 94:245-268.

Humphrey, S. R. 1978. Status, winter habitat, and management of the endangered Indiana bat, *Myotis sodalis*. Florida Scientist 41:65-76.

Humphrey, S. R., A. R. Richter, and J. B. Cope. 1977. Summer habitat and ecology of the endangered Indiana bat, *Myotis sodalis*. Journal of Mammalogy 58:334-346.

Johnson, S. A., V. Brack, Jr. and R. K. Dunlap. 2002. Management of hibernacula in the state of Indiana. Pp. 106-115 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Johnson, S. A., V. Brack, Jr., and R. E. Rolley. 1998. Overwinter weight loss of Indiana bats (*Myotis sodalis*) from hibernacula subjected to human visitation. American Midland Naturalist 139:255-261.

Kath, J. A. 2002. A review of the hibernacula in Illinois, with emphasis on the Magazine Mine. Pp. 110-117 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Kerth, G., M. Wagner and B. Konig. 2001. Roosting together, foraging apart: information transfer about food is unlikely to explain sociality in female Bechstein's bats (*Myotis bechsteinii*). Behaviora; Ecology and Sociobiology 50:283-291.

Kiser, J. D., and C. L Elliott. 1996. Foraging habitat, food habits, and roost tree characteristics of the Indiana bat (*Myotis sodalis*) during autumn in Jackson County, Kentucky. Unpubl. report to Kentucky Department of Fish and Wildlife Resources, Frankfort.

Kiser, J. D., J. R. MacGregor, H. D. Bryan, and A. Howard. 2002. Use of concrete bridges as night roosts. Pp. 208-215 in The Indiana bat: biology and

management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Kurta, A., D. King, J. A. Teramino, J. M. Stribley, and K. J. Williams. 1993. Summer roosts of the endangered Indiana bat (*Myotis sodalis*) on the northern edge of its range. American Midland Naturalist 129:132-138.

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

Kurta, A., S. W. Murray, D. H. Miller. 2002. Roost selection and movements across the summer landscape. Pp. 118-129 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Kurta, A, and J. O. Whitaker, Jr. 1998. Diet of the endangered Indiana bat (*Myotis sodalis*) on the northern edge of its range. American Midland Naturalist 140:280-286.

Kurta, A., K. J. Williams, and R. Mies. 1996. Ecological, behavioral, and thermal observations of a peripheral population of Indiana bats (*Myotis sodalis*). Pp. 102-117 in Bats and Forest Symposium October 19 – 21, 1995 Victoria, British Columbia, Canada (R. M. R. Barclay and R. M. Brigham, eds.). Research Branch, British Columbia Ministry of Forests, Victoria, Canada.

LaVal, R. K., and M. L. LaVal. 1980. Ecological studies and management of Missouri bats, with emphasis on cave-dwelling species. Missouri Department of Conservation Terrestrial Series 8:1-53.

MacArthur, R. H. 1972. Geographical Ecology. Harper and Row, New York.

Miller, N. E., R. D. Drobney, R. L. Clawson, and E. V. Callahan. 2002. Summer habitat in northern Missouri. Pp. 165-171 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Murray, S. W., and A. Kurta. 2002. Spatial and temporal variation in diet. Pages 182-192 *In* The Indiana bat: Biology and Management of an Endangered Species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin.

Murray, S. W., and A. Kurta. 2004. Nocturnal activity of the endangered Indiana bat (*Myotis sodalis*). London Journal Zoology 262:197-206.

Myers, R. F. 1964. Ecology of three species of species of myotine bats in the Ozark Plateau. Ph.D. dissertation, University of Missouri, Columbia.

Parsons, K. N., G. Jones, and F. Greenway. 2003. Swarming activity of temperate zone microchiropteran bats: effects of season, time of night and weather conditions. London Journal Zoology 261:257-264.

Racey, P. A. 1982. Ecology of bat reproduction. Pp. 57-103 in Ecology of bats (T. H. Kunz, ed.). Plenum Publishing Corporation, New York.

Richter, A. R., S. R. Humphrey, J. B. Cope, and V. Brack, Jr. 1993. Modified cave entrances, thermal effects on body mass, and resulting decline of endangered

Indiana bats (*Myotis sodalis*). Conservation Biology 7:407-415.

Sanders, C., and J. Changer. 2001. Williams Lake telemetry study: New York Indiana bat spring migration tracking. Report to the Independence Pipeline Company.

Schultes, K. L., and C. L. Elliott. 2002. Roost tree selection by Indiana bats and northern bats on Wayne National Forest, Ohio. Unpublished report to U.S. Fish and Wildlife Service, Reynoldsburg, Ohio Field Office and USDA Forest Service, Wayne National Forest.

Stones, R. C., and J. E. Wiebers. 1967. Temperature regulation in the little brown bat, *Myotis lucifugus*. Pp. 97-109 in Mammalian hibernation III (Fisher, K. C., A. R. Dawe, C. P. Lyman, E. Schonbaum, and F. E. South, Jr., eds.). Oliver and Boyd, Edinburgh and London, United Kingdom.

Summit County Metro Parks. 2003. Preliminary inventory of bat species Pond Brook Metro Park and Twinsburg Park and Nature Preserve. Summit County Metro Parks, Akron.

3D/Environmental. 1995. Literature summary and habitat suitability index model. Components of summer habitat for the Indiana bat, *Myotis sodalis*. Cincinnati.

Tibbels, A. E., and A. Kurta. 2003. Bat activity is low in thinned and unthinned stands of red pine. Canadian Journal of Forest Research 33:2436-2442.

Twente, J. W., J. Twente, and V. Brack, Jr. 1985. The duration of the period of hibernation of three species of vespertilionid bats II: laboratory studies. Canadian Journal of Zoology 63:2955-2961.

(USFWS) U.S. Fish and Wildlife Service. 1999. Indiana Bat (*Myotis sodalis*) revised recovery plan, Agency Draft. Ft. Snelling, Minnesota.

(USFWS) U.S. Fish and Wildlife Service. 2005. Bat survey protocol for assessing use of potential hibernacula (I-69 Tier 2 Studies). Bloomington, Indiana.

Whitaker, J. O., Jr., D. W. Sparks, and V. Brack Jr. In prep. Use of artificial roost structures by bats at the Indianapolis International Airport. In prep for Environmental Management.

Whitaker, J. O., Jr., and V. Brack Jr. 2002. Distribution and ecology in Indiana. Pp. 48-54 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Whitaker, J. O., Jr., and L. J. Rissler. 1992. Seasonal activity of bats at copperhead cave. Proceedings of the Indiana Academy of Science 101:127-134.

Wimsatt, W. 1944. Further studies on the survival of spermatozoa in the female reproductive tract of the bat. Anatomical Record 88:193-204.

Appendix A

Figures

N
W E
S

Figure 1. Location of Section 4 of the proposed I-69 corridor in Greene and Monroe counties, Indiana

Project No. 123

ESI ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.

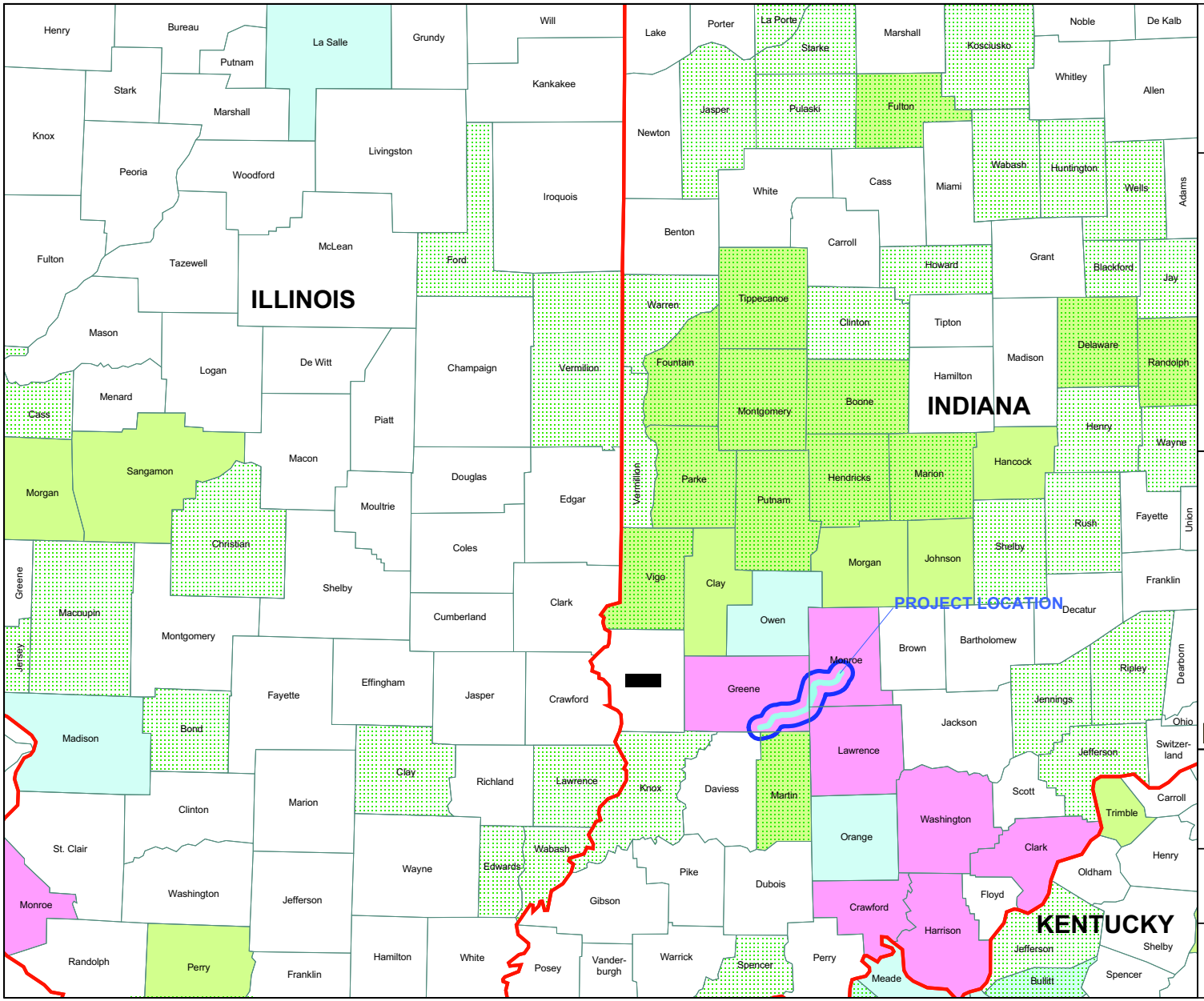
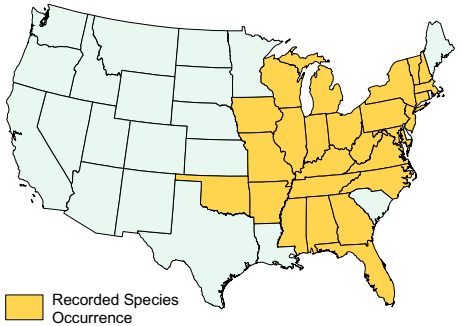


Figure 2. Counties near the project area with hibernacula, summer maternity, and other summer (nonreproductive) records for the Indiana bat (*Myotis sodalis*).

- County with Record of Indiana Bat Hibernacula Occurrence
- County with Record of Indiana Bat Summer Maternity Occurrence
- County with Record of Indiana Bat Other Summer (Nonreproductive) Occurrence
- County with Record of Indiana Bat Hibernacula and Other Summer (Nonreproductive) Occurrences
- State Boundary
- County Boundary

STATES WITH RECORDS OF INDIANA BAT OCCURRENCE



Recorded Species Occurrence

N W E S

Miles
10 0 10

Sources: USFWS, Indiana Bat Revised Recovery Plan, Agency Draft, 1999.

ESI ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.

Project No. 123

Figure 3 ("Locations of winter hibernacula (caves) of the Indiana bat (*Myotis sodalis*) in Greene and Monroe counties, Indiana.") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

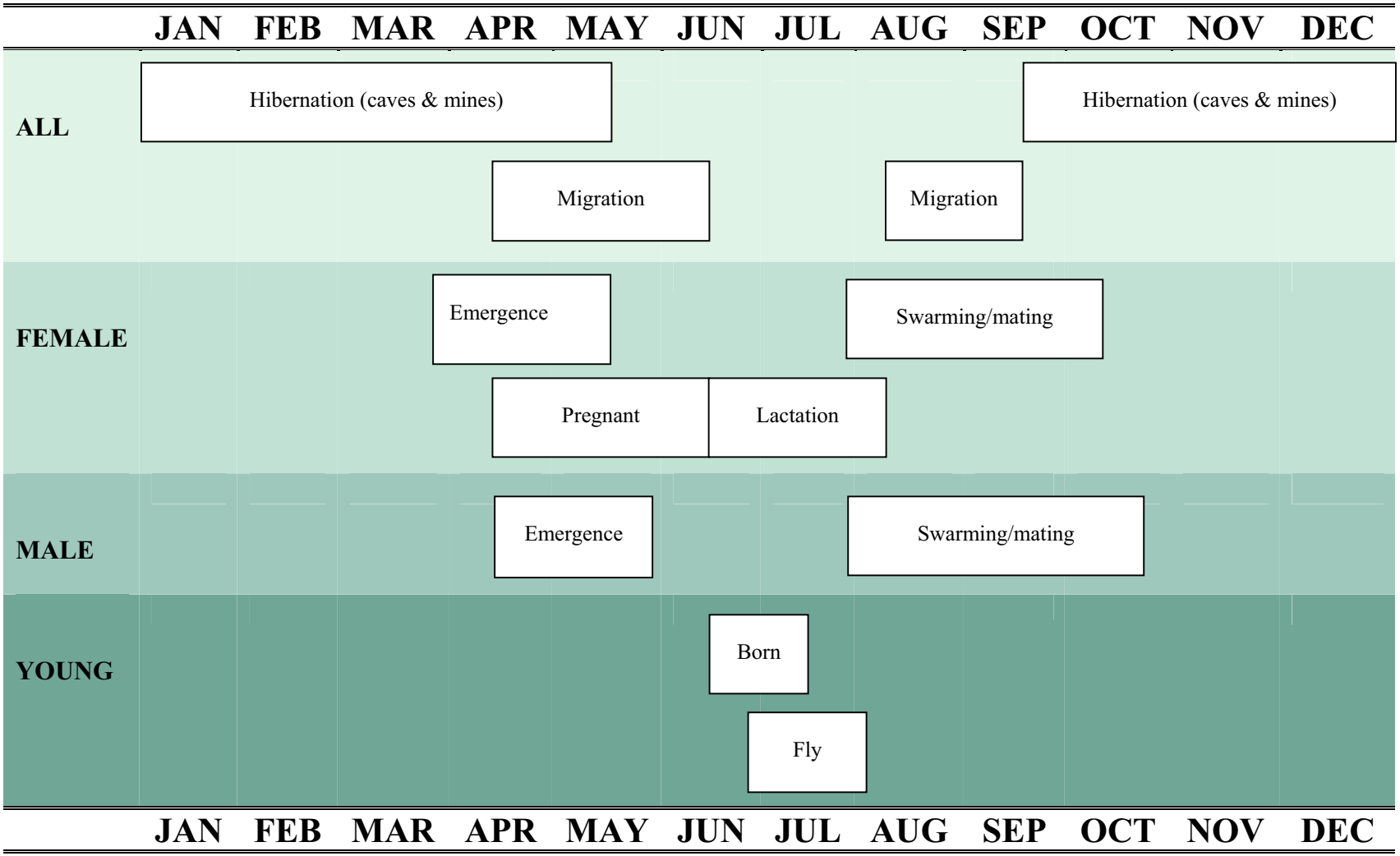


Figure 4. Seasonal chronology of Indiana bat activities.

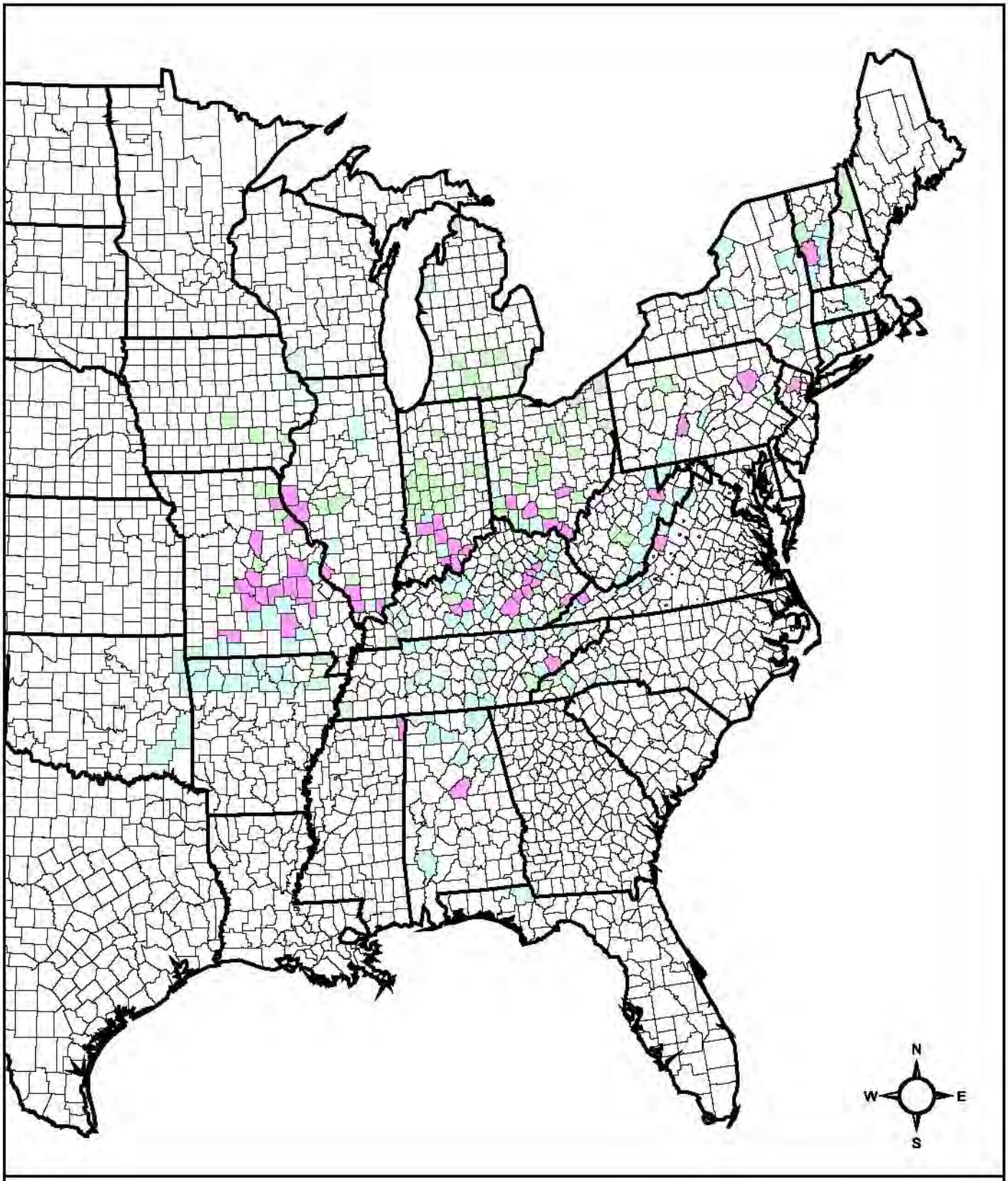


Figure 5. Counties with hibernacula and other summer (nonreproductive) records for the Indiana bat (*Myotis sodalis*) range wide.

County with Record of Indiana Bat Hibernacula Occurrence	County with Record of Indiana Bat Other Summer (Nonreproductive) Occurrence	County with Record of Indiana Bat Hibernacula and Other Summer (Nonreproductive) Occurrence

Project No. 123	Sources: USFWS, Indiana Bat Revised Recovery Plan, Agency Draft, 1999.	ESI ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.

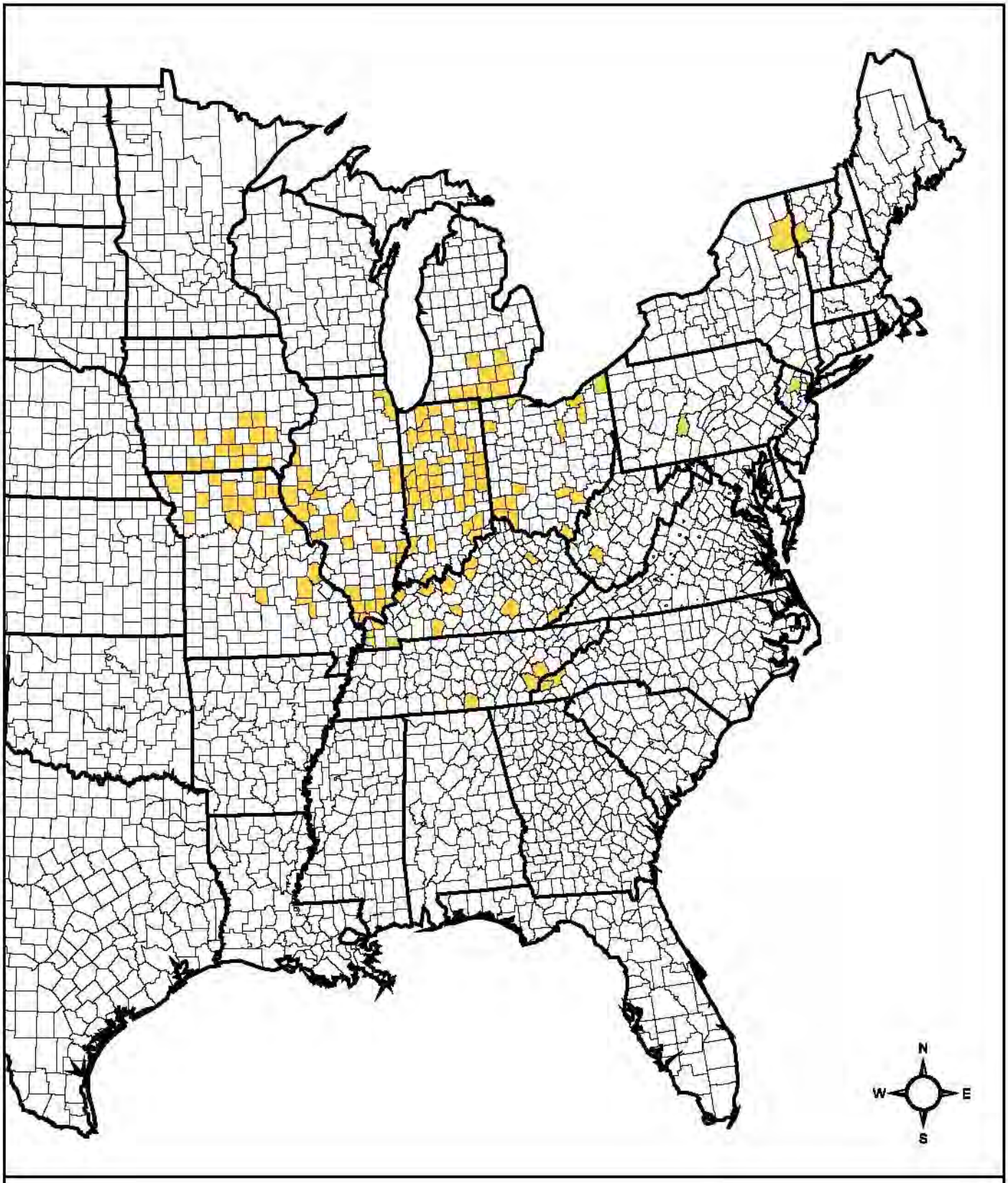


Figure 6. Counties with reproductive (adult female and/or young-of-the-year) records for the Indiana bat (*Myotis sodalis*) range wide.

County with Record of Indiana Bat Reproductive Occurrence

Project No. 123	Sources: USFWS, Indiana Bat Revised Recovery Plan, Agency Draft, 1999.	ESI ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.

Figure 7 ("Location of cave entrances surveyed on Section 4 of the proposed I-69 corridor.") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 8 ("Locations of cave entrances on Section 4 of the proposed I-69 corridor where Indiana bats (*Myotis sodalis*) were captured, autumn 2004.") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 9 ("Locations of cave entrances on Section 4 of the proposed I-69 corridor where Indiana bats (*Myotis sodalis*) were found hibernating, winter 2005.") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Appendix B

Tables

Table 1. County and location of 30 caves surveyed on a portion of Section 4 of the proposed I-69, autumn 2004, winter 2005, and spring 2005.

No.	Cave	County	Location
1		Monroe	
2		Monroe	
3		Monroe	
4		Greene	
5		Greene	
6		Greene	
7		Greene	
8		Monroe	
9		Lawrence	
10		Monroe	
11		Lawrence	
12		Monroe	
13		Monroe	
14		Greene	
15		Monroe	
16		Lawrence	
17		Lawrence	
18		Greene	
19		Greene	
20		Monroe	
21		Monroe	
22		Greene	
23		Lawrence	
24		Monroe	
25		Monroe	
26		Monroe	
27		Lawrence	
28		Lawrence	
29		Lawrence	
30		Lawrence	

Table 2. Entrance trapping guidelines followed on a portion of Section 4 of the proposed I-69, autumn 2004 and spring 2005.

Entrance Trapping Guidelines

1. Trapping/Netting Season: 25 August to 15 October for autumn sampling, 9 April to 30 April for spring sampling
2. Equipment:
   - Harp Traps (first choice): Placed in front of entrance, blocking flight path
   - Mist Nets (second choice): 50 denier, 38mm mesh placed in front of or around openings that can not be harp trapped
   - Alternative Monitoring Techniques: When caves can not be safely/effectively trapped or netted, bat detectors and/or night-vision/infrared/thermal-imaging recorders should be used to monitor bat activity at entrances
   - Bat Detector: an ultrasonic bat detector should be on site to periodically monitor bat activity and assess general effectiveness of trap placement
3. Sample Period: Begin 30 minutes before sunset and trap for at least five hours
4. Minimum Level of Effort Per Site:
   - Each entrance is trapped for 2 consecutive (preferred) or non-consecutive nights.
   - If no bat captures (of any species) occur and no bat activity is noted with a bat detector on the first evening during acceptable weather conditions, sampling may be suspended for the site
   - Traps are monitored at approximately 20-minute intervals (preferred), or at least once per hour, depending on capture rates and weather
5. Weather must provide for temperatures at or above 50°F (10°C) for the first two hours of sampling and not fall below 35°F(1.6°C) by midnight, and at least three hours of the sampling time be free of heavy rain and thunderstorms
6. Noise, and the shining of lights are kept to a minimum with no smoking near the sample site; use of radios, campfires, running vehicles, punk sticks, citronella candles, and other disturbances are not permitted within 300 feet (91 m) of the survey site

Source: USFWS 2005

Table 3. High and low temperatures (°F) recorded during entrance trapping surveys on a portion of Section 4 of the proposed I-69, autumn 2004.

Survey Dates (2004)	Survey Period (approx. 1830 – 2330 h)	
	High Temp. °F	Low Temp. °F
2 September	73	67
3 September	74	68
5 September	74	70
6 September	78	68
7 September	72	66
8 September	69	60
9 September	66	56
10 September	65	57
11 September	68	58
12 September	70	64
13 September	70	62
14 September	73	66
15 September	74	67
16 September	78	65
17 September	66	50
18 September	62	52
19 September	65	53
20 September	72	63
21 September	74	67
22 September	70	59
23 September	71	61
24 September	70	64
25 September	60	54
26 September	65	53
27 September	70	54
28 September	62	52
29 September	63	48
30 September	66	44
1 October	64	59
6 October	66	50
7 October	70	60
8 October	67	60
9 October	68	62
17 October	60	54
19 October	55	48

Table 4. Summary of Cave Emergence Counts, autumn 2004.

Date	Temperature °F	Start Time	End Time	Total Bats	Peak Rate Bats/minute
10 September	62	1830	1935	1323	64
19 September	59	1818	1940	2547	113
28 September	28	1800	1933	2001	88
19 October	19	1733	1927	47	3

Table 5. Hibernacula survey and reporting guidelines followed on a portion of Section 4 of the proposed I-69, winter 2005.

Hibernacula Survey and Reporting Guidelines

1. To ensure accurate comparison over time, the following factors will be considered:
    - Data must be collected consistently across caves and years
    - Hibernacula must be appropriately searched
    - Methods must provide reproducible results
    - Safety of surveyors must be assured
    - Other data of potential value, now or in the future, and compatibility over time
2. The following items are essential to standardize collection, interpretation, and comparison of data over time:
    - Cave name, location, legal description, and date of visit
    - A general description of the cave, including published accounts of the cave (when available)
    - Portion of the cave surveyed, including a map showing features of the cave important to the survey (when available)
    - Number of Indiana bats found
    - Locations of Indiana bats, including maps (when available) marking locations where bats were found
    - Temperatures of areas where Indiana bats hibernate (at a minimum) and other related temperature data such as of areas where other species hibernate and where no bats were found
    - Other species and numbers of bats using the cave
3. In reporting, each cave is introduced with a brief description of its morphology and character. The name and legal description, including county, USGS quadrangle, and quarter section are provided in a table. Other data are standardized using the following headings:
    - Portion of Cave Visited
    - Date
    - Number of Indiana Bats
    - Location of Indiana Bats
    - Hibernaculum Temperatures
    - Other Species of Bats
    - Equipment or Safety Considerations

Source: Brack et al. 1995

Table 6. High and low temperatures (°F) recorded during entrance trapping surveys on a portion of Section 4 of the proposed I-69, spring 2005.

Survey Dates (2004)	Survey Period (approx. 1830 – 2330 h)	
	High Temp. °F	Low Temp. °F
13-Apr	53	46
15-Apr	61	42
16-Apr	65	47
17-Apr	69	50

Table 7. Total bat captures by sex, reproductive condition, and age during entrance surveys on a portion of Section 4 of the proposed I-69, autumn 2004.

Species	Adult Male	Adult Female[1]				Juvenile		Escape[2]	Total
		P	L	PL	NA	Male	Female		
Big brown bat	1	0	0	0	1	0	0	0	**2**
Eastern pipistrelle	151	0	0	0	64	15	1	1	**232**
Indiana bat	5	0	0	0	1	0	0	0	**6**
Little brown bat	395	0	0	0	19	3	0	0	**417**
Northern bat	314	0	0	0	99	8	2	1	**424**
Total	**866**	**0**	**0**	**0**	**184**	**26**	**3**	**2**	**1081**

[1] P = pregnant; L = lactating; PL = Post lactating; NA = not available
[2] Escape = escaped from trap or hand before processing was complete

Table 8. Summary of total bat captures by cave and Indiana bat (*Myotis sodalis*) captures by sex and age on a portion of Section 4 of the proposed I-69, autumn 2004.

No.	Cave Name	Survey Dates	No. of Adult Female *M. sodalis*	No. of Adult Male *M. sodalis*	Total No. of *M. sodalis*	*Little brown bat*	*Northern bat*	*Big brown bat*	*Eastern pipistrelle*	Total # of Bats
1		2-3 September				2	14		14	**30**
2		5-6 September				3	9		5	**17**
3		7-8 September								**0**
4		9-10 September								**0**
5		9,11 September				59	55		24	**138**
6		12-13 September				45	45		15	**105**
7		14-15 September				8	23		3	**34**
8		16-17 September		1	1	8	3		3	**15**
9		16-17 September				5	11		1	**17**
10		18-19 September				6			1	**7**
11		18-19 September	1	3	4	191	88		43	**326**
12		20-21 September					2			**2**
13		22-23 September				14	35	1	30	**80**
14		24-25 September		1	1	51	41		15	**108**
15		26,29 September				10	10		3	**23**
16		27-28 September				1			1	**2**
17		27-28 September				1			8	**9**
18		27-28 September				2	45		15	**62**
19		27-28 September					1		2	**3**
20		29-30 September					3		2	**5**
21		29-30 September				2	1			**3**
22		29-30 September				1	1	1	3	**6**
23		29-30 September	Anabat Only- 43 Calls Recorded							
24		30 Sept-1 October				6	27		31	**64**
25		6,9 October					3		2	**5**
26		6,9 October							2	**2**
27		7-8 October					3		4	**7**
28		7-8 October				2	4		5	**11**
29		7,9 October								**0**
30		17-19 October	Anabat Only- 141 Calls Recorded							
Total			**1**	**5**	**6**	**417**	**424**	**2**	**232**	**1081**

Table 9. Numbers of adult bats captured, catch per net-night, and chi-square analysis of males and females captured on a portion of Section 4 of the proposed I-69, autumn 2004.

	Adult Male		Adult Female				Catch/trap-night
Species	**Bats**	**%**	**Bats**	**%**	X^2	***P***	**Total**
Big brown bat	1	0.1	1	0.1			**0.04**
Eastern pipistrelle	151	14.0	64	5.9	35.2	<0.0001	**4.14**
Indiana bat	5	0.5	1	0.1			**0.11**
Little brown bat	395	36.6	19	1.8	341.5	<0.0001	**7.45**
Northern bat	314	29.1	99	9.2	111.9	<0.0001	**7.57**
Total	**866**	**80.2**	**184**	**17.1**	**442.9**	**<0.0001**	**19.30**

Table 10. Biology and capture information of banded Indiana bats (*Myotis sodalis*) on a portion of Section 4 of the proposed I-69, autumn 2004.

Band Number	Capture Date	Cave Name	County	Sex	Age Class	Reproductive Condition
1711	17 September		Monroe	Male	Adult	Descended
1731	18 September		Lawrence	Male	Adult	Descended
1732	18 September		Lawrence	Male	Adult	Non-descended
NA[1]	19 September		Lawrence	Male	Adult	Non-descended
1733	19 September		Lawrence	Female	Adult	Non-reproductive
1734	24 September		Greene	Male	Adult	Descended

[1]Bat escaped before band was attached

Table 11. Summary of total bat census by cave on a portion of Section 4 of the proposed I-69, winter 2005.

No.	Cave Name	Survey Date	*Indiana bat*	*Little brown bat*	*Northern bat*	*Big brown bat*	*Eastern pipistrelle*	Total
2		4 February						**0**
3		5 February						**0**
4		6 February					3	**3**
5		7 February					2	**2**
6		18 February		2			6	**8**
7		13 February					3	**3**
8		18 February						**0**
9		6 February					13	**13**
10		6 February						**0**
11		11 February		3	1		26	**30**
12		12 February						**0**
14		13 February			1			**1**
15		31 January				2		**2**
16		19 February					3	**3**
17		19 February					4	**4**
18		11 February						**0**
19		4 February					1	**1**
20		18 February	1				8	**9**
21		7 February		1	1		24	**26**
22		4 February				1		**1**
23		5 February				2	2	**4**
24		5 February					9	**9**
25		5 February					11	**11**
26		12 February						**0**
27		14 January					1	**1**
28		14 January		3			4	**7**
29		6 February					1	**1**
30		31 January	28	373	1	1	85	**488**
Total			**29**	**382**	**4**	**6**	**206**	**627**

Note: No. 1 and No. 13 not surveyed in winter 2005.

Table 12. Total bat captures by sex, reproductive condition, and age during entrance surveys on a portion of Section 4 of the proposed I-69, spring 2005.

Species	Adult Male	Adult Female[1]				Juvenile		Escape[2]	Total
		P	L	PL	NA	Male	Female		
Eastern pipistrelle	6	0	0	0	13	0	0	0	**19**
Little brown bat	26	0	0	0	62	0	0	0	**88**
Northern bat	140	0	0	0	49	0	0	0	**189**
Total	**172**	**0**	**0**	**0**	**124**	**0**	**0**	**0**	**296**

[1] P = pregnant; L = lactating; PL = Post lactating; NA = not available
[2] Escape = escaped from trap or hand before processing was complete

Table 13. Summary of total bat captures by cave and Indiana bat (*Myotis sodalis*) captures by sex and age on a portion of Section 4 of the proposed I-69, spring 2005.

No.	Cave Name	Survey Dates	No. of Adult Female *M. sodalis*	No. of Adult Male *M. sodalis*	Total No. of *M. sodalis*	*Little brown bat*	*Northern bat*	*Eastern pipistrelle*	Total # of Bats
1		13-15 April				4	8		**12**
11		16-17 April				84	181	19	**284**
Total						**88**	**189**	**19**	**296**

Table 14. Numbers of adult bats captured, catch per net-night, and chi-square analysis of males and females captured on a portion of Section 4 of the proposed I-69, spring 2005.

Species	Adult Male		Adult Female				Catch/trap-night
	Bats	%	Bats	%	X^2	*P*	Total
Eastern pipistrelle	6	2.0	13	4.4	2.6	0.11	**4.75**
Little brown bat	26	8.8	62	20.9	14.7	0.0001	**22.00**
Northern bat	140	47.3	49	16.6	43.8	<0.0001	**47.25**
Total	**172**	**58.1**	**124**	**41.9**	**7.8**	**0.005**	**74.00**

Appendix C

Photographs

Appendix C: (Photographs) has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Appendix D

Data Sheets

Appendix D: (Data Sheets) has been removed for confidentiality reasons related to the federally endangered Indiana bat.

INVESTIGATING PRESENCE OF THE INDIANA BAT DURING THE SUMMER MATERNITY SEASON WITHIN THE MITCHELL PLAIN BETWEEN BLOOMINGTON AND MARTINSVILLE, INDIANA

Amy B. Henry[1], Ryan A. Slack[2], and Russell C. Rommé[2]
[1]*BHE Environmental, Inc., 7041 Maynardville Highway, Knoxville TN 37918*
[2]*BHE Environmental, Inc. 11733 Chesterdale Road, Cincinnati, OH 45246*

Abstract

BHE Environmental, Inc. (BHE) investigated the presence of, and habitat use by, the Indiana bat during the summer maternity season along a section of the proposed Interstate Highway 69 between Bloomington and Martinsville in Monroe and Morgan counties, Indiana. Mist nets were used at 24 sites to trap bats. An AnaBat II ultrasound detector was used to record vocalizations of bats near each mist net site. Captures included four adult male Indiana bats and one lactating female Indiana bat from five sites (21 percent). Two of these five Indiana bats were captured within approximately 1,000 feet of existing State Road 37, a 4-lane divided highway. Radio transmitters were attached to adult male and female Indiana bats, and attempts were made to track the bats to their summer roost sites. Two roost trees were identified and emergence counts were conducted to determine the number of bats present. These roost trees (a live tulip poplar and a dead silver maple) were greater than 2 miles from State Road 37. No bats emerged from the two trees during emergence counts. We inspected the undersides of 13 bridges during the night to identify night-roosting bats. No Indiana bats or guano were identified under any of these bridges.

Key words: Indiana bat, *Myotis sodalis*, radiotelemetry, mist net, maternity roost, AnaBat

---

Introduction

The Indiana Department of Transportation (INDOT) is proposing construction of Interstate Highway 69 (I-69) from Indianapolis to Evansville, Indiana. A detailed description of the proposed action was presented in the Tier 1 Final Environmental Impact Statement (Tier 1 FEIS; FHWA and INDOT 2003a). This study is part of the Tier 2 Environmental Impact Statement (EIS) for the proposed I-69 project (FHWA and INDOT 2003a). The proposed interstate is approximately 142 miles (228.5 kilometers [km]) in length and is divided into six sections to facilitate Tier 2 EIS studies. Investigations described herein address Section 5, located between Bloomington, and Martinsville in Morgan and Monroe counties (Appendix A, Figure 1). Studies were conducted along the preferred alternative, Alternative 3C (FHWA and INDOT 2003a).

The INDOT, Federal Highway Administration (FHWA), and the U.S. Fish and Wildlife Service (USFWS) are conducting ongoing consultation under Section 7 of the Endangered Species Act to evaluate potential impacts of the proposed action. The surveys described in this report were conducted in accordance with requirements of the Tier 1 Biological Assessment (FHWA and INDOT 2003b). Methods used in these investigations were

developed in consultation with the USFWS, Bloomington Field Office. The purpose of these studies was to investigate the presence of the federally listed endangered Indiana bat (*Myotis sodalis*) and identify summer habitat use by the species in Section 5 of the proposed I-69 corridor.

Study Area

Section 5 of the proposed route is a 22-mile (35.4-km) long segment from State Road 37 approximately 3 miles (4.8 kilometers) southwest of Bloomington, to State Road 39, approximately 1.5 miles (2.4 kilometers) southwest of Martinsville (Appendix A, Figure 1). The proposed road alignment will be within a corridor extending 1000 feet (304.8 meters [m]) on each side of the Alternative 3C centerline (total width of 2000 feet [609.6 m]). The proposed alignment represents the maximum width of direct construction impacts under Alternative 3C. The centerline of Alternative 3C closely follows State Road 37 through the entire length of Section 5.

The study area for this investigation was a 5-mile (8 km) wide band, 2.5 miles (4 km) on either side of the proposed centerline of Alternative 3C. The 2.5-mile (4 km) distance is based upon studies in Illinois and Pennsylvania that found the maximum distance an Indiana bat traveled from its daytime roost to its foraging area was 2.5–2.7 miles (4–4.5 km; Gardner et al. 1991; Butchkoski and Hassinger 2002). It is also consistent with unpublished data from Indiana bat studies conducted at Jefferson Proving Ground in Indiana and the Indianapolis Airport in Indiana (Pruitt 1995; BHE 1995). The Tier 1 Biological Assessment established the 5-mile (8 km) wide study area and identifies it as the "Indiana bat summer action area" (FHWA and INDOT 2003b). The 5-mile (8-km) wide Indiana bat summer action area is identified herein as the Section 5 Study Area.

The Section 5 Study Area crosses the Mitchell Karst Plain and Brown County Hills subregions of the Highland Rim Natural Region of Indiana (Homoya et al. 1985). Terrain in these subregions is characterized by unglaciated area with distinctive features of large expanses of karst topography and other major topographical features, such as cliffs and hills. Much of the area was forested in presettlement times but large barrens, small glades, and gravel wash communities also occurred. The Section 5 Study Area is currently approximately 46 percent forested (FHWA and INDOT 2003b). The remaining nonforested area in the Section 5 Study Area is mainly agricultural and urban land use. It contains several named streams including the White River (Appendix A, Figure 1). Elevations in the Section 5 Study Area range from approximately 590 feet (180 m) to 950 feet (290 m).

Materials and Methods

Access permission was sought and provided by landowners prior to implementation of the mist net survey, radiotelemetry study, roost tree identification, and bridge surveys described below.

Nightly temperatures were within seasonal norms during the survey period, ranging from 52° to 78° Fahrenheit, and were within the range recommended by the Recovery Team survey protocol (USFWS 1999). During mist netting, conditions ranged from clear to cloudy, with occasional fog and brief light rain. Mist net surveys were discontinued during periods of significant precipitation. During the survey, the moon was new to full, and rarely visible at net sites due to a late moonrise, cloud cover, and/or canopy closure over the mist nets.

Mist Net Survey

The goal of the mist net survey was to assess the presence of Indiana bats, particularly groups of reproductively active females and their young (i.e. maternity colonies), during the summer maternity season, within the Section 5 Study Area.

Twenty-four mist net sites were surveyed between June 3 and July 21, 2004 (Appendix A, Figures 2-1 to 2-7). The 24 net sites were identified by INDOT and the USFWS, Bloomington Field Office (BFO). All 24 net sites were located within the Section 5 Study Area, and five of the 24 net sites were within 1000 feet (304.8 m) of the proposed centerline (Appendix A, Figures 2-1, 2-2, 2-5, and 2-7; Appendix B, Table 1). Net sites ranged from 403 feet (132.2 m) to 2.2 miles (3.5 km) from the Alternative 3C centerline. Mist nets were deployed at six upland and 18 stream sites. Upland sites consisted of trails and roads bordered with forest, and forest corridors in pastures. Stream sites were established along streams with forested riparian zones and in one forested wetland (Net Site 10).

All of the net sites were located in second-growth deciduous forest (Appendix C). At the majority of sites, dominant overstory trees near mist nets were eastern sycamore (*Platanus occidentalis*), sugar maple (*Acer saccharum*), black walnut (*Juglans nigra*) and green ash (*Fraxinus pennsylvanica*). Also present in the overstory at several sites were boxelder (*Acer negundo*), silver maple (*Acer saccharinum*), and shagbark hickory (*Carya ovata*). At the majority of net sites, dominant understory trees were boxelder, sugar maple, musclewood (*Carpinus caroliniana*), and eastern sycamore. Also present in the understory at several sites were black walnut, silver maple, and green ash. Average diameter breast height (dbh) of overstory trees at the mist net sites was approximately 16 inches (41 cm), which appeared to be consistent with the average size of overstory trees in forests throughout the Study Area. At the majority of net sites, understory vegetation was relatively sparse, providing space beneath the tree canopy for flying bats to maneuver.

At each net site, two mist nets were deployed for two nights, for a total of four net-nights per site (one net-night equals one net deployed for one night), and a total of 96 net-nights during the survey. Some net sites were sampled for a third night if a previous night's survey was interrupted by capture of an Indiana bat. The survey was conducted in accordance with Indiana Bat Recovery Team guidance regarding the seasonal timing of surveys, equipment, net placement, minimum level of effort, acceptable weather conditions, and moonlight (USFWS 1999). One mist net is composed of 2–4 nets stacked vertically and suspended by a system of poles, ropes, and pulleys (Gardner et al. 1989). Nets were constructed of two-ply, 50-denier nylon with a mesh size no larger than 1.75 inches (4.4 cm). Mist nets were 18–42 feet (5.6-13.8 m) wide and 20–30 feet (6.6–9.9 m) tall, depending upon the width of the forested corridor. When possible, nets were bounded by vegetation above and on both sides to facilitate capturing bats. Mist nets were deployed at dusk (2010–2030h) and monitored at least every 20 minutes for five hours. When possible, nets were checked more frequently than once every 20 minutes. Disturbance near nets between checks was minimized. A QMC ultrasound detector was used, when possible, during "interim checks" between the 20-minute checks to detect ultrasound distress calls of bats caught in the net; ultrasound detectors were used to avoid shining lights on nets.

Upon capture, bats were removed from mist nets, identified to species, measured, and released unharmed at the capture site. Data recorded for each bat captured included species, age, gender, reproductive condition, right forearm length (RFA), and body weight. Bats were identified to species based upon distinctive morphological characteristics (e.g., body size, hair color, ear length, tragus length and shape, presence/absence of a keeled calcar). Adult female bats were classified as reproductive if they were pregnant (determined by palpation of abdomen), lactating (i.e., teats conspicuous and enlarged, lack of hair around teats), or post-lactating (visible regrowth of hair around teats). Male bats with testicles descended into the scrotum were considered reproductive. Young-of-the-year of both sexes were classified as juveniles. Young-of-the-year were distinguished from adults by examining ossification (bone growth) in phalangeal joints. Adults have completely ossified joints, while the joints of juveniles contain visible cartilaginous layers and blood vessels.

Weather conditions were documented each night to confirm that netting was conducted in accordance with Indiana Bat Recovery Team Guidance (USFWS 1999). Each hour, the air temperature, wind speed, cloud cover, precipitation, and visibility of the moon were recorded. A standard mercury thermometer was used to record temperature, and wind speed, percent cloud cover, and moon phase were estimated (Appendix C). Each net site was photographed and the location of each mist net was recorded using a Trimble XR Pro GPS unit (Trimble Navigation Limited, Sunnyvale, California) with submeter accuracy.

Each captured Indiana bat was photographed, specifically the face, the whole body, and the calcar (Appendix D). All Indiana bats captured were banded using an individually numbered, white celluloid split-ring band placed on the forearm (males on the right forearm and females on the left). The band color and number was recorded (Appendix C).

In addition to sampling with mist nets, an AnaBat II detector (Titley Electronics Pty Limited, Ballina, New South Wales, Australia) and compact flash storage ZCAIM unit were used to record ultrasound near the mist nets. The combination of the AnaBat II detector and the ZCAIM unit is referred to herein as the AnaBat. The AnaBats were used to assist the BFO in assessing application of that technology in endangered species surveys. On both nights that mist nets were operated, an AnaBat was deployed near the mist net site (not closer than 65.6 feet [20m]) to passively record bat vocalizations throughout the mist netting period (approximately five hours per night). The AnaBat was deployed in an area relatively clear of vegetation. The microphone of the AnaBat was set at an approximately 45 degree angle (relative to the ground) and directed into the clearing. The position of settings on the AnaBat were recorded (e.g. sensitivity and division ratio) each night. The location of the AnaBat relative to the mist net site was sketched on data forms.

In accordance with instructions from the BFO, data recorded with the AnaBat II detector were not analyzed. Upon completion of the mist net survey, a copy of the digital raw data files and a cross-referencing table indicating the date and collection site for each file was sent to the BFO for its use.

Radiotelemetry

The primary goal of radiotelemetry was to assess Indiana bat presence within the study area and identify Indiana bat maternity colonies and their maternity roost trees (primary and alternate). Secondarily, radiotelemetry was conducted to identify roost trees used by male or non-reproductive female Indiana bats.

Upon capture, a 0.25-ounce (0.7–gram) radio transmitter (Wildlife Materials, Inc., Carbondale, Illinois) was attached to the mid–scapular pelage of each bat using non-toxic skin-bond cement. A TRX-2000 radio receiver (Wildlife Materials, Carbondale, Illinois) was used to ensure each transmitter was functioning properly before the transmitter was attached. Transmitter-equipped bats were released unharmed from the point of capture (Appendix C).

Attempts were made to locate radio signals from transmitters on day-roosting Indiana bats for at least six days following release of each transmitter-equipped bat. Radiotracking was conducted between approximately 1200h and 1600h each day. If a signal was lost, the search for the signal was continued each day for at least six days following release. Up to three bats were tracked concurrently. Searches for radio signals were conducted most intensively within the 2000-foot (609-meter) wide proposed alignment, but occurred up to 5 miles (8 km) on either side of the proposed alignment. The majority of radiotracking was conducted within the Study Area, which is up to 2.5 miles (4 km) from the proposed road centerline.

Roost Tree Characterization and Emergence Counts

Upon identification of a transmitter-equipped Indiana bat roosting in a tree, characteristics of the tree were recorded and the tree observed to monitor emergence of bats.

Each roost tree was assigned a unique identification number. The species (if recognizable), status (live or dead), estimated dbh, area type (riparian/upland), distance from roost tree to capture site, percent of the tree exhibiting exfoliating bark, and the stage of tree decay (USFS 1979) were recorded (Appendix C). To characterize habitat surrounding the roost tree, dominant and co-dominant tree species; estimated canopy closure, average dbh of canopy trees, and topographic slope; estimated distance to nearest water source; estimated distance to nearest flight corridor (i.e., space beneath the tree canopy that offers protected foraging and travel space for bats); and estimated height from ground to roost were recorded (Appendix C). A Trimble XR Pro GPS unit with submeter accuracy was used to record the location, and each roost tree was photographed (Appendix D). The location of each roost tree was identified with plastic flagging; care was taken to avoid marking the roost tree to avoid attracting passersby that may disturb roosting bats.

Emergence counts were conducted at each roost tree. The counts commenced at dusk and emerging bats were counted for at least one hour per night. A QMC ultrasound detector was used to assist in detection of bats. Trees containing 15 or more bats in the first night were surveyed for at least five nights. Trees containing fewer than 15 bats were surveyed for at least three nights.

Bridge Survey

The goal of the bridge survey was to identify Indiana bat night-roosting sites. Bridges within the proposed alignment, along State Road 37 and connecting roads, were inspected.

Each bridge was surveyed once between the 0100h and 0400h. For each bridge inspected, presence and relative abundance of guano, stream name, estimated closure of tree canopy over the bridge, estimated distance to water, and dominant tree species near the bridge were recorded (Appendix C). The location of each bridge was recorded using a Trimble Pro XR GPS unit with submeter accuracy. If bats were present, attempts were made to capture them by hand and identify them to species. The number of bats observed under each bridge was recorded. Bridges occupied by roosting bats were surveyed again on a subsequent night.

Results

Mist Net Survey

Twenty-four net sites were surveyed for bats using mist nets between June 3 and July 21, 2004 (Appendix A, Figures 2-1–2-7). One hundred eighty-five bats representing eight species were captured in mist nets, including five Indiana bats and seven evening bats (*Nycticeius humeralis*; Appendix A, Figure 3; Appendix B, Table 2). The evening bat is not listed by the USFWS, but is listed by the State of Indiana as endangered. The big brown bat (*Eptesicus fuscus*) was the species most commonly encountered, making up 22 percent of the total capture. Other species captured included the little brown bat (*M. lucifugus*), northern long-eared bat (*M. septentrionalis*), eastern pipistrelle (*Pipistrellus subflavus*), red bat (*Lasiurus borealis*), and hoary bat (*L. cinereus*).

At least one bat was captured at all 24 net sites. The greatest number of bats (n=28) was captured at Net Site 23 and the greatest number of species (n=6) was captured at Net Site 20.

A single Indiana bat was captured at five mist net sites (Appendix A, Figures 3 and 4; Appendix B, Table 3). A post lactating female was captured at Net Site 19 and a single adult male Indiana bat was captured at net sites 4, 6, 20, and 22. All five Indiana bats were equipped with radio transmitters. Seven evening bats (six reproductive females and one juvenile male) were captured at Net Site 23.

Radiotelemetry, roost tree identification and characterization

In the following discussion, Indiana bats are identified by numbers on the bands we applied to each bat (Appendix B, Table 3).

Male Indiana bat no. 1071 was released near Net Site 20 on July 5. The bat remained near the net site for approximately one hour before flying south generally along Little Indian Creek. The last site of signal detection was within the Morgan-Monroe State Forest west of Creek on Ridge. The radio signal was not detected after 0200h. Searches were conducted for the radio signal daily during July 6–11 near Net Site 20, along Little Indian Creek, and in Morgan-Monroe State Forest.

Male Indiana bat No. 1365 was released near Net Site 4 and flew north. The signal was detected for approximately 20 minutes, and then was no longer detected. Tracking (i.e. searching) efforts during July 12–18 were concentrated near the net site and along Stout Creek from near the net site to the confluence with Beanblossom Creek. The radiosignal was not relocated after July 12 at 2230h.

Male Indiana bat No. 1752 was released near Net Site 6 and remained near the site for approximately 15 minutes. The bat then flew downstream (north) apparently along Beanblossom Creek. The radiosignal was not relocated during tracking efforts on July

17–22 (primarily along Beanblossom Creek, Griffy Creek and State Road 37.)

Female Indiana bat No. 1351 was released near Net Site 19 on July 18 at 0200h. The bat remained near the site for 10 minutes, then flew upstream (south) apparently along Bryant Creek. The radio signal was not detected after July 18 at 0230h. Searches for the radio signal were conducted during July 18–23 along Bryant Creek and the White River.

Male Indiana bat No. 1482 was released near Net Site 22 on July 16. The bat foraged near the site for approximately one hour before the radio signal was lost. The bat was identified in Roost Tree No. 1 on July 17 at 1330h. By 1930h, the bat was no longer present in Roost Tree No. 1, but after searching, the signal was detected in Roost Tree No. 2, approximately 1033 feet (315m) away, indicating the bat had relocated during daylight hours.

Roost Tree No. 1 was a live tulip poplar (*Liriodendron tulipifera*) located in an upland residential area approximately 374 feet (114 m) from Net Site 22 (Appendix A, Figure 4; Appendix B, Table 4). The tree is located on the edge of a forested hillside overlooking the White River valley (Appendix A, Figures 2-5 and 4). The tree is approximately from the nearest water source (unnamed tributary to the White River). The tree is about 20 feet (6 m) from the nearest apparent flight corridor, which is a residential driveway lined with trees that crosses (fords) the stream. The tree has a dbh of 10.2 in (40.5 cm) and had no exfoliating bark (Appendix C and D). The bat roosted in small cavities (apparently holes created by wookpeckers) approximately 53 feet (16 m) from the ground. Bat No. 1482 was detected roosting in Roost Tree No. 1 on July 17 but was not detected there on the other six days the radio signal was tracked. Roost Tree No. 1 was monitored for three evenings, but no bats were observed emerging from the tree.

Roost Tree No. 2 was a dead silver maple located on an island in the White River approximately 1148 feet (350 m) from Net Site 22 (Appendix A, Figure 4; Appendix B, Table 4). The tree is approximately from the White River, which provides the nearest water source and the nearest apparent flight corridor. The tree has a dbh of 6.9 in (27 cm) and no more than 5 percent of the bark is exfoliating (Appendix C and D). The bat roosted in a cavity approximately 20 feet (6 m) from the ground. The radio signal from Bat No. 1482 was detected in Roost Tree No. 2 each day from July 17 to July 22. However, it is likely that the radio transmitter fell off the bat near this tree, because the signal was detected emanating from the same location for six days. Emergence counts at Roost Tree No. 2 were conducted for three evenings, but no bats were observed emerging from the tree.

Bridge Survey

Seventeen locations within the 2000-ft (609.6-m) proposed alignment potentially contained bridges that may provide roost sites for bats. Bridges within the proposed alignment may be removed or otherwise affected by proposed road construction. The 17 locations were inspected to determine if bridges (when present) are suitable for night-roosting bats (Appendix A, Figures 2-2, 2-5, and 2-7). At four of the locations, a bridge was not present (i.e., the stream was crossed by a culvert, or the bridge had been removed).

Thirteen bridges were inspected between June 30 and August 4, 2004 to detect the presence of night-roosting bats or their sign

(Appendix B, Table 5). All of the bridges spanned streams with flowing water present. Most bridges were constructed with metal I-beams supporting smooth concrete decks. The only exception was the northbound bridge on SR 37 over Bryant Creek (Bridge 1) which had corrugated steel on the underside of the deck. The bridges ranged from 3.3–26.2 feet (1 to 8 m) above the surface of the water. Bridge 9 had 80 percent tree canopy closure over the bridge deck, while the other 12 bridges had 0–5 percent tree canopy closure over the deck.

No Indiana bats or guano were identified under any of the bridges surveyed (Appendix B, Table 5). On July 12, 2004, bats were found roosting under two bridges, one under Bridge (Creek) and one under Bridge (Creek), both of which are part of (Appendix A, Figure 2-2). Six bats were found under Bridge 7, including one northern long-eared bat, one little brown bat, two eastern pipistrelles, and two *Myotis* that escaped before we could identify them to species (Appendix B, Table 5). One eastern pipistrelle was identified under Bridge . On July 20, Bridges were resurveyed. Seven bats were found under Bridge , including one northern long-eared bat, one little brown bat, four eastern pipistrelles, and one bat that took flight before it could be identified. No bats were found roosting beneath Bridge on July 20. On both nights, bats observed roosting beneath the bridges were clinging to the concrete deck of the bridge; no bats were observed in crevices or expansion joints, or clinging to structures other than the deck.

Discussion

This mist net survey was conducted with the appropriate level of effort, and under the appropriate conditions, to investigate presence of the Indiana bat within the Section 5 Study Area during the maternity season. Indiana bats were captured at five of the 24 net sites (21 percent). Two of the five Indiana bats were captured within approximately 1000 feet (305 m) of the proposed I-69 centerline. These captures were within 1000 feet (305m) of existing SR 37, an established, four-lane divided highway. All Indiana bats were captured over streams with flowing water. Three of the five Indiana bat capture sites were over tributaries that flow directly into the White River (Net Sites 19, 20, and 22). The Indiana bat trapped at Net Site 4 was captured within 5 miles (8 km) of a known Indiana bat hibernaculum.

The reproductive female Indiana bat was captured greater than 2 miles (3.2 km) from the proposed centerline. Female Indiana bats exhibit strong site fidelity to summer roosting and foraging areas. The female bat was not tracked to a roost tree. Based upon the previous studies cited in the Tier 1 Biological Assessment (FHWA and INDOT 2003b) and used to estimate the 2.5-mile (4-km) wide "Indiana bat summer action area," we estimate roost trees used by the bat during summer are likely to be within 2.5 miles (4 km) of Net Site 19 (Gardner et al. 1991; Appendix A, Figures 2-6 and 4). Roost trees used by Bat No. 1351 are likely to be located both within and outside of the Section 5 Study Area; approximately 56 percent of the potential roost area lies within the Study Area, and approximately 4 percent lies within the proposed alignment (Appendix A, Figure 2-6). Because we did not detect the radio signal from Bat No. 1351, she may roost greater than 2.5 miles (4 km) from the proposed centerline.

Two roost trees used by an adult male Indiana bat were identified. Roost Tree No. 1 was a live tulip poplar located about 374 feet (114 m) from Net Site 22, where the bat

was captured and released. A live tulip poplar tree is an atypical roost tree species for Indiana bats (Rommé et al. 1995). Most Indiana bats roost in dead or dying trees (Menzel et al. 2001; Rommé et al. 1995). About 10 percent of the Indiana bat roost trees investigated in an Illinois study, 28 percent in a Missouri study (Menzel et al. 2001), and 5 percent in a Michigan study (Kurta et al. 2002) were live trees, primarily shagbark hickories (Menzel et al. 2001). Male Indiana bats appear to have less restrictive roost tree requirements than females, as demonstrated by males found roosting in artificial roosts near the Indianapolis Airport (BHE 1995). The cavities in Roost Tree No. 1 were the only apparent portion of the live tree suitable for roosting bats. The roost evidently was not used extensively because no bats were observed during three emergence counts at the tree. Bat No. 1482 remained in Roost Tree No. 1 for less than 8 hours and then relocated to Roost Tree No. 2.

The characteristics (e.g., diameter, species, location, and condition) of Roost Tree No. 2 were consistent with those of roost trees used by male Indiana bats (Gumbert et al. 2002; Kiser and Elliot 1996). Male Indiana bats typically roost singly or in small groups, and roost trees used by males appear to be smaller in diameter and have less exfoliating bark than those used by females. Male Indiana bats have been found using roost trees as small as 1.6 in (6.4 cm) dbh (Gumbert et al. 2002).

Indiana bats typically roost within 656 feet (200 m) of a water source (Menzel et al 2001). Roost Tree No. 1 was located approximately 164 feet (50 m) from a stream, and Roost Tree No. 2 was on a small island in the White River.

Radiotelemetry was conducted according to the procedures and level of effort recommended by the USFWS BFO. However, radio signals from only one of the five transmitter-equipped bats were detected in the six days following release of each bat. In some areas, radio transmissions may have been blocked by topography (i.e., rolling hills). Rainfall was very frequent during July 5–17, which may have cause radio transmitters to malfunction or fall off the bats. Conclusions based upon failure to detect radio signals must be made with caution.

Bats were observed roosting under two of 13 bridges inspected. Bats were observed clinging directly to the concrete bridge deck. The bridge under which we identified several species, including an unidentified species of *Myotis*, was similar in construction to the majority of bridges found in the study area. No difference was observed in characteristics (dominant species of trees, tree size (dbh), or extent of tree canopy cover over the deck, or presence of water below the deck) between bridges where bats were found and those where no bats were present.

Three of the five net sites where Indiana bats were captured were located on tributaries of the White River near their confluence with the White River. Additionally, one Indiana bat was tracked to a roost tree on an island in the White River. Evidence from this investigation suggests the White River, its tributaries, and the associated riparian habitat may be important habitat for Indiana bats, including reproductive females, near Section 5.

Seven evening bats were captured at Net Site 23, which is located within 1,000 feet (305 m) of the proposed centerline. Six reproductive female evening bats and one

juvenile male were captured early in the evening, suggesting an evening bat maternity colony is located near Net Site 23. Evening bats typically roost in buildings or under exfoliating bark of trees.

In addition to Indiana bats and evening bats, six other bat species were captured. Each commonly occurs in southeastern Indiana, and none of the species was unexpected in Monroe and Morgan counties. None of the six species is listed by the USFWS or the State of Indiana as rare, threatened, or endangered.

Net sites 4, 6, 19, 20, 22, and 23 produced an abundance of bats. Five of the sites are locations where Indiana bats were captured; evening bats were captured at Net Site 23. Generally, sampling at these sites resulted in greater total captures and greater species diversity than other sites we surveyed. Additionally, these sites are within 11,370 feet (3,567 m) to the proposed alignment. These sites should be considered if a pre- and post-construction monitoring plan is designed.

Acknowledgements

We appreciate the cooperation and access that landowners provided during the surveys. We would like to thank the City of Bloomington for access to Wapahani Mountain Bike Trail and Leonard Springs Nature Park. Thanks to Morgan-Monroe State Forest for letting us access their land. Special thanks to Dallas Drummond, Steve Bartlett, Penny Montgomery, Beverly Johnson, and Mr. Manaheim for helping us find the best areas to survey on their property and helping with access to roost sites.

Special thanks go out to INDOT, Federal Highways Administration (FHWA), Tom Cervone and Jason Dupont of Bernardin, Lochmueller and Associates, Inc., Wendy Vachet of Michael Baker Jr. Inc., and Andrew King, Scott Pruitt, and Lori Pruitt of the U.S. Fish and Wildlife Service (Bloomington Field Office) for their roles and support throughout the project.

Literature Cited

BHE Environmental, Inc. (BHE) 3DE Group. 1995. Environmental technical report: 1995 field studies for interim Indiana bat habitat mitigation at the Indianapolis International Airport in Marion County, Indiana. Cincinnati, Ohio.

Butchkoski, C. and J. Hassinger. 2002. Ecology of a maternity colony roosting in a building *in* A. Kurta and J. Kennedy (eds.) The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International, Austin, Texas. 253 pp.

Federal Highway Administration (FHWA) and Indiana Department of Transportation (INDOT). 2003a. Final Environmental Impact Statement & Section 4(f) Evaluation: I-69 Evansville to Indianapolis, Indiana. United States Department of Transportation, Federal Highway Administration and Indiana Department of Transportation. FHWA-IN-EIS-02-01-F. Prepared by Bernardin, Lochmueller and Assoc., Inc. http://www.deis.i69indyevn.org/FEIS/index.html.

Federal Highway Administration (FHWA) and Indiana Department of Transportation (INDOT). 2003b. Tier 1 Biological Assessment for Threatened and Endangered Species: I-69 Indianapolis to Evansville. Prepared by Bernardin, Lochmueller and Assoc., Inc. Evansville, Indiana.

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.

Gardner, J.E., J.D. Garner, and J.E. Hofmann. 1991. Summary of *Myotis sodalis* summer habitat studies in Illinois: with recommendations for impact assessment. Unpublished report prepared for the Indiana/Gray Bat Recovery Team Meeting, Columbia, Missouri, Illinois Natural History Survey, Section of Faunistic Surveys and Insect Identification. 28 pp.

Gumbert M.W., J.M. O'Keefe, and J.R. MacGregor. 2002. Roost site fidelity *in* A. Kurta and J. Kennedy (eds.) The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International, Austin, Texas. 253 pp.

Homoya, M.A., B.D. Abrell, and J.R. Aldrich. 1985. The Natural Regions of Indiana *in* D.R. Winslow (ed.) Proceedings of the Indiana Academy of Science 94:245–268.

Kurta, A., S. Murray, and D. Miller. 2002. Roost selection and movements across the summer landscape *in* A. Kurta and J. Kennedy (eds.) The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International, Austin, Texas. 253 pp.

Kiser, J.D. and C.L. Elliot. 1996. Foraging habitat, food habits, and roost tree characteristics of the Indiana bat (*Myotis sodalis*) during autumn in Jackson County, Kentucky. Report submitted to the Non-Game Program, Kentucky Department of Fish and Wildlife Resources, Frankfort, Kentucky.

Menzel, M., J.M. Menzel, T.C. Carter, W.M. Ford, and J.W. Edwards. 2001. Review of the Forested Habitat Relationships of the Indiana bat (*Myotis sodalis*). General Technical Report NE-284. Newtown Square Pennsylvania, USDA, Forest Service, Northeastern Research Station. 21 pp.

Pruitt, L. 1995. Summary of Jefferson Proving Ground bat surveys: 1993–1995. US Fish and Wildlife Service, Bloomington Indiana Ecological Services Office, Unpublished Report. 5 pp.

Rommé, R., K. Tyrell, and V. Brack. 1995. Literature summary and habitat suitability index model: components of summer habitat for the Indiana bat (*Myotis sodalis*). Unpublished report, Indiana Department of Natural Reources, Bloomington, Indiana.

U.S. Fish and Wildlife Service (USFWS). 1999. Agency Draft Indiana bat (*Myotis sodalis*) Revised Recovery Plan. Fort Snelling, Minnesota. 53 pp.

U.S. Department of Agriculture, Forest Service (USFS). 1979. Wildlife habitats in managed forests, the Blue Mountains of Oregon and Washington. Agricultural Handbook 553. J.W. Thomas (ed.) Washington, DC.

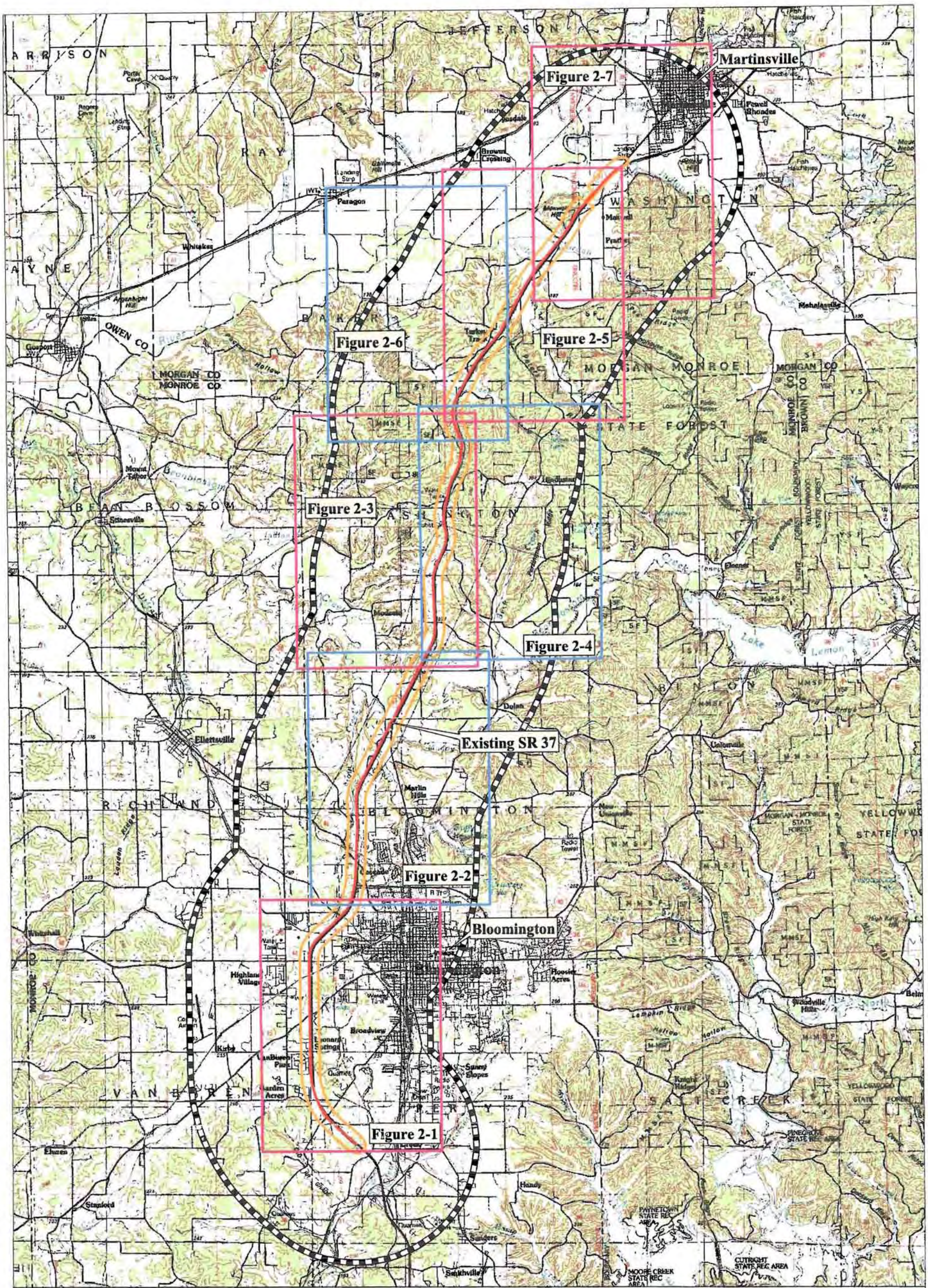


Figure 1. Section 5 of the proposed Interstate 69 between Bloomington and Martinsville, in Morgan and Monroe Counties, Indiana.

N W E S	Section 5 Study Area	Proposed Road Alignment	Centerline	BHE ENVIRONMENTAL
	Project No. 1230.008	December 6, 2004	Base Map: USGS 30 x 60 Minute Topographic Maps - Bloomington, IN and Indianapolis, IN	Feet 5000 0 5000 10000

Figure 2-1. (“Location of mist net sites sampled, bridged inspected and roost trees identified within section 5 of the proposed Interstate 69”) has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 2-2. ("Location of mist net sites sampled, bridges inspected and roost trees identified within Section 5 of the proposed Interstate 69") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 2-3. (“Location of mist net sites sampled, bridges inspected, and roost trees identified within Section 5 of the proposed Interstate 69”) has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 2-4. ("Location of mist net sites sampled, bridges inspected, and roost trees identified within Section 5 of the proposed Interstate 69") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 2-5. (“Location of mist net sites sampled, bridges inspected, and roost trees identified within Section 5 of the proposed Interstate 69”) has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 2-6. (“Location of mist net sites sampled, bridges inspected, and roost trees identified within Section 5 of the proposed Interstate 69”) has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 2-7. ("Location of mist net sites sampled, bridges inspected, and roost trees identified within Section 5 of the proposed Interstate 69") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 3. ("Location of mist net sites sampled, bridges inspected, and roost trees identified within Section 5 of the proposed Interstate 69") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 4. ("Location of mist net sites sampled, bridges inspected, and roost trees identified within Section 5 of the proposed Interstate 69") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Appendix B
Tables

Table 1. Location of 24 sites surveyed with mist nets in the Section 5 Study Area.

Site no.	County	Habitat feature surveyed	Approximate distance to proposed centerline in feet (meters)
1	Monroe	Clear Creek	5,180 (1,579)
2	Monroe	Leonard Springs Nature Park – upland site	5,295 (1,614)
3	Monroe	Wapahani Mountain Bike Trail – upland site	958 (300)
4	Monroe	Stout Creek	4,356 (1,328)
5	Monroe	Stout Creek	1,455 (444)
6	Morgan	Beanblossom Creek	403 (123)
7	Monroe	wooded corridor in a farm pasture – upland site	2,411 (735)
8	Monroe	Muddy Fork Creek	9,041 (2,756)
9	Monroe	forested corridor adjacent to Beanblossom Creek – upland site	5,520 (1,683)
10	Monroe	Beanblossom Creek oxbow wetland	6,604 (2,013)
11	Monroe	forested road adjacent to Beanblossom Creek – upland site	11,548 (3,520)
12	Monroe	Buck Creek	6,604 (2,013)
13	Monroe	Morgan Monroe State Forest – upland site	4,064 (1,239)
14	Monroe	unnamed tributary to Indian Creek	6,242 (1,903)
15	Monroe	Bryant Creek	7,328 (2,234)
16	Monroe	Bryant Creek	830 (253)
17	Monroe	Little Indian Creek	11,703 (3,567)
18	Morgan	Little Indian Creek	4,719 (1,438)
19	Morgan	Bryant Creek	11,370 (3,466)
20	Morgan	Little Indian Creek	1,000 (305)
21	Morgan	Jordan Creek	9,755 (2,973)
22	Morgan	Unnamed Tributary to White Fork	8,243 (2,513)
23	Morgan	Indian Creek	937 (286)
24	Morgan	Lamb Creek	11,102 (3,384)

Table 2. Number of Indiana bats captured, radiotracked; and identified in roost trees, and number of other species captured from 24 mist net sites in the Section 5 Study Area.

Site no.	Survey dates (2004)	Repro. adult female *M. sodalis*	Non-repro. adult female and adult male *M. sodalis*	Juvenile *M. sodalis*	Total no. *M. sodalis*	No. radio-tagged *M. sodalis*	Total no. diurnal roosts identified	*M. lucifugus*	*M. septentrionalis*	*E. fuscus*	*P. subflavus*	*L. borealis*	*L. cinereus*	*N. humeralis*	Total no. bats captured
1	7/15, 7/18	0	0	0	0	0	0	1	0	2	2	3	0	0	8
2	6/11, 6/12	0	0	0	0	0	0	1	2	2	0	0	0	0	5
3	6/3, 6/4	0	0	0	0	0	0	1	2	4	1	0	0	0	8
4	7/12, 7/13, 7/14	0	1	0	1	1	0	1	1	15	1	4	0	0	23
5	7/10, 7/11	0	0	0	0	0	0	0	1	1	0	0	0	0	2
6	7/14, 7/15	0	1	0	1	1	0	2	0	2	2	0	0	0	7
7	6/5, 6/6	0	0	0	0	0	0	0	0	1	0	0	0	0	1
8	7/18, 7/19	0	0	0	0	0	0	3	1	1	2	0	0	0	7
9	6/27, 6/28	0	0	0	0	0	0	1	7	0	1	0	1	0	10
10	6/24, 6/25	0	0	0	0	0	0	0	0	0	2	2	0	0	4
11	7/20, 7/21	0	0	0	0	0	0	0	0	0	0	1	0	0	1
12	6/7, 6/9	0	0	0	0	0	0	0	2	3	5	1	0	0	11
13	6/14, 6/15	0	0	0	0	0	0	0	2	0	0	0	0	0	2

Site no.	Survey dates (2004)	Repro. adult female *M. sodalis*	Non-repro. adult female and adult male *M. sodalis*	Juvenile *M. sodalis*	Total no. *M. sodalis*	No. radio-tagged *M. sodalis*	Total no. diurnal roosts identified	*M. lucifugus*	*M. septentrionalis*	*E. fuscus*	*P. subflavus*	*L. borealis*	*L. cinereus*	*N. humeralis*	Total no. bats captured
14	7/1, 7/2	0	0	0	0	0	0	0	0	0	2	1	1	0	4
15	6/22, 6/23	0	0	0	0	0	0	0	1	0	0	1	1	0	3
16	6/29, 6/30	0	0	0	0	0	0	0	0	0	3	4	0	0	7
17	6/18, 6/20	0	0	0	0	0	0	1	1	0	0	2	2	0	6
18	7/7, 7/8	0	0	0	0	0	0	0	1	1	1	1	0	0	4
19	7/16, 7/17	1	0	0	1	1	0	3	2	0	0	0	0	0	6
20	7/4, 7/5, 7/7	0	1	0	1	1	0	2	2	2	2	3	1	0	13
21	7/4, 7/5	0	0	0	0	0	0	0	0	0	0	1	0	0	1
22	7/16, 7/17	0	1	0	1	1	2	0	0	1	0	1	0	0	3
23	7/8, 7/10	0	0	0	0	0	0	4	0	4	5	8	0	7	28
24	7/11, 7/12	0	0	0	0	0	0	10	5	2	4	0	0	0	21
Totals		1	4	0	5	5	2	30	30	41	33	33	6	7	185

Table 3. Description of Indiana bats captured within the Section 5 Study Area.

Net site no.	Date captured (2004)	Time captured	Gender	Age	Reproductive condition*	Weight (g)	Band no. (white)	Radio-transmitter frequency (mHz)	Dates of radiotracking
4	July 12	2100	Male	Adult	NR	7.0	1365	151.175	July 12–18
6	July 16	0115	Male	Adult	NR	7.0	1752	150.947	July 16–22
19	July 18	0100	Female	Adult	PL	8.5	1351	150.028	July 18–23
20	July 5	2340	Male	Adult	NR	7.6	1071	150.907	July 5–11
22	July 16	2100	Male	Adult	NR	7.0	1482	150.066	July 16–22

*NR=non-reproductive, PL=post-lactating

Table 4. Description of roost trees used by Indiana bats within the Section 5 Study Area.

Roost tree no.	Species	Condition	Diameter at breast height in inches (cm)	Percent exfoliating bark	Distance to capture site in feet (meters)	Distance to nearest water in feet (meters)	Distance to nearest flyway in feet (meters)	No. bats observed emerging from tree
1	*Liriodendron tulipifera*	live	10.2 (40.5)	0	374 (114)	164 (50)	20 (6)	0
2	*Acer saccharinum*	dead	6.9 (27)	5	1148 (350)	8.2 (2.5)	8.2 (2.5)	0

Table 5. Bridges inspected within the working alignment (within 1000 feet (304.8 meters) of the centerline) of the proposed Alternative 3C of Interstate Highway 69.

Bridge no.	UTM Coordinates Zone 16		Feature bridged	Bridge deck material	Date inspected (2004)	Time inspected	No. bats observed
	Northing	Easting					
1				Steel (northbound), Concrete (southbound)	June 30	0145	0
2				Concrete	July 12	0200	0
3				Concrete	July 12	0215	0
4				Concrete	July 12	0230	0
5				Concrete	July 14	0200	0
6				Concrete	July 14	0230	0
7				Concrete	July 14	0300	6
					July 20	0230	7
8				Concrete	July 14	0330	1
					July 20	0300	0
9				Concrete	August 4	0100	0
10				Concrete	August 4	0200	0
11				Concrete	August 4	0230	0
12				Concrete	August 4	0300	0
13				Concrete	August 4	0400	0

Appendix C

Field Data Sheets

Appendix C: Data Sheets have been removed for confidentiality reasons related to the federally endangered Indiana bat.

Appendix D
Selected Photographs of Indiana Bats and Roost Trees Used by Indiana Bats

Photo 1. Site 4 Male Indiana bat

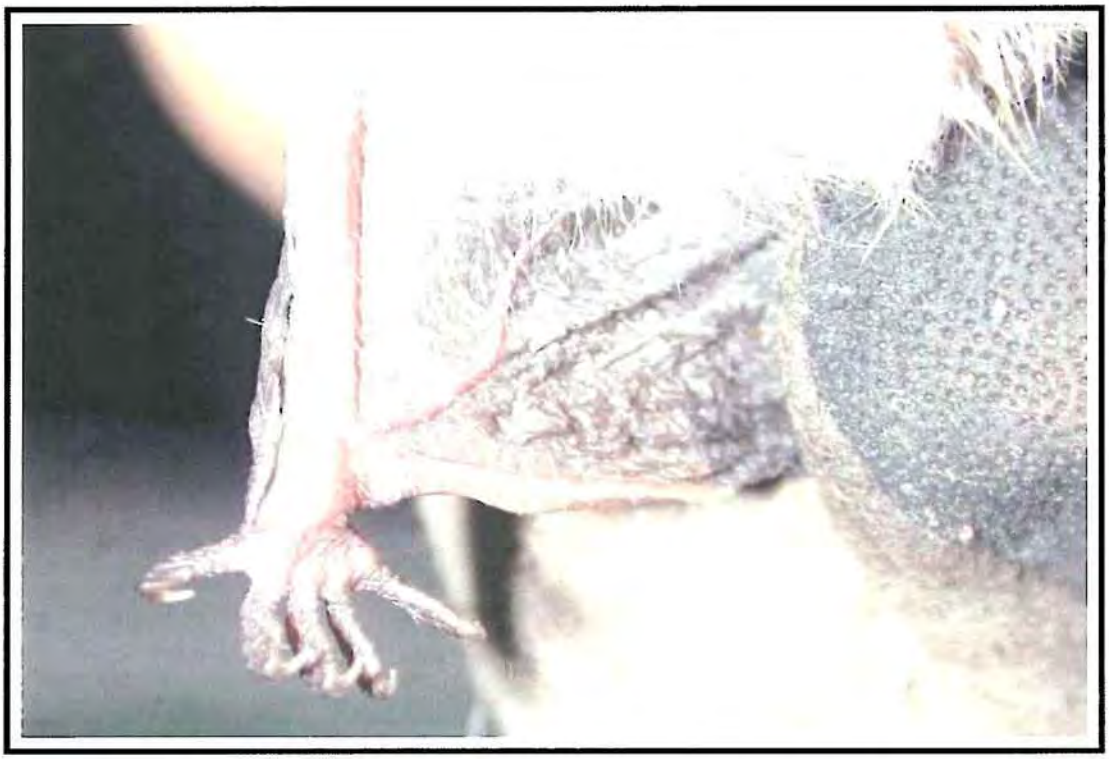


Photo 2. Site 4 Male Indiana bat keel on calcar and no toe hair present

Photo 3. Site 6 Male Indiana bat face

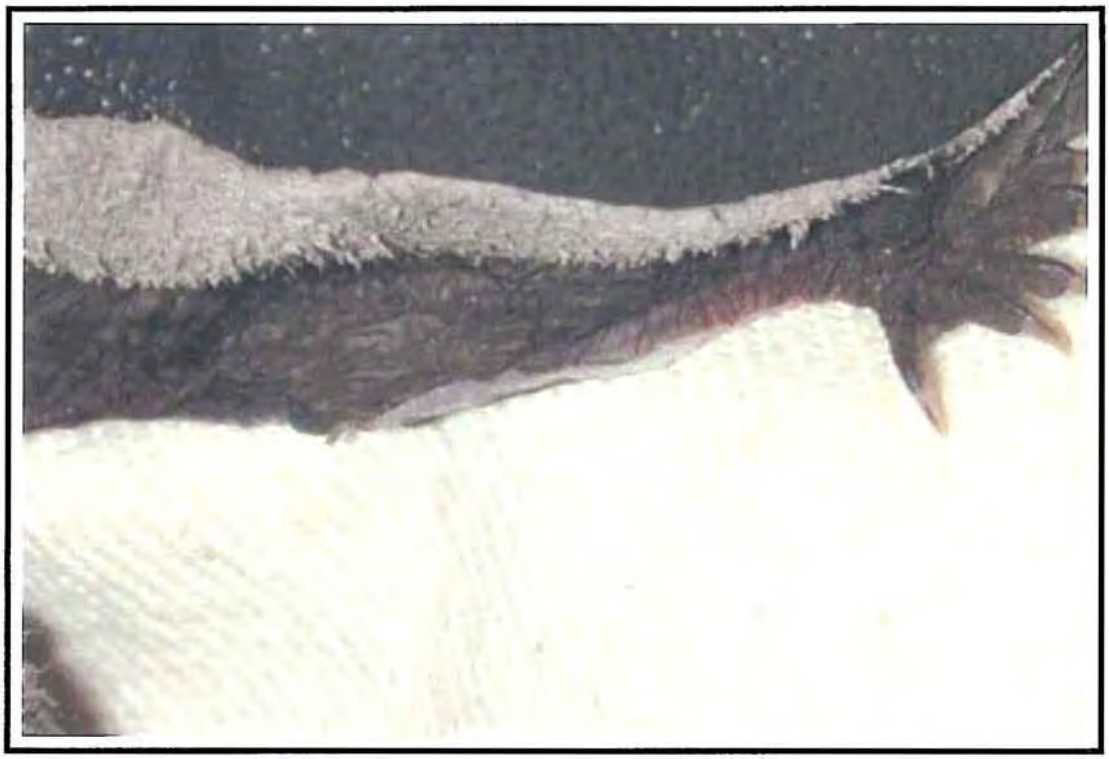


Photo 4. Site 6 Male Indiana bat keel on calcar and no toe hair present

Photo 5. Site 19 Female Indiana bat with transmitter.

Photo 6. Site 19 Female Indiana bat keel on calcars

Photo 7. Site 20 Male Indiana bat

Photo 8. Site 20 Male Indiana bat keel on calcar

Photo 9. Site 22 Male Indiana bat

Photo 10. Site 22 Male Indiana bat keel on calcar and sparse short toe hair present

Photo 11. Roost Tree 1

Photo 12. Roost Tree 2