APPENDIX I

INDIANA BAT SURVEYS

SUMMER HABITAT FOR THE INDIANA BAT (*MYOTIS SODALIS*) WITHIN THE WABASH LOWLAND REGION FROM OAKLAND CITY TO WASHINGTON, 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, 31 sites within Section 2 were mist netted during the summer of 2004 for the Federally-endangered Indiana bat (*Myotis sodalis*) and the state endangered evening bat (*Nycticeius humeralis*). A total of 280 bats representing 7 species was captured: 146 eastern red bats (*Lasiurus borealis*), 47 big brown bats (*Eptesicus fuscus*), 46 eastern pipistrelles (*Pipistrellus subflavus*), 14 northern bats (*Myotis septentrionalis*), 12 little brown bats (*Myotis lucifugus*), 10 Indiana bats (*Myotis sodalis*), and 5 evening bats (*Nycticeius humeralis*). Fourteen bats escaped before sex and morphometric data were collected, although each bat was identified to species. Adult Indiana bats were caught and fitted with transmitters on seven different dates at six different sites. No juvenile Indiana bats were caught. Radio-transmitters were not placed on any evening bats. Radio-transmitters were placed on nine of the ten Indiana bats; including six non-reproductive adult females, two post-lactating adult females, and one non-reproductive adult male. Five of the bats were tracked to diurnal roosts; two had more than one roost. A total of eight roost trees was located during the study. Roost tree species included American elm (*Ulmus americana*), sugar maple (*Acer saccharum*), shagbark hickory (*Carya ovata*), and unknown snags in various degrees of decomposition. Numbers ranging from one bat to 100 bats were seen during roost emergence counts. In addition to mist netting and radio-telemetry, biologists conducted surveys of 51 bridges within the Section 2 corridor. One bat was seen leaving a bridge in Daviess County; however, species identification could not be determined before the bat departed. Guano was found at two other bridges in Daviess County. No other bridges on Section 2 showed evidence of bats or guano.

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

1.0 Regulatory Setting

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 Tier 2 Environmental Impact Statements for Section 2 of the proposed I-69 from Evansville to Indianapolis, Indiana. Quality Environmental Professionals, Inc. (QEPI) and their client, the Indiana Department of Transportation, contracted Environmental Solutions and Innovations, Inc (ESI) to conduct summer mist net surveys for the endangered Indiana bat (*Myotis sodalis*) at 30 sites on Section 2 of I69, where Indiana bats had been previously captured. The proposed interstate would be approximately 142 miles in length. Each of the six sections is studied in formal Section 7 Consultation with the US Fish and Wildlife Service.

ESI completed field efforts under Federal Endangered species permit TE 023664-13 and State of Indiana Division of Natural Resources permit 2939, 2942, 2991, 2994, and 3050.

2.0 Project Setting

2.1 Location –

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 1). The total length of Section 2 is approximately 29 miles.

2.2 Physiography –

Section 2 of I-69 stretches across Gibson, Pike, and Daviess counties in a northeasterly direction, crossing 4 geologic sections within 2 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: the Plainville Sand Section, Glaciated Section, and Driftless Section (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 remnant 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).

3.0 Ecological Setting

3.1 Indiana bat –

3.1.1 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

3.1.2 Regional Occurrence –

The Indiana bat is known to occur in the region that includes Section 2 (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, Pike, and Daviess counties.

3.1.2.1 Winter hibernation / Spring staging and Autumn swarming –

Indiana bat winter hibernacula (caves) are not known from Gibson, Pike, and Daviess counties in Section 2; however, several hibernacula are known, from nearby Greene, Lawrence, Martin, and Monroe counties (BLA 2003; Figure 3).

3.1.2.2 Spring and Autumn Migration –

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

3.1.2.3 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, including two records in Gibson County (Whitaker and Brack 2002). Maternity colonies may be more abundant in the northern part of the state. However, records of female Indiana bats also exist for neighboring Knox and Martin 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 (BLA 2003). Dr. John Whitaker surveyed 19 sites along the proposed corridor from I-64 to Bloomington, Indiana. Eight 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 nearby Sites 6 and 7 for summer 2004 surveys.

3.1.2.4 Spring and Autumn Migration –

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3.1.2.5 Summer Roosting –

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2 from the 1993 surveys is nearby Sites 6 and 7 for summer 2004 surveys.

3.1.3 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.

3.1.4 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; 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. 2003; Brack in prep; Brack et al. in prep; 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. Clusters of bats are not sexually segregated.

3.1.5 Spring Staging and Autumn Swarming –

3.1.5.1 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.

3.1.5.2 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 hibernacula 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 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 caves. 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.

3.1.6 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).

3.1.7 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).

3.1.7.1 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).

3.1.7.2 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 (**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.

3.1.8 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).

3.2 Evening Bat –

3.2.1 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).

3.2.2 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 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.

3.2.3 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).

4.0 Methods

4.1 Mist Net Survey –

4.1.1 Site Selection –

Locations of 30 mist net sites were pre-selected by BLA and USFWS, and underwent field reviews and adjustments in conjunction with BLA, QEPI 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.

4.1.2 Mist Netting –

Thirty mist net sites (2 net sets per site) were operated for two nights over the period between 23 July and 14 August 2004, for a total of four net nights per site. In addition, Site 10a was netted for one night only. At the request of the client, Site 10a was moved to a new location (Site 10) after the first night.

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.

4.1.3 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 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.

4.1.4 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 (>40 cm 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.

4.1.5 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 and temperature were lower than normal for the project area during the survey period. Over the entire project time period, nighttime lows ranged from 48 to 70°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 at Site 2 on 13 August before the conclusion of netting; therefore, an additional night of netting was required. Appendix D contains completed weather data sheets.

4.2 Radiotelemetry –

4.2.1 Transmitter Attachment –

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, allowing the transmitter to fall 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. Appendix D contains completed bat transmitter data sheets

4.2.2 Telemetry –

After radio-tagged bats were released, they were tracked using either TRX-2000S PLL Synthesized Tracking Receivers (manufactured by Wildlife Materials, Inc.) or Australis 26k Tracking Recievers (manufactured by Titley Electronics) attached to omni-directional whip antennas or three-element folding yagi directional antennas (manufactured by Wildlife Materials, Inc.). The transmitters, which weighed 0.6 grams or less (depending on the model), were supplied by Titley Electronics, PTY, LTD and Blackburn Transmitters.

On subsequent days after attaching a radio-transmitter to a bat, an omni-directional whip antenna was attached to a radio-receiver to scan for bats while driving on area roads or trails during daylight hours. Three-element Yagi directional antennas were attached to the receivers in order to pinpoint signals and locate roosts. Each bat was tracked for a minimum of 5 days. If a radio signal was not detected for 6 consecutive days, monitoring of the radio signal was terminated.

4.2.3 Bat Roosts and Emergence Counts –

Emergence counts were typically conducted at each roost location for 5 consecutive nights. Beginning at sunset, counts lasted approximately 1 hour or until bats finished emerging and/or darkness precluded accurate counting. Roost tree characterization and habitat assessment data sheets were completed for each roost, which included GPS locations. Appendix D contains completed roost tree and roost tree emergence data sheets.

4.3 Bridges –

Fifty-one bridges were pre-selected by BLA in consultation with the U.S. Fish and Wildlife Service (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.

4.4 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 five hours. Anabat recordings were not obtained at 5 mist net sites on Section 2, due to equipment failure or the potential for damage to equipment from impending inclement weather. On 29 September 2004, all Anabat files were sorted and sent to Andrew King (USFWS) for analysis.

5.0 Results

5.1 Total Bat Capture –

A total of 280 bats (including 7 individuals caught at Site 10a) representing 7 species was captured: 146 eastern red bats (*Lasiurus borealis*), 47 big brown bats (*Eptesicus fuscus*), 46 eastern pipistrelles (*Pipistrellus subflavus*), 14 northern bats (*Myotis septentrionalis*), 12 little brown bats (*Myotis lucifugus*), 10 Indiana bats (*Myotis sodalis*), and 5 evening bats (*Nycticeius humeralis*) (Table 5, Figure 10). Evidence of reproduction, namely reproductive females and/or juveniles, was obtained for all species (Table 6). Fourteen bats escaped before sex and morphometric data were collected, although each was identified to species. The catch of bats in mist nets averaged 2.3 bats/net night (Table 7). The mean number of bats per net site was approximately nine individuals. No bats were caught at sites 17 or 26.

5.1.1 Species Diversity –

The species complement was typical for the geographic location and habitat types within the project area. In addition to the Indiana bat, six other species of bats were captured. Sites 3, 6, and 30 produced the most bats, with 29, 25, and 28 individuals captured, respectively. The mean number of species captured per site was approximately 2.7. Species richness was highest at Site 5, where six species were caught (including all but the Indiana bat).

The eastern red bat was the most commonly netted species on Section 2, representing approximately 52 percent of the total catch. Twenty-five of 29 sites (including Site 10a) that captured any bat species recorded eastern red bats. Collectively, the eastern red bat, big brown bat, and eastern pipistrelle accounted for approximately 85 percent of the bats captured. A Chi-square test confirmed that species were not evenly represented in the catch (χ^2 = 372.7, P < 0.0000). The MacArthur (1972) diversity index for bats captured on Section 2 in 2004 was 3.0, 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).

5.1.2 Occurrence by Sex and Age –

A total of 280 bats was captured over 122 net nights. Five percent of the bats (14 individuals) escaped before sex or age could be determined. Of the remaining 95 percent, adult males and females accounted for 14 percent (38 individuals) and 30 percent (79 individuals), respectively (Table 7). A Chi-square test indicates a significant difference between the total number of adult males and reproductive females (χ^2 = 24.3, P < 0.0000). Juvenile males and females accounted for 56 percent (149 individuals) of bats that were identified for sex and age. Juveniles are commonly caught during mid and late summer, which is when mist netting was conducted on Section 2.

Except for the little brown bat, adult males and females of each species were captured during the late-July to mid-August mist netting survey. The majority of adult females caught were non-reproductive, indicating that they were no longer nursing or rearing young. Of the total 79 females, only 15 individuals were still reproductive. In every species captured, non-reproductive adult females were of equal or greater number than adult males (Table 6). Adult (male and female) big brown bats and eastern red bats comprised the highest

percentage of total adult individuals captured (Table 7).

5.2 Indiana Bat Capture –

A total of 10 Indiana bats was captured on Section 2 at Sites 8, 11, 12, 22, 29 and 30 between 25 July and 7 August (Figure 11a and 11b). These bats included two lactating females, seven non-reproductive adult females, and one adult male. Transmitters were attached to nine of these bats, and eight diurnal roosts were located. One non-reproductive female from Site 30 was not radio-tagged or tracked. Indiana bats were removed from mist nets and processed for data on sex, reproductive condition, and morphometric measurements. No bats were banded; guano and/or hair samples were collected from some individuals. All bats were released in good condition at or near the point of capture.

5.3 Evening Bat Capture –

A total of five evening bats was captured on Section 2 at Sites 5, 6, 10, and 21 between 24 July and 14 August (Figure 11a and 11b). These bats included two non-reproductive adult females, two adult males, and one juvenile female. Both males had descended testes. No transmitters were attached to any evening bats. Bats were removed from the mist nets and processed for data on sex, reproductive condition, and morphometric measurements. No bats were banded; guano was collected from two individuals. All bats were released in good condition at or near the point of capture.

5.4 Habitat Assessment –

A total of 30 sites (plus Site 10a) was netted between 23 July and 14 August 2004. Net site habitat descriptions were completed for each site. The following descriptions of the habitats were grouped according to relative proximity and similar habitat types. Net site habitat description data sheets are provided in Appendix D.

Sites 1, 2, and 3 were located in Gibson County, near the Wabash and Erie Canal and its associated tributaries. All three areas were predominantly young forested uplands or riparian areas. When present, dominant canopy trees (>40 cm dbh) included shagbark hickory (*Carya ovata*), red maple (*Acer rubrum*), tuliptree (*Lireodendron tulipifera*), and white oak (*Quercus alba*). Subdominant canopy trees included American sycamore (*Platanus occidentalis*), red maple, and sweetgum (*Liquidambar styraciflua*). Roost tree potential and canopy closure was high at Sites 1 and 3, due to the presence of large trees and snags. Site 2 contained few large trees or snags that could potentially serve as roost sites, and the canopy was open. No Indiana bats or evening bats were captured at these sites. All nets at Sites 1 and 3 were placed in terrestrial corridors. At Site 2, one net was placed over East Fork Creek, while the other was in a nearby corridor.

Sites 4 through 10 (including Site 10a) were located near the borders of Gibson County and Pike counties, along the bottomlands of the Patoka River and its associated watershed. All sites were primarily riparian forests or nearby upland deciduous forests. The most common dominant and subdominant tree species was silver maple (*Acer saccharinum*), followed by American sycamore. Boxelder (*Acer negundo*) and river birch (*Betula nigra*) were also abundant. Other dominant canopy trees include sweetgum, green ash (*Fraxinus pennsylvanica*), and shagbark hickory. Other subdominant canopy trees included northern red oak (*Quercus rubra*), hackberry (*Celtis occidentalis*), and red maple. Depending on the site, roost tree potential

ranged from moderate to high, due to the presence of snags and large trees. The subcanopy was generally moderate to open, with clutter largely attributed to lower branches of canopy trees. Site 8 captured one Indiana bat. Both nets on this site were located in a woodland corridor. Sites 5, 6, and 10 captured a total of four evening bats. All nets on these sites were in terrestrial corridors in close proximity to the Patoka River. Both nets at Site 4 were over the Patoka River, while nets at Sites 7 and 9 were in nearby upland corridors.

Sites 11 through 15 were located in Pike County, near small tributaries of the Patoka River and White River East Fork. Site 11 was located in an upland area near Robinson Creek. Sites 12, 13, and 14 were in upland and riparian areas near Flat Creek. Both of these watersheds flow into the Patoka River. Site 15 was nearby in a riparian area on Prides Creek, which flows northward into the White River East Fork. Agricultural fields bordered most of these areas. Northern red oak, red maple, and American Sycamore were common as dominant canopy trees. Subdominant canopy trees included black locust (*Robinia pseudoacacia*), slippery elm (*Ulmus rubra*), and black willow (*Salix nigra*). Roost tree potential ranged from moderate to low, due to the low percentage of large trees and snags. Subcanopy clutter was generally high, due to a large number of small saplings. Site 11 captured one Indiana bat. Both nets were in an upland corridor near a dry streambed. Site 12 captured two Indiana bats, one in each net. One net was placed over Flat Creek, while the other was on a woodland corridor running parallel to the stream channel. No evening bats were captured at Sites 11 through 15.

Sites 16 through 18 were in Pike County, northeast of Petersburg, in the vicinity of Mud Creek. All three sites were primarily young forested lowlands or riparian strips. When present, dominant canopy trees included tuliptree, American sycamore, and red maple. Subcanopy trees included boxelder, black locust, sassafras (*Sassafras albidium*), and slippery elm. Roost tree potential ranged from moderate to low, although some snags were present. Subcanopy clutter was generally high, due to the presence of smaller saplings and shrubs. No Indiana bats or evening bats were captured at these sites. All nets at Sites 16 and 17 were placed in terrestrial corridors. At Site 18, both nets were placed over Mud Creek near the bridge at CR 650.

Sites 19 through 24 were located near the borders of Pike and Daviess counties, near the convergence of the North and East Forks of the White River. All sites were primarily riparian forests or nearby upland deciduous forests. A diverse variety of trees were found in this bottomland area of the White River. The most common dominant and subdominant tree species was silver maple. Other dominant canopy trees included black walnut (*Juglans nigra*), American elm (*Ulmus americana*), American sycamore, and several species of oaks. Subdominant canopy species included black locust, black cherry (*Prunus serotina*), American beech (*Fagus grandifolia*), boxelder, and black willow. Subdominant trees were generally more abundant, except for Sites 21 and 22, which bordered the White River East Fork. Roost tree potential was moderate to low in most sites; however, due to the abundance of large trees and snags, Site 22 had a high roost potential. The subcanopy was moderately cluttered at most sites. Site 22 captured one Indiana bat. Both nets at this site were on a road running parallel to the

White River East Fork. Site 21 caught one juvenile evening bat. The net that caught the bat was in a wooded corridor near a stream, and the other was over the stream itself. Except for one net at Site 24 that was over Aikman Creek, all nets at the other sites were in wooded corridors.

Sites 25 and 26 were located in the hilly uplands of Daviess County, to the north of the White River bottomlands. Both sites possessed different vegetation. Site 25 was in a forested area bordered by agricultural fields, containing tree species such as sweetgum, aspen (*Populus tremuloides*), red maple, and American sycamore. Roost tree potential was moderate, due to the presence of large trees and snags. Site 26 was in a forest containing mainly oaks and hickories, as well as tuliptree and red maple. The subcanopy was moderately cluttered at both sites. No Indiana bats or evening bats were captured at these sites. All nets were placed in terrestrial corridors.

Sites 27 to 30 were located in Daviess County along Veale Creek. All sites were near the riparian stream corridor and nearby upland forest. Many dominant and canopy trees were found in this area, including American sycamore, black walnut, river birch, red maple, sugar maple, cottonwood (*Populus deltoides*), shagbark hickory, and white ash (*Fraxinus americana*). Subdominant canopy trees consisted of the same species. River birch and white ash were most common in these areas. Roost tree potential was high at Sites 27, 29, and 30, due to the presence of large trees and snags. The subcanopy was moderately cluttered at all sites but Site 27. Sites 29 and 30 caught a total of 5 Indiana bats. Both bats at Site 29 were caught in the same net placed in a woodland corridor near Veale Creek. The other net at that site was also placed in a woodland corridor. All three bats at Site 30 were caught in the same net placed over the stream channel on Veale Creek. The other net was also placed over the stream channel. Both nets at Site 27 were placed over the stream channel on Veale Creek. At Site 28, one net was over the stream channel, and the other was in a nearby woodland corridor. No evening bats were captured at Sites 27 through 30.

5.5 Radiotelemetry –

A total of 10 Indiana bats was captured; nine were fitted with radio-transmitters (Table 8; Figures 12a and 12b). All of the bats were adult, and all but one was female. Only two of these females were considered reproductive (post-lactating). Mist netting commenced between 23 July and 14 August. Indiana bats were caught and fitted with transmitters on seven different dates at six different sites between 25 July and 11 August.

Five of the bats were tracked to diurnal roosts; two had more than one roost. A total of eight roost trees was located after capture (Table 9). No roosts were found for the four Indiana bats from Sites 11,12, or 22. Two roosts were found for the non-reproductive female caught at Site 8. These roosts were about 0.5 mile west of the corridor near the Patoka River. Four separate roosts were found for the two non-reproductive females caught at Site 29, while one roost was found for each of the two non-reproductive females caught at Site 30. Five of these six roosts were located east of the corridor near Veale Creek; the last was found east of the corridor in a woodland area near New Veale Creek Cemetery.

5.5.1 Indiana Bat 285 –

5.5.1.1 Capture and Transmitter Attachment –

Indiana bat 285 was an adult post-lactating female captured at Site 22 at 2240 h on 25 July 2004. She was caught in a 30-foot mist net over CR 700 S, on the north bank of the White River. She was fitted with a 0.6-gram transmitter (frequency number 151.285) and released unharmed at 2317 h after a guano sample was obtained. She was in excellent condition, and flew off with no difficulty in a southwestern direction. Transmitter attachment data sheets are provided in Appendix D.

5.5.1.2 Roosts –

No roosts were located for Indiana bat 285.

5.5.1.3 Telemetry –

Indiana bat 285 was tracked for 2 minutes following release, heading in a southwest direction from the capture site. She returned to the area briefly at approximately 2356 h before disappearing. Biologists were unable to locate her again, despite 6 days of active radio-telemetry scanning. Extensive searches surrounding the area of capture were performed during that time period using pedestrian and vehicular routes.

5.5.2 Indiana Bat 356 –

5.5.2.1 Capture and Transmitter Attachment –

Indiana bat 356 was an adult non-reproductive female captured at Site 8 at 2230 h on 28 July 2004. She was caught in an 18-foot net in a woodland corridor near CR 500 S, adjacent to an agricultural field. She was fitted with a 0.4 gram transmitter (frequency number 151.356) and released unharmed at 2359 h. She was released in the woodland corridor, west of the mist nets. She was in good condition, and flew off with no difficulty. Transmitter attachment data sheets are provided in Appendix D.

5.5.2.2 Roosts –

Indiana bat 356 was found 29 July roosting on a live sugar maple (*Acer saccharum*) approximately 19 cm dbh (Table 9). The roost was in a riparian floodplain approximately 1.54 km southeast of the capture site (Table 10). On 30 July, she was found roosting on a second tree approximately 41 cm dbh, about 1.53 km southwest of the capture site The distance between roost trees was approximately 1.63 km. The second roost was a dead tree of unknown species in a swamp surrounded by young dense woodlands near the Patoka River.

5.5.2.3 Emergence –

Two roosts were identified for Indiana bat 356. When initially found, the female appeared to roost in a clump of dead leaves hanging from a live tree (Table 11). When found in mid-afternoon, she immediately departed the area (in broad daylight). No other bats were seen emerging from the roost tree between 31 July and 2 August. The following day, she was found on the second roost tree. Sixty-nine to 100 bats emerged from the second roost each evening between 31 July and 3 August.

5.5.3 Indiana Bat 442 –

5.5.3.1 Capture and Transmitter Attachment –

Indiana bat 442 was an adult non-reproductive female captured at Site 11 at 0030 h on 29 July 2004. She was caught in a 30-foot net in a woodland corridor near a dry creek bed in the vicinity Robinson Creek. She was fitted with a 0.5-gram transmitter (frequency number 151.442) and

released unharmed at 0130 h. She was in good condition, and flew off with no difficulty. Transmitter attachment data sheets are provided in Appendix D.

5.5.3.2 Roosts –

No roosts were located for Indiana bat 442.

5.5.3.3 Telemetry –

Indiana bat 442 disappeared immediately after release. The signal was never reacquired. Biologists were unable to locate her again, despite six days of active radio-telemetry scanning. Extensive searches surrounding the area of capture were performed during that time period using pedestrian and vehicular routes.

5.5.4 Indiana Bat 523 –

5.5.4.1 Capture and Transmitter Attachment

Indiana bat 523 was an adult male captured at Site 29 at 2119 h on 5 August 2004. He was caught in an 18-foot net placed in a woodland corridor near Veale Creek. He was fitted with a 0.5-gram transmitter (frequency number 151.523) and released unharmed at 2230 h in an open field near the net of capture. Guano and hair samples were obtained before release. He was in good condition, and flew off with no difficulty. Transmitter attachment data sheets are provided in Appendix D.

5.5.4.2 Roosts –

Indiana bat 523 was found 6 August roosting on a dead American elm approximately 76 cm dbh (Table 9). The roost was in a riparian area approximately 1.47 km from the capture site (Table 12). The roost was also near a powerline corridor. A deer stand was positioned on the east side of the tree. On 7 August, the bat was found roosting on a dead elm tree approximately 48 cm dbh, about 20 meters from the first roost. On 8 August, he was found roosting on a third tree approximately 64 cm dbh, about 145 m from the second roost. This third roost was a dead tree of unknown species, at the edge of a cornfield near Veale Creek.

5.5.4.3 Emergence –

Indiana bat 523 was first found on the day after capture. After that day, he moved to a different roost the next 2 days. Three roosts were identified (Table 13). Bats were only seen emerging from these roosts on the first nights of emergence counts. Seventeen bats emerged from the first roost on 6 August. Five bats emerged from the second roost on 8 August. On the same night, three bats emerged from the third roost.

5.5.5 Indiana Bat 117 –

5.5.5.1 Capture and Transmitter Attachment –

Indiana bat 117 was an adult non-reproductive female captured at Site 29 at 2150 h on 6 August 2004. She was caught in the same 18-foot net as Indiana bat 523, which was set in a woodland corridor near Veale Creek. She was fitted with a 0.3-gram transmitter (frequency number 151.117) and released unharmed at 2255 h after guano and hair samples were obtained. She was in good condition, and flew off with no difficulty in the same open field near the net of capture. Transmitter attachment data sheets are provided in Appendix D.

5.5.5.2 Roosts –

Indiana bat 117 was found on 7 August roosting on a dead American elm approximately 50 cm dbh (Table 9). The roost was in an upland area approximately

1.98 km from the capture site. No other roosts were found on subsequent days.

5.5.5.3 Emergence –

Indiana bat 117 was first found the day after capture. She stayed at the same roost for the next several days. Six to 36 bats emerged from the roost each evening between 7 August and 12 August (Table 14).

5.5.6 Indiana Bat 082 –

5.5.6.1 Capture and Transmitter Attachment –

Indiana bat 082 was an adult non-reproductive female captured at Site 30 at 2120 h on 7 August 2004. She was caught in an 18-foot net placed over the stream corridor of Veale Creek. She was fitted with a 0.3-gram transmitter (frequency number 151.082) and released unharmed at 2235 h after guano and hair samples were obtained. She was in good condition, and flew off with no difficulty in an open field west of Veale Creek. Transmitter attachment data sheets are provided in Appendix D.

5.5.6.2 Roosts –

Indiana bat 082 was found on 8 August roosting on a live shagbark hickory approximately 36 cm dbh (Table 9). The roost was in a riparian area approximately 240 m from the capture site. This roost was also approximately 150 meters from the first roost of Indiana bat 523. No other roosts were found on subsequent days.

5.5.6.3 Emergence –

Indiana bat 082 was first found the day after capture. The roost tree was monitored for emergence on 5 non-consecutive nights. A total of two bats emerged from the roost during the entire period between 8 August and 13 August (Table 15).

5.5.7 Indiana Bat 036 –

5.5.7.1 Capture and Transmitter Attachment –

Indiana bat 036 was an adult non-reproductive female captured at Site 30 at 2200 h on 7 August 2004. She was caught in the same 18-foot net as Indiana bat 082, which was set over the stream corridor of Veale Creek. She was fitted with a 0.3-gram transmitter (frequency number 151.036) and released unharmed at 2245 h after guano and hair samples were obtained. She was in good condition, and flew off with no difficulty in an open field west of Veale Creek (the same field as Indiana bat 082). Transmitter attachment data sheets are provided in Appendix D.

5.5.7.2 Roosts –

Indiana bat 082 was found on 8 August roosting on a live shagbark hickory approximately 36 cm dbh (Table 9). The roost was in a riparian area approximately 165 m from the capture site. This roost was also in the same vicinity as the identified roost of Indiana bat 082, in an area with many live shagbark hickories that provide roost sites. No other roosts for Indiana bat 036 were found on subsequent days.

5.5.7.3 Emergence –

Indiana bat 036 was first found the day after capture. The roost tree was monitored for emergence on five non-consecutive nights. Between one and 32 bats were recorded on separate nights. A total of 38 bats emerge from the roost during the entire duration between 8 August and 13 August (Table 16). Thirty-two of the 38 bats emerged on 13 August, the last evening that the roost was monitored.

5.5.8 Indiana Bat 482 –

5.5.8.1 Capture and Transmitter Attachment –

Indiana bat 482 was an adult non-reproductive female captured at Site 12 at 2130 h on 11 August 2004. She was caught in an 18-foot mist net in a woodland corridor running parallel to the stream channel of Flat Creek. She was fitted with a 0.5-gram transmitter (frequency number 151.482) and released unharmed at 2200 h after guano and hair samples were obtained. She was in good condition, and flew off with no difficulty in a northwestern direction. Transmitter attachment data sheets are provided in Appendix D.

5.5.8.2 Roost – s

No roosts were located for Indiana bat 482.

5.5.8.3 Telemetry

Indiana bat 482 disappeared immediately after release, flying in a northwestern direction. The signal was never reacquired. Biologists were unable to locate her again, despite six days of active radio-telemetry scanning. Extensive searches surrounding the area of capture were performed during that time period using pedestrian and vehicular routes.

5.5.9 Indiana Bat 385 –

5.5.9.1 Capture and Transmitter Attachment –

Indiana bat 385 was an adult post-lactating female captured at Site 12 at 0000 h on 11 August 2004. She was caught in an 18-foot mist net set over the stream channel of Flat Creek. She was fitted with a 0.2-gram transmitter (frequency number 151.385) and released unharmed at 0035 h after guano and hair samples were obtained. She was in good condition, and flew off with no difficulty in a northern direction. Transmitter attachment data sheets are provided in Appendix D.

5.5.9.2 Roosts –

No roosts were located for Indiana bat 385.

5.5.9.3 Telemetry –

Indiana bat 385 disappeared immediately after release, flying in a northern direction. The signal was never reacquired. Biologists were unable to locate her again, despite six days of active radio-telemetry scanning. Extensive searches surrounding the point of capture were performed during that time period using pedestrian and vehicular routes.

5.6 Bridges –

Section 2 contained 51 bridges that were pre-selected (for possible bat presence) by BLA, in consultation with the U.S. Fish and Wildlife Service (Figure 8a and 8b). Biologist checked these bridges for the presence of night-roosting bats and/or guano (Table 17). Bridge types ranged from corrugated metal culverts to large concrete or steel spans. One bat was seen leaving Bridge 6 in Daviess County; however, species identification could not be determined before the bat departed. Another bat was seen flying past Bridge 21 in Pike County; however, no roosting bats or guano were found. Guano was found at Bridges 13 and 17 in Daviess County. No other bridges on Section 2 showed direct evidence of bats or guano. Other animals, including pigeons, swallows, snakes, and raccoons, were seen at several bridges (Table 17).

6.0 Discussion and Conclusions

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 2 of I-69. Surveys conducted in summer 2004 provide information about the following:

- Presence and distribution of Indiana bats and evening bats on Section 2
- Roosting habitat use by adult male and female Indiana bats captured on Section 2
- Nighttime use of bridges for roosts by Indiana bats and evening bats on Section 2.

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 2 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.

6.1 Bat Capture and Species Diversity –

Species complement was typical for the geographic location and habitat types within the project area. In addition to the Indiana bat, six other species of bats were captured on Section 2 in 2004 (Table 6). Indiana bats were the sixth most common species captured in the project area with a capture rate of 0.082 bats per net night. Evening bats were the least encountered species, represented by only five individuals, or .040 bats per net night. The species diversity index (MacArthur, 1972) was 3.0, indicating that the diversity was equivalent to having three equally represented species.

The eastern red bat was the most commonly netted species on Section 2, representing approximately 52 percent of the total catch. Red bats, which are one of the most abundant tree bats in North America, typically forage along wooded edges or clearings such as those in the project area. Most red bats (101 of 146) caught during the study were juveniles. Juvenile red bats were 36 percent of the total catch of bats. Red bats usually give birth to two or more offspring, thus high concentrations are possible during mid to late summer.

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). Seven of these sites were located in the Section 2 corridor. Whitaker documented four bat species and a diversity index (MacArthur 1972) of 2.8, compared to seven species and a diversity index of 3.0 in 2004.

During mist net surveys between 1987 and 1998 at Crane Navel Surface Warfare Center (Crane) near Bedford, Indiana, Brack and Whitaker (2004) found eight species, including eight Indiana bats (6 males and 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 and caught six male Indiana bats. The capture rate was 0.025 Indiana bats per net night, compared to 0.082 bats per net night on Section 4. Total bat catch per night on

HNF was 2.1 bats per net night, compared to 2.3 on Section 2 of I-69.

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 on NECD.

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 3.0, due largely to the high numbers of eastern red bats.

6.2 Evening Bat –

Five evening bats were captured on Section 2 during summer 2004 mist net surveys, including two non-reproductive adult females, two adult males, and one juvenile female. Sites 5, 6, and 10 captured four of the five bats. The two non-reproducrive females were caught late in summer and may have been females that dropped their pups early or that lost their young early in the season. These riparian sites consisted of mist nets placed in terrestrial corridors near the Patoka River. Site 21, also in riparian habitat (near the White River East Fork), caught one juvenile female in a mist net placed across a terrestrial corridor near a stream. No telemetry data were acquired from any evening bats during the 2004 survey.

Except Section 2, evening bats were captured on all sections of the I-69 corridor (from Evansville to Indianapolis, Indiana) during 2004 (Tom Cervone pers. comm.). During Tier I Environmental Impact Statement surveys in 1993, Whitaker (1996) reported having detected echolocation calls from evening bats along the north side of the White River in the northeast portion of Section 2. Buildings with potential to be roost sites were checked within a mile of the detection site, but no bats were found.

Maternity colonies of evening bats are historically known (1961) from nearby Clay, Orange, Washington, and Clark counties; however, these colonies are now defunct (Whitaker and Gummer 2003). Existing colonies are known from Vigo, Sullivan, and Posey counties in southeastern Indiana (Whitaker and Gummer 2003) (Figure 7).

6.3 Indiana Bat –

6.3.1 Bat Captures –

Ten Indiana bats were captured on Section 2 at Sites 8, 11, 12, 22, 29 and 30. All six sites were in riparian habitats or nearby upland corridors or roads. Indiana bats have historically been caught in mist nets placed over stream corridors, where they have been known to travel. Five of the seven mist nests that captured Indiana bats on Section 2 were in woodland corridors; only two were over water across stream corridors. Nevertheless, upland corridors often produce large numbers of bats (Brown and Brack 2003). Roost tree potentials were generally moderate to high among all six sites, while subcanopies were moderately to highly cluttered. Percent canopy closure was highly variable, ranging from open to closed. In contrast to catch, seven of eight roosts were in riparian sites.

All Indiana bats caught on Section 2 in 2004 were adults, and all but one was female. Reproductive characteristics could only be found on two of the nine females. Only two Indiana bats were captured along the entire I-69 corridor during the 1993 survey. Both of these bats were lactating females, and were caught on Section 2 in the same vicinity of the Potoka River bottomland as

Sites 6 and 7 during 2004. Sites 6 and 7 were approximately 640 m and 710 m away from Site 2 in 1993. In 2004, neither Site 6 nor 7 captured any Indiana bats; however, Site 8 (approximately 1.6 km away) captured one non-reproductive female.

The capture of 10 Indiana bats included 1 adult male, 2 reproductive females, and 7 non-reproductive females. This concentration of non-reproductive females is unusual. If these individuals had all been reproductive, the anticipated catch would have included juveniles as well. It is possible some of these females may have dropped their pups very early in the season or lost their young early in the season, making them (in effect) post-reproductive.

6.3.2 Roosts –

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/Environmental 1995). Indiana bats have been found using many different species of trees as roosts, 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).

Five of the radio-tagged bats from Section 2 were tracked to diurnal roosts, two had more than one roost. Eight roost trees were located; seven were in riparian areas associated with either Veale Creek or the Patomic River. Species used as roosts were shagbark hickory, American elm, sugar maple, and other unidentified snags in various stages of decay. Most roost trees were considered "typical" for Indiana bats, due to the presence of exfoliating bark of live trees or decomposing snags. Indiana bats 356, 523, and 117 roosted on dead snags characterized in Stage 4 of decay (loose bark), which had between 30 and 40 percent exfoliated bark. Indiana bats 082 and 036 roosted separately on live shagbark hickories of 35 cm dbh, which had between 50 and 70 percent exfoliated bark. Two adult male Indiana bats used three shagbark hickories (mean dbh 25.3 cm) with extensive exfoliating bark 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. Those roosts trees averaged 46 cm dbh, compared to 43 cm dbh for all roost trees on Section 2, and 35 cm for the two live roost trees used by Indiana bats 082 and 036.

On the day after capture, Indiana bat 356 was found in a live sugar maple in a riparian floodplain of the Patoka River. The female bat appeared to roost in a clump of dead leaves approximately 6 m above the ground. When approached, the bat flew away in broad daylight. She never returned to this atypical roost; and no other bats were seen emerging during subsequent nights of

emergence counts. Use of this type of roost is common for the eastern pipistrelle (Veillux et al. 2003). This female was found later at a more typical roost in a dead tree of unknown species, where a total of 334 (average 83.5 bats/night) bats emerged over the course of 4 nights.

6.3.3 Bridges –

Only one bat was found roosting on a concrete bridge (Bridge 6) in Daviess County, about 4 m above a stream. The bat flew away when disturbed, and was not identified to species. There was no other evidence of bats using bridges; however, numerous pigeons and swallows nested amongst support beams. Guano was found at two other bridges (Bridges 13 and 17) in Daviess County. One bat was seen flying past Bridge 21 in Pike County; however, no signs of bat use were evident. Although no bats or guano were found, Bridge 28 in Pike County was potentially suitable for bats, due to the presence of crevices and openings in the concrete understructure.

In contrast to this survey, 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 these bridges, allowing direct solar radiation to strike the bridge surface. Those bridges were made 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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8.0 Literature Cited

Anderson, J. R., E. E. Hardy, J. T. Roach, and R. E. Witmer. 1967. A land use and land cover classification system for use with remote sensor data. Geological Survey Professional paper 964:1-28.

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

Baker, W. W., S. G. Marshall, and V. B. Baker. 1968. Autumn fat deposition in the evening bat (*Nycticeius humeralis*). Journal of Mammalogy 49:329. Barbour, R. W., and W. H. Davis. 1969. Bats of America. University Press of Kentucky, Lexington.

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

Boyles, J. G., B. M. Mormann, and L. W. Robbins. In submission. Use of a subterranean roost by a male evening bat (*Nycticeius humeralis*). In submission to Southeastern Naturalist.

BLA-Bernardin-Lochmueller & Associates. 2003. Tier 1 biological assessment for threatened and endangered species, Interstate 69, Indianapolis to Evansville [dated July 18, 2003, revised October 27, 2003; submitted to the Bloomington Field Office of the U.S. Fish and Wildlife Service by the Federal Highway Administration and Department of Transportation.

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

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

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

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

Brack, V., Jr., and J. C. Carter. 1985. Use of an underground burrow by *Lasionycteris*. Bat Research News 26:28-29.

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

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

Brack, V., Jr., and K. Dunlap. 2003. A 2001-2002 winter survey for Indiana bats (*Myotis sodalis*) in hibernacula of Indiana. Unpubl. report to Indiana DNR, Nongame and Endangered Wildlife Program, Indianapolis.

Brack, V. Jr., S. A. Johnson, and R. K. Dunlap. 2003. Wintering populations of bats in Indiana, with emphasis on the endangered Indiana myotis, *Myotis*

sodalis. Proceedings of the Indiana Academy of Science 112:61-74.

Brack, V. Jr., C. W. Stihler, R. J. Reynolds, C. Butchkoski, and C. S. Hobson. 2002. Effects of climate and elevation on distribution and abundance in the mideastern United States. Pp. 21-28 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

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

Brack, V. Jr., J. O. Whitaker, Jr., & S. E. Pruitt. 2004. Bats of Hoosier National Forest. Proceedings of the Indiana Academy of Science 113:76-86.

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

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

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

Butchkoski, C. M., and J. D. Hassinger. 2002. Ecology of a maternity colony in a building. Pp. 130-142 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

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

Carter, T. C., M. A., Menzel, D. M. Krishon, and J. Laerm. 1998. Prey selection by five species of vespertilionid bats on Sapelo Island, Georgia. Brimleyana 25:158-170.

Carter, T. 2002. Bat houses for conservation of endangered Indiana myotis. The Bat House Researcher 10:1-3.

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

Clark, B., J. Bowles, and B. Clark. 1987. Summer occurrences of the Indiana bat, Keen's Myotis, evening bat, silver-haired bat and eastern pipistrelle in Iowa. Iowa Academy of Science 94:89-93.

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

Clawson, R. L. 2002. Trends in population size and current status. Pp. 2-8 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Clem, P. D. 1992. Seasonal population variation and emergence patterns in the evening bat, Nycticeius humeralis, at a west-central Indiana colony. Proceedings of the Indiana Academy of Science

101:33-43.Cope, J., and S. Humphrey. 1977. Spring and autumn swarming behavior in the Indiana bat, *Myotis sodalis*. Journal of Mammalogy 58:93-95.

Clem, P. D. 1993. Foraging patterns and the use of tempoirary roost in female evening bats, Nycticeius humeralis, at an Indiana maternity colony. Proceedings of the Indiana Academy of Science 102:201-206.Cope, J. B., W. W. Baker, and J. Confer. 1961. Breeding colonies of four species of bats of Indiana. Proceedings of the Indiana Academy of Science 70:262-266.

ESI-Brack, V., Jr. 2000. 1999-2000 winter visits to known and potential hibernacula of endangered bats, Bland County, Virginia, for AEP's proposed Wyoming-Jacksons Ferry 765 kV Alternative project, Appendix A *in* Biological Assessment for AEP's 90-mile Wyoming-Jacksons Ferry 765 kV Alternative project.

ESI-Brack, V., Jr., and D. Little. 2001. An autumn survey for the endangered Indiana bat (*Myotis sodalis*) at mine portals along alternate corridors for U.S. Route 33 Nelsonville Bypass (HOC/ATH-33-17.00/0.00), Hocking and Athens counties, Ohio. Report to Ohio Department of Transportation.

ESI-Little, M. J., V. Brack, Jr., and R. Slack. 2001. A spring staging survey for endangered bats and an assessment of Indiana bat summer habitat suitability for Meg-Lynn Land Company Inc. Wise County, Virginia. A Report to D.R. Allen & Associates, P.C.

ESI-Brown, R. J., and V. Brack, Jr. 2002. A 2002 winter census for the Indiana bat in the Lewisburg Limestone Mine, Preble County, Ohio. A report to Ohio Department of Natural Resources, Division of Wildlife Columbus.

ESI-Brown, R. J., and V. Brack, Jr. 2002a. A mist net survey for the endangered Indiana bat on three reservoirs in Cherokee, Clay, Jackson, and Macon counties, North Carolina. A report to Duke Engineering & Services, Charlotte, North Carolina, 22 pp.

ESI-Brown, R. J., and V. Brack, Jr. 2002b. Autumn 2000 radiotelemetry study of the Indiana bat in Skydusky Hollow, Bland County, Virginia, for AEP's Wyoming-Jacksons Ferry 765 kV alternative project. A report to American Electric Power, Roanoke, Virginia.

ESI- Brown, R. J. and Brack, V. Jr., 2003. A summer mist net survey for the federally endangered Indiana bat (*Myotis sodalis*) at the Newport Chemical Depot, Newport, Indiana. Unpublished report for Newport Chemical Depot. 41 pages plus appendices.

Feldhamer, G. A., J. O. Whitaker, Jr., J. K. Kreica, and S. J. Taylor. 1995. Food of the evening bat (*Nycticeius humeralis*) and red bat (*Lasiurus borealis*) from southern Illinois. Transactions of the Illinois State Academy of Science 88:139-143.

Foster, R. W., and A. Kurta. 1999. Roosting ecology of the northern bat (*Myotis septentrionalis*) and comparisons with the endangered Indiana bat (Myotis sodalis). Journal of Mammalogy 80:659-672.

Gardner, J. E., J. D. Garner, and J. E. Hofmann. 1991. Summer roost selection and roosting behavior of *Myotis sodalis* (Indiana bat) in Illinois. A report prepared for U. S. Fish and

Wildlife Service, Region 3 Endangered Species Coordinator, Twin Cities, Minnesota.

Gardner, J. E., and E. A. Cook. 2002. Seasonal and geographic distribution and quantification of potential summer habitat. Pp. 9-20 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

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

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

Gumbert, M. W., J. M. O'Keefe, and J. R. MacGregor. 2002. Roost fidelity in Kentucky. Pp. 143-152 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

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

Henshaw, R. E. 1965. Physiology of hibernation and acclimation in two species of bats (*Myotis lucifugus* and *Myotis sodalis*). Ph.D. dissertation, State University Iowa, Ames.

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

Hicks, A., and P. G. Novak. 2002. History, status, and behavior of hibernating populations in the Northeast. Pp. 35-47 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Homoya, M. A., D. B. Abrell, J. R. Aldrich, and T. W. Post. 1985. The natural regions of Indiana. Proceedings of the Indiana Academy of Science 94:245-268.

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

Humphrey, S. R., and J. B. Cope. 1968. Records of migration of the evening bat, *Nycticeius humeralis*. Journal of Mammalogy 49:329. Humphrey, S. R., A. R. Richter, and J. B. Cope. 1977. Summer habitat and ecology of the endangered Indiana bat, *Myotis sodalis*. Journal of Mammalogy 58:334-346.

Indiana State University (ISU) - Whitaker, J. O. Jr., J. Villeux, and E. Vincent. 1998. Progress report on the status of *Myotis sodalis* and other bat species at Newport Chemical Depot. .

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

Johnson, S. A., V. Brack, Jr. and R. K. Dunlap. 2002. Management of hibernacula in the state of Indiana. Pp. 106-115 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Kath, J. A. 2002. A review of the hibernacula in Illinois, with emphasis on the Magazine Mine. Pp. 110-117 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Keeley, B. W., and M. D. Tuttle. 1999. Bats in American bridges. Bat Conservation International, Resource Publication 4:1-41.

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

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

Kirkpatrick, C. M., and C. H, Conaway. 1948. Some notes on Indiana mammals. American Midland Naturalist. 39:128-136.

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

Kiser, J. D., J. R. MacGregor, H. D. Bryan, and A. Howard. 2002. Use of concrete bridges as night roosts. Pp. 208-215 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

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

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

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

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

Kurta, A., S. W. Murray, D. H. Miller. 2002. Roost selection and movements across the summer landscape. Pp. 118-129 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

LaVal, R. K., R. L. Clawson, M. L. LaVal, and W. Caire. 1977. Foraging behavior

and nocturnal activity patterns of Missouri bats, with emphasis on the endangered species *Myotis grisescens* and *Myotis sodalis*. Journal of Mammalogy 58:592-599.

LaVal, R. K., and M. L. LaVal. 1980. Ecological studies and management of Missouri bats, with emphasis on cave-dwelling species. Missouri Department of Conservation Terrestrial Series 8:1-53.

Lewis, S. E. 1995. Roost fidelity of bats: a review. Journal of Mammalogy 76:481-496.

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

MacArthur, R. H. 1972. Geographical Ecology. Harper and Row, New York, New York.

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

Miles A. C., S. A. Castleberry, D. A. Miller, and L. M. Conner. 2004. Interesting observations at evening bat maternity colonies in southwest Georgia. Presentation *at* The 9th annual meeting of the Southeastern Bat Diversity Network and 14th colloquium on conservation of mammals in the southeastern United States.

Miller, N. E., R. D. Drobney, R. L. Clawson, and E. V. Callahan. 2002. Summer habitat in northern Missouri. Pp. 165-171 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Minton, S. A., Jr. 2001. Amphibians and Reptiles of Indiana: Revised 2nd Edition. Indiana Academy of Science, Indianapolis, Indiana.

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

Mumford, R. E. & J. O. Whitaker, Jr. 1982. Mammals of Indiana. Bloomington University Press, Indiana.

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

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

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

Perlmeter, S. I. 1996. Bats and bridges: patterns of night roost activity in the Willamette National Forest. Pp. 132-150 *In* Bats and Forests Symposium (R. M. R. Barclay and R. M. Brigham, eds.) Research Branch, Ministry of Forests, Province of British Columbia, Victoria, British Columbia, Canada.

Racey, P. A. 1982. Ecology of bat reproduction. Pp. 57-103 in Ecology of bats (T. H. Kunz, ed.). Plenum Publishing Corporation, New York, New York.

Richter, A. R., S. R. Humphrey, J. B. Cope, and V. Brack, Jr. 1993. Modified cave

entrances, thermal effects on body mass, and resulting decline of endangered Indiana bats (*Myotis sodalis*). Conservation Biology 7:407-415.

Sanders, C., and J. Changer. 2001. Williams Lake telemetry study: New York Indiana bat spring migration tracking. Report to the Independence Pipeline Company.

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

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

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

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

3D/Environmental. 1995. Literature summary and habitat suitability index model. Components of summer habitat for the Indiana bat, *Myotis sodalis*. Cincinnati, Ohio.

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

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

(USFWS) U.S. Fish and Wildlife Service. 1999. Indiana Bat (*Myotis sodalis*) revised recovery plan, Agency Draft. Ft. Snelling, Minnesota.

Veilleux, J. P., J. O. Whitaker, Jr., and E. A. Vincent. 1998. Mammals of the Newport Chemical Depot, Vermillion County, Indiana. Proceeding of the Indiana Academy of Science 107:91-104.

Veilleux, J. P., J. O. Whitaker, Jr., and S. L. Veilleux. 2003. Tree-roosting ecology of reproductive female eastern pipistrelles, *Pipistrelles subflavus*, in Indiana. Journal of Mammalogy 84:1068-1075.

Watkins, L.C. 1970. Observatons on the distribution and natural history of the evening bat (*Nycticeius humeralis*) in northeastern Missouri and adjacent Iowa, Transactions of the Kandsas Acadeny of Science 72:330-336.

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

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

Whitaker, J. O., Jr. 1996. Survey of summer bat communities and search for endangered bat species at 21 sites along

the proposed Bloomington to Evansville highway route in Gibson, Pike, Daviess, Greene, and Monroe counties in southwest Indiana highway corridor - Draft EIS Appendix. Indiana Department of Transportation, Indianapolis.

Whitaker, J. O., Jr., and V. Brack Jr. 2002. Distribution and ecology in Indiana. Pp. 48-54 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

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

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

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

Whitaker, J. O., Jr., and P. Clem. 1992. Food of the evening bat *Nycticeius humeralis* from Indiana. American Midland Naturalist 127:211-214.

Whitaker, J. O. Jr. and W. J. Hamilton, Jr. 1998. Mammals of the Eastern Untied States. Cornell University Press, Ithaca. 608 pp.

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

Wilkinson, G.S. 1992. Communal nursing in the evening bat, *Nycticeius humeralis*. Behavioral Ecology and Sociobiology 31:225-235.

Wimsatt, W. 1944. Further studies on the survival of spermatozoa in the female reproductive tract of the bat. Anatomical Record 88:193-204.

Appendix A

Figures

Figure 1. Location of Section 2 of the I-69 corridor in Gibson, Daviess, and Pike Counties, Indiana

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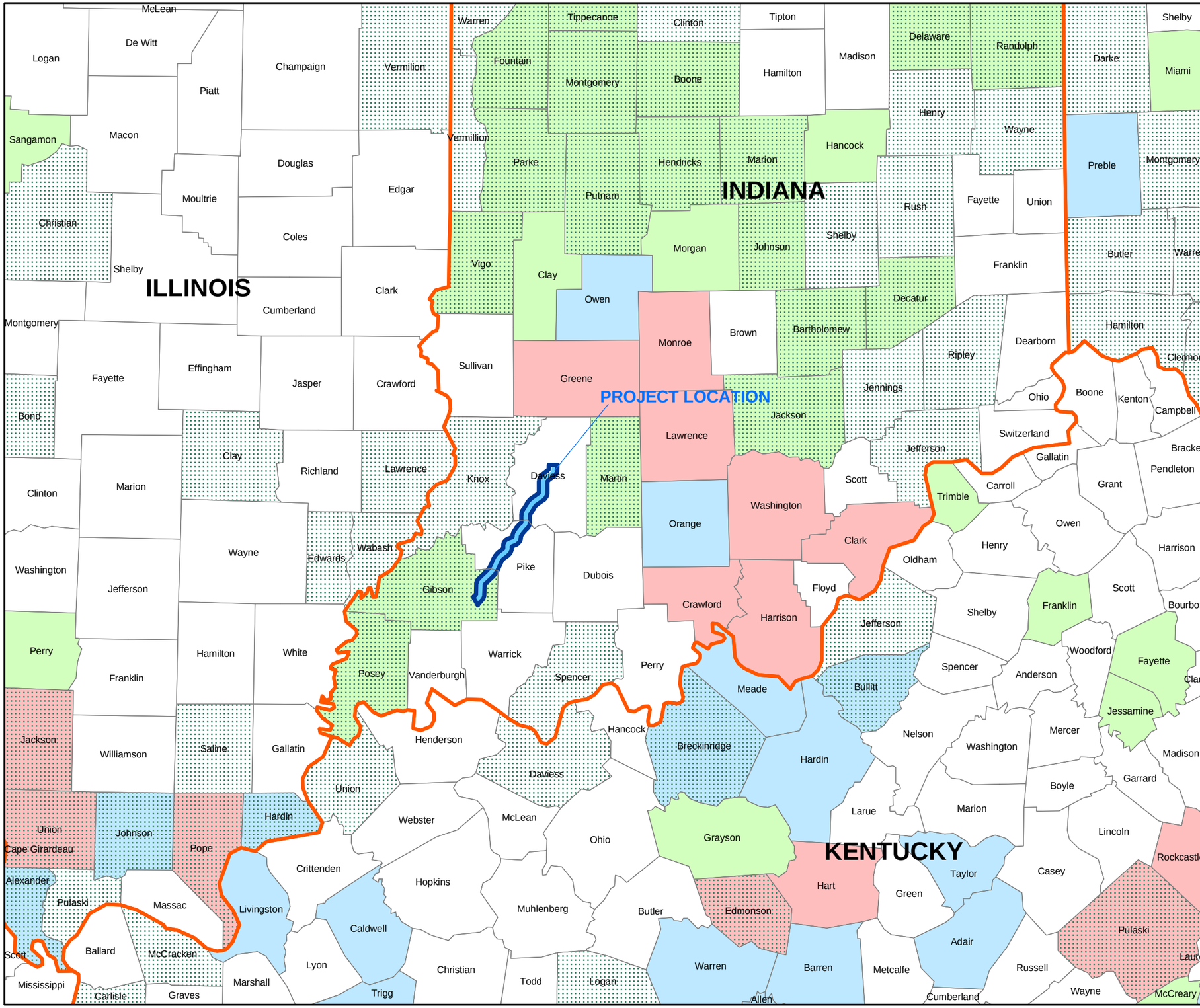
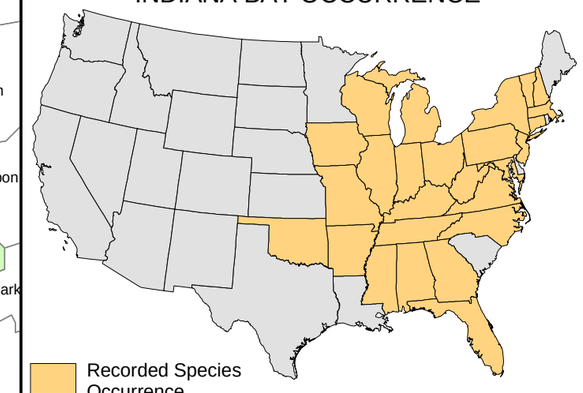


Figure 2. Counties near the project area with hibernacula, summer maternity, and other summer (nonreproductive) records for the Indiana bat (*Myotis sodalis*).

- 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

STATES WITH RECORDS OF INDIANA BAT OCCURRENCE



Recorded Species Occurrence

N W E S

Miles
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Sources: USFWS, Indiana Bat Revised Recovery Plan, Agency Draft, 1999.

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Project No. 112, September 2003

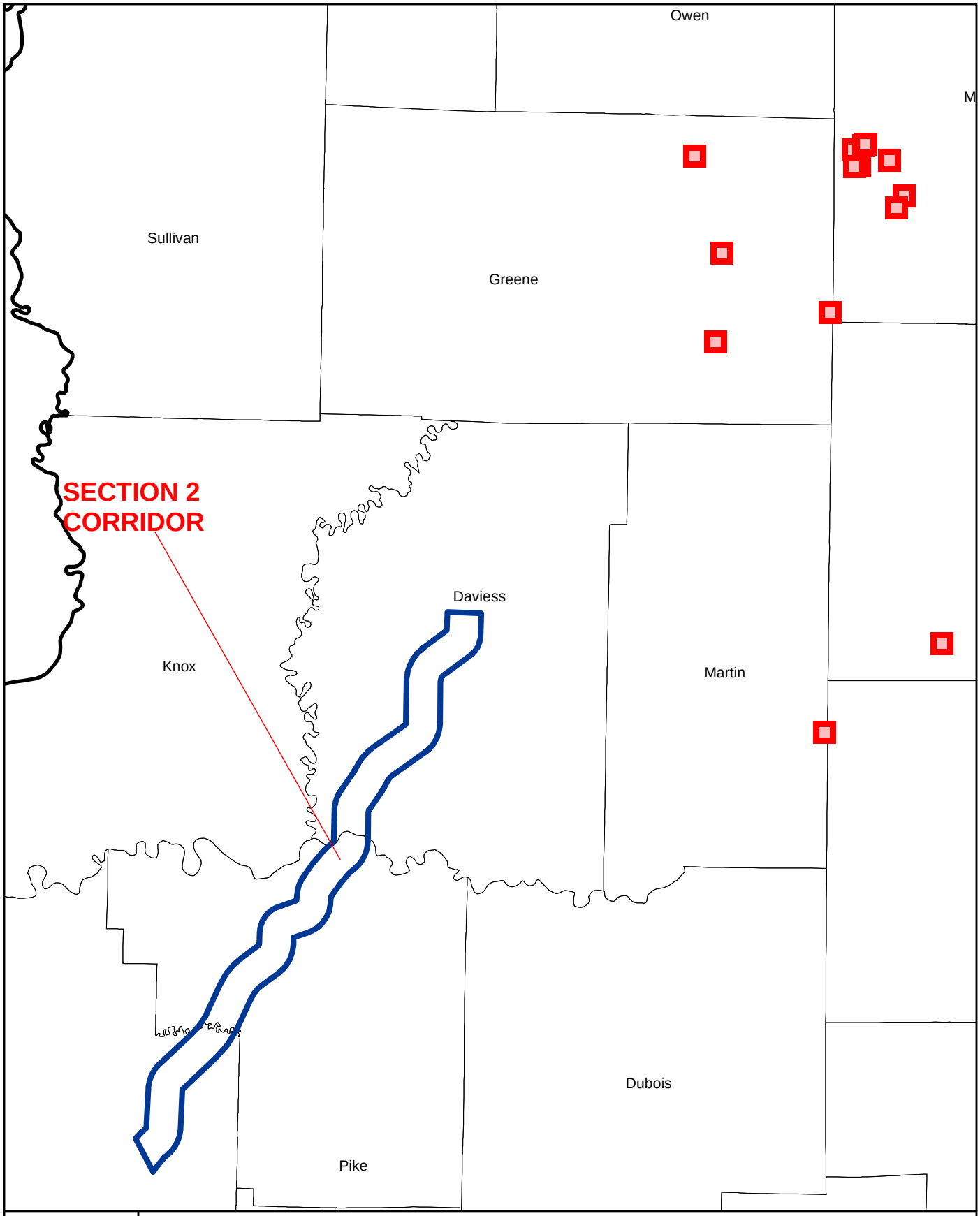

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Figure 3. Location of winter hibernacula near Section 2 of the I-69 corridor.

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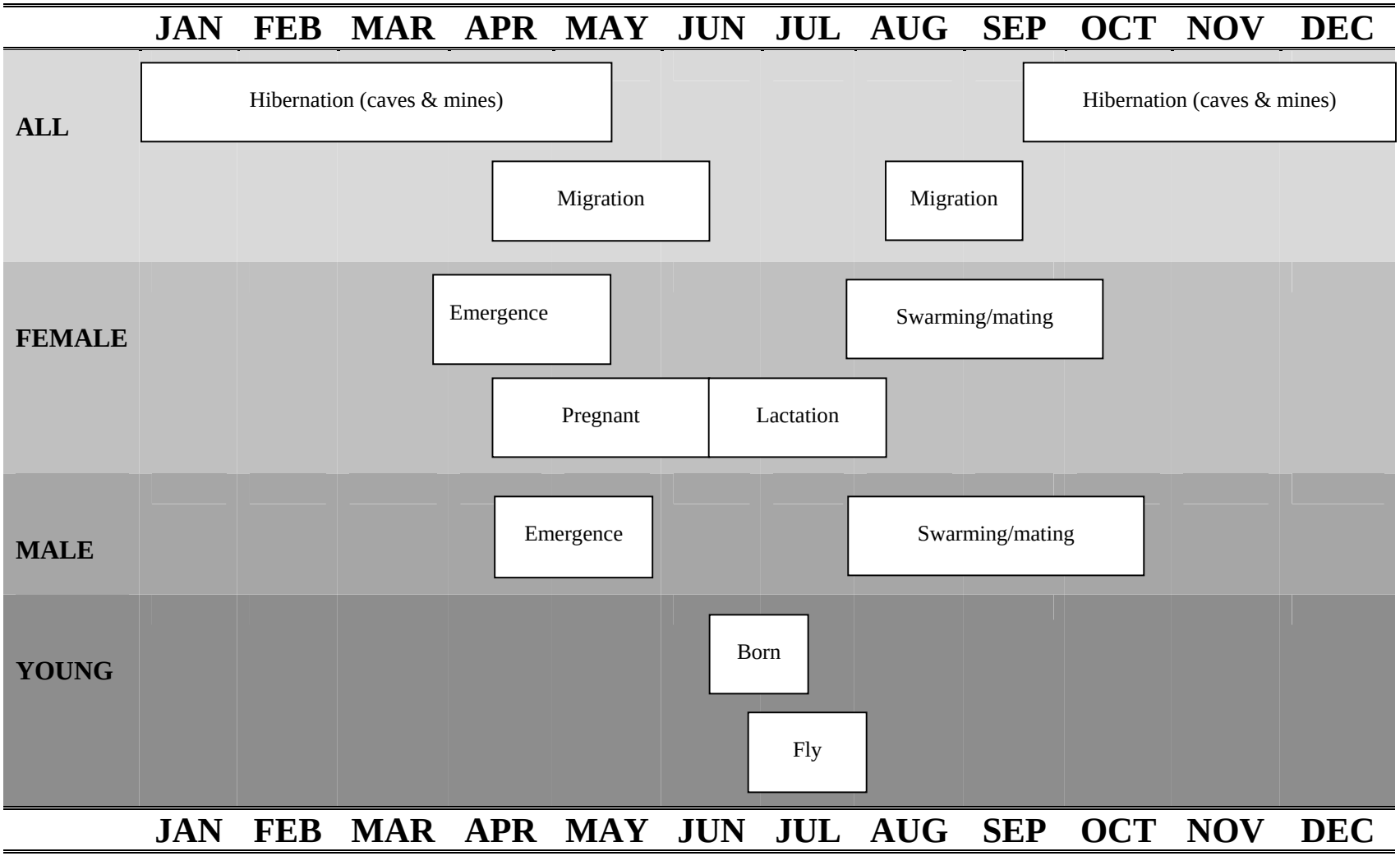


Figure 4. Seasonal chronology of Indiana bat activities.

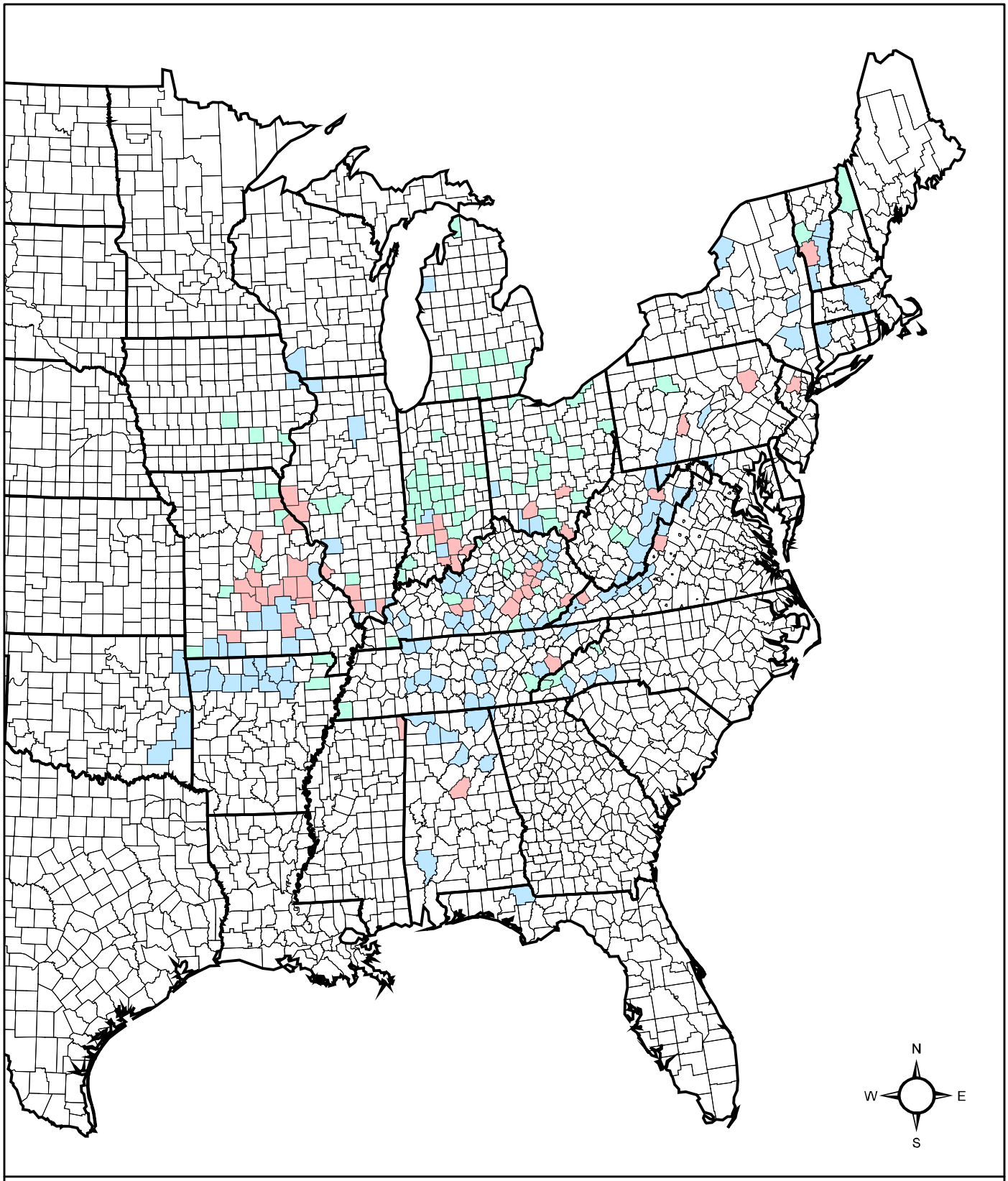


Figure 5. Counties with hibernacula and other summer (nonreproductive) records for the Indiana bat (*Myotis sodalis*) range wide.

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

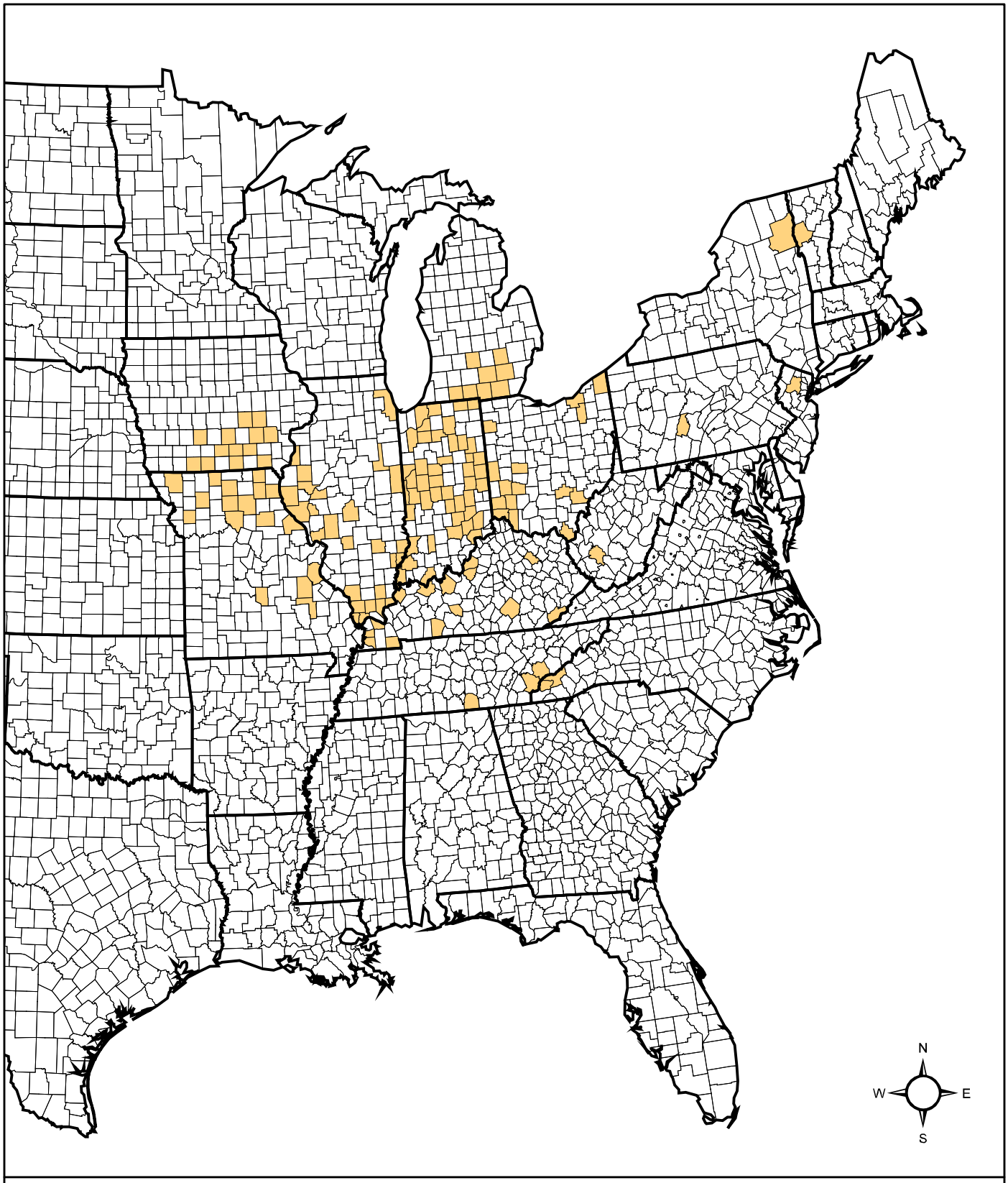
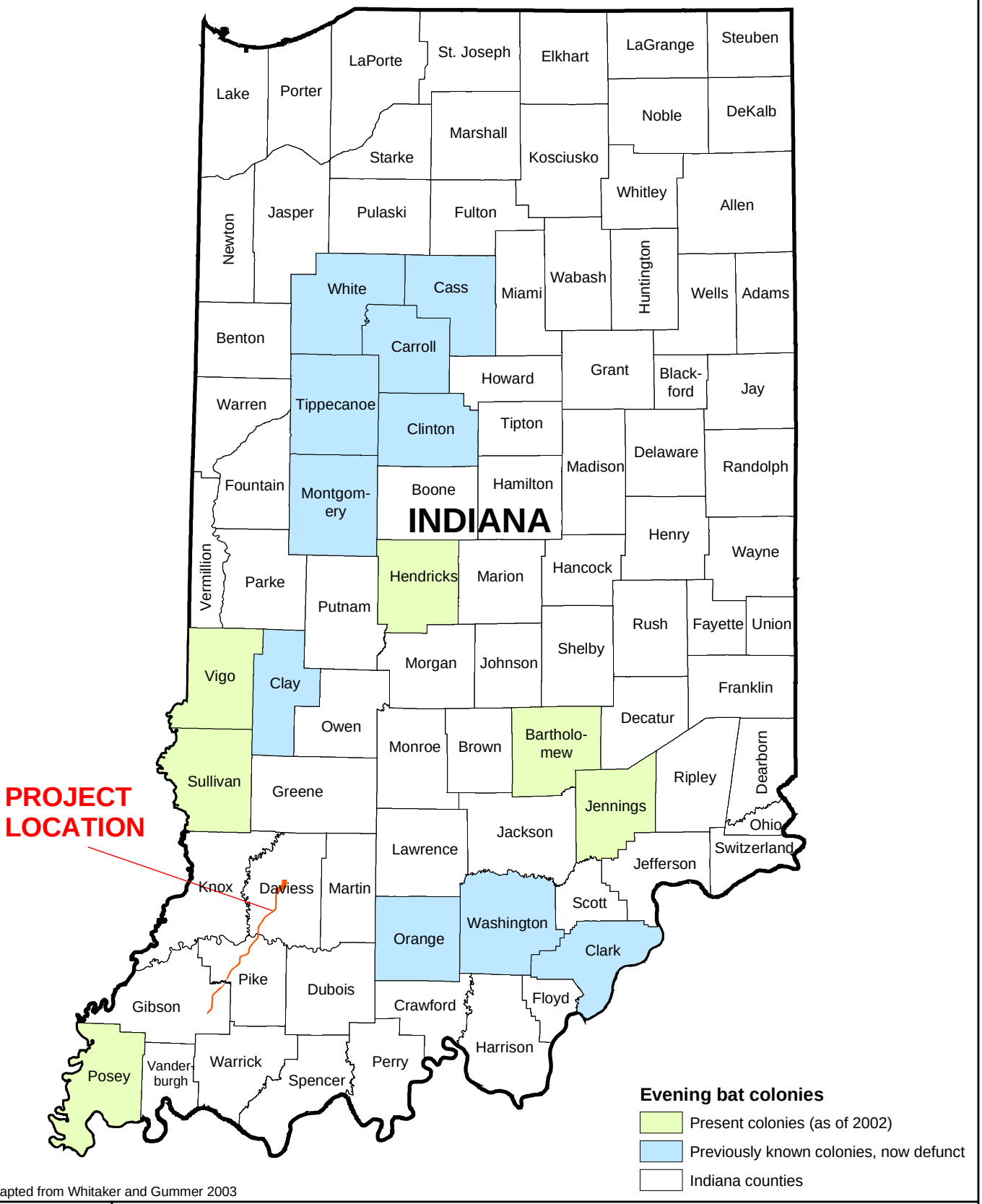


Figure 6. Counties with reproductive (adult female and/or young-of-the-year) records for the Indiana bat (*Myotis sodalis*) range wide.

County with Record of Indiana Bat Reproductive Occurrence

Project No. 112 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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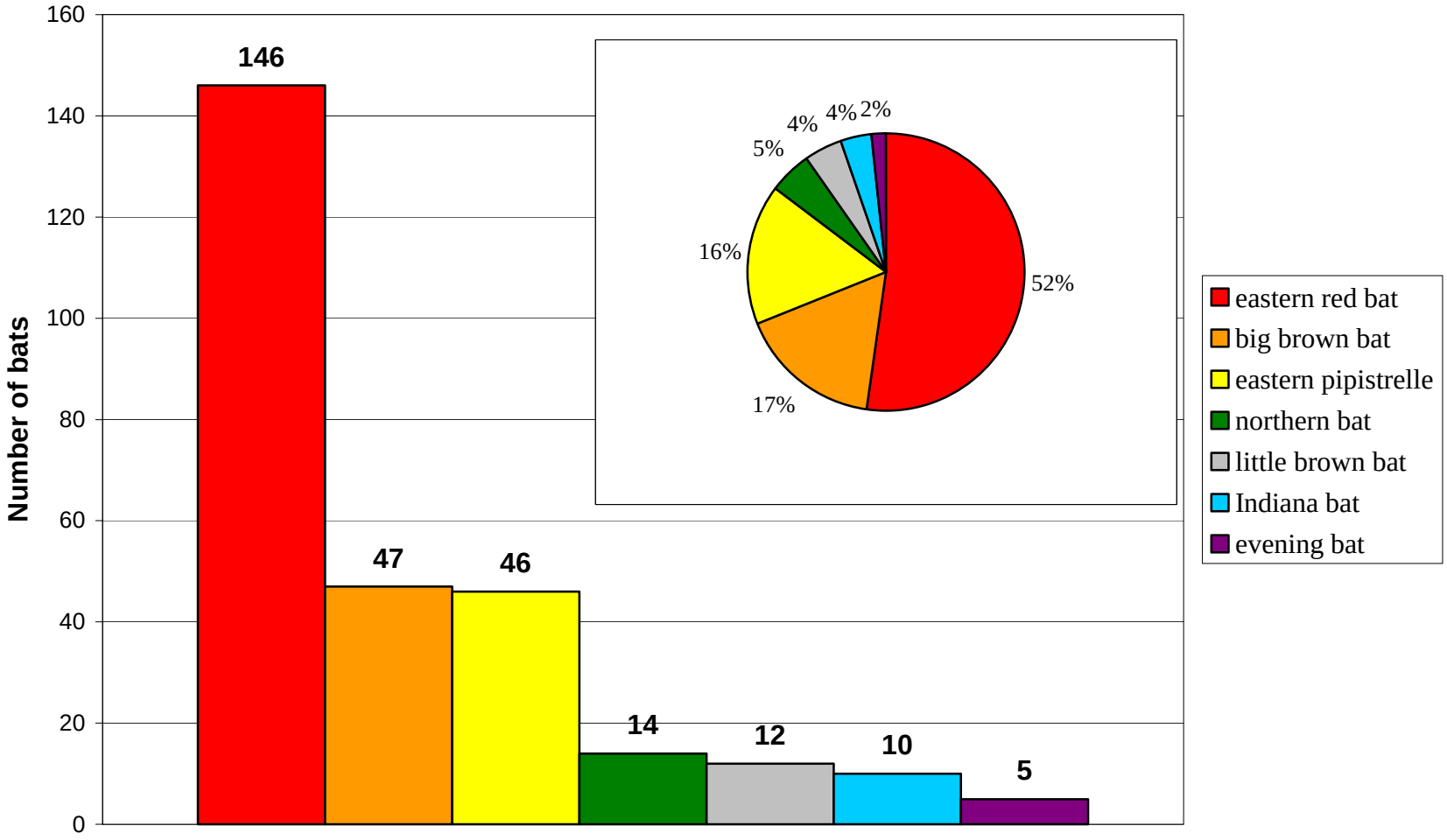
Figures 8 and 9 have been removed for confidentiality reasons related to the federally endangered Indiana bat (*Myotis sodalis*).

Figure 10. Total number and percentage of bats caught on Section 2 of I-69.



Figures 11 and 12 have been removed for confidentiality reasons related to the federally endangered Indiana bat (*Myotis sodalis*).

Appendix B

Tables

Table 1 has been removed for confidentiality reasons related to the federally endangered Indiana bat (*Myotis sodalis*).

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 2004 summer mist net surveys on Section 2 of I-69.

Survey Dates (2004)	**Survey Period (approx. 2000 – 0200 h)**	
	High Temp. °F	**Low Temp. °F**
23-Jul	75	63
24-Jul	71	64
25-Jul	66	60
26-Jul	68	54
27-Jul	65	56
28-Jul	69	61
29-Jul	72	65
3-Aug	79	70
4-Aug	79	70
5-Aug	74	58
6-Aug	69	54
7-Aug	73	55
8-Aug	68	60
9-Aug	75	66
10-Aug	75	56
11-Aug	64	55
12-Aug	62	56
13-Aug	62	48
14-Aug	64	51

Table 4. Bridge number, county, and location of bridges on Section 2 of I-69.

Bridge Number	County	UTM Zone	Coordinates (meters) Northing	Easting
1	Daviess	16 S	4277452	488828
2	Daviess	16 S	4277005	493231
3	Daviess	16 S	4276103	488751
4	Daviess	16 S	4274487	489791
5	Daviess	16 S	4276093	491267
6	Daviess	16 S	4274500	487603
7	Pike	16 S	4274250	489823
8	Daviess	16 S	4273848	481123
9	Daviess	16 S	4273737	486151
10	Daviess	16 S	4273188	480627
11	Daviess	16 S	4272883	483073
12	Daviess	16 S	4273034	484055
13	Daviess	16 S	4273053	485549
14	Daviess	16 S	4273902	487605
15	Daviess	16 S	4270413	483861
16	Daviess	16 S	4269714	484684
17	Daviess	16 S	4269578	487165
18	Daviess	16 S	4269202	485425
19	Daviess	16 S	4267132	485091
20	Pike	16 S	4264688	481459
21	Pike	16 S	4264325	480825
22	Pike	16 S	4264200	481485
23	Pike	16 S	4263218	479035
24	Pike	16 S	4263081	479049
25	Pike	16 S	4263297	480878
26	Pike	16 S	4262089	482293
27	Pike	16 S	4261178	482803
28	Pike	16 S	4259560	475003
29	Pike	16 S	4257267	474184
30	Pike	16 S	4255044	470237
31	Pike	16 S	4252490	473695
32	Pike	16 S	4251660	471691
33	Pike	16 S	4250825	468223
34	Pike	16 S	4251073	469227
35	Pike	16 S	4250533	468846
36	Pike	16 S	4250574	472510
37	Pike	16 S	4251008	475726
38	Pike	16 S	4250176	475704
39	Pike	16 S	4247688	467683
40	Gibson	16 S	4247531	467630
41	Pike	16 S	4248332	470469
42	Gibson	16 S	4247900	470317

43	Gibson	16 S	4246661	471299
44	Pike	16 S	4261573	478605
45	Daviess	16 S	4269066	484864
46	Daviess	16 S	4269180	485434
47	Gibson	16 S	4238868	465660
48	Gibson	16 S	4239755	464339
49	Gibson	16 S	4240197	461046
50	Pike	16 S	4259934	467695
51	Pike	16 S	4258333	469329

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 2 of I-69.

Site	Survey Dates	# of Adult pregnant Female Indiana bat	# of Adult lactating Female Indiana bat	#of Adult post-lactating Female Indiana bat	# of Non-repro. Adult Female Indiana bat	# of Juvenile Female Indiana bat	# of Adult Male Indiana bat	# of Juvenile Male Indiana bat	Total # of Indiana bat	# of Radio-tagged Indiana bat	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 Captured*
1	8/12 & 8/13								0						1				1
2	8/12 & 8/14								0			2			1	5			8
3	8/12 & 8/13								0					12	2	15			29
4	7/29 & 8/9								0			2	1		1	3			7
5	7/27 & 7/28								0			3	8	5	2	1		2	21
6	7/29 & 8/9								0				1	5	5	13		1	25
7	7/27 & 7/28								0			1			1	4			6
8	7/27 & 7/28				1				1	1	2					2			3
9	7/27 & 7/28								0			1		1		6			8
10	8/9 & 8/14								0							1		1	2
10a	7/29								0				1	1	1	4			7
11	7/29 & 8&13				1				1	1			1	1	6	7			16
12	8/10 & 8/11			1	1				2	2						1			3
13	8/11 & 8/12								0				1		1	4			6
14	8/10 & 8/11								0					1	4	15			20
15	8/10 & 8/12								0							1			1
16	8/3 & 8/4								0					5	1	5			11
17	8/7 & 8/8								0										0
18	8/3 & 8/4								0						1	1			2
19	8/7 & 8/8								0						1	5			6
20	7/23 & 7/24								0					1	2	14			17
21	7/23 & 7/24								0				1	1	1	2		1	6
22	7/25 & 7/26			1					1	1						8			9
23	7/25 & 7/26								0						1	7			8
24	7/23 & 7/24								0						3	3			6
25	7/25 & 7/26								0							5			5
26	8/7 & 8/8								0										0
27	8/5 & 8/6								0			1			2	5			8
28	8/5 & 8/6								0			1			3				4
29	8/5 & 8/6				1		1		2	2	4			1		4			7
30	8/7 & 8/8				3				3	2	2			12	7	6			28
Totals			0	2	7		1		10	9	8	11	13	45	46	143	0	5	280

Table 6. Total bat captures by sex, reproductive condition, and age during 2004 summer mist netting on Section 2 of I69.

Species	Adult Male	Adult Female[1]				Juvenile		Escape[2]	Total
		P	L	PL	NR	Male	Female		
Big brown bat	16	0	0	0	20	2	7	2	**47**
Eastern red bat	13	0	2	6	13	44	57	11	**146**
Little brown bat	0	0	0	2	7	3	0	0	**12**
Northern bat	2	0	0	1	10	1	0	0	**14**
Indiana bat	1	0	0	2	7	0	0	0	**10**
Evening bat	2	0	0	0	2	0	1	0	**5**
Eastern pipistrelle	4	0	0	2	5	15	19	1	**46**
Total	**38**	**0**	**2**	**13**	**64**	**65**	**84**	**14**	**280**

[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 2 of I-69.

Species	Male Bats		Female Bats				Catch/net-night
	No.	%	No.	%	X^2	*P*	Total
Big brown bat	16	42.1	20	25.3	6.770	0.8602	0.39
Eastern red bat	13	34.2	21	26.6	15.852	0.4037	1.20
Evening bat	2	5.3	2	2.5			0.04
Little brown bat	0	0	9	11.4			0.10
Northern bat	2	5.3	11	13.9			0.11
Indiana bat	1	2.6	9	11.4			0.08
Eastern pipistrelle	4	10.5	7	8.9	5.284	.6297	0.38
Total	**38**		**79**				**2.30**

Table 8. Biology, capture, and telemetry information of radio-tagged Indiana bats on Section 2 of I-69.

Bat Number	Capture Date	Transmitter Frequency	Capture Site	Sex	Age Class	Reproductive Condition	Number of Roosts
Bat 285	25 July	151.285	22	Female	Adult	Post-lactating	0
Bat 356	28 July	151.356	8	Female	Adult	Non-reproductive	2
Bat 442	29 July	151.442	11	Female	Adult	Non-reproductive	0
Bat 523	5 August	151.523	29	Male	Adult	Non-descended	3
Bat 117	6 August	151.117	29	Female	Adult	Non-reproductive	1
Bat 082	7 August	151.082	30	Female	Adult	Non-reproductive	1
Bat 036	7 August	151.036	30	Female	Adult	Non-reproductive	1
Bat 482	11 August	151.482	12	Female	Adult	Non-reproductive	0
Bat 385	11 August	151.385	12	Female	Adult	Post-lactating	0

Table 9. Summary of roost tree data for radio-tagged Indiana bats on Section 2 of I-69.

Bat Number	Tree Species	Roost Status	DBH (cm)	% Exfoliating Bark	% Canopy Closure	Roost Height (m)	Roost Habitat
Bat 356	Sugar maple	Live	19	0	100	6	Riparian
	Unknown	Dead	41	70	0	9	Riparian
Bat 523	American elm	Dead	76	40	30	8	Riparian
	Elm sp.	Dead	48	40	50	8	Riparian
	Unknown	Dead	64	30	0	-	Riparian
Bat 117	American elm	Dead	50	40	15	6	Upland
Bat 082	Shagbark Hickory	Live	35	70	80	6	Riparian
Bat 036	Shagbark Hickory	Live	35	50	75	6	Riparian

Table 10. Distance matrix in kilometers (km) between capture site and roost trees for Indiana bat 356.

	Capture Site 8	**Roost 1**	**Roost 2**
Capture Site 8		1.54 km	1.53 km
Roost 1	1.54 km		1.63 km
Roost 2	1.53 km	1.63 km	

Table 11. Roost tree species, size, status, and emergence count numbers for Indiana bat 356.

Roost Number	Roost Tree Species	Tree Size (dbh)	Status	Date	Emergence Count
1	sugar maple	19 cm	Live	31 July	0
				1 August	0
				2 August	0
2	unknown	41 cm	Dead	31 July	69
				1 August	100
				2 August	85
				3 August	80

Table 12. Distance matrix in meters (m) or kilometers (km) between capture site and roost trees for Indiana bat 523.

	Capture Site 29	**Roost 1**	**Roost 2**	**Roost 3**
Capture Site 29		1.47 km	1.45 km	1.55 km
Roost 1	1.47 km		20 m	140 m
Roost 2	1.45 km	20 m		145 m
Roost 3	1.55 km	140 m	145 m	

Table 13. Roost tree species, size, status, and emergence count numbers for Indiana bat 523.

Roost Number	**Roost Tree Species**	**Tree Size (DBH)**	**Status**	**Date**	**Emergence Count**
1	American elm	76 cm	Dead	6 August	17
				7 August	0
2	Elm sp.	41 cm	Dead	8 August	5
				9 August	0
				11 August	0
3	Unknown	64 cm	Dead	8 August	3
				9 August	0
				10 August	0

Table 14. Roost tree species, size, status, and emergence count numbers for Indiana bat 117.

Roost Number	Roost Tree Species	Tree Size (dbh)	Status	Date	Emergence Count
1	American elm	50 cm	Dead	7 August	6
				8 August	22
				9 August	36
				10 August	28
				11 August	34
				12 August	33

Table 15. Roost tree species, size, status, and emergence count numbers for Indiana bat 082.

Roost Number	Roost Tree Species	Tree Size (dbh)	Status	Date	Emergence Count
1	Shagbark hickory	36 cm	Live	8 August	0
				9 August	0
				11 August	2
				12 August	0
				13 August	0

Table 16. Roost tree species, size, status, and emergence count numbers for Indiana bat 036.

Roost Number	Roost Tree Species	Tree Size (dbh)	Status	Date	Emergence Count
1	Shagbark hickory	36 cm	Live	8 August	1
				9 August	5
				11 August	0
				12 August	0
				13 August	32

Table 17. County, location, and evidence of bats for all bridges on Section 2 of I-69.

Bridge Number	County	Bat Species Found	Number of Bats	Presence of Guano (Y/N)	Comments / Observations
1	Daviess	None	0	No	
2	Daviess	None	0	No	
3	Daviess	None	0	No	
4	Daviess	None	0	No	
5	Daviess	None	0	No	
6	Daviess	Unknown[1]	1	No	pigeon and swallow nests
7	Pike	None	0	No	
8	Daviess	None	0	No	
9	Daviess	None	0	No	lots of swallow nests
10	Daviess	None	0	No	
11	Daviess	None	0	No	
12	Daviess	None	0	No	
13	Daviess	None	0	Yes	
14	Daviess	None	0	No	
15	Daviess	None	0	No	
16	Daviess	None	0	No	
17	Daviess	None	0	Yes	
18	Daviess	None	0	No	
19	Daviess	None	0	No	
20	Pike	None	0	No	
21	Pike	None	0	No	1 bat seen flying past
22	Pike	None	0	No	snakes seen
23	Pike	None	0	No	
24	Pike	None	0	No	
25	Pike	None	0	No	
26	Pike	None	0	No	
27	Pike	None	0	No	
28	Pike	None	0	No	possible crevices for bats
29	Pike	None	0	No	
30	Pike	None	0	No	
31	Pike	None	0	No	
32	Pike	None	0	No	
33	Pike	None	0	No	
34	Pike	None	0	No	
35	Pike	None	0	No	
36	Pike	None	0	No	
37	Pike	None	0	No	
38	Pike	None	0	No	raccoons present
39	Pike	None	0	No	
40	Gibson	None	0	No	
41	Pike	None	0	No	

42	Gibson	None	0	No	
43	Gibson	None	0	No	
44	Pike	None	0	No	
45	Daviess	None	0	No	
46	Daviess	None	0	No	
47	Gibson	None	0	No	
48	Gibson	None	0	No	
49	Gibson	None	0	No	
50	Pike	None	0	No	
51	Pike	None	0	No	

[1] Bat flew away before positive identification could be made.

Appendix C has been removed for confidentiality reasons related to the federally endangered Indiana bat (*Myotis sodalis*).

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

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). King Blair (Brinegar) Cave, Buckner Cave, Salamander Cave, Saltpeter Cave, Reeve's Cave, and Leonard Spring Cave are Priority III hibernacula. Coon Cave and Grotto Cave are Priority II hibernacula. These caves range from 1.0 (Reeve's Cave) to 4.6 miles (Salamander Cave) from the Section 4 corridor (BLA 2003).

Eastern Greene County contains four known Indiana bat hibernacula (Figure 3). Ashcraft Cave and Sexton Spring Cave are Priority III hibernacula located approximately 0.5 miles from the Section 4. Clifty Cave, another Priority III cave, is 10 miles from the corridor. Ray's 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). Ray's 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 Highway 57 on West Fork of White River 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 Highway 57 on West Fork of White River, 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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7.0 Literature Cited

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

Baker, W. W., S. G. Marshall, and V. B. Baker. 1968. Autumn fat deposition in the evening bat (*Nycticeius humeralis*). Journal of Mammalogy 49:329.

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

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

Boyles, J. G., B. M. Mormann, and L. W. Robbins. In submission. Use of a subterranean roost by a male evening bat (*Nycticeius humeralis*). In submission to Southeastern Naturalist.

BLA-Bernardin-Lochmueller and associates. 2003. Tier 1 biological assessment for threatened and endangered species, Interstate 69, Indianapolis to Evansville [dated July 18, 2003, revised October 27, 2003; submitted to the Bloomington Field Office of the U.S. Fish and Wildlife Service by the Federal Highway Administration and Department of Transportation.

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

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

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

Brack, V. Jr. 2004. The biology and life history of the Indiana bat: hibernacula. Pages xx-xx In Indiana Bat and Coal Mining (K. C. Vories,

ed.). US DOI, Office of Surface Mining, Washington, D.C.

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

Brack, V., Jr., and J. C. Carter. 1985. Use of an underground burrow by *Lasionycteris*. Bat Research News 26:28-29.

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

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

Brack, V., Jr., and S. A. Johnson. 1990. An albino Indiana bat (*Myotis sodalis*). Bat Research News, 31:8.

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

Brack, V. Jr., C. W. Stihler, R. J. Reynolds, C. Butchkoski, and C. S. Hobson. 2002. Effects of climate and elevation on distribution and abundance in the mideastern United States. Pp. 21-28 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

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

Brack, V. Jr., J. O. Whitaker, Jr., and S. E. Pruitt. 2004. Bats of Hoosier National Forest. Proceedings of the Indiana Academy of Science 113:76-86.

Brack, V., Jr., R. K. Dunlap, and S. A. Johnson. 2005. Albinism in the Indiana bat, *Myotis sodalis*. Bat Research News: In press.

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

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

ESI- Brown, R. J. and Brack, V. Jr., 2003. A summer mist net survey for the federally endangered Indiana bat (*Myotis sodalis*) at the Newport Chemical Depot, Newport, Indiana. Unpublished report for Newport Chemical Depot. 41 pages plus appendices.

ESI-2004. Summer habitat for the Indiana Bat (*Myotis sodalis*) within the Crawford upland and Mitchell Plain from Scotland to Bloomington, Indiana

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

Butchkoski, C. M., and J. D. Hassinger. 2002. Ecology of a maternity colony in a building. Pp. 130-142 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

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

Carter, T. C., M. A., Menzel, D. M. Krishon, and J. Laerm. 1998. Prey selection by five species of vespertilionid bats on Sapelo Island, Georgia. Brimleyana 25:158-170.

Carter, T. 2002. Bat houses for conservation of endangered Indiana myotis. The Bat House Researcher 10:1-3.

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

Clark, B., J. Bowles, and B. Clark. 1987. Summer occurrences of the Indiana bat, Keen's Myotis, evening bat, silver-haired bat and eastern pipistrelle in Iowa. Iowa Academy of Science 94:89-93.

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

Clawson, R. L. 2002. Trends in population size and current status. Pp. 2-8 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Clem, P. D. 1992. Seasonal population variation and emergence patterns in the evening bat, *Nycticeius humeralis*, at a west-central Indiana colony. Proceedings of the Indiana Academy of Science 101:33-43.

Clem, P. D. 1993. Foraging patterns and the use of tempoirary roost in female evening bats, *Nycticeius humeralis*, at an Indiana maternity colony. Proceedings of the Indiana Academy of Science 102:201-206.

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

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

Feldhamer, G. A., J. O. Whitaker, Jr., J. K. Kreica, and S. J. Taylor. 1995. Food of the evening bat (*Nycticeius humeralis*) and red bat (*Lasiurus borealis*) from southern Illinois. Transactions of the Illinois State Academy of Science 88:139-143.

Foster, R. W., and A. Kurta. 1999. Roosting ecology of the northern bat (*Myotis septentrionalis*) and comparisons with the endangered Indiana bat (Myotis sodalis). Journal of Mammalogy 80:659-672.

Gardner, J. E., J. D. Garner, and J. E. Hofmann. 1991. Summer roost selection and roosting behavior of *Myotis sodalis* (Indiana bat) in Illinois. A report prepared for U. S. Fish and Wildlife Service, Region 3 Endangered Species Coordinator, Twin Cities, Minnesota.

Gardner, J. E., and E. A. Cook. 2002. Seasonal and geographic distribution and quantification of potential summer habitat. Pp. 9-20 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

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

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

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

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

Hicks, A., and P. G. Novak. 2002. History, status, and behavior of hibernating populations in the Northeast. Pp. 35-47 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Homoya, M. A., D. B. Abrell, J. R. Aldrich, and T. W. Post. 1985. The Natural Regions of Indiana. Indiana Academy of Science 94: 245-268.

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

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

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

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

Johnson, S. A., V. Brack, Jr. and R. K. Dunlap. 2002. Management of hibernacula in the state of Indiana. Pp. 106-115 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Kath, J. A. 2002. A review of the hibernacula in Illinois, with emphasis on the Magazine Mine. Pp. 110-117 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

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

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

Kirkpatrick, C. M., and C. H, Conaway. 1948. Some notes on Indiana mammals. American Midland Naturalist. 39:128-136.

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

Kiser, J. D., J. R. MacGregor, H. D. Bryan, and A. Howard. 2002. Use of concrete bridges as night roosts. Pp. 208-215 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

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

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

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

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

Kurta, A., S. W. Murray, D. H. Miller. 2002. Roost selection and movements across the summer landscape. Pp. 118-129 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

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

LaVal, R. K., and M. L. LaVal. 1980. Ecological studies and management of Missouri bats, with emphasis on cave-dwelling species. Missouri Department of Conservation Terrestrial Series 8:1-53.

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

Logan, W. N., E.R. Cumings, C.A. Malott, S.S. Visher, W.M. Tucker, and J.R. Reeves. 1922. Handbook of Indiana Geology. Department of Conservation Publication 21, Indianapolis, Indiana. 1120 pages.

MacArthur, R. H. 1972. Geographical Ecology. Harper and Row, New York, New York.

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

Miles A. C., S. A. Castleberry, D. A. Miller, and L. M. Conner. 2004. Interesting observations at evening bat maternity

colonies in southwest Georgia. Presentation *at* The 9th annual meeting of the Southeastern Bat Diversity Network and 14th colloquium on conservation of mammals in the southeastern United States.

Miller, N. E., R. D. Drobney, R. L. Clawson, and E. V. Callahan. 2002. Summer habitat in northern Missouri. Pp. 165-171 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

Minton, S. A., Jr. 2001. Amphibians and Reptiles of Indiana: Revised 2nd Edition. Indiana Academy of Science, Indianapolis, Indiana.

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

Mumford, R. E. and J. O. Whitaker, Jr. 1982. Mammals of Indiana. Bloomington University Press, Indiana.

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

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

Paradsio, J. L., and A. M. Greenhall. 1967. Longevity records for American bats. American Midland Naturalist 78:251-252.

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

Racey, P. A. 1982. Ecology of bat reproduction. Pp. 57-103 in Ecology of bats (T. H. Kunz, ed.). Plenum Publishing Corporation, New York, New York.

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

Sanders, C., and J. Chenger. 2001. Williams Lake telemetry study: New York Indiana bat spring migration tracking. Report to the Independence Pipeline Company.

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

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

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

Summit County Metro Parks. 2003. Preliminary inventory of bat species

Pond Brook Metro Park and Twinsburg Park and Nature Preserve. Summit County Metro Parks, Akron, Ohio.

3D/Environmental. 1995. Literature summary and habitat suitability index model. Components of summer habitat for the Indiana bat, *Myotis sodalis*. Cincinnati, Ohio.

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

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

(USFWS) U.S. Fish and Wildlife Service. 1999. Indiana Bat (*Myotis sodalis*) revised recovery plan, Agency Draft. Ft. Snelling, Minnesota.

Watkins, L.C. 1970. Observatons on the distribution and natural history of the evening bat (*Nycticeius humeralis*) in northeastern Missouri and adjacent Iowa, Transactions of the Kandsas Acadeny of Science 72:330-336.

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

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

Whitaker, J. O., Jr., and V. Brack Jr. 2002. Distribution and ecology in Indiana. Pp. 48-54 in The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds.). Bat Conservation International, Austin, Texas.

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

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

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

Whitaker, J. O., Jr., and P. Clem. 1992. Food of the evening bat *Nycticeius humeralis* from Indiana. American Midland Naturalist 127:211-214.

Whitaker, J. O. Jr. and W. J. Hamilton, Jr. 1998. Mammals of the Eastern Untied States. Cornell University Press, Ithaca. 608 pp.

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

Wilkinson, G.S. 1992. Communal nursing in the evening bat, *Nycticeius humeralis*. Behavioral Ecology and Sociobiology 31:225-235.

Wimsatt, W. 1944. Further studies on the survival of spermatozoa in the female reproductive tract of the bat. Anatomical Record 88:193-204.

Whitaker, J. O., Jr., D. W. Sparks, and V. Brack Jr. In submission. Use of Artifical Roost Structures by bats at the Indianapolis International Airport. In submission to Wildlife Society Bulletin.

Appendix A

Figures

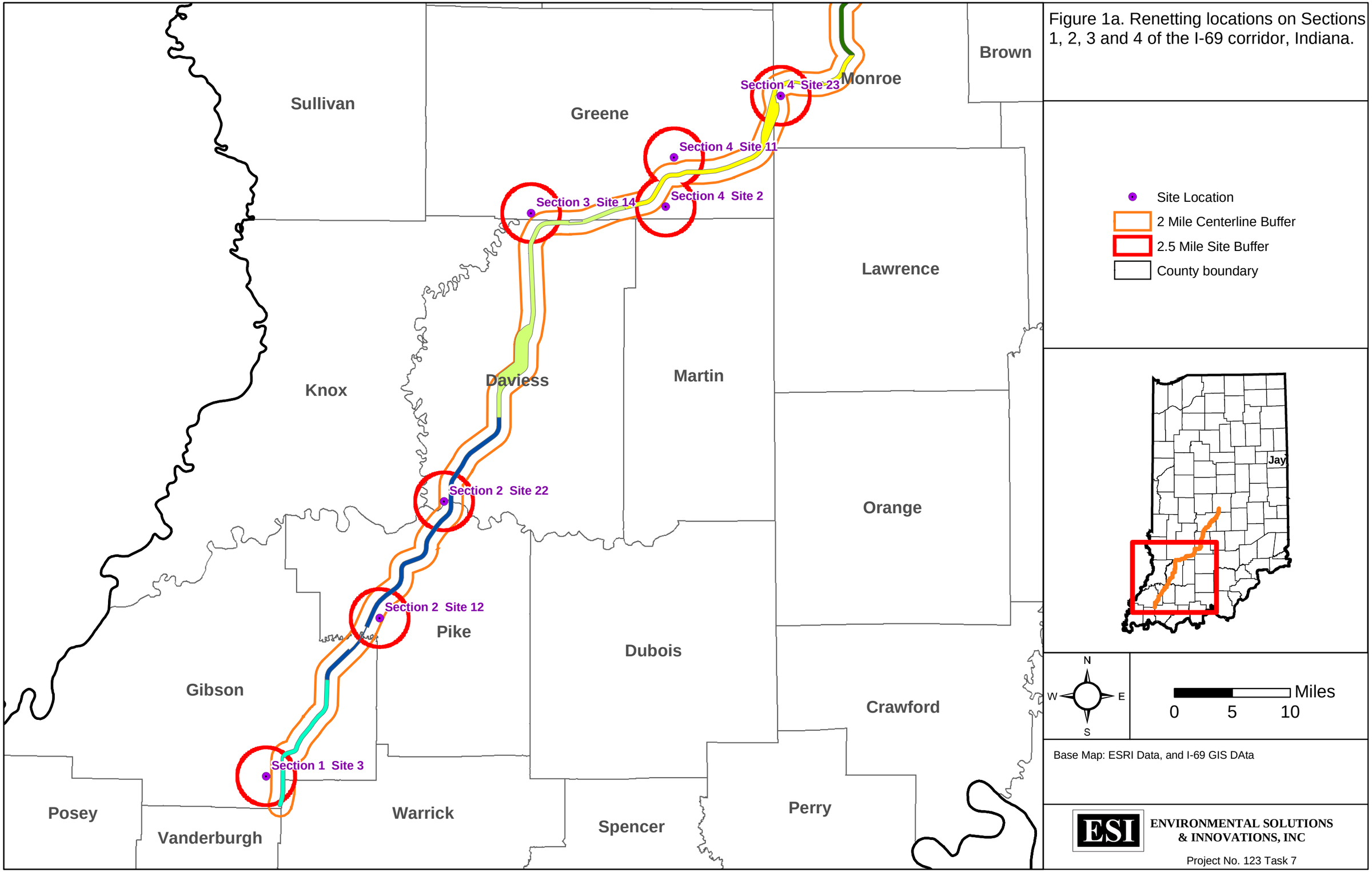

Figure 1a. Renetting locations on Sections 1, 2, 3 and 4 of the I-69 corridor, Indiana.

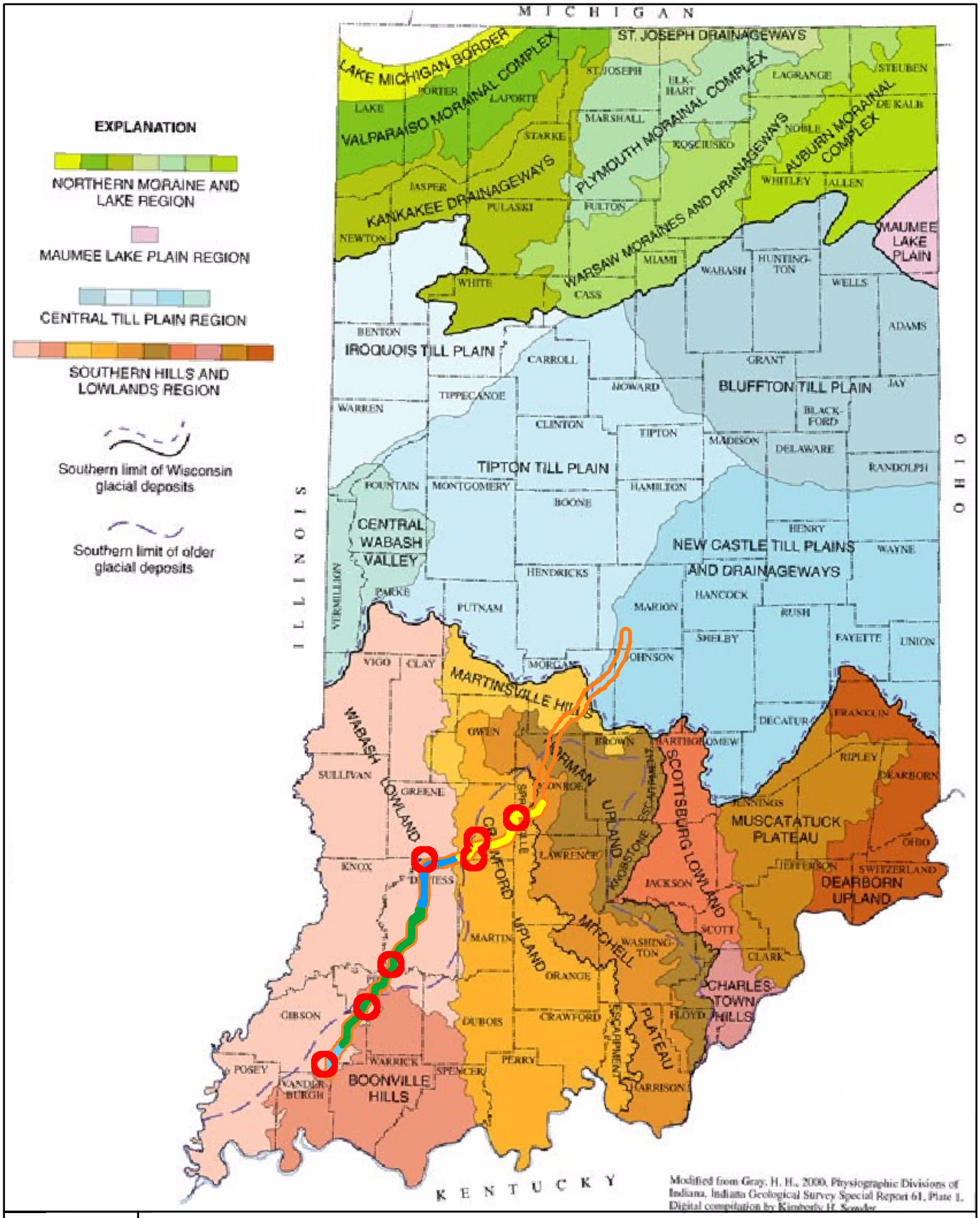

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Figure 1b. Physiography of Indiana.

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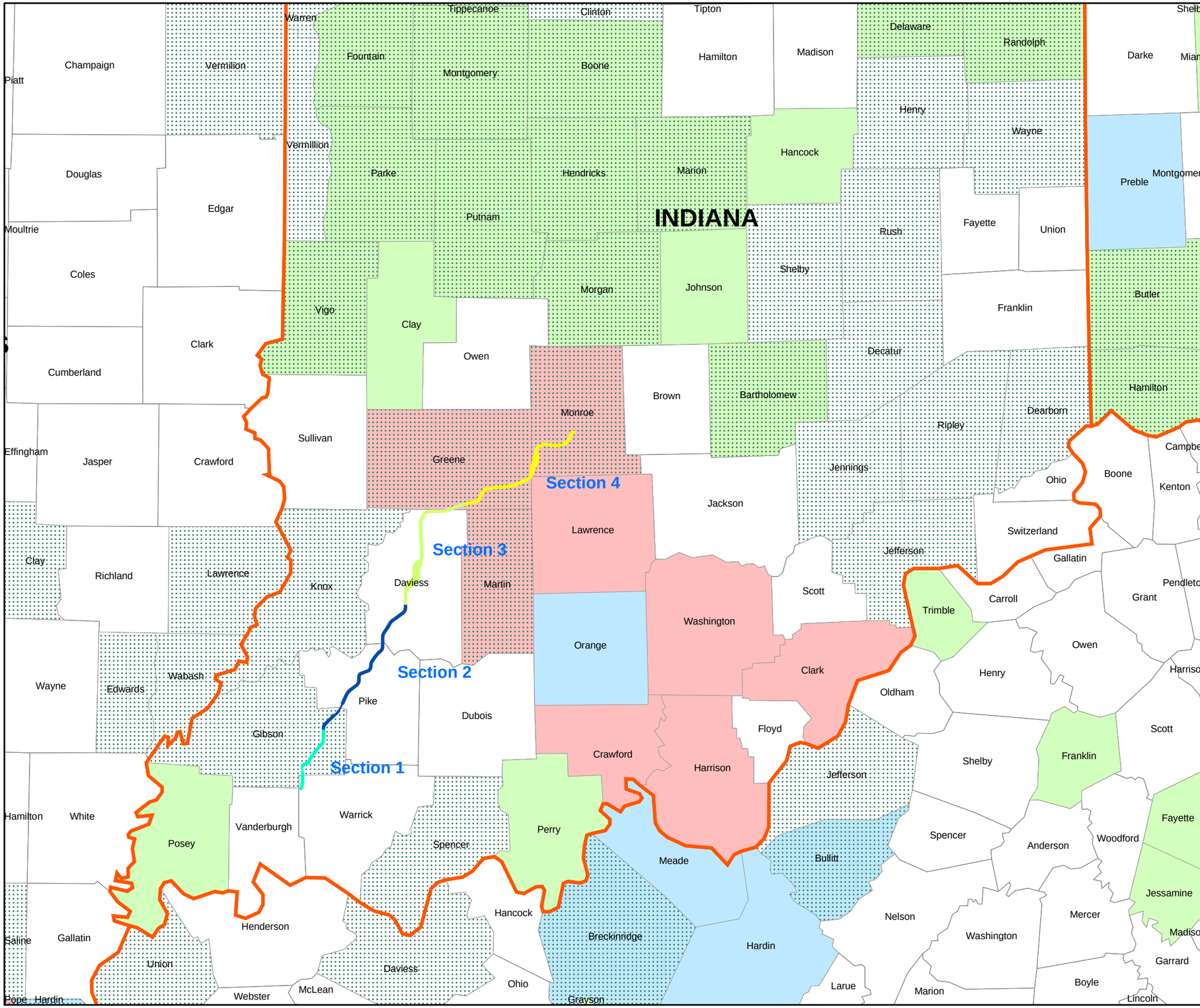
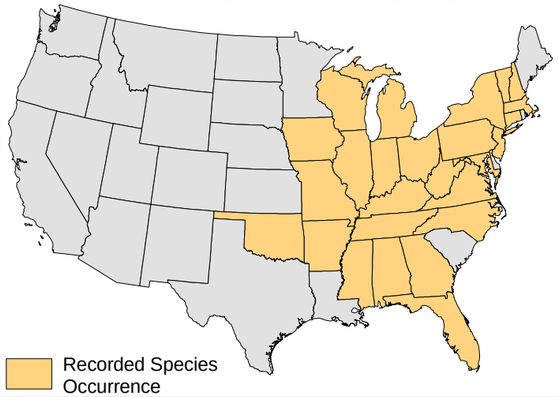


Figure 2. Counties near the project area with hibernacula, summer maternity, and other summer (nonreproductive) records for the Indiana bat (*Myotis sodalis*).

- 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

STATES WITH RECORDS OF INDIANA BAT OCCURRENCE



Recorded Species Occurrence

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Sources: USFWS, Indiana Bat Revised Recovery Plan, Agency Draft, 1999.

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Figure 3 has been removed for confidentiality reasons related to the federally endangered Indiana bat (*Myotis sodalis*).

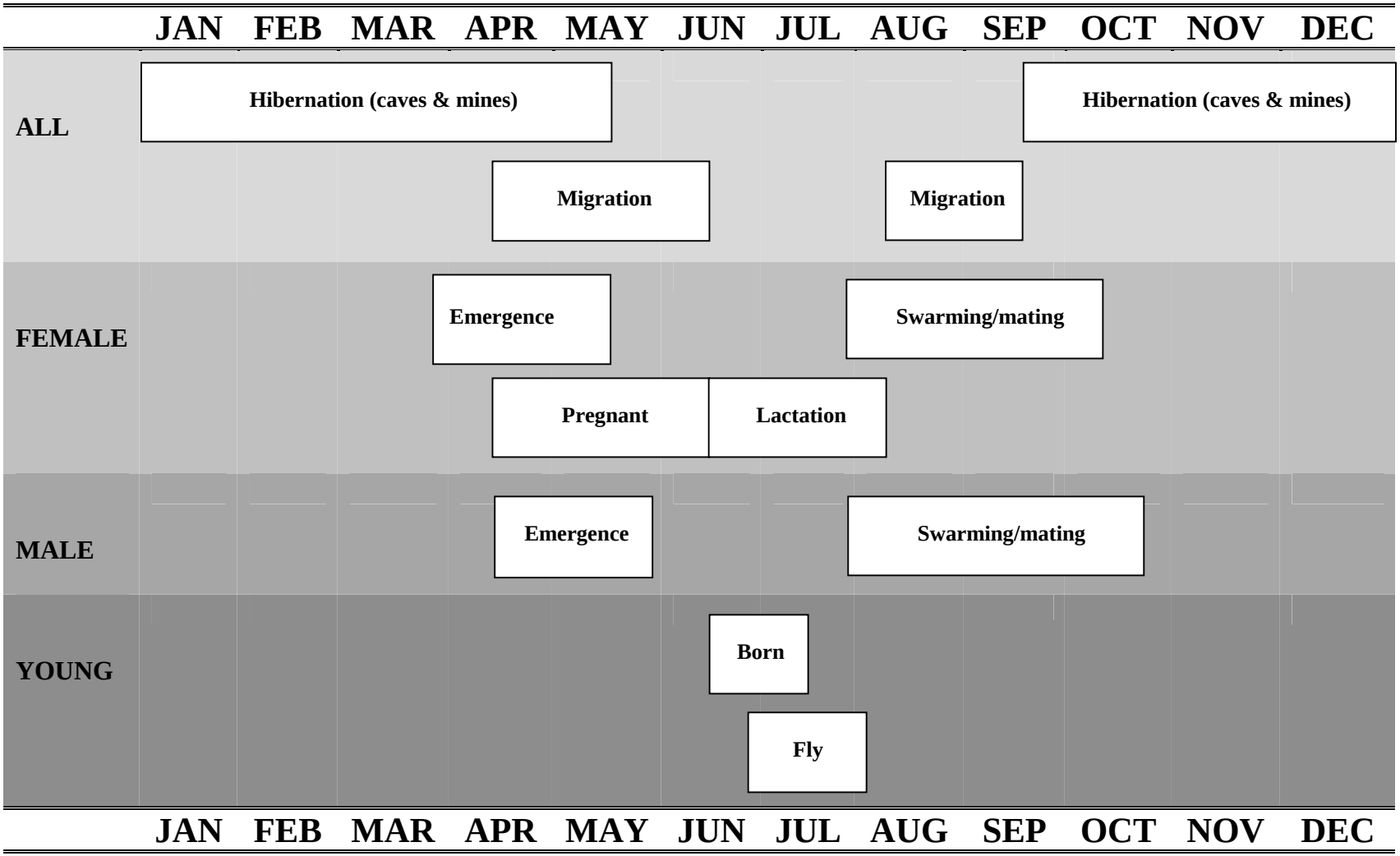


Figure 4. Seasonal chronology of Indiana bat activities.

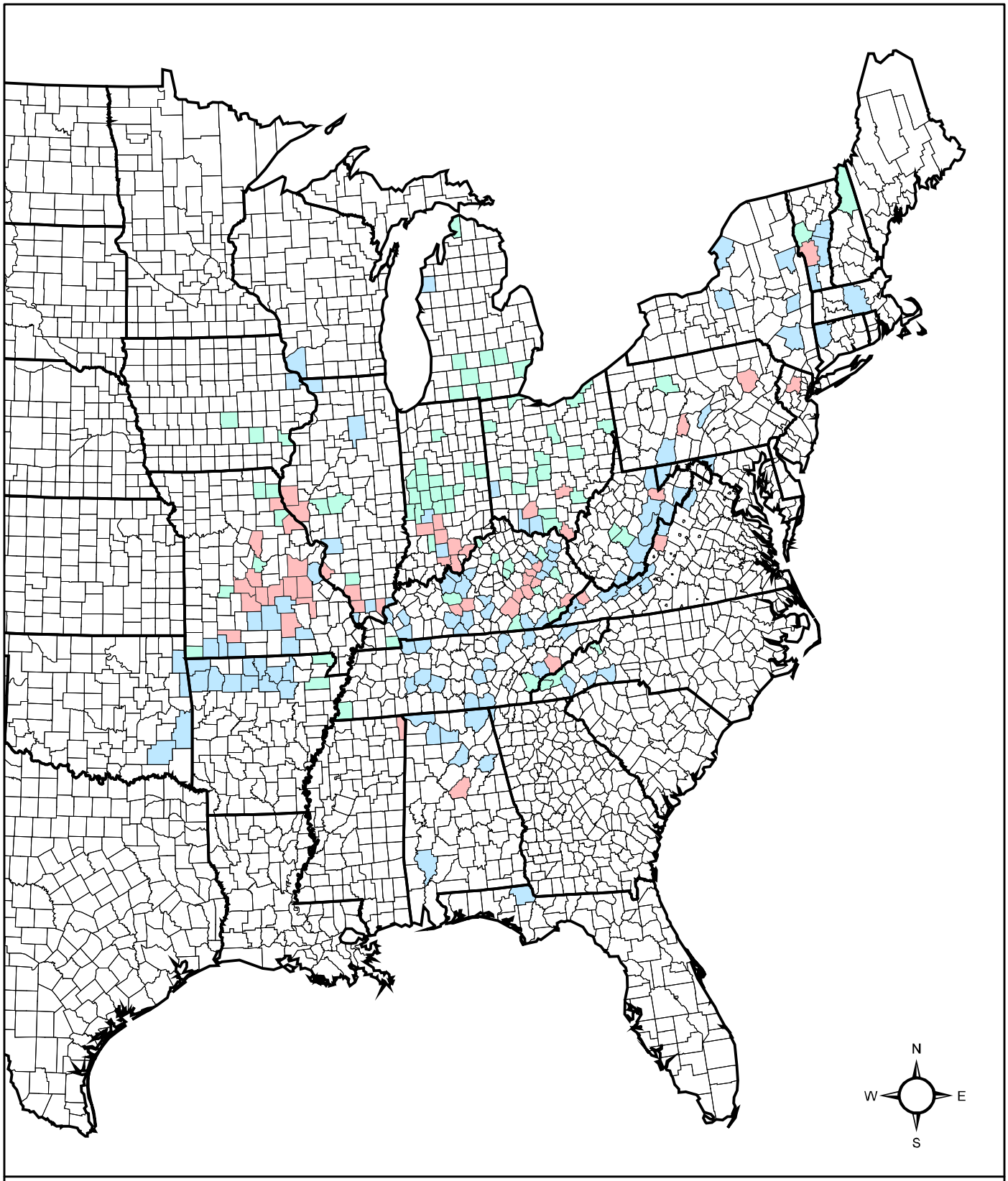


Figure 5. Counties with hibernacula and other summer (nonreproductive) records for the Indiana bat (*Myotis sodalis*) range wide.

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.

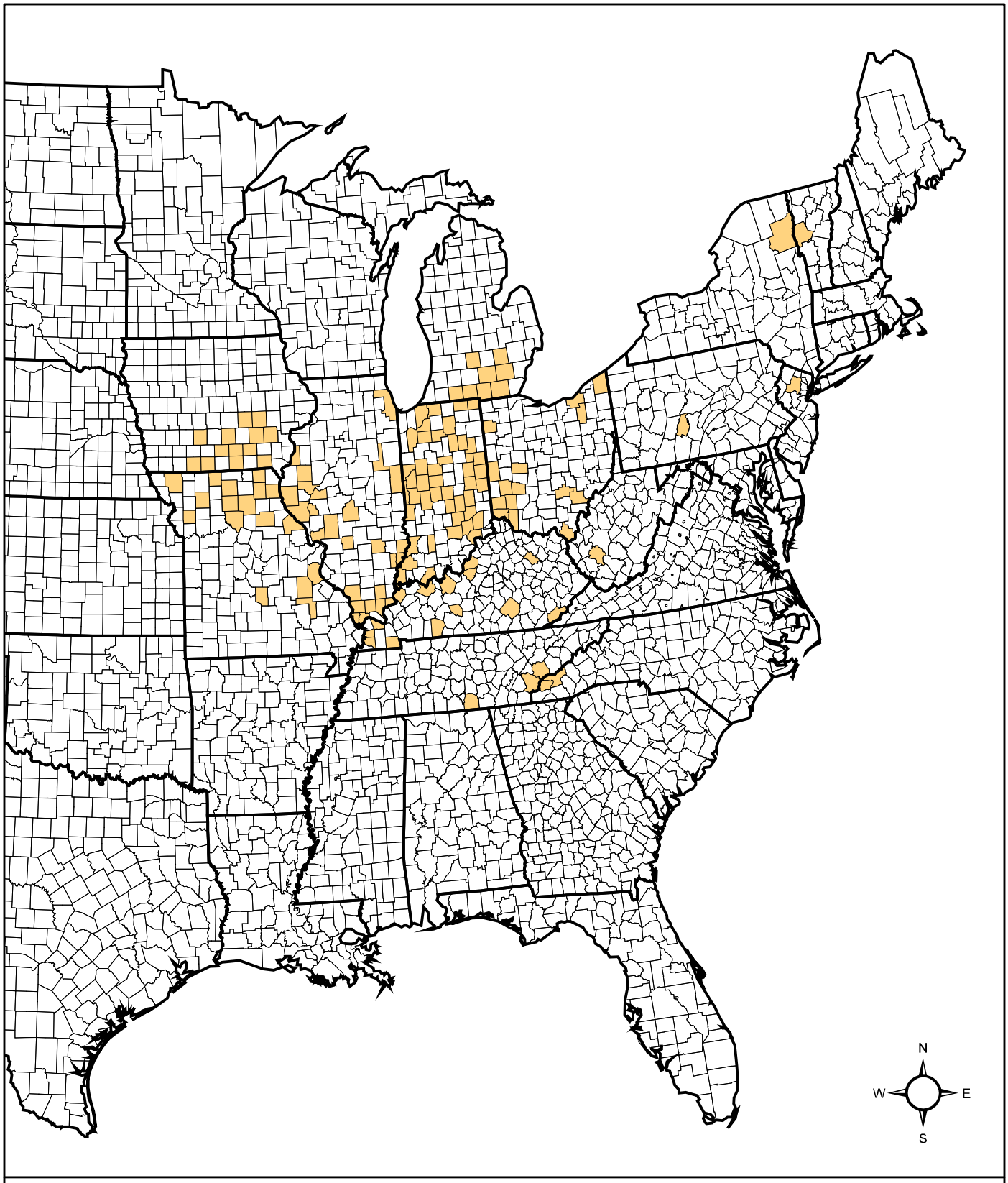
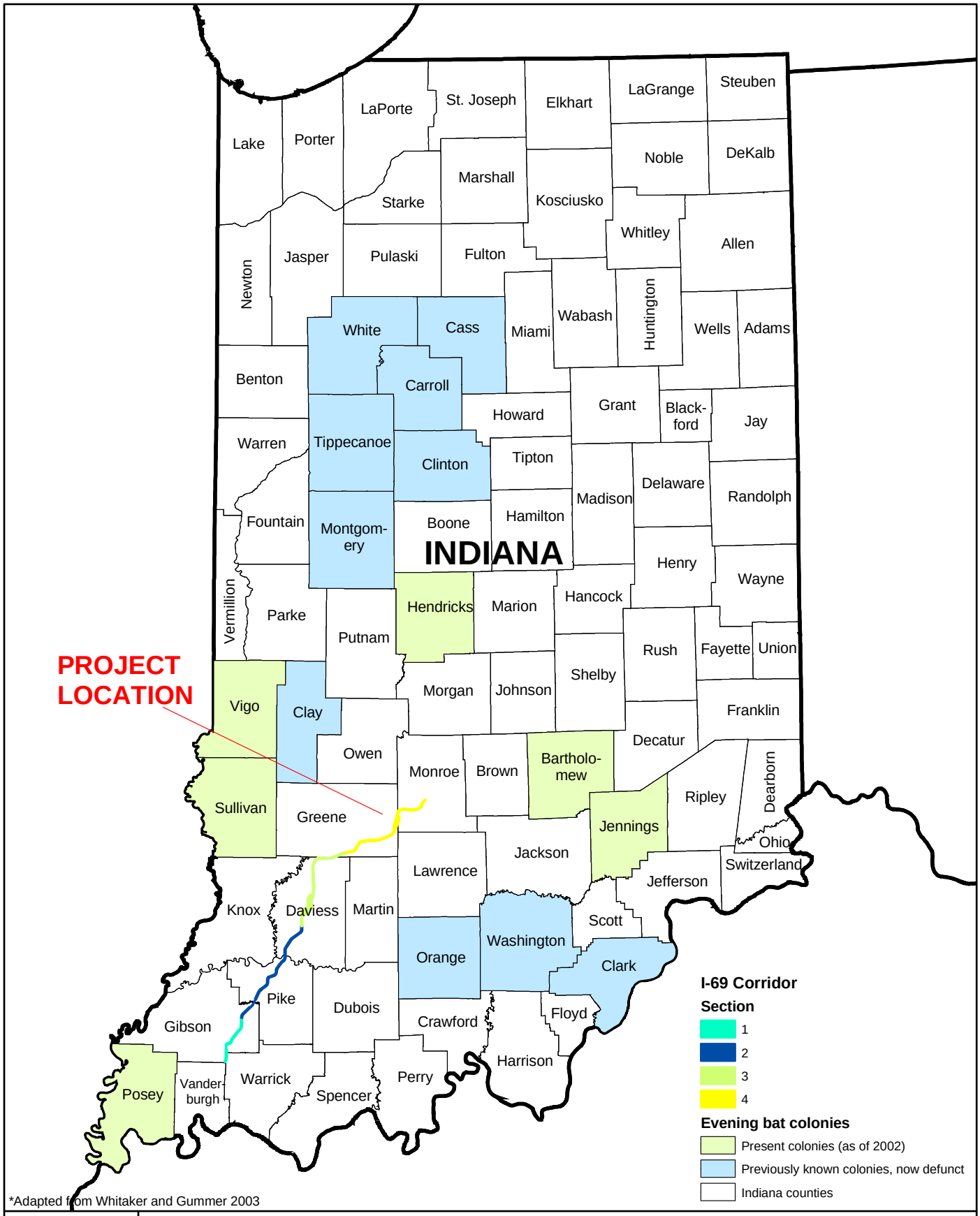


Figure 6. Counties with reproductive (adult female and/or young-of-the-year) records for the Indiana bat (*Myotis sodalis*) range wide.

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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Figures 8-11 have been removed for confidentiality reasons related to the federally endangered Indiana bat (*Myotis sodalis*).

Appendix B

Tables

Table 1 has been removed for confidentiality reasons related to the federally endangered Indiana bat (*Myotis sodalis*).

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 has been removed for confidentiality reasons related to the federally endangered Indiana bat (*Myotis sodalis*).

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

Appendix E
Notice of Survey Letter

I-69 Evansville to Indianapolis Tier 2 Studies

August 9, 2004

To Whom it may concern
I-69 Project Section 2
Gibson, Pike & Daviess County

RE: Notice of Entry for Survey or Investigation
I-69 Environmental Impact Statement, Tier 2 - Section 2

Dear Property Owner:

Our information indicates that you own property in _____ County, _____ Township. This property is within the vicinity of Alternative 3C, the route for I-69 approved by the Federal Highway Administration (Evansville to Indianapolis). Representatives from the Hannum, Wagle & Cline Engineering Team, under contract with the Indiana Department of Transportation (INDOT), may be conducting surveys and investigations of the project area in the near future. It may be necessary for them to enter onto your property. This is permitted by law under Indiana Code IC 8-23-7-26. Field personnel performing this type of work have been instructed to identify themselves to you, if you are available, before they enter your property. If you no longer own this property or it is currently occupied by someone else, please let us know the name of the new owner or occupant so that we may contact them.

The work may include, but is not limited to, studies in the following categories: biological, geological, topographical, wetland, karst (may include dye tracing), historical, archaeological, noise, hazardous waste, socioeconomic, and possibly other investigations. The information we obtain from such studies is necessary for the proper planning and design of this highway project. It is our sincere desire to cause you as little inconvenience as possible during this survey.

At this stage of the project, we generally do not know what effect, if any, our project may eventually have on your individual property. If we determine later that your property is involved, we will contact you with additional information. This Notice of Survey does not involve any taking, purchasing or evaluating of property to be acquired for right-of-way purposes. At this time, it is anticipated the study in your area may be completed within 36 months. This Notice of Survey serves for survey and study purposes only.

If you should have any questions or comments, please call me at (812) 354-3462. By way of this Notice of Survey letter, we are extending a warm welcome to visit our office in Petersburg. It is located at 804 South Industrial Park Drive, which is just off Illinois street adjacent to the railroad tracks on the south side of Petersburg. We look forward to working with you on this project.

Sincerely,

The Hannum, Wagle & Cline Engineering Team

Randall M. Perkinson

Randall M. Perkinson, P.E.
Project Manager

Project Office Section 2
804 S. Industrial Park Dr.
P.O. Box 97
Petersburg, IN 47567
812-354-3462