ADDITIONAL TELEMETRY AND ROOST STUDIES OF SUMMER HABITAT FOR THE INDIANA BAT (*MYOTIS SODALIS*) WITHIN THE WABASH LOWLAND, CRAWFORD UPLAND, AND MITCHELL PLAIN REGIONS FROM ELBERFELD TO BLOOMINGTON, INDIANA

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ADDITIONAL TELEMETRY AND ROOST STUDIES OF SUMMER HABITAT FOR THE INDIANA BAT (*MYOTIS SODALIS*) WITHIN THE WABASH LOWLAND, CRAWFORD UPLAND, AND MITCHELL PLAIN REGIONS FROM ELBERFELD TO BLOOMINGTON, INDIANA

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Abstract

In fulfillment of Tier II Environmental Impact Studies (EIS) of the proposed I-69 corridor from Evansville to Indianapolis, Indiana, re-netting and telemetry studies for the federally endangered Indiana bat (*Myotis sodalis*) were conducted in July and August of 2005. The primary objective of this study was to intensify the search for Indiana bat roost sites. Another objective was to note the presence of the state-endangered evening bat (*Nycticeius humeralis*).

Seven sites mist netted in summer 2004, including Site 3 within Section 1, Sites 12 and 22 within Section 2, Site 14 within Section 3, and Sites 2, 11, and 23 within Section 4, were re-mist netted for 12 net nights per site. A total of 212 bats representing 8 species was captured: 68 eastern red bats (*Lasiurus borealis*), 46 eastern pipistrelles (*Pipistrellus subflavus*), 39 northern bats (*Myotis septentrionalis*), 29 big brown bats (*Eptesicus fuscus*), 13 little brown bats (*Myotis lucifugus*), 13 evening bats, 3 Indiana bats, and 1 hoary bat (*Lasiurus cinereus*). One non-reproductive female Indiana bat was captured on Section 2 (Site 12), and despite intensive efforts to track it using both ground and aerial telemetry, roost sites could not be located. Two adult male Indiana bats were captured on Section 4 (Site 2) and were not fitted with transmitters. No Indiana or evening bats were captured on Sections 1 and 3. One bridge roost site at Highway 57 was located and a total of 15 Indiana bats were observed exiting the roost on 13 August 2005. Twelve evening bats were captured on Section 3 and one was captured on Section 2.

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

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 II Environmental Impact Statement for the proposed I-69 from Evansville to Indianapolis, Indiana. Environmental Solutions and Innovations, Inc. (ESI) was contracted by Bernardin, Lochmueller and Associates (BLA) and their client, the Indiana Department of Transportation, to conduct summer mist net surveys for the endangered Indiana bat (*Myotis sodalis*) on the proposed I-69. Little is known in southwestern Indiana about the occurrence of the Indiana bat. The objective of these mist net surveys was to supplement the information gathered in the 2004 survey, in terms of finding additional primary roosts for the Indiana bat and improving understanding of the summer habitat, distribution and use of night roost sites, specifically on Section 1, 2, 3 and 4 of the proposed I-69 corridor.

ESI completed field efforts under federal endangered species permit TE 023664-15 and State of Indiana Division of Natural Resources permit 3086.

2.0 Study Area

2.1 Location –

2.1.1 Section 1 –

Section 1 of the I-69 corridor extends from I-64 near Evansville via the State Route (SR) 57 corridor to SR 64 near Princeton and Oakland City. Section 1 is located in eastern Gibson County and runs adjacent to the Gibson and Warrick county line (Figure 1a). The total length of Section 1 is approximately 12 miles.

2.1.2 Section 2 –

Section 2 of the I-69 corridor begins at SR 64 in Gibson County near Princeton and Oakland City. It proceeds northeast via the SR 57 corridor to US 50 near Washington in

Daviess County (Figure 1a). The total length of Section 2 is approximately 29 miles.

2.1.3 Section 3 –

Section 3 begins at US 50 and SR 57 near Washington. It proceeds north through Daviess County into Greene County and ends at US 231 just north of SR 58 near the northwest corner of Crane Naval Surface Warfare Center (Figure 1a). The total length of Section 3 is approximately 25 miles.

2.1.4 Section 4 –

Section 4 begins at US 231 in southeast Greene County just north of SR 58 near the northwest corner of Crane Naval Surface Warfare Center. It proceeds northeast into Monroe County and ends at SR 37 near Victor Pike south of Bloomington (Figure 1a). The total length of Section 4 is approximately 27 miles.

2.2 Physiography –

2.2.1 Section 1 –

The Section 1 project area (Figure 1b) is located in the Wabash Lowland region in southwest Indiana. The Wabash Lowland is a tract that extends widely on both sides of the Wabash River. The eastern border of this region is the western limit of the Crawford upland physiographic region. This region occupies areas in Kentucky and Illinois and covers approximately 4,900 square miles in Indiana. The Wabash Lowland is characterized by a wide extent of alluvial lands with frequent steep slopes that rise from the flat floodplain area. Isolated bedrock hills, which range from a few feet high to 100 or more feet in height, and often cover several square miles, are a unique feature of the Wabash Lowland region. The uplands of the region often rise 150 feet above the flat, wide valleys (Logan et al. 1922).

2.2.2 Section 2 –

The Section 2 project area (Figure 1b) stretches across Gibson, Pike, and Daviess counties in a northeasterly direction, crossing four geologic Sections within two natural regions of southwestern Indiana. A large portion of the corridor is within the Southwestern Lowlands natural region, where wide, flat valleys separate islands of upland forest interspersed with flatwoods (Minton 2001). Small areas of sand and tall grass prairies once existed; however, previous mining and agriculture have virtually eliminated them. Low relief and extensive aggraded valleys characterize this region, which is divided into three separate Sections: Plainville Sand, Glaciated, and Driftless (Homoya et al. 1985). Bordering areas east of the White River North Fork in Daviess County, the Plainville Sand Section was once glaciated by the Illinoian ice sheet, and is now part of a small, unique area of eolian sand dunes that contain somewhat acidic soils (Homoya et al. 1985). Natural community remnants of barrens and prairies can still be found in this area. In Northern Pike County, the corridor crosses the Glaciated Section, which contains predominantly acid to neutral silt loams with a think layer of loess (Homoya et al. 1985). Natural communities are mostly forest types, but prairie and flatwood community types are also common. North and south of the Patoka River Bottoms, the corridor crosses the Driftless Section, which is characterized by low hills and broad valleys that contain well-drained soils (Homoya et al. 1985). Most of the natural communities in this Section, which encompasses most upland portions of southwestern Indiana, are mixed forest types dominated by oak and hickory.

Portions of the corridor are located in the Southern Bottomlands Natural Region (Homoya et al. 1985). This region includes the bottomlands along rivers and larger streams of southwestern Indiana. In Section 2, this includes the Patoka River and White River East Fork. Much of the area encounters frequent flooding, and the soils are mostly neutral to acidic silt loams. Natural communities of this region include bottomland forests, swamps, ponds, sloughs, and former marshes and prairies (Homoya et al. 1985). These major river valleys support certain vegetation and wildlife that is associated more with southern communities, such as those found in the lower Mississippi Valley and Gulf Coastal Plain (Minton 2001)

2.2.3 Section 3 –

The Section 3 project area (Figure 1b) is located in the Glaciated Section of the Southwestern Lowlands, which contains predominantly acid to neutral silt loams with a think layer of loess (Homoya et al. 1985). Natural communities are mostly forest types, but prairie and flatwoods community types are also common. Additional community types include swamp, marsh, pond and low gradient stream. (Homoya et al. 1985).

2.2.4 Section 4 –

The Section 4 project area (Figure 1b) 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 the 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 Ecology –

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 decline.

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 all four sections of I-69 (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 Gibson (Section 1), Pike (Section 2), Daviess (Sections 2 and 3), Greene (Sections 3 and 4) and Monroe (Section 4) counties.

2.3.2.1 Winter hibernation / Spring Staging and Autumn Swarming –

Indiana bat winter hibernacula (caves) are not known from Gibson, Pike, and Daviess counties; however, several hibernacula are known from nearby Crawford, Greene, Lawrence, Martin, and Monroe counties (BLA 2003; Figure 3).

The Indiana bat is known to hibernate in 12 caves in the region that includes Section 4 of I-69 (Figure 3). Eight hibernacula are known from western Monroe County. Hibernacula are classified based on winter population sizes of Indiana bats in each cave. Priority I hibernacula exceed 30,000 bats, Priority II caves traditionally contain between 1,000 and 30,000 bats, and Priority III caves contain less than 1,000 Indiana bats. Recently, however, the lower limit of Priority II populations was decreased to 500 individuals (USFWS 1999).
(Cave, Cave, Cave, Cave, Cave, and Cave are Priority III hibernacula. and 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 (Figure 3). and Cave are Priority III hibernacula located approximately 0.5 miles from the Section 4. 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). Cave is approximately 6 miles from the I-69 corridor.

2.3.2.2 Spring and Autumn Migration –

Because winter hibernacula are known from seven counties in southern Indiana, it is reasonable to assume migration of transient bats occur during spring and autumn within the impact area.

2.3.2.3 Summer Roosting –

Gibson, Pike, and Daviess counties are not among the 24 counties with records of adult male Indiana bats (Whitaker and Brack 2002). Adult males are known from nearby Martin, Greene, and Sullivan counties. 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. Prior to the 2004 surveys on Section 1, two records of adult reproductive females were known from Gibson County. During the 2004 mist net survey in Section 1, one pregnant female Indiana bat was captured in the upper headwaters of Pigeon Creek, about 1.5 miles west of the corridor. Female Indiana bats were not known from either Greene or Monroe counties until the summer 2004 mist-netting season. During the 2004 mist net survey in Section 4, two female Indiana bats, one pregnant and one lactating were captured in Green County. Reproductive females are also known from nearby Posey, Spencer, Jackson, Knox, Martin and Vigo

counties in Indiana; Clay, Edwards, Lawrence, and Wabash counties in Illinois; and Union and Daviess counties in Kentucky.

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 5). During the 2004 mist net survey for Section 4, six male Indiana bats in Green County and one in Monroe County were captured. During summer, males often remain at or near hibernacula, visiting them periodically, although some disperse longer distances from the hibernacula.

The Draft Environmental Impact Statement (DEIS) on the Southwest Indiana Highway Corridor prepared for INDOT included information on 1993 mist net surveys for Indiana bats (BLA 2003). Dr. John Whitaker Jr. surveyed 19 sites along the proposed corridor from I-64 to Bloomington, Indiana. One site was located within the Section 1 corridor. No bats were captured and mist netting ceased when a thunderstorm hit the area. Seven sites were located within the Section 2 corridor. A total of 16 bats was captured; including two lactating female Indiana bats at Site 2. Site 2 from the 1993 surveys is near Sites 6 and 7 of the summer 2004 surveys. Four sites were located within the Section 3 corridor. A total of 32 bats was captured; no Indiana bats were caught. Eleven sites were located within the Section 4 corridor. A total of 41 bats was 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, 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.

2.3.4 Winter Hibernation –

Although the winter range of the Indiana bat is large, it is restricted to regions of well-developed limestone caves and the species overwinters in approximately 300 known hibernacula. Most hibernacula are in caves, but abandoned mines (Kath 2002; Hicks and Novak 2002; Brack et al. in prep) are sometimes used. 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; 2005, 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 (Myers 1964; Clawson et al. 1980; Brack et al. 2003a; 2003b; 2005; Brack and Reynolds in prep). Therefore, Indiana bats use areas that are cool but thermally stable. Colder areas, especially areas closer to the entrance, are often unstable.

A review of ecological and physiological aspects of hibernation is provided in Brack (2004). Clusters of bats are not sexually segregated. The incidence of white and leucistic Indiana bats, although rare, is a reoccurring phenomenon (Brack and Johnson 1990; Brack et al 2005).

2.3.4.1 Spring Staging and Autumn Swarming –

2.3.4.2 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.

2.3.4.3 Autumn –

Autumn swarming is a term used to describe the activity of microchiropterans 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 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 individuals begin to return to hibernacula in early August.

During swarming, the abundance of females wax and wane 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 submission). 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 caves. At smaller hibernacula, some individuals roost in woodlands near the cave: 0.5 mi (0.8 km) in Virginia (Brack in submission) 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 et al. 2005). 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 et al. 2005). 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; $\bar{\chi}$ = 251 ha), with a great deal of overlap among activity areas of individuals (Brack in submission). 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 submission). 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 submission). 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 submission; 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 in review; 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.

2.3.4.4 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 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).

2.3.5 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 (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).

2.3.5.1 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).

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).

2.3.5.2 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 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 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 submission). 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 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 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 Interstate 70, routinely crossed this 6-lane interstate to forage (Brack, unpublished data). 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 (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.

2.3.5.3 Food Habits and Foraging Ecology –

The diet of Indiana bats 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 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 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 males 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).

2.3.9 Survivorship -

Detailed studies of survivorship of the Indiana bat have not been completed. Humphrey and Cope (1977) found survival rates high for years 1 – 6 after banding, 75.9% annually for females and 69.9% for males (72.9% combined), lower after 6 years, at 66.0% for females and 36.3% for males (51.2% combined), and only 4.1% (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%), which was attributed to low survivorship of young-of-the-year. Brack et al. (2005) found that survivorship of white and leucistic *M. sodalis* was low, about 7.7% (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.

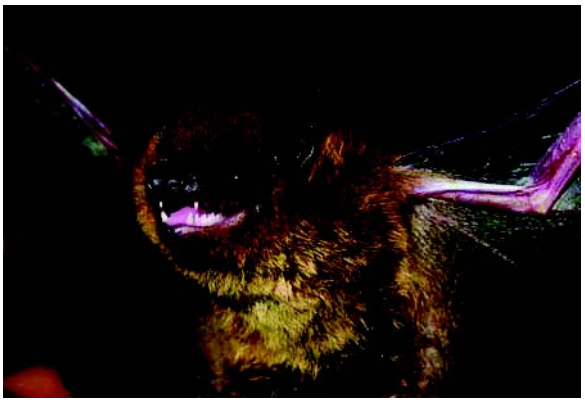
Twenty-five years of studies in the caves of Indiana indicate that flooding of hibernacula may be a significant source of mortality for Indiana bats (Brack et al. 2005). Twenty-four percent of caves in Indiana known to have served as a hibernaculum for at least one Indiana bat during at least one winter during the last 25 years flood, and are thus potential population sinks.

2.4 Evening Bat Ecology –

2.4.1 Status and Distribution –

Evening bats (*Nycticeius humeralis*) occur throughout much of the southeastern United States. Their geographic distribution extends from the coastal plain and piedmont regions of the Mid-Atlantic States, south and west throughout states bordering the Gulf of Mexico, and northward throughout the Mississippi embayment (Barbour and Davis 1969). The species appears most abundant in the southern states and is scarce in the Appalachian Mountains and northern parts of the range (Whitaker and Hamilton 1998). Evening bats have been captured sporadically at upland sites throughout the eastern United States, but are most abundant in regions where swamps and river bottomlands are common (Whittaker and Gummer 2003).

2.4.2 Ecology –



During the 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 (Cope et al. 1961; Mumford 1953; Whitaker and Gummer 1988, 1993. However, the species often uses natural roosts, including cavities and exfoliating bark, in the southeastern United Sates (Menzel et al. 2001) and in Indiana (Whitaker and Gummer 2003). Recently, Miles et al. (2004) documented roosts in the tops of living pine trees in Georgia.

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 (Watkins 1972). 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). In Missouri, Boyles et al. (in submission) documented a male evening bat burrowing into the leaf litter during the cold of winter. 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.

The diet of the evening bat is not well known. In Indiana, Brack (1983) found that the diet included beetles, moths, leafhoppers, flies, and ants. Whitaker and Clem (1992) found the prey consisted mainly of beetles, moths, and leafhoppers; many prey items were agricultural pests. Studies of food habits have also been completed in Illinois (Feldhamer et al. 1995) and Georgia (Carter et al. 1998). In central Indiana, Brack (1985) caught evening bats foraging in the canopy layer of an open, grazed upland woodlot and Sparks et al. (2004) reported that the species foraged primarily in agricultural and wooded areas. In southern Missouri, LaVal et al. (1977) reported that several light-tagged bats foraged over and near the streams where they were caught. In Kansas, the species apparently forages near and around riparian woodlands; in southern Arkansas, the species was often netted over ponds (Baker and Ward 1967). Clem (1993) indicated that only while lactating did this species exhibit a bimodal activity period indicative of many insectivorous bats. Lactating females also sometimes failed to return to the maternity roost and therefore day roosted at an alternate location.

2.4.3 Regional Occurrence –

Population trends of evening bats are unknown in most parts of the range and the species has no federal protective status. In Indiana it is considered state endangered. 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. Since then several colonies have been located in eastern and south-central Indiana, mainly along the Wabash and White rivers (Whitaker and Gummer 2003), all using natural tree roosts (Figure 7). Brack et al. (2004) also recorded a single adult male in 1998 from Hoosier National Forest, over a tributary to the Little Blue River. During the 2004 mist net survey ten evening bats in Section 1 and five in Section 2 were captured in the proposed I-69 corridor.

3.0 Methods

3.1 Mist Net Survey –

3.1.1 Site Selection –

BLA/INDOT identified 2.5 mile circles around seven Indiana bat capture sites in Sections 1 – 4 (Figure 1a), some of which did not produce primary roosts in summer 2004. Within each circle, the best available net sites that could be accessed were chosen for netting. U.S. Fish and Wildlife Service agreed with this assessment. Net sites that produced captures of Indiana bats in 2004 were given priority. Qualities of other suitable sites were evaluated based on the availability of travel corridors within the context of suitable habitat that includes large trees suitable for roosting, foraging habitat, and access to water.

3.1.1.1 Section 1 –

During the 2004 mist net survey in Section 1, one Indiana bat was captured at Site 3 on 24 May. It was a pregnant female captured in the upper headwaters of Pigeon Creek, about 1.5 miles west of the corridor. A radio transmitter was attached, but no roost was located, although the bat was detected briefly twice while active at night.

Locations of four mist net sites were pre-selected collectively by BLA, ESI, and INDOT and then approved by USFWS (Table 1) within the 2.5-mile circle around the capture site.

3.1.1.2 Section 2 –

During the 2004 mist net survey in Section 2, ten Indiana bats were captured, of which nine were adult females. These nine bats were tracked and roosts were found for five of them. Roosts for two post lactating female Indiana bats (#285 from Site 22 and #385 from Site 12) and two non-reproductive female Indiana bats (#482 from Site 12 and #442 from Site 11) were not found (ESI 2004).

Locations of four mist net sites at Site 12 and five mist net sites at Site 22 within the 2.5-mile circle around the capture sites were pre-selected collectively by BLA, ESI, and INDOT and then approved by USFWS (Table 1).

3.1.1.3 Section 3 –

During the 2004 mist net survey in Section 3, twelve Indiana bats were captured, of which three were female lactating bats, three were pregnant bats and the remainder were adult male bats (BLA pers. comm.).

Locations of six mist net sites at Site 14 of Section 3 were pre-selected collectively by BLA, ESI, and INDOT and then approved by USFWS (Table 1). One bridge on Hwy 57 in Section 3 was also pre-selected and was checked for the presence of guano and roosting bats during both day and night hours.

3.1.1.4 Section 4 –

During the 2004 mist net survey in Section 4, nine Indiana bats were captured; of which two were adult females and the remainder were adult males. Transmitters were attached to three of these bats from Site 2 (#554), Site 11(#186), and Site 23(#753), and five diurnal roost trees were identified. Transmitters were not attached to six adult males (ESI 2004).

Five mist net locations at Site 2, four mist net locations at Site 11 and six mist net locations at Site 23 were pre-selected collectively by BLA, ESI, and INDOT and

then approved by USFWS (Table 1). In addition, roost tree emergence studies were done for trees that were identified as roosts for bats #186 and #554 in 2004.

Property owners were provided Notice of Survey letters and were also contacted by the Project Manager and the field crews. Site coordinates were obtained with hand held Garmin GPS 12 units and recorded in UTM meters. If net sets were close together, a single GPS UTM was collected; usually between the two net sets. If the net sets were far apart, (i.e., one over a stream and one over a trail), coordinates were taken at each net set (Table 1).

3.1.2 Mist Netting –

Efforts to survey for endangered bats are difficult to standardize because of the large amount of variability that exists in a field situation. Guidelines provided by U.S. Fish and Wildlife Service (1999) in the most recent (Agency Draft) revision of the Indiana bat Recovery Plan have provided structure for implementation of netting (Table 2).

The objective of the present study was the capture of Indiana bats for radio-telemetry, rather than a documentation of presence/absence in the area; therefore, strict adherence to the USFWS guidelines for the number and placement of nets, or the number of nights of effort was not required. The maximum level of effort used to search for bats was 6 nights of effort (typically equating to 12 net nights with high nets) or about three times the level in a typical presence/absence survey.

At any point during the six-night survey, if two reproductive (pregnant, lactating, or post-lactating females and juveniles) Indiana bats were caught, netting for that site was suspended. If only one reproductive bat was caught, then logistics, the most efficient use of labor, and professional judgment to maximize the probability of finding the primary roost were used to determine whether to continue netting for capture of a second reproductive bat. At that point, (1) netting was temporarily suspended to see if a primary roost is located, or (2) netting was continued while telemetry of the first individual is being completed. Transmitters were not attached to adult males.

Net sites that produced captures of Indiana bats in 2004 were given priority. In addition, net placement was based upon canopy cover, presence of a flight corridor, water, and habitat conditions near the site. Nets were set to maximize coverage of flight paths used by Indiana bats along suitable corridors. The location and specific orientation of each net was determined in the field.

3.1.2.1 Section 1 –

Four mist net sites (five nets at one location and two net sets each at the other three locations) were operated between 25 and 31 July 2005, for a total of 12 net nights (Table 1).

3.1.2.2 Section 2 –

Four mist net locations at Site 12, with a pair of nets at each location, 2 net nights at three locations and 6 net nights at the fourth, were operated between 4 and 6August 2005 for a total of 12 net nights (Table 1).

Five mist net locations at Site 22, with a pair of nets at each location, 2 net nights at four locations and 4 net nights at the fifth, were operated between 4 and 6August 2005 for a total of 12 net nights (Table 1).

3.1.2.3 Section 3 –

Six mist net locations at Site 14 with two nets at each site were operated between 8 and 10 August 2005 for a total of 12 net nights (Table 1).

One bridge on Hwy 57 was pre-selected by BLA in consultation with USFWS. It was checked for the presence of guano and roosting bats during day and nighttime hours. Completed bridge roost characterization and habitat assessment data sheets are provided in Appendix D.

3.1.2.4 Section 4 –

Five mist net locations at Site 2, with a pair of nets at each location, 2 net nights at four locations and 4 net nights at the fifth were operated between 11 and 14 August 2005 for a total of 12 net nights (Table 1).

Four mist net locations at Site 11, with a pair of nets at each location, 2 net nights at two locations and 4 net nights at the other two, were operated between 12 and 14 August 2005 for a total of 12 net nights (Table 1).

Six mist net locations at Site 23, with a pair of nets and 2 net nights at each location were operated between 11 and 15 August 2005 for a total of 12 net nights (Table 1).

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 0.1 grams 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.

Only female Indiana bats were banded. Bat processing and data collection was typically completed within 30 minutes of the time the bat was removed from the net (bat capture data sheets are provided in Appendix D).

Data collected was used in comparative analyses with surveys from previous years 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.

3.1.4 Habitat Assessment –

Habitat assessment at net sites focused on features indicative of suitability for Indiana bats. A habitat description of each net 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, stream or pond characteristics (if net was placed over them), and flight corridors. Habitat form was emphasized because the Indiana bat roosts in many species of trees. 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 (>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 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 net site was documented with a sketch.

3.1.5 Weather –

Temperature, percent cloud cover, wind, and rainfall were monitored and recorded hourly while mist netting to insure compliance with weather conditions outlined in the netting guidelines (Table 3).

Over the entire project period, nighttime lows ranged from 59.0 to 82.22°F, and high temperatures ranged from 66.92 to 85.1°F (Table 3). Appendix D contains completed Weather Data Sheets.

3.2 Radiotelemetry –

3.2.1 Transmitter Application –

After collecting morphometric data, female adult Indiana bats, if caught, were fitted with radio transmitters, each with a specific frequency. Transmitters were activated and tested before attachment to bats. A small interscapular area was trimmed of fur and the transmitter was attached to this area with non-toxic Skin-Bond® cement (Smith and Nephew, Inc., manufacturer). This cement degrades over time and the transmitter falls off the bat. Transmitter weight, weight of the bat before and after transmitter attachment, and holding time were recorded. Bats were released at the point of capture, unharmed.

3.2.2 Bat Tracking and Exit Counts –

After radio-tagged bats were released, bats were tracked using TRX-2000S PLL Synthesized Tracking Receivers with three element folding yagi directional antennas manufactured by Wildlife Materials, Inc. Transmitters came from Titley Electronics, PTY, LTD and Blackburn Transmitters. Transmitter weights were 0.4 grams.

Because the intent of this effort was to find primary roosts and efforts to locate bats with transmitters was a main objective, entire days into dusk would be devoted to this effort as necessary. The decision on the duration of tracking efforts and the types of effort were employed as follows:

- **IF** at least 1 primary roost was located within the initial 5 days of tracking, **THEN** tracking would be suspended after 5 days
- **IF** a primary roost was not found in the first 5 days, **AND** the bats could still be located, **THEN** tracking would continue until a primary roost was found, or the transmitter quits or was shed by the bat
- **IF** a bat with a transmitter could not be located after 3 - 5 days of effort, **THEN** an initiative to secure an airplane for an aerial survey would be undertaken with the intent of completing an aerial survey within the first 7 - 9 days after tagging, or if the bat was still not found, twice within the first 8 - 10 days after tagging

❖ Efforts to locate a bat would be suspended after 10 days

If a roost tree was found, exit counts were conducted at each roost location for five consecutive nights. Beginning at sunset, counts last 1 hour, until bats quit emerging, and/or darkness precludes accurate counting. Roost tree characterization and habitat assessment data sheets (including GPS locations) are completed for each roost.

4.0 Results

4.1 Section 1 –

4.1.1 Bat Capture –

A total of eleven bats representing three species was captured at the four locations in Site 3, including: eight eastern pipistrelles (*Pipistrellus subflavus*), two eastern red bats (*Lasiurus borealis*), and one big brown bat (*Eptesicus fuscus*). (Table 4). The catch of bats in mist nets averaged 0.92 bats/net night (Table 8).

4.1.1.1 Species Diversity –

Species complement and number of bats captured in the project area was "typical" for the geographic location and type of habitat. Only three species of bats were captured at Site 3, Section 1 of I-69 in 2005. The MacArthur (1972) diversity index for bats captured in 2005 on Section 1, Site 3 was 1.75 compared to 2 for the same site in 2004.

4.1.1.2 Occurrence by Sex and Age –

A total of eleven bats were captured in Section 1, Site 3, over 12 net nights. Sex and age were determined for all the bats. Juveniles accounted for 63.6 percent of the catch (n=7). Only one female bat (an eastern pipistrelle) was captured.

4.1.2 Indiana Bat Capture –

No Indiana bats were captured at Section 1, Site 3, in 2005.

4.1.3 Evening Bat Capture –

No evening bats were captured at Section 1, Site 3, in 2005.

4.1.4 Net Site Habitat Assessment –

At net location 1 (designated 1-03-1), five nets were placed in a young lowland forest. One net was placed across a creek and the remaining four were placed across dirt roads near the creek (Figure 8). The creek channel was approximately 13 feet wide and the stream 10 feet wide. Average water depth was 1.6 feet with low clarity. Dominant canopy trees included tulip tree (*Liriodendron tulipifera*), shagbark hickory (*Carya ovata*) and northern hackberry (*Celtis occidentalis*). Subdominant canopy trees included shagbark hickory, sweet gum

(*Liquidambar styraciflua*) and northern hackberry. The canopy closure and subcanopy clutter was moderate. Roost tree potential for the area was high, consisting of large trees and snags.

Net location 2 (1-03-2) was 330 feet from Pigeon Creek and the nets were placed across a farm road. Dominant canopy trees included swamp oak (*Quercus bicolor*), American elm *(Ulmus americana*) and sweet gum. Subdominant trees included sugar maple, box elder (*Acer negundo*), and ash (*Fraxinus spp*). The canopy closure and subcanopy clutter was moderate. Roost tree potential for the area was moderate, consisting of large trees and snags.

Net location 3 (1-03-3) was in a young lowland forest, where one of the nets was placed across a creek and the other across a dirt road adjacent to the creek. Dominant canopy trees included white oak (*Quercus alba*), sugar maple and eastern sycamore (*Platanus occidentalis*). The canopy was closed and the subcanopy clutter was moderate. Roost tree potential was moderate with large trees and snags.

Net location 4 (1-03-4) was in a young lowland forest, with a creek surrounded by mixed deciduous woodlot, agricultural field and pond. Dominant species included pin oak (*Quercus palustris*), shingle oak (*Quercus imbricaria*) and sugar maple. Subdominant canopy trees included red maple, sassafras (*Sassafras albidum*) and black cherry (*Prunus serotina*). The canopy closure and subcanopy clutter was moderate. Herbaceous cover was dense. The roost tree potential was moderate consisting of large trees.

4.1.5 Radiotelemetry –

No Indiana bats were captured at Site 3 on 2005; therefore, no telemetry was conducted.

4.2 Section 2 –

4.2.1 Bat Capture –

A total of 58 bats representing eight species was captured at Site 12 and Site 22 of Section 2, including: 25 eastern red bats, 7 big brown bats, 16 eastern pipistrelles, 6 northern bats (*Myotis septentrionalis*), 1 each of little brown bat (*Myotis lucifugus*), Indiana bat (*Myotis sodalis*), evening bat (*Nycticeius humeralis*), and hoary bat (*Lasiurus cinereus*) were captured (Table 5, Figure 9). Evidence of reproduction, namely reproductive females and/or juveniles, was obtained for all species. Only one big brown bat escaped before sex and morphometric data were collected. The catch of bats in mist nets averaged 2.4 bats/ net night (Table 8).

4.2.1.1 Species Diversity –

The species complement was typical for the geographic location and habitat types within the project area. In addition to the Indiana bat, seven other species of bats were captured. Twenty bats including the one Indiana bat were captured at Site 12 and 38 were captured at Site 22. Species richness was six at both sites.

The eastern red bat was the most commonly netted species, representing approximately 43 percent of the total catch. Collectively, the eastern red bat, big brown bat, eastern pipistrelle, and northern bat accounted for approximately 93 percent of the bats captured. The MacArthur (1972) diversity index for bats captured in 2005 on Section 4, Sites 12 and 22 was 3.4 and 2.7 respectively, compared to 1.8 and 1.2 for the same sites in 2004 (ESI 2004).

4.2.1.2 Occurrence by Sex and Age –

A total of 58 bats were captured over 24 net nights. One big brown bat escaped before sex or age could be determined. Of the remaining, adult males and females accounted for 17 percent (10 individuals) and 24 percent (14 individuals), respectively. Juvenile males and females accounted for 58 percent (33 individuals). The largest percentage of the juvenile population was eastern red bats (40%).

The majority of adult females caught were non-reproductive (64%, 9 individuals) indicating that they were no longer nursing or rearing young. Of the 14 females, only five individuals were still in the reproductive stage.

4.2.2 Indiana Bat Capture –

Only one Indiana bat, a non-reproductive adult female, was captured at Site 12, net location 2 (2-12-2). A transmitter was attached to the bat, and an effort was made to locate the roost using ground and aerial telemetry. The bat was released in good condition at the point of capture. Transmitter attachment data sheets are provided in Appendix D.

4.2.3 Evening Bat Capture –

One evening bat, a non-reproductive adult female, was captured at Site 12, net location 2 (2-12-2). No transmitters were attached and the bat was not banded. The bat was released in good condition at the point of capture.

4.2.4 Net Site Habitat Assessment –

Net site habitat descriptions were completed for each site. Net site habitat description data sheets are provided in Appendix D.

Site 12 is located near the borders of Pike and Daviess counties, near the convergence of the North and East Forks of the Patoka River. It is primarily riparian forest or nearby upland deciduous forest. A diverse variety of trees were found in this bottomland area of the White River. Four mist net sites were established at Site 12. Three sites (2-12-1, 2-12-2 and 2-12-3) were located in close proximity of each other near the Patoka River (Figure 9a). The common dominant canopy species in this area were pin oak, swamp oak, silver maple (*Acer saccharinum*), and ash (*Fraxinus spp*). Sub dominant canopy was composed of silver maple, eastern sycamore, black cherry and American beech (*Fagus grandifolia*). The canopy closure was moderate. The subcanopy clutter ranged from closed to moderate. Herbaceous cover was moderate to dense and roost tree potential was moderate at one net site (2-12-1) and was low at the other two sites. One female non-reproductive Indiana bat was captured at Site 12, net location 2 (2-12-2). The fourth net location (2-12-4) was also close to Patoka River and the nets were placed across two access roads. Dominant canopy species were composed of pin oak, sweet gum and silver maple. Subdominant species were silver maple, eastern sycamore and swamp oak. The canopy closure was moderate. Subcanopy clutter and herbaceous cover was moderate. The roost tree potential was high with large trees and snags.

Five mist net sites were located at Site 22 (Figure 9b). Netting locations 1 and 5 (2-22-1 and 2-22-5) were in close proximity and adjacent to east fork of Patoka River. The dominant canopy species at these sites included white oak, silver maple, eastern sycamore, beech, swamp oak, northern hackberry and honey locust (*Gleditsia triacanthos*). The subdominant canopy was

composed of northern hackberry, honey locust, Ohio buckeye (*Aesculus glabra*), white oak, silver maple and black locust (*Robinia pseudoacacia*). The canopy closure and subcanopy clutter was moderate. Herbaceous cover was moderate to dense. Roost tree potential for the area was moderate consisting of large trees and snags. Net location 2 (2-22-2), was about 800 feet from the White River and the nets were placed across a road corridor. The dominant canopy was composed of silver maple and cottonwood (*Populus deltoides*). The subdominant canopy was also composed mostly of silver maple. The canopy closure, subcanopy clutter and herbaceous cover were moderate. The roost potential of the site was low, consisting of only large trees. Net location 3 (2-22-3) was in a mixed deciduous woodlot with neighboring agricultural fields. The dominant canopy was composed of ash, pin oak, and sweet gum. The subcanopy was composed of sugar maple, eastern sycamore, and black walnut (*Juglans nigra*). The canopy closure, subcanopy clutter and herbaceous cover were moderate. The roost potential of the site was moderate, consisting of both large trees and snags. Net location 4 (2-22-4) was in a narrow riparian strip close to Aikman Creek. The channel width of the creek was approximately 21 ft. and the stream width was 12 ft. Average water depth was 0.5 ft. and the water was very clear. The dominant canopy species were red maple, sycamore and pin oak. The subdominant canopy was composed of red maple and American elm. The canopy closure and subcanopy clutter was moderate. Herbaceous cover was dense and the roost potential of the area was high composed of large trees.

4.2.5 Radiotelemetry –

One female Indiana bat was captured and fitted with a radio-transmitter (#873) on 4 August 2005.

4.2.5.1 Indiana Bat 873 –

4.2.5.1.1 *Capture and Transmitter Attachment –*

Indiana bat 873 was an adult non-reproductive female captured at Site 12, net location 2 at 0100 h on 4 August 2005. She was caught in an 18-foot mist net set across the south fork of Patoka River. She was fitted with a 0.2-gram transmitter (frequency number 151.873) and released unharmed at 0130 h after a hair sample was obtained. She was also banded (red TNTech 0052). She was in good condition, and flew off with no difficulty. Transmitter attachment data sheets are provided in Appendix D.

4.2.5.1.2 Roosts –

No roosts were located for Indiana bat 873.

4.2.5.1.3 Radiotelemetry –

After release, the signal for Indiana bat 873 was never reacquired. Biologists were unable to locate her, despite six days of active ground and aerial radio-telemetry scanning.

4.3 Section 3 –

4.3.1 Bat Capture –

A total of 44 bats representing six species was captured at the six locations at Site 14, including: 12 evening bats, 10 northern bats, 4 eastern pipistrelles, 8 eastern red bats, 7 little brown bats and 3 big brown bats (Table 6). The catch of bats in mist nets averaged 3.67 bats/ net night (Table 8).

4.3.1.1 Species Diversity –

Species complement and number of bats captured in the project area was "typical" for the geographic location and type of habitat. Six species of bats were captured in Site 14, Section 3 of I-69 in 2005. The MacArthur (1972) diversity index for bats captured on Section 3, Site 14 in 2005 was 5.06.

4.3.1.2 Occurrence by Sex and Age –

A total of 44 bats was captured in Section 3, Site 14, over 12 net nights. Sex and age were determined for all the bats. Juveniles accounted for 47.6 percent of the catch (n=20). Forty percent of the bats captured were female adults (n=17).

4.3.2 Indiana Bat Capture –

No Indiana bats were captured in Section 3, Site 14, in 2005.

4.3.3 Evening Bat Capture –

Twelve evening bats were captured at Section 3, Site 14, in 2005, representing 28.5 percent of the total bat capture. Nine of these were juvenile females and the remaining three were adult non-reproductive females.

4.3.4 Net Site Habitat Assessment –

At net location 1 (3-14-1), two nets were placed in a young upland forest (Figure 10). Both the nets were placed across a road. There were no dominant canopy trees i.e., no trees with dbh>16 inches were observed. Subdominant trees included silver maple and cottonwood. The canopy was closed and subcanopy clutter was moderate. Roost tree potential for the area was low.

Net location 2 (3-14-2) was 39 feet from White River and both the nets were placed across a dirt road. Dominant canopy trees included sugar maple, cottonwood and eastern sycamore. Subdominant species were silver maple, northern hackberry and black walnut. The canopy was closed with moderate subcanopy clutter. Roost tree potential for the area was high, consisting of large trees and snags.

Net location 3 (3-14-3) was in a mature lowland forest 165 feet from White River, where the nets were placed in an open area. Dominant canopy trees were silver maple and cottonwood. Subdominant species was composed of silver maple. The canopy was closed and the subcanopy clutter was moderate. Roost tree potential was high with large trees.

Net location 4 (3-14-4) was in a young lowland forest surrounded by agricultural field. Dominant species included silver maple, eastern sycamore and black willow (*Salix nigra*). Subdominant canopy included sugar maple, black willow and eastern sycamore. The canopy was open and subcanopy clutter was moderate. Herbaceous cover was dense. The roost tree potential was moderate consisting of large trees and snags.

Net locations 5 and 6 (3-14-5 and 3-14-6) were close to each other and about 65 – 115 feet from White River. Dominant species included silver maple, American elm, and cottonwood. Subdominant species included silver maple, cottonwood, and eastern sycamore. The canopy was moderate to closed and the subcanopy clutter was moderate. Roost tree potential for these sites were low.

4.3.5 Radiotelemetry –

No Indiana bats were captured at Site 3 on 2005; therefore, no telemetry was conducted.

4.3.6 Highway 57 bridge –

The bridge at was assessed for Indiana bat habitat. Nine Indiana bats were observed during the day and six were observed at night. Other bat species included 485 little brown bats and seven big brown bats observed during the day and 186 little brown bats and six big brown bats observed during the night. Bridge roost characterization data sheet is located in Appendix D.

4.4 Section 4 –

4.4.1 Bat Capture –

A total of 99 bats representing six species was captured at Sites 2, 11, and 23: 27 eastern red bats, 24 eastern pipistrelles, 23 northern bats, 18 big brown bats, 5 little brown bats, and 2 Indiana bats (Table 7). Evidence of reproduction (reproductive females and/or juveniles) was obtained for all species except little brown and Indiana bat. Seven bats escaped before sex and morphometric data were collected, although each was identified to species. The catch of bats in mist nets averaged 2.75 bats/ net night (Table 8).

Collectively, the northern bat, red bat, and eastern pipistrelle accounted for 75 percent of the total bats captured.

4.4.1.1 Species Diversity –

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 Section 4 of I-69 in 2005. The MacArthur (1972) diversity index for bats captured in 2005 on Section 4, Sites 2, 11 and 23 was 3.4, 3.6, and 3.6 respectively, compared to 4.4, 3.2, and 4.2 for the same sites in 2004.

4.4.1.2 Occurrence by Sex and Age –

A total of 99 bats was captured over 36 net nights. Seven percent of the bats (7 individuals) escaped before age and sex could be determined. Adult males and females (reproductive and non-reproductive) accounted for 45 percent (41 individuals) and 12 percent (11 individuals) of the total capture, respectively. Juvenile males and females accounted for 43 percent (40 individuals) of the total bats captured. Forty five percent of adult females were reproductive and were all in the post lactating phase (Table 7).

4.4.2 Indiana Bat Captures –

Only two Indiana bats, both adult males, were captured at Site 2 on Section 4 (Table 7; Figure 11b). Transmitters were not attached to these bats. Both Indiana bats were removed from the mist nets and processed for data on sex, reproductive condition, and morphometric measurements. Both bats were released in good condition at or near the point of capture.

4.4.3 Evening Bat Capture –

No evening bats were captured on Section 4, at Sites 2, 11 and 23 in 2005.

4.4.4 Net Site Habitat Assessment –

Net locations on Site 2 were located close to Doans Creek, a small tributary of the West Fork White River in Greene County (Figure 11b). The creek's channel width was approximately 20 feet. Water depth was 5 inches at each site and clarity was high. Net sets at location 2 (4-02-2) were placed across the stream. The other net set locations (4-02-1, 4-02-3, 4-02-4 and 4-02-5) were 330 - 1000 feet from the creek and were placed across roads. Dominant canopy trees included American sycamore, eastern white pine (*Pinus strobus*), tulip tree, red oak

(*Quercus rubra*), white oak, shagbark hickory, shellbark hickory (*Carya laciniosa*) and sugar maple. Subdominant trees included white oak, American elm, sassafras, red maple (*Acer rubrum*) American sycamore, and tulip tree. Canopy closure was generally moderate with moderate subcanopy clutter. Roost tree potential was moderate at net locations 1, 2, and 3 consisting of snags and large trees. Roost tree potential was high at locations 4 and 5 because of numerous shellbark and shagbark hickory trees. Net site habitat description data sheets are provided in Appendix D.

Net locations at Site 11 (Figure 11a) were near Plummer Creek and smaller branches of Plummer Creek. Plummer Creek is also a tributary of the West Fork White River. Net sets at location 1 (4-11-1) were placed across Clifty Branch of Plummer Creek. Net sets at location 2 (4-11-2) were placed across Plummer Creek. Net sets at location 3 (4-11-3) were placed across a gravel county road and at location 4 (4-11-4), one net was placed across a creek and the other was placed across a dirt road. Dominant trees were silver maple, sycamore, sugar maple, box elder, pin oak, ash, black oak (*Quercus velutina*) and cottonwood. Subdominant canopy was composed of silver maple, box elder, sycamore, sugar maple, American elm, and black walnut. The canopy was moderate at all locations except at net location 1, where it was closed. Subcanopy clutter was moderate at all locations. Roost potential was moderate at net locations 1, 2, and 3 consisting of large trees and snags. Roost potential was low at location 4 consisting of only snags.

Net locations at Site 23 (Figure 11c) were located near Indian Creek and various smaller branches of Indian Creek. Indian Creek is a smaller tributary of the East Fork White River. Net sets at location 1 (4-23-1) were placed across a clear rocky creek 3 ft. wide and 1 ft. deep. Net sets at location 2 (4-23-2) and 3 (4-23-3) were placed across dirt roads. Net sets at location 4 (4-23-4) and 6 (4-23-6) were placed across dry creek beds and at location 5 (4-23-5) they were placed across Indian Creek. Dominant canopy trees included American sycamore, sugar maple, beech, shagbark hickory, tulip tree, and black walnut. Subdominant trees included American sycamore, black walnut, black locust, beech, shagbark hickory, American elm, red maple and sugar maple. Canopy closure was generally moderate. Subcanopy clutter was moderate at all locations. Roost tree potential was moderate at all locations except 5 where it was low. Net site habitat description data sheets are provided in Appendix D.

4.4.5 Radiotelemetry –

Two Indiana bats were captured (both adult males) therefore, they were not fitted with radio-transmitters.

In 2004, five diurnal roost trees were located for three Indiana bats. Two roosts were found for the pregnant female (#554) caught at Site 2. Two roosts were found for a lactating female (#186) captured at Site 11. An adult male (#753) caught at Site 23 was tracked to a conduit tube on the south side of a telephone pole approximately 0.5 mile (0.8 km) east of the corridor along Indian Creek.

4.4.6 Roosts –

4.4.6.1 Indiana bat 554 Roost Emergence Counts –

In 2004, one of the roost trees identified for Indiana bat 554, found on 8 June 2004 was a dead shagbark hickory 18 cm (7 inches) dbh. Five to 13 bats exited the second roost

between 7 and 11 June 2004. It was located approximately 1 mile south of the corridor near the boundary with Crane Navel Surface Warfare Center.

This roost tree was observed on 13 August 2005 and no bats were found exiting the roost.

4.4.6.2 Indiana bat 186 Roost Emergence Counts –

In 2004, one of the roost trees identified for Indiana bat 186, found on 18 June 2004, was a live shagbark hickory approximately 43.2 cm (17 inches) dbh. It was located along Plummer Creek approximately 1.5 miles north of the corridor. One to five bats exited this roost between 18 and 22 June 2004.

This roost tree was observed on 12 and 13 August 2005 and five bats were found exiting the roost.

4.4.6.3 Indiana bat 753 Roost Emergence Counts –

Indiana bat 753 was found 29 June 2004 roosting behind a plastic guard to protect a high voltage transformer cable on the south side of a utility pole 20 cm (8 inches) dbh. Eight to 20 bats exited the light pole roost from 29 June to 5 July 2004.

Despite repeated requests, landowner permission was not received for conducting roost emergence counts in 2005.

5.0 Discussion

The objective of these mist net surveys was to find primary roosts for Indiana bats and improve understanding of the summer occurrence and habitat use by Indiana bats specifically on Sections 1, 2, 3, and 4 of I-69.

Combining and comparing this study with the 2004 survey data and other regional studies is helpful in identifying roosting areas for the Indiana bat near the I-69 corridor. 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 Capture and Species Diversity –

The species complement on all sites was typical for the geographic location and habitat types. The number of bats captured per net was highest at Site 14 on Section 3 (3.67) and lowest on Site 3 on Section 1 (0.92) (Table 8). The species richness on the sites ranged from three to six. Site 3 on Section 1 had the lowest number of species, Sites 11 and 23 on Section 4 had five species each and all the other sites had six species each (Table 8).

The McArthur diversity index was highest (5.06) on Site 14 (Section 3) and lowest (1.75) on Site 3 (Section 1) (Table 8) compared to 4.4 on the Crane Naval Surface Warfare Center in Crane, Indiana in northern Martin County (Brack and Whitaker 2004) and 3.5 in Hoosier National Forest (Brack et al. 2004).

The eastern red bat and eastern pipistrelle were the most common species captured at all sites.

5.2 Indiana Bat –

5.2.1 Section 1 –

No Indiana bats were captured in Section 1, Site 3, in 2005.

One pregnant female Indiana bat was captured at Site 3 during the 2004 survey. A radio-transmitter was attached, but no roosts were found, although the bat was found briefly twice while active at night.

5.2.2 Section 2 –

One Indiana bat was captured and tagged at Site 12 in 2005; however, roost trees were not located despite 6 days of ground and aerial telemetry search. No Indiana bats were captured at Site 22 in 2005.

In 2004, ten Indiana bats were captured on Section 2 at Sites 8, 11, 12, 22, 29, and 30. Five of the radio-tagged bats were tracked to eight roost trees. Roost trees were not found for the remaining four radio-tagged bats. Of these four bats, three were captured at Sites 12 and 22.

5.2.3 Section 3 –

No Indiana bats were captured in Section 3, Site 14, in 2005.

In 2004, 12 Indiana bats were captured on Section 3, six of which were female. Three female lactating bats were captured at Site 14.

5.2.4 Section 4 –

No Indiana bats were caught in Section 4, Sites 2, 11 and 23 in 2005.

A roost emergence study was done for certain roost trees that were found in 2004. No bats were found exiting a shagbark hickory tree that served as a roost site for Indiana bat 554. Five Indiana bats were observed exiting a shagbark hickory identified in 2004 as a roost of Indiana bat 186. The roost for the adult male Indiana bat (#753) on Site 23 could not be studied in 2005 due to lack of landowners permission.

5.2.5 Bridges –

Only one bridge, located on , was assessed for Indiana bat habitat in 2005. Nine Indiana bats were observed during the day and six were observed at night.

5.3 Evening Bat –

5.3.1 Section 1 –

No evening bats were caught at Site 3 in 2005, which was also true of 2004. However, a total of ten evening bats were captured at Site 8 on Section 1 in 2004.

5.3.2 Section 2 –

One evening bat, an adult non-reproductive female was captured at Site 12 in Section 2 in 2005. Five evening bats were captured on all of Section 2 during summer 2004 mist net surveys; however, none were captured at Sites 12 or 22.

5.3.3 Section 3 –

Twelve evening bats were captured at Section 3, Site 14 in 2005. Nine of these were juvenile females; the remainder was adult non-reproductive females.

Fifty-five evening bats were captured in 2004, of which two lactating and four pregnant bats were captured at Site 14.

5.3.4 Section 4 –

No evening bats were captured on Section 4 during summer 2005 mist net surveys, which was also true during the 2004 survey.

Evening bats are historically known from neighboring Clay, Orange, Washington, and Clark counties, but these colonies are now defunct (Whitaker and Gummer 2003). Existing colonies are known from Bartholomew, Jennings, Vigo, Sullivan, and

Posey counties in southern Indiana (Whitaker and Gummer 2003) (Figure 7).

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Appendix A

Figures

Figure 1a. ("Renetting locations on Sections 1, 2, 3 and 4 of the I-69 corridor, Indiana") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

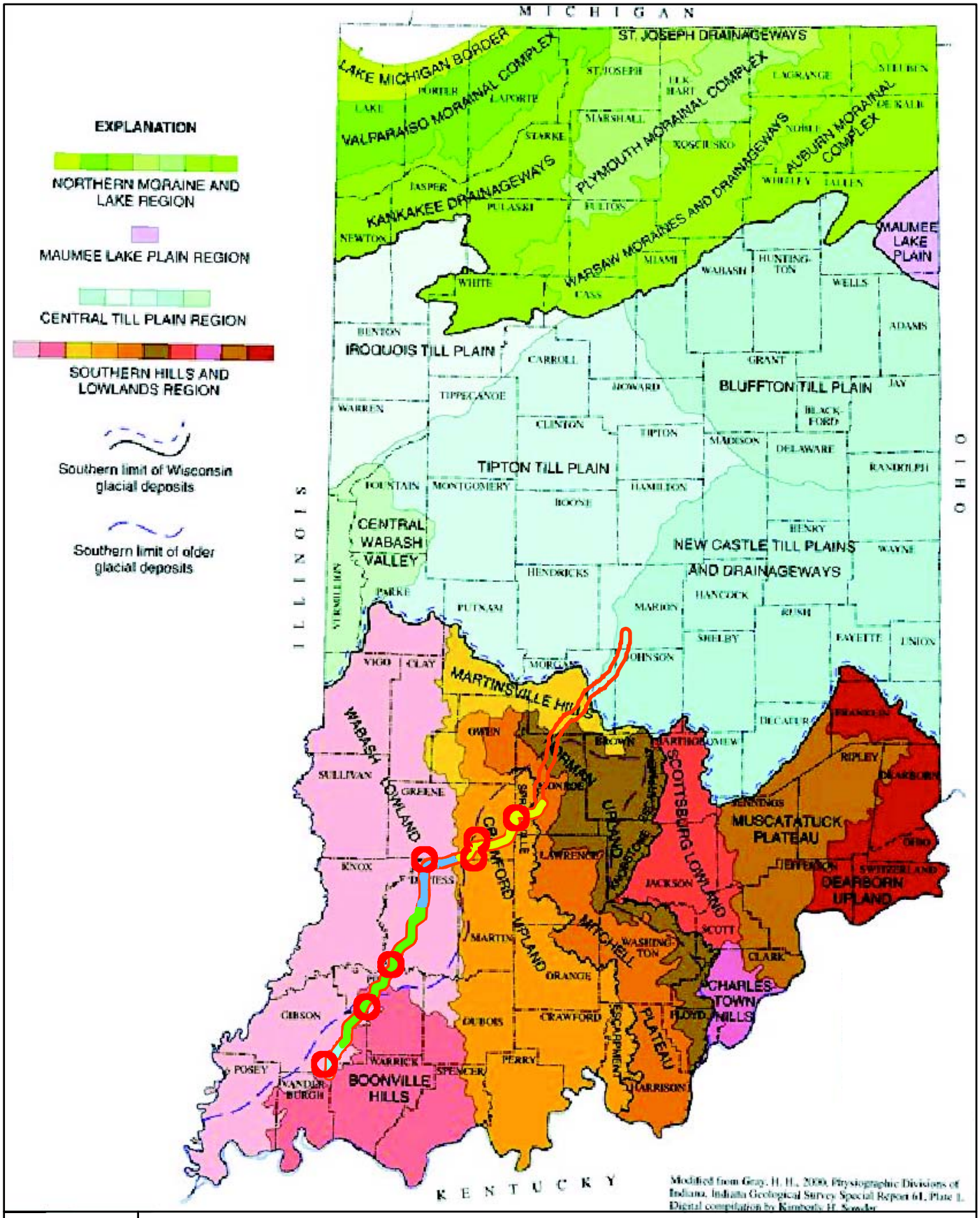

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Figure 1b. Physiography of Indiana.

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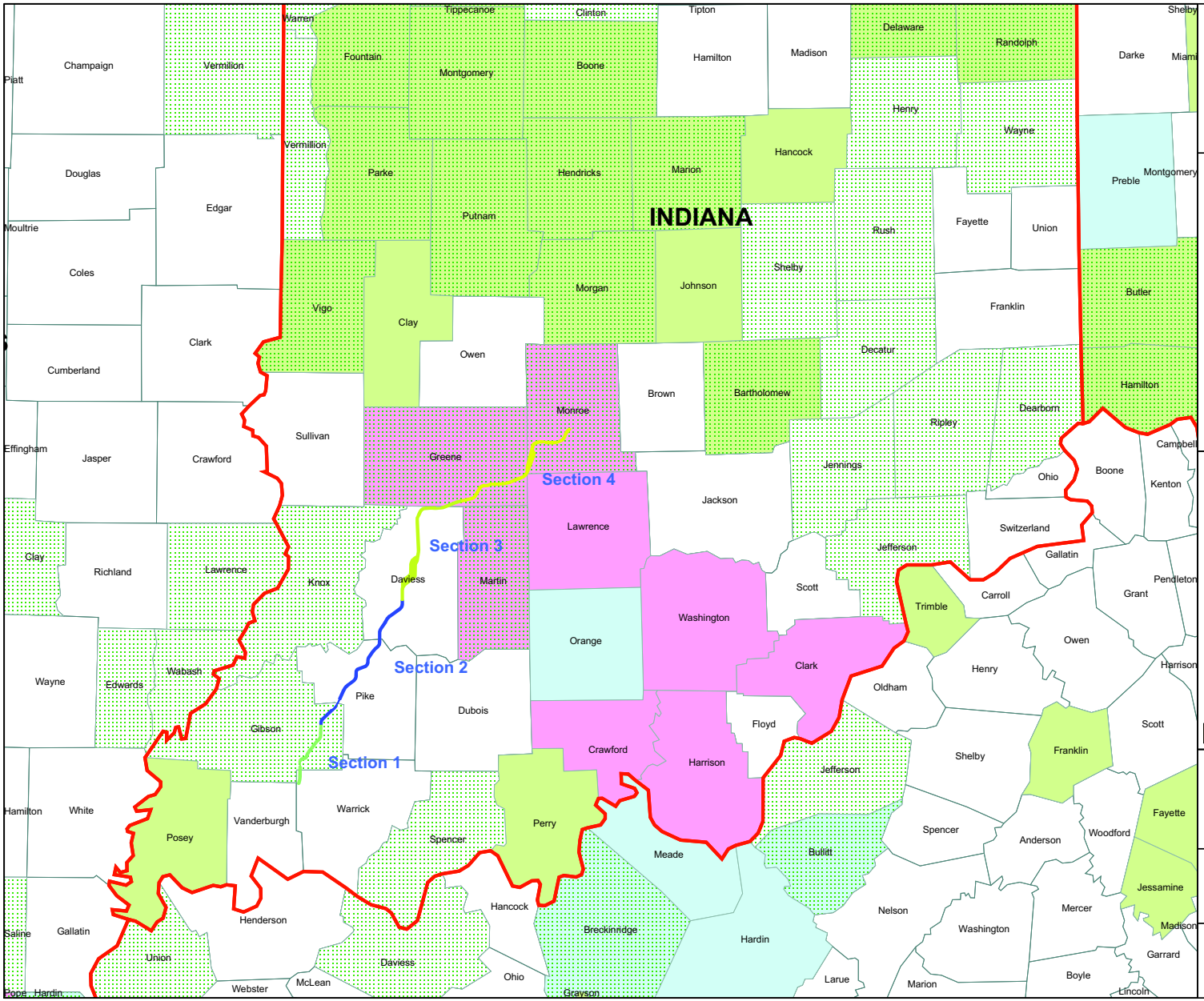

Figure 2. Counties near the project area with hibernacula, summer maternity, and other summer (nonreproductive) records for the Indiana bat (*Myotis sodalis*).

- 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.

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Figure 3. ("Locations of winter hibernacula (caves) of the Indiana bat (*Myotis sodalis*) along I-69 corridor, Indiana") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

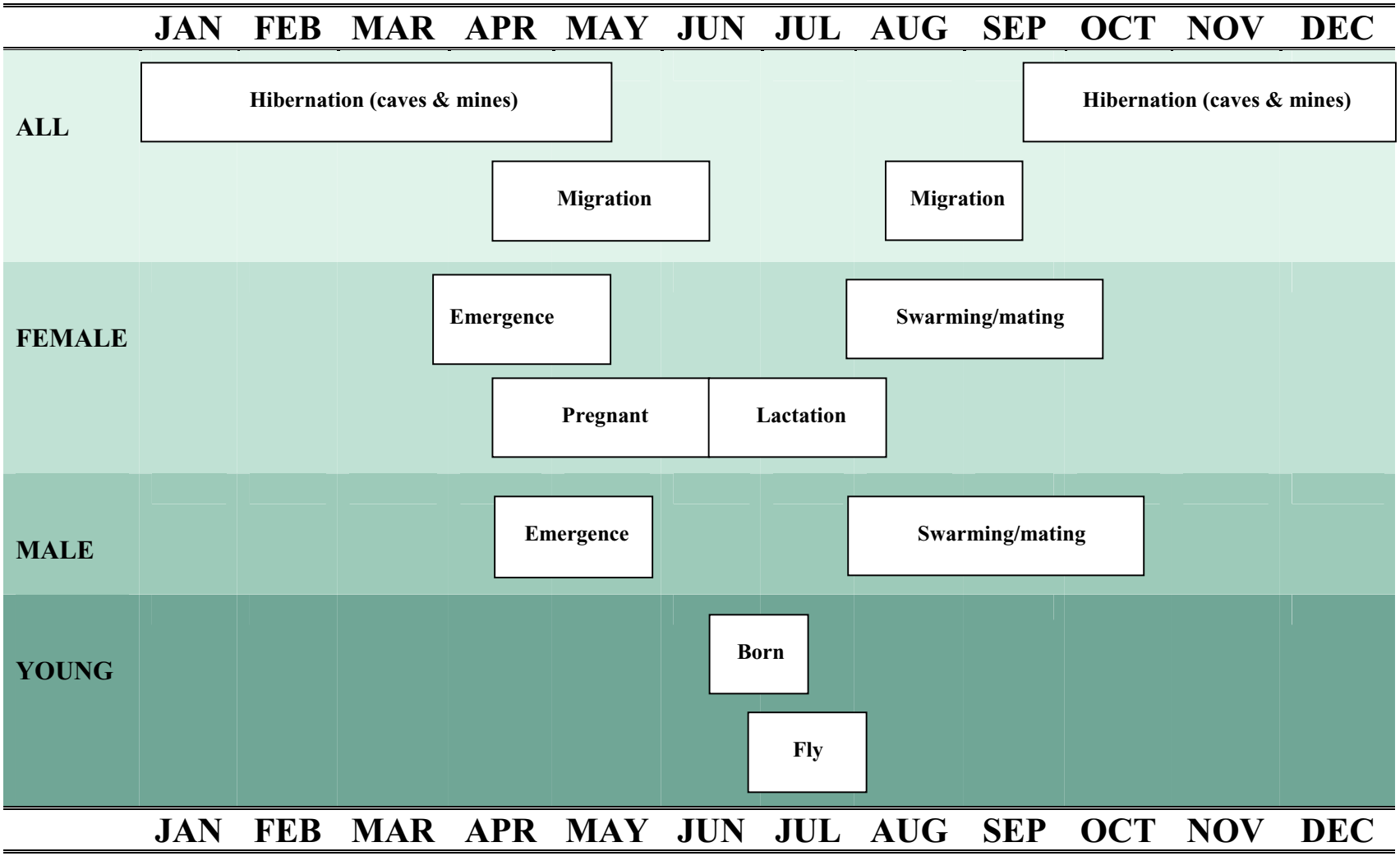


Figure 4. Seasonal chronology of Indiana bat activities.

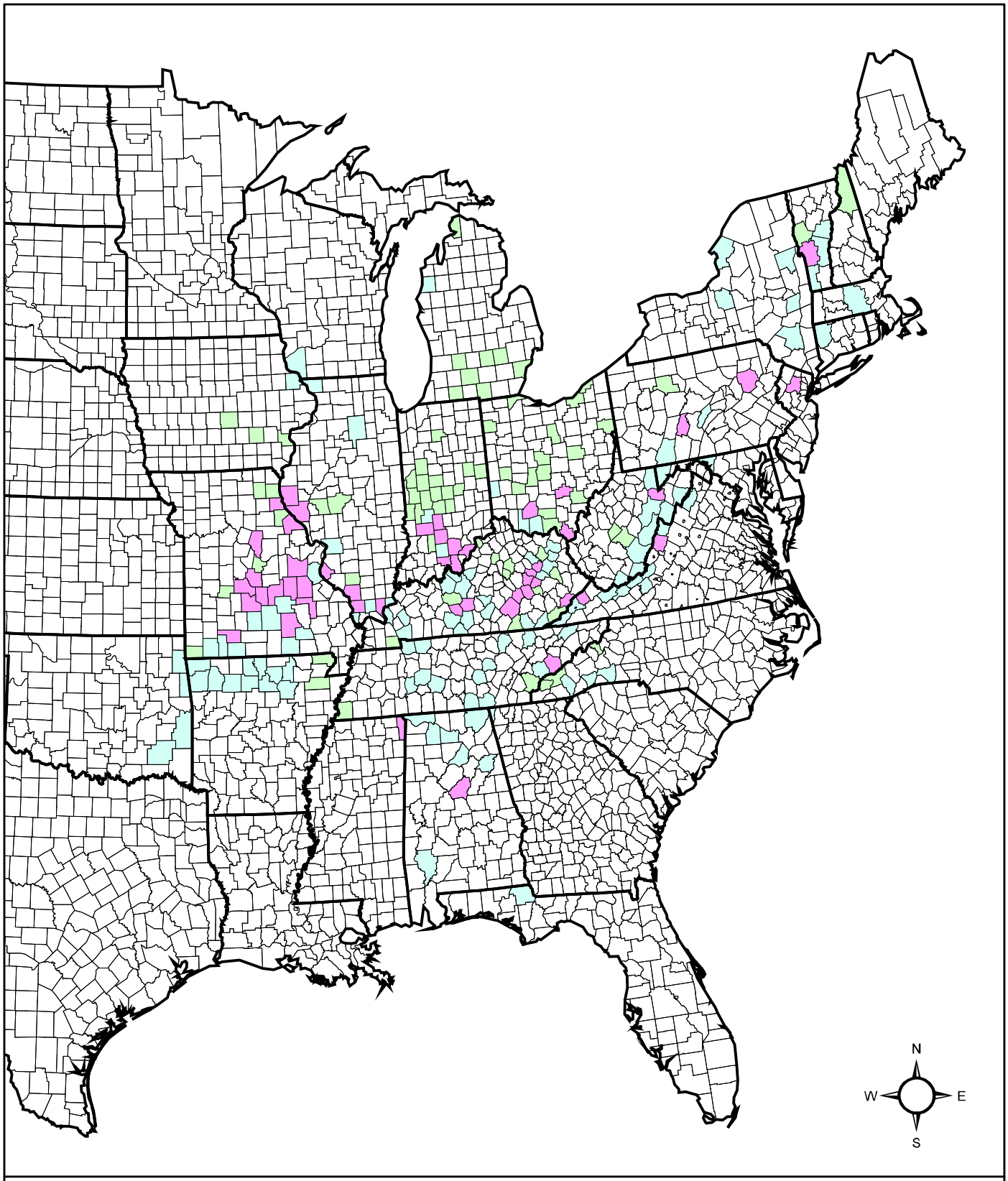


Figure 5. Counties with hibernacula and other summer (nonreproductive) records for the Indiana bat (*Myotis sodalis*) range wide.

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 Task 7, 2005	Sources: USFWS, Indiana Bat Revised Recovery Plan, Agency Draft, 1999.	ESI ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.

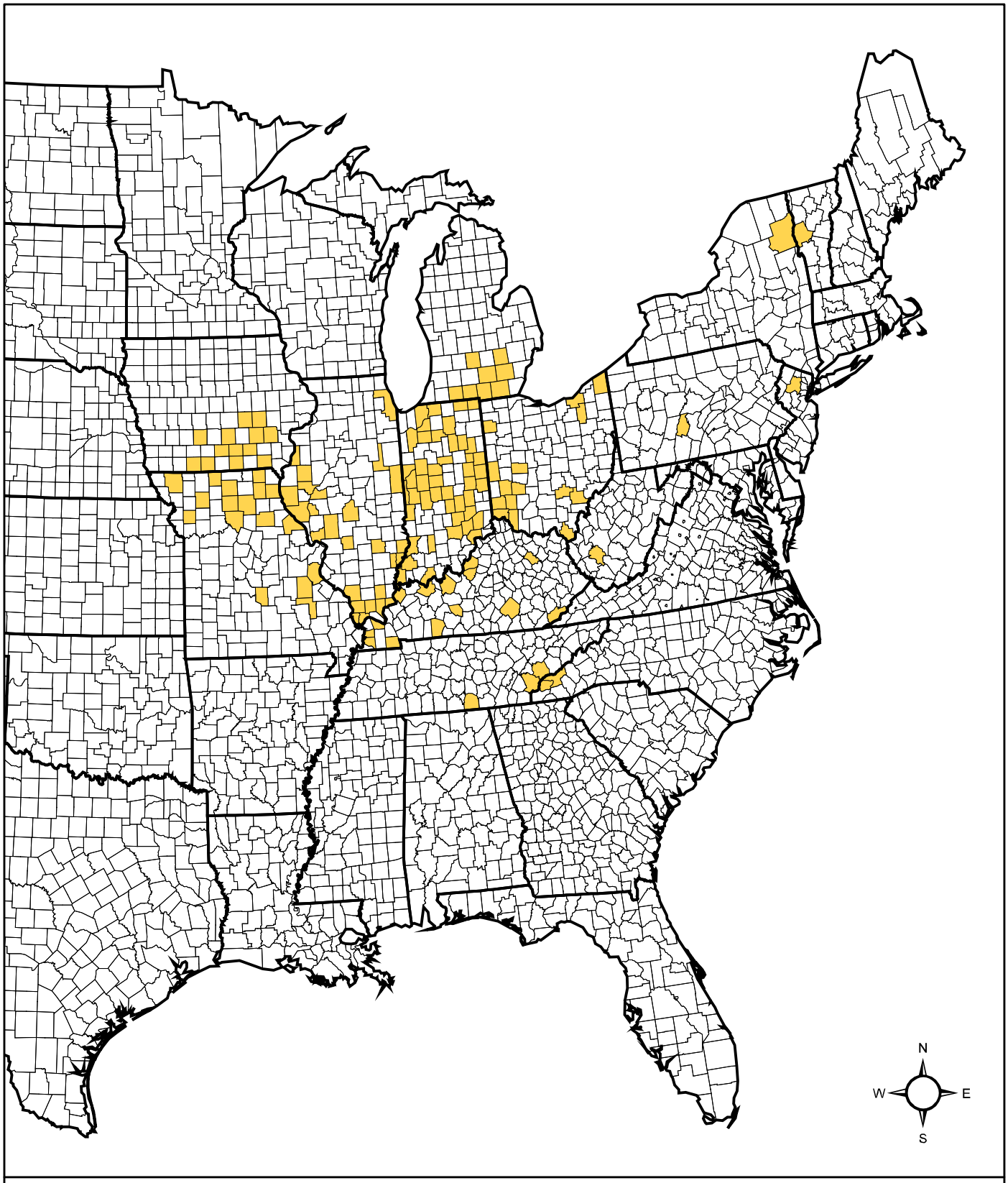
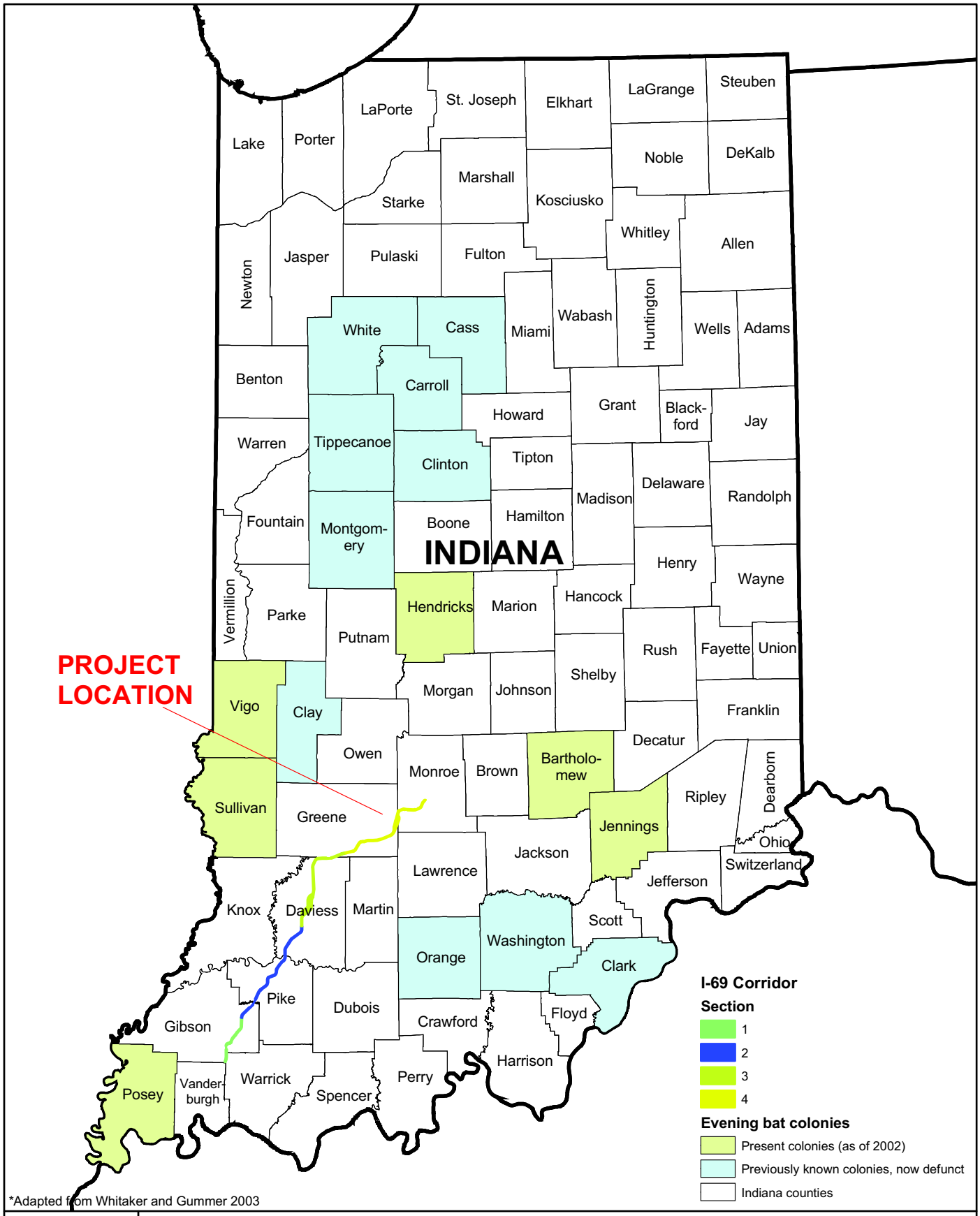


Figure 6. Counties with reproductive (adult female and/or young-of-the-year) records for the Indiana bat (*Myotis sodalis*) range wide.

County with Record of Indiana Bat Reproductive Occurrence

Project No. 123 Task 7, 2005	Sources: USFWS, Indiana Bat Revised Recovery Plan, Agency Draft, 1999.	ESI ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.



*Adapted from Whitaker and Gummer 2003

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Figure 7. Former and presently known maternity colonies of evening bat (*Nycticeius humeralis*) in Indiana

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Figure 8. ("Location of mist net sites on Section 1 Site 03 of the I-69 corridor, Warrick and Gibson counties, Indiana") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 9a. ("Location of mist net sites on Section 2 Site 12 of the I-69 corridor, Pike, Daviess and Gibson counties, Indiana") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 9b. ("Location of mist net sites on Section 2 Site 22 of the I-69 corridor, Pike, Daviess and Gibson counties, Indiana") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 10. ("Location of mist net sites on Section 3 Site 14 of the I-69 corridor, Daviess, and Greene counties, Indiana") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 11a. ("Location of mist net sites on Section 4 Site 11 of the I-69 corridor, Greene, and Monroe counties, Indiana") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 11b. ("Location of mist net sites on Section 4 Site 02 of the I-69 corridor, Greene, and Monroe counties, Indiana") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 11c. ("Location of mist net sites on Section Site 23 of the I-69 corridor, Greene, and Monroe counties, Indiana") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Appendix B

Tables

Table1. Net locations, coordinates, nights of netting, number of net nights and total net nights for additional telemetry and roost studies on the proposed I-69, summer 2005.

Note: Name of the site follows this rule: Sec # (1,2,3,4) & Site # (03,22,12,14,23,11,02) follow 2004 net locations, 2005 net locations (1,2,3,4,5,6) and net set (designated as A, B, C, D, E)

Example: 1-03-1A means, section 1-site 03- net location1- net set A

SEC #	SITE #	NAME	DATE	NORTHING	EASTING	UTM zone	County	Nights of netting	Net nights
SEC1	Site 3	1-03-1A	27-Jul			16	Gibson	2	4
		1-03-1B				16	Gibson		
		1-03-1C	28-Jul			16	Gibson		
		1-03-1D	31-Jul			16	Gibson	1	2
		1-03-1E				16	Gibson		
		1-03-2A	30-Jul			16	Gibson	1	2
		1-03-2B				16	Gibson		
		1-03-3A	29-Jul			16	Gibson	1	2
		1-03-3B				16	Gibson		
		1-03-4A	25-Jul			16	Gibson	1	2
		1-03-4B				16	Gibson		
				Total net nights				**6**	**12**
SEC2	Site 22	2-22-1A	1-Aug			16	Daviess	1	2
		2-22-1B				16	Daviess		
		2-22-2A	1-Aug			16	Daviess	1	2
		2-22-2B				16	Daviess		
		2-22-3A	2-Aug			16	Daviess	1	2
		2-22-3B				16	Daviess		
		2-22-4A	2,3-Aug			16	Daviess	2	4
		2-22-4B				16	Daviess		
		2-22-5A	3-Aug			16	Daviess	1	2
		2-22-5B				16	Daviess		
				Total net nights				**6**	**12**
SEC2	Site 12	2-12-1A	4-Aug			16	Pike	1	2
		2-12-1B				16	Pike		
		2-12-2A	4,5,6-Aug			16	Pike	3	6
		2-12-2B				16	Pike		

SEC #	SITE #	NAME	DATE	NORTHING	EASTING	UTM zone	County	Nights of netting	Net nights
SEC2	Site 12	2-12-3A	6-Aug			16	Pike	1	2
		2-12-3B				16	Pike		
		2-12-4A	6-Aug			16	Pike	1	2
		2-12-4B				16	Pike		
				Total net nights				**6**	**12**
SEC3	Site 14	3-14-1A	8-Aug			16	Daviess	1	2
		3-14-1B				16	Daviess		
		3-14-2A	8-Aug			16	Daviess	1	2
		3-14-2B				16	Daviess		
		3-14-3A	8-Aug			16	Greene	1	2
		3-14-3B				16	Greene		
		3-14-4A	9-Aug			16	Daviess	1	2
		3-14-4B				16	Daviess		
		3-14-5A	10-Aug			16	Greene	1	2
		3-14-5B				16	Greene		
		3-14-6A	10-Aug			16	Greene	1	2
		3-14-6B				16	Greene		
				Total net nights				**6**	**12**
SEC4	Site 23	4-23-1A	15-Aug			16	Greene	1	2
		4-23-1B				16	Greene		
		4-23-2A	11-Aug			16	Monroe	1	2
		4-23-2B				16	Monroe		
		4-23-3A	11-Aug			16	Monroe	1	2
		4-23-3B				16	Monroe		
		4-23-4A	11-Aug			16	Monroe	1	2
		4-23-4B				16	Monroe		
		4-23-5A	15-Aug			16	Greene	1	2
		4-23-5B				16	Greene		
		4-23-6A	15-Aug			16	Monroe	1	2
		4-23-6B				16	Monroe		
				Total net nights				**6**	**12**
SEC4	Site 11	4-11-1A	12,13,14- Aug			16	Greene	2	4
		4-11-1B				16	Greene		
		4-11-2A	12,13,14- Aug			16	Greene	2	4
		4-11-2B				16	Greene		

SEC #	SITE #	NAME	DATE	NORTHING	EASTING	UTM zone	County	Nights of netting	Net nights
SEC4	Site 11	4-11-3A	14-Aug			16	Greene	1	2
		4-11-3B				16	Greene		
		4-11-4A	14-Aug			16	Greene	1	2
		4-11-4B				16	Greene		
		Total net nights						**6**	**12**
SEC4	Site 2	4-02-1A	11-Aug			16	Greene	1	2
		4-02-1B				16	Greene		
		4-02-2A	12,13,14- Aug			16	Greene	2	4
		4-02-2B				16	Greene		
		4-02-3A	14-Aug			16	Greene	1	2
		4-02-3B				16	Greene		
		4-02-4A	13-Aug			16	Greene	1	2
		4-02-4B				16	Greene		
		4-02-5A	12-Aug			16	Greene	1	2
		4-02-5B				16	Greene		
		Total net nights						**6**	**12**

Table 2. Mist Netting Guidelines.

Mist 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 1½ inch (1¼ –1¾) (38 mm).
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 60 feet (20 m).
4. Net Site Spacing:
   - Streams – one net site per 0.5 mile (1 km)
   - Land Tracts – two net sites per 250 acres (1 square km)
5. Minimum Level of Effort Per Net Site:
   - Two net locations (sets) per net site, with locations (sets) at least 100 feet (30 m) apart
   - Two (calendar) nights of netting
   - At least three 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 20-minute intervals
   - No disturbances near the nets between checks
6. Weather Conditions: net only if the following weather conditions are met:

- No precipitation
- Temperature $\geq$ 50°F (10°C)
- No strong winds

7. Moonlight: avoid net sets with direct exposure to a moon ½ -full or greater – typically by utilizing forest canopy cover

Source: U.S. Fish and Wildlife Service, 1999

Table 3. High and low temperatures (°F) recorded during additional telemetry and roost studies on the proposed I-69, summer 2005.

Site	Survey Dates*	High °F	Low °F
1-03-1	27-Jul-05	67	63
1-03-1	28-Jul-05	71	59
1-03-1	31-Jul-05	75	72
1-03-2	30-Jul-05	75	65
1-03-3	29-Jul-05	73	60
1-03-4	25-Jul-05	85	77
2-12-1	4-Aug-05	79	72
2-12-2	4-Aug-05	78	72
2-12-2	5-Aug-05	76	72
2-12-2	6-Aug-05	78	72
2-12-3	6-Aug-05	78	72
2-12-4	6-Aug-05	78	73
2-22-1	1-Aug-05	77	69
2-22-2	1-Aug-05	74	69
2-22-3	2-Aug-05	76	70
2-22-4	2-Aug-05	77	67
2-22-4	3-Aug-05	77	67
2-22-5	3-Aug-05	75	70
3-14-1	9-Aug-05	78	71
3-14-2	8-Aug-05	80	72
3-14-3	8-Aug-05	78	71
3-14-4	9-Aug-05	78	71
3-14-5	10-Aug-05	76	71
3-14-6	10-Aug-05	76	71
4-02-1	11-Aug-05	79	74
4-02-2	12-Aug-05	75	70
4-02-2	13-Aug-05	77	73
4-02-2	14-Aug-05	72	67
4-02-3	14-Aug-05	84	79
4-02-4	13-Aug-05	83	69
4-02-5	12-Aug-05	80	76
4-11-1	12-Aug-05	77	73
4-11-1	13-Aug-05	80	78
4-11-1	14-Aug-05	75	70
4-11-2	12-Aug-05	78	73
4-11-2	14-Aug-05	76	70
4-11-3	14-Aug-05	76	70
4-11-4	14-Aug-05	76	70
4-23-1	15-Aug-05	71	69
4-23-2	11-Aug-05	83	73
4-23-3	11-Aug-05	83	73
4-23-4	11-Aug-05	78	71
4-23-5	15-Aug-05	83	82
4-23-6	15-Aug-05	83	82

*Survey Period (Approx. 2000-0200h)

Table 4. Total bat captures by sex, reproductive condition and age during additional telemetry and roost studies on Section 1 of the proposed I-69, summer 2005.

Species	Adult Male	Adult Female[1]				Juvenile		Escape[2]	Total
		P	L	PL	NR	Male	Female		
Big brown bat	1	0	0	0	0	0	0	0	**1**
Eastern red bat	2	0	0	0	0	3	3	0	**8**
Hoary bat	0	0	0	0	0	0	0	0	**0**
Little brown bat	0	0	0	0	0	0	0	0	**0**
Northern bat	0	0	0	0	0	0	0	0	**0**
Indiana bat	0	0	0	0	0	0	0	0	**0**
Eastern pipistrelle	0	0	0	1	0	0	1	0	**2**
Evening bat	0	0	0	0	0	0	0	0	**0**
Total	**3**	**0**	**0**	**1**	**0**	**3**	**4**	**0**	**11**

[1] P = pregnant; L = lactating; PL = Post lactating; NR = non-reproductive
[2] Escape = escaped from net or hand before processing was complete

Table 5. Total bat captures by sex, reproductive condition and age during additional telemetry and roost studies on Section 2 of the proposed I-69, summer 2005.

Species	Adult Male	Adult Female[1]				Juvenile		Escape[2]	Total
		P	L	PL	NR	Male	Female		
Big brown bat	0	0	0	1	2	3	0	1	**7**
Eastern red bat	5	0	0	2	0	5	13	0	**25**
Hoary bat	0	0	0	0	0	0	1	0	**1**
Little brown bat	0	0	0	0	1	0	0	0	**1**
Northern bat	2	0	0	1	3	0	0	0	**6**
Indiana bat	0	0	0	0	1	0	0	0	**1**
Eastern pipistrelle	3	0	0	1	1	8	3	0	**16**
Evening bat	0	0	0	0	1	0	0	0	**1**
Total	**10**	**0**	**0**	**5**	**9**	**16**	**17**	**1**	**58**

[1] P = pregnant; L = lactating; PL = Post lactating; NR = non-reproductive
[2] Escape = escaped from net or hand before processing was complete

Table 6. Total bat captures by sex, reproductive condition and age during additional telemetry and roost studies on Section 3 of the proposed I-69, summer 2005.

Species	Adult Male	Adult Female[1]				Juvenile		Escape[2]	Total
		P	L	PL	NR	Male	Female		
Big brown bat	0	0	0	0	1	0	2	0	**3**
Eastern red bat	0	0	0	0	0	2	4	2	**8**
Hoary bat	0	0	0	0	0	0	0	0	**0**
Little brown bat	1	0	0	1	5	0	0	0	**7**
Northern bat	3	0	0	1	6	0	0	0	**10**
Indiana bat	0	0	0	0	0	0	0	0	**0**
Eastern pipistrelle	1	0	0	0	0	1	2	0	**4**
Evening bat	0	0	0	0	3	0	9	0	**12**
Total	**5**	**0**	**0**	**2**	**15**	**3**	**17**	**2**	**44**

[1] P = pregnant; L = lactating; PL = Post lactating; NR = non-reproductive
[2] Escape = escaped from net or hand before processing was complete

Table 7. Total bat captures by sex, reproductive condition and age during additional telemetry and roost studies on Section 4 of the proposed I-69, summer 2005.

Species	Adult Male	Adult Female[1]				Juvenile		Escape[2]	Total
		P	L	PL	NR	Male	Female		
Big brown bat	6	0	0	2	3	4	2	1	**18**
Eastern red bat	4	0	0	1	0	7	9	6	**27**
Hoary bat	0	0	0	0	0	0	0	0	**0**
Little brown bat	4	0	0	0	1	0	0	0	**5**
Northern bat	16	0	0	1	2	1	3	0	**23**
Indiana bat	2	0	0	0	0	0	0	0	**2**
Eastern pipistrelle	9	0	0	1	0	8	6	0	**24**
Evening bat	0	0	0	0	0	0	0	0	**0**
Total	**41**	**0**	**0**	**5**	**6**	**20**	**20**	**7**	**99**

[1] P = pregnant; L = lactating; PL = Post lactating; NR = non-reproductive
[2] Escape = escaped from net or hand before processing was complete

Table 8. Comparison of bat species captured in 2004 and 2005 during mist netting and additional telemetry and roost studies on Sections 1 – 4 of the proposed I-69.

	SECTION 1		**SECTION 2**				**SECTION 3**	**SECTION 4**					
	Site 3		Site 12		Site 22		Site 14	Site 2		Site 11		Site 23	
	2004	**2005**	**2004**	**2005**	**2004**	**2005**	**2005**	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**
Big brown bat	0	1	1	4	0	3	3	1	10	1	5	3	3
Eastern red bat	1	8	0	4	8	21	8	8	17	1	5	0	5
Hoary bat	0	0	0	0	0	1	0	0	0	0	0	0	0
Little brown bat	0	0	0	0	0	1	7	4	1	0	3	1	1
Northern bat	0	0	0	1	0	5	10	3	5	1	8	3	10
Indiana bat	1	0	2	1	1	0	0	2	2	1	0	1	0
Eastern pipestrell	0	2	0	9	0	7	4	7	3	4	16	2	5
Evening bat	0	0	0	1	0	0	12	0	0	0	0	0	0
Total	**2**	**11**	**3**	**20**	**9**	**38**	**44**	**25**	**38**	**8**	**37**	**10**	**24**
# of net nights	*4*	*12*	*4*	*12*	*4*	*12*	*12*	*4*	*12*	*4*	*12*	*4*	*12*
species richness	*2*	*3*	*2*	*6*	*2*	*6*	*6*	*6*	*6*	*5*	*5*	*5*	*5*
# of bats per net	*0.50*	*0.92*	*0.75*	*1.67*	*2.25*	*3.17*	*3.67*	*6.25*	*3.17*	*2.00*	*3.08*	*2.50*	*2.00*
diversity index	*2*	*1.75*	*1.8*	*3.4*	*1.2*	*2.7*	*5.06*	*4.4*	*3.4*	*3.2*	*3.6*	*4.2*	*3.6*

Appendix C

Photographs

1-3-1A

1-3-1B

1-3-2A

1-3-2B

2-22-3A

2-22-3B

4-2-3A

4-2-3B

4-2-2B

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
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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).

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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:
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SURVEYS FOR INDIANA BATS IN CAVES IN GREENE AND MONROE COUNTIES, INDIANA 2005

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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

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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.

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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
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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:

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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.

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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

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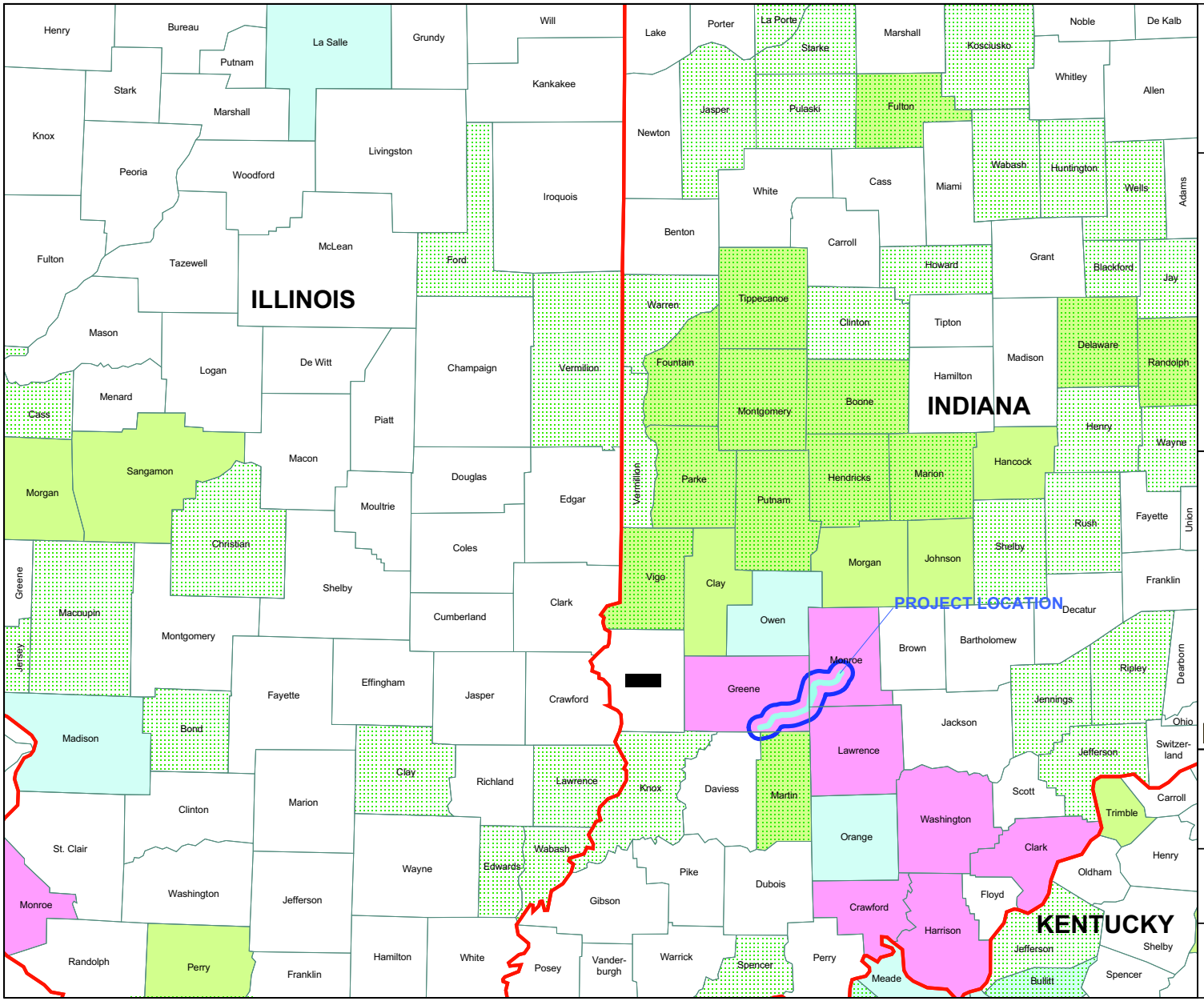
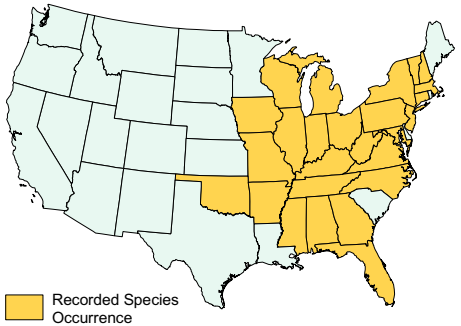


Figure 2. Counties near the project area with hibernacula, summer maternity, and other summer (nonreproductive) records for the Indiana bat (*Myotis sodalis*).

- 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.

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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.

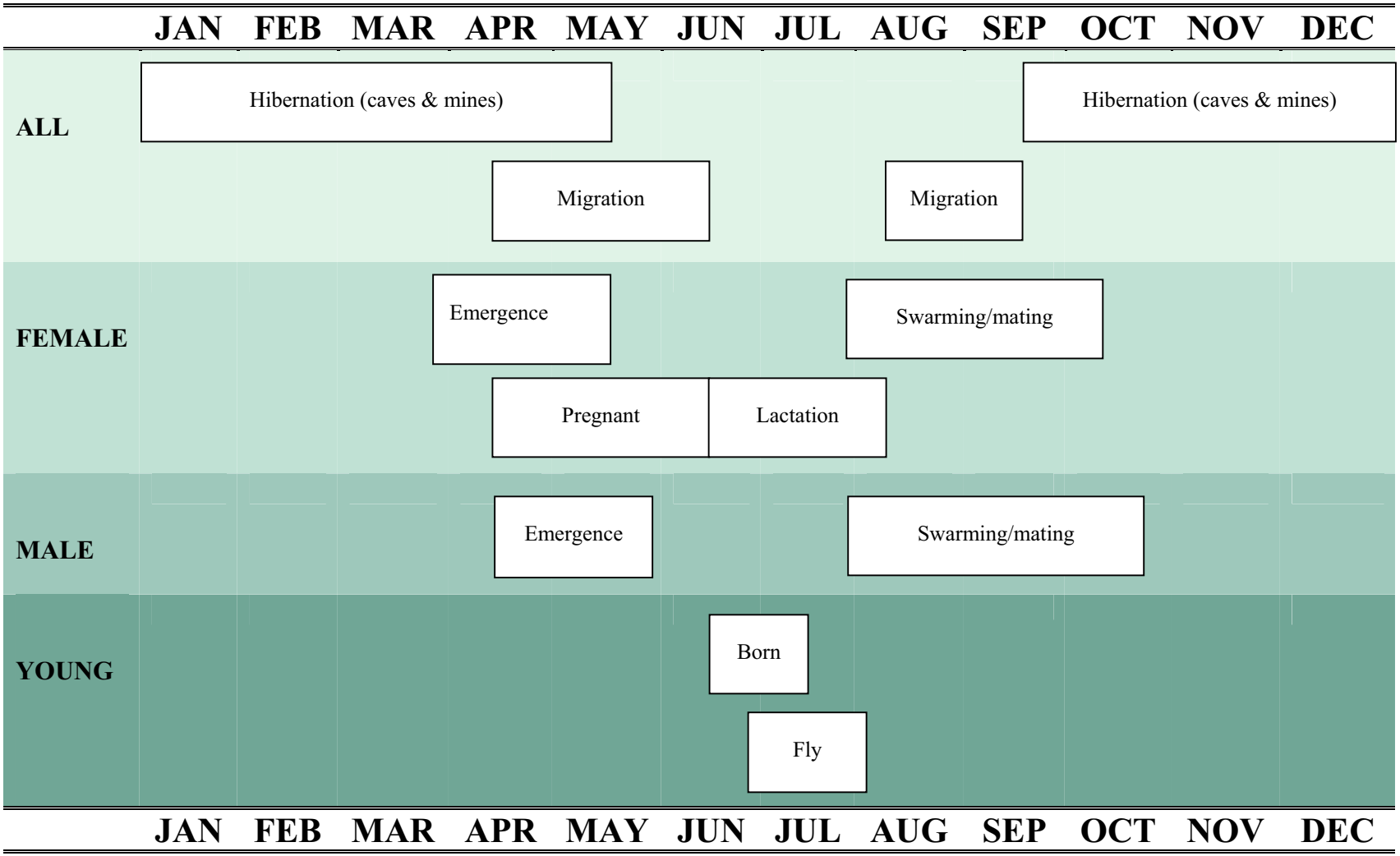

Figure 4. Seasonal chronology of Indiana bat activities.

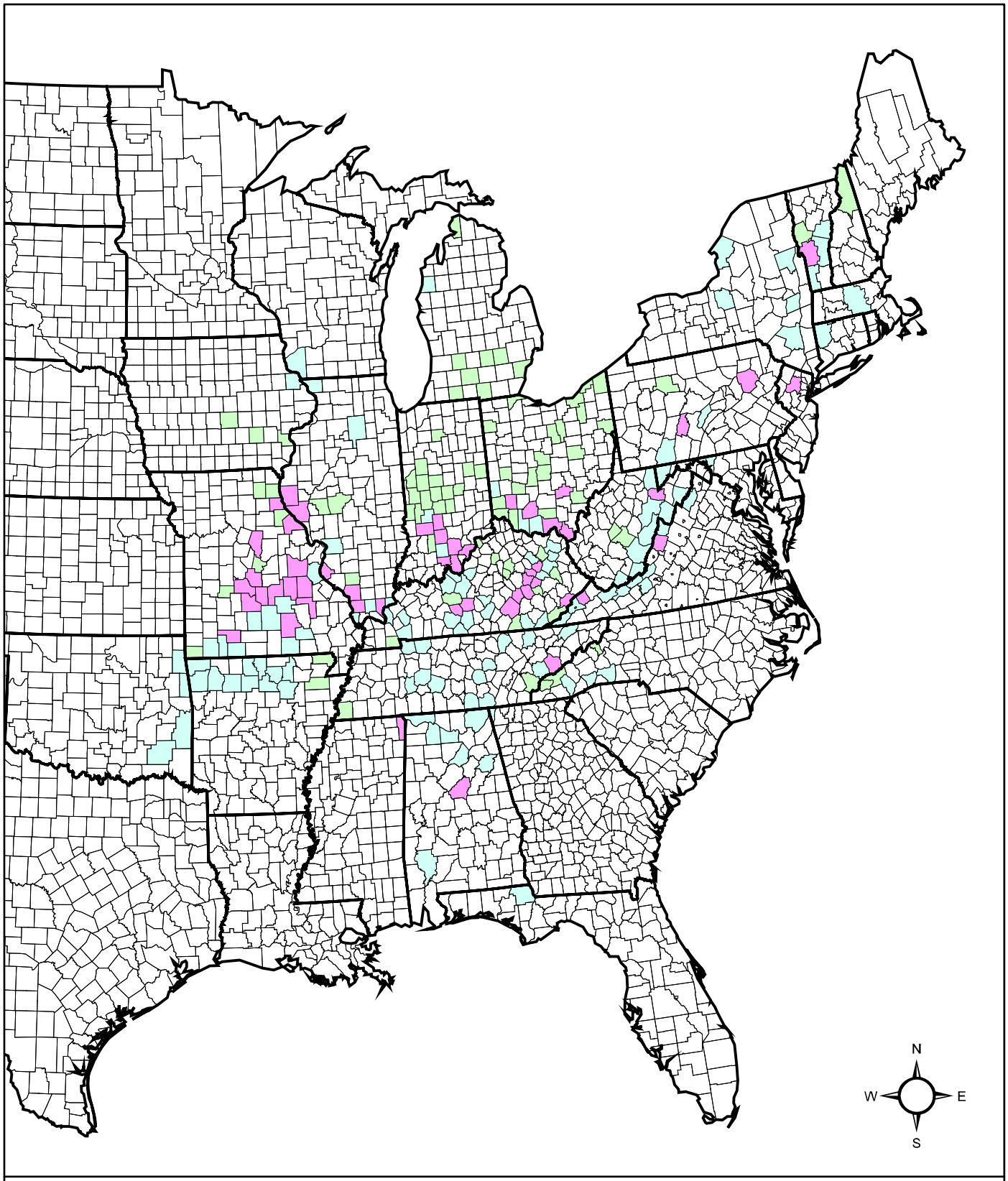

Figure 5. Counties with hibernacula and other summer (nonreproductive) records for the Indiana bat (*Myotis sodalis*) range wide.

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.

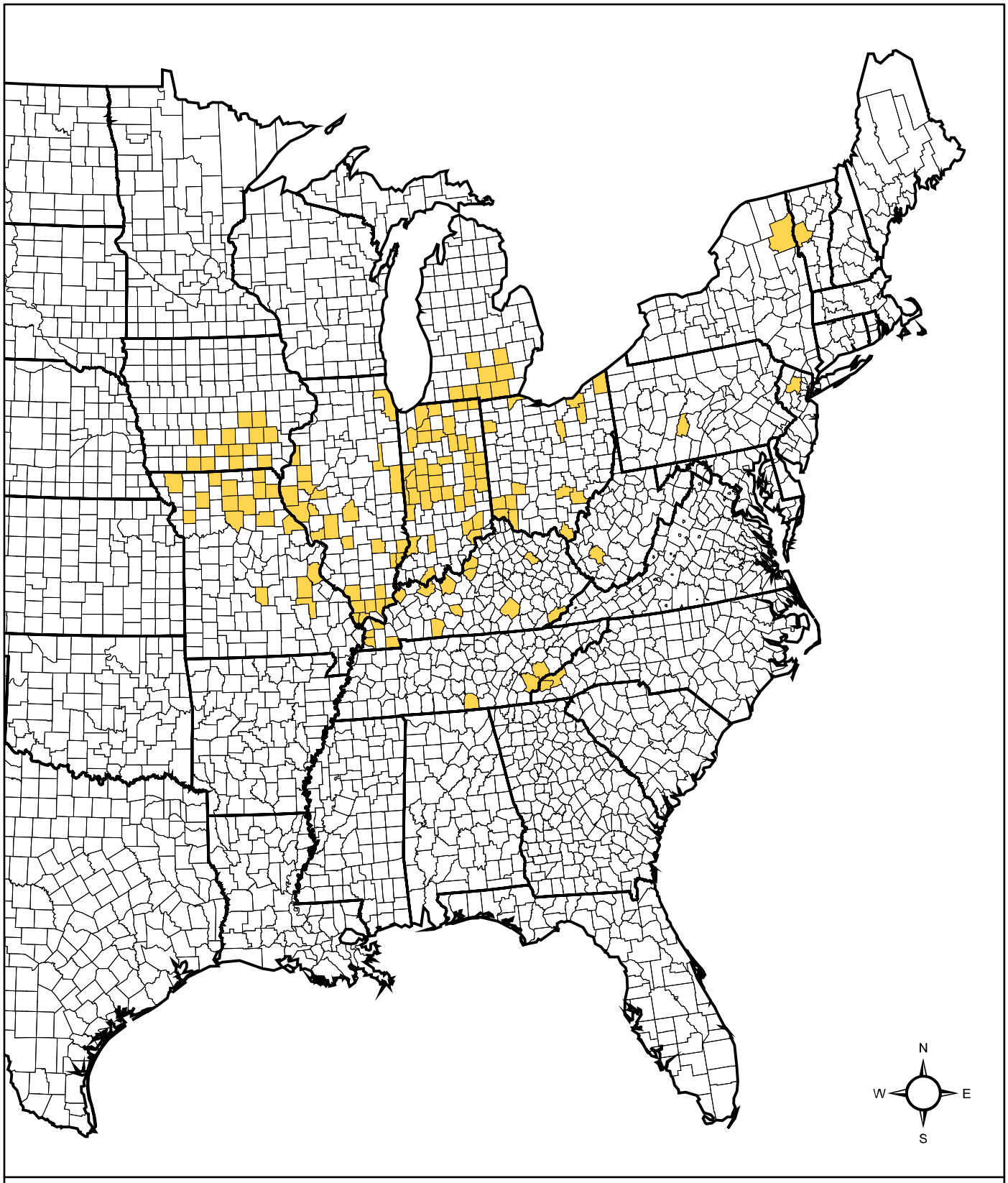

Figure 6. Counties with reproductive (adult female and/or young-of-the-year) records for the Indiana bat (*Myotis sodalis*) range wide.

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.

Surveys for Indiana Bats in Caves in Greene and Monroe Counties, Indiana 2006

February 21, 2006

Prepared by
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SURVEYS FOR INDIANA BATS IN CAVES IN GREENE AND MONROE COUNTIES, INDIANA 2006

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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

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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.

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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
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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
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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
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Knoxville, Tennessee 37918
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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
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Indiana Department of Transportation
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FINAL REPORT

Prepared by:

Jason A. Duffey, Jeffrey A. Hawkins, and Virgil Brack, Jr. Ph.D.

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AUTUMN 2005 AND WINTER 2006 HABITAT FOR THE INDIANA BAT (*MYOTIS SODALIS*) WITHIN THE CRAWFORD UPLAND AND MITCHELL PLAIN FROM SCOTLAND TO BLOOMINGTON, INDIANA

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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.

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Appendix A

Figures

N
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Figure 1. Location of Section 4 of the proposed I-69 corridor in Greene and Monroe counties, Indiana

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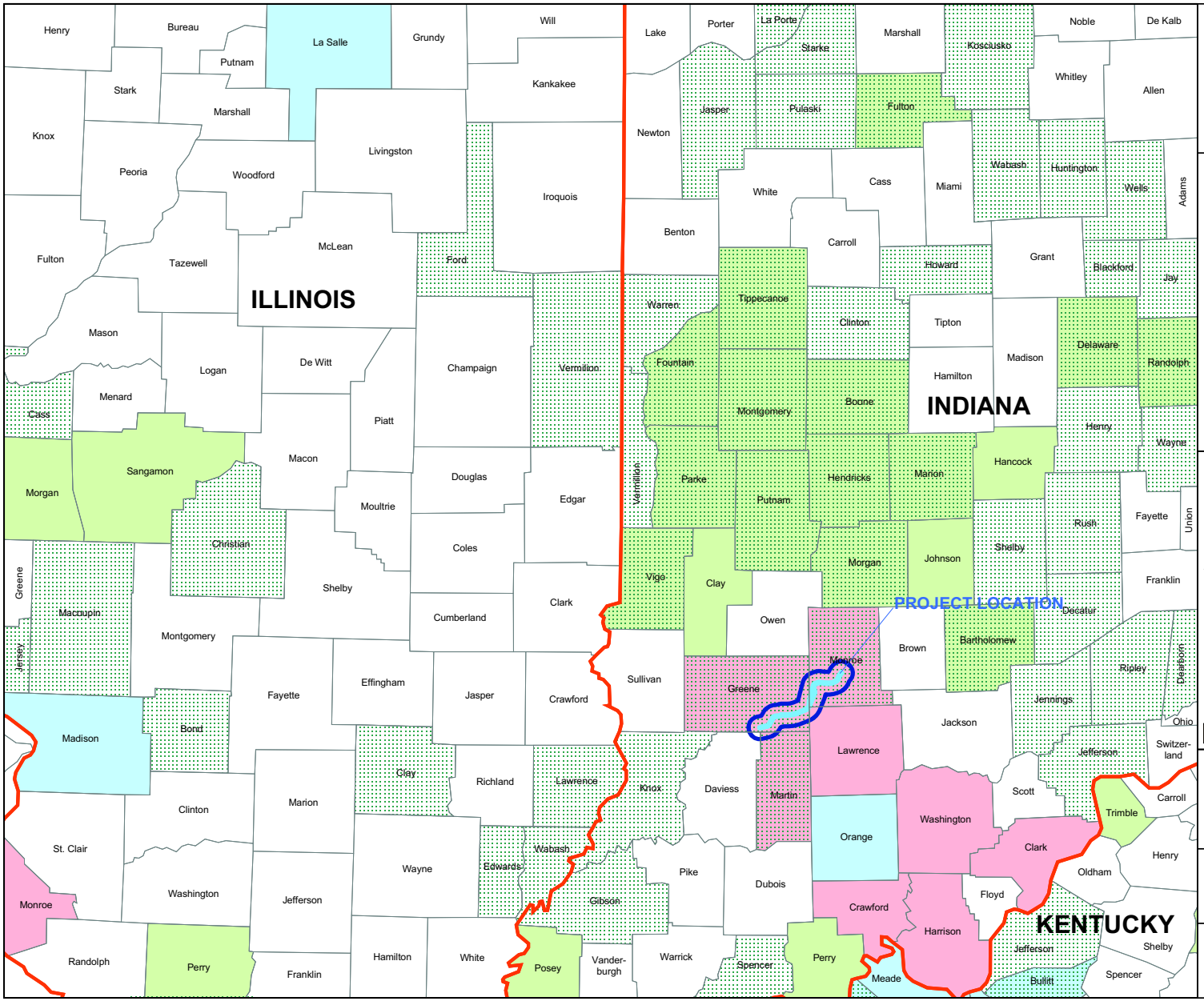

Figure 2. Counties near the project area with hibernacula, summer maternity, and other summer (nonreproductive) records for the Indiana bat (*Myotis sodalis*).

- 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.

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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.

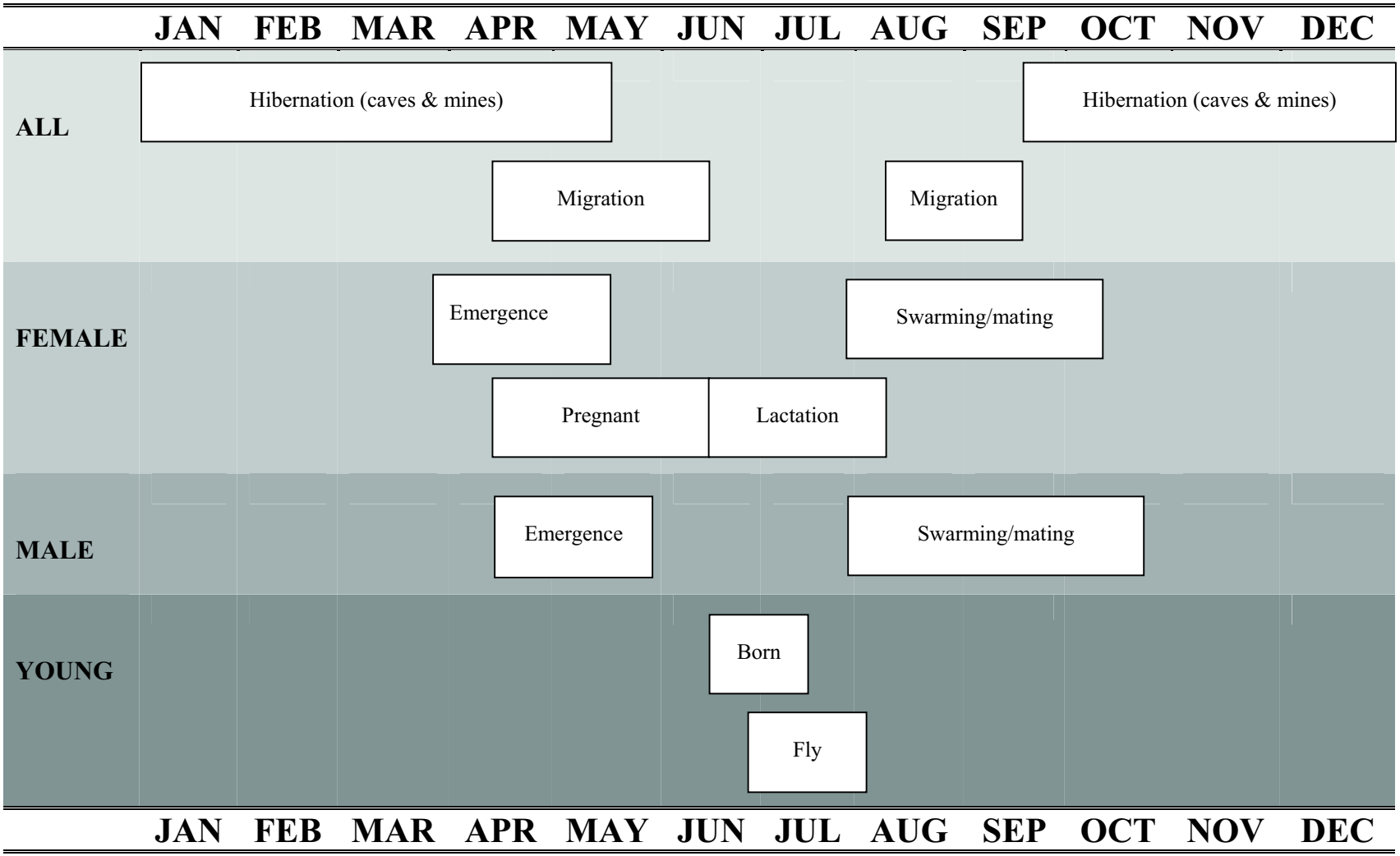
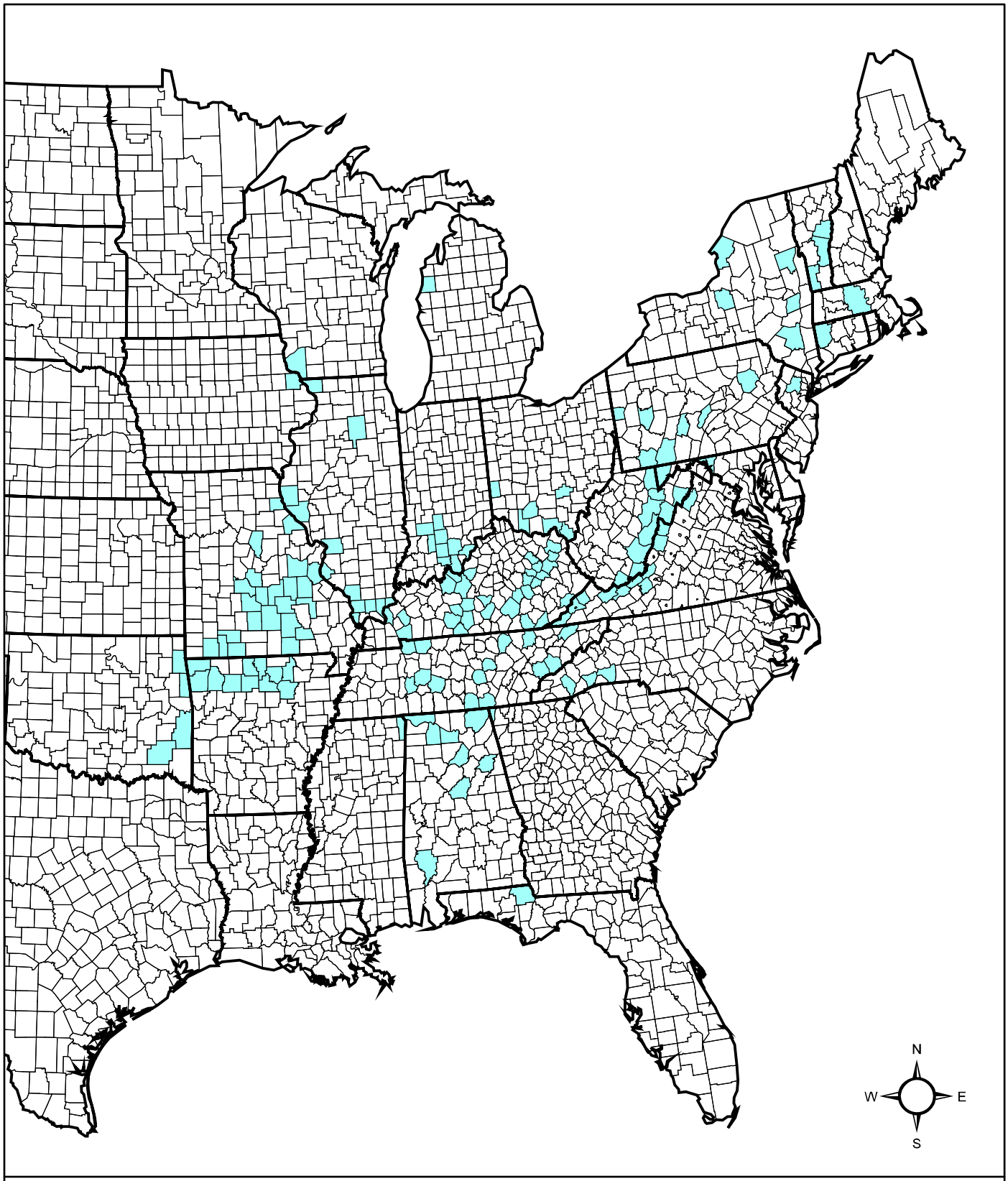


Figure 4. Seasonal chronology of Indiana bat activities.



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.

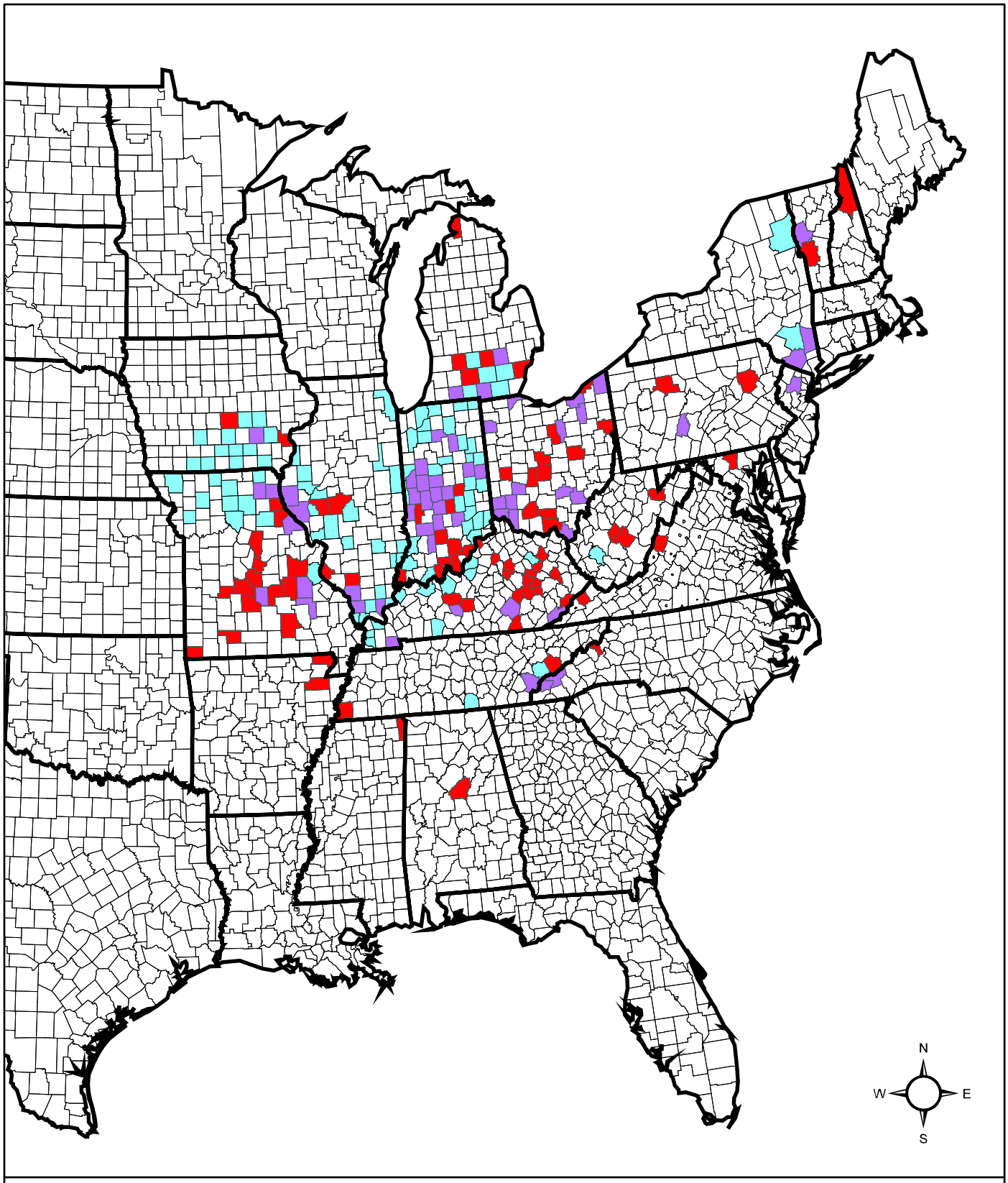


Figure 6. Range-wide distribution of the Indiana bat during summer, showing counties with reproductive (adult female and/or young-of-the-year) and nonreproductive records.

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.

SUMMER HABITAT FOR THE INDIANA BAT (*MYOTIS SODALIS*) WITHIN THE CRAWFORD UPLAND AND MITCHELL PLAIN FROM SCOTLAND TO BLOOMINGTON, INDIANA

13 December 2004

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SUMMER HABITAT FOR THE INDIANA BAT (*MYOTIS SODALIS*) WITHIN THE CRAWFORD UPLAND AND MITCHELL PLAIN FROM SCOTLAND TO BLOOMINGTON, INDIANA

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Abstract

In fulfillment of Tier II Environmental Impact Studies (EIS) of the proposed I-69 corridor from Evansville to Indianapolis, Indiana, 30 sites within Section 4 were mist netted during summer 2004 for the federally endangered Indiana bat (*Myotis sodalis*) and the state endangered evening bat (*Nycticeius humeralis*). A total of 252 bats representing seven species was captured: 71 eastern pipistrelles (*Pipistrellus subflavus*), 69 eastern red bats (*Lasiurus borealis*), 43 northern bats (*Myotis septentrionalis*), 35 big brown bats (*Eptesicus fuscus*), 23 little brown bats (*Myotis lucifugus*), 9 Indiana bats, and 2 hoary bats (*Lasiurus cinereus*). No evening bats were captured. Radio-transmitters were placed on two adult reproductive females and one adult male Indiana bats and five roost trees were identified. A pregnant female was tracked to two roost trees approximately 1 mile south of the corridor near the boundary of Crane Naval Warfare Center. A lactating female Indiana bat was tracked to two roost trees along Plummer Creek approximately 1.5 miles north of the corridor. An adult male Indiana bat was tracked to a conduit tube on a telephone pole 0.5 mile east of the corridor. Up to 20 bats were seen during emergence counts at this site. In addition, surveys of 72 bridges within the Section 4 corridor produced two northern bats roosting under one bridge.

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

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 Section 4 of the proposed I-69 from Evansville to Indianapolis, Indiana. Environmental Solutions and Innovations, Inc (ESI) was contracted by DLZ Indiana, LLC and their client, the Indiana Department of Transportation, to conduct summer mist net surveys for the endangered Indiana bat (*Myotis sodalis*) on 30 sites on Section 4 of I-69.

ESI completed field efforts under Federal Endangered species permit TE 023664-13 and State of Indiana Division of Natural Resources permit 2939.

2.0 Study Area

2.1 Location –

Section 4 of the I-69 corridor begins at US 231 in southeast Greene County just north of SR 58 near the northwest corner of Crane Naval Surface Warfare Center. 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.

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 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 and Monroe 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 Section 4 of I-69 (Figure 3). Eight hibernacula are known from western Monroe County. Hibernacula are classified based on winter population sizes of Indiana bats in each cave. Priority I hibernacula exceed 30,000 bats, Priority II caves contain population between 1,000 and 30,000 bats, and Priority III caves contain less than 1,000 Indiana bats. ( ) Cave. Cave, Cave, r Cave, Cave, and Cave are Priority III hibernacula. Cave and Cave 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 (Figure 3). t Cave and Cave are Priority III hibernacula located 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). _ 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 impact 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 3). 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. Female Indiana bats were not known from either Greene and Monroe counties until the summer 2004 mist netting season. However, records of female Indiana bats exist for neighboring counties including Jackson, Knox, Martin, and Vigo counties.

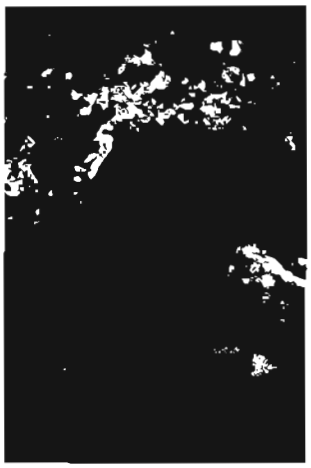
The Draft Environmental Impact Statement on the Southwest Indiana Highway Corridor prepared for INDOT in 2003 included information on 1993 mist net surveys for Indiana bats. Dr. John Whitaker surveyed 19 sites along the proposed corridor from I-64 to Bloomington, Indiana. Eleven sites were located within the Section 4 corridor. A total of 41 bats was 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.

2.3.4 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, 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 8°C

(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 8°C (Brack et al. 2003a; 2003b; Brack and Reynolds 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.

2.3.5 Spring Staging and Autumn Swarming –

2.3.5.1 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.

2.3.5.2 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; $\bar{\chi}$ = 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.

2.3.6 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 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).

2.3.7 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).

2.3.7.1 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).

2.3.7.2 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 (diameter at breast height) 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 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 submission). 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 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 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 Interstate 70, routinely crossed this 6-lane interstate to forage (Brack, unpub. data). 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 (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.

2.3.8 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).

2.4 Evening Bat

2.4.1 Status and Distribution-

Evening bats (*Nycticeius humeralis*) occur throughout much of the southeastern United States. Their geographic distribution extends from the coastal plain and piedmont regions of the Mid-Atlantic States, south and west throughout states bordering the Gulf of Mexico, and northward throughout the Mississippi embayment (Barbour and Davis 1969). The species appears most abundant in the southern states and is scarce in the Appalachian Mountains and northern parts of the range (Whitaker and Hamilton 1998). Evening bats have been captured sporadically at upland sites throughout the eastern United States, but are most abundant in regions where swamps and river bottomlands are common (Whittaker and Gummer 2003).

2.4.2 Ecology-

During the 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 (Cope et al. 1961; Mumford 1953; Whitaker and Gummer 1988, 1993). However, the species often uses natural roosts, including cavities and

exfoliating bark, in the southeastern United States (Menzel et al. 2001) and in Indiana (Whitaker and Gummer 2003). Recently, Miles et al. (2004) documented roosts in the tops of living pine trees in Georgia.

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 (Watkins 1972). 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). In Missouri, Boyles et al. (in submission) documented a male evening bat burrowing into the leaf litter during the cold of winter. 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.

The diet of the evening bat is not well known. In Indiana, Brack (1983) found that the diet included beetles, moths, leafhoppers, flies, and ants. Whitaker and Clem (1992) found the prey consisted mainly of beetles, moths, and leafhoppers; many prey items were agricultural pests. Studies of food habits have also been completed in Illinois (Feldhamer 1995) and Georgia (Carter et al. 1998). In central Indiana, Brack (1985) caught evening bats foraging in the canopy layer of an open, grazed upland woodlot and Sparks et al. (2004) reported that the species foraged primarily in agricultural and wooded areas. In southern Missouri, LaVal et al. (1977) reported that several light-tagged bats foraged over and near the streams where they were caught. In Kansas, the species apparently forages near and around riparian woodlands; in southern Arkansas, the species was often netted over ponds (Baker and Ward 1967). Clem (1993) indicated that only while lactating did this species exhibit a bimodal activity period indicative of many insectivorous bats. Lactating females also sometimes failed to return to the maternity roost and therefore day roosted at an alternate location.

2.4.3 Regional Occurrence-

Population trends of evening bats are unknown in most parts of the range and the species has no federal protective status. In Indiana it is considered state endangered. 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. Since then several colonies have

been located in eastern and south-central Indiana, mainly along the Wabash and White rivers (Whitaker and Gummer 2003), all using natural tree roosts. Brack et al. (2004) also recorded a single adult male in 1998 from Hoosier National Forest, over a tributary to the Little Blue River (Figure 7).

3.0 Methods

3.1 Mist Net Survey –

3.1.1 Site Selection –

Locations of 30 mist net sites were pre-selected by BLA and underwent field reviews and adjustment in conjunction with DLZ and ESI (Figure 8a and 8b, Table 1).

Property owners were provided Notice of Survey letters and were contacted by the Project Manager prior to mist netting efforts.

3.1.2 Mist Netting –

Thirty mist net sites (2 net sets per site) were operated for two nights over the period between 3 June and 17 July 2004 for a total of at least four net nights per site. No mist netting took place 10, 18, and 21 June and 9 July due to poor weather conditions.

Efforts to survey for endangered bats are difficult to standardize because of the large amount of variability that exists in a field situation. However, guidelines provided by the U.S. Fish and Wildlife Service (1999) in the most recent (Agency Draft) revision of the Indiana Bat Recovery Plan have provided structure for implementation of netting (Table 2).

Net placement was based upon canopy cover, presence of a flight corridor, water, and habitat conditions near the site. Nets were set to maximize coverage of flight paths used by Indiana bats along suitable corridors. The location and specific orientation of each net was determined in the field.

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 0.1 grams using a Pesola spring scale. Length of the right forearm of each bat was estimated to the nearest 1.0 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.

Bats were not banded. Bat processing and data collection was typically completed within 30 minutes of the time the bat was removed from the net (bat capture data sheets are provided in Appendix D).

Data collected was used in comparative analyses with surveys from previous years 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.

In addition while Indiana bats were being processed, fecal samples of Indiana bats were collected and provided for the USFWS Bloomington Ecological Services Field Office for analysis not associated with INDOT or its operating mission.

3.1.4 Habitat Assessment –

Habitat assessment at net sites focused on features indicative of suitability for Indiana bats. A habitat description of each net 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, stream or pond characteristics (if net was placed over them), and flight corridors. Habitat form was emphasized because the Indiana bat roosts in many species of trees. 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 (>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 0.6 m (2 feet) and the canopy layers, usually beginning at about 7.6 m (25 feet).

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 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 net site was documented with a sketch. Photographs of each site are provided in Appendix C.

3.1.5 Weather –

Temperature, percent cloud cover, wind, and rainfall were monitored and recorded hourly while mist netting to insure compliance with weather conditions outlined in the netting guidelines (Table 2).

In general, precipitation was lower than normal and temperatures normal for the project area during the survey period, as they were regionally for most of the 2004 netting season. Over the entire project time period, nighttime lows ranged from 48 to 73°F, and high temperatures ranged from 62 to 79°F. The nightly spread of temperatures between high and low was 48 to 79°F (Table 3). A temperature of 48°F was recorded 23

June at the conclusion of netting at 0200 h. Appendix D contains completed Weather Data Sheets.

3.2 Radiotelemetry –

3.2.1 Transmitter Application –

After collecting morphometric data, Indiana bats were fitted with radio-transmitters, each with a specific frequency. Transmitters were activated and tested before attachment to bats. A small interscapular area was trimmed of fur and the transmitter was attached to this area with non-toxic Skin-Bond® cement (Smith and Nephew, Inc., manufacturer). This cement degrades over time and the transmitter falls off the bat. Transmitter weight, weight of the bat before and after transmitter attachment, and holding time were recorded. Bats were released unharmed at the point of capture.

3.2.2 Bat Tracking and Exit Counts –

After radio-tagged bats were released, bats were tracked using TRX-2000S PLL Synthesized Tracking Receivers with three element folding yagi directional antennas manufactured by Wildlife Materials, Inc. Transmitters came from Titley Electronics, PTY, LTD and Blackburn Transmitters. Transmitter weights were 0.4 grams.

On subsequent days after attaching a radio transmitter to a bat, a radio receiver attached to an omni-directional whip antenna was used during daylight hours to locate roost sites. Each bat was tracked for a minimum of five days. If a radio signal was not detected for six consecutive days, monitoring of the radio signal was terminated.

Exit counts were typically conducted at each roost location for five consecutive nights. Beginning at sunset, counts lasted approximately 1 hour or until bats quit emerging and/or darkness precluded accurate counting. Roost tree characterization and habitat assessment data sheets were completed for each roost, which included GPS locations. Completed roost tree and habitat assessment data sheets are located in Appendix D.

3.3 Bridges –

Seventy-two bridges were pre-selected by BLA in consultation with the U.S. Fish and Wildlife Service. Bridge numbers are consistent with those identified by BLA (Figures 9a and 9b; Table 4). Bridges were checked for the presence of guano and roosting bats during nighttime hours during the survey period. Morphometric data were collected on roosting bats and the habitat surrounding each bridge was generally characterized. Completed bridge roost characterization and habitat assessment data sheets are provided in Appendix D.

3.4 Anabat –

Bats use echolocation in a nocturnal environment to efficiently maneuver and detect prey. Anabat systems are designed to detect and record these 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 typically placed at or near the mist nets for each night of netting. Microphones were positioned along the flight corridor to maximize call detection, and were typically functional for 5 hours. Anabat recordings were not obtained at six mist net sites due to equipment failure or inclement weather conditions. On 29 September 2004, all Anabat files were sorted and sent to Andrew King (USFWS) for analysis.

4.0 Results

4.1 Total Bat Captures –

A total of 252 bats representing 7 species was captured: 71 eastern pipistrelles (*Pipistrellus subflavus*), 69 eastern red bats (*Lasiurus borealis*), 43 northern bats (*Myotis septentrionalis*), 35 big brown bats (*Eptesicus fuscus*), 23 little brown bats (*Myotis lucifugus*), 9 Indiana bats (*Myotis sodalis*), and 2 hoary bats (*Lasiurus cinereus*) (Table 5). Evidence of reproduction, reproductive females and/or juveniles, was obtained for all species (Table 6). Fifteen bats escaped before sex and morphometric data were collected, although each was identified to species.

Collectively, the northern bat, red bat, and eastern pipistrelle accounted for 73 percent of the total bats captured. A Chi-square confirmed that species were not evenly represented ($\chi^2 = 122.7$, $P = 0.0001$). The catch of bats in mist nets was 2.1 bats/net night (Table 7). The mean number of bats per net site was 8.4. No bats were caught at site 22 (Table 5).

4.1.1 Species Diversity –

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, six other species of bats were captured on Section 4 of I-69 in 2004. Bat activity at sites 18, 2, and 25 produced the most bats: 15, 25, and 40 respectively (Table 5). The mean number of species captured per site was 3.1. Species richness was highest at site 2 where six species were caught including two Indiana bats. The MacArthur (1972) diversity index for bats captured on Section 4 in 2004 was 4.7 compared to 4.4 on the Crane Naval Surface Warfare Center in Crane, Indiana in northern Martin County (Brack and Whitaker 2004) and 3.5 in the Hoosier National Forest (Brack et al. 2004).

4.1.2 Occurrence by Sex and Age –

A total of 252 bats were captured over 120 net nights. Six percent of the bats (15 individuals) escaped before age and sex could be determined. Adult males and females (reproductive and non-reproductive) accounted for 58 percent (137 individuals) and 40 percent (94 individuals) of the total capture, respectively. A Chi-square test of the data indicates no significant difference between the number of adult males and females ($\chi^2 = 0.03$, $P = 0.87$). Juvenile males and females accounted for only 2.5 percent (6 individuals) of the total bats captured. Lower percentages of juvenile bats are expected earlier in the summer, which is when mist netting was conducted on Section 4.

Except for the hoary bat, adult males and reproductive females of each species were captured during the summer 2004 mist netting season. Only 6 percent of adult females were non-reproductive. Lactating females accounted for 49 percent of all reproductive females, followed by pregnant (27%) and post-lactating females (24%; Table 6). Female big brown bats ($\chi^2 = 6.23$, $P = 0.01$) and eastern red bats ($\chi^2 = 28.0$, $P = <0.0000$) were each significantly more abundant than males (Table 7). Male Eastern pipistrelles, however, were significantly more abundant than females ($\chi^2 = 16.6$, $P <0.0000$).

4.2 Indiana Bat Captures –

A total of 9 Indiana bats were captured at Sites 2, 3, 11, 14, 21, 23 and 24 on Section 4 (Table 5; Figure 10a and 10b). Bats

captured include 1 pregnant female, 1 lactating female, and 7 adult males (Table 5). Transmitters were attached to three of these bats from Sites 2, 11, and 23, and 5 diurnal roost trees were identified. Transmitters were not attached to six adult males. All Indiana bats were removed from the mist nets and processed for data on sex, reproductive condition, and morphometric measurements. No bats were banded; guano and/or hair were collected from some individuals. All bats were released in good condition at or near the point of capture.

4.3 Evening Bat Captures –

No evening bats were captured on Section 4.

4.4 Net Site Habitat Assessment –

Mist-net sites 1 and 2 were located over Doans Creek, a small tributary of the West Fork White River in Greene County. The creek's channel width was approximately 20 feet. Water depth was 5 inches at each site and clarity was high.

Dominant canopy trees (>16 inches [40 cm] dbh) included American sycamore (*Plantanus occidentalis*), American beech (*Fagus grandifolia*), and sugar maple (*Acer saccharum*). Subdominant trees (<16 inches dbh) included American sycamore, black walnut (*Juglans nigra*), and American beech. Canopy closure was generally open with moderate subcanopy clutter. Roost tree potential was moderate, consisting of snags and large trees. Net site habitat description data sheets are provided in Appendix D.

Sites 3 through 5 and 7 through 14 were located over Plummer Creek and smaller branches of Plummer Creek. Plummer Creek is also a tributary of the West Fork White River. At sites 7, 8, and 10, at least one mist net was located over a stream and the other net positioned over an upland corridor (road). Site 6 was located over a gravel road next to a small branch of Plummer Creek. Creek channel width ranged from 2 to 10 meters wide, and averaged 5 meters. Average water depth was 1 meter with moderate to high clarity.

Dominant canopy trees (>16 inches [40 cm] dbh) included American sycamore, black walnut, and American beech. Subdominant trees (<16 inches dbh) included American sycamore, black walnut, and red maple (*Acer rubrum*). Canopy closure was generally moderate to open with moderate subcanopy clutter. Roost tree potential was moderate, consisting of large trees and snags. Net site habitat description data sheets are provided in Appendix D.

All mist nests at sites 15 through 21 and sites 23, 25, and 30 were located over Indian Creek or various smaller branches of Indian Creek. Indian Creek is a smaller tributary of the East Fork White River. Creek channel width ranged from 4.5 to 15 meters wide, and averaged 9 meters. Average water depth was 0.6 meters and clarity was high.

Dominant canopy trees (>16 inches [40 cm] dbh) included American sycamore, sugar maple, and black walnut. Subdominant trees (<16 inches dbh) included American sycamore, black walnut, and sugar maple. Canopy closure was generally moderate. Roost tree potential was low to moderate. Net site habitat description data sheets are provided in Appendix D.

Sites 22, 24, and 26 through 30 were located over Clear Creek, a tributary of the East Fork White River. Creek channel width ranged from 3 to 9 meters feet wide, and averaged 6 meters. Average water depth was 15 cm with moderate to high clarity.

One mist net at site 26 was over a road and the other net was over Clear Creek.

Dominant canopy trees (>16 inches [40 cm] dbh) included American sycamore, sugar maple, and black walnut. Subdominant trees (<16 inches dbh) included American sycamore, black walnut, and tulip poplar (*Liriodendron tulipifera*). Canopy closure was generally moderate and roost tree potential was moderate. Net site habitat description data sheets are provided in Appendix D. Photographs of net sites are provided in Appendix C.

4.5 Radiotelemetry –

A total of nine Indiana bats were captured; three were fitted with radio transmitters (Table 8; Figures 11a and 11b). A total of five diurnal roost trees was located after capture. Two roosts were found for the pregnant female caught at Site 2. These roosts were approximately 1 mile (0.6 km) south of the corridor near the boundary of Crane Naval Weapons Support Center in southern Greene County. Two roosts were found for a lactating female captured at site 11. Both roosts were along Plummer Creek approximately 1 and 1.5 miles (0.6 and 2.4 km) north of the corridor. An adult male caught at Site 23 was tracked to a conduit tube on the south side of a telephone pole approximately 0.5 mile (0.8 km) east of the corridor along Indian Creek.

Six adult male Indiana bats were captured at Sites 3, 14, 21, and 24. Transmitters were not attached. Site 14 is west of SR 45 near the headwaters of Little Clifty Branch and is in the middle of the corridor. The remaining sites were located between 1 and 1.5 miles (0.6 and 2.4 km) from the corridor.

4.5.1 Indiana Bat 554 –

The first bat was an adult pregnant female captured at site 2 at 2305 h on 5 June 2004. The frequency of the transmitter was 151.554, hereafter referred to as "bat 554." Indiana bat 554 was not banded and a guano sample was not obtained. She was released unharmed at the site and departed with no difficulty. Transmitter attachment data sheets are provided in Appendix D.

4.5.1.1 Roosts –

Indiana bat 554 was found 6 June roosting in a live shagbark hickory (*Carya ovata*) approximately 43 cm (7 inches) dbh (Figure 11a; Table 9). The roost was in riparian habitat approximately 0.37 km (0.23 miles) from the capture site (Table 10). On 8 June bat 554's signal was located in a dead shagbark hickory 18 cm (7 inches) dbh approximately 46 meters (152 ft) from the first roost tree in the same forest. Roost trees were located approximately 1 mile south of the corridor near the boundary with Crane Navel Weapons Support Center. On 10 July, bat 554's transmitter fell off and was found on the forest floor 0.57 km (0.36 miles) from the capture site (Figure 11a; Table 10).

4.5.1.2 Emergence Counts –

Two roosts were identified for Indiana bat 554. Zero to nine bats exited the first roost 6 to 11 June (Table 11). Five to 13 bats exited the second roost 7 to 11 June 2004.

4.5.2 Indiana Bat 186 –

The second of three Indiana bats captured during mist net surveys was an adult lactating female caught at net site 11 at 0000 h on 16 June 2004 (Figure 11a). The frequency of the transmitter was 151.186. Indiana bat 186 was not banded; a hair and guano sample was collected. She was

released unharmed at the site and departed with no difficulty. Transmitter attachment data sheets are provided in Appendix D.

4.5.2.1 Roosts –

Indiana bat 186 was found on 18 June roosting in a live shagbark hickory approximately 43.2 cm (17 inches) dbh (Table 9). The roost was in upland habitat approximately 0.26 km (0.16 miles) from the capture site (Table 12). On 19 June, bat 186's signal was located in a dead tree 76.2 cm (30 inches) dbh. Due to the stage of decay the species could not be determined. The roost was located approximately 0.38 km (0.24 miles) from the capture site (Table 12). The distance between roost trees was 0.35 km (0.22 miles). Roost trees were located along Plummer Creek approximately 1 and 1.5 miles north of the corridor.

4.5.2.2 Emergence Counts –

Two roosts were identified for Indiana bat 186. One to 5 bats exited the first roost 18 to 22 June (Table 13). Zero to 8 bats exited the second roost 19 to 22 June 2004.

4.5.3 Indiana Bat 753 –

The third of three Indiana bats captured was an adult male caught at site 23 at 2130 h on 28 June 2004 (Figure 11b). The frequency of the transmitter was 151.753. Indiana bat 753 was not banded; a guano sample was obtained. He was released unharmed at the site and departed with no difficulty. Transmitter attachment data sheets are provided in Appendix D.

4.5.3.1 Roosts –

Indiana bat 753 was found 29 June roosting behind a plastic guard to protect a high voltage transformer cable on the south side of a utility pole 20 cm (8 inches) dbh (Table 14; Photo in Appendix C). The plastic shield was approximately 6 meters (20 ft.) tall and 10 cm (4 inches) wide. Guano filled the plastic shield to 1.7 meters (5.5 ft.) and was piled on the ground at the base of the pole. The roost was located approximately 117 meters (385 ft.) from the capture site in upland habitat on private property. The roost was approximately 0.8 meters (0.5 miles) east of the corridor. Each day thereafter, Indiana bat 753 roosted in the same light pole.

4.5.3.2 Emergence Counts –

Only one roost was identified for Indiana bat 753. Eight to 20 bats exited the light pole roost 29 June to 5 July 2004 (Table 14). An emergence count was not performed on 6 July at the request of the landowner.

4.6 Bridges –

A total of 72 bridges was pre-selected by BLA in consultation with the U.S. Fish and Wildlife Service (Figure 9a and 9b). One bridge was not found at the specified location. Five bridges were not checked for roosting bats; one bridge was under construction and four bridges were small culverts. A total of sixty-six bridges was checked for guano and roosting bats on Section 4 (Table 15).

On 26 June 2004, two northern bats (*M. septentrionalis*) were found in a small crevice in bridge 88 near net site 23. One male and one female northern bat were captured and morphometric data collected. A guano sample from each bat was obtained. On 15 July, one bat was observed roosting at bridge 84 over Jackson Creek in Monroe County. The bat was too high up in the bridge to confirm identification. No bats or guano were observed at any other bridges on Section 4 (Table 15). Bridge roost characterization datasheets are located in Appendix D.

5.0 Discussion

The objective of mist net surveys was to improve understanding of the summer occurrence and habitat use by the Indiana bat and evening bat on Section 4 of I-69. Surveys conducted in summer 2004 provide information about the following:

- Presence and distribution of Indiana bats and evening bats on Section 4
- Roosting habitat use by male and adult reproductive female Indiana bats captured on Section 4
- Nighttime use of bridges for roosts by Indiana bats and evening bats on Section 4.

By adding to and comparing with previous regional studies, data can be used to help identify important roosting areas 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 Capture 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, six other species of bat were captured on Section 4 in 2004. Indiana bats were the sixth most common species captured in the project area with a capture rate of 0.075 bats per net night (Table 6). The diversity index (MacArthur, 1972) was also high, 4.7.

Nineteen sites on the I-69 corridor were surveyed for bats by Dr. John O. Whitaker, Jr. in 1993, the results of which are included in the I-69 Tier I Environmental Impact Statement (BLA 2003). Eleven of these sites were located in the Section 4 corridor. Whitaker documented six bat species and a diversity index (MacArthur 1972) of 4.3, compared to 4.7 in 2004. No Indiana bats were captured during the 1993 surveys on Section 4.

During mist net surveys between 1987 and 1998 at Crane Navel Surface Warfare Center (Crane) near Bedford, Indiana, Brack and Whitaker (2004) found 8 species, including 8 Indiana bats (6 males, 2 females). The capture rate for Indiana bats was 0.025 bats per net night, and the total bat capture rate was 1.8 bats per net night.

During 237 net nights of survey from 1981 to 1999 on Hoosier National Forest (HNF), Indiana, Brack et al. (2004) found 10 species, including six Indiana bats (all male). The capture rate was 0.025 Indiana bats per net night, compared to 0.075 bats per net night on Section 4. Total bat catch per night on both HNF and Section 4 was 2.1 bats per net night.

Surveys at Newport Chemical Depot NECD in Vermillion county produced 0.2 Indiana bats per net night between 1994 and 2003 (ESI-Brown and Brack 2003). Eleven Indiana bats were captured.

The species diversity index (MacArthur, 1972) on HNF, Crane, and NECD was 4.3, 4.4, and 5.1, respectively. The diversity index on Section 4 of I-69 was 4.7.

5.2 Evening Bat –

No evening bats were captured on Section 4 during summer 2004 mist net surveys.

Evening bats were captured on all other sections of the I-69 corridor from Evansville to Indianapolis, Indiana (Tom Cervone pers. comm.). During Tier I Environmental Impact Statement surveys in 1993, Whitaker (1996) believed to have detected echolocation calls from evening bats along the north side of the White River in the northwest portion of Section 4. Buildings with potential to be roost sites were checked within a mile of the detection site, but no bats were found.

Evening bats are historically known (1961) from neighboring Clay, Orange, Washington, and Clark counties, but these colonies are now defunct (Whitaker and Gummer 2003). Existing colonies are known from Bartholomew, Jennings, Vigo, Sullivan, and Posey counties in southern Indiana (Whitaker and Gummer 2003) (Figure 7).

5.3 Indiana bat –

5.3.1 Roosting –

A single maternity colony typically consists of 25 to 100 adult females (although the largest maternity colony found was nearly 400 individuals) that may travel 2 or more miles to forage (Gardner et al. 1991; Kurta et al. 2002; Carter 2003). Maternity roost trees are generally larger than 30 cm (12 inches) dbh (USFWS 1999) and often >16" (3D/I 1995). Indiana bats have been found using many different tree species as roosts across its range indicating that tree form, not species, is important for suitability (USFWS 1999). This is no doubt correlated with the ephemeral nature of roosts, as they are generally dead or dying with sloughing or exfoliating bark. Roost suitability depends on whether the tree is alive or dead, the extent of exfoliating or sloughing bark, exposure to solar energy in relation to other trees, and distance to water resources (USFWS 1999). However, habitat is made difficult to further identify because individual Indiana bats may roost in small groups (<5) or even individually (Gumbert 2001; USFWS 1999; Kurta et al. 2002; ESI-Brown and Brack 2003; Brack et al. 2004; Brack and Whitaker 2004).

Roosts located for Indiana bat 554 and 186 captured from net Sites 2 and 11 were characteristic of "typical" roost trees in southern Indiana. Indiana bat 554, a pregnant female, roosted in two shagbark hickories, 43 and 18 cm dbh, respectively. Indiana bat 186, a lactating female, roosted in a shagbark hickory 43 cm dbh. Three shagbark hickories (mean dbh 25.3 cm) with extensive exfoliating bark were used by 2 adult male Indiana bats during studies completed in the HNF (Brack et al. 2004). At NECD, a lactating female used a live shagbark hickory 29 cm (11 inches) dbh (ESI-Brown and Brack 2003). A total of six roosts were identified for four Indiana bats at NECD between 1997 and 2003. Roosts trees averaged 46.3 cm (18.2 inches) dbh, compared to 40.0 cm (15.7 inches) dbh for five roosts on Section 4.

An adult male Indiana bat captured at Site 23 was found roosting on the south side of a utility pole on private property on 29 June 2004. Guano accumulated in the conduit tube beneath the roost to 1.5 m (5 ft). Such roosts, while not typical, have been previously documented for Indiana bats and other species. Harvey (2002) observed a male Indiana bat using a metal bracket on a utility pole in Arkansas, and Winterhalter (2004) observed members of a maternity colony of big brown bats (4 – 25 individuals) similarly using plastic guard on a utility pole, with a similar accumulation of guano at the bottom of the tube. In Cuba,

velvety free-tailed bats (*Molossus molossus*) roosted in the crevice of a utility pole (Silva-Taboada, 1979). 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 (unpub. report), and bat boxes (Whitaker et al. in submission). Individuals that may or may not have been 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). A juvenile Indiana bat was taken from the side of a building with a rough cement exterior (Brack, unpub. data). During migration, individual Indiana bats have been found under porches of houses (Sanders and Chenger, 2001), as well as in the sidings of houses and in trees of suburban yards (Hicks, pers. comm.).

5.3.2 Bridges –

On 26 June at 0100, one male and one non-reproductive female Northern bat were found roosting in a small crevice under Bridge 88 over Indian Creek. The bridge, 4.5 m (15 feet) long and raised 2.5 m (7 feet) above the creek, was a concrete slab surrounded by lowland forest. In addition, one bat (species unknown) was found underneath Bridge 84 over Jackson Creek.

Surveys at 421 bridges and culverts in 25 states found 4,250,000 bats from 24 species, including 13 species of bat that live in eastern forests, using bridges as either day or nightroosts (Keeley and Tuttle 1999). Between nighttime foraging bouts, bridges provide warm, dry resting place and are important sites for social interactions (Perlmeter 1996). In 1998, Kiser et al (2002) discovered 159 bats from five species using five bridges at Camp Atterbury in south-central Indiana. The Indiana bat (51 %) and the big brown bat (38 %) were the most common species. A single northern bat was seen dayroosting underneath one bridge. At two bridges, lactating and postlactating female Indiana bats were found. The bridges at Camp Atterbury were over streams and were bordered by forested, riparian corridors that connected to larger tracts of forest. Nearby trees did not overhang any of the bridges, thus allowing direct solar radiation to strike the bridge surface. Bridges were made out of concrete slab or girder. Two bridges not used as roosts were either flat bottomed, with no compartments, or were supported by trusses.

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APPENDIX A

Appendix A

Figures

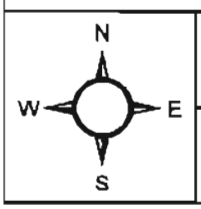

Figure 1. Location of Section 4 of the I-69 corridor in Greene and Monroe counties, Indiana

Project No. 113

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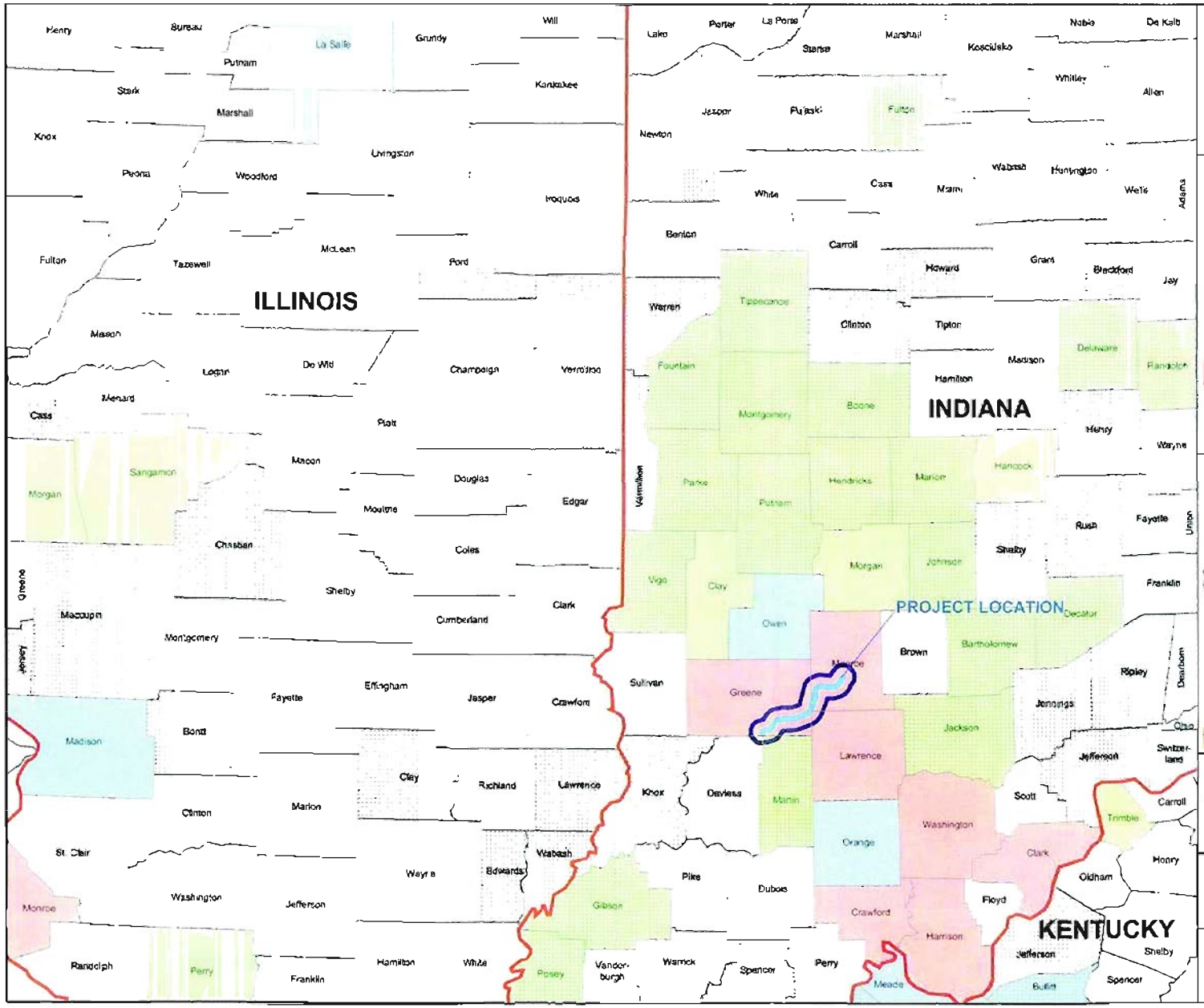

Figure 2. Counties near the project area with hibernacula, summer maternity, and other summer (nonreproductive) records for the Indiana bat (*Myotis sodalis*).

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.

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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.

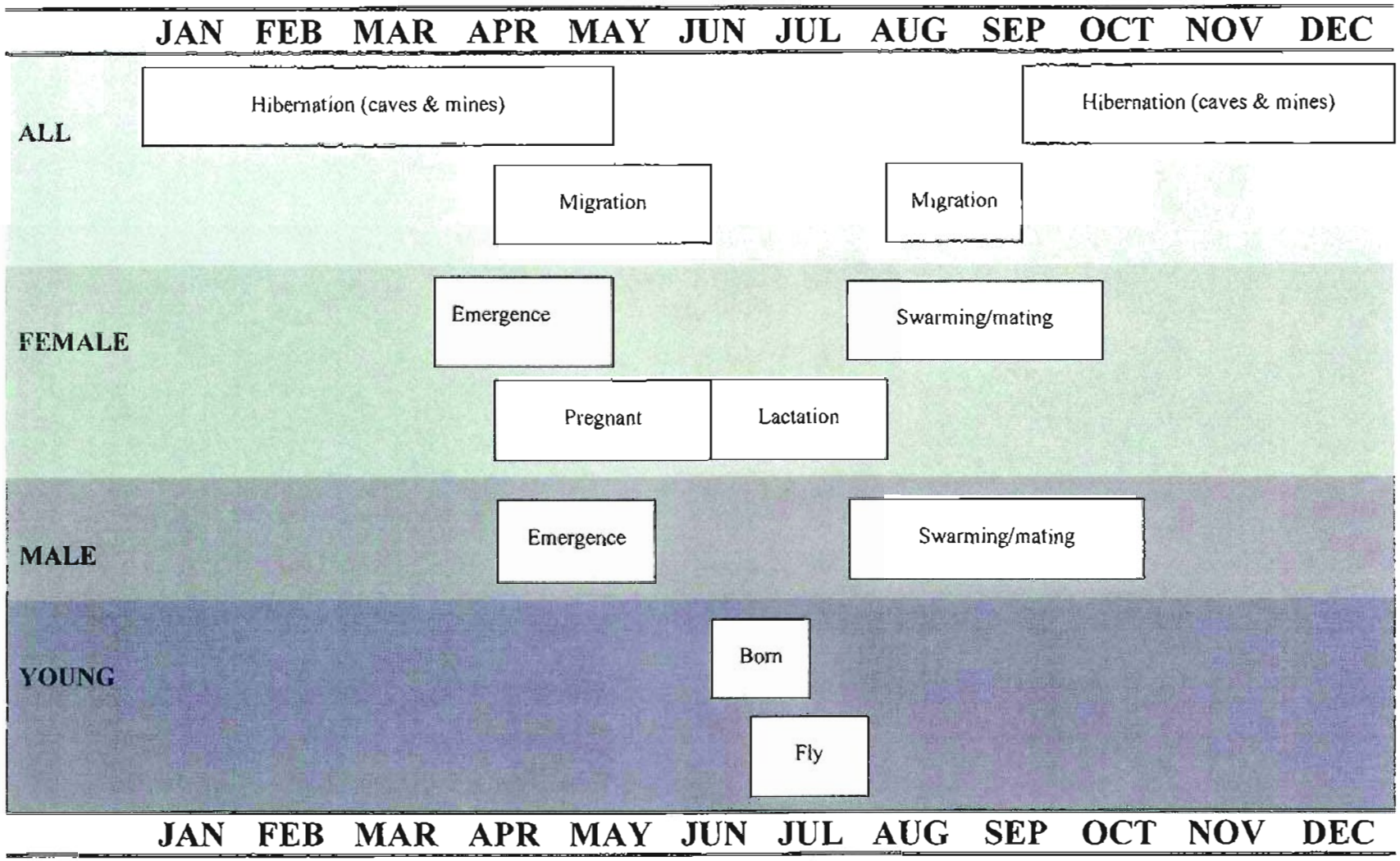


Figure 4. Seasonal chronology of Indiana bat activities.

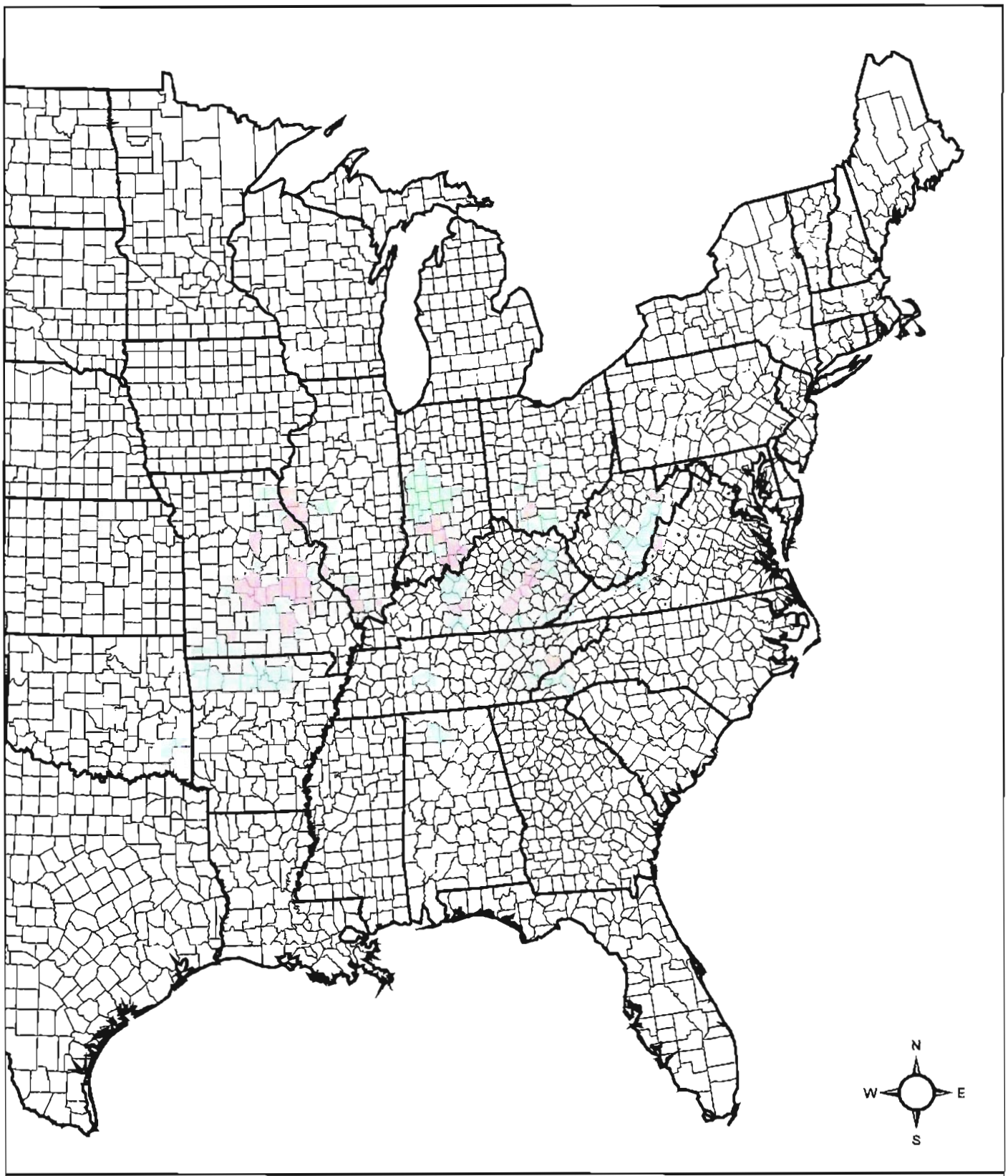


Figure 5. Counties with hibernacula and other summer (nonreproductive) records for the Indiana bat (*Myotis sodalis*) range wide.

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. 113 September 2003	Sources: USFWS, Indiana Bat Revised Recovery Plan, Agency Draft, 1999.	ESI ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.

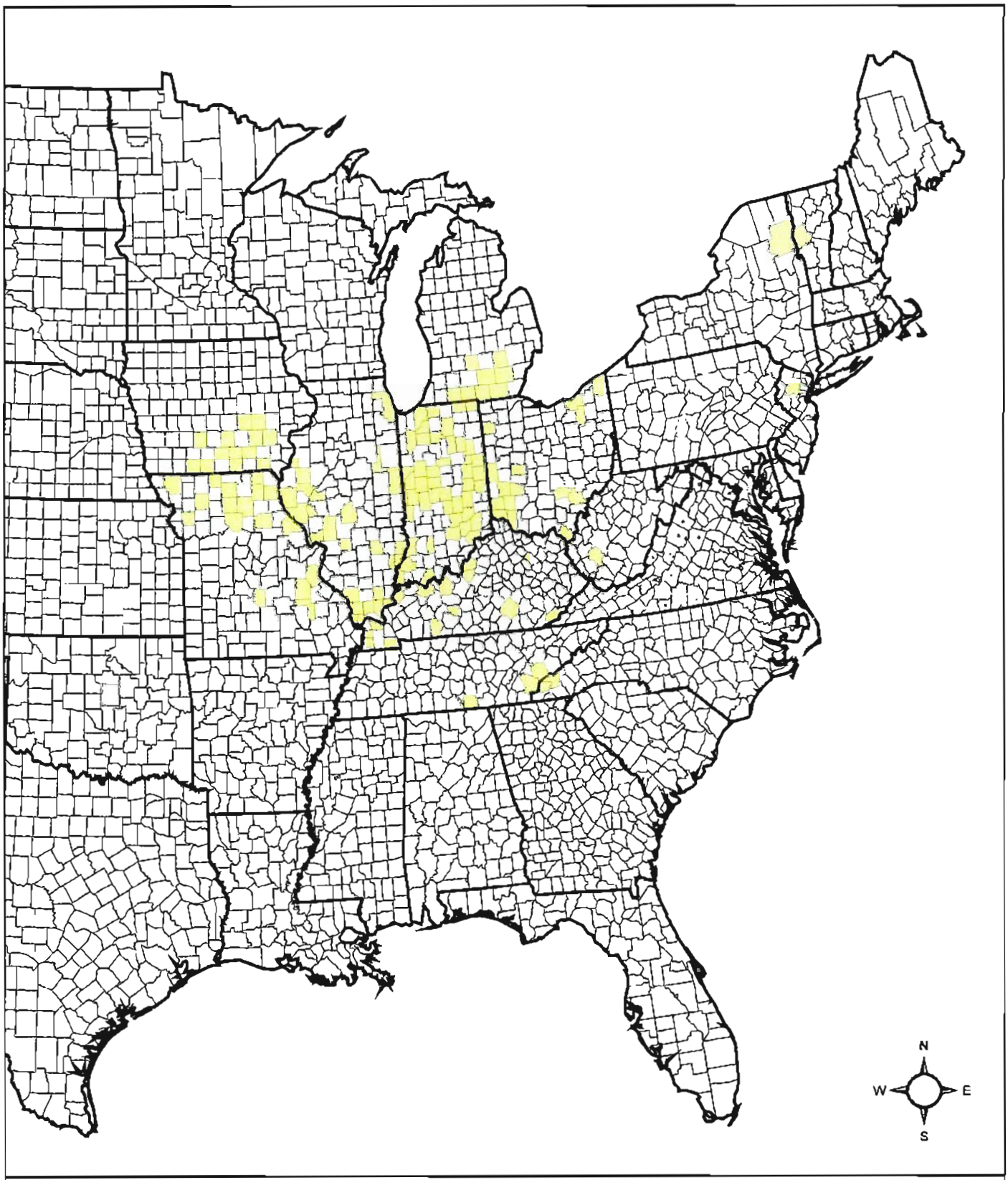
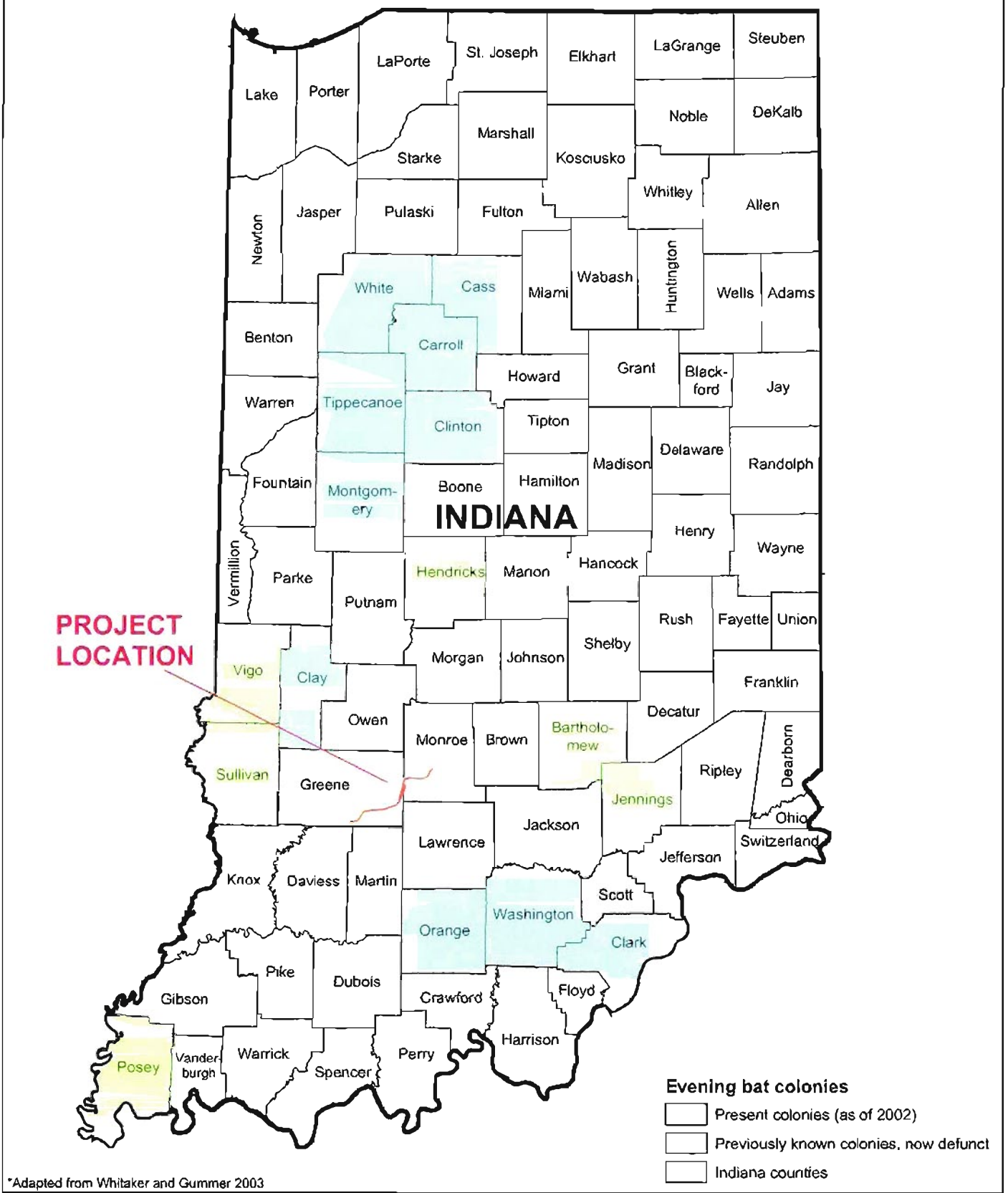


Figure 6. Counties with reproductive (adult female and/or young-of-the-year) records for the Indiana bat (*Myotis sodalis*) range wide.

County with Record of Indiana Bat Reproductive Occurrence

Project No. 113 September 2003	Sources: USFWS, Indiana Bat Revised Recovery Plan, Agency Draft, 1999.	ESI ENVIRONMENTAL SOLUTIONS & INNOVATIONS, INC.



*Adapted from Whitaker and Gummer 2003

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Figure 7. Former and presently known maternity colonies of evening bat (*Nycticeius humeralis*) in Indiana

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Figure 8a. ("Location of mist net sites on Section 4 of the I-69 Corridor") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 8b. ("Location of mist net sites on Section 4 of the I-69 Corridor") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 9a. ("Location of Bridges on Section 4 of the I-69 Corridor") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 9b. ("Location of Bridges on Section 4 of the I-69 Corridor") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 10a. ("Capture sites of the Indiana bat (*Myotis sodalis*) on Section 4 of the I-69 corridor") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 10b. ("Capture sites of the Indiana bat (*Myotis sodalis)* on Section 4 of the I-69 corridor") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

Figure 11b. ("Location of Indiana bat (*Myotis sodalis*) capture sites and roost trees") has been removed for confidentiality reasons related to the federally endangered Indiana bat.

APPENDIX B

Appendix B

Tables

Table 1. County and GPS coordinates for 30 sites on Section 4 of I-69.

Site No.	County	Coordinates (meters)		
		Northing	Easting	UTM Zone
1	Greene			16 S
2	Greene			16 S
3	Greene			16 S
4	Greene			16 S
5	Greene			16 S
6	Greene			16 S
7	Greene			16 S
8	Greene			16 S
9	Greene			16 S
10	Greene			16 S
11	Greene			16 S
12	Greene			16 S
13	Greene			16 S
14	Greene			16 S
15	Greene			16 S
16	Greene			16 S
17	Greene			16 S
18	Greene			16 S
19	Greene			16 S
20	Greene			16 S
21	Greene			16 S
22	Monroe			16 S
23	Greene			16 S
24	Monroe			16 S
25	Greene			16 S
26	Greene			16 S
27	Greene			16 S
28	Monroe			16 S
29	Monroe			16 S
30	Monroe			16 S

Table 2. Mist netting guidelines.

Mist 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 1½ inch (1¼ –1¾) (38 mm).
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 60 feet (20 m).
4. Net Site Spacing:
   - Streams – one net site per 0.5 mile (1 km)
   - Land Tracts – two net sites per 250 acres (1 square km)
5. Minimum Level of Effort Per Net Site:
   - Two net locations (sets) per net site, with locations (sets) at least 100 feet (30 m) apart
   - Two (calendar) nights of netting
   - At least three 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 20-minute intervals
   - No disturbances near the nets between checks
6. Weather Conditions: net only if the following weather conditions are met:
   - No precipitation
   - Temperature ≥ 50°F (10°C)
   - No strong winds
7. Moonlight: avoid net sets with direct exposure to a moon ½ -full or greater – typically by utilizing forest canopy cover

Source: U.S. Fish and Wildlife Service, 1999

Table 3. High and low temperatures (°F) recorded during 2004 summer mist net surveys on Section 4 of I-69.

Survey Dates (2004)	Survey Period (approx. 2000 – 0200 h)	
	High Temp. °F	Low Temp. °F
3-June	64	57
4-June	63	54
5-June	67	59
6-June	68	61
7-June	71	65
8-June	74	68
9-June	74	68
11-June	75	71
16-June	77	73
17-June	71	67
19-June	62	51
20-June	68	58
21-June	66	58
22-June	64	48
23-Jun	64	53
24-June	74	60
25-June	66	56
26-June	64	58
27-June	62	62
28-June	68	60
8-July	73	68
10-July	77	71
11-July	76	70
12-July	79	73
14-July	71	65
15-July	70	62
16-July	73	69
17-July	72	62

Table 4. Bridge number, county, feature, location, and GPS coordinates of bridges in Section 4 of I-69.

Bridge Number.	County	Feature	Bridge Location	Coordinates (meters)		
				Northing	Easting	UTM Zone
	Greene	Richland Creek				16 S
	Greene	Branch of Beech Cr.				16 S
	Greene	Beech Creek				16 S
	Greene	Beech Creek				16 S
	Greene	Lost Creek				16 S
	Greene	Lost Creek				16 S
	Greene	Indian Creek				16 S
	Greene	Indian Creek				16 S
	Greene	Indian Creek				16 S
	Greene	Clifty Creek				16 S
	Greene	Doans Creek				16 S
	Greene	Doans Creek				16 S
	Greene	Doans Creek				16 S
	Greene	Plummer Creek				16 S
	Greene	Branch of Clifty Cr.				16 S
	Greene	Plummer Creek				16 S
	Greene	Clifty Creek				16 S
	Greene	Clifty Creek				16 S
	Greene	Little Clifty Creek				16 S
	Greene	Town Branch				16 S
	Greene	Spring Creek				16 S
	Greene	Mitchell Branch				16 S
	Greene	Plummer Creek				16 S
	Greene	Black Ankle Creek				16 S
	Greene	Plummer Creek				16 S
	Monroe	Indian Creek				16 S
	Monroe	Branch of Clear Cr.				16 S
	Monroe	Indian Creek				16 S
	Monroe	Indian Creek				16 S
	Monroe	Indian Creek				16 S
	Monroe	Keller Branch				16 S
	Monroe	Jackson Creek				16 S
	Monroe	Branch of Clear Cr.				16 S
	Monroe	Clear Creek				16 S
	Monroe	Jackson Creek				16 S
	Monroe	Branch of Clear Cr.				16 S
	Greene	Indian Creek				16 S
	Monroe	Branch of Indian Cr.				16 S
	Monroe	Little Indian Creek				16 S
	Greene	Stone Branch				16 S
	Monroe	Branch of Popcorn Cr.				16 S
	Monroe	Popcorn Creek				16 S
	Greene	Little Indian Creek				16 S

Bridge Number	County	Feature	Location	Coordinates (meters)		
				Northing	Easting	UTM Zone
93	Monroe	Indiana Creek				16 S
94	Monroe	Branch of Clear Cr.				16 S
95	Greene	Indian Creek				16 S
97	Monroe	Clear Creek				16 S
98A	Monroe	Clear Creek				16 S
98B	Lawrence	Linden Hollow				16 S
99	Monroe	Branch of Clear Cr.				16 S
100	Monroe	Clear Creek				16 S
106	Lawrence	Branch of Popcorn Cr.				16 S
110	Greene	Plummer Creek				16 S
116	Lawrence	Popcorn Creek				16 S
118	Lawrence	Popcorn Creek				16 S
178	Greene	Branch of Indian Cr.				16 S
181	Monroe	Clear Creek				16 S
203	Lawrence	Branch of Popcorn Cr				16 S
254	Greene	Indiana Railroad Co.				16 S
255	Greene	Indiana Railroad Co.				16 S
256	Greene	Indiana Railroad Co.				16 S
258	Greene	Indiana Railroad Co.				16 S
300	Greene	Branch of Richland Cr.				16 S
308	Greene	Indian Creek				16 S
311	Greene	Little Indian Creek				16 S
607	Monroe	Smithville Road/Ditch				16 S
608	Monroe	Jackson Creek				16 S
907	Monroe	Moore Creek				16 S
909	Monroe	Branch of Indian Creek				16 S
912	Monroe	Butcher Branch				16 S
914	Monroe	Branch of Clear Creek				16 S
919	Monroe	Branch of Clear Creek				16 S

Table 5. Summary of total bat captures by site and Indiana bat (*Myotis sodalis*) captures by sex, reproductive condition, number tagged, and number of roosts found on Section 4.

Site	Survey Dates	# of Adult pregnant Female M. sodalis	# of Adult lactating Female *M. sodalis*	#of Adult post-lactating Female *M. sodalis*	# of Non-repro. Adult Female *M. sodalis*	# of Juvenile Female *M. sodalis*	# of Adult Male *M. sodalis*	# of Juvenile Male *M. sodalis*	Total # of *M. sodalis*	# of Radio-tagged *M. sodalis*	Total # of Diurnal Roosts Identified	*Little brown bat*	*Northern bat*	*Big brown bat*	*Eastern pipistrelle*	*Eastern red bat*	*Hoary bat*	*Evening bat*	Total # of Bats
1	6/5 & 6/6								0				2		3	5	1		11
2	6/5 & 6/6	1					1		2	1	2	4	3	1	7	8			25
3	6/8 & 6/9						2		2			1	2		1	3			9
4	6/7 & 6/8								0			2	1		1	4			8
5	6/9 & 6/11								0				3			1			4
6	6/22 & 6/23								0			1	1			4			6
7	6/16 & 6/17								0			1	3		1	2			7
8	6/19 & 6/20								0				1	3	2	6			12
9	6/19 & 6/20								0						3				3
10	6/16 & 6/17								0				1			2			3
11	6/16 & 6/17		1						1	1	2		1	1	4	1			8
12	6/20 & 6/22								0				1			1			2
13	6/20 & 6/22								0			1				1			2
14	6/22 & 6/23						1		1			1	3			4			9
15	6/3 & 6/4								0			2			6				8
16	6/3 & 6/4								0				3		5	2			10
17	6/23 & 6/24								0				3	1		2			6
18	6/23 & 6/24								0			2		5	5	3			15
19	6/24 & 6/25								0					1	6	2	1		10
20	6/25 & 6/27								0			1				3			4
21	6/25 & 6/26						1		1										1
22	7/11 & 7/12								0										0
23	6/26 & 6/28						1		1	1	1	1	3	3	2				10
24	7/16 & 7/17						1		1				1		1				3
25	7/6 & 7/7								0				9	15	10	6			40
26	7/8 & 7/10								0							1			1
27	7/11 & 7/12								0				1						1
28	7/14 & 7/15								0			2		2	1	2			7
29	7/8 & 7/10								0			1	1	1	8	3			14
30	7/14 & 7/15								0			3		2	5	3			13
Totals:		1	1				7		9	3	5	23	43	35	71	69	2	0	252

Table 6. Total bat captures at 30 sites by sex, reproductive condition, and age during 2004 summer mist netting on Section 4 of I-69.

Species	Adult Male	Adult Female[1]				Juvenile		Escape[2]	Total
		P	L	PL	NR	Male	Female		
Big brown bat	11	2	13	3	1	0	0	5	**35**
Eastern red bat	16	9	20	13	4	1	1	5	**69**
Hoary bat	0	1	1	0	0	0	0	0	**2**
Little brown bat	19	1	1	0	1	0	0	1	**23**
Northern bat	30	2	4	5	0	0	2	0	**43**
Indiana bat	7	1	1	0	0	0	0	0	**9**
Eastern pipistrelle	54	8	3	0	0	2	0	4	**71**
Total	**137**	**24**	**43**	**21**	**6**	**3**	**3**	**15**	**252**

[1] P = pregnant; L = lactating; PL = Post lactating; NR = non-reproductive
[2] Escape = escaped from net or hand before processing was complete

Table 7. Numbers of bats caught, catch per net-night, and chi-square analysis of males and females captured on Section 4 of the I-69 corridor.

Species	Male Bats	Male %	Female Bats	Female %	X^2	*P*	Catch/net-night Total
Big brown bat	11	7.9	19	19.6	6.228	0.0125	0.29
Eastern red bat	17	12.1	47	48.5	27.976	< 0.00001	0.58
Hoary bat	0	0	2	2.1			0.02
Little brown bat	19	13.6	3	3.1			0.19
Northern bat	30	21.4	13	13.4	2.035	0.1537	0.36
Indiana bat	7	5.0	2	2.1			0.08
Eastern pipistrelle	56	40.0	11	11.3	16.648	< 0.00001	0.59
Total	140		97				2.11

Table 8. Biology, capture, and telemetry information of three radio-tagged Indiana bats on Section 4.

Bat Number	Capture Date	Transmitter Frequency	Capture Site	Sex	Age Class	Reproductive Condition	Number of Roosts
554	5 June	151.554	2	Female	Adult	Pregnant	2
186	16 June	151.186	11	Female	Adult	Lactating	2
753	28 June	151.753	23	Male	Adult	Non-descended	1

Table 9. Summary of roost tree data for radio-transmittered Indiana bats on Section 4.

Bat Number	Roost	Tree Species	Status	dbh (cm)	% of Bark Exfoliating	% Canopy Closure	Roost Height (m)	Roost Habitat
554	1	Shagbark hickory (*Carya ovata*)	Live	43	85	80	Unknown	Riparian
	2	Shagbark hickory (*Carya ovata*)	Dead	18	30	50	2.5	Riparian
186	1	Shagbark hickory (*Carya ovata*)	Live	43	70	50	Unknown	Upland
	2	Unknown	Dead	76	80	30	Unknown	Riparian
753	1	Utility pole	Dead	20	0	0	2-5	Upland

Table 10. Distance matrix in kilometers (km) or meters (m) and miles or feet between captures site, roost trees, and the location of the dropped transmitter for Indiana bat 544.

	Capture Site 2	Roost 1	Roost 2	Dropped Transmitter
Capture Site 2		0.37 km (0.23 miles)	0.37 km (0.23 miles)	0.57 km (0.36 miles)
Roost 1	0.37 km (0.23 miles)		46 m (152 feet)	0.76 km (0.47 miles)
Roost 2	0.37 km (0.23 miles)	46 m (152 feet)		0.95 km (0.59 miles)
Dropped Transmitter	0.57 km (0.36 miles)	0.76 km (0.47 miles)	0.95 km (0.59 miles)	

Table 11. Roost tree species, size, health status, and exit count numbers for Indiana bat 554.

Roost	Roost Tree Species	Tree Size (dbh)	Status	Date	Exit Count
1	Shagbark hickory (*Carya ovata*)	43 cm (17.0 in.)	Live	6 June	9
				7 June	0
				8 June	0
				9 June	0
				10 June	5
				11 June	7
2	Shagbark hickory (*Carya ovata*)	18 cm (7.0 in.)	Dead	7 June	13
				8 June	7
				9 June	5
				10 June	5
				11 June	9

Table 12. Distance matrix in kilometers (km) and miles between capture site and roost trees for Indiana bat 186.

	Capture Site 11	Roost 1	Roost 2
Capture Site 11		0.26 km (0.16 miles)	0.38 km (0.24 miles)
Roost 1	0.26 km (0.16 miles)		0.35 km (0.22 miles)
Roost 2	0.38 km (0.24 miles)	0.35 km (0.22 miles)	

Table 13. Roost tree species, size, health status, and exit count numbers for Indiana bat 186.

Roost	Roost Tree Species	Tree Size (dbh)	Status	Date	Exit Count
1	Shagbark hickory (*Carya ovata*)	43.2 cm (17.0 in.)	Live	18 June	4
				19 June	3
				20 June	4
				21 June	1
				22 June	5
2	Unknown tree species	76.2 cm (30.0 in.)	Dead	19 June	8
				20 June	2
				21 June	0
				22 June	2

Table 14. Roost tree, size, health status, and exit count numbers for Indiana Bat 753.

Roost	Roost Tree	Tree Size (dbh)	Status	Date	Exit Count
1	Plastic conduit of utility pole	20 cm (8 in.)	Dead	29 June	8
				30 June	8
				1 July	15
				2 July	18
				3 July	20
				5 July	19
				6 July	No count[1]

[1] Emergence count not performed at request of landowner

Table 15. Bridge number, county, location, and presence of bats and guano on Section 4 of I-69.

Bridge Number	County	Feature	Bridge Location	Bat Species	Number of Bats	Guano	Comments
9	Greene	Richland Creek			0	No	
16	Greene	Branch of Beech Creek			0	No	
17	Greene	Beech Creek			0	No	
27	Greene	Beech Creek			0	No	
29	Greene	Lost Creek			0	No	
30	Greene	Lost Creek			0	No	
31	Greene	Indian Creek			0	No	
34	Greene	Indian Creek			0	No	
35	Greene	Indian Creek			0	No	
37	Greene	Clifty Creek			0	No	
41	Greene	Doans Creek			0	No	
43	Greene	Doans Creek			0	No	
44	Greene	Doans Creek			0	No	
45	Greene	Plummer Creek			0	No	
47	Greene	Branch of Clifty Creek			0	No	
48	Greene	Plummer Creek			0	No	
49	Greene	Clifty Creek			0	No	
50	Greene	Clifty Creek			0	No	
51	Greene	Little Clifty Creek					No bridge
55	Greene	Town Branch			0	No	
56	Greene	Spring Creek			0	No	
57	Greene	Mitchell Branch			0	No	
58	Greene	Plummer Creek			0	No	
59[1]	Greene	Black Ankle Creek			0	No	
59[1]	Greene	Black Ankle Creek			0	No	
60	Greene	Plummer Creek			0	No	
64	Monroe	Indian Creek			0	No	
65	Monroe	Branch of Clear Creek			0	No	
67	Monroe	Indian Creek			0	No	
68	Monroe	Indian Creek			0	No	
70	Monroe	Indian Creek					No bridge
71	Monroe	Keller Branch			0	No	
77	Monroe	Jackson Creek			0	No	
82	Monroe	Branch of Clear Creek			0	No	
83	Monroe	Clear Creek			0	No	
84	Monroe	Jackson Creek		Unknown[2]	1	No	
86	Monroe	Branch of Clear Creek			0	No	
87	Greene	Indian Creek			0	No	
88[1]	Monroe	Branch of Indian Creek		Northern bat	2	No	
88[1]	Monroe	Branch of Indian Creek			0	No	
89A	Monroe	Little Indian Creek			0	No	
89B	Greene	Stone Branch			0	No	
90	Monroe	Branch of Popcorn Cr.			0	No	
91	Monroe	Popcorn Creek			0	No	
92	Greene	Little Indian Creek			0	No	
93	Monroe	Indiana Creek			0	No	

Bridge Number	County	Feature	Bridge Location	Bat Species	Number of bats	Guano	Comments
94	Monroe	Branch of Clear Creek					No bridge
95	Greene	Indian Creek			0	No	
97	Monroe	Clear Creek			0	No	
98A	Monroe	Clear Creek			0	No	
98B	Lawrence	Linden Hollow					No bridge
99	Monroe	Branch of Clear Creek			0	No	
100	Monroe	Clear Creek					Construction
106	Lawrence	Branch of Popcorn Cr.					No bridge
110	Greene	Plummer Creek			0	No	
116	Lawrence	Popcorn Creek					No bridge
118	Lawrence	Popcorn Creek			0	No	
178	Greene	Branch of Indian Creek			0	No	
181	Monroe	Clear Creek			0	No	
203	Lawrence	Branch of Popcorn Creek			0	No	
254	Greene	Indiana Railroad Company			0	No	
255	Greene	Indiana Railroad Company			0	No	
256	Greene	Indiana Railroad Company			0	No	
258	Greene	Indiana Railroad Company			0	No	
300	Greene	Branch of Richland Creek			0	No	
308	Greene	Indian Creek					No bridge
311	Greene	Little Indian Creek			0	No	
607	Monroe	Smithville Road/Ditch			0	No	
608	Monroe	Jackson Creek			0	No	
907	Monroe	Moore Creek			0	No	
909	Monroe	Branch of Indian Creek					No bridge
912	Monroe	Butcher Branch			0	No	
914	Monroe	Branch of Clear Creek			0	No	
919	Monroe	Branch of Clear Creek					No bridge

[1] Bridge checked twice during the survey period.
[2] Bat too high in the bridge for accurate identification.

APPENDIX C

Appendix C

Photographs

Site 4-2 Net 1

Site 4-2 Net 2

Site 4-3 Net 1

Site 4-3 Net 2

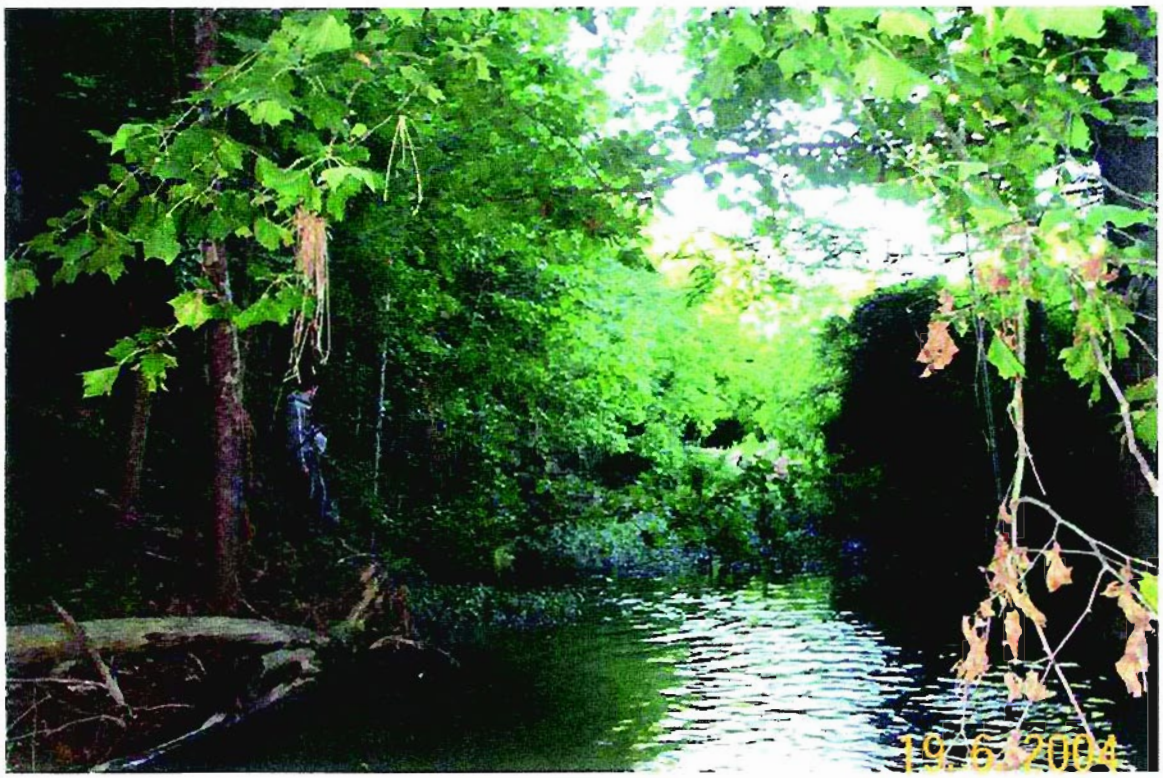
Site 4-4

Site 4-5

Site 4-6

Site 4-7 Net 1

Site 4-7 Net 2



Site 4-8 Net 1

Site 4-8 Net 2

Site 4-11 Net 1

Site 4-11 Net 2

Site 4-12

Site 4-13 Net 1

Site 4-13 Net 2

Site 4-14 Net 1

Site 4-14 Net 2

Site 4-15 Net 1

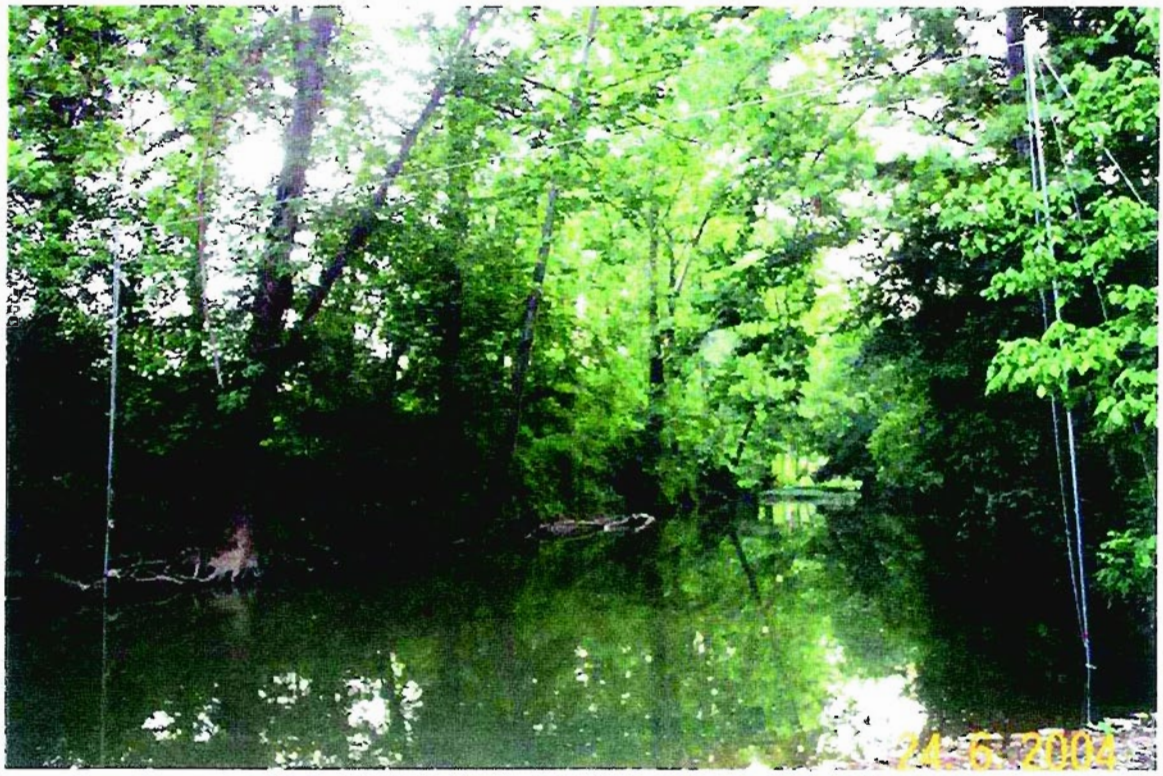
Site 4-15 Net 2

Site 4-16

Site 4-16

Site 4-17

Site 4-18 Net 1



Site 4-18 Net 2

Site 4-19

Site 4-20 Net 1

Site 4-20 Net 2

Site 4-21 Net 1

Site 4-21 Net 2

Site 4-22 Net 1

Site 4-22 Net 2

Site 4-23

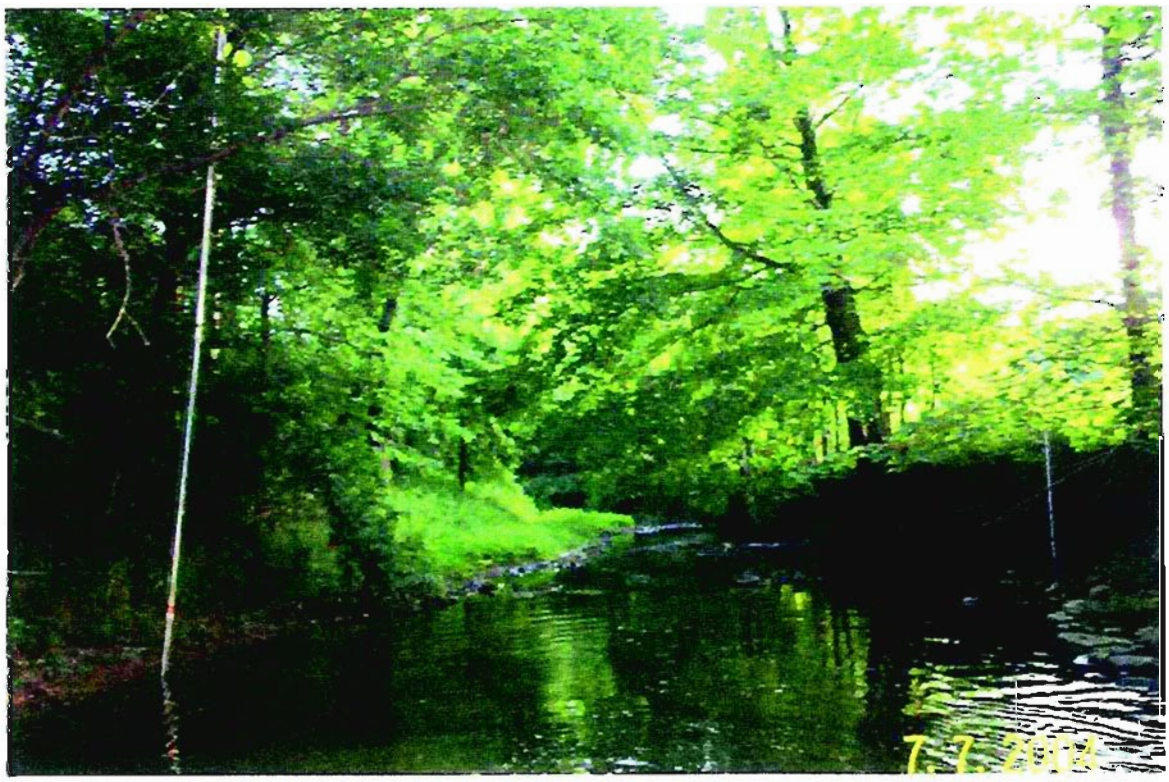
Site 4-23 Indiana Bat 753 Roost

Site 4-23 Indiana Bat 753 Roost

Site 4-23 Indiana Bat 753 Roost

Site 4-23 Indiana Bat 753 Roost

Site 4-24



Site 4-25

Site 4-25

Site 4-26

Site 4-27

Site 4-28

Site 4-28

Site 4-29 Net 1

Site 4-29 Net 2

Site 4-30 Net 1

Site 4-30 Net 2

APPENDIX D

Appendix D

Data Sheets

Appendix D: Data Sheets has been removed for confidentiality reasons related to the federally endangered Indiana bat.

PRE-CONSTRUCTION MIST NETTING FOR THE INDIANA BAT (*MYOTIS SODALIS*) FOR SITES 2, 3, 8, 11 AND 14 FROM US231 TO SR45 LOWER WHITE RIVER WATERSHED IN SECTION 4 (GREENE COUNTY, IN)

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Abstract

In fulfillment of INDOT and FHWA's Section 7 Consultation commitments for the proposed I-69 corridor from Evansville to Indianapolis, Indiana, pre-construction mist netting of 5 sites (Sites 2, 3, 8, 11 and 14) within Section 4 were mist netted from July 28 to August 2, 2010 for the federally endangered Indiana bat (*Myotis sodalis*). A total of 34 bats representing 6 species were captured: 11 eastern red bats (*Lasiurus borealis*), 11 little brown bats (*Myotis lucifugus*), 6 big brown bats (*Eptesicus fuscus*), 4 northern bats (*Myotis septentrionalis*), 1 eastern tricolored bat (*Pipistrellus subflavus*), and 1 Indiana bat (*Myotis sodalis*). A radio-transmitter was placed on 1 adult male Indiana bat. It was tracked for 7 days and roosted in a live shagbark hickory the 1st night; an adjacent live shagbark hickory the 2nd night; a dead snag (sugar maple) with loose bark the 3rd night; a live shagbark hickory the 4th night; and the above snag for the 5th, 6th and 7th nights. The snag is a primary roost with the following counts: 34, 34, 32, 27, and 30. DNA analysis of 20 guano pellets from under the snag showed 18 pellets from *Myotis sodalis* and 2 pellets from *Myotis lucifigus*. Attempts to determine gender from the 20 guano pellets using mammalian primers was unsuccessful. The snag had the lower 20 feet bare and without bark, with the bats under the remaining loose bark above. The life expectancy of the remaining bark is unknown, but ephemeral in nature. Live shagbark hickory and snags are common in this forested area near Little Clifty Branch.

Key Words Indiana bat, *Myotis sodalis*, Indiana, mist netting, radio-telemetry, roost trees, DNA analysis.

INTRODUCTION

This study is part of the Tier 2 Environmental Impact Studies for Section 4 of I-69. Bernardin, Lochmueller and Associates (BLA) conducted these summer mist net surveys for the endangered Indiana bat (*Myotis sodalis*) in the first 5 sites of 11 sites in Section 4. BLA completed field efforts under Federal Endangered Species Permit TE06845-A-0 and State of Indiana Division of Natural Resources Permit No. 10-0111.

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.

USFWS coordination determined that surveys would be conducted at approximately 50 sites through the I-69 project area. The number of sites to be surveyed within each of the six Sections was determined using a prorated percentage based on the length of the Section compared to the entire length of I-69. In the case of Section 4, 11 sites were selected to represent the 26.4 miles that comprise this Section. Specific survey sites were selected based on the capture results of Indiana bats from mist netting studies conducted in 2004 and 2005. In decreasing order of priority, sites were selected if they yielded Indiana bats that were reproductive females, non-reproductive females, males, or exhibited high species diversity.

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The purpose of this study was to evaluate the occurrence of Indiana bats at five of the 11 sites selected for Section 4. These five sites represent that portion of Section 4 between US231 and SR45. As of the summer of 2010, INDOT believed that tree clearing activities required for the construction of the interchanges at US231 and SR45, as well as other locations between US231 and SR45, might begin in the fall of 2010 or prior to the spring of 2011. As such, pre-construction mist netting was conducted at five locations that were approved by USFWS (BFO). These sites included: Site 2 (Doans Creek Maternity Colony); Sites 3, 8, and 11 (Plummer Creek Maternity Colony); and Site 14 near SR45. The remaining 6 sites to be mist netted in Section 4 will be completed during the summer of 2011 prior to the scheduled 2012 start of construction for the portion between SR45 and SR37 within the Lower East Fork Watershed.

The project area for the five sites mist netted in 2010 is the Crawford Upland Section of the Shawnee Hills Natural Region (Homoya et al. 1985). The Crawford Upland Section is hilly and forested. Elevations range from 550 to 900 feet above sea level in Section 4. Open areas are usually pasture unless in bottomlands to the west that allow for row crops.

Caves are common in Section 4 (Bernardin, Lochmueller and Associates, 2003). Sixteen hibernacula for the Indiana bat have been recorded in Greene and Monroe Counties. The nearest cave to the five mist netting sites is Cave. It is a wet cave owned by the Indiana Department of Natural Resources. It supported 20 Indiana bats in 1993, 28 in 1995, 3 in 1999 and none since. It is very close to Site 8. Cave is about 1 mile from Site 14. One male Indiana bat was reported from Cave in September 24-25 of 2004.

Section 4 of the I-69 corridor begins immediately east of US231 in southeast Greene County just north of SR58 near the northwest comer of Crane Naval Surface Warfare Center. It proceeds northeast into Monroe County and ends at SR37 near Victor Pike south of Bloomington. The total length of Section 4 is approximately 26.4 miles. The portion of I-69 from US231 to SR45 is approximately 10.6 miles.

The Indiana bat is a federally endangered species. Population declines and vulnerability to human disturbances in winter prompted its listing by the USFWS on 11 March 1967. A Recovery Plan was developed in 1976 and revised in 1983. A new revision to the Plan is presently underway. Its geographic range is 16 states. The most current range-wide estimate of the population is 387,835 in 2009. This total is a 17.2 % down from 2007.

Previous studies in Section 4 on Indiana bats and I-69 were Jaskula and Brack (13 December 2004), Kudlu and Brack, (14 September 2005), Duffey and Brack, (7 September 2005), and Henry et al. (2005). These are excellent documents that provide life history on the species and specific information on caves and sampling. It is highly recommended that these studies be consulted for additional life history data.

MATERIAL AND METHODS

For the Section 4 Pre-Construction mist netting requirements, 11 of 30 sites surveyed in 2004 were pre-selected by BLA and approved by USFWS. Five of the 11 were approved by USFWS for Pre-Construction Mist Netting in 2010.

The property owners for Sites 2, 3, 8, 11 and 14 were contacted by phone or in person. Permission to mist net was approved by all owners. Property owners not only granted permission, but in some cases came to the mist netting site. All efforts were made to keep them informed of our activities and efforts. Similarly, permission was granted for access to properties for the purposes of radio-telemetry. Specific mist net locations from 2004 were reproduced in 2010 as closely as possible.

This survey was conducted in accordance with the USFWS mist netting guidelines included in Appendix A. Five mist net sites (2 net sets per site) were surveyed for two nights over the period between July 28 and 2 August 2010 for a total of four net nights per site. Net placement was based upon best professional judgment following best use of existing flyways and maximizing such coverage. Radio-telemetry was conducted in accordance with guidelines provided by USFWS in Appendix A. Decontamination of field equipment was conducted in accordance with the white nose syndrome (WNS) protocol in Appendix A. Appendix B includes figures showing the locations of the mist net sites and mist net placement. Appendix C includes tables documenting survey site locations and results. Appendix D includes data sheets. Appendix E includes photos of the net locations.

Site 2 was located in the small community of Doans. A 30’ X 26’ mist net was set up over Doans Creek immediately upstream of a big overhanging rock, while the second net (20’ X 17’) was set up over the frontage road to the property owner’s house. The frontage road was blocked with flagging and cones as was suggested by the owner.

Site 3 was located on a tributary of Black Ankle Creek. Two nets (20’ X 17’) were set up over this creek. The next door neighbor visited both nights.

Site 11 was located on Clifty Branch west of the town of Koleen. Two nets (30’ x 17’) were set up on the main channel. The nearest net was approximately

Site 8 was located across from and east of the town of Koleen. A 20' x 17' was set up over Plummer Creek while the second 20' x 17' net was set up over An adjoining property owner met us in the field the first night.

Site 14 was located over Little Clifty Branch immediately west of A 20' X 17' net was set up immediately upstream of the bridge of a driveway, while the second was set up downstream where is the closest to the stream. The property owner visited the mist net site the second night.

Habitat and meteorological conditions were documented for each mist netting site. Habitat assessment at net sites focused on features indicative of suitability for Indiana bats. Temperature, percent cloud cover, wind, and rainfall were monitored and recorded every half hour during the mist netting effort to insure compliance with weather conditions outlined in the netting guidelines. Table 2 of Appendix C includes temperature ranges for each site for each night. Data sheets for each site are included in Appendix D

Bats were identified to species using a combination of morphological and meristic 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. Age (adult or juvenile) of bats is determined by examining epiphyseal discs of long bones in the wing. Weight was measured to 0.5 gram using a Pesola® 30g spring scale. Length of the right forearm of each bat was estimated to the nearest 1.0 mm using either calipers or metric rule. 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.

Bats were not banded as part of this survey. Bat processing and data collection was typically completed within 30 minutes of the time the bat was removed from the net. Captured bats were marked with a small dab of white correction fluid prior to release in order to document any recaptures.

One male Indiana bats was fitted with a Holohil Systems Ltd. LB-2N radio-transmitter weighing 0.36 grams. The transmitter was activated and tested at the manufacturer's designated frequency before attachment to the bat. A small inter-scapular area was trimmed of fur and the transmitter was attached to this area with non-toxic Torbot Group, Inc. bonding cement. This cement degrades over time and the transmitter falls off the bat. Transmitter weight, weight of the bat before and after transmitter attachment, and holding time were recorded. The male bat was released unharmed at the point of capture.

On subsequent days following release of this transmittered bat, it was tracked to daylight roosts using a Wildlife Materials, Inc. TRX-2000S multiple band receiver equipped with a Wildlife Materials, Inc. three element folding Yagi directional antenna. The transmitted bat was tracked to roosts for a minimum of five days.

Evening emergence counts were conducted for each roost tree discovered through radio-telemetry tracking. Coordination with USFWS clarified that multiple night exit counts were required for only a roost tree with more than 1 bat since the transmittered bat was a male. Exit counts at each roost tree began at sunset, and lasted approximately 1 hour or until bats quit emerging and/or darkness precluded accurate counting. Multiple night exit counts were only required at a dead snag tree identified on the 3rd day of tracking. Roost tree characterization and habitat assessment were documented for

the dead snag and the other temporary roosts used by the male. Completed roost tree and habitat assessment data sheets are included in Appendix D under Site 14.

An Anabat SD 1 (Titley Electronics, PTY, LTD) was deployed at 3 of the 5 sites (Sites 2, 8 and 11) to passively detect and record high frequency bat calls in the general vicinity of the mist netting site. Each call is digitally recorded as an individual file that can be analyzed at a later time. The Anabat SD 1 was typically placed away from the mist nets to record activity in adjacent open habitats in the immediate vicinity where mist netting would be ineffective, but where bat activity was expected. Anabat data was collected for approximately 5 hours each night during the same time frame the mist netting was conducted. All Anabat files will be sorted and sent to USFWS (BFO) for analysis.

On August 11, 2010 guano samples from beneath a dead snag roost tree, where more than 15 bats were recorded during emergence, were collected and shipped to Western Michigan University (Dr. Maarten Vonhof) for DNA analysis to determine species and gender. From the 40 samples submitted, 20 were selected for the analysis. Standard methods for DNA extraction, amplification and sequencing were followed.

RESULTS AND DISCUSSION

In the 2010 survey, a total of 34 bats representing 6 species were captured: 11 eastern red bats (*Lasiurus borealis*), 11 little brown bats (*Myotis lucifugus*), 6 big brown bats (*Eptesicus fuscus*), 4 northern longeared bats (*Myotis septentrionalis*), 1 eastern pipistrelle (*Pipistrellus subflavus*), and 1 male Indiana bat (*Myotis sodalis*). Tables 3 and 4 of Appendix C include capture data by species and reproductive condition for each net site. All five sites yielded at least one bat capture. The most common species were the eastern red bat and little brown bat comprising 65% of the total, followed by the big brown and northern longeared bats comprising an additional 29%. Tricolored and Indiana bats totaled 1 each. The capture of bats in mist nets averaged 1.7 bats/net night. The mean number of bats per net site was 6.8. The mean number of species captured per site was 2.8. Species richness was highest at Site 2 with 5 species. Sites 3 and 11 followed with 3 species, while Site 14 yielded two species (Indiana bat and big brown bat). Table 5 includes a summary of species capture data by sex and capture rates/net night.

In 2004, the northern longeared bat, eastern red bat, and eastern pipistrelle accounted for 73 percent of the total bats captured. The catch of bats in mist nets was 2.1 bats/net night. The mean number of bats per net site was 8.4. The mean number of species captured per site was 3.1. Species richness was highest at Site 2 where six species were captured including two Indiana bats. In 2005, no Indiana bats were captured at Site 2.

In 2010, adult males and females (reproductive and non-reproductive) accounted for 97 percent, while juveniles only accounted for 3%. Nineteen females and 15 males were captured (55:45). The majority of females (13) were non-reproductive; 4 were post-lactating; 1 was lactating; and 1 was a juvenile. Ten males were non-reproductive (non-descended testes) and 5 were reproductive (descended testes). Male little brown bats appeared higher in number than females (8 to 3), while the number of female big brown bats and female eastern red bats appeared higher than males (big brown bat: 5 to 1; eastern red bat: 8 to 3).

In 2004, adult males and females (reproductive and non-reproductive) accounted for 58 percent (137 male individuals) and 40 percent (94 female individuals) of the total capture, respectively. Juvenile males and females accounted for only 2.5 percent (6 individuals) of the total bats captured. Only 6 percent of adult females were non-reproductive. Lactating females accounted for 49 percent of all

reproductive females, followed by pregnant (27%) and post-lactating females (24%). In 2004, female big brown bats and eastern red bats were each significantly more abundant than males. However, male eastern pipistrelles were significantly more abundant than females.

In 2010, one (1) non-reproductive male Indiana bat (No. 297) was captured at Site 14 on the last day of the survey at 1:40 am August 3. According to protocol, a radio-transmitter (Frequency 150.297 MHz) was attached to the bat for the purposes of radio-telemetry tracking (Table 6 of Appendix C). It had an open lesion (pre-existing condition) on its right forearm, but otherwise appeared healthy for use in radio-telemetry. This male bat was released in good condition near the point of capture and tracked briefly in a westerly direction.

This Indiana bat was tracked to daytime roost trees for 7 days. Table 7 of Appendix C provides a matrix of distances between capture Site 14 and each roost tree location for bat No. 297. Tables 8 and 9 of Appendix C provide data on the roost trees and emergence counts.

On Day 1, it roosted in a live shagbark hickory (Roost 297A). Evening exit counts showed it to leave the tree with no other bats observed emerging.

On Day 2, it was found roosting in an adjacent live shagbark hickory (Roost 297B). Evening exit counts showed it to also leave the tree with no other bats observed emerging.

On Day 3, it was found roosting in a dead sugar maple snag (Roost 297C) approximately 980 feet from Roosts 297A and 297B. The snag is a dead tree with no bark for the first 20 feet or so. At approximately 20 feet, a large section of bark has become detached and forms a space of one to two inches between the trunk and the bark. On Day 3, the evening exit count for the snag was 34.

On Day 4, the transmitted bat roosted in a live shagbark hickory (Roost 297D) about 850 feet from Roost 297C. Evening exit counts showed it to leave the tree with no other bats observed emerging. For the 2nd night of emergence counts at the dead snag (Roost 297C), 34 bats were observed emerging.

On Day 5 of the tracking, the male bat returned to the dead snag Roost 297C. For the 3rd night of emergence counts at the dead snag, 32 bats were observed. On Days 6 and 7 following capture, radio telemetry confirmed that the male remained at the dead snag. For the 4th and 5th nights of emergence counts at the dead snag, 27 and 30 bats were observed respectively, Figures 7 and 8 indicate the location of roost trees for Indiana bat No. 297 relative to the capture site and the Section 4 preferred alternative.

The live shagbark hickories are near the alternatives, while the snag is located in the middle of the preferred alternative. Roosts are generally considered ephemeral in nature, as they are generally dead or dying with sloughing or exfoliating bark. Roost suitability depends on whether the tree is alive or dead, the extent of exfoliating or sloughing bark, exposure to solar energy in relation to other trees, and distance to water resources (USFWS 1999).

Roost 297C is considered to be in a Stage 4 (loose bark) state of decay. The lower portion is clean of bark, but the shedding bark occurs within the middle of the tree. How long it might remain as a primary roost is not known; however, it is believed to be ephemeral in nature. The surrounding woods within the Little Clifty Branch valley has mature trees with many shagbark hickory trees and other snags outside the construction limits of the preferred alternative.

The Western Michigan University analysis of the guano from roost tree 297C indicated that this dead snag supports both Indiana bats and little brown bats (Appendix F). Of 20 fecal pellets

analyzed, 18 were Indiana bats and 2 were little brown bats. Two different mammalian primers were used to attempt to determine the gender of each individual that produced each of the 20 fecal pellets. Both primers were inexplicably incapable of differentiating female and male DNA from control tissues derived from known male and female M. sodalis and M. lucifigus sources. Because these primers (which have worked in the past) failed to yield gender results on the control tissues, no attempt to analyze the DNA from the 20 fecal pellets could be conducted, and thus gender was not determined.

The species and number of bats captured in 2010 and 2004 is typical for the geographic location and type of habitat. In 2004, seven species were captured including the hoary bat. In this survey, the same species, with the exception of the hoary bat which is not commonly captured in mist netting surveys, were again determined to be active in the survey area. The capture rate for Indiana bats was 0.1 bats per net night, and the total bat capture rate was 3.4 bats per night.

Similarly, 19 mist netting sites in the 1-69 corridor were surveyed for bats by Dr. John O. Whitaker, Jr. in 1993, the results of which are included in the I-69 Tier I Biological Assessment (BLA 2003). Ten of these sites were located in the Section 4 corridor. Whitaker documented seven bat species. No Indiana bats were captured during the 1993 surveys on Section 4.

During mist net surveys between 1987 and 1998 at Crane Navel Surface Warfare Center (Crane) near Bedford, Indiana, Brack and Whitaker (2004) found 8 species, including 8 Indiana bats (6 males, 2 females). The capture rate for Indiana bats was 0.025 bats per net night, and the total bat capture rate was 1.8 bats per net night.

During 237 net nights of survey from 1981 to 1999 on Hoosier National Forest (HNF), Indiana, Brack et al. (2004) found 10 species, including six Indiana bats (all male). The capture rate for Indiana bats was 0.025 bats per net night, compared to 0.075 bats per net night on Section 4. Total bat capture rate for both HNF and Section 4 was 2.1 bats per net night (Jaskula and Brack, 2004)

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We would like to thank all of the property owners for access to their properties and their support in field efforts. Similarly, we extend our thanks to USFWS and IDNR for permitting and supporting such studies along with INDOT and FHWA funding these endangered species efforts. Also, we would like to thank specifically Kia Gillette, Jaime Sias and Michael Elsner for helping in mist netting and emergence counts without whose efforts we could not have completed the activities.

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Appendix A

USFWS Indiana Bat Mist Netting Protocol

Indiana Bat Radio Telemetry Guidelines

Disinfection Protocol for Bat Field Studies – USFWS Region 3

APPENDIX 5: Indiana Bat Mist-Netting Guidelines

RATIONALE

A typical mist-net 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 mist netting. It will help maximize the potential for capture of Indiana bats at a minimum acceptable level of effort. Although capture of bats confirms their presence, failure to catch bats does not absolutely confirm their absence. Netting effort as extensive as outlined below usually is sufficient to capture Indiana bats if they are present. However, there have been instances in which additional effort yielded detection when the standard effort did not.

Some mist-netting projects will require modification (or clarification) of these guidelines; these situations must be resolved through coordination with the Service Field Office responsible for the state in which your project occurs. Consultation with the Field Office is always recommended, particularly for large-scale netting efforts.

The Service accepts the results of these surveys to determine presence for the purposes of Section 7 consultation. Survey results are valid for at least two years.

NETTING SEASON: May 15 - August 15

May 15-August 15 are acceptable limits for documenting the presence of summer populations of Indiana bats, especially maternity colonies. (However, see Kiser and MacGregor 2005 for precautions regarding early-season surveys between May 15 and June 1, as well as late-season surveys between August 1 and August 15). Capture of reproductive adult females (i.e., pregnant, lactating, or post-lactating) and/or young of the year during May 15-August 15 indicates that a nursery colony is active in the area. Outside these dates, data cannot be used to document the presence or probable absence of summer populations.

EQUIPMENT

Mist nets to be used for Indiana bat surveys should be the finest, lowest visibility mesh commercially available: 1) In the past, this was 1 ply, 40 denier monofilament–denoted 40/1; 2) Currently, monofilament is not available, and the finest on the market is 2 ply, 50 denier nylon denoted 50/2; 3). The finest mesh size available is approximately 38 mm (~1 1/2 in).

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

NET PLACEMENT

Potential travel corridors such as streams or logging trails typically are the most effective places to net. Place nets approximately perpendicular across the corridor. Nets should fill the corridor from side to side and from stream (or ground) level up to the overhanging canopy. A typical set is 7 m high consisting of three or more nets stacked on top one another and up to 20 m wide. (Nets of different width may be used as the situation dictates).

Occasionally it may be desirable to net where there is no good corridor. Take caution to get nets up into the canopy. The typical equipment described in the section above may be inadequate for these situations, requiring innovation on the part of the researchers.

Exercise safety precautions when placing nets. Poles and nets must be clear of overhead wires.

See Kiser and MacGregor (2005) for additional discussion of net placement.

RECOMMENDED NET SITE SPACING

Stream and other linear corridors – one net site per km (0.6 mi) of stream or corridor.
Non-corridor study areas – two net sites per square km of habitat (equivalent to one net site per 123 acres).

The Service Field Office responsible for the state in which your project occurs should be consulted during survey design to resolve issues related to net site spacing for specific projects.

MINIMUM LEVEL OF EFFORT

Netting at each site should include at least four net nights, consisting of: 1) a minimum of two net locations at each site (at least 30 m apart, especially in linear habitat such as a stream corridor); and 2) a minimum of two nights of netting (i.e., two net locations for two nights = four net nights per site). A "net night" is defined as one net set up for one night. The sample period should begin at sunset and continue for at least 5 hours (longer sample periods may improve success). For purposes of determining presence or probable absence of Indiana bats, four net nights at a site are not required if Indiana bats are caught sooner (i.e., if Indiana bats are caught on the first night of netting, a second night is not required for purposes of documenting presence).

CHECKING NETS

Each net should be checked approximately every 10 minutes. Some researchers prefer continuous monitoring (with or without an electronic bat detector); care must be taken to avoid noise and movement near the nets if this technique is used. When monitoring the site continuously with a bat detector, bats can be detected immediately when they are captured in the net. Prompt removal from the net decreases stress on the bat and potential for the bat to escape (MacCarthy et al. 2006). Monitoring the net with a bat detector also allows the researcher to assess the effectiveness of their net placement (i.e., if bats are active near the nets but avoiding

capture); this may allow for adjustments that will increase netting success on subsequent nights. There should be no disturbance near the nets, other than to check nets and remove bats.

WEATHER AND LIGHT CONDITIONS

Severe weather adversely affects capture of bats. If Indiana bats are caught during weather extremes, it is probably because they are at the site and active despite inclement weather. On the other hand, if bats are not caught, it may be that bats are at the site but inactive due to the weather. Negative results combined with any of the following weather conditions throughout all or most of a sampling period are likely to require additional netting: 1) precipitation; 2) temperatures below 10°C; and/or 3) strong winds (use good judgment-- moving nets are more likely to be detected by bats). Further, consider human safety when netting during adverse weather.

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

DOCUMENTATION OF *MYOTIS SODALIS* CAPTURES

Photo documentation of *M. sodalis* captured during mist netting is not required, but is encouraged. Photos taken of a bat's head, calcar, tragus, toe hairs, etc. using a macro lens or a digital camera's macro-mode are often diagnostic and aid in validating the record.

If a bat from the genus *Myotis* is captured during mist netting that cannot be readily identified to the species level, species can be verified through fecal DNA analysis. Collect one or more fecal pellets (i.e., guano) from the bat in question by placing it temporarily in a holding bag (15 minutes is usually sufficient, no more than 30 minutes is recommended). The pellet (or pellets) collected should be placed in a 1.5 ml vial with silica gel desiccant; pellets from each individual bat should be stored in separate vials. Samples should be stored out of direct light. Samples should be shipped to Dr. Jan Zinck, Department of Biology, Portland State University, 630 SW Mill St., Portland, Oregon, 97201 for subsequent fecal DNA analysis to assign or confirm the specimens' identification to the species level. The current cost for sequencing is approximately $50 per individual pellet of guano. Contact Dr. Zinck (e-mail: zinckj@pdx.edu) prior to shipping samples. To our knowledge, this is the only lab that currently provides this service. Any additional information (or additional sources) on this technique will be made available on the Indiana bat webpage on the Service's Region 3 website (www.fws.gov/midwest).

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Radio Telemetry of Selected Indiana Bats

Our primary goal in conducting radio telemetry is to locate and enumerate as many maternity colonies and their maternity roost trees (primary and alternate) as possible that may be present within the I-69 Action Area so that I-69 related impacts may be avoided and/or minimized. For this reason, we request that surveyors attach radio transmitters to the first two bats that are either reproductively active adult females or juveniles at each site. As a general rule, the attached transmitter and adhesive should not weigh more than 10% of a bat's weight. Transmitters may be placed on pregnant females, but please use your professional judgment as to whether the bat will be overly stressed from the additional weight. If two *Myotis sodalis* are captured and radio-tagged on the first night of netting at a site, but can not be located the following day, the second night of netting should be completed in hopes of capturing an additional adult female or juvenile *Myotis sodalis* that could also be radio-tagged. We do not believe it is necessary to radio-tag more than three *Myotis sodalis* at any one survey site.

You are welcome to radio-tag and track males and non-reproductive females, but if your number of transmitters is limited, then they should be held in reserve for higher priority bats (reproductively active adult females and juveniles). However, if you are approaching the completion of your assigned surveys and still have not used most or any of your radio transmitters, then it is O.K. to start placing some of them on adult male or non-reproductive females. We would rather have some roosting data generated from these individuals than to have no roosting data at all. Of course, some transmitters should still be held in reserve until all of your sites have been surveyed in case females and/or juveniles are captured at the last few sites.

To fulfill Term and Condition No. 1 of the December 3, 2003 I-69 Biological Opinion and Incidental Take Statement, surveyors are to track all radio-tagged bats to their diurnal roosts for <u>at least 5 days</u> (do not necessarily have to be consecutive days). However, we highly encourage surveyors to voluntarily continue daily tracking each bat for as long as feasible to generate more data and to allow a more complete picture of each colony's roosting behavior. An exhaustive search should be conducted during daylight hours in an attempt to locate each radio-tagged bat's diurnal roost tree each day. Land owners should be notified before entering their property to search for a roost tree.

Disinfection Protocol for Bat Field Studies
U.S. Fish and Wildlife Service – Region 3
July 2009

To minimize the potential for transmission of white-nose syndrome (WNS) while handling bats (both between handler and bats and between bats), these procedures shall be implemented. To date, WNS has been discovered in the northeastern U.S. and mid-Atlantic states.[1] The Midwest Region of the U.S. Fish and Wildlife Service (Service) has implemented these protocols in the interest of preventing WNS from spreading any further. In addition, we recommend that these guidelines be used any time people handle wildlife to minimize potential disease-related impacts to wildlife and people. Please note that individual states may have additional permitting requirements above and beyond these general procedures. In addition, these guidelines may be revised upon review of new information.

Any equipment that comes in contact with bats, with individuals handling bats, or the environments where bats occur, has the potential to be a vector for spread of WNS. Examples include mist nets, harp traps, bat bags, wing biopsy punches, weighing tubes, rulers, clothing, and gloves.

Decontamination requirements target the fungus *Geomyces* sp., which, to date, has been the most consistent pathogen recovered from bats exhibiting signs of WNS. Fortunately, many of the disinfectants and techniques tested for efficacy against the fungus are also suitable to kill other bacterial or viral agents should another causative agent of this disease be identified.

CAUTION: Disinfectant efficacy is based on application to hard, nonporous surfaces and the ability to prevent the regrowth of *Geomyces* sp. on artificial culture media. Tests are currently being conducted on porous fiber materials such as ropes and harnesses to determine disinfectant efficacy to kill the fungus on these substrates and their effects on gear integrity. The repeated use of disinfecting agents may compromise the effective use of vertical equipment; therefore, this equipment should be dedicated to one cave or not used at all.

Although a site may be affected with WNS, it should not be assumed that all individual bats within the site are infected or will become infected, and thus, care should be taken not to cross-contaminate specimens by lax handling methods. This is especially true if samples are to be submitted for diagnostic purposes.

Decontaminate all clothing, footwear, and gear prior to departing for a bat netting or cave outing if you did not decontaminate these items after last netting activity or exiting a cave. In affected and adjacent states, you may not take gear into a cave if that gear cannot be thoroughly decontaminated or disposed of (i.e. if harnesses, ropes, or webbing cannot be decontaminated, we advise that you not enter caves or parts of caves requiring use of this gear). In addition, only bring essential equipment used for bat netting and processing to a site; other non-essential items should be left home as they may contribute to spreading the fungus.

[1]WNS Affected States: Connecticut, Massachusetts, New York, New Jersey, New Hampshire, Pennsylvania, Vermont, Virginia and West Virginia

PROCEDURES:

Vehicles:

Do not put bats in vehicles. Vehicles used to transport equipment may harbor spores. Do all processing on vehicle hood or on a table away from the vehicle. The tailgate is not preferred since it is likely near netting equipment. A drawstring garbage bag should be placed at each site outside the field vehicle each night so all contaminated bags, gloves, wipes, etc., are contained.

Submersible Gear (i.e. clothing and soft-sided equipment):

- For clothing – Wash all clothing and any appropriate equipment in washing machine using the hottest cycle possible for material and conventional detergents. Laboratory testing has found Woolite® fabric wash the best surfactant for clothing. Rinse and air dry. Then follow by soaking with sodium hypochlorite bleach (i.e. household bleach) solution diluted to 1 part bleach to 10 parts water in a tub or plastic container. Soak for 10 minutes. Rinse and air dry.

- For other submersible gear (i.e. bags, gloves, nets, etc.) – Disinfect any equipment that can be submersed in a solution with an appropriate and compatible disinfectant such as sodium hypochlorite bleach (i.e. household bleach) solution diluted to 1 part bleach to 10 parts water in a tub or plastic container or ≥ 3% concentration of quaternary ammonium compounds (i.e. Sparquat 256, Lysol® All-purpose Professional Cleaner, or the antibacterial form of Formula 409®). Keep submersed for 10 minutes. Rinse and air dry.

Nets:

- Use separate sets between states affected by WNS[1] and unaffected states.

- Under no circumstances should nets that have been used in an affected site be used in an unaffected site. Contact your state wildlife agency (www.fws.gov/offices/statelinks.html) for county by county listings for WNS affected and unaffected sites.

Bats should be kept in breathable holding bags rather than holding cages. To avoid cross-contamination of samples, it is imperative to keep bats separated using holding bags that are kept as clean as possible. Non-disposable holding bags should be used only once per night of field work and should be washed and decontaminated (following procedures above) and dried between nights of use. Disposable paper bags are also a convenient option for holding bats temporarily. Only one bat should be in a given bag, and that bag should not be reused during the field night. White paper bags are best to avoid misplacing bats in the woods.

Disposable latex gloves should be worn over handling gloves and changed in between handling each bat. Disposable gloves should be one size larger than the handling gloves. Smooth leather gloves may be wiped down with a disinfectant (i.e. Purell®, Lysol® disinfecting wipes or alcohol wipes) in between handling bats. If only using leather gloves, each handler should have several sets of gloves to interchange in between handling bats. This allows time to effectively kill the fungus and for the

[1]WNS Affected States: Connecticut, Massachusetts, New York, New Jersey, New Hampshire, Pennsylvania, Vermont, Virginia and West Virginia

disinfectant to completely dry. After each night of netting (or prior to the next night of use), remove heavy soil deposits from surface of bags and gloves, soak in an appropriate disinfectant, then dry completely.

For situations when gloves may hinder field work (i.e. transmitter attachment) and bats come in contact with bare hands, apply hand sanitizer with alcohol (i.e. Purell®) after handling each bat. Make sure it dries completely before handling the next bat.

Non-submersible Gear (i.e. hard-sided equipment):

- For non-submersible gear (i.e. bat processing equipment, mist net poles, harp trap frames and legs, folding chairs, etc.) – Disinfect any equipment that cannot be submersed by applying an appropriate and compatible disinfectant to the outside surface by using ≥ 3% concentration of quaternary ammonium compounds such as Sparquat 256, Lysol® All-purpose Professional Cleaner or the antibacterial form of Formula 409®, or use sodium hypochlorite bleach (i.e. household bleach) solution diluted to 1 part bleach to 10 parts water. Keep on surface for 10 minutes. Rinse and air dry.

- For boots – Boots need to be fully scrubbed and rinsed so that all soil and organic material is removed. The entire rubber and leather boot, including soles and leather uppers, can then be disinfected with an appropriate disinfectant such as ≥ 3% concentration of quaternary ammonium compounds (i.e. Sparquat 256, Lysol® All-purpose Professional Cleaner or the antibacterial form of Formula 409®) and sodium hypochlorite bleach (i.e. household bleach) solution diluted to 1 part bleach to 10 parts water. Keep on surface for 10 minutes. Rinse and air dry.

Use one of the disinfecting agents listed above to sanitize all equipment that comes into contact with a bat's body, including light boxes, banding pliers, rulers, calipers, scale, etc. Any instrument coming into direct contact with bat skin should be rinsed free of chemical disinfectant using clean water or physiologic (0.9%) saline. Clean items after handling each bat. If using containers to weigh bats, separate containers used to weigh tree bats from cave bats, do not place tree bats in the same container previously used for a cave bat. Containers used to weigh bats (film canisters, baggies, cardboard rolls) should be disinfected in between handling each bat. Paper lunch bags can be used for holding and weighing individual bats, and can be immediately discarded after each use. Plastic baggies can also be used to line weighing containers, and bats can even be held in unsealed plastic bags during forearm measurements, reducing contact with wing rulers or calipers. Discard used bags after each bat. Disinfect gloves or discard disposable gloves after handling each bat.

Harp traps:

- Use separate traps between states affected by WNS[1] and unaffected states. Under no circumstances should traps that have been used in an affected site be used in an unaffected site. Contact your state wildlife agency for county by county listings for WNS affected and unaffected sites.

[1]WNS Affected States: Connecticut, Massachusetts, New York, New Jersey, New Hampshire, Pennsylvania, Vermont, Virginia and West Virginia

- Each night after use in affected states[1], remove any dirt/debris from wires/lines and bags, and spray on one of the above-listed disinfecting agents. Swab the bag with disinfectant and allow to dry completely (preferably in the sun) prior to the next use. Do not use equipment in an unaffected site following use in affected sites.

- Bats should not be allowed to remain in the catch bag for more than 10 minutes. Checking the catch bag more frequently will reduce the amount of time that bats are in contact with each other. Bats collected should then be put in their own bag until processing is complete. Disposable bags should be discarded after handling each bat and reusable bags should be decontaminated using one of the disinfecting agents listed above. To reduce cross-contamination, the catch bag may also be lined with a sheet of plastic and replaced with new plastic after every hour or wiped down with one of the disinfecting agents above.

Cameras, Computers, and Other Electronic Equipment:
If possible, do not bring electronic equipment to a netting site. If practical, cameras and other similar equipment that must be brought to a site may be wrapped in plastic wrap where only the lens is left unwrapped to allow for photos to be taken. The plastic wrap can then be decontaminated by using Lysol® disinfecting wipes and discarded after use. If using plastic wrap is not practical, alcohol wipes or Lysol® disinfecting wipes can be applied directly on surfaces.

Wing Biopsies:

If collecting wing biopsies for any approved research studies on Federally threatened or endangered bats, use a new (unused) punch for each bat. For other bats, punches may be reused, but only if they are still sharp enough to make clean punches. If there is evidence of fungal infection on any individual, use new punches. Be sure to completely sterilize recycled punches between bats by dipping the cutting end in alcohol and flaming until it naturally extinguishes, and then allowing them to cool completely. The cutting board must also be disinfected between processing individual bats using one of the agents detailed above. Disposable, stiff cardboard squares (1 per individual) can be used as an alternate surface for biopsy.

Notification of Signs of WNS
As a reminder, the white fungus is only one of the signs of WNS. We do not expect to find bats with fungus on them during the summer or fall, but bats could still be infected during these seasons. Other possible signs of WNS may be damage to wings and tail membranes in the form of lesions, flakiness or dehydrated skin, discolored spots/scarring, multiple holes, or tears to leading edge of membranes. We encourage the use of Reichard's Wing Damage Index (link below) for assessing bats. Please photograph any damage you observe and report it to the nearest U.S. Fish and Wildlife Service Field Office and the state agency that issued your bat handling permit within 24 hours.
http://www.fws.gov/northeast/PDF/Reichard_Scarring%20index%20bat%20wings.pdf

Important Note: These protocols are posted on the U.S. Fish and Wildlife Service Midwest Region website at: http://www.fws.gov/midwest/Endangered/mammals/BatDisinfectionProtocol.html. Please visit the site at least once every six weeks to ensure that you are using the most recent protocol in your permitted activities.

[1]WNS Affected States: Connecticut, Massachusetts, New York, New Jersey, New Hampshire, Pennsylvania, Vermont, Virginia and West Virginia

What is known about *Geomyces* sp. viability:

- The fungus survives exposure to mammalian body temperature (38° C/100° F) for at least 3 days, but does not remain viable after 8 days (W. Stone, NYSDEC, pers. communication 4/14/09).

- The fungus survives exposure to temperature (30° C/86° F) for at least 15 days. (W. Stone, NYSDEC, pers. communication 4/14/09).

- Short-term incubation of fungus at higher temperatures reduces the number of conidia present and alters the morphology of the hyphae which may not inhibit growth once returned to colder temperatures (W. Stone, NYSDEC and D. Blehert, USGS NWHC, pers. communication 4/14/09).

- Clothes dryer heat treatment (49° C/ 120° F) alone increases fungal spore germination and does not kill the fungus (H. Barton, NKU, pers. communication 4/22/09).

What kills the *Geomyces* sp. fungus:

Method	Conditions	Kill Time	Source	Cautions*
Disinfectant				
5.25% Chlorine bleach	10% bath solution (1 part bleach: 9 parts water)	10 min	Over the counter	Inactivated by organic material, detergents; corrosive to metals; produces toxic gas if combined with ammonia; skin irritant
Lysol® Professional Antibacterial All Purpose Cleaner	1:128 bath solution (1 oz per 1 gal water)_	10 min	Janitorial supply	Corrosive; skin & eye irritant
	1:64 bath solution (2 oz per 1 gal water)	5 min		
Sparquat 256	½ oz per 1 gal water	10 min	www.chemsearch.com	May require license to obtain; requires special disposal methods
Promicidal™	1:128 bath solution (1 oz per 1 gal water)	10 min	www.chemsearch.com	May require license to obtain; requires special disposal methods
Grenadier™	1:64 bath solution (2 oz per 1 gal water)	10 min	www.chemsearch.com	May require license to obtain; requires hazardous waste disposal methods

[1]WNS Affected States: Connecticut, Massachusetts, New York, New Jersey, New Hampshire, Pennsylvania, Vermont, Virginia and West Virginia

	1:32 bath solution (4 oz per 1 gal water)	5 min		
Formula 409®	At least 0.3% concentration	10 min	Over the counter	
Woolite®	Refer to product label		Over the counter	
Dawn® antibacterial hand soap	Refer to product label		Over the counter	
Purell®	Refer to product label		Over the counter	
Lysol® disinfecting wipes	Refer to product label		Over the counter	
70%-95% ethanol	Undiluted bath	2 min	Lab supply distributor	Flammable, skin irritant
Temperature				
Dry heat	110° F/ 43°C	12 hr	Oven, incubators	
	165° F/ 74° C	15 min		
	175° F/ 79° C	5 min		
	180° F/ 82° C	5 min		
Sterilization				
Steam autoclave	121 F; 15 psi	15 min	Laboratory or hospital settings	
Gas sterilization	Ethylene oxide	16-18 hr	Only available at hospitals	
Flame sterilization	Alcohol & open flame	15-20 sec		Fire hazard; burn injuries

* Effects of different decontamination methods on the integrity of caving equipment are currently being tested.

Important Note: These protocols are posted on the USFWS Midwest Region web site at:
http://www.fws.gov/midwest/Endangered/mammals/BatDisinfectionProtocol.html
You are responsible for visiting the site at least once every six weeks to ensure that you are using the most recent protocol in your permitted activities.

[1]WNS Affected States: Connecticut, Massachusetts, New York, New Jersey, New Hampshire, Pennsylvania, Vermont, Virginia and West Virginia

Appendix B: *Figures* has been removed for confidentiality reasons related to the federally endangered Indiana bat (*Myotis sodalis*)

Appendix C

Tables

Table 1. GPS coordinates for mist netting survey sites for I-69 Section 4 in 2010

Site	County	UTM Coordinates (meters)		
		Northing	Easting	UTM Zone
2	Greene			
3	Greene			
8	Greene			
11	Greene			
14	Greene			

Table 2. Maximum and minimum temperatures recorded during mist netting surveys for I-69 Section 4 in 2010

Site	Date	Maximum Temp		Minimum Temp	
		°C	°F	°C	°F
2	28 July 2010	24.9	76.8	23.0	73.4
	29 July 2010	25.5	77.9	19.7	67.5
3	30 July 2010	21.0	69.8	20.0	68.0
	31 July 2010	24.4	75.9	20.9	69.6
8	1 August 2010	23.5	74.3	19.4	66.9
	2 August 2010	24.0	75.2	21.0	69.8
11	30 July 2010	26.1	79.0	20.7	69.3
	31 July 2010	25.0	77.0	21.8	71.2
14	1 August 2010	24.3	75.7	18.7	65.7
	2 August 2010	25.1	77.2	21.5	70.7

Table 3 Site specific and date specific data for mist net survey bat captures by sex and reproductive condition.

Site #	Date	Indiana bat								Little brown bat								northern longear bat								big brown bat								eastern red bat								tricolored bat								Total # of bat per site & night	Total # of bats per site
		Adult female - pregnant	Adult female - lactating	Adult female - post lactating	Adult female - non-reproductive	Juvenile female	Adult male - reproductive	Adult male - non-reproductive	Juvenile male	Adult female - pregnant	Adult female - lactating	Adult female - post lactating	Adult female - non-reproductive	Juvenile female	Adult male - reproductive	Adult male - non-reproductive	Juvenile male	Adult female - pregnant	Adult female - lactating	Adult female - post lactating	Adult female - non-reproductive	Juvenile female	Adult male - reproductive	Adult male - non-reproductive	Juvenile male	Adult female - pregnant	Adult female - lactating	Adult female - post lactating	Adult female - non-reproductive	Juvenile female	Adult male - reproductive	Adult male - non-reproductive	Juvenile male	Adult female - pregnant	Adult female - lactating	Adult female - post lactating	Adult female - non-reproductive	Juvenile female	Adult male - reproductive	Adult male - non-reproductive	Juvenile male	Adult female - pregnant	Adult female - lactating	Adult female - post lactating	Adult female - non-reproductive	Juvenile female	Adult male - reproductive	Adult male - non-reproductive	Juvenile male		
Site 2	28-Jul															1												1	1							1											1					5	12
	29-Jul														1						1		1						1								3															7	
Site 3	30-Jul																			1									1								2	1														5	8
	31-Jul																							1																2													3	
Site 8	1-Aug														2																																						2	3
	2-Aug												1																																								1	
Site 11	30-Jul										1					2													1								1															5	9
	31-Jul											1				2																							1														4	
Site 14	1-Aug																																																			0	2
	2-Aug							1																								1																				2	
Totals								**1**			**1**	**1**	**1**		**3**	**5**				**1**	**1**		**1**	**1**				**1**	**4**			**1**				**1**	**6**	**1**	**1**	**2**					**1**					**34**	

Table 4 2010 bat capture summary by sex and reproductive condition for five mist net sites in Section 4.

Species	Adult					Juvenile		Total
	Male	Female[1]				Male	Female	
		P	L	PL	NR			
Indiana bat	1							1
little brown bat	8		1	1	1			11
northern longear bat	2			1	1			4
big brown bat	1			1	4			6
eastern red bat	3			1	6		1	11
tricolored bat					1			1
Total	15	0	1	4	13	0	1	34

[1] P = pregnant; L = lactating; PL = post-lactating; NR = non-reproductive

Table 5 Bats captured by sex and capture/net-night data for five net sites in Section 4.

Species	Male		Female		χ^2	*P*	Capture/net-night
	Number	Percent	Number	Percent			
Indiana bat	1	6.7	0	0.0	*	*	0.05
little brown bat	8	53.3	3	15.8	*	*	0.55
northern longear bat	2	13.3	2	10.5	*	*	0.20
big brown bat	1	6.7	5	26.3	*	*	0.30
eastern red bat	3	20.0	8	42.1	*	*	0.55
tricolored bat	0	0.0	1	5.3	*	*	0.05
Total	15	100.0	19	100.0			1.70

*The use of the Chi-squared test is not appropriate because in each case more than 20% of the expected frequencies are less than 5.

Table 6 Condition and telemetry information for single individual Indiana bat captured from five net sites in Section 4.

Bat Number	Capture Date	Capture Site	Transmitter Frequency	Sex	Age Class	Reproductive Condition	Number of Roosts
297	8/2/10	14	150.297	M	Adult	Non –Descended	4

Table 7 Capture site and roost tree distance matrix for Indiana bat 297

	Capture Site 14	Roost 297A	Roost 297B	Roost 297C	Roost 297D
Capture Site 14		505 m 1656 ft.	495 m 1624 ft.	728 m 2388 ft.	471 m 1545 ft.
Roost 297A	505 m 1656 ft.		14 m 46 ft.	299 m 981 ft.	141 m 462 ft.
Roost 297B	495 m 1624 ft.	14 m 46 ft.		298 m 978 ft.	128 m 420 ft.
Roost 297C	728 m 2388 ft.	299 m 981 ft.	298 m 978 ft.		259 m 850 ft.
Roost 297D	471 m 1545 ft.	141 m 462 ft.	128 m 420 ft.	259 m 850 ft.	

Table 8 Summary of roost tree information for radio-transmitted Indiana bat 297.

Bat Number	Roost ID	Tree Species	Condition	dbh (cm)	Exfoliating bark %	Canopy closure %	Roost height (m)	Roost Habitat
297	297A	*Carya ovata* shagbark hickory	Live	51	30	90	unknown	upland
	297B	*Carya ovata* shagbark hickory	Live	43	30	90	unknown	upland
	297C	*Acer saccharum* red maple	Dead	40	2	70	6	riparian
	297D	*Carya ovate* shagbark hickory	Live	38	50	80	unknown	upland

Table 9 Roost tree character and emergence count results for Indiana bat 297

Roost ID	Tree Species	Roost Tree dbh	Condition	Emergence Count Date	Emergence Count
297A	*Carya ovata* shagbark hickory	51 cm 20 in.	Live	8/3/10	1
297B	*Carya ovata* shagbark hickory	43 cm 17 in.	Live	8/4/10	1
297C	*Acer saccharum* red maple	41 cm 16 in.	Dead snag	8/5/10 8/6/10 8/7/10 8/8/10 8/9/10	34 34 32 27 30
297D	*Carya ovata* shagbark hickory	38 cm 15 in.	Live	8/6/10	1

Appendix D: *Data Sheets* has been removed for confidentiality reasons related to the federally endangered Indiana bat (*Myotis sodalis*)

Appendix E

Photos

Photo #1 - Site 2 - Net 1 (7/28/10)

Photo #2 - Site 2 - Net 2 (7/28/10)

Photo #3 - Site 2 - Anabat (7/28/10)

Photo #4 - Site 3 - Net 1 (7/31/10)

Photo #5 - Site 3 - Net 2 (7/31/10)

Photo #6 - Site 8 - Net 1 (8/2/10)

Photo #7 - Site 8 - Net 2 (8/2/10)

Photo #8 - Site 8 - Anabat (8/2/10)

Photo #9 - Site 11 - Net 1 (7/31/10)

Photo #10 - Site 11 - Net 2 (7/31/10)

Photo #11 - Site 11 - Anabat (7/31/10)

Photo #12 - Site 14 - Net 1 (8/2/10)

Photo #13 - Site 14 - Net 2 (8/2/10)

Photo #14 - Indiana bat 297 right wing calcar (8/2/10)

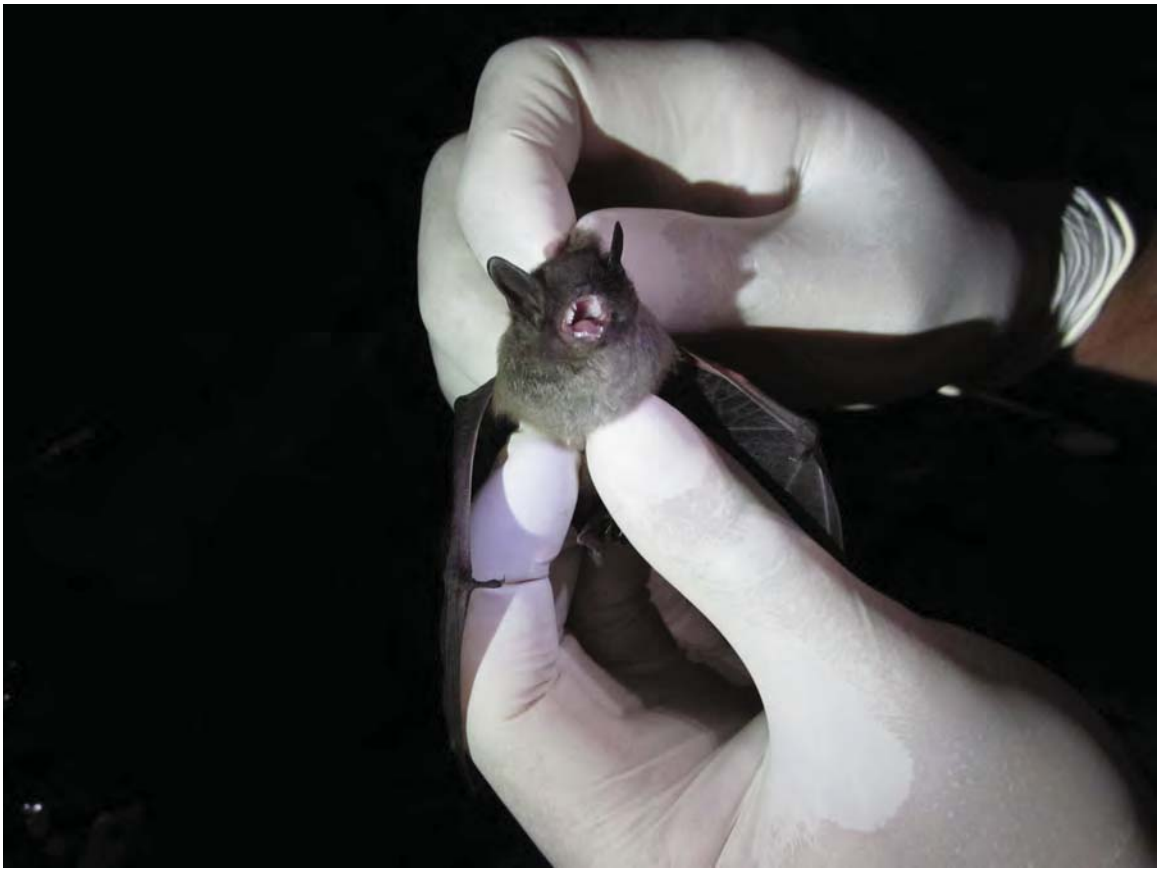

Photo #15 - Indiana bat 297 (8/2/10)

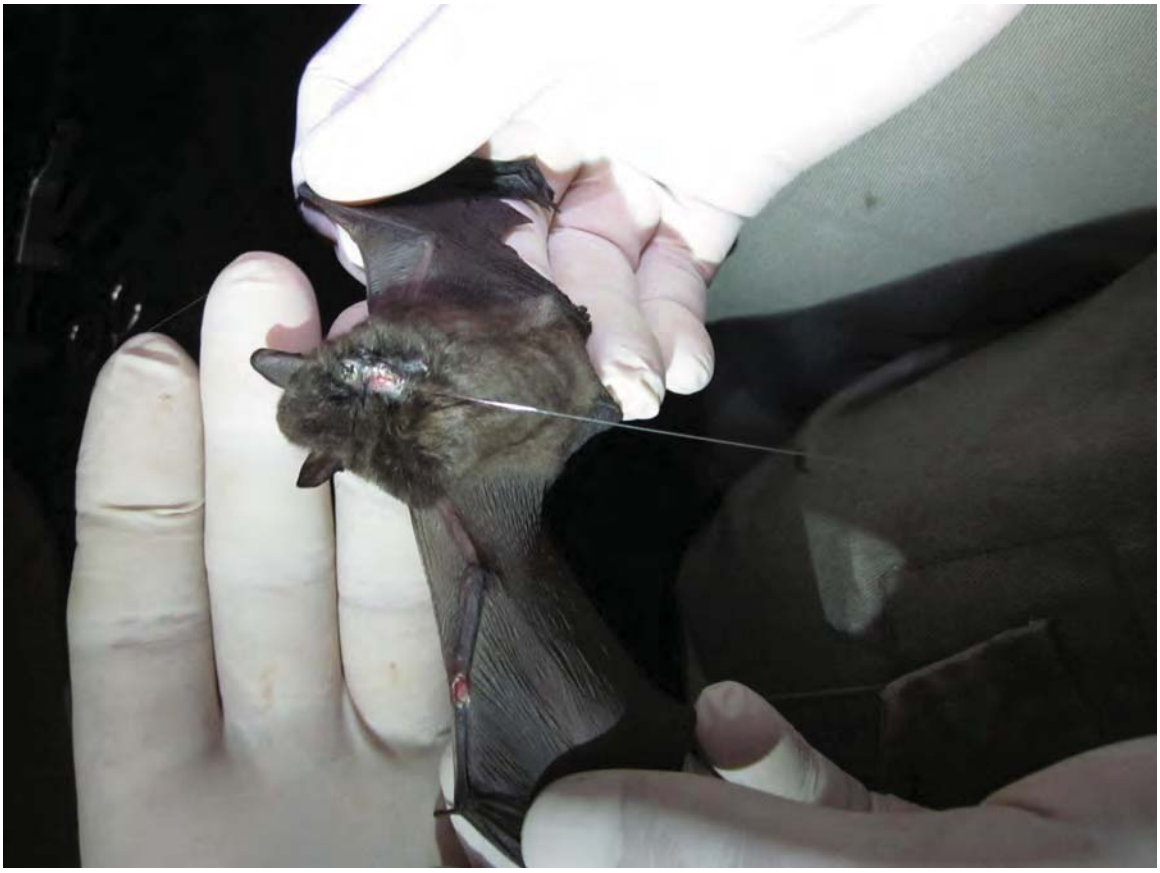

Photo #16 - Indiana bat 297 with transmitter - lesion on left forearm (8/2/10)

Photo #17 - Roost 297A (8/3/10) south side facing north

Photo #18 - Roost 297C (8/6/10)

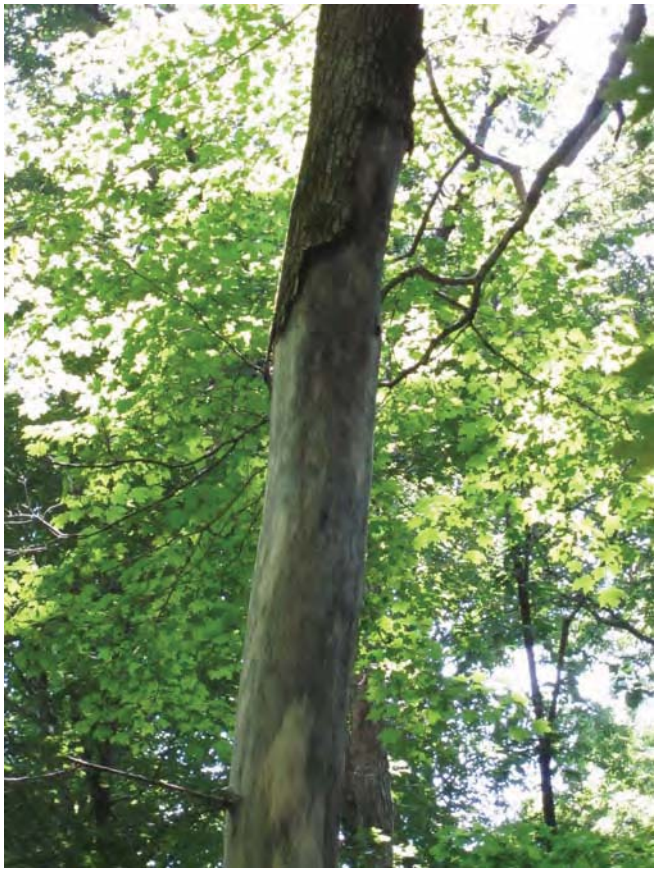

Photo #19 - Roost 297C (8/6/10) loose bark is the single point of emergence

Photo #20 - Roost 297D (8/6/10) west side facing east

Appendix F

Western Michigan University

Molecular Species and Gender Assessment

Molecular Species and Gender Assessment of Bats Utilizing a Roost Near an Interstate Expansion Project

Submitted by

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October 19, 2010

Introduction

Accurate species identification is a critical precursor to activities associated with Endangered Species Act compliance. A colony of bats was found roosting in a tree associated with a proposed interstate project in the summer of 2010, and fecal samples were collected from that roost. I used molecular markers to identify the species of bat that deposited these samples.

Methods

DNA was extracted from 20 fresh fecal pellets using commercial DNA extraction kits (QiagenDNeasy kits) following manufacturer's protocols. Two primer sets were used to amplify two variable regions of the 12S and 16S Ribosomal subunits of the mitochondrial genome: Mysp1 (5'GCACCTAGTTTACACCTAGAAGATT3')/Mysp2 (5'TCTTTCATTTWTTCCCTTACGGTAC3') and Mysp3 (5'AGAAGCAATAATGTTAATATGAG3')/Mysp4 (5'GCCGAGTTCCTTTTACTTCTTTT3') (Zinck et al. 2004). Amplifications were carried out using Pure-TaqPCR Ready-To-Go Beads (Amersham Bioscience), with 10 pmol of each primer, 20 ng of DNA, and water to a final

volume of 25 μL. Amplification was performed on a PTC-200 thermal cycler (MJ Research) under the following conditions: 2 min at 95 °C; 28 cycles of 1 min at 95 °C, 1 min at 55 °C; 1 min 30 s at 72 °C; and final extension at 72 °C for 7 min.

PCR products were cleaned using a PCR Product Pre-Sequencing Kit (USB Corp), and sequenced on an ABI 3100 Automatic sequencer. Sequences were checked and aligned using CodonCode Aligner (CodonCode Corp). Identical haplotypes were identified using Collapse1.2, and a neighbor-joining tree based on simple *p* distances was assembled using Mega 4.0, with the inclusion of three reference sequences for *Myotis sodalis*, and two reference sequences each for *M. lucifugus* and *M. septentrionalis*. The neighbor-joining analysis grouped sequences based on their similarity (based on a genetic distance), and therefore individuals from the same species grouped together.

I attempted to assess the gender of the bats using a short section of the SRY gene, using the primers and methodology of Bryja and Konecny (2003). These primers either amplify a short segment (~202 bp) of the gene for males, or fail to amplify for females. Because of the possibility of false negatives (e.g., no band in a male due to PCR failure), the reaction was multiplexed with Zinc Finger gene primers from Aasen and Medrano (1990) as a PCR control. Amplifications were run on a 1% agarose gel, and visualized using SYBRgold stain on a UV transilluminator. I tested the primers using DNA from eight known-sex individuals for which I had tissues in my collection. This sample included two males and two females for both *M. sodalis* and *M. lucifugus*. However, despite repeated attempts with different PCR and cycling conditions, and the use of an alternate set of primers (RG4/RG7; Griffiths and Tiwari 1993) for the SRY gene, I could not obtain the appropriate banding pattern for males of either species. Because the gender test did not work on

known controls, I did not attempt to perform the gender test on the DNA derived from the fecal samples.

Results

There were a total of seven unique haplotypes among the 20 pellets sequenced. One haplotype (found in two fecal pellets) grouped with *M. lucifugus*, and was identical to that of a known individual from Essex County, New York. The other six haplotypes (representing the other 18 pellets) grouped with *M. sodalis* (Figure 1). One of these haplotypes (I69-04, present in 12 pellets) was identical to that of known individuals from Cave in Missouri and Cumberland Gap Cave in Virginia.

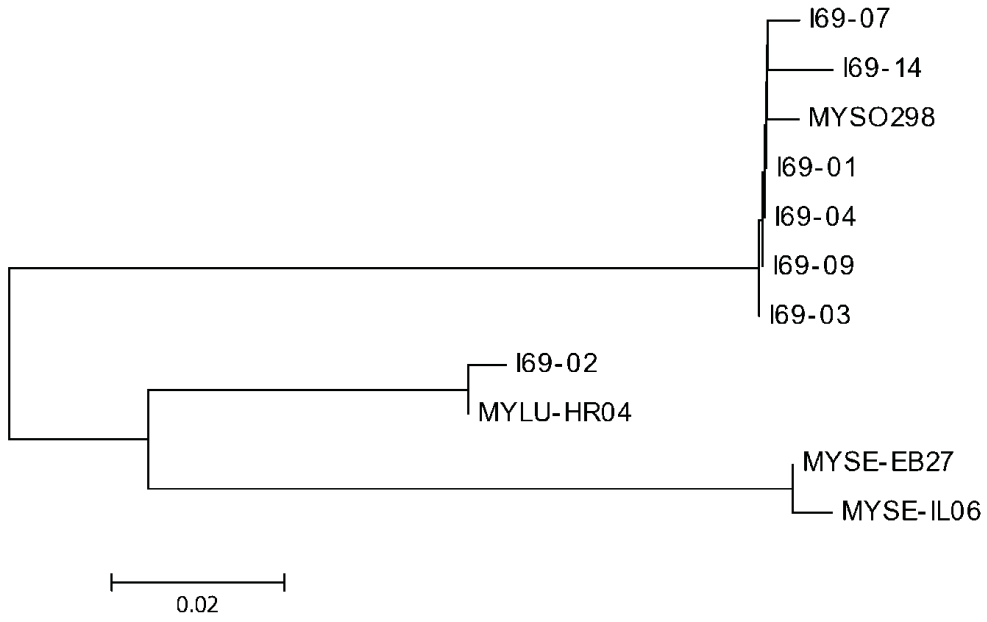

Figure 1. Midpoint-rooted neighbor-joining phylogram showing the clear grouping of pellet haplotypes (seven total, 'I69' labels represent numbers given to individual fecal pellets from which the sequences were derived) with known sequences of *M. sodalis*.and*M. lucifugus.*

Discussion

There are limitations to the approach of sequencing individual pellets that must be kept in mind. Individual bats can produce many fecal pellets in a given day, and thus I assumed that a random sample of fecal pellets produced by all of the individuals that had recently used the roost in question was collected (rather than 20 pellets from the same individual). If this assumption is invalid, then we may have sampled the DNA from only a portion of the bats using the roost. Without testing all of the pellets in the roost, it will not be possible to state with confidence that other species do not use the roost in question. However, there is no doubt that a large proportion (18 of 20) of the sampled pellets were deposited by *M. sodalis*.

The initial intent was to assess the gender of the bats that deposited the fecal pellets, and I am at a loss to explain why the techniques would not work. The primers from Bryja and Konecny (2003) are the only sex-determination markers that have been tested on bats (although they were originally developed based on sequences from other mammalian orders), and have worked in my lab previously. I troubleshot all aspects of amplification, and used many different PCR and cycling conditions during the testing process, but to no avail. The next step would be to test a wider range of primers developed for other mammal orders from the literature, or to sequence the SRY gene in bats and develop bat-specific primers. However, funding and time were too limited to pursue these options.

Literature Cited

Aasen, E., and J. Medrano. 1990. Amplification of the ZFY and ZFX genes for sex identification in humans, cattle, sheep and goats. Bio/Technology 8:1279-1281.

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